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Impact of integrated nutrient management on growth and yield of potato (*Solanum tuberosum* L.) var. Kufri Ashoka

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Abstract

A field experiment entitled "Impact of Integrated Nutrient Management on Growth and Yield of Potato (*Solanum tuberosum* L.)" was conducted during the Rabi season to evaluate the effect of different organic, inorganic and biofertilizer-based nutrient-management practices on potato growth and tuber yield. The experiment comprised eight treatments, including control, individual organic manures with phosphate-solubilizing bacteria (PSB), a combination of organic manures with PSB, different proportions of recommended nitrogen through inorganic fertilizer and FYM with PSB, and farmer's organic practice. The experiment was conducted in a randomized block design with three replications. Growth and yield attributes were recorded at different stages of crop growth and at harvest. The results indicated that nutrient management significantly influenced plant growth, haulm biomass, tuber development and yield, whereas emergence percentage was not significantly affected. Among the treatments, T₆ (67% recommended nitrogen through inorganic fertilizer + 33% recommended nitrogen through FYM + PSB) recorded the superior performance, with maximum plant height, haulm production, fresh and dry haulm weight, tuber number and total tuber yield. The highest tuber yield of 386.60 q ha⁻¹ was obtained under T₆, whereas the minimum yield of 150.00 q ha⁻¹ was recorded under the control (T₁). The study indicates that partial substitution of inorganic nitrogen with FYM in combination with PSB can effectively improve potato growth and productivity. Thus, integrated application of inorganic nitrogen, FYM and PSB may be recommended as an efficient nutrient-management strategy for enhancing potato production under the conditions of the study.

Keywords: Potato, integrated nutrient management, farmyard manure, nitrogen, phosphate-solubilizing bacteria, tuber yield

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food and vegetable crops cultivated worldwide and is valued for its high productivity, short duration, nutritional importance and versatility in food and processing industries. The crop produces a large quantity of tuber biomass within a comparatively short growing period and consequently has a high demand for readily available nutrients. Potato tuber is an important source of carbohydrates, particularly starch, and also contributes appreciable amounts of protein, minerals, vitamins and dietary fibre to the human diet. In India, potato occupies an important position among vegetable crops and contributes substantially to food and nutritional security. With increasing demand for potato, improvement in productivity needs to be accompanied by efficient and sustainable management of soil and plant nutrients.

Potato is considered a nutrient-responsive crop because rapid canopy development, stolon formation, tuber initiation and tuber bulking require an adequate and balanced supply of nutrients. Among the major nutrients, nitrogen plays a critical role in chlorophyll formation, leaf development, photosynthetic activity and biomass production, whereas phosphorus is essential for root development, energy metabolism and reproductive growth. Potassium is particularly important for carbohydrate translocation, water regulation, enzyme activation and tuber development. An inadequate supply of nutrients can restrict vegetative growth and tuber formation, whereas excessive or imbalanced fertilization can reduce nutrient-use efficiency and increase the risk of nutrient losses.

Therefore, the synchronization of nutrient availability with crop demand is essential for achieving higher potato productivity and efficient nutrient utilization (Kiran *et al.*, 2021; Koch *et al.*, 2020) ^[7, 8].

Nitrogen management is especially important in potato because both insufficient and excessive nitrogen application can negatively influence crop performance. Adequate nitrogen promotes vigorous canopy development and photosynthetic capacity, which are important for subsequent tuber growth. However, excessive nitrogen may promote excessive vegetative growth, delay crop maturity and reduce the efficiency of assimilate partitioning towards tubers. Therefore, optimizing nitrogen application is necessary to obtain a desirable balance between vegetative growth and tuber production. Recent studies have emphasized that appropriate nitrogen management can simultaneously improve tuber yield and nitrogen-use efficiency while reducing the environmental losses associated with excessive fertilizer application (Koch *et al.*, 2020; Zhang *et al.*, 2023; Pan *et al.*, 2026) ^[8, 15, 13].

Although chemical fertilizers provide nutrients in readily available forms, continuous dependence on inorganic fertilizers without adequate addition of organic matter may adversely affect soil quality and long-term sustainability. Organic manures such as farmyard manure (FYM), poultry manure and vermicompost can contribute nutrients as well as organic carbon to the soil. Their application can improve soil structure, aggregation, water-holding capacity, microbial activity and nutrient-retention capacity. Organic amendments also release nutrients gradually through microbial decomposition, thereby providing a comparatively sustained nutrient supply to the crop (Agegehu *et al.*, 2016; Hijbeek *et al.*, 2017) ^[2, 6]. A meta-analysis of organic inputs reported that potatoes showed a positive yield response to organic amendments, with farmyard manure among the inputs producing significant benefits (Hijbeek *et al.*, 2017) ^[6].

Farmyard manure is an important source of organic matter and plant nutrients and can improve the physical and biological properties of soil. Its relatively slow mineralization allows nutrients to become available progressively during crop growth. Poultry manure is generally richer in nutrients than FYM and can provide a considerable quantity of nitrogen and phosphorus. Vermicompost, produced through the biological decomposition of organic materials by earthworms and associated microorganisms, contains plant nutrients in relatively available forms and may improve soil microbial activity and nutrient availability. The effectiveness of these organic sources depends upon their nutrient composition, rate of application, decomposition characteristics and interaction with soil and climatic conditions. Studies on potato have demonstrated that organic fertilizers can influence nitrogen mineralization, plant growth, tuber number and tuber yield (Abdel-Wahab *et al.*, 2022) ^[1].

The integration of organic and inorganic nutrient sources is considered a promising strategy for maintaining productivity while improving nutrient-use efficiency. Integrated nutrient management (INM) combines mineral fertilizers, organic manures and biological sources in appropriate proportions to meet crop nutrient requirements and sustain soil fertility. The complementary nature of these nutrient sources may provide immediately available nutrients through mineral fertilizers while organic materials supply nutrients

progressively and improve soil conditions. In potato, the integrated use of organic and inorganic sources has been reported to improve plant growth, tuber development, nutrient uptake and yield compared with the use of individual nutrient sources. Sharma and Rattan (2022) ^[14] observed significant effects of combinations of FYM, poultry manure, vermicompost and chemical fertilizers on growth and yield attributes of potato.

Evidence from field experiments also supports the potential of combining a portion of the recommended fertilizer dose with organic sources. An experiment conducted under Indian conditions reported that supplying 50% of the recommended fertilizer dose through inorganic fertilizers along with the remaining nutrient requirement through FYM, vermicompost or neem cake resulted in greater tuber growth, tuber bulking rate, tuber weight and yield than chemical fertilizer alone. The integrated treatments also improved nutrient uptake and soil nutrient status. Similarly, Chaudhary *et al.* (2023) ^[5] reported that combinations of recommended fertilizer doses with FYM and vermicompost significantly influenced potato productivity and profitability, indicating the potential of integrated nutrient sources for sustainable potato production.

Biofertilizers constitute another important component of sustainable nutrient management. Phosphate-solubilizing bacteria (PSB) are beneficial microorganisms capable of converting relatively unavailable forms of soil phosphorus into forms that can be absorbed by plants. Improved phosphorus availability can enhance root development, energy metabolism and tuber formation. Integration of PSB with organic manures may be particularly advantageous because organic amendments provide a favourable substrate and environment for microbial activity, while PSB can improve the availability of phosphorus. Thus, the combined use of organic manures and phosphate-solubilizing microorganisms can potentially increase nutrient-use efficiency and reduce dependence on inorganic fertilizers.

Recent research further supports the importance of combining organic and inorganic sources for improving potato productivity. A field study in Ethiopia demonstrated that combined application of FYM and inorganic NPS fertilizer enhanced potato tuber productivity, with the optimum combination varying according to location and fertilizer rate (2024). Likewise, recent research on organo-mineral fertilization has shown that integrated nutrient sources can improve potato yield, nitrogen uptake and soil nutrient status while providing an alternative approach to complete dependence on conventional mineral fertilizers (2025). These findings indicate that nutrient management based on a combination of organic and inorganic sources can be an effective strategy for improving both productivity and sustainability.

The proportion of nitrogen supplied through organic and inorganic sources is particularly important in INM. In the present investigation, the recommended nitrogen dose of 150 kg ha⁻¹ was evaluated through different proportions of inorganic fertilizer and FYM. Supplying 67% of recommended nitrogen through inorganic fertilizer and 33% through FYM, as well as the reverse combination, provides an opportunity to determine the relative contribution of rapidly available inorganic nitrogen and slowly mineralizing organic nitrogen to potato growth and yield. Such combinations may improve synchronization between nutrient release and crop demand and may consequently

increase nitrogen-use efficiency. The importance of optimizing nitrogen supply rather than simply increasing its rate has been demonstrated in potato production systems (Koch *et al.*, 2020; Zhang *et al.*, 2023) [8, 15].

The use of multiple organic nutrient sources may provide additional benefits because FYM, poultry manure and vermicompost differ in nutrient concentration, decomposition rate and nutrient-release pattern. Their combined application may provide a more diversified nutrient supply and improve soil biological activity. In addition, the inclusion of PSB may enhance phosphorus availability and complement the nitrogen supplied through organic and inorganic sources. Therefore, an INM approach involving FYM, poultry manure, vermicompost, PSB and inorganic nitrogen may be more effective than relying on a single nutrient source.

The present experiment was therefore designed to compare different organic, biological and integrated nutrient-management strategies in potato. The treatments included an unfertilized control, individual organic sources such as FYM, poultry manure and vermicompost combined with PSB, a combination of FYM, poultry manure and vermicompost with PSB, different proportions of recommended nitrogen supplied through inorganic fertilizer and FYM along with PSB, and farmer practice based on organic nutrient sources. Such a treatment structure provides a comprehensive assessment of the relative and combined effects of organic manures, biofertilizer and inorganic nitrogen on potato growth and yield.

Therefore, the present investigation entitled “Impact of Integrated Nutrient Management on Growth and Yield of Potato (*Solanum tuberosum* L.)” was undertaken with the objective of evaluating the influence of different combinations of organic manures, PSB and inorganic nitrogen on growth and yield performance of potato.

Materials and Methods

Experimental Site and Season

The present investigation entitled “Impact of Integrated Nutrient Management on Growth and Yield of Potato (*Solanum tuberosum* L.)” was conducted during the Rabi season of 2024-25 at the Research Farm of the Department of Horticulture (Vegetable Science), School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat, Madhya Pradesh. The experimental field had sandy loam soil, which was well drained and had good water-holding capacity. The soil analysis indicated that the experimental soil was alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and relatively rich in available potassium.

The variety Kufri Ashoka was used as the experimental material. It is an early-maturing potato variety producing white-skinned, oval to long-shaped tubers and is suitable for table purposes. The experiment was conducted during the Rabi season of 2024-25. The experiment was laid out in a Randomized Block Design (RBD) with eight nutrient-management treatments and three replications, resulting in a total of 24 experimental plots. Potato was planted at a spacing of 60 cm × 20 cm (row-to-row × plant-to-plant). Each plot consisted of three rows.

Treatment Details

Eight integrated nutrient-management treatments comprising organic manures, phosphate-solubilizing

biofertilizer and inorganic nitrogen were evaluated. T₁ was maintained as the control, without application of the specified nutrient-management treatment. T₂ consisted of FYM @ 30 t ha⁻¹ along with phosphate-solubilizing bacteria (PSB), whereas T₃ received poultry manure @ 5 t ha⁻¹ along with PSB. T₄ comprised vermicompost @ 7.5 t ha⁻¹ along with PSB. In T₅, FYM @ 10 t ha⁻¹, poultry manure @ 1.7 t ha⁻¹ and vermicompost @ 2.7 t ha⁻¹ were applied together with PSB. T₆ consisted of the recommended nitrogen dose of 150 kg ha⁻¹, with 67% of the recommended nitrogen supplied through inorganic fertilizer and the remaining 33% through FYM along with PSB. In T₇, the recommended nitrogen dose of 150 kg ha⁻¹ was supplied in the reverse proportion, i.e., 33% through inorganic fertilizer and 67% through FYM along with PSB. T₈ represented the farmer's practice based on organic nutrient management. The treatment combinations were designed to compare individual organic sources, combinations of organic manures, different proportions of organic and inorganic nitrogen and the prevailing farmer practice. The potato seed was planted manually at approximately 25-30 q ha⁻¹ using a spacing of 60 cm between rows and 20 cm between plants. Planting was carried out on 15 November 2024.

Observations Recorded

Five representative plants from each experimental plot were selected randomly for observations at successive stages of crop growth. Plant height (cm), Number of haulms, Number of leaves, Fresh weight of haulm, Dry weight of haulm, Number of tubers per hill, Weight of tubers per hill, Grade-wise tuber weight per plot, Total tuber yield for comparison among treatments.

Statistical Analysis

The experimental data were subjected to statistical analysis appropriate for a Randomized Block Design (RBD) with three replications. Treatment means were compared using the standard analysis of variance procedure. The significance of treatment differences was assessed using the appropriate critical difference (CD) and standard error of mean (SEM±) values at the prescribed level of significance. The analysis was used to determine whether the observed differences among integrated nutrient-management treatments were statistically significant.

I analyzed the data in the uploaded file. The strongest and statistically significant treatment response was T₆, while emergence was non-significant. The results below are kept deliberately concise and focus on the maximum, minimum, statistical significance, and a short scientific explanation, as you requested.

Results and Discussion

Effect on Growth Parameters

The data revealed that integrated nutrient management significantly influenced most of the growth parameters of potato, whereas plant emergence at 30 DAP was non-significant. Emergence ranged from 91.30% in T₂ and T₇ to 94.40% in T₆, with the control (T₁) recording 92.34%. The non-significant response indicates that nutrient treatments had comparatively little influence on initial emergence, which is primarily governed by seed-tuber vigour and environmental conditions. Similar observations regarding the importance of adequate nutrient availability for subsequent potato growth have been reported by Koch *et al.* (2020) [8].

Plant height was significantly affected by nutrient management at 60 and 90 DAP. T₆ (67% RDN through inorganic fertilizer + 33% RDN through FYM + PSB) recorded the maximum plant height of 24.00, 47.09 and 49.14 cm at 30, 60 and 90 DAP, respectively, whereas the minimum values were observed in T₁ (18.55, 41.20 and 44.26 cm). The superiority of T₆ may be attributed to the complementary availability of readily available inorganic nitrogen and gradually mineralizable nitrogen from FYM, supported by PSB-mediated nutrient availability. Similar improvements in potato growth through integrated application of organic and inorganic nutrient sources have been reported by Sharma and Rattan (2022)^[14].

The number of haulms also followed a similar trend. T₆ recorded the maximum number of haulms (8.01, 36.37 and 38.59 at 30, 60 and 90 DAP, respectively), while the minimum was observed under T₁ (7.60, 33.29 and 34.08). The higher haulm production under T₆ indicates improved vegetative growth resulting from better nitrogen availability. Adequate nitrogen is particularly important during early and mid-growth stages of potato for canopy development and photosynthetic activity (Koch *et al.*, 2020)^[8].

The trend in leaf production also favoured integrated nutrient management, with the highest values recorded under T₆ and the lowest under the control. Better leaf development under integrated nutrition may have increased the photosynthetic surface and consequently enhanced assimilate production for tuber development. Similar positive effects of integrated FYM, poultry manure, vermicompost and inorganic fertilizers on potato growth have been documented by Sharma and Rattan (2022)^[14].

Effect on Haulm Biomass

Integrated nutrient management significantly increased haulm biomass. The maximum fresh weight of haulm (383.79 g plant⁻¹) and dry weight of haulm (38.45 g plant⁻¹) were recorded in T₆, whereas the minimum fresh haulm weight (356.47 g) and dry haulm weight (34.08 g) were recorded in T₁. The superiority of T₆ may be attributed to a balanced and continuous nutrient supply from inorganic nitrogen, FYM and PSB, which promoted greater vegetative biomass accumulation. The present findings are consistent with reports that combined organic and mineral nutrient sources improve biomass production and nutrient uptake in potato (Mohanty *et al.*, 2014; Sharma & Rattan, 2022)^[10, 14].

Effect on Tuber Number and Grade-wise Tuber Production

Nutrient management also improved the number and weight of tubers across different grades. T₆ recorded the highest values in all major tuber grades, with approximately 3.26, 2.24, 2.05 and 2.04 tubers hill⁻¹ in the respective grades, compared with the lower values recorded under T₁. Similarly, T₆ produced the highest grade-wise tuber weights, including 115.66, 138.93 and 184.88 g hill⁻¹ in the reported grades. This improvement may be associated with enhanced vegetative growth, greater assimilate production and improved nutrient availability during tuber initiation and bulking. Previous research has also demonstrated that integrated nutrient management enhances tuber growth, tuber weight and yield in potato.

Effect on Tuber Yield

A pronounced effect of nutrient management was observed on tuber yield. The maximum tuber yield was recorded

under T₆ (386.60 q ha⁻¹), followed by T₇ (324.53 q ha⁻¹), T₈ (308.26 q ha⁻¹), T₅ (298.66 q ha⁻¹), T₄ (292.60 q ha⁻¹), T₃ (280.50 q ha⁻¹), T₂ (262.53 q ha⁻¹), while the minimum yield was recorded in T₁ (150.00 q ha⁻¹). The critical difference (CD at 5%) was 8.20 q ha⁻¹, indicating a significant treatment effect.

The substantially higher yield under T₆ may be attributed to the combined effect of 67% inorganic nitrogen + 33% nitrogen through FYM + PSB, which likely provided both immediately available and gradually released nitrogen while improving nutrient availability in the rhizosphere. The result agrees with earlier findings that partial substitution of mineral fertilizers with organic nutrient sources can improve potato tuber growth and yield compared with unfertilized or poorly balanced nutrient regimes (Mohanty *et al.*, 2014; Sharma & Rattan, 2022)^[10, 14].

The beneficial contribution of PSB may also have supported the response of T₆ by improving phosphorus availability and nutrient uptake. Recent research has demonstrated that phosphate-solubilizing bacterial inoculation can enhance potato tuber production and nutrient accumulation under integrated nutrient-management systems (Bansal *et al.*, 2025)^[3].

Conclusion

The present investigation demonstrated that integrated nutrient management had a significant influence on the growth and yield performance of potato, although initial emergence was not significantly affected by the treatments. Among the eight nutrient-management treatments, T₆, consisting of 67% of the recommended nitrogen through inorganic fertilizer + 33% RDN through FYM + PSB, performed consistently better than the other treatments. It recorded the highest plant height, number of haulms, leaf production, fresh and dry haulm weight, tuber development and total tuber yield. The maximum tuber yield of 386.60 q ha⁻¹ was obtained under T₆, compared with only 150.00 q ha⁻¹ under the control (T₁). The results indicate that combining inorganic and organic sources of nitrogen with PSB provides a more favourable nutrient supply for vegetative growth and tuber development than individual organic sources or the control. Therefore, under the experimental conditions, T₆ may be considered the most promising integrated nutrient-management treatment for improving growth and tuber yield of potato and can serve as a suitable nutrient-management approach for sustainable potato production.

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