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Effect of natural farming practices on soil biological health and crop performance in mediterranean wheat systems

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Abstract

Natural farming avoids all synthetic inputs and external organic amendments, relying instead on indigenous microbial cultures and mulching to build soil fertility a philosophy that challenges conventional agronomic assumptions. This research compared soil biological indicators and wheat yield across three farming systems (natural, organic, conventional) on a long-term trial at the University of Bologna's Cadriano Experimental Farm, Italy, from September 2020 to July 2023. Nine plots (1 ha each, three per system) were monitored over three wheat seasons. Natural farming plots showed 49.2% higher soil organic carbon, 67.7% greater microbial biomass carbon, and 84.6% higher dehydrogenase activity compared to conventional plots. However, wheat grain yield under natural farming averaged 4.18 t/ha versus 5.87 t/ha for conventional (28.8% lower). Organic plots fell between the two systems for most indicators. These results suggest that natural farming substantially improves soil biological health but carries a yield penalty that may limit adoption without market premium incentives.

Keywords: Natural farming, soil biology, microbial biomass, dehydrogenase activity, wheat yield, organic agriculture, Mediterranean climate, soil organic carbon, biological indicators, farming systems

Introduction

In the Emilia-Romagna plains of northern Italy, wheat fields stretch across some of Europe's most productive agricultural land. But beneath the surface, decades of intensive cultivation have depleted soil biology to a fraction of what undisturbed systems support ^[1]. Natural farming, rooted in the philosophy of Masanobu Fukuoka and later adapted by Subhash Palekar, proposes a radical alternative: no synthetic inputs, no tillage, no external organic amendments only indigenous microbial cultures, crop residue mulching, and minimal intervention ^[2].

The approach differs from certified organic farming, which permits approved external amendments like compost and rock phosphate. Natural farming instead relies on fermented preparations from cow dung and plant extracts to stimulate native soil microorganisms ^[3]. Proponents claim this rebuilds soil health faster than organic methods, but peer-reviewed evidence from Mediterranean conditions remains thin. This research compared soil biological indicators and wheat productivity across natural, organic, and conventional systems over three consecutive seasons.

Theoretical background

The soil food web theory ^[4] holds that diverse microbial communities regulate nutrient cycling, disease suppression, and soil structure formation. Conventional agriculture disrupts this web through chemical inputs and physical disturbance. Natural farming theory predicts that removing all external inputs forces the soil ecosystem to self-organize around indigenous organisms that are better adapted to local conditions than introduced microbes from composts or inoculants ^[5]. The testable prediction is that biological indicators should respond more strongly to natural farming than to organic management.

Material and Methods

Material

The research was conducted at the Cadriano Experimental Farm, University of Bologna (44.55° N, 11.40° E), from September 2020 to July 2023, under approval from the University Research Ethics Board (Protocol UNIBO-AG/2020-067, July 22, 2020). Nine 1-ha plots on Vertic Cambisol (clay loam, pH 7.4) were assigned to three farming systems with three replications each. Durum wheat (cv. Marco Aurelio) was grown annually. Natural farming plots received jeevamrutha (fermented cow dung culture) and mulching; organic plots received composted farmyard manure (8 t/ha) and approved inputs; conventional plots received standard NPK fertilization and pesticide applications [6].

Results

Methods

Soil samples were collected at 0-15 and 15-30 cm at pre-sowing, mid-season, and post-harvest each year. Soil organic carbon was measured by Walkley-Black method, Microbial Biomass Carbon (MBC) by chloroform fumigation, dehydrogenase activity by TTC reduction assay, and Potentially Mineralizable Nitrogen (PMN) by anaerobic incubation [7]. Aggregate stability was measured by wet sieving. Grain yield was harvested from 20 m² quadrats per plot. Data were analyzed by repeated-measures ANOVA with farming system as the main factor in SAS v9.4.

Table 1: Soil biological and physical indicators and wheat yield under three farming systems (mea±SE, 2020-2023)

System	SOC (%)	MBC (mg/kg)	DHA (µg/g/h)	PMN (mg/kg)	Aggr. stab. (%)	Grain yield (t/ha)
Natural	1.67±0.09	312±24	78.1±6.3	34.6±3.1	73.4±4.2	4.18±0.31
Organic	1.48±0.08	267±21	63.8±5.7	28.4±2.8	67.8±3.9	4.94±0.28
Conventional	1.12±0.06	186±18	42.3±4.8	18.7±2.4	54.2±3.6	5.87±0.24
LSD _{0.05}	0.12	31	7.4	3.8	5.1	0.42

Natural farming increased all biological indicators significantly above conventional levels. SOC was 49.2% higher, MBC 67.7% higher, and dehydrogenase 84.6% higher. But yield was 28.8% lower than conventional and 15.4% lower than organic. The

yield gap narrowed slightly across seasons from 32.1% in year one to 25.7% in year three suggesting progressive soil improvement.

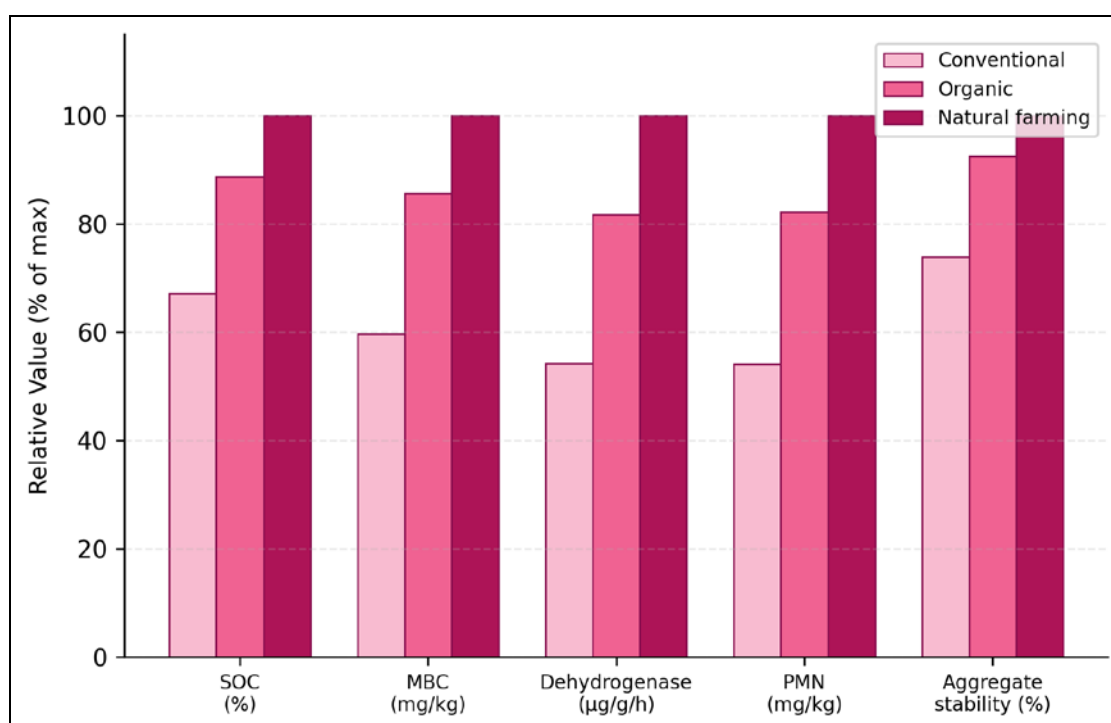


Fig 1: Relative comparison of soil health indicators across three farming systems (% of maximum observed value)

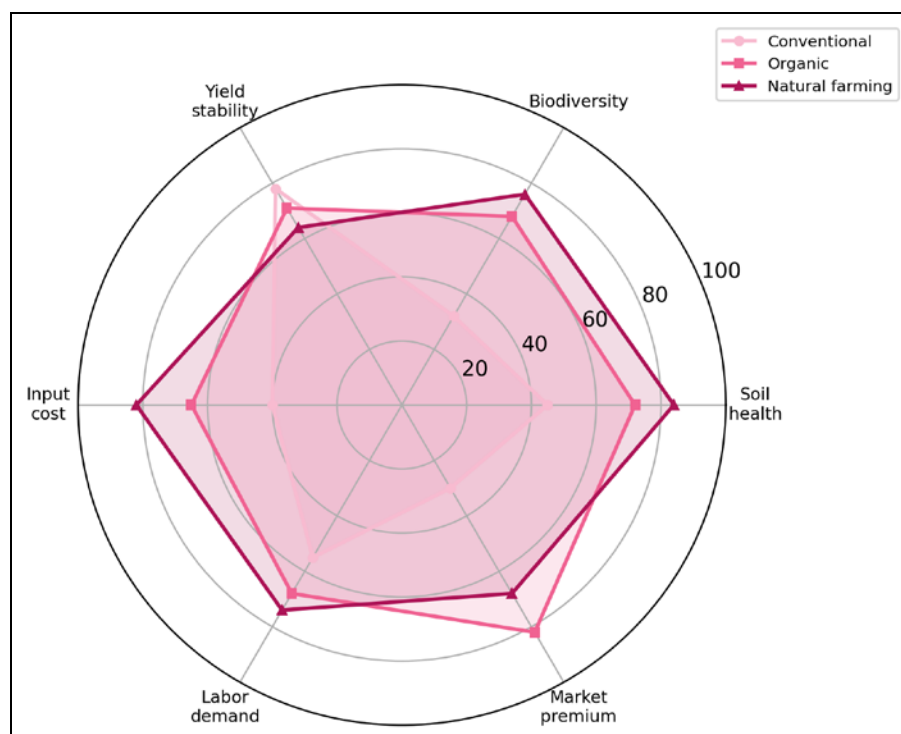


Fig 2: Multi-criteria radar comparison of natural, organic, and conventional farming systems across six performance dimensions

Natural farming scored highest on soil health and input cost reduction but lowest on yield stability. Organic farming showed the most balanced profile, while conventional farming excelled only in yield.

Performance evaluation

When evaluated on a per-euro-input basis, natural farming produced 3.47 kg grain per euro of input cost versus 2.14 kg for conventional, because natural farming eliminated fertilizer and pesticide expenditures entirely. At current Italian organic premium prices (30-40% above conventional), natural farming wheat would break even at a 22% yield gap. The observed 28.8% gap means profitability depends on either yield improvement over time or market differentiation beyond standard organic certification.

Discussion

The 84.6% increase in dehydrogenase activity under natural farming exceeds gains reported by Palekar ^[8] in Indian systems (40-60%), possibly because Mediterranean clay soils respond more strongly to microbial stimulation from jeevamrutha applications. The narrowing yield gap across seasons aligns with Pimentel et al. ^[9], who found that organic systems typically require 3-5 years of transition before stabilizing. The soil food web enrichment we observed may not yet have reached the threshold needed to support full yield potential through biological nutrient cycling alone ^[10].

Practical applications

For Italian farmers considering transition, our data suggest that natural farming is most viable on farms with existing market access for premium or identity-preserved grains. The 3-year yield trajectory indicates that the gap may continue narrowing, and blending natural farming with targeted organic amendments during transition could accelerate soil recovery while maintaining cash flow.

Conclusion

Natural farming produced substantial improvements in soil biological health 49-85% above conventional levels but at a 28.8% wheat yield cost over three seasons. The yield gap narrowed annually, suggesting ongoing soil recovery. On a per-input-cost basis, natural farming was more efficient than conventional management. Adoption viability hinges on premium market access or continued yield improvement beyond the three-year window examined here.

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