J. Farm Sci., 39(1): (47-51) 2026

RESEARCH PAPER

Long term manuring and its residual effects on soil properties in dryland soils of northern dry zone of Karnataka

RIA BHATTACHARJEE[1*], VIDYAVATHI G. YADAHALLI[1], G. S. YADAHALLI[2] AND B. SAVITA[1]

[1]Department of Soil Science and Agril. Chemistry, [2]Department of Agronomy, College of Agriculture, Dharwad
University of Agricultural Sciences, Dharwad - 580 005, India
*E-mail: riaaabhatt2@gmail.com

(Received: March, 2025 ; Accepted:March,2026)

DOI: 10.61475/JFS.2026.v39i1.10

Abstract:A field experiment was conducted to assess the residual effect of permanent manurial trial (initiated during 2017-18)on soil physical, chemical and biological properties established at RARS, Vijayapura during *kharif* 2024-25. Treatments comprised of unfertilised control (T_1), sole inorganics (T_2), 50% N through FYM + 50% through inorganic sources (T_3), 50% N through Vermicompost + 50% through inorganic sources (T_4), 50% N through sunhemp + 50% inorganic sources (T_5), 50% N through Gliricidial loppings + 50% inorganic sources (T_6) and 50% N through crop residues + 50% inorganic sources (T_7). The experiment was laid out in randomised complete block design replicated thrice.The study revealed that, the treatment receiving 50% N through FYM + 50% through inorganic sources (T_3) significantly reduced soil bulk density, water holding capacity, soil organic carbon (SOC), available nitrogen, cation exchange capacity (CEC) and dehydrogenase activity followed by treatment receiving 50% N through Vermicompost + 50% through inorganic sources (T_4). Across treatments, SOC and nutrient availabilities declined with soil depth, underscoring the dominance of surface-applied organics and root activity in top soil layers.

Key words: Cation exchange capacity, Permanent manurial trial, Recommended doses of fertilizers, Soil organic carbon, Soil depth

Introduction

Soil health is determined by an interplay of physical, chemical and biological attributes. Beyond agricultural importance, soil serves as a crucial component of natural and engineered ecosystems. It supports infrastructure, filters pollutants and maintains environmental quality (Fausak *et al*., 2024). It regulates water, cycles nutrients and sustains life, earning it the metaphorical title: "the soul of infinite life". Therefore, preserving soil integrity is not just an agricultural necessity but a global ecological responsibility.

In semi-arid regions such as Northern Dry Zone of Karnataka (Zone-3), specifically Vijayapura, maintaining soil fertility is an ongoing challenge due to erratic rainfall, high temperature and low organic matter content. This region receives an annual precipitation average of approximately 594 mm and features medium to deep black soils of soil order *Vertisol*, with a clayey texture known for their high cation exchange capacity and nutrient retention potential. Under proper management, these soils offer substantial agronomic advantages. However, high temperatures in semi-arid climates accelerate the decomposition of organic matter, often resulting in declining soil organic carbon (SOC) levels (Mazadiego *et al.,* 2020).

To address these region-specific concerns, permanent manurial trials (PMTs) have emerged as essential long-term experiments for evaluating the effects of varied organic and inorganic nutrient management strategies on soil functioning. These trials provide insights into shifts in soil physical properties, nutrient dynamics, microbial activity and organic carbon content.

Numerous studies have been documented that prolonged application of organic amendments, such as manures or crop residues, substantially increases topsoil SOC and improves nutrient availability (Zhang *et al.,* 2022). The residual effects of such practices also promote microbial proliferation, enzymatic activity and nutrient mineralization factors that accelerate carbon stabilization.

Material and methods

A field study was carried out during *kharif* 2024-25 taking maize as uniformity trial at the Regional Agricultural Research Station, Vijayapura, to evaluate the residual impact of a long-term manurial trial (2017-2023) on soil properties under rainfed *Vertisols*. The site (16°072 N, 75°072 E, 593.6 m MSL) was laid out in a randomized block design with seven treatments (Table 1) and three replications.

Soil samples were collected from each plot at 0-20, 20-40, and 40-60 cm depths before sowing and at harvest. After air-drying and sieving (2 mm), samples were stored for analysis of bulk density, water holding capacity, SOC, available N, P, O…,

Table 1. Treatment details

Treatment No.	Treatment Details
T_1	Control
T_2	RDF (Safflower: 40: 40:12 N: P_2O_5: K_2O kg ha^{-1} Sorghum: 50: 25: 0 N: P_2O_5: K_2O kg ha^{-1})
T_3	50% through FYM + 50% inorganic sources
T_4	50% N through Vermicompost + 50% through inorganic sources
T_5	50% N through sunhemp + 50% inorganic sources
T_6	50% N through Gliricidialoppings + 50% inorganic sources
T_7	50% N through cropresidues + 50% inorganic sources

K, O, CEC and dehydrogenase activity using standard procedures.

Bulk density was determined by core sampler (Black, 1965), water holding capacity by Keen's cup (Piper, 2002), SOC by Walkley and Black's wet oxidation, available N by modified alkaline permanganate (Sahrawat & Burford, 1982), available $P_2O_5$by Olsen's method, available K_2O by NH_4OAc extraction, CEC by ammonium acetate (Schollenberger & Dreibelbis, 1930), and dehydrogenase activity by Casida *et al.* (1964).

The experimental soil was classified as clayey (>60 cm depth) with 3.5% sand, 36.4% silt and 60.1% clay. It had a field capacity of 37%, wilting point of 14.9% and bulk density of 1.43 Mg m^{-3}. Chemically, the soil was slightly alkaline (pH 7.85) with 4.9 g kg^{-1} organic carbon and available nutrients of 201.4 kg ha^{-1} N, 15.8 kg ha^{-1} P_2O_5 and 418.0 kg ha^{-1} K_2O.

Results and discussion

Bulk density was significantly higher in the treatment receiving 50% N through FYM + 50% inorganic sources (T_3), both before sowing (1.31, 1.32, and 1.35 Mg m^{-3} at 0-20, 20-40, and 40-60 cm) and at harvest (1.30, 1.31, and 1.34 Mg m^{-3}, respectively) (Table 2), whereas control (T_1) and RDF (T_2) recorded the lowest values. FYM incorporation enriched surface soil organic matter, lowering bulk density and improving structure and microbial activity (Aytenew & Bore, 2020), while deeper layers showed higher bulk density due to limited organic inputs and root growth (Nazari *et al*., 2021).

Water holding capacity (WHC) was also significantly higher in plots receiving 50% N through FYM + 50% inorganic sources (T_3), both at sowing (55.33, 51.43, and 47.57%) and harvest (56.69, 52.49 and 47.97%) at respective depths (Table 2) while the lowest was in control (T_1) and RDF-T_2. FYM enhanced soil structure by adding organic matter that increased water retention (Hudson, 1994). WHC declined with depth from compaction but improved at harvest through residual SOM and maize root exudates, as also observed by Angulo *et al.* (2024).

SOC was recorded highestwith application of 50% N through FYM + 50% inorganic sources (T_3) both at sowing (6.90, 5.83, and 3.93 g kg^{-1}) and harvest (7.23, 5.97 and 3.97 g kg^{-1}) at respective depths, followed by 50% N through Vermicompost + 50% through inorganic sources (T_4), while control (T_1) and RDF (T_2) recorded the lowest (Table 3). FYM enhanced SOC in surface layers through slow carbon release, while deeper soils showed lower levels due to surface application and root concentration (Singh *et al*., 2020). A slight

Table 2. Residual effect of permanent manurial trial on soil bulk density and water holding capacity at different depths under maize crop

Treatments	Bulk density (Mg m^{-3})						WHC (%)					
	(Before sowing)			(at harvest)			(Before sowing)			(at harvest)		
	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
T_1	1.48	1.50	1.52	1.48	1.51	1.52	42.11	38.75	33.64	39.19	37.40	33.07
T_2	1.43	1.44	1.46	1.42	1.43	1.46	44.32	40.30	36.45	44.67	40.55	36.56
T_3	1.31	1.32	1.35	1.30	1.31	1.34	55.33	51.43	47.57	56.69	52.49	47.97
T_4	1.32	1.33	1.37	1.31	1.32	1.36	53.79	50.17	45.57	54.27	51.08	46.02
T_5	1.34	1.36	1.39	1.32	1.34	1.39	49.67	46.92	40.17	50.40	47.72	40.36
T_6	1.36	1.37	1.40	1.35	1.36	1.39	47.12	44.09	41.04	47.88	44.33	41.20
T_7	1.38	1.40	1.41	1.37	1.38	1.40	46.19	43.67	37.78	47.18	44.82	37.97
S. Em±	0.05	0.05	0.05	0.05	0.05	0.05	2.69	1.70	3.40	1.95	1.70	3.15
C. D (p=0.05)	0.14	0.15	0.16	0.14	0.14	0.16	8.28	5.25	10.48	6.00	5.23	9.70

T_1: Control, T_2: RDF, T_3: 50% N through FYM + 50% inorganic sources, T_4: 50%N through vermicompost + 50% inorganic sources T_5: 50% N through sunhemp + 50% inorganic sources, T_6: 50% N through Gliricidia loppings + 50% inorganic sources, T_7: 50% N through crop residues + 50% inorganic sources,

Table 3.Residual effect of permanent manurial trial on soil organic carbon and available nitrogen at different soil depths under maize crop

Treatments	Soil organic carbon (g kg^{-1})						Available N (kg ha^{-1})					
	(Before sowing)			(at harvest)			(Before sowing)			(at harvest)		
	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
T_1	3.93	3.60	2.73	3.23	2.80	2.53	161.19	145.67	122.78	156.90	142.01	121.90
T_2	4.77	4.37	3.19	4.80	4.40	3.21	172.48	164.14	133.93	168.67	161.67	132.75
T_3	6.90	5.83	3.93	7.23	5.97	3.97	238.85	220.19	183.71	233.52	217.11	182.12
T_4	6.67	5.57	3.87	6.93	5.83	3.90	233.56	216.82	173.26	229.25	213.65	171.70
T_5	6.20	5.23	3.57	6.73	5.60	3.61	226.82	212.68	166.89	220.25	208.67	164.89
T_6	5.83	5.13	3.43	6.17	5.30	3.47	221.67	208.01	160.45	217.55	206.34	159.66
T_7	5.47	4.97	3.30	5.83	5.13	3.33	211.43	203.45	156.84	207.07	201.45	155.77
S. Em±	0.34	0.34	0.25	0.35	0.29	0.24	8.20	7.81	8.57	8.87	9.51	9.16
C. D. (p=0.05)	1.05	1.05	0.71	1.06	0.90	0.73	25.27	24.06	26.39	27.33	29.29	28.23

T_1: Control, T_2: RDF, T_3: 50% N through FYM + 50% inorganic sources, T_4: 50%N through vermicompost + 50% inorganic sources, T_5: 50% N through sunhemp + 50% inorganic sources, T_6: 50% N through Gliricidia loppings + 50% inorganic sources, T_7: 50% N through crop residues + 50% inorganic sources

Table 4.Residual effect of permanent manurial trial on soil available phosphorus and potassium at different soil depths under maize crop

Treatments	Available P_2O_5 (kg ha^{-1})						Available K_2O (kg ha^{-1})					
	(Before sowing)			(at harvest)			(Before sowing)			(at harvest)		
	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
T_1	13.75	12.40	11.15	12.41	11.19	10.63	360.85	353.10	320.29	364.84	345.74	316.0
T_2	15.93	13.50	12.77	14.16	12.34	12.58	376.07	362.52	330.41	370.62	358.88	324.48
T_3	23.62	21.98	20.85	21.72	20.50	20.04	475.11	427.41	395.46	466.58	424.01	390.56
T_4	24.06	22.02	20.95	22.64	21.12	20.12	470.92	425.71	362.95	462.11	421.54	359.32
T_5	22.90	20.85	19.16	19.62	19.15	18.87	479.71	431.16	380.33	471.93	424.01	375.34
T_6	18.37	17.60	16.61	16.73	16.63	16.56	482.37	432.04	410.75	473.93	429.88	405.56
T_7	19.28	18.08	17.78	17.84	17.82	15.55	463.29	390.00	345.50	456.23	382.09	340.45
S.Em±	0.93	1.17	0.73	0.80	1.19	1.01	19.03	17.90	22.61	33.00	24.55	25.84
C.D (p=0.05)	2.85	3.59	2.25	2.47	3.66	3.11	58.62	55.14	69.65	101.68	75.65	79.60

T_1: Control , T_2: RDF, T_3: 50% N through FYM + 50% inorganic sources, T_4: 50%N through vermicompost + 50% inorganic sources, T_5: 50% N through sunhemp + 50% inorganic sources, T_6: 50% N through Gliricidia loppings + 50% inorganic sources, T_7: 50% N through crop residues + 50% inorganic sources

Table 5. Residual effect of permanent manurial trial on soil, cation exchange capacity at different depth under maize crop

Treatments	CEC [cmol (p+) kg^{-1}]					
	(Before sowing)			(at harvest)		
	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
T_1:Control	44.73	42.38	38.14	44.30	41.12	37.71
T_2:RDF	49.78	47.68	42.67	49.97	47.84	42.51
T_3:50% N through FYM + 50% inorganic sources	58.02	57.10	52.31	59.78	58.19	52.56
T_4:50%N through vermicompost + 50% inorganic sources	57.30	54.43	50.19	57.60	55.12	50.66
T_5:50% N through sunhemp + 50% inorganic sources	55.09	52.05	48.04	55.45	53.22	48.52
T_6:50% N through Gliricidia loppings + 50% inorganic sources	53.68	50.25	46.48	54.19	51.67	46.77
T_7:50% N through crop residues + 50% inorganic sources	52.95	49.41	44.02	53.01	50.34	44.69
S. Em±	2.24	2.46	3.35	2.07	1.72	3.04
C.D (p=0.05)	6.90	7.59	10.31	6.38	5.29	9.35

SOC rise at harvest was linked to residual decomposition and maize roots, with cooler, wetter conditions conserving carbon (Liu *et al.*, 2025).

Available nitrogen was also highest in treatment receiving, 50% N through FYM + 50% inorganic sources (T_3), both before sowing (238.85, 220.19, and 183.71 kg ha^{-1}) and at harvest (233.52, 217.11and 182.12 kg ha^{-1}) across respective depths (Table 3), followed by 50% N through Vermicompost + 50% through inorganic sources (T_4), while control (T_1) and RDF recorded lower values. This reflected the combined effect of slow-release FYM and available fertilizer N (Vidyavathi *et al.*, 2012), with N decline from sowing to harvest due to uptake, volatilization and minor leaching in alkaline soils (Zhang *et al.*, 2021).

Available phosphorus was maximum in treatment, 50% N through vermicompost + 50% inorganic), both before sowing (24.06, 22.02, and 20.95 kg ha^{-1}) and harvest (22.64, 21.12 and 20.12 kg ha^{-1} across depths), compared tocontrol (T_1) and RDF (T_2) recorded the lowest (Table 4). Vermicompost improved P availability by promoting phosphate-solubilizing microbes and reducing Ca²z fixation via its high CEC (Kamaleshwaran & Elayaraja, 2021; Oyege & Balaji, 2023). P declined with depth due to limited inputs and activity, while surface retention was aided by localized application and root exudates, as also observed by Zhang *et al.* (2014).

Available potassium was significantly higher in plots receiving, 50% N through Gliricidia loppings + 50% inorganic) at sowing (482.37, 432.04 and 410.75 kg ha^{-1}) and harvest (473.93, 429.88 and 405.56 kg ha^{-1}) at respective depths (Table 4) compared to Control (T_1) and RDF (T_2) recorded lower values. Gliricidia, rich in K and organic matter, improved CEC, microbial activity and K retention, with nutrient distribution following typical cycling patterns (Beedy *et al.*, 2010; Gurav, 2018; Johnston & Poulton, 2018).

CEC was significantly higher in plots receiving 50% N through FYM + 50% inorganic sources (T_3), both before sowing (58.02, 57.10 and 52.31 cmol(pz) kg^{-1}) and at harvest (59.78,

Table 6. Residual effect of permanent manurial trial on soil dehydrogenase activity under maize crop at vegetative stage

Treatments	Dehydrogenase activity(µg TPF $g^{-1}day^{-1}$)
T_1:Control	12.43
T_2:RDF	14.44
T_3:50% N through FYM + 50% inorganic sources	23.06
T_4:50%N through vermicompost + 50% inorganic sources	19.31
T_5:50% N through sunhemp + 50% inorganic sources	16.83
T_6:50% N through Gliricidia loppings + 50% inorganic sources	16.18
T_7:50% N through crop residues + 50% inorganic sources	15.59
S.Em±	1.37
C.D(p=0.05)	

58.19 and 52.56 cmol (pz) kg^{-1} at respective depths, while control (T_1) and RDF (T_2) recorded the lowest (Table 5). Regular FYM application enhanced organic matter, cation retention and buffering in Vertisols, while vermicompost showed similar benefits due to its high CEC (Brady & Weil, 2017; Jha *et al.,* 2025).

Dehydrogenase activity (DHA) was significantly higher in treatment, 50% N through FYM + 50% inorganic sources (T_3), recording 23.06 µg TPF g^{-1} day^{-1}, followed by 50% N through vermicompost + 50% inorganic (T_4) (Table 6). This was attributed to organic carbon supply, which supports microbes, improves soil structure and porosity and enhances DHA (Kumawat *et al*., 2025).

Conclusion

The experimental results revealed that the integration of organic manures with inorganic fertilizers exerted a pronounced residual effect on soil physico-chemical and biological properties compared to sole inorganic fertilization or unfertilized control. Among the treatments, the application of 50% N through FYM + 50% through inorganic sources (T_3) consistently lowered soil bulk density, enhanced water holding capacity, improved soil organic carbon, available nitrogen, cation exchange capacity, and dehydrogenase activity, reflecting the synergistic role of FYM in improving soil structure, nutrient retention, and microbial activity followed by application of 50% N through vermicompost + 50% inorganic sources (T_4). With increase in depth, nutrient availability and SOC declined across all treatments. Overall, the findings establish that long-term integrated nutrient management not only sustains soil fertility but also enhances soil health by improving nutrient cycling, structural stability, and biological activity in *Vertisols*.

References

Angulo V, Bleichrodt R J, Dijksterhuis J, Erktan A, Hefting M M, Kraak B and Kowalchuk G A, 2024, Enhancement of soil aggregation and physical properties through fungal amendments under varying moisture conditions. *Environmental Microbiology*, 26(5): 16-27

Aytenew M and Bore G, 2020. Effects of organic amendments on soil fertility and environmental quality: A review. *Plant Science*, 8(5): 112-119.

Black C A, 1965, *Methods of analysis part-II.* American Society of Agronomy, Madison, USA.

Brady N C and Weil R R, 2017, *The Nature and Properties of Soils* (15th ed.). Pearson Education.

Casida Jr L E, Klein D A and Santoro T, 1964, Soil dehydrogenase activity. *Soil Science*, 98(6): 371-376.

Fausak LK, Bridson N, Diaz-Osorio F, Jassal RS and Lavkulich LM, 2024, Soil health–a perspective. *Frontiers in Soil Science*, 4 :146-151.

Gurav P P, Ray S K, Choudhari P L, Biswas A K and Shirale A O, 2018, A review on soil potassium scenario in vertisols of India. *Journal of Science*, 2(1): 89-90.

Hudson B D, 1994, Soil organic matter and available water capacity. *Journal of Soil and Water Conservation*, 49(2): 189-194.

Jha P, Hati K M, Lenka N K, Lakaria B L, Coumar M V, Meena B P, Thakur J K, Biswas A K and Patra A K, 2025, Soil health in Indian Vertisols. *Soil Health Series: Volume 4, Soil Health and Sustainability in India*, 42(5): 212-242.

Johnston A E and Poulton P R, 2018, The importance of long-term experiments in agriculture: Their contribution to soil fertility and nutrient management. *Archives of Agronomy and Soil Science*, 64(7): 911-928.

Kamaleshwaran R and Elayaraja D, 2021, Influence of vermicompost and FYM on soil fertility, rice productivity and its nutrient uptake. *International Journal of Agriculture and Environmental Research*, 7(4): 575-583.

Kumawat A, Kumar D, Shivay Y S, Sangwan S, Yadav D, Pooniya V, Ali S, Madhu M, Rashmi I, Bhargavi B and Kumar A, 2025, Exploring optimal combinations of green manures, composts andmicrobial inoculums to boost soil biological properties, nutrient release and basmati rice yield. *International Journal of Plant Production*, 19(1): 99-116.

Liu L, Yang J, Wang J, Yu Q, Wei C, Jiang L, Huang J, Zhang Y, Jiang Y, Zhang H and Han X, 2025, Increase in mineral-associated organic carbon does not offset the decrease in particulate organic carbon under long-term nitrogen enrichment in a steppe ecosystem. *Soil Biology and Biochemistry*, 202: 109-123.

Mazadiego FL, de Miguel Garcia E, Barrio-Parra F and Izquierdo-Díaz M eds, 2020, *Applied Geochemistry with Case Studies on Geological Formations, Exploration Techniques and Environmental Issues*. Intech Open.

Meena A L, Pandey R N, Kumar D, Sharma V K, Meena M D, Karwal M, Dutta D, Meena L K, Narwal E, Mishra R P and Panwar A S, 2022, Impacts of long-term rice-based organic farming on fractions and forms of soil organic carbon and nitrogen in the Indo-Gangetic Plain. *Soil Research*, 61(2): 159-175.

Nazari M, Eteghadipour M, Zarebanadkouki M, Ghorbani M, Dippold MA, Bilyera N and Zamanian K, 2021, Impacts of logging-associated compaction on forest soils: a 77 meta-analysis. *Frontiers in Forests and Global Change*, 4:780-789.

Oyege I and Balaji B M S, 2023, Effects of vermicompost on soil and plant health and promoting sustainable agriculture. *Soil Systems*, 7(4): 101.

Piper C S, 2002, Soil and Plant Analysis. Hans publishers, Bombay, India.

Sahrawat K L and Burford J R, 1982, Modification of alkaline permanganate method for assessing the availability of soil nitrogen in upland soils. *Soil Science*, 133(1): 53-57.

Schollenberger C J and Dreibelbis F R, 1930, Analytical methods in base exchange investigations on soils. *Soil Science*, 30(3): 161-174.

Singh M, Sharma K L, Srinivasarao C. H, Vittal K P R andVenkateswarlu B, 2020, Effect of long-term integrated nutrient management on soil carbon dynamics in rainfed semi-arid tropical Alfisol. *Soil Research*, 58(2): 110-121.

Sparks, 1996, Methods of Soil Analysis Part-3: Chemical Methods. *Soil Science Society of America*, 70(4): 441.

Vidyavathi, V, Dasog G S, Babalad H B, Hebsur N S, Gali S K, Patil S G and Alagawadi A R, 2012. Nutrient status of soil under different nutrient and crop management practices. *Karnataka Journal of Agricultural Sciences*, 25(2):193-198

Walkley A J and Black C A, 1934, An estimation of method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Science*, 37(1): 29- 38.

Zhang S, Huffman T, Zhang X, Liu W and Liu Z, 2014, Spatial distribution of soil nutrient at depth in black soil of Northeast China: a case study of soil available phosphorus and total phosphorus. *Journal of soils and sediments*, 14(11): 1775-1789.

Zhang Y, Dalal R C, Bhattacharyya R, Meyer G, Wang P, Menzies N W and Kopittke P M, 2021, Effect of long-term no-tillage and nitrogen fertilization on phosphorus distribution in bulk soil and aggregates of a Vertisol. *Soil and Tillage Research*, 205: 104760.

Zhang Y, Wu L, Zhang X, Deng A, Abdulkareem R, Wang D, Zheng C and Zhang W, 2022, Effect of long-term organic amendment application on the vertical distribution of nutrients in a Vertisol. *Agronomy*, 12(5): 1-11.