

Effect of organic, inorganic and biofertilizers on soil characteristics and potato tuber yield (*Solanum tuberosum* L.)

ABSTRACT

An experiment was conducted during winter (*rabi*) seasons of 2022–23 at Vegetable Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, (UP), India. To assess the effect of various organic, inorganic and biofertilizer tuber yield of potato (*Solanum tuberosum* L.). The experiment consisted of 6 treatments combination of organic and inorganic applications in a randomized block design with 4 replications. The results revealed that the application of recommended dose of NPK (150:100:120 kg ha⁻¹) T₂ recorded highest tuber yield, plant height, emergence percentage and number of leaves, followed by treatment T₄ (Compost (like NADEP method) + Crop residue incorporation + Biofertilizer (Azotobacter and Phosphobacteria) + Microbial culture to decompose crop Residue + FYM @ 25 t ha⁻¹). The experiment highlights the importance of organic fertilizer improve the soil physical properties and soil health.

Key words: FYM, Vermicompost, Azotobacter, Phosphobacteria and Yield.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of major crops contributing to the world's food security. (Karam *et al.*, 2009). It is the most popular tuber crops in the world. Potato is one of the most important field crops not only to its local consumption but also to increase meeting income through its exportation among different countries in the world (Kandil *et al.*, 2011). It is a highly input intensive crop, fertilization with inorganic sources of nutrients plays an important role for its higher production, but due to increased cost and detrimental effects on soil fertility and human health, supplementing the nutrients through organic sources like farmyard manure (FYM), vermicompost, mustard cake, neem cake, etc. and biofertilizers like Azotobacter and Phosphobacteria has become necessary to sustain production, improved food quality and to maintain soil health (Patel *et al.*, 2002).

The major potato producing states are Uttar Pradesh, West Bengal, Madhya Pradesh, Bihar, Gujarat, Punjab, Haryana, Assam, Jharkhand and Chhattisgarh. Potatoes are a valuable commodity that can be processed and exported. Potatoes offer a low-cost energy source in the human diet and are rich in starch, as well as vitamins C and B, along with various minerals. (Rajet *et al.*, 2020). Potatoes are a vital component of the world's food supply, providing essential nutrients and calories to millions of people (Beals *et al.*, 2019). Developing nations in Asia currently account for over 46% of the world's total potato production. Ranked fourth among the world's most significant food crops, after rice, wheat, and maize, potatoes serve an essential function in global food security. India stands as the second-largest potato producer worldwide, following China. China and India emerged as the leading producers, collectively contributing approximately one-third of the global production. In India, the potato occupies a prominent position in the agricultural sector. The Ministry of Agriculture, Government of India, reported that in 2023, the country produced around 59.74 million metric tons of potatoes.

Organic material is used to prevent or improve the negative stress effects in plants and yield decreasing. It is material to decrease soil salinity. Increase the organic matter, improve the soil structure and increase water and air permeability by root developing in soil. It is one of the best used fertilizers (Kumari *et al.*, 2024; Shukla *et al.*, 2024).

Continuous Use of chemical fertilizers had increased the crop yield, but caused many environmental problems including soil, air and water pollution and finally human health hazards and making the crop productivity unsustainable (Eid *et al.*, 2006). The amount of organic matter in the soil influences the accessibility of micronutrients. Because they are cost-effective and environmentally friendly, employing organic matter and micronutrients offers significant benefits. It promotes long-term ecological sustainability and soil fertility, essential for successful crop cultivation. Bio-fertilizer, an organic product containing specific microorganisms, plays a crucial role in enhancing nutrient availability for crops. These microorganisms biologically transform inaccessible nutrients into formats readily accessible for plant uptake. The continuous application of heavy doses of chemical fertilizers without incorporating organic manure or bio-fertilizers has led to soil health deterioration. This includes physical and chemical degradation, reduced microbial activity, declining soil humus, and increased soil, water, and air pollution.

MATERIALS AND METHODS

Site Description:

The experiment was conducted at Vegetable Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (UP). The Vegetable Research Farm lies on Ayodhya-Raebareilly Road, about 43 km from Ayodhya district headquarter. Geographically, this region falls under sub-tropical climate and it is situated at 26°47'N latitude, 82°12' E longitude and at an Indo-Gangetic alluvial of eastern Uttar Pradesh in India. This region experiences an annual rainfall of approximately 110 cm, with 85 percent of it occurring during the monsoon season, which lasts from mid-June to the end of September. The experimental soil was silty loam in texture having the pH (8.10), EC (0.24 dSm⁻¹) and organic carbon (3.10 gkg⁻¹).

Variety Description:

Kufri Ashoka variety was taken for experiment. Variety was developed through clonal selection from a segregating population derived from the hybrid EM/C-1021 x CP-1468. Central Potato Research Institute, Shimla, released this variety in 1996. Kufri Ashoka an early-maturing variety (70-80 days), suited for cultivation in Bihar, Haryana, Punjab, Uttar Pradesh and West Bengal. The tubers of Kufri Ashoka are medium to large in size, white, oval-shaped, with moderately shallow eyes and white flesh. The plants are medium-tall, upright, moderately compact, and vigorous. The stems are limited in number, medium-thick, lightly pigmented at the base, and characterized by poorly developed straight wings. Foliage is green. Leaves are intermediate having green rachis. Leaflets are ovate lanceolate, smooth glassy surface with entire margin. Flowers are light red purple. This variety has profuse flowering. The anthers are orange-yellow, well-developed, and exhibit medium pollen stainability. Although the variety is susceptible to late blight, it manages to evade its impact due to its early maturity.

Soil Sampling and Analysis:

Soil sampling done by Auger randomly from each replicated plot after, harvesting of rice crop and collect the sample in polythene bag plot wise. Samples are brought to Soil Science Lab ANDUAT Kumarganj Ayodhya for analysis. Soil texture, Bulk density, Soil pH, Electrical conductivity, Organic carbon.

RESULTS AND DISCUSSION

Physico-chemical Properties of soil-

Soil pH: The effect of various treatment combinations on soil pH is presented in Table 1. There were non-significantly affected by various treatment combinations. The highest value of pH (8.18) was recorded with T₁ control and lowest value (7.92) was recorded with T₄ (Compost (like NADEP method) + Crop residue incorporation + Biofertilizer (Azotobacter and Phosphobacteria) + Microbial culture to decompose crop Residue + FYM @ 25 t ha⁻¹). However, soil pH maintained or slight decreased to the initial value might be due to the formation of organic acids during the decomposition of organic manure and crop residues. Similar result has been reported by (Tiwari *et al.*, 2021).

Electrical Conductivity (dSm⁻¹): The data regarding effect of various treatment combinations on electrical conductivity remained non-significant in between the treatments but there is slightly decrease from initial (0.31 dSm⁻¹) to harvest (0.25 dSm⁻¹). However, the lowest EC (0.22 dSm⁻¹) at harvest recorded with T₄ (Compost (like NADEP method) + Crop residue incorporation + Biofertilizer (Azotobacter and Phosphobacteria) + Microbial culture to decompose crop Residue + FYM @ 25 t ha⁻¹) and highest EC (0.25 dSm⁻¹) was recorded at harvest with T₂ (RDF 150:100:120 N: P₂O₅: K₂O). in potato have been presented in Table 1. The abrupt drop in electrical conductivity in treatments involving organic materials might be caused by the buffering effect of the organic matter, which reduces the concentration of ionic species in the solution, thereby lowering the EC. In FYM, the significant increase in microbial activity leads to the uptake of soluble salts by microorganisms for the growth of microbial cell mass leads to less EC when compared to vermicompost. Similar result has been reported by (Tiwari *et al.*, 2021).

Organic carbon (g kg⁻¹)

¹): The maximum organic carbon content was recorded with T₄ (T₃ + FYM @ 25 t/ha) at 3.6 g kg⁻¹, followed by T₅ (T₃ + vermicompost @ 7.5 t ha⁻¹) at 3.4 g kg⁻¹. The lowest organic carbon content was observed under the T₁ control (3.0 g kg⁻¹). The increased organic carbon content due to use of enriched FYM can be attributed to higher contribution of biomass to the soil in the form of root, crop stubbles and residues but

also to better root growth and plant residue addition by the growing crop after harvesting. It is an important source of soil organic matter and nutrients which after decomposition by the microorganisms becomes available to the plants. These results are in line with findings of (Tiwari *et al.*, 2021; Verma *et al.*, 2024).

Growth and Development studies-

Emergence percentage:

The plant emergence percentage was significantly affected by the application of various organic and inorganic treatments. The plant emergence percentage higher in the treatment T₂ (97.97 %) that was followed by T₄ significantly superior to control (94.69 %). Organic and inorganic fertilizers are applied, then inorganic fertilizers have a quick effect on the plant, but when germination takes place then there is not much difference in the emergence of the plant. The similar result is reported by Nagaret *et al.*, (2019).

Plant height:

The plant height was found also affected by the application of inorganic fertilizer to the crop. The highest plant height was recorded with the treatment T₂ at 30 and 60 DAP (19.40 cm) and (48.50 cm) respectively, that was at par with the treatment T₄ at 30 and 60 DAP (18.30 cm) and (47.10 cm) respectively. Biofertilizers increased the efficiency of nutrients in the soil and increased the plant height when applied in combination with fertilizers. Similar result reported by Rametal., (2017).

Numbers of leaves:

The number of leaves per hill were also significantly influenced by the application of organic, inorganic and biofertilizer. The maximum number of leaves at 30 DAP (16.90) and 60 DAP (53.65) were recorded in the treatment T₂ (where the recommended dose of N 150 : P₂O₅ 100: K₂O 120 is applied), statistically at par with T₄ (16.20) at 30 DAP and T₄ and T₅ (52.90) (52.30) at 60 DAP respectively, significantly higher than the control treatment. Similar result has been reported by Sayedet *et al.*, (2014), Barmanet *et al.*, (2018).

Yield attributes and tuber yield-

Tuber yield:

The potato tuber yield was found to be significantly affected by the various organic and inorganic

eatments. RDF(N:P:K=150:100:120 kg ha⁻¹) recorded the highest tuber yield, which was significantly superior to all other nutrient treatments. This was followed by the treatment T₄ (Compost (like NADEP method) + Crop residue incorporation + Biofertilizer (Azotobacter and Phosphobacteria) + Microbial culture to decompose crop Residue + FYM @ 25 t/ha). compared to control. The tuber yield under T₂ was 5.10% higher than T₄ (Table 2). The increased tuber yields due to integrated nutrient management of the above said fertilizer levels have resulted in more vegetative growth and accumulation of more photosynthates. Thus, there may be more translocation of photosynthates to sink. Hence, they have resulted in more tuber yield. Higher number of tubers per hill also contributed to significantly higher total tuber yield. The favourable effect of integrated nutrient management through both inorganic fertilizers and organic manures on increasing the tuber yield. Production was also noticed by **Kumar et al. (2011); Sarkar et al., (2017); Sati et al., 2017); Kromann et al., 2017).**

Grade wise tuber yield:

The weight of tubers (q ha⁻¹) in different size categories (0-25g, 25-50g, 50-75g, and >75g) was significantly influenced by the various treatments. It was observed that under treatment T₂, which involved the recommended dose of fertilizers (N 150: P₂O₅ 100: K₂O 120 kg ha⁻¹), significantly higher weights of tuber yield (14.10, 64.70, 76.50, and 102.90 (q ha⁻¹) were recorded at par T₄ = T₃ + FYM @ 25 t ha⁻¹ with yields of 12.90, 62.20, 66.70, and 95.30 quintals per hectare. The control treatment, T₁, produced the statistically lowest yield per hectare (9.50, 51.70, 58.20, and 65.10 q) across all size categories. The favourable effect of integrated nutrient management through both inorganic fertilizers and organic manures on increasing the different grades tuber production was also reported by **Daset et al., (2009); Kumari et al., (2017); Tiwari et al., (2022); Chandra et al., (2023).**

Table 1. Effect of various organic, inorganic and biofertilizer on the soil properties.

Treatments	pH(1:2.5)	EC(dSm⁻¹)	OC(g kg⁻¹)
T ₁	8.18	0.24	3.0
T ₂	8.03	0.25	3.1
T ₃	7.98	0.23	3.3
T ₄	7.92	0.22	3.6

T ₅	7.94	0.23	3.4
T ₆	7.96	0.23	3.2
SEm±	0.03	0.02	0.22
C.Dat 5%	0.09	N/A	N/A

Table 2: Effect of various organic, inorganic and biofertilizer on the plant emergence (%), number of leaves hill⁻¹ and plant height (cm) .

Treatments	Emergence (%)	Number of leaves hill ⁻¹		Plant Height (cm)	
	30 DAP	30 DAP	60 DAP	30 DAP	60 DAP
T ₁	94.69	14.10	42.00	16.00	30.50
T ₂	97.97	16.90	53.65	19.40	48.50
T ₃	95.31	14.50	45.70	16.15	40.20
T ₄	97.03	16.20	52.90	18.30	47.10
T ₅	96.09	15.60	52.30	17.20	46.20
T ₆	95.31	14.75	47.00	16.40	44.00
SEm±	1.05	0.36	1.39	0.14	1.53
C.Dat 5%	NS	1.12	4.24	0.43	4.66

Table 3: Effect of various organic, inorganic and biofertilizer on the tuber yield (q ha⁻¹) and grade wise tuberyield.

Treatments	Tuberyield (q ha ⁻¹)	Weight of tuber (q ha ⁻¹)			
		(0-25g)	(25-50g)	(50-75g)	(>75g)
T ₁	184.50	09.50	51.70	58.20	65.10
T ₂	249.20	14.10	64.70	68.50	101.90
T ₃	194.40	10.30	53.60	60.40	70.10
T ₄	237.10	12.90	62.20	66.70	95.30
T ₅	229.50	11.50	61.80	65.00	91.20

T ₆	206.80	11.20	54.30	64.80	76.50
SEm±	2.75	0.61	1.24	1.26	2.17
C.Dat 5%	8.38	1.87	3.78	3.85	6.62

CONCLUSION:

On the basis of experimental results, it may be concluded that the application of various treatments the maximum yield and yield attributes, was found in treatment (T₂) RDF (N:P:K=150:100:120 kg ha⁻¹). Although the organic manure treatments resulted in low yields, but they improved the tubers quality and also improve the soil health parameters.

REFERENCE

1. Barman, S. K., Kumar, A., Kasero, S., and Ram, B. (2018). Integrated nutrient management potato cv. Ashoka. *Journal of pharmacognosy and phytochemistry*, SP1:1936-1938.
2. Beals, K. A. (2019). Potatoes, nutrition and health. *American journal of potato research*, 96(2), 102-110.
3. Chandra, J., Sachan, R., Kumar, D., Kumar, C., Tiwari, T., Singh, A., & Verma, A. (2023). Integrated Effect of Synthetic Fertilizers and Bio-Inoculant on Growth, Yield Attributes and Yield of Wheat (*Triticum aestivum* L.). *International Journal of Plant & Soil Science*, 35(23), 175-181.
4. Chauhan, A. P. S., Singh, D., Sharma, A., Chouhan, S., Kushwah, N., Singh, N., & Sharma, J. (2023). Assessment of Potato (*Solanum tuberosum* L.) Performance for Yield and Quality Production under Natural Farming System in Gird Region of Madhya Pradesh, India. *Journal of Experimental Agriculture International*, 45(12), 16-22.
5. Das, P. P., Sarkar, A., & Zamen, A. (2009, January). Response of organic and inorganic sources of nutrients on growth and yield of potato in Gangetic alluvial plains of west Bengal. In *Proceedings of 96th Indian Science Congress, part-II* (pp. 3-7).
6. Eid, R. A., Sedra, A., Attia, M. (2006). Influence of nitrogen fixing bacteria incorporation with organic

- and inorganic fertilizer on growth, flower yield and chemical composition of celosia argentea. *World J. Agri. Sci.* 2(4):450-458.
7. Kandil, A. A., Attia, A. N., Badawi, M. A., Sharief, A. E., & Abido, W. A. H. (2011). Effect of water stress and fertilization with inorganic nitrogen and organic chicken manure on yield and yield components of potato. *Australian Journal of Basic and Applied Sciences*, 5(9), 997-1005.
 8. Karam, F., Rouphael, Y., Lahoud, R., Breidi, J., & Colla, G. (2009). Influence of genotypes and potassium application rates on yield and potassium use efficiency of potato. *J. Agron*, 8(1), 27-32.
 9. Kromann P, Franklin V, Soraya AL, Rodrigo VV and Jose P, Byron P, Arturo T, David C, Amalia C, Cabezas C and Andre D. (2017). Can Andean potatoes be agronomically biofortified with iron and zinc fertilizers. *Plant Soil* 411: 121–38.
 10. Kumar, M., Baishya, L. K., Ghosh, D. C., & Gupta, V. K. (2011). Yield and quality of potato (*Solanum tuberosum*) tubers as influenced by nutrient sources under rainfed condition of Meghalaya. *Indian Journal of Agronomy*, 56(3), 260-266.
 11. Kumar, V., & Sharma, S. Malik Asheesh, 2017. Study the different level of Nitrogen and Phosphorus on growth, yield of Potato Crop (*Solanum tuberosum* L.). *International Journal of Scientific & Engineering Research*, 8(7), 101-107.
 12. Kumari, M., Meena, R., Kumar, C., & Kumar, D. (2024). Efficacy of rock phosphate enriched compost on growth, yield and uptake of nutrients by summer mung bean (*Vigna radiata* (L.) Wilczek) in inceptisol of Varanasi. *Journal of Eco-friendly Agriculture*, 19(2), 287-293.
 13. Lal, M. and Khurana, S.C. (2007). Effect of organic manure, biodynamic compost and bio-fertilizer on potato. *Potato Journal* 34(1-2): 105–106.
 14. Nagar, B. L., Yadav, D. L., Narolia, R. S., & Yadav, R. K. (2019). Effect of Different Dose of Nitrogen on Various Varieties of Potato in South Eastern Rajasthan. *Int. J. Curr. Microbiol. App. Sci*, 8(8), 1081-1087.

15. Patel, C. K., Sasani, G. V., Kadian, M. S., Patel, R. N., & Patel, N. H. (2002). Integrated nutrient management in Potato (*Solanum tuberosum*). Extended seminars. Vol. 1. In *2nd International Agronomy Congress* (pp. 26-30).
16. Raj, S., Verma, S., Bisen, R. K., Sharma, G. and Agrawal, H. P. (2020). Effect of growth parameters as influenced by nutrient sources of Potato (*Solanum tuberosum* L.). *International Journal of Agriculture and Plant Science*, 2(4): 29-33.
17. Ram B, Singh BN, Kumar H. (2017). Impact of various organic treatments on growth, yield and quality parameters of potato. *International Journal of Pure and Applied Bioscience*. 5(3): 643-647.
18. Sarkar, A., Sarkar, S., Zaman, A., & Devi, W. P. (2011). Productivity and profitability of different nutrients. *Indian Journal of Agronomy*, 56(2), 159-163.
19. Sati K, Raghav M, Singh CP, Singh VK and Shukla A. (2017). Effect of zinc sulphate application on growth and yield of potato (*Solanum tuberosum* L.). *Research on Environment and Life Sciences* 10(8): 685-87.
20. Sayed, F., Hassan, and Mohamed, M. (2014). Impact of bio- and organic fertilizers on potato yield, quality and tuber weight loss after harvest. *Potato Research* 58: 67-81.
21. Shukla, A. K., Singh, R. R., Mishra, T., Tripathi, K. M., Mishra, S., & Kumar, D. (2024). Optimizing nutrient uptake in rice crops through integrated organic manure application: A comprehensive analysis of grain and straw composition. *Asian Journal of Soil Science and Plant Nutrition*, 10(1), 167-174.
22. Tiwari, A., Kumar, R., Prakash, V., Pandey, S. R., Pathak, D., & Kumar, N. (2021). Effect of organic manures on potato yield, nutrient uptake and soil fertility.
23. Tiwari, A., Kumar, R., Sachan, R., Tiwari, H., & Pandey, S. R. (2022). Effect of Organic and Inorganic Manure on Yield, Quality Trait and Economics of Potato (*Solanum tuberosum* L.) under Indo Gangetic Plain of Eastern Uttar Pradesh. *Journal of Experimental Agriculture International*, 44(3), 10-14.
24. Verma, N., Kumar, R., Yadav, A. K., Kumar, D., Baheliya, A. K., & Chandra, J. (2024).

Effect of Farm Yard Manure, Green Manure and Vermicompost on Growth and Yield of Rice. *International Journal of Environment and Climate Change*, 14(1), 581-585.

UNDER PEER REVIEW