# Effect of Integrated Nutrient Management on Tuber Yield and Post-Harvest Soil Fertility of Potato (Solanum tuberosum L.)

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## Abstract
A field experiment was conducted during the rabi season of 2025–26 at the Research Farm of Integral University, Lucknow, Uttar Pradesh, India, to evaluate the effect of integrated nutrient management practices on tuber yield and post-harvest soil fertility of potato (Solanum tuberosum L.). The experiment was laid out in a Split Plot Design with three potato varieties and six nutrient management treatments comprising different combinations of recommended dose of fertilizers (RDF), farmyard manure (FYM), and vermicompost. Tuber yield and post-harvest soil organic carbon, available nitrogen, phosphorus, and potassium were recorded and analyzed statistically. The results revealed significant variation among varieties and nutrient management treatments. Among the varieties, Kufri Chipsona-1 recorded the highest tuber yield (33.90 t $ha^{-1}$), followed by Kufri Ashok (28.12 t $ha^{-1}$), while the lowest yield was observed in Kufri Anand (21.49 t $ha^{-1}$). Among nutrient management treatments, application of 50% RDF + Vermicompost @ 15 t $ha^{-1}$ (T5) produced the highest tuber yield (30.84 t $ha^{-1}$), available nitrogen (163.56 kg $ha^{-1}$), and available potassium (244.78 kg $ha^{-1}$). The highest soil organic carbon content (0.638%) and available phosphorus (12.55 kg $ha^{-1}$) were recorded under 50% RDF + FYM @ 30 t $ha^{-1}$ (T4). Integrated application of organic manures with inorganic fertilizers significantly improved soil fertility compared with the sole application of chemical fertilizers. The study demonstrated that partial substitution of chemical fertilizers with vermicompost and FYM enhanced potato productivity and improved post-harvest soil nutrient status. Among the treatments, 50% RDF + Vermicompost @ 15 t $ha^{-1}$ proved to be the most effective nutrient management strategy for sustainable potato production under the agro-climatic conditions of Uttar Pradesh

**Keywords:** Potato, integrated nutrient management, vermicompost, farmyard manure, tuber yield, soil fertility

## 1. Introduction
Potato (*Solanum tuberosum* L.) is one of the most important food crops in the world and ranks fourth after rice, wheat, and maize in terms of human consumption. It is a highly productive crop with a short growth duration and serves as an important source of carbohydrates, vitamins, minerals, and dietary fibre. In India, potato plays a significant role in ensuring food and nutritional security and contributes substantially to the agricultural economy. The increasing demand for potato production necessitates the adoption of sustainable nutrient management strategies capable of enhancing productivity while maintaining soil fertility (Barbaś et al., 2023). The intensive cultivation of potato requires substantial quantities of nutrients due to its shallow root system and high nutrient demand. To achieve higher yields, farmers often rely heavily on chemical fertilizers (Ren et al., 2023). Although the continuous use of inorganic fertilizers can increase crop productivity in the short term, excessive dependence on these inputs may adversely affect soil health, reduce nutrient use efficiency, and lead to deterioration of soil physical, chemical, and biological properties. Consequently, maintaining long-term soil fertility has become a major challenge in potato-based production systems (Ierna and Distefano, 2024). Integrated Nutrient Management (INM) has emerged as a sustainable approach for improving crop productivity and soil quality through the combined use of inorganic fertilizers and organic nutrient sources. Organic amendments such as farmyard manure (FYM) and vermicompost not only supply essential plant nutrients but also improve soil structure, moisture retention, microbial activity, and nutrient availability (Gulshan, 2022). The integration of organic manures with chemical fertilizers enhances nutrient use efficiency, promotes balanced nutrient supply, and contributes to the maintenance of soil organic matter. Several studies have reported that the combined application of organic and inorganic nutrient sources improves potato growth, yield, and nutrient uptake while sustaining soil fertility (Mwakidoshi et al., 2026; Yaseen et al., 2025). Among organic nutrient sources, FYM and vermicompost have received considerable attention because of their beneficial effects on soil health and crop performance. Farmyard manure contributes to the gradual release of nutrients and improves soil physical properties, whereas vermicompost provides readily available nutrients, beneficial microorganisms, and growth-promoting substances (Patel et al., 2022). The combined use of these organic inputs with recommended fertilizer doses may reduce the dependence on chemical fertilizers and enhance the sustainability of potato production systems (Ren et al., 2025, Mazeed et al., 2026). Despite the recognized benefits of integrated nutrient management, information regarding the comparative performance of different combinations of FYM, vermicompost, and inorganic fertilizers on potato productivity and post-harvest soil fertility under the agro-climatic conditions of Uttar Pradesh remains limited (Gelaye, 2023; Mohasin et al., 2025). Therefore, the present investigation was undertaken to evaluate the effect of integrated nutrient management practices on tuber yield and post-harvest soil fertility of potato. The study aimed to identify an efficient nutrient management strategy

capable of improving productivity while maintaining soil nutrient status under potato cultivation.

## 2. Materials and Methods

### 2.1 Experimental Site and Soil Characteristics

A field experiment was conducted during the rabi season of 2025–26 at the Research Farm of the Department of Agriculture, Integral Institute of Agricultural Science and Technology, Integral University, Lucknow, Uttar Pradesh, India. The experimental site is situated in the Indo-Gangetic plains and experiences a subtropical climate characterized by hot summers and cool winters. Before sowing, composite soil samples were collected from the experimental field and analyzed for their physico-chemical properties. The soil was slightly alkaline in reaction with pH ranging from 7.91 to 7.98 and electrical conductivity (EC) ranging from 0.41 to 0.48 dS $m^{-1}$. The organic carbon content varied between 0.56 and 0.62%. The available nitrogen, phosphorus, and potassium contents ranged from 128 to 142 kg $ha^{-1}$, 8.90 to 13.63 kg $ha^{-1}$, and 145 to 162 kg $ha^{-1}$, respectively, indicating medium fertility status of the experimental soil.

### 2.2 Experimental Design and Treatments

The experiment was laid out in a Split Plot Design (SPD) with three replications. Three potato varieties viz., Kufri Anand (V1), Kufri Ashok (V2), and Kufri Chipsona-1 (V3) were assigned to the main plots, whereas six integrated nutrient management treatments were allocated to the sub-plots.

**The nutrient management treatments were:**

- T1: 100% RDF (180:80:100 kg N:$P_2O_5$:$K_2O$ $ha^{-1}$)
- T2: 100% RDF + FYM @ 15 t $ha^{-1}$
- T3: 100% RDF + Vermicompost @ 7.5 t $ha^{-1}$
- T4: 50% RDF + FYM @ 30 t $ha^{-1}$
- T5: 50% RDF + Vermicompost @ 15 t $ha^{-1}$
- T6: 50% RDF + FYM @ 15 t $ha^{-1}$ + Vermicompost @ 7.5 t $ha^{-1}$

### 2.3 Crop Management

The crop was planted following the recommended agronomic practices for potato cultivation in the region. Farmyard manure and vermicompost were incorporated into the soil before planting according to the treatment schedule. Chemical fertilizers were applied as per the recommended dose and treatment combinations. Irrigation, weeding, earthing-up, and plant protection measures were carried out uniformly in all plots throughout the crop growth period.

### 2.4 Soil Analysis

After harvest, soil samples were collected from each experimental plot and analyzed for organic carbon, available nitrogen, available phosphorus, and available potassium using standard analytical procedures. Organic carbon was determined by the Walkley and Black wet oxidation method, available nitrogen by the alkaline potassium permanganate method, available phosphorus by Olsen's method, and available potassium using a flame photometer.

### 2.5 Tuber Yield

Tubers harvested from each net plot were weighed and converted into tuber yield expressed as tonnes per hectare (t $ha^{-1}$).

### 2.6 Statistical Analysis

The recorded data were subjected to analysis of variance (ANOVA) appropriate for Split Plot Design. The significance of treatment effects was tested using the F-test, and treatment means were compared using the Critical Difference (CD) test at the 5% level of significance.

## 3. Results and Discussion

**Table 1. Effect of integrated nutrient management on soil organic carbon and available nutrients after harvest of potato.**

| Treatment | Organic Carbon (%) | Available N (kg $ha^{-1}$) | Available P (kg $ha^{-1}$) | Available K (kg $ha^{-1}$) |
|---|---|---|---|---|
| T1 | 0.587 | 157.67 | 11.57 | 215.11 |
| T2 | 0.587 | 158.67 | 11.71 | 217 |
| T3 | 0.581 | 157.44 | 11.52 | 213 |
| T4 | 0.638 | 162.78 | 12.55 | 241.78 |
| T5 | 0.631 | 163.56 | 12.53 | 244.78 |
| T6 | 0.63 | 162.56 | 12.54 | 236.44 |
| SE(m) ± | 0.006 | 0.592 | 0.075 | 2.711 |
| CD (P=0.05) | 0.017 | 1.718 | 0.218 | 7.866 |
| **Variety means** | | | | |

| Variety | Organic Carbon (%) | Available N (kg ha⁻¹) | Available P (kg ha⁻¹) | Available K (kg ha⁻¹) |
|---|---|---|---|---|
| | | | | |
| V1 (Kufri Anand) | 0.523 | 149.89 | 10.72 | 186.89 |
| V2 (Kufri Ashok) | 0.631 | 160.72 | 12.3 | 238.39 |
| V3 (Kufri Chipsona-1) | 0.672 | 170.72 | 13.2 | 258.78 |
| SE(m) ± | 0.003 | 0.111 | 0.06 | 1.312 |
| CD (P=0.05) | 0.012 | 0.448 | 0.242 | 5.288 |

**Table 2. Effect of integrated nutrient management on tuber yield of potato.**

| **Treatment** | **Tuber yield (t ha$^{-1}$)** |
|---|---|
| T1 | 24.98 |
| T2 | 25.58 |
| T3 | 25.07 |
| T4 | 30.19 |
| T5 | 30.84 |
| T6 | 30.37 |
| SE(m) ± | 0.327 |
| CD (P=0.05) | 0.949 |
| **Variety means** | |
| Variety | Tuber yield (t ha$^{-1}$) |
| V1 (Kufri Anand) | 21.49 |
| V2 (Kufri Ashok) | 28.12 |
| V3 (Kufri Chipsona-1) | 33.9 |
| SE(m) ± | 0.043 |
| CD (P=0.05) | 0.174 |

### 3.1 Tuber Yield

Tuber yield was significantly influenced by potato varieties and integrated nutrient management treatments (Table 2). Among the varieties, Kufri Chipsona-1 (V3) recorded the highest tuber yield (33.90 t ha$^{-1}$), followed by Kufri Ashok (28.12 t ha$^{-1}$), whereas the lowest yield was observed in Kufri Anand (21.49 t ha$^{-1}$). The superior performance of Kufri Chipsona-1 may be attributed to its greater genetic potential, efficient nutrient utilization, and better assimilate partitioning towards tuber development. Among nutrient management treatments, application of 50% RDF + Vermicompost @ 15 t ha$^{-1}$ (T5) produced the highest tuber yield (30.84 t ha$^{-1}$), which was significantly superior to the sole application of recommended fertilizers (T1, 24.98 t ha$^{-1}$). Treatments T6 (50% RDF + FYM @ 15 t ha$^{-1}$ + Vermicompost @ 7.5 t ha$^{-1}$) and T4 (50% RDF + FYM @ 30 t ha$^{-1}$) also recorded higher yields of 30.37 and 30.19 t ha$^{-1}$, respectively. The increase in tuber yield under integrated nutrient management treatments may be attributed to improved nutrient availability, enhanced soil microbial activity, better root growth, and improved soil physical conditions resulting from the addition of organic manures. Organic amendments not only supply essential nutrients but also improve nutrient use efficiency of applied fertilizers, thereby promoting greater tuber formation and development (Karubakee et al., 2024; Xu et al., 2022; Sahu et al., 2023).

### 3.2 Post-harvest Soil Fertility

Post-harvest soil fertility was significantly influenced by integrated nutrient management practices (Table 1). The application of organic nutrient sources in combination with inorganic fertilizers resulted in a marked improvement in soil organic carbon and available nutrient status compared with the sole application of chemical fertilizers. The highest organic carbon content was recorded under T4 (50% RDF + FYM @ 30 t ha$^{-1}$) with a value of 0.638%, followed by T5 (50% RDF + Vermicompost @ 15 t ha$^{-1}$) and T6 (50% RDF + FYM @ 15 t ha$^{-1}$ + Vermicompost @ 7.5 t ha$^{-1}$), which recorded 0.631 and 0.630%, respectively. The improvement in soil organic carbon under these treatments may be attributed to the direct addition of organic residues and enhanced microbial activity, leading to greater accumulation of soil organic matter. Similarly, available nitrogen, phosphorus, and potassium contents were significantly enhanced under integrated nutrient management treatments. The highest available nitrogen (163.56 kg ha$^{-1}$) and available potassium (244.78 kg ha$^{-1}$) were recorded under T5, while T4 registered the highest available phosphorus content (12.55 kg ha$^{-1}$), which was statistically at par with T5 (12.53 kg ha$^{-1}$) and T6 (12.54 kg ha$^{-1}$). In contrast, lower values of available nutrients were observed under treatments receiving either sole chemical fertilizers or lower levels of organic amendments. The increased availability of nitrogen under integrated nutrient management treatments could be attributed to the gradual mineralization of nutrients from FYM and vermicompost, which ensured a continuous nutrient supply throughout the crop growth period. Enhanced phosphorus availability might be due to the release of organic acids during decomposition, which reduced phosphorus fixation and improved its solubility in soil. Likewise, the higher potassium content observed in organic manure-treated plots may be associated with the direct addition of potassium through organic materials and improved nutrient retention resulting from increased cation exchange capacity. Overall, the results demonstrated that the integration of organic manures with inorganic fertilizers not only improved soil organic carbon but also enhanced the availability of major nutrients after harvest. Among the treatments, T5 (50% RDF + Vermicompost @ 15 t ha$^{-1}$) proved most effective in maintaining soil fertility and sustaining nutrient availability under potato cultivation (Shi et al., 2023; Asaye et al., 2022; Sun et al., 2025).

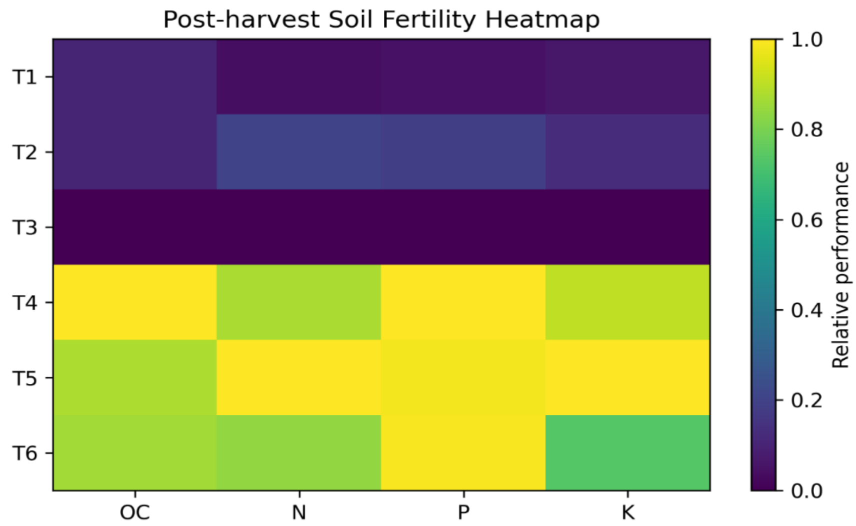


**Figure 1. Heatmap showing the relative effect of integrated nutrient management treatments on post-harvest soil organic carbon (OC), available nitrogen (N), available phosphorus (P), and available potassium (K). Higher intensity values indicate better soil fertility status**.

## 4. Conclusion

The present study demonstrated that integrated nutrient management significantly improved tuber yield and post-harvest soil fertility of potato. Among the nutrient management treatments, application of 50% RDF combined with vermicompost @ 15 t ha$^{-1}$ (T5) produced the highest tuber yield (30.84 t ha$^{-1}$) and enhanced the availability of nitrogen and potassium in the soil. Higher organic carbon content was observed under T4 (50% RDF + FYM @ 30 t ha$^{-1}$). The results indicate that partial substitution of chemical fertilizers with organic nutrient sources can improve productivity while maintaining soil fertility. Therefore, integrated nutrient management may be recommended for sustainable potato cultivation under the agro-climatic conditions of Uttar Pradesh.

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## 5. References

1. Asaye, Z., Kim, D. G., Yimer, F., Prost, K., Obsa, O., Tadesse, M., ... & Brüggemann, N. (2022). Effects of combined application of compost and mineral fertilizer on soil carbon and nutrient content, yield, and agronomic nitrogen use efficiency in maize-potato cropping systems in southern Ethiopia. *Land*, *11*(6), 784.
2. Barbaś, P. I. O. T. R., Noaema, A. H., & Sawicka, B. A. R. B. A. R. A. (2023). Potato (Solanum tuberosum L.) as a rich source of nutrients and bioactive compounds: a review. *Journal of Cell and Tissue Research*, *23*(2), 7337-7355.
3. Gelaye, Y. (2023). Effect of combined application of organic manure and nitrogen fertilizer rates on yield and yield components of potato: A review. *Cogent food & agriculture*, *9*(1), 2217603.
4. Gulshan, T. (2022). Integrated nutrient management: A long-term approach towards sustainability. *International Journal of Plant & Soil Science*.
5. Ierna, A., & Distefano, M. (2024). Crop nutrition and soil fertility management in organic potato production systems. *Horticulturae*, *10*(8), 886.
6. Karubakee, S., Rath, B. S., Satapathy, M., & Mishra, A. (2024). Effect on yield, nutrient uptake and quality of potato (Solanum tuberosum L.) under integrated nutrient management. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *52*(2), 13288-13288.
7. Mazeed, A., Mohasin, M., Kumar, N., Fatima, F., & Ansari, M. I. Environmental Stress and the Regulation of Secondary Metabolite Production in Plants. In *Plant Secondary Metabolites in Ecological, Biochemical, and Agricultural Systems* (pp. 239-252). CRC Press.
8. Mohasin, M., Habib, K., Rao, P. S., Ahmad, M., & Siddiqui, S. (2025). Microplastics in agricultural soils: sources, impacts, and mitigation strategies. *Environmental Monitoring and Assessment*, *197*(6), 684.
9. Mwakidoshi, E. R., Alotaibi, M., Alenazi, M. M., Muui, C., Muindi, E. M., Maitra, S., ... & Seleiman, M. F. (2026). Augmenting sustainable potato growth and mineral uptake under integrated organic and inorganic soil amendments. *Journal of Crop Improvement*, 1-36.
10. Patel, A., Gurjar, P. K. S., & Patel, P. (2022). Study on the effect of organic manures and biofertilizers on growth, yield and quality of potato (Solanum tuberosum L.). The Pharma Innovation Journal, 11(2), 507-511.
11. Ren, J., Shen, Y., & Shen, F. (2025). Optimizing fertilization strategies for high-yield potato crops. *Molecular Soil Biology*, *16*.

12. Ren, J., Shen, Y., & Shen, F. (2025). Optimizing fertilization strategies for high-yield potato crops. *Molecular Soil Biology*, *16*.
13. Sahu, V., Mani, D., Singh, B., Mohasin, M., & Verma, J. (2023). Enrichment of Cd, Cr, Pb and biological detoxification strategies in sewage irrigated soils. *International Journal of Plant & Soil Science*, *35*(18), 599-609.
14. Shi, M., Guo, A., Kang, Y., Zhang, W., Fan, Y., Yang, X., ... & Qin, S. (2023). Partial substitution of chemical fertilizer with organic manure enhances yield attributes and tuber quality in potato. *Journal of Soil Science and Plant Nutrition*, *23*(3), 3932-3943.
15. Sun, X., Zhang, W., Wang, T., Li, W., Li, Y., Yan, B., ... & Fan, M. (2025). Coupling Effects of Organic Fertilizer Substituting Chemical Fertilizer on Potato Yield, Quality and Soil Nitrogen Content in the Erhai Lake Basin of China. *Agronomy*, *15*(11), 2470.
16. Xu, X., He, P., Qiu, S., Zhao, S., Ding, W., & Zhou, W. (2022). Nutrient management increases potato productivity and reduces environmental risk: Evidence from China. *Journal of Cleaner Production*, *369*, 133357.
17. Yaseen, M., Khan, M. A., Singh, N., Singh, A. K., Pratap, D., & Mohasin, M. (2025). From degradation to regeneration: nano-based solutions for global soil health and fertility challenges. *Journal of the Saudi Society of Agricultural Sciences*, *24*(7), 58.