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Effect of integrated application of fertilizers and liquid organic manures on soil physicochemical properties and available nutrients under okra (*Abelmoschus esculentus* L.) cultivation

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ABSTRACT

Integrated nutrient management using liquid organic formulations alongside recommended fertilizers may influence soil chemical properties and nutrient availability in vegetable production. This study evaluated soil pH, electrical conductivity (EC), organic carbon and available N, P and K under different fertilizer–liquid manure combinations in okra. The field experiment was conducted during the zaid season at the Research Field, Department of Horticulture, College of Agriculture, Gwalior, Madhya Pradesh. Seventeen treatments were evaluated in a randomized block design with three replications. Treatment-wise results for two years and pooled means were transcribed from the supplied thesis document. The manuscript reports the values available in that source; no new statistical tests were conducted because replicate-level raw data were not supplied. In pooled results, T10 (100% recommended dose of fertilizers [RDF] + vermiwash 100 L ha⁻¹ + panchagavya 500 L ha⁻¹) recorded the lowest pH (7.11) and the highest EC (0.43 dS m⁻¹), organic carbon (0.63%), available N (190.29 kg ha⁻¹), available P (17.13 kg ha⁻¹) and available K (330.68 kg ha⁻¹). The RDF-only treatment (T1) had the lowest pooled EC (0.18 dS m⁻¹), organic carbon (0.52%), available N (175.44 kg ha⁻¹), available P (14.51 kg ha⁻¹) and available K (306.26 kg ha⁻¹), alongside the highest pH (7.24). Under the conditions of this experiment, combining RDF with vermiwash and panchagavya was associated with higher pooled soil organic carbon and available macronutrients than RDF alone. The interpretation should be considered in light of the available summary data and verified against the original statistical output before submission.

Keywords: Available nutrients, Electrical conductivity, Liquid organic manure, Okra, Organic carbon, Soil fertility

1. Introduction

Soil fertility is a central determinant of vegetable crop productivity and the sustainability of nutrient management. Repeated reliance on mineral fertilizers can supply readily available nutrients, while organic inputs may contribute carbon compounds, nutrients and substrates that support soil biological processes. The effects depend on the composition of the amendment, the soil, application rate and the crop-management system. Research on okra has shown that organic manures and mineral fertilizers can modify soil nutrient status and crop performance, although responses vary among manure sources and experimental conditions (Adekiya *et al.*, 2020) [1].

Fermented liquid formulations such as jeevamrit and panchagavya, along with vermiwash, are used in several low-input and integrated farming systems. Research on brinjal has documented changes in soil microbial and enzyme indicators following application of fermented liquid organic formulations and manures (Rathore *et al.*, 2023) [2]. Studies of okra have also examined bioorganic nutrient sources in relation to residual soil fertility and nutrient uptake (Sharma *et al.*, 2022) [3], while recent work has considered bioformulation-based systems and soil microbial properties under okra (Lalkhumliana *et al.*, 2025) [4]. These findings support the need to assess treatment-specific soil responses rather than assume that all organic formulations behave identically.

The present study uses a two-year field dataset from Gwalior, Madhya Pradesh, to compare soil pH, EC, organic carbon and available N, P and K under 17 fertilizer and liquid-organic-manure treatment combinations. The specific objective was to identify treatment combinations associated with higher post-treatment soil organic carbon and available macronutrient values while documenting the observed pH and EC response.

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2. Materials and methods

2.1 Experimental site and design

The field experiment was conducted at the Research Field, Department of Horticulture, College of Agriculture, Gwalior, Madhya Pradesh, India, using okra (*Abelmoschus esculentus* L.) cv. Pusa Bhindi-5 during the zaid season. The experiment followed a randomized block design with 17 treatments and three replications, giving 51 plots. Net plot size was 4×3 m, spacing was 45×30 cm, and the reported net and gross experimental areas were 612 m^2 and 803.25 m^2 , respectively.

2.2 Initial soil sampling and analysis

Before the field experiment, ten soil samples were collected randomly from 0–15 cm depth using a soil auger and mixed to form a composite sample. The source document describes the experimental soil as sandy clay loam in its narrative, while the reported particle-size values (62.40% sand, 22.50% silt and 15.10% clay) should be checked against the USDA textural triangle because these proportions may indicate a different texture class. Initial reported soil pH was 7.60 and EC was 0.99 dS m^{-1} . The source also lists initial organic carbon as 10.71%; this value appears inconsistent with the post-experiment organic-carbon values (0.52–0.63%) and must be verified against the original laboratory record before publication.

2.3 Treatments

Code	Treatments
T1	100% RDF (control)
T2	RDF + vermiwash (100 L ha^{-1})
T3	RDF + vermiwash (50 L ha^{-1})
T4	RDF + jeevamrit (500 L ha^{-1})
T5	RDF + jeevamrit (250 L ha^{-1})
T6	RDF + panchagavya (500 L ha^{-1})
T7	RDF + panchagavya (250 L ha^{-1})
T8	RDF + vermiwash (100) + jeevamrit (500 L ha^{-1})
T9	RDF + vermiwash (50) + jeevamrit (250 L ha^{-1})
T10	RDF + vermiwash (100) + panchagavya (500 L ha^{-1})
T11	RDF + vermiwash (50) + panchagavya (250 L ha^{-1})
T12	Beejamrit + vermiwash (100) + Brahmasra
T13	Beejamrit + vermiwash (50) + jeevamrit (250) + Brahmasra
T14	Beejamrit + vermiwash (50) + panchagavya (250) + Brahmasra
T15	Beejamrit + jeevamrit (500) + Brahmasra
T16	Beejamrit + panchagavya (500) + Brahmasra
T17	Beejamrit + jeevamrit (250) + panchagavya (250) + Brahmasra

2.4 Soil parameters and analytical methods

Soil pH was measured potentiometrically in a soil suspension (1:2.5). EC was measured using a conductivity meter and expressed as dS m^{-1} . Organic carbon was determined by the Walkley–Black method. Available nitrogen was determined by the alkaline KMnO_4 method; available phosphorus was determined by an extraction/colorimetric method described in the source as Bray *et al.* (1945) [5]; and available potassium was extracted with neutral normal ammonium acetate and measured by flame photometry.

2.5 Data handling and statistical analysis

Treatment-wise first-year, second-year and pooled means were transcribed from the supplied Word file. Pooled means were used for the principal comparison and graphs. The source reports standard errors of means (SEm) and critical differences (CD) at 5% for available N, P and K; these are reproduced below. Complete ANOVA output was not supplied for every parameter, and no significance tests were recalculated.

Therefore, claims of statistical significance should be retained only after the authors cross-check the original ANOVA tables and treatment comparisons.

3. Results and discussion

3.1 Soil pH and electrical conductivity

The pooled data revealed that soil pH ranged from 7.11 to 7.24 across the different treatments. The lowest pH was recorded under T10 (7.11), whereas the highest was observed under T1 (7.24). The narrow variation in pH values indicated that the treatments had only a marginal influence on soil reaction, and the soil remained neutral to slightly alkaline under all treatments. The relatively stable pH may be attributed to the buffering capacity of the soil, which limits substantial changes in soil reaction following the application of organic and inorganic nutrient sources.

The pooled electrical conductivity (EC) ranged from 0.18 to 0.43 dS m^{-1} . The lowest EC was recorded under T1, while the highest was observed under T10. The increase in EC under certain treatments involving liquid formulations may be associated with the addition of soluble nutrients and other ionic constituents present in these inputs. However, all the recorded EC values remained below 0.5 dS m^{-1} , indicating that the treatments did not result in substantial salt accumulation in the soil. The relatively low EC values suggest that soil salinity was not a major concern under the experimental conditions. A similar pattern was reported by Sharma *et al.* (2021).

3.2 Organic carbon

The pooled soil organic carbon content ranged from 0.52 to 0.63%. The lowest value was recorded under T1 (0.52%), while the highest was observed under T10 (0.63%). Treatment T11 also recorded a comparatively high organic carbon content of 0.62%, followed by T8 (0.61%). These findings indicated that the treatments involving the combined application of recommended dose of fertilizers (RDF) and liquid organic inputs were associated with higher soil organic carbon content than RDF alone. Similar findings were reported by Padbhushan *et al.* (2021) [6].

3.3 Available nitrogen, phosphorus and potassium

The pooled data on available soil nutrients revealed considerable variation among the different treatments. Treatment T10 recorded the highest available nitrogen ($190.29 \text{ kg ha}^{-1}$), phosphorus (17.13 kg ha^{-1}) and potassium ($330.68 \text{ kg ha}^{-1}$). The second-highest values for all three nutrients were recorded under T8, with $187.15 \text{ kg N ha}^{-1}$, $16.91 \text{ kg P ha}^{-1}$ and $327.45 \text{ kg K ha}^{-1}$. In contrast, T1 recorded the lowest available nitrogen ($175.44 \text{ kg ha}^{-1}$), phosphorus (14.51 kg ha^{-1}) and potassium ($306.26 \text{ kg ha}^{-1}$). Similar findings were reported by Randhawa *et al.* (2021) [7], Yaduvanshi *et al.* (2013) [8], and Sharma *et al.* (2017) [9].

The pooled critical differences (CD) at the 5% level were reported as 4.36, 0.41 and 4.67 kg ha^{-1} for available N, P and K, respectively. The differences between T10 and T1 were 14.85 kg ha^{-1} for nitrogen, 2.62 kg ha^{-1} for phosphorus and 24.42 kg ha^{-1} for potassium. All three differences exceeded their respective reported critical differences, indicating that T10 recorded significantly higher available N, P and K than T1 at the 5% level, provided that the reported pooled CDs are applicable to these treatment comparisons.

The higher availability of nitrogen under T10 may be attributed to improved nutrient availability resulting from the combined application of inorganic fertilizers and liquid organic inputs. Organic inputs may influence nitrogen mineralization and microbial activity, thereby contributing to the availability of nitrogen in the soil. Furthermore, the maintenance of a favourable soil environment may support nutrient transformations and reduce the risk of nutrient losses.

The increase in available phosphorus under T10 may be associated with the contribution of phosphorus from the applied nutrient sources and the possible influence of organic compounds on phosphorus availability.

Similarly, the higher available potassium content under T10 may be related to the contribution of potassium from the applied inputs and its subsequent release into the soil solution. Organic amendments may also influence potassium availability through nutrient cycling and interactions with soil exchange sites.

The consistently higher values of available N, P and K under T10, followed by T8, indicate that these treatments were associated with improved soil nutrient availability. In contrast, the comparatively lower values under T1 suggest that RDF alone was less effective in maintaining the measured levels of available nutrients under the experimental conditions.

Table 1. Pooled soil parameters under the 17 treatments

Treatment	Treatments	pH	EC (dS m ⁻¹)	OC (%)	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)
T1	100% RDF (control)	7.24	0.18	0.52	175.44	14.51	306.26
T2	RDF + vermiwash (100 L ha ⁻¹)	7.16	0.24	0.55	180.90	15.53	317.62
T3	RDF + vermiwash (50 L ha ⁻¹)	7.18	0.30	0.54	180.26	15.46	316.69
T4	RDF + jeevamrit (500 L ha ⁻¹)	7.20	0.32	0.56	182.56	15.90	318.80
T5	RDF + jeevamrit (250 L ha ⁻¹)	7.17	0.38	0.59	181.51	15.75	318.06
T6	RDF + panchagavya (500 L ha ⁻¹)	7.19	0.39	0.59	183.61	16.01	320.93
T7	RDF + panchagavya (250 L ha ⁻¹)	7.20	0.40	0.57	183.49	15.95	320.20
T8	RDF + vermiwash (100) + jeevamrit (500 L ha ⁻¹)	7.22	0.41	0.61	187.15	16.91	327.45
T9	RDF + vermiwash (50) + jeevamrit (250 L ha ⁻¹)	7.12	0.42	0.58	184.52	16.28	323.29
T10	RDF + vermiwash (100) + panchagavya (500 L ha ⁻¹)	7.11	0.43	0.63	190.29	17.13	330.68
T11	RDF + vermiwash (50) + panchagavya (250 L ha ⁻¹)	7.20	0.39	0.62	185.49	16.48	325.34
T12	Beejamrit + vermiwash (100) + brahmastra	7.19	0.20	0.56	176.32	14.54	308.31
T13	Beejamrit + vermiwash (50) + jeevamrit (250) + brahmastra	7.15	0.28	0.55	178.30	15.01	314.22
T14	Beejamrit + vermiwash (50) + panchagavya (250) + Brahmastra	7.16	0.29	0.57	178.90	15.12	314.86
T15	Beejamrit + jeevamrit (500) + brahmastra	7.16	0.29	0.57	176.86	14.70	309.56
T16	Beejamrit + panchagavya (500) + brahmastra	7.18	0.26	0.59	177.80	14.89	311.16
T17	Beejamrit + jeevamrit (250) + panchagavya (250) + Brahmastra	7.14	0.22	0.56	179.79	15.30	315.86

Table 2. Reported statistical summary for available macronutrients

Parameter	SEm ± (Pooled)	CD at 5% (Pooled)
Available N (kg ha ⁻¹)	1.54	4.36
Available P (kg ha ⁻¹)	0.14	0.41
Available K (kg ha ⁻¹)	1.65	4.67

4. Conclusion

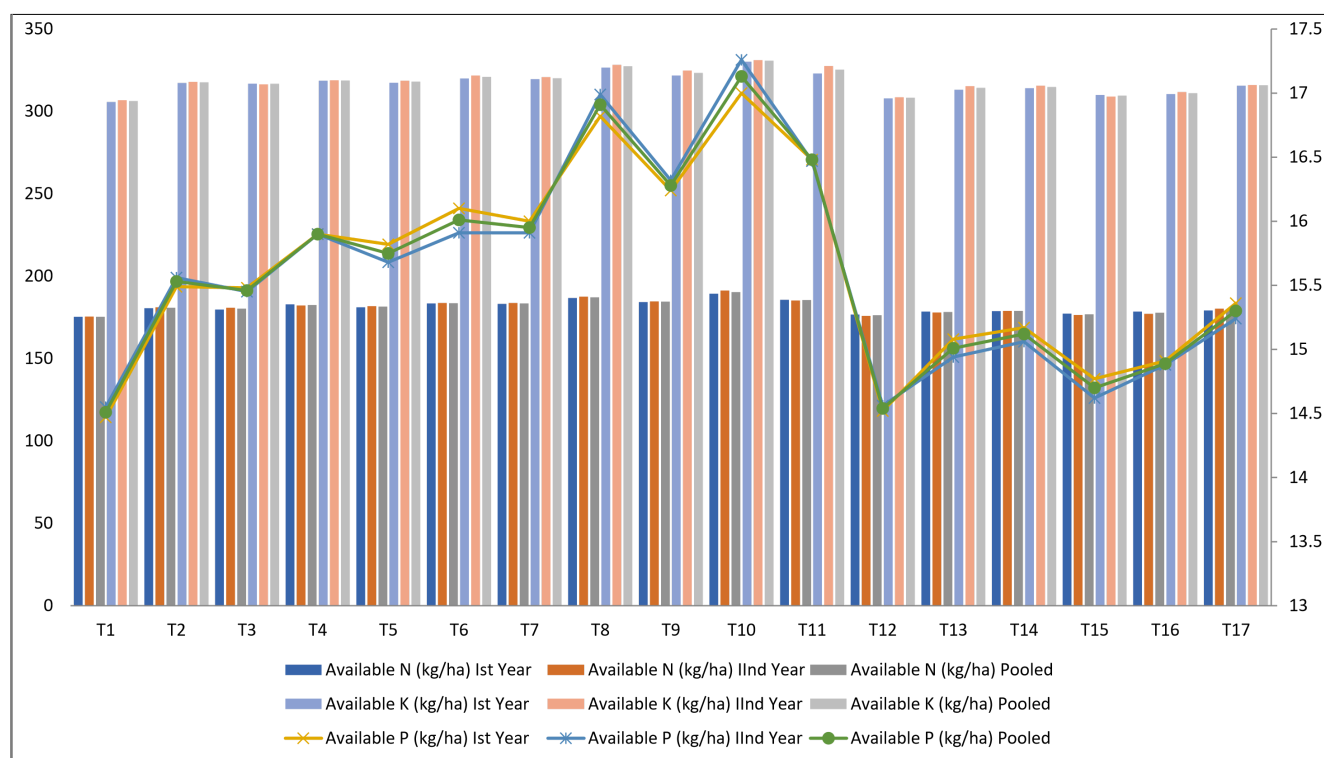
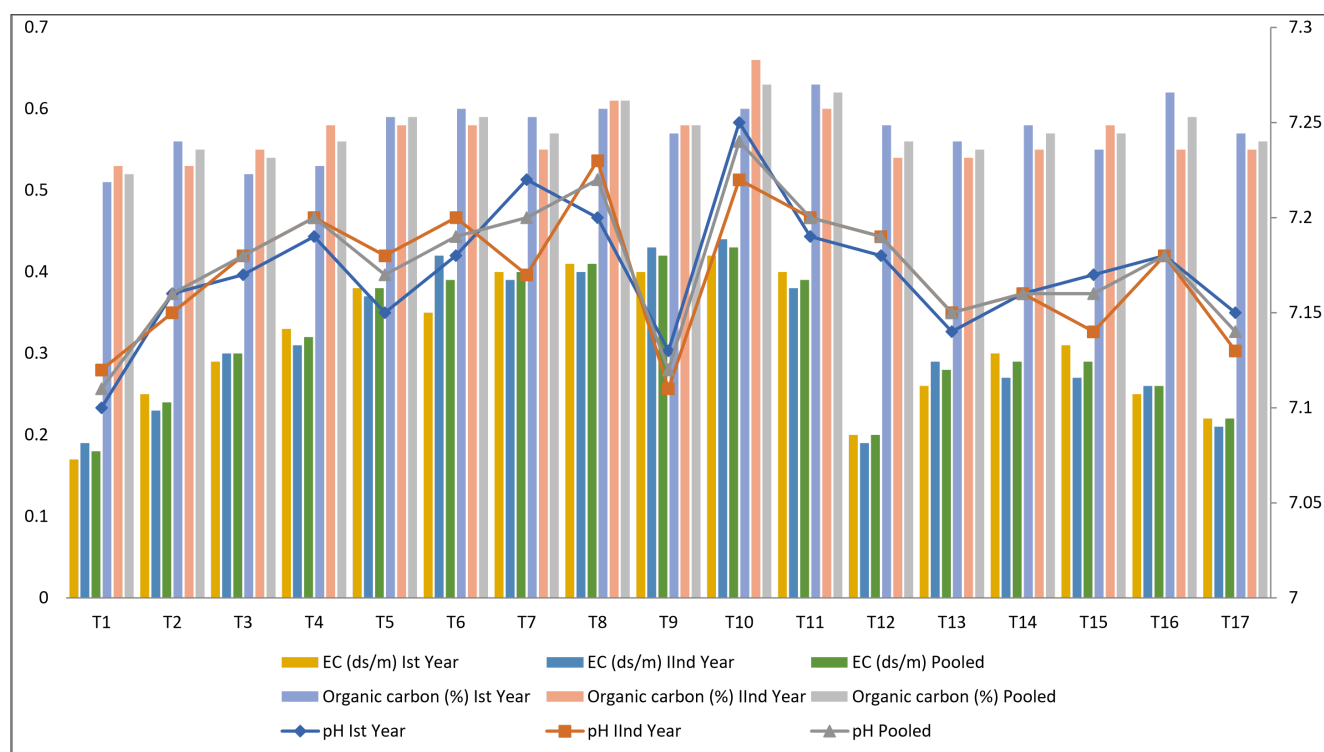
Among the 17 treatment combinations, T10 (RDF + vermiwash 100 L ha⁻¹ + panchagavya 500 L ha⁻¹) recorded the highest pooled soil organic carbon (0.63%) and available N (190.29 kg ha⁻¹), P (17.13 kg ha⁻¹) and K (330.68 kg ha⁻¹), as well as the lowest pooled pH (7.11) and highest EC (0.43 dS m⁻¹). The RDF-only treatment had the lowest pooled organic carbon and available N, P and K in the reported dataset. These findings indicate that integrated use of liquid organic

formulations with RDF may improve selected soil fertility indicators under the tested conditions. Before submission, the authors should validate the source data, harmonize units and methods, and verify statistical significance against the complete ANOVA.

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3.4 Graphical presentation



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