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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
Impact Factor (RJIF): 6.34
TPI 2025; 14(12): 13-16

www.thepharmajournal.com
Received: 11-09-2025
Accepted: 16-10-2025

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Response of blended fertilizers on growth, yield and quality of potato (*Solanum tuberosum* L.) under open field conditions

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DOI: https://www.doi.org/10.22271/tpi.2025.v14.i12a.26332

Abstract
The field experiment was carried out at the Campus for Research and Advanced Studies, G.S.S.D.G.S. Khalsa College, Patiala during the *rabi* season of 2023-24. The experiment was laid out in randomized block design with comprising of eleven treatment and three replications. The results revealed that application of blended fertilizers recorded significantly superior in growth, yield and quality characters. All the highest values for plant height (30.67 cm), number of compound leaves plant^{-1} (74.37), leaf length (24.83 cm), leaf width (7.96 cm), and leaf area index (2.59) were observed under treatment T11, which consisted of 25% RDF combined with 25% each of FYM, vermicompost, and poultry manure. Similarly yield parameters record the highest number of tubers (12.36) and the greatest average tuber weight (300.19 g) were recorded under the treatment combining RDF (25%) + FYM (25%) + Vermicompost (25%) + Poultry Manure (25%), outperforming all other treatments, quality parameters were observed the highest values for protein content (2.60%), starch content (25.62%), firmness (149.66 N), and TSS (4.07 °Brix) were recorded under treatment T11: RDF (25%) + FYM (25%) + Vermicompost (25%) + Poultry Manure (25%).

Keywords: Potato, FYM, Vermicompost, Poultry manure

Introduction
Potato (*Solanum tuberosum* L.) is a major global food crop from the Solanaceae family, with a chromosome number of 2n = 4x = 48. It is known for its high yield potential, rich nutritional value, and adaptability, making it the third most important food crop globally, after wheat and rice. The potato tuber is composed of 70–82% water, 17–29% dry matter, 11–23% carbohydrates, and smaller amounts of protein, fat, and minerals. It is a rich source of starch, vitamins C and B, essential amino acids, and has a high protein-calorie ratio (17g protein per 1000 Kcal), outperforming cereals in edible energy, protein, and dry matter yield per area and time. Globally, China and India are the top producers, with India contributing 41.55 million tonnes from 1.97 million ha at a productivity of 21.1 t ha^{-1}. The Indo-Gangetic plains in North India account for 85% of the country's potato production, with major contributions from Uttar Pradesh, West Bengal, Bihar, Punjab, and Gujarat. Potatoes are heavy feeders due to their shallow root system and rapid dry matter accumulation, requiring substantial and timely fertilizer input for optimal yields. Effective nutrient management is essential for both high productivity and sustainable soil health. India has seen significant growth in potato farming over the last 70 years, with annual growth rates of 3.23% in area, 5.32% in production, and 2.02% in productivity (GoI, 2021).

Organic inputs like poultry manure, vermicompost, and farmyard manure (FYM) significantly enhance soil fertility, crop productivity, and sustainability. These amendments improve soil structure, nutrient availability, and microbial activity, while also aiding in carbon sequestration and reducing soil degradation (e.g., salinity, SAR, EC). Poultry manure is rich in macro- and micronutrients, making it highly effective for improving soil fertility and plant growth (Ud Din *et al*., 2023) [14]. Vermicompost, produced by earthworms and microbes, boosts nutrient availability, microbial activity, and crop yield. Its integration with chemical fertilizers (especially NPKS) significantly improves potato growth and yield (Getie *et al*., 2015) [6]. FYM enhances nutrient mineralization, improves nitrogen-use efficiency, and supports better soil moisture retention and organic carbon levels. It plays a key role in sustainable nutrient cycling and long-term soil health (Bama *et al*., 2017) [3]. Nitrogen play crucial for shoot development,

canopy establishment, and photosynthesis. Nitrogen deficiency leads to reduced growth, yield, and early senescence (Fayera, 2017) [5]. Phosphorus (vital for vine growth, tuber initiation, and starch formation. Potatoes are poor at P uptake due to shallow roots, making proper placement and dosage essential to prevent inefficiency and runoff (Nyiraneza *et al*., 2017) [9]. Potassium affects tuber size, starch content, marketability, and nutritional quality. Potassium enhances physiological functions like enzyme activation and nutrient translocation (Trehan *et al*., 2009) [13].

Materials and Methods

The experiment was performed during winter season of 2023-2024 at the Campus for Research and Advanced Studies, G.S.S.D.G.S. Khalsa College, Patiala (Punjab). The soil of field experiment was clayey soil having pH 7.4, organic carbon 0.60%, available N, P2O5 and K2O with low nitrogen and medium phosphorus, potash availability. The treatments consists of eleven different nutrient management which was laid out in randomized block design with three replications. Germination of tubers takes place with in 2-3 weeks after sowing. The potato was planted on November, 2023 with recommended spacing of 60 × 20 cm.

The application of blended fertilizers such as farmyard manure, vermicompost and poultry manure were applied during field preparation in all treatment plots before 2-3 days transplanting. Recommended dose of fertilizers such as half dose of nitrogen, phosphorus and potash were applied at basal dose in all treatment plots in the form of urea, single super phosphate and muriate of potash and second half quantity of nitrogen was given at 30 days after sowing. For tagging, five plants are randomly selected from each plot after they attained a reasonable growth stage. The tagged plants were recording for various parameters were used to measure growth, yield and quality parameters.

Table 1: Details of layout

Experimental design	Randomised block design (RBD)
No. of replications	03
No. of treatments	11
Total no. of plots	33
Gross plot size	4.2 x 3.2 m
Net plot size	3.6 x 2.8 m
Spacing	60 x 20 cm
Seed rate	18 q ha^{-1}
Variety	Kufri Pukhraj

Table 2: Treatments details

T_1	Control
T_2	RDF (75%) + FYM (25%)
T_3	RDF (50%) + FYM (50%)
T_4	RDF (25%) + FYM (75%)
T_5	RDF (75%) + Poultry manure (25%)
T_6	RDF (50%) + Poultry manure (50%)
T_7	RDF (25%) + Poultry manure (75%)
T_8	RDF (75%) + Vermicompost (25%)
T_9	RDF (50%) + Vermicompost (50%)
T_{10}	RDF (25%) + Vermicompost (75%)
T_{11}	RDF (25%) + FYM (25%) + Vermicompost (25%) + Poultry manure (25%)

Note:- [RDF-150:100:100, FYM-10 t ha^{-1}, Vermicompost-3 t ha^{-1}, Poultry manure-5 t ha^{-1}]

Result and Discussions

Growth parameters

The data on growth parameters, (Table 3) shows that the growth parameters of the crop were significantly best among different nutrient applications i.e The highest plant height (30.67 cm), no. of compound leaves $plant^{-1}$ (74.34), leaf length $plant^{-1}$ (24.83 cm), leaf width (7.96 cm) and leaf area index (2.59) were recorded in treatment T11, which involved the application of RDF (25%) + FYM (25%) + Vermicompost (25%) + Poultry manure (25%). This treatment was statistically on par with T5 (RDF 75% + Poultry manure 25%) and T8 (RDF 75% + Vermicompost 25%). The lowest plant heights were observed in T1 (Control).

Zewide *et al*. (2018) [16] reported that the combined use of organic and inorganic fertilizers can be credited for supplying sufficient amounts of both macro- and micronutrients. This enhanced availability of micronutrients likely supported increased metabolic activity during the early stages of growth, contributing to improved overall development. The organic manures and inorganic fertilizers together supplied most of the essential nutrients needed during the growth period, resulting in an increase in growth parameters such as plant height. Alam *et al*. (2007) [1] reported that the vermicompost decomposes quickly, making nutrients readily available to plants, which supports vegetative growth by improved nutrient mobility. FYM, being a bulky organic manure, enhances microbial activity during its decomposition. Pandey *et al*. (2007) [10] reported that the application of RDF increases the number of shoots per plant. Number of leaves per plant is influenced positively due to increasing level of nitrogen.

Table 3: Response of blended fertilizers on growth parameters of potato.

Treatments	Plant height (cm)	No. of compound Leaves $plant^{-1}$	Leaf length $plant^{-1}$ (cm)	Leaf width $plant^{-1}$ (cm)	Leaf area index (cm^2)
T_1	24.50	51.02	15.01	6.35	1.94
T_2	28.74	68.61	22.90	7.18	2.39
T_3	37.93	65.57	22.10	7.03	2.22
T_4	27.87	54.03	20.43	6.83	2.04
T_5	29.71	72.34	24.20	7.50	2.47
T_6	28.11	67.73	22.66	7.09	2.33
T_7	27.55	57.29	21.02	6.95	2.08
T_8	30.21	73.38	24.33	7.80	2.53
T_9	28.19	68.08	22.68	7.11	2.40
T_{10}	27.83	64.04	21.20	7.01	2.21
T_{11}	30.67	74.37	24.83	7.96	2.59
SE(m)±	0.48	1.05	0.91	0.37	0.91
CD (0.05)	1.01	2.19	1.91	0.77	0.20

Yield parameters

The data on growth parameters, (Table 4) shows that the yield parameters of the crop were significantly affected among different nutrient applications i.e The highest no. of tuber plant^{-1} (12.36 cm), weight of tubers plant^{-1} (300.19 gm), total tuber yield (381.12 q/ha), tuber length (8.10 cm) and tuber width (6.29 cm) were recorded in treatment T11, which involved the application of RDF (25%) + FYM (25%) + Vermicompost (25%) + Poultry manure (25%). This treatment was statistically on par with T5 (RDF 75% + Poultry manure 25%) and T8 (RDF 75% + Vermicompost 25%). The lowest plant heights were observed in T1 (Control).

Zewide *et al*. (2021) [15] suggested that the combined application of mineral NP fertilizers and cattle manure likely led to higher marketable tuber yields due to their synergistic effect. Adequate nitrogen availability may have enhanced vegetative growth and boosted photo assimilation, resulting in a greater number of marketable tubers per hill. This outcome can be attributed to improved carbohydrate metabolism and enhanced photosynthetic activity, supported by increased chlorophyll synthesis in the plants. Atanaw (2021) [2] concluded that the nutrients provided by manure, along with a balanced supply of nitrogen and phosphorus from mineral fertilizers, likely contributed to improved cell division, cell wall expansion, meristematic activity, photosynthetic efficiency, and regulation of water uptake—factors that collectively enhanced yield parameters. The study also noted that different application rates of organic manure and inorganic fertilizers significantly influenced potato yield. Furthermore, tuber yield was higher when cow dung was combined with NPK (20:10:10) compared to the use of either cow dung or NPK alone.

Table 4: Response of blended fertilizers on yield parameters of potato.

Treatments	No. of tuber plant^{-1}	Weight of tubers plant^{-1} (gm)	Total tubers yield (q ha^{-1})	Tuber length (cm)	Tuber width (cm)
T_1	9.77	200.74	162.36	4.56	3.23
T_2	11.45	280.95	311.67	7.50	5.56
T_3	11.23	255.46	264.32	6.7	4.96
T_4	10.40	220.75	239.15	5.37	4.42
T_5	12.17	294.28	316.42	7.67	5.87
T_6	11.31	265.17	274.51	6.52	5.45
T_7	11.03	235.18	245.21	6.19	4.83
T_8	12.30	295.02	330.15	8.02	5.92
T_9	11.39	272.61	301.11	6.78	5.47
T_{10}	11.10	243.25	251.56	6.23	4.84
T_{11}	12.36	300.19	381.12	8.10	6.29
SE(m)±	0.57	2.50	0.18	0.15	0.22
CD (0.05)	0.19	5.23	0.39	0.32	0.47

Quality parameters

The data on quality parameters, (Table 5) shows that the quality parameters of the crop were found best among different nutrient applications i.e, The highest protein content (2.72%), starch (25.62%), tuber firmness (149.66 N)and total soluble solids (4.07^{0}brix) were recorded in treatment T11, which involved the application of RDF (25%) + FYM (25%) + Vermicompost (25%) + Poultry manure (25%). This treatment was statistically on par with T5 (RDF 75% + Poultry manure 25%) and T8 (RDF 75% + Vermicompost 25%). The lowest plant heights were observed in T1 (Control).

Biomy AMM (2012) reported that the use of blended fertilizers led to an increase in total soluble solids (TSS) content. This effect is attributed to the presence of essential macronutrients that facilitate efficient nutrient uptake, while organic manures improve soil structure, further enhancing nutrient absorption and contributing to higher TSS levels. Sarkar *et al*. (2007) [11] concluded that the rise in protein content could be attributed to the enhanced supply of inorganic fertilizers and organic manures. This increase plays a vital role in activating starch synthetase and aids in the translocation of protein from the leaves to the tubers in potato-growing regions. Zewidie *et al*. reported that the increase in starch content was attributed to higher application rates of blended fertilizers. The presence of nitrogen and phosphorus in the soil played a key role in enhancing starch accumulation in potato tubers. These findings are consistent with those Shubhadip *et al*. (2017) [12], who also observed the highest starch content in potatoes following the combined use of cattle manure and NP fertilizers. Furthermore, noted that increasing the application of both organic and mineral fertilizers led to a rise in tuber starch content. Harikrishna *et al.* (2002) [8] reported that the use of blended fertilizers produced the best outcomes for quality traits such as total soluble solids (TSS) and ascorbic acid content, which were notably higher in organically grown tomato plants.

Table 5: Response of blended fertilizers on quality parameters of potato.

Treatments	Protein content (%)	Starch content (%)	Tuber firmness (N)	TSS (^{0}brix)
T_1	2.15	23.75	118.79	3.30
T_2	2.60	24.68	142.41	3.76
T_3	2.46	24.54	130.33	3.46
T_4	2.30	24.41	120.85	3.43
T_5	2.64	25.30	147.16	3.81
T_6	2.48	24.55	135.41	3.52
T_7	2.32	24.40	124.67	3.44
T_8	2.68	25.47	147.33	3.93
T_9	2.55	24.60	138.35	3.68
T_{10}	2.36	24.29	128.09	3.45
T_{11}	2.72	25.62	149.66	4.07
SE(m)±	0.15	0.29	1.59	0.07
CD (0.05)	0.32	0.60	3.33	0.15

Conclusion

From this study, it can be concluded that the application of RDF (25%) combined with FYM (25%), vermicompost (25%), and poultry manure (25%) significantly increased the maximum potato tuber yield. Additionally, the use of blended fertilizers improved both the productivity and quality of

potatoes compared to the use of inorganic fertilizers alone. Providing an adequate amount of nutrients in a combined form not only enhances plant growth characteristics but also improves the physicochemical and biological properties of the soil. This nutrient management approach also helps reduce the economic burden on farmers.

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