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Impact of Organic Farming Practices on Soil Health and Crop Yield in Small Landholdings of Western Uttar Pradesh

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Abstract: The increasing degradation of agricultural soils due to intensive chemical-input farming has prompted growing interest in the viability of organic farming as an alternative approach for Indian small-scale farmers. This study examined the short- to medium-term impacts of organic farming practices — including vermicompost application, green manuring, biopesticide use, and crop rotation — on soil physicochemical and biological properties and on wheat and sugarcane yield among small landholding farmers in four blocks of Muzaffarnagar district, western Uttar Pradesh. A field-based quasi-experimental design was employed over two cropping seasons (Rabi 2022–23 and Kharif 2023). Twenty-five farmer participants practising organic methods for at least two years were matched with 25 control farmers using conventional chemical inputs, selected through purposive sampling with matching on landholding size, soil type, and irrigation access. Soil samples were collected pre- and post-season from all plots and analysed for organic carbon, available nitrogen, phosphorus, potassium, and microbial biomass carbon. Results showed significantly higher soil organic carbon (mean increase of 0.31%; $p<0.01$), improved microbial biomass carbon ($p<0.05$), and reduced soil bulk density ($p<0.05$) in organic plots compared to chemical-input plots. Wheat yield in organic plots was 7.2% lower on average, though sugarcane yield difference was not statistically significant. Input cost reduction of approximately 28% was recorded for organic farmers. The study concludes that organic farming offers promising long-term soil health benefits with manageable short-term yield trade-offs for small landholders, provided market access and transitional support are available.

Keywords: *Organic Farming, Soil Health, Soil Organic Carbon, Small Landholdings, Western Uttar Pradesh, Sustainable Agriculture*

1. Introduction

Indian agriculture faces a compounding crisis of soil degradation, groundwater depletion, and escalating input costs, all exacerbated by decades of intensive Green Revolution-era chemical farming. In western Uttar Pradesh — a region historically central to India's agricultural output, particularly in wheat and sugarcane — soil organic matter has declined sharply across many districts, reducing water-holding capacity, nutrient cycling efficiency, and long-term productivity. The IndoGangetic Plain's soils, once among the most fertile in the subcontinent, are increasingly showing signs of micronutrient exhaustion and loss of biological activity.

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Organic farming — broadly understood as a production system relying on ecological processes, biodiversity, and cycles adapted to local conditions, avoiding synthetic off-farm inputs — has gained increasing policy attention in India as a potential pathway to sustainable agricultural development. The Government of India's Paramparagat Krishi Vikas Yojana (PKVY), launched in 2015, aims to promote cluster-based organic farming and has reached over 30,000 clusters across the country. Uttar Pradesh has also initiated its own Organic Farming Mission under the State Agriculture Department.

However, the uptake of organic practices among small and marginal farmers in western Uttar Pradesh remains limited, partly due to concerns about short-term yield losses during the transition period and partly due to a lack of localised empirical evidence on soil and productivity outcomes. Research on organic farming in this specific agro-climatic zone is sparse: most available studies are from peninsular India or from larger farm settings in Punjab and Haryana, where contextual factors differ significantly from western UP's fragmented landholding patterns and market access constraints.

This study directly addresses this evidence gap by conducting a rigorous field-based comparison of organic and conventional farming practices on small landholdings in Muzaffarnagar district over two cropping seasons. The study aims to provide locally grounded data on soil health outcomes, yield performance, and input cost economics to inform extension advisory services and policy implementation in the region.

2. Methodology

A quasi-experimental matched-pairs design was adopted to compare organic and conventional farming outcomes across 25 matched pairs of farmer plots in four blocks of Muzaffarnagar district: Muzaffarnagar, Charthawal, Purkazi, and Khatauli. Organic farming participants were identified through the district PKVY cluster list maintained by the Krishi Vigyan Kendra, Muzaffarnagar; only farmers with at least two consecutive growing seasons of certified or documented organic practice (verified through input purchase records and field officer certifications) were included. Each organic farmer was matched with a conventional chemical-input farmer from the same block with comparable landholding size (0.5–2.0 hectares), soil texture class (primarily sandy loam to silty loam), and source of irrigation (tubewell).

Composite soil samples (from 0–20 cm depth, five sub-samples per plot) were collected from all 50 plots at the beginning and end of each cropping season. Samples were analysed at the Soil Testing Laboratory, Krishi Vigyan Kendra, Muzaffarnagar for: soil organic carbon (Walkley-Black method), available nitrogen (alkaline permanganate method), available phosphorus (Olsen method), available potassium (flame photometry), soil pH, electrical conductivity, bulk density, and microbial biomass carbon (substrate-induced respiration method). Wheat (variety PBW-343) and sugarcane (variety CO-238) yield data were recorded plot-wise at harvest.

Input cost data were collected through structured interviews with participating farmers covering expenditure on seeds, fertilisers or organic inputs, pesticides or biopesticides, and labour over the study period. Statistical analysis was performed in R version 4.2.1. Paired t-tests were used to compare soil parameter and yield outcomes between organic and conventional plots. Results were considered significant at $p<0.05$. Farmers provided written informed consent to participate, and all identifiable data were anonymised in the dataset.

3. Results and Findings

Soil analysis results revealed consistently superior organic matter and biological indicators in organic plots compared to conventional plots. Mean soil organic carbon in organic plots increased from a baseline of 0.52% to 0.83% over two seasons (a mean increase of 0.31%), compared to a marginal increase from 0.48% to 0.56% in conventional plots (mean increase 0.08%). The difference was statistically significant ($t=4.21$, $p<0.001$). Microbial

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biomass carbon was significantly higher in organic plots at end-of-season measurements (mean 312 μg C/g soil) compared to conventional plots (mean 228 μg C/g soil; $p<0.05$). Soil bulk density showed a modest but significant decline in organic plots (from 1.52 to 1.44 g/cm³), indicating improved soil structure.

Available nitrogen, phosphorus, and potassium showed mixed results. While organic carbon and microbial indicators showed clear organic farming advantages, available phosphorus in organic plots was marginally lower than in conventional plots (mean 16.2 kg/ha vs 21.8 kg/ha) due to the reduced use of soluble phosphatic fertilisers. Available nitrogen showed no significant difference between treatment groups at end of season, suggesting that nitrogen mineralisation from organic matter was sufficient to maintain nitrogen supply at levels comparable to chemical fertilisation over the study period.

Wheat grain yield in organic plots averaged 38.7 quintals per hectare compared to 41.7 quintals per hectare in conventional plots, representing a mean yield penalty of approximately 7.2% ($p<0.05$). Sugarcane yield difference was not statistically significant (organic: 742 quintals/ha; conventional: 758 quintals/ha; $p=0.21$). Input cost analysis revealed that organic farming households spent approximately Rs. 9,200 per hectare per season on inputs compared to Rs. 12,800 per hectare for conventional farmers — a cost saving of 28.1% — primarily driven by the elimination of synthetic fertiliser costs and the use of farm-produced compost and locally available biopesticides.

4. Discussion

The significant improvement in soil organic carbon and microbial biomass carbon in organic plots is consistent with established agronomic literature on the benefits of vermicompost and green manure application in Indo-Gangetic Plain soils. Soil organic carbon is the primary indicator of long-term soil fertility, serving as a substrate for microbial activity, a determinant of water retention capacity, and a reservoir of slow-release nitrogen. The trajectory observed in this study — from a low baseline of approximately 0.52% to 0.83% over two seasons — suggests that further improvement towards the agronomically desirable threshold of 1.0% is achievable over a longer time horizon.

The wheat yield gap of approximately 7.2% documented here is lower than the typical first-year transition yield penalties of 15–25% reported in literature, suggesting that participating farmers' two-year prior experience with organic methods and their use of integrated nutrient management strategies had already ameliorated early transition losses. The lack of a statistically significant yield difference in sugarcane is noteworthy: sugarcane is a nutrient-intensive crop where conventional wisdom would predict larger organic yield penalties, and this finding warrants further investigation in controlled experimental trials.

The 28% input cost reduction for organic farmers represents a substantial economic advantage, and when combined with the premium prices available in certified organic markets — which these farmers had not yet accessed at the time of study — net farm income potential for organic producers appears competitive with and potentially superior to conventional farming over the medium term. The key bottlenecks identified by participating farmers were the absence of local organic certified input suppliers, difficulties in obtaining organic certification due to procedural complexity and cost, and limited access to premium organic market channels. These structural barriers require targeted policy interventions beyond agronomic extension support.

5. Conclusion

This study provides localised empirical evidence from western Uttar Pradesh that organic farming practices yield meaningful improvements in soil health indicators — particularly soil organic carbon and biological activity — over two cropping seasons, with manageable yield trade-offs and significant input cost savings. The findings

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support the case for promoting organic farming as a long-term soil restoration strategy for small landholdings in the region.

Policy recommendations include: (i) establishing community-level vermicompost production units under MGNREGS and PKVY linkages to reduce organic input costs; (ii) simplifying the organic certification process for small farmers through group certification mechanisms; (iii) creating dedicated organic produce collection points and market linkages at the block level; (iv) intensifying Krishi Vigyan Kendra extension advisory services on integrated nutrient management; and (v) funding multi-season, multi-site longitudinal studies on organic farming outcomes to build the long-term evidence base needed for confident policy scaling in western Uttar Pradesh.

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