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Long-term nutrient management effects on soil pH, and electrical conductivity, in a vertisol under rice-based cropping system of Chhattisgarh plain

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Abstract
Long-term nutrient management practices play a pivotal role in maintaining soil health and fertility. This study evaluated the influence of different nutrient management treatments on soil pH and electrical conductivity (EC) at two soil depths (0-15 cm and 15-30 cm) under a rice-based cropping system during Kharif seasons of 2022 and 2023. Ten nutrient management treatments were imposed, including balanced fertilization, organic amendments, and integrated nutrient management combinations. The results revealed that soil pH values ranged from 6.92 to 7.23 in the surface layer and 7.27 to 7.50 in the subsurface layer, with no statistically significant variation among treatments. Similarly, EC values varied between 0.22 and 0.27 dS m^{-1} in the surface soil and 0.25 to 0.33 dS m^{-1} in the sub-surface soil, showing a slight increase with higher fertilizer application but remaining within safe limits. Although statistical differences were non-significant, integrated treatments (50% NPK + FYM and 50% NPK + GM) exhibited relatively stable pH and moderate EC values, suggesting improved soil buffering and ionic balance. Overall, long-term integrated nutrient management helped maintain near-neutral soil reaction and safe salinity levels, indicating its importance in sustaining soil chemical quality under intensive cultivation.

Keywords: Nutrient management, soil pH, electrical conductivity, integrated nutrient management, soil fertility, rice-based system

Introduction
Soil health is a fundamental component of sustainable agriculture, and its maintenance largely depends on balanced nutrient management practices. Continuous use of inorganic fertilizers, though essential for meeting the nutrient demand of high-yielding crops, can adversely affect soil chemical properties over time. Among these, soil pH and electrical conductivity (EC) are key indicators of soil chemical balance and nutrient availability.

Prolonged use of nitrogen-based fertilizers, particularly urea, tends to acidify the soil due to the release of hydrogen ions during nitrification. Conversely, balanced fertilization or incorporation of organic sources such as farmyard manure (FYM), green manure (GM), and biofertilizers can buffer soil acidity and maintain pH near neutrality. Soil EC, representing the concentration of soluble salts, is another vital indicator of soil chemical health. Excessive use of mineral fertilizers may elevate EC, whereas organic amendments often help regulate salt accumulation by improving soil structure and water percolation.

Long-term field experiments provide critical insights into how different fertilization regimes influence soil chemical properties across depths. Understanding these changes is crucial for developing sustainable nutrient management strategies. Hence, the present study was conducted to assess the influence of long-term nutrient management practices on soil pH and EC at two depths in a rice-based system under Chhattisgarh conditions.

Materials and Methods
The study was carried out under a long-term nutrient management experiment established in a rice-based cropping system. Soil samples were collected after the Kharif harvest during the years 2022 and 2023 from the experimental field representing Inceptisol soils. The experiment consisted of ten nutrient management treatments including control, balanced

fertilization, and organic amendments. Soil samples were collected from two depths: surface (0-15 cm) and sub-surface (15-30 cm) layers from all replications. Composite samples were air-dried, ground, and sieved (2 mm) for chemical analysis.

Soil pH was measured in a 2.5:1 water-soil suspension using a glass electrode pH meter after 30 minutes of equilibration (Piper, 1967) [10]. Electrical conductivity (EC) of the same soil suspension (supernatant) was determined using a conductivity bridge and expressed as dS m⁻¹ (Black, 1965) [2]. Data obtained from both years were statistically analyzed, and treatment means were compared using LSD ($p = 0.05$).

Results and Discussion

The long-term application of nutrient management practices slightly influenced soil pH and EC, though differences among treatments were statistically non-significant.

Soil pH ranged from 6.92 to 7.23 in the surface layer and 7.27 to 7.50 in the sub-surface layer. The lowest pH occurred under 100% NP treatment, while the highest was in the control. Slight acidification under nitrogen-dominant treatments may be attributed to urea hydrolysis and nitrification, whereas balanced fertilization and organic amendments maintained near-neutral pH. These results confirm that organic sources like FYM and GM buffer acidity due to their cation exchange and liming effects.

Soil EC ranged from 0.22 to 0.27 dS m^{-1} at the surface and 0.25 to 0.33 dS m^{-1} at the sub-surface layer. Slightly higher EC in treatments receiving higher fertilizer doses (e.g., 150% NPK) could result from soluble salt accumulation. However, all EC values remained below the salinity threshold, indicating no salt hazard. Sub-surface EC values were marginally higher, likely due to salt leaching during the monsoon season.

These findings align with earlier reports (Aref & Wander, 1998; Ellmer *et al.*, 2000; Hera, 1996) [1, 5, 6] emphasizing that balanced and integrated nutrient management practices maintain favorable soil chemical conditions over time.

Table 1: Effect of different nutrient management treatments on soil pH and EC at two depths (0-15 cm and 15-30 cm).

Treatments details		Soil pH					
		Surface Soil (0-15 cm)			Sub surface Soil (15-30 cm)		
		Kharif-2022	Kharif-2023	Pooled	Kharif-2022	Kharif-2023	Pooled
T_1	Control	7.31	7.15	7.23	7.59	7.40	7.50
T_2	50% NPK	7.14	7.14	7.14	7.44	7.35	7.39
T_3	100% NPK	7.16	7.08	7.12	7.45	7.27	7.36
T_4	150% NPK	7.11	7.08	7.10	7.41	7.26	7.33
T_5	100% NPK+ Zn	7.11	7.08	7.09	7.38	7.25	7.31
T_6	100% NP	6.92	7.04	6.98	7.33	7.27	7.30
T_7	100% N	7.06	7.06	7.06	7.40	7.26	7.33
T_8	100% NPK+FYM	7.12	7.03	7.07	7.35	7.12	7.23
T_9	50% NPK+BGA	7.20	7.08	7.14	7.40	7.23	7.31
T_{10}	50% NPK+GM	7.23	7.13	7.18	7.43	7.30	7.37
SEm (±)		0.08	0.06	0.05	0.06	0.07	0.05
LSD(p = 0.05)		NS	NS	NS	NS	NS	0.13

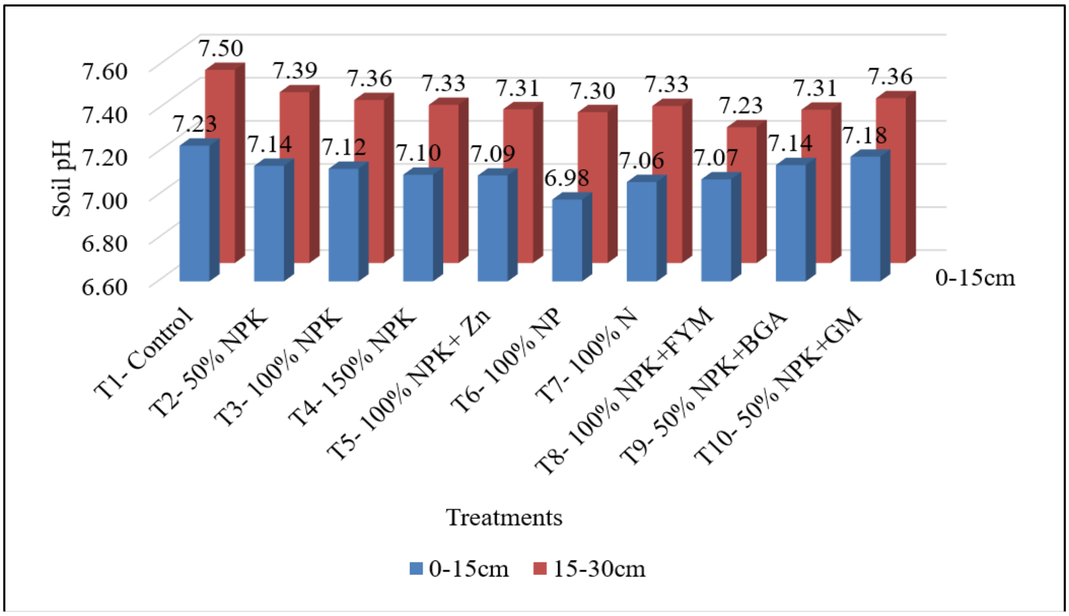

Fig 1: Influence of long-term nutrient management practices on soil pH at two soil depths

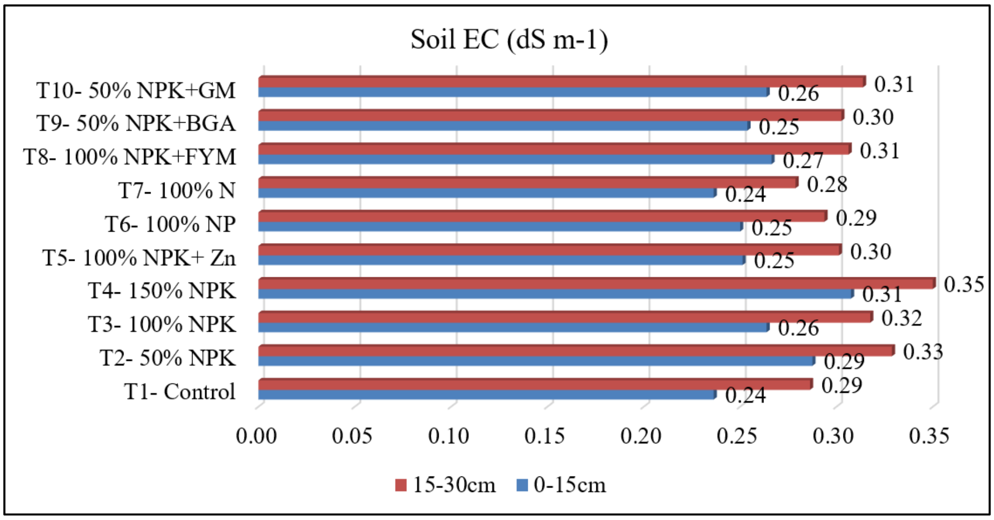

Fig 2: Influence of long-term integrated nutrient management on soil EC at two soil depths

Table 2: Effect of long-term nutrient management practices on soil electrical conductivity at two soil depths

Treatments details		Soil pH					
		Surface Soil (0-15 cm)			Sub surface Soil (15-30 cm)		
		Kharif-2022	Kharif-2023	Pooled	Kharif-2022	Kharif-2023	Pooled
T_1	Control	7.31	7.15	7.23	7.59	7.40	7.50
T_2	50% NPK	7.14	7.14	7.14	7.44	7.35	7.39
T_3	100% NPK	7.16	7.08	7.12	7.45	7.27	7.36
T_4	150% NPK	7.11	7.08	7.10	7.41	7.26	7.33
T_5	100% NPK+ Zn	7.11	7.08	7.09	7.38	7.25	7.31
T_6	100% NP	6.92	7.04	6.98	7.33	7.27	7.30
T_7	100% N	7.06	7.06	7.06	7.40	7.26	7.33
T_8	100% NPK+FYM	7.12	7.03	7.07	7.35	7.12	7.23
T_9	50% NPK+BGA	7.20	7.08	7.14	7.40	7.23	7.31
T_{10}	50% NPK+GM	7.23	7.13	7.18	7.43	7.30	7.37
SEm (±)		0.08	0.06	0.05	0.06	0.07	0.05
LSD(p = 0.05)		NS	NS	NS	NS	NS	0.13

Conclusion

The findings of this study indicate that long-term nutrient management practices have minimal influence on soil pH and EC. Balanced fertilization combined with organic sources such as FYM and GM effectively maintained near-neutral pH and safe EC levels, while nitrogen-only or NP treatments tended to lower soil pH slightly. Overall, integrated nutrient management proved most effective in preserving soil chemical quality and supporting sustainable agricultural productivity.

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