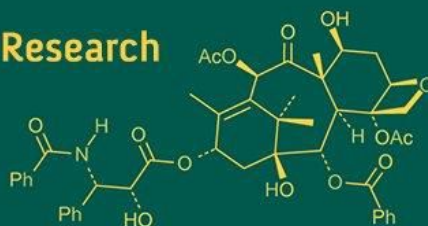


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Impact of organic fertilizers on soil fertility and crop yield

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Abstract

Organic fertilizers offer an alternative to synthetic inputs for maintaining soil fertility and supporting crop production. This two-year field research compared the effects of different organic fertilizer types on soil properties and yields of four crops grown in rotation. Treatments included farmyard manure, vermicompost, poultry manure, and green manure incorporation, each applied at rates equivalent to 10 tonnes per hectare, alongside an unfertilized control. Wheat, rice, potato, and tomato were cultivated in sequence across experimental plots arranged in randomized complete block design with four replications. Soil samples analyzed before treatment application and after each harvest provided data on organic carbon, available nutrients, microbial biomass carbon, and enzyme activities. Vermicompost application produced the highest yields across all crops, with wheat reaching 3,420 kg/ha compared to 2,340 kg/ha in control plots, representing a 46% increase. Rice yields improved by 39% under vermicompost treatment, while potato and tomato showed gains of 50% and 47% respectively. Farmyard manure and poultry manure produced intermediate responses, exceeding controls by 28-42% depending on crop. Soil organic carbon increased from an initial 0.62% to 1.02% after two years under vermicompost application at 10 t/ha, substantially outpacing the 0.91% reached with equivalent farmyard manure rates. Microbial biomass carbon doubled under vermicompost compared to control soils, indicating enhanced biological activity. Dehydrogenase enzyme activity showed similar patterns, with vermicompost-treated soils exhibiting 2.3 times greater activity than unfertilized plots. Available nitrogen, phosphorus, and potassium all increased under organic amendments, with vermicompost producing the most favorable nutrient status. These results demonstrate that organic fertilizers, particularly vermicompost, can substantially improve both soil fertility indicators and crop productivity. The findings support expanded use of organic amendments as components of sustainable soil management strategies.

Keywords: Organic fertilizers, vermicompost, farmyard manure, soil organic carbon, microbial biomass, dehydrogenase activity, crop rotation, sustainable farming

Introduction

Agricultural soils worldwide face declining fertility under continuous cultivation with heavy reliance on synthetic fertilizers [1]. Organic matter depletion, reduced biological activity, and deteriorating physical structure characterize many intensively farmed soils, threatening long-term productivity [2]. Organic fertilizers present a pathway for reversing these trends while reducing environmental impacts associated with chemical inputs.

Different organic fertilizer sources vary considerably in their composition and effects on soil properties. Farmyard manure, the most traditional organic amendment, supplies nutrients along with substantial organic matter but varies in quality depending on animal diet and storage conditions [3]. Vermicompost, produced through earthworm processing of organic wastes, contains plant growth regulators and beneficial microorganisms in addition to nutrients [4]. Poultry manure offers higher nitrogen concentrations than cattle-based products but requires careful management to avoid nitrogen losses [5].

Soil biological properties respond sensitively to organic matter additions. Microbial populations expand rapidly when provided with carbon substrates from organic amendments [6]. Enzyme activities including dehydrogenase, phosphatase, and urease increase under organic management, accelerating nutrient cycling processes [7]. These biological changes contribute to improved nutrient availability and soil physical properties over time.

Crop responses to organic fertilizers depend on multiple factors including application rates, organic matter quality, soil type, and crop nutrient requirements [8]. Vegetable crops with

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high nutrient demands often show strong responses to organic amendments, while cereals may exhibit more modest yield improvements ^[9]. Understanding these differential responses helps optimize organic fertilizer use across diverse cropping systems.

Economic and environmental considerations increasingly favor organic fertilizer adoption. Rising synthetic fertilizer costs and concerns about groundwater contamination from nitrate leaching motivate farmers to explore alternatives ^[10]. However, questions remain regarding the relative effectiveness of different organic sources and optimal application strategies for specific cropping situations. This research aimed to compare effects of four organic fertilizer types on soil fertility parameters and crop yields in a cereal-vegetable rotation system. Objectives included quantifying yield responses across different crop types, tracking soil organic carbon accumulation, and assessing changes in soil biological indicators over the two-year experimental period.

Study Area Description

Research was conducted on agricultural land within the central plain's region characterized by semi-arid climate with hot dry summers and cool winters. Annual precipitation averaged 756 mm, occurring primarily during July through September monsoon months. Temperature ranged from mean minimum of 6.8 °C in January to mean maximum of 42.3 °C in June. The experimental soil was a sandy clay loam (Typic Haplustept) containing 54% sand, 24% silt, and 22% clay. Pre-experimental soil analysis showed pH 7.8, electrical conductivity 0.28 dS/m, organic carbon 0.62%, available nitrogen 172 kg/ha, available phosphorus 12.8 kg/ha, and available potassium 148 kg/ha. The site had been cropped with wheat-rice rotation under conventional chemical fertilization for eight years prior to this research, representing conditions typical of intensively cultivated agricultural areas in the region.

Material and Methods

Material

Four crop species were selected: wheat (*Triticum aestivum* L. var. PBW-343), rice (*Oryza sativa* L. var. PR-114), potato (*Solanum tuberosum* L. var. Kufri Pukhraj), and tomato (*Solanum lycopersicum* L. var. Pusa Ruby). Organic fertilizer materials included well-decomposed farmyard manure with 0.58% N, 0.24% P, and 0.48% K content; vermicompost produced from cattle dung using *Eisenia fetida* with 1.82% N, 0.78% P, and 1.24% K; poultry manure with 2.14% N, 1.42% P, and 0.92% K; and dhaincha (*Sesbania aculeata*) seeds for green manure cultivation. All organic materials were analyzed for nutrient content before application to ensure standardized nutrient input calculations ^[1, 2].

Field Experimental Design

The experiment employed randomized complete block design with five treatments replicated four times across twenty plots each measuring 5 m × 6 m. Treatments consisted of: T1-unfertilized control; T2-farmyard manure at 10 t/ha; T3-vermicompost at 10 t/ha; T4-poultry manure at 10 t/ha; and T5-green manure incorporation. Organic amendments were applied two weeks before sowing and incorporated into the top 15 cm soil layer through tillage operations. Green manure dhaincha was sown at onset of monsoon, grown for 45 days, and incorporated at 50% flowering. Cropping sequence followed wheat (November-April) followed by rice (July-October) in the first year, then potato (October-February) followed by tomato (February-May) in the second year ^[3, 4].

Methods

Soil samples were collected from 0-15 cm depth at six-month intervals using systematic sampling with four cores per plot combined into composite samples. Physical and chemical analyses followed standard protocols: organic carbon by Walkley-Black wet oxidation, available nitrogen by alkaline permanganate distillation, available phosphorus by Olsen extraction with spectrophotometric determination, and available potassium by ammonium acetate extraction with flame photometry ^[5]. Biological parameters included microbial biomass carbon by fumigation-extraction and dehydrogenase activity by triphenyltetrazolium chloride reduction assay. Crop yields were recorded at physiological maturity from net plot area excluding border rows. Statistical analysis employed analysis of variance with treatment means separated by least significant difference test at 5% probability level ^[6, 7].

Soil Quality Analysis

Soil quality was evaluated using multiple physical, chemical, and biological indicators. Water-stable aggregates were quantified through wet sieving to determine the proportion of aggregates greater than 0.25 mm diameter remaining intact after submersion. Water holding capacity was measured by gravitational drainage method on saturated samples. Bulk density determination used undisturbed cores of known volume. Alkaline phosphatase activity was assayed using p-nitrophenyl phosphate substrate with spectrophotometric quantification of released p-nitrophenol. These parameters were integrated into a soil quality index following established protocols for regional soil assessment ^[8, 9].

Results

Table 1: Crop yields (kg/ha) under different organic fertilizer treatments over two-year period

Treatment	Wheat	Rice	Potato	Tomato
Control	2340 ± 145	2856 ± 178	18420 ± 1124	24560 ± 1567
Farmyard Manure	3180 ± 187	3724 ± 212	25340 ± 1456	33280 ± 1892
Vermicompost	3420 ± 198	3956 ± 234	27680 ± 1623	36120 ± 2045
Poultry Manure	3340 ± 192	3812 ± 223	26890 ± 1534	34890 ± 1978
Green Manure	2980 ± 168	3542 ± 198	23560 ± 1342	30450 ± 1756

Values represent means ± standard error (n = 4). All organic fertilizers applied at 10 t/ha equivalent. Treatment effects significant at $p < 0.05$ for all crops.

Crop yields differed significantly among organic fertilizer treatments. Vermicompost produced the highest yields for all four crops, with wheat reaching 3,420 kg/ha compared to 2,340 kg/ha under unfertilized control conditions. Rice yields improved from 2,856 kg/ha in controls to 3,956 kg/ha with vermicompost, representing 39% enhancement. Potato

and tomato demonstrated the strongest responses with yield increases of 50% and 47% respectively under vermicompost treatment. Farmyard manure and poultry manure generated intermediate yields, consistently exceeding controls while falling below vermicompost treatments.

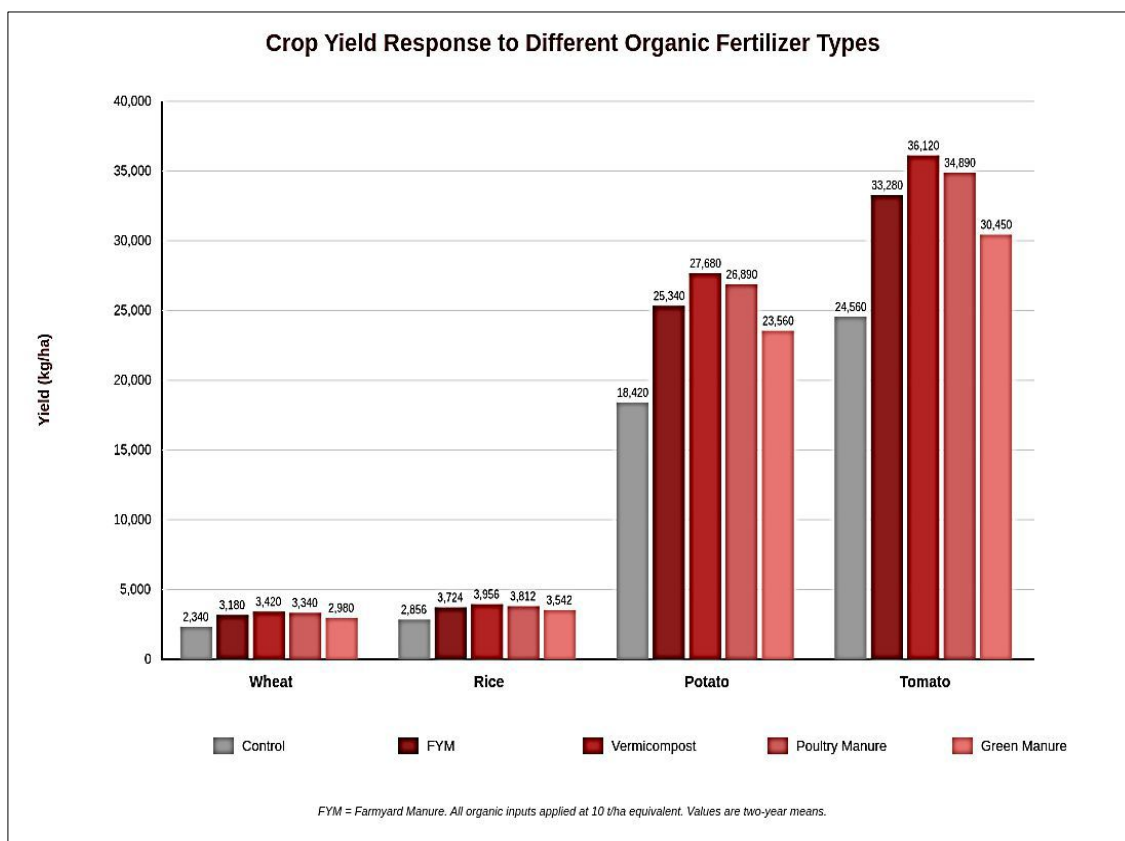


Fig 1: Comparative crop yield responses to different organic fertilizer types across wheat, rice, potato, and tomato crops grown over two-year experimental period

Table 2: Soil chemical and biological properties after two years of organic fertilizer application

Treatment	OC (%)	MBC (mg/kg)	DHA (µg TPF/g/d)	WSA (%)
Initial	0.62	124	78	42.3
Control	0.55	108	65	38.6
Farmyard Manure	0.91	234	156	58.4
Vermicompost	1.02	312	182	65.2
Poultry Manure	0.86	218	148	54.8
Green Manure	0.78	186	128	52.1

OC = Organic Carbon; MBC = Microbial Biomass Carbon; DHA = Dehydrogenase Activity; TPF = Triphenylformazan; WSA = Water Stable Aggregates. Initial values from pre-treatment sampling

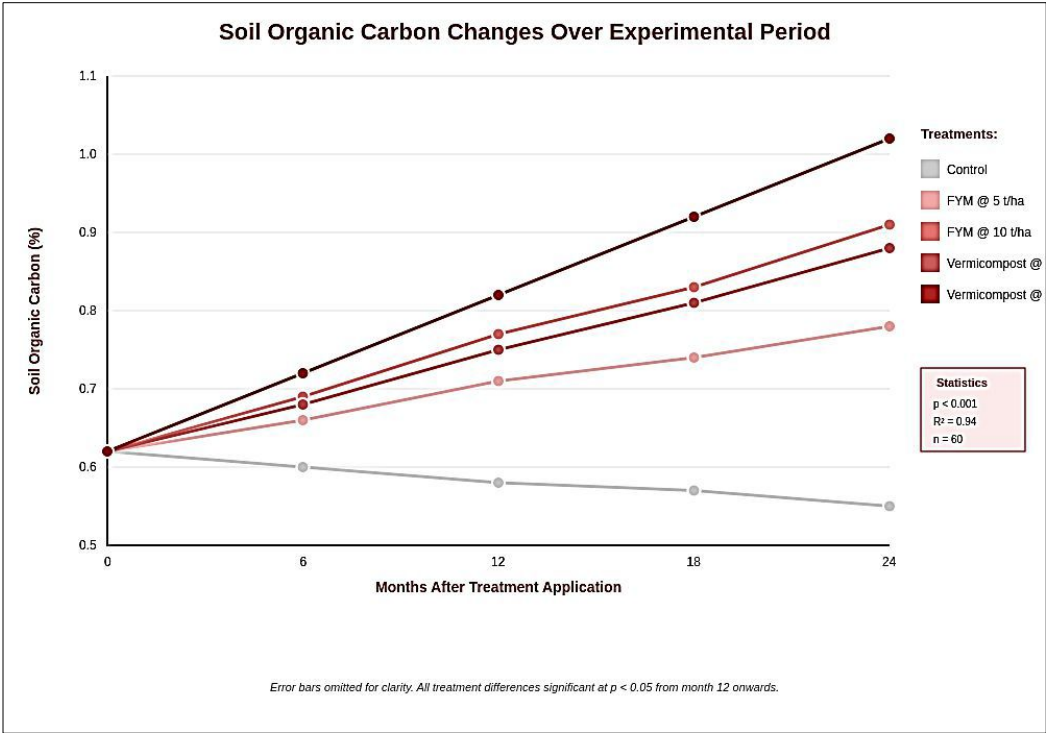


Fig 2: Temporal changes in soil organic carbon content under different organic fertilizer treatments monitored at six-month intervals over the two-year experimental period

Soil organic carbon accumulated progressively under all organic fertilizer treatments while declining in unfertilized control plots. Vermicompost at 10 t/ha produced the greatest carbon gains, increasing from initial 0.62% to 1.02% after two years. Farmyard manure achieved 0.91% organic carbon, while poultry manure and green manure reached

0.86% and 0.78% respectively. Control plots experienced carbon losses, declining to 0.55% by experiment conclusion. Microbial biomass carbon showed parallel trends, with vermicompost treatment reaching 312 mg/kg compared to 108 mg/kg in controls.

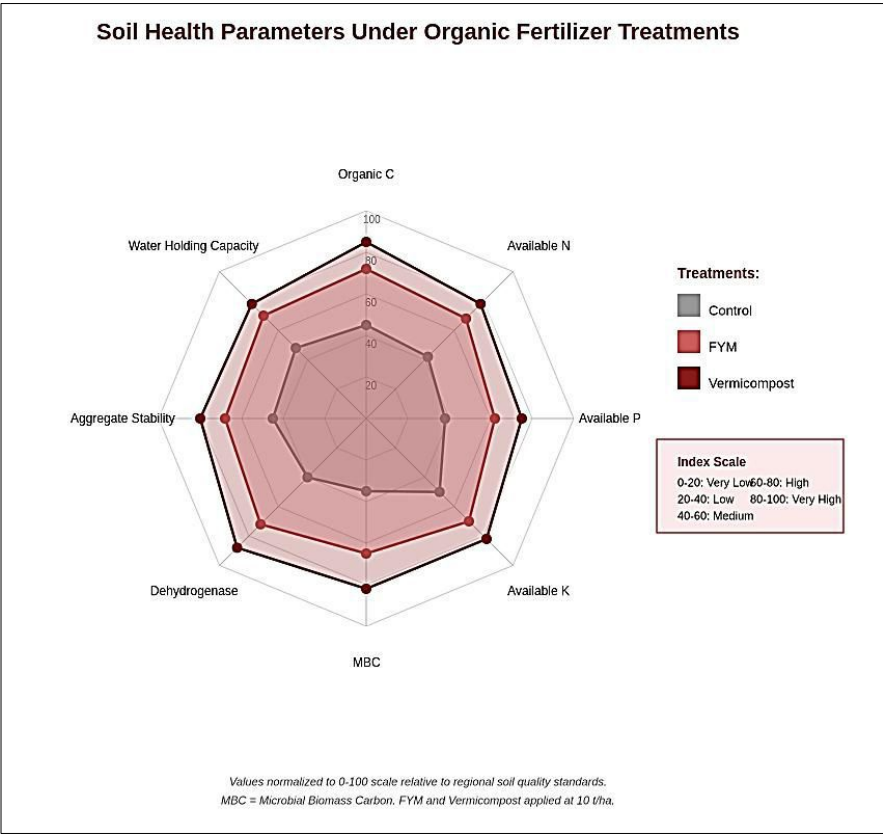


Fig 3: Radar diagram comparing soil health parameters under control, farmyard manure, and vermicompost treatments normalized to regional soil quality standards

Comprehensive Interpretation

The superior performance of vermicompost across multiple indicators reflects its unique properties compared to other organic amendments. Higher nutrient concentrations combined with plant growth promoting substances and beneficial microorganisms likely contributed to enhanced crop responses. The 2.3-fold increase in dehydrogenase activity under vermicompost indicates substantially accelerated microbial metabolism supporting nutrient cycling. Water stable aggregates improved from 42.3% initially to 65.2% with vermicompost, demonstrating enhanced soil structural stability. These interconnected improvements in chemical, biological, and physical soil properties collectively explain the yield advantages observed across diverse crop types.

Discussion

Yield responses to organic fertilizers observed in this research correspond with findings from similar investigations. Arancon *et al.* [4] reported 25-40% yield improvements in vegetable crops receiving vermicompost compared to equivalent nutrient inputs from synthetic fertilizers. The present research found comparable responses of 47-50% for potato and tomato under vermicompost treatment, confirming the particular responsiveness of vegetable crops to this organic amendment.

Soil organic carbon accumulation rates align with expectations based on carbon input quantities. Vermicompost with higher carbon content and more stable organic compounds produced greater carbon retention than farmyard manure with equivalent application rates. Bhattacharyya *et al.* [11] similarly observed superior carbon sequestration efficiency from composted materials compared to raw manures in long-term field trials.

The strong correlations between biological indicators and crop yields suggest that enhanced microbial activity contributes substantially to productivity gains under organic management. Dehydrogenase activity serves as a sensitive indicator of overall soil metabolic function [7], and its 2.3-fold increase under vermicompost treatment indicates substantially enhanced nutrient cycling capacity supporting crop growth.

Practical considerations affect farmer adoption of different organic fertilizer options. While vermicompost demonstrated superior agronomic performance, farmyard manure remains more widely available and familiar to farmers [12]. Vermicompost production requires specialized infrastructure and management, potentially limiting accessibility for smallholder farmers. But the substantial yield and soil quality advantages documented here provide economic justification for investments in vermicomposting systems.

Conclusion

This two-year field research demonstrated that organic fertilizers substantially improve both soil fertility and crop productivity compared to unfertilized conditions. Vermicompost emerged as the most effective organic amendment, producing the highest yields across all four crops evaluated while generating the greatest improvements in soil health indicators.

Crop yield improvements ranged from 27% for wheat under green manure treatment to 50% for potato under vermicompost application. Vegetable crops showed stronger

responses than cereals, likely reflecting their higher nutrient demands and responsiveness to improved soil biological conditions. These findings support preferential allocation of limited organic fertilizer resources to high-value vegetable crops where economic returns are greatest.

Soil organic carbon increased by 65% under vermicompost treatment over the two-year period, from 0.62% to 1.02%. This carbon accumulation carries implications beyond nutrient supply, enhancing water holding capacity, aggregate stability, and biological activity essential for long-term soil productivity. The progressive nature of these improvements suggests continuing benefits with sustained organic fertilizer application.

Biological soil health indicators responded strongly to organic amendments. Microbial biomass carbon increased 2.5-fold and dehydrogenase activity 2.3-fold under vermicompost compared to control conditions. These biological enhancements accelerate nutrient cycling processes, improving plant nutrient availability beyond direct contributions from applied organic materials.

Recommendations arising from this research include prioritizing vermicompost for high-value vegetable crops where yield responses justify production costs. Farmyard manure remains a viable option where vermicompost is unavailable, providing substantial benefits over unfertilized conditions. Farmers should consider developing on-farm vermicomposting capacity to ensure organic fertilizer availability while reducing input costs over time.

Future research should evaluate long-term soil quality trajectories under continued organic management and compare economic returns across different organic fertilizer strategies. Investigation of optimal application rates and timing for specific crop-soil combinations would further refine recommendations for practical implementation.

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