

Effect of Organic, Inorganic and Biofertilizers on Soil Characteristics and Potato tuber yield (*Solanum tuberosum* L.)

ABSTRACT

This study evaluates the impact of organic, inorganic, and biofertilizers on soil characteristics and potato tuber yield in the variety KufriAshoka. The experiment was conducted at the Vegetable Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Ayodhya, Uttar Pradesh, using treatments involving different combinations of fertilizers, including recommended doses of inorganic nutrients (RDF), farmyard manure (FYM), vermicompost, *Azotobacter*, and *Phosphobacteria*. Key findings demonstrated that RDF treatment (150:100:120 kg N:P₂O₅ ha⁻¹) produced the highest tuber yield (249.2 q ha⁻¹), significantly outperforming all other treatments. However, the organic treatment T4, which included compost, crop residue, biofertilizers, and FYM, also yielded a substantial 237.1 q ha⁻¹, with improvements in soil health attributes like increased organic carbon (3.6 g kg⁻¹) and reduced pH (7.92) and electrical conductivity (0.22 dSm⁻¹). Results indicated that the integration of organic and biofertilizers led to moderate yield gains compared to RDF but significantly enhanced soil properties, contributing to long-term soil health. Organic treatments promoted improved microbial activity and soil structure, essential for sustainable agriculture. This study highlights the effectiveness of integrated nutrient management, where combining organic and biofertilizers with inorganic nutrients can enhance crop yields while maintaining soil fertility and reducing the negative environmental impact associated with exclusive inorganic fertilizer use.

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

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the major crops contributing to the world's food security. (Karam *et al.*, 2009). It is the most popular tuber crop in the world. Potato is one of the most important field crops not only for its local consumption but also to increase 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), vermi compost, 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 micronutrient offers significant benefits. It promotes long-term ecological sustainability and soil fertility, essential for successful crop. 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 subtropical 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 slightly 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 Ramet *et al.*, (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 Sayed *et al.*, (2014), Barman *et al.*, (2018).

Yield attributes and tuberyield-

Tuberyield:

Thepotatotubersyieldwasfoundtobesignificantlyaffectedbythevariousorganicandinorganictr eatments. RDF(N:P:K=150:100:120 kg ha⁻¹)recordedthehighesttuberyield,whichwassignificantly superior to all other nutrient treatments. This was followed by the treatment T₄(Compost (like NADEP method) + Crop residue incorporation +Biofertilizer (Azotobacter andPhosphobacteria) + Microbial culture to decompose crop Residue + FYM @ 25 t/ha). comparedtocontrol. Thetuberyield underT₂was 5.10% higher than T₄(**Table 2**).The increased tuberyields due to integrated nutrient management of the above saidfertilizerlevelshaveresultedinmorevegetativegrowthandaccumulationofmorephotosynthates.T hus, there may be more translocation of photosynthates to sink. Hence, they have resulted inmoretuberyield.Highernumberoftubersperhillalsocontributedtosignificantlyhighertotaltuberyiel d. The favourable effect of integrated nutrient management through both inorganic fertilizersand organic manures on increasing the tuber yield. Production was also noticed by **Kumar et al.(2011);Sarkaret al., (2017);(Sati et al., 2017);(Kromann et al., 2017)**.

Gradewisetuberyield:

Theweightoftubers(qha⁻¹)indifferentsizecategories(0-25g,25-50g,50-75g, and >75g) was significantly influenced by the various treatments. It was observed thatunder treatment T₂, which involved the recommended dose of fertilizers (N 150: P₂O₅ 100: K₂O120 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 95.30quintals per hectare. The control treatment, T₁, produced the statistically lowest yield per hectare(9.50,51.70, 58.20, and65.10 q)acrossall sizecategories.Thefavourableeffectofintegratednutrientmanagementthroughbothinorganicfertilize rsand organic manures on increasing the different grades tuber production was also reported by**Daset al., (2009); Kumaret al., (2017);Tiwari et al., (2022); Chandra et al.,(2023)**.

Table1.Effectofvariousorganic,inorganicandbiofertilizeronthesoilproperties.

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

Table2:Effectofvariousorganic,inorganicandbiofertilizerontheplantemergence(%), numberof leaveshill¹ and plantheight(cm).

Treatments	Emergence(%)	Numberof leaveshill ¹		Plantheight(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 gradewise 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 loweryields, but they improved the tubers quality and also improve the soil health parameters.

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