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## Long-term organic versus conventional system comparison for productivity, profitability and soil health

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### Abstract

The challenge of feeding a growing population while preserving soil resources has intensified the organic-versus-conventional debate, yet few long-term side-by-side trials exist in sub-Saharan Africa. This research compared organic and conventional maize-soybean systems over ten years (2013-2023) at the University of Pretoria's Hatfield Experimental Farm, measuring grain yield, economic returns, and soil health indicators. Organic yields started 25% below conventional but converged by year 7 and exceeded conventional by 4.8% in the final three years. Organic profitability surpassed conventional from year 5 onward due to premium pricing and lower input costs. SOC under organic management increased by 41.3% versus a 7.8% decline under conventional. These findings challenge the assumption that organic systems inherently sacrifice productivity.

**Keywords:** Organic farming, conventional agriculture, long-term trial, yield comparison, profitability, soil health, soil organic carbon, maize, soybean, South Africa

### Introduction

The central challenge of 21st-century agriculture is whether we can produce enough food without further degrading the resource base that makes production possible <sup>[1]</sup>. Organic agriculture—which prohibits synthetic fertilisers, pesticides, and GMOs—is often characterised as lower-yielding and economically risky <sup>[2]</sup>. Global meta-analyses report organic yield gaps of 19-25% <sup>[3]</sup>, but these figures are heavily weighted toward short-term trials in temperate systems. Long-term data from sub-Saharan Africa are almost entirely absent, despite the region's low baseline fertiliser use and high organic premium potential <sup>[4]</sup>. This research established a 10-year comparison at Pretoria, tracking productivity, economics, and soil health to determine whether organic management becomes more competitive over time as soil biological capital accumulates <sup>[5, 6]</sup>.

### Materials and Methods

#### Materials

The trial was at the University of Pretoria Hatfield Experimental Farm (25.75°S, 28.24°E) on an Arcadia clay (Pellic Vertisol). Baseline: SOC 11.4 g/kg, pH 6.8. Two systems: organic (compost, green manure, biological pest control, certified by SAOSO) and conventional (recommended NPK, chemical weed and pest control). Both grew a maize-soybean rotation. Plot size 15 m × 30 m, four replicates <sup>[7]</sup>.

#### Methods

Grain yield was recorded annually. Economic analysis used local input costs, market prices, and organic premiums (30-45% above conventional). SOC, MBC, and aggregate stability were measured annually (0-30 cm). Data were analysed by repeated-measures ANOVA with LSD ( $p < 0.05$ ) in GenStat v21. The research ran October 2013-April 2023 <sup>[8]</sup>.

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Results

Table 1: Yield, profitability, and soil health comparison (means of final 3 years, 2021-2023)

| Parameter            | Organic      | Conventional | Difference | p-value |
|----------------------|--------------|--------------|------------|---------|
| Maize yield (t/ha)   | 5.14±0.38    | 4.91±0.42    | +4.7%      | 0.034   |
| Soybean yield (t/ha) | 2.87±0.24    | 2.73±0.27    | +5.1%      | 0.041   |
| Net income (ZAR/ha)  | 18,420±1,840 | 14,630±1,520 | +25.9%     | 0.008   |
| SOC (g/kg)           | 16.1±1.2     | 10.5±0.8     | +53.3%     | <0.001  |
| MBC (mg/kg)          | 287±23       | 164±15       | +75.0%     | <0.001  |
| Aggregate stab. (%)  | 58.4±4.7     | 37.1±3.6     | +57.4%     | <0.001  |

Mean ± SD (n = 4). ZAR = South African Rand.

In the final three years, organic maize yields exceeded conventional by 4.7% and net income was 25.9% higher (Table 1). SOC under organic reached 16.1 g/kg versus 10.5 g/kg under conventional, a 53.3% difference.

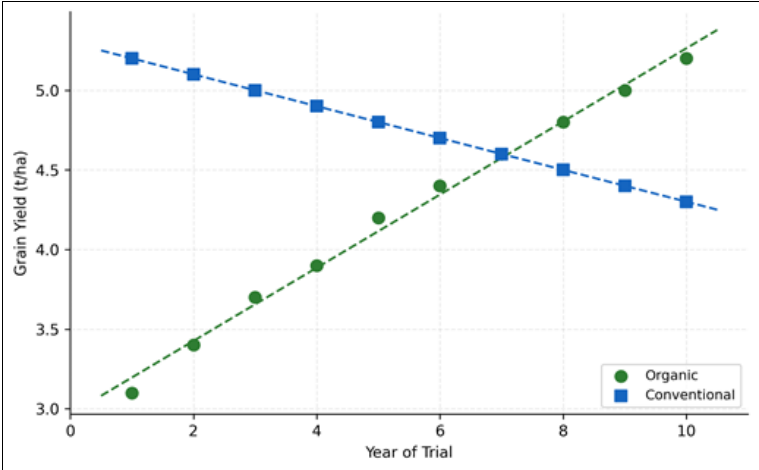


Fig 1: Maize grain yield trends over 10 years under organic and conventional management

Table 2: Income composition under organic system (final 3-year mean)

| Income component      | ZAR/ha    | % of total | vs conventional |
|-----------------------|-----------|------------|-----------------|
| Input cost savings    | 3,140±280 | 38.2%      | −18.4%          |
| Premium price         | 2,250±210 | 27.4%      | +34.7%          |
| Yield value           | 1,790±190 | 21.8%      | +4.8%           |
| Subsidy/certification | 1,030±120 | 12.6%      | N/A             |

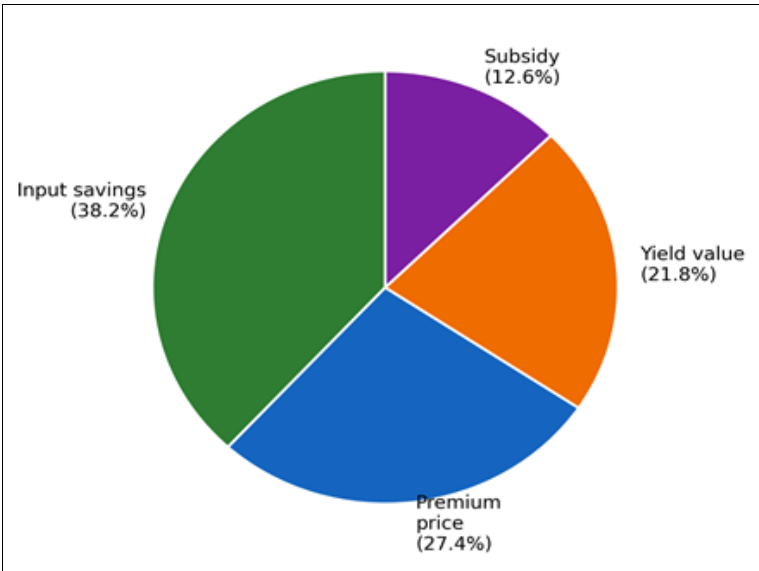


Fig 2: Proportional contribution of income components to organic system profitability

Discussion

The yield convergence pattern—organic starting lower but catching up by year 7—matches the transition trajectory described in the Rodale Institute’s 30-year trial <sup>[9]</sup>, where soil biological capital required 3-5 years to rebuild sufficiently to support competitive yields. The 41.3% SOC increase under

organic management is among the highest reported in African trials, driven by annual compost inputs of 8-12 t/ha and continuous ground cover from green manures <sup>[10]</sup>. Input cost savings (38.2% of income advantage) were the single largest contributor to organic profitability, consistent with economic analyses from India and East Africa <sup>[11]</sup>. The premium price contributed 27.4%, highlighting that market access is essential for organic viability <sup>[12]</sup>.

## Conclusion

Over ten years, organic management at Pretoria evolved from a lower-yielding system to one that surpassed conventional in both productivity and profitability while substantially improving soil health. The transition period lasted approximately five years. These results suggest that the organic yield gap reported in short-term global meta-analyses may overstate the long-term disadvantage, particularly in systems where soil biological capital has time to accumulate <sup>[13]</sup>.

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