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## Productivity and utilization of nutrients by rainfed lentil (*Lens culinaris* L.) under integrated nutrient management

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### Abstract

This experiment was conducted over two winter seasons (2024-25 and 2025-26) at the research farm of A.K.S. University, Satna (M.P.). The objective was to study the productivity and nutrient uptake of rainfed lentil under Integrated Nutrient Management (INM). The results indicated significant variations in the N, P, K, and S content of grain and straw across different INM treatments. The application of 100% RDF (N20 P60 K20) + 5 tonnes FYM + 2.5 tonnes vermicompost/ha (T<sub>9</sub>) resulted in the highest nutrient levels: N content of 4.00% and 0.98% in seed and straw respectively; P content of 0.44% and 0.23%; K content of 1.00% and 1.34%; and S content of 0.16% and 0.36%. Consequently, the T<sub>9</sub> treatment produced the highest total biomass (grain + straw), associated with a nutrient uptake of 62.40 kg N, 8.64 kg P, 31.83 kg K, and 7.21 kg S/ha. This was followed by treatments T<sub>7</sub> and T<sub>8</sub>, which involved reducing RDF levels by 50% to 75% while maintaining the same quantity of organic inputs. The findings suggest that due to the substantial nutrient uptake by the JL-3 lentil variety, it is essential to provide balanced nutrition to the subsequent crop based on soil test results.

**Keywords:** Integrated nutrient management, uptake, lentil

### Introduction

Soil nutrient deficiencies pose a significant threat to the sustainable production of lentils. The depletion of various soil nutrients has been exacerbated by factors such as the cultivation of high-yielding varieties, intensive farming practices, the unbalanced and inadequate use of manures and fertilizers, and the use of sulfur-free fertilizers. Generally, the nutrients extracted from the soil by the crop are never fully replenished. Consequently, maintaining soil health and ensuring sustainable lentil yields are becoming critical issues. It is well known that lentils are a nutrient-demanding crop that responds exceptionally well to applied nutrients, including sulfur. Due to variations in soil fertility, the response of a specific lentil variety to direct fertilizer application varies significantly and differs from one location to another. (Saket *et al.*, 2014 and Pandey *et al.*, 2023) [3, 6].

New crop varieties require higher levels of nutrients to achieve their full yield potential. The correct and appropriate use of fertilizers not only boosts yield but also positively influences the quality of the produce. To arrest the trend of declining yields, it is essential to adopt the Integrated Nutrient Management (INM) approach. Organic manures are a crucial component of INM and can help improve soil health. Furthermore, organic manures provide micronutrients that are often lacking in chemical fertilizers. Therefore, it is important to compare various organic manures with chemical fertilizers to determine the most effective combination. The integrated system approach is not only a reliable method for achieving higher yields while significantly saving on fertilizers, but it also represents a concept that fosters environmentally sound and sustainable agriculture. The fundamental concept of the Integrated Plant Nutrient System is to maintain and enhance soil fertility to ensure sustained crop productivity over the long term. Limited research has been conducted in the Satna region regarding the response of the 'JL-3' lentil variety to the integrated supply of nutrients from diverse sources. This research was undertaken with this context in mind.

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## Materials and Methods

A field experiment was conducted at the research farm of A.K.S. University, Satna (M.P.), during the two winter seasons of 2024-25 and 2025-26. The soil of the experimental field was silty clay-loam, with a pH of 7.35, electrical conductivity of 0.23 dS/m, organic carbon of 0.48%, and available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, and S contents of 188.6, 12.5, 220.4 kg/ha, and 7.60 ppm, respectively. Total rainfall during the June-to-January period was 28.4 mm in 2024-25 and 32.8 mm in 2025-26. The study involved 10 INM treatments arranged in a randomized block design with four replications. These 10 treatments were: T<sub>0</sub> - Control, T<sub>1</sub> - 50% RDF, T<sub>2</sub> - 75% RDF, T<sub>3</sub> - 100% RDF, T<sub>4</sub> - 50% RDF + 5 t FYM/ha, T<sub>5</sub> - 75% RDF + 5 t FYM/ha, T<sub>6</sub> - 100% RDF + 5 t FYM/ha, T<sub>7</sub> - 50% RDF + 5 t FYM + 2.5 t VC/ha, T<sub>8</sub> - 75% RDF + 5 t FYM + 2.5 t VC/ha, and T<sub>9</sub> - 100% RDF + 5 t FYM + 2.5 t VC/ha. The 100% RDF (N<sub>20</sub> P<sub>60</sub> K<sub>20</sub>) was supplied through urea, single superphosphate, and muriate of potash, respectively. The lentil variety JL-3 was sown at a rate of 40 kg/ha in rows spaced 30 cm apart on November 18 and 19 in the years 2024 and 2025, respectively. The crop was grown under rainfed conditions, although pre-sowing irrigation was applied to ensure proper seed germination and establishment. Harvesting was carried out on March 13 and 14 in 2025 and 2026, respectively. The percentage content of N, P, K, and S in the lentil seeds and straw was determined following standard analytical procedures (A.O.A.C., 1997). Nutrient uptake per hectare was calculated by multiplying the seed or straw yield by the percentage content of N, P, K, and S nutrients present in the seed or straw.

## Results and Discussion

### Nutrient contents in seed and straw

Table 1 provides detailed information on the N, P, K, and S nutrient content in lentil seeds and straw. Generally, the levels of N and P are higher in the seeds than in the straw. This higher nutrient concentration in seeds compared to straw may be attributed to the seeds acting as a 'sink' for photosynthates and nitrogen; essentially, nutrients are translocated from the plant's vegetative parts toward the reproductive organs (the sink). Increasing the INM level up to the T<sub>9</sub> treatment resulted in a significant rise in N, P, K, and S content in both seeds and straw. Under the T<sub>9</sub> treatment, the maximum nutrient levels recorded

were 4.00% N and 0.98% N, 0.44% P and 0.23% P, 1.00% K and 1.34% K, and 0.16% S and 0.36% S in seeds and straw, respectively. Nutrient levels decreased when the nutrient supply was reduced in other INM treatments. Finally, the lowest levels of N, P, K, and S in both seeds and straw were observed under the T<sub>0</sub> (control) treatment.

Thus, a significant difference persisted between the low and high nutrient levels applied. This may be attributed to the plants absorbing a greater proportion of the multi-nutrients derived from NPK and VC, as the higher dosages of these nutrient sources increased the availability of nutrients in the soil. Essentially, the increase in N, P, K, and S content in the grain and straw resulting from INM treatments can be linked to the elevated levels of these nutrients in various plant parts across different growth stages. The current findings align with the research conducted by Saket *et al.*, (2014) [3]; Singh and Pandey (2017) [7]; and Maniram Jakhar *et al.*, (2020) [4], Khan *et al.*, (2023) [8], and Dahal *et al.*, (2014) [9].

### Uptake of Nutrients

The application of the highest level treatment—100% NPK (RDF) + 5 tonnes FYM + 2.5 tonnes vermicompost/ha (T<sub>9</sub>)—resulted in the highest uptake of N, P, K, and S in lentil seeds and straw (Table 2). Consequently, at this highest nutrient level (T<sub>9</sub>), the total biomass (seed + straw) production was 26.85 quintals/ha, accompanied by the highest uptake of 62.40 kg N, 8.64 kg P, 31.83 kg K, and 7.21 kg S/ha. The higher uptake of NPKS nutrients across various INM levels can be attributed to increased seed and straw yields and elevated N, P, K, and S concentrations in the produce under these INM treatments. This was followed by treatments T<sub>8</sub> and T<sub>7</sub>. The combined application of FYM and vermicompost in treatments T<sub>7</sub> through T<sub>9</sub> showed varying effects on the parameters under study; this variation may be due to differences in nutrient content, decomposition rates of organic residues, C:N ratios, nutrient release patterns, climatic conditions, and soil characteristics. (Sanwal *et al.*, 2007 and Pandey *et al.*, 2023) [5, 6].

The current results confirm the findings of many researchers (Singh *et al.*, 2016; Pandey *et al.*, 2015; Singh and Pandey, 2017; Saket *et al.*, 2017 and Mandram Jakhar *et al.*, 2020; Khan *et al.*, 2023 and Dahal *et al.*, 2024) [10, 11, 7, 4, 8, 9].

**Table 1:** Nutrient contents in grain and straw under INM treatments (Pooled of two years)

| Tr.            | Treatments                                                      | Total biomass (q/ha) | N – content (%) |       | P – content (%) |       | K – content (%) |       | S – content (%) |       |
|----------------|-----------------------------------------------------------------|----------------------|-----------------|-------|-----------------|-------|-----------------|-------|-----------------|-------|
|                |                                                                 |                      | Seed            | Straw | Seed            | Straw | Seed            | Straw | Seed            | Straw |
| T <sub>0</sub> | Control                                                         | 16.42                | 3.80            | 0.84  | 0.30            | 0.14  | 0.84            | 0.94  | 0.07            | 0.21  |
| T <sub>1</sub> | 50% RDF (N <sub>10</sub> P <sub>30</sub> K <sub>10</sub> ) / ha | 17.58                | 3.83            | 0.87  | 0.32            | 0.15  | 0.88            | 0.98  | 0.08            | 0.24  |
| T <sub>2</sub> | 50% RDF (N <sub>15</sub> P <sub>45</sub> K <sub>15</sub> ) / ha | 18.38                | 3.86            | 0.89  | 0.35            | 0.17  | 0.90            | 1.01  | 0.09            | 0.26  |
| T <sub>3</sub> | 75% RDF (N <sub>20</sub> P <sub>60</sub> K <sub>20</sub> ) / ha | 19.22                | 3.88            | 0.90  | 0.36            | 0.17  | 0.92            | 1.07  | 0.10            | 0.27  |
| T <sub>4</sub> | 50% RDF + 5t FYM / ha                                           | 19.96                | 3.90            | 0.92  | 0.37            | 0.18  | 0.94            | 1.08  | 0.10            | 0.29  |
| T <sub>5</sub> | 75% RDF + 5t FYM / ha                                           | 20.44                | 3.91            | 0.93  | 0.38            | 0.19  | 0.95            | 1.14  | 0.11            | 0.31  |
| T <sub>6</sub> | 100% RDF + 5t FYM / ha                                          | 21.14                | 3.93            | 0.95  | 0.40            | 0.21  | 0.95            | 1.18  | 0.12            | 0.32  |
| T <sub>7</sub> | 50% RDF + 5t FYM + 2.5 t VC / ha                                | 22.82                | 3.94            | 0.96  | 0.41            | 0.22  | 0.96            | 1.27  | 0.14            | 0.33  |
| T <sub>8</sub> | 75% RDF + 5t FYM + 2.5 t VC / ha                                | 24.90                | 3.96            | 0.96  | 0.42            | 0.22  | 0.98            | 1.29  | 0.14            | 0.34  |
| T <sub>9</sub> | 100% RDF + 5t FYM + 2.5 t VC / ha                               | 26.85                | 4.00            | 0.98  | 0.44            | 0.23  | 1.00            | 1.34  | 0.16            | 0.36  |
|                | S.Em ±                                                          | 0.61                 | 0.03            | 0.05  | 0.02            | 0.01  | 0.05            | 0.09  | 0.005           | 0.02  |
|                | C. D. (5%)                                                      | 1.74                 | 0.07            | 0.13  | 0.05            | 0.02  | 0.13            | 0.24  | 0.012           | 0.06  |

RDF = Recommended dose of fertilizers

**Table 2:** Uptake of nutrients / ha of lentil under different INM treatments (Pooled of two years)

| Tr.            | Treatments                                                      | N – uptake (kg/ha) |       |       | P – uptake (kg/ha) |       |       | K – uptake (kg/ha) |       |       | S – uptake (kg/ha) |       |       |
|----------------|-----------------------------------------------------------------|--------------------|-------|-------|--------------------|-------|-------|--------------------|-------|-------|--------------------|-------|-------|
|                |                                                                 | Seed               | Straw | Total | Seed               | Straw | Total | Seed               | Straw | Total | Seed               | Straw | Total |
| T <sub>0</sub> | Control                                                         | 25.18              | 8.17  | 33.35 | 1.96               | 1.37  | 3.33  | 5.58               | 9.20  | 14.78 | 0.43               | 2.01  | 2.44  |
| T <sub>1</sub> | 50% RDF (N <sub>10</sub> P <sub>30</sub> K <sub>10</sub> ) / ha | 27.65              | 8.96  | 36.61 | 2.28               | 1.56  | 3.84  | 6.32               | 10.15 | 16.47 | 0.58               | 2.44  | 3.02  |
| T <sub>2</sub> | 50% RDF (N <sub>15</sub> P <sub>45</sub> K <sub>15</sub> ) / ha | 29.74              | 9.44  | 39.18 | 2.67               | 1.82  | 4.49  | 6.95               | 10.71 | 17.66 | 0.66               | 2.72  | 3.38  |
| T <sub>3</sub> | 75% RDF (N <sub>20</sub> P <sub>60</sub> K <sub>20</sub> ) / ha | 32.11              | 9.79  | 41.90 | 2.94               | 1.86  | 4.80  | 7.59               | 11.65 | 19.24 | 0.79               | 2.90  | 3.69  |
| T <sub>4</sub> | 50% RDF + 5t FYM / ha                                           | 33.75              | 10.33 | 44.08 | 3.17               | 2.03  | 5.20  | 8.10               | 12.19 | 20.29 | 0.87               | 3.28  | 4.15  |
| T <sub>5</sub> | 75% RDF + 5t FYM / ha                                           | 34.67              | 10.76 | 45.43 | 3.37               | 2.20  | 5.57  | 8.29               | 13.19 | 21.48 | 0.93               | 3.53  | 4.46  |
| T <sub>6</sub> | 100% RDF + 5t FYM / ha                                          | 36.14              | 11.27 | 47.41 | 3.69               | 2.45  | 6.14  | 8.70               | 14.07 | 22.77 | 1.06               | 3.76  | 4.82  |
| T <sub>7</sub> | 50% RDF + 5t FYM + 2.5 t VC / ha                                | 39.07              | 12.32 | 51.39 | 4.02               | 2.78  | 6.80  | 9.47               | 16.39 | 25.86 | 1.34               | 4.19  | 5.53  |
| T <sub>8</sub> | 75% RDF + 5t FYM + 2.5 t VC / ha                                | 42.98              | 13.47 | 56.45 | 4.57               | 3.09  | 7.66  | 10.60              | 18.03 | 28.63 | 1.53               | 4.70  | 6.23  |
| T <sub>9</sub> | 100% RDF + 5t FYM + 2.5 t VC / ha                               | 47.86              | 14.54 | 62.40 | 5.23               | 3.41  | 8.64  | 11.95              | 19.88 | 31.83 | 1.87               | 5.34  | 7.21  |
|                | S.Em ±                                                          | 0.59               | 0.03  | 0.62  | 0.20               | 0.12  | 0.32  | 0.36               | 0.36  | 0.72  | 0.05               | 0.13  | 0.18  |
|                | C. D. (5%)                                                      | 1.71               | 0.09  | 1.80  | 0.58               | 0.33  | 0.91  | 1.02               | 1.03  | 2.05  | 0.12               | 0.37  | 0.49  |

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