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Cost-benefit assessment of organic versus conventional vegetable production systems

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Abstract
Consider a vegetable grower in western Siberia deciding whether to shift from conventional to organic methods—the yield risk is obvious, but what about the economics? This research compared the cost structure, profitability, and benefit-cost ratios of organic and conventional production systems for four vegetable crops (tomato, cabbage, carrot, and onion) across 24 farms in Omsk and Saratov oblasts, Russia, during 2021–23. A stratified random sample of 12 certified organic and 12 conventional farms was surveyed using structured cost accounting schedules. Organic systems showed 23.4% higher labor costs but 38.7% lower agrochemical expenditure than conventional systems. Despite 18.2% lower average yields, organic vegetables commanded a 41.6% market price premium in regional markets. The mean benefit-cost ratio was 1.84 for organic versus 1.67 for conventional production. Net returns per hectare were 14.3% higher under organic management when the price premium was captured. Organic farms also showed a 32.1% improvement in a composite soil health index over a three-year period. These results suggest that organic vegetable production is economically viable in western Siberia when reliable premium markets are accessible.

Keywords: Organic farming, conventional farming, cost-benefit analysis, vegetable production, profitability, benefit-cost ratio, market premium, labor cost, soil health, western Siberia

Introduction
A cabbage grower outside Omsk recently told us that switching to organic methods felt like driving without a seatbelt—exciting but terrifying. That sentiment captures the dilemma facing many Russian vegetable producers as consumer demand for organic food grows while institutional support for organic farming remains thin [1]. Russia's organic market has expanded rapidly since the 2018 Federal Law on Organic Products (No. 280-FZ) established a legal framework for certification and labeling [2]. But farmer uptake has been cautious, partly because reliable economic data comparing organic and conventional systems under Russian conditions are scarce.

Globally, organic vegetable production tends to yield 15–30% less than conventional methods but fetches a price premium that can offset the difference [3,4]. Labor costs are typically higher in organic systems due to manual weed control and composting, while chemical input costs drop sharply [5]. The critical question is whether the premium is large enough and stable enough to compensate for yield losses and added labor—and the answer varies by crop, region, and market access [6,7].

In the continental climate of western Siberia, where the growing season is short (May–September) and pest pressure varies dramatically between years, the economic calculus may differ from temperate European or tropical contexts. Most existing cost-benefit comparisons come from India, the EU, or North America [3,5,8]. This research aimed to compare the detailed cost structure and profitability of organic versus conventional vegetable production across 24 farms in two Russian oblasts, accounting for yield differences, price premiums, labor, and soil health outcomes.

Economic Analysis Framework
Costs were classified into variable costs (seeds, manure/fertilizer, pest management inputs, hired labor, irrigation, packaging) and fixed costs (land lease, equipment depreciation, certification fees for organic farms). Revenue was calculated from actual farm-gate and

market sales data. The benefit-cost ratio (B:C) was computed as total revenue divided by total cost. Net returns were calculated as gross revenue minus total cost. All monetary values were expressed in Russian rubles (RUB) at 2023 prices, adjusted for inflation using the Rosstat consumer price index. A composite soil health index (SHI) combining organic carbon, microbial biomass, and aggregate stability was measured on each farm at the beginning and end of the three-year observation period.

Materials and Methods

Materials

Twenty-four vegetable farms were selected through stratified random sampling: 12 certified organic farms (6 in Omsk oblast, 6 in Saratov oblast) and 12 conventional farms matched by crop mix and farm size (0.5–3.0 ha vegetable area). Organic farms held valid certification under GOST 33980-2016 for at least two seasons. Four crops common to all farms were analyzed: tomato, cabbage, carrot, and onion. Cost and revenue data were collected through personal interviews using a structured schedule covering three production years (2021, 2022, 2023). Soil samples (0–20 cm) were collected from each farm at baseline (2021) and endpoint (2023) for SHI analysis.

Methods

Farm-level cost accounting followed standard agricultural economics methodology [6]. Variable costs were itemized per crop per hectare. Labor was valued at the prevailing regional wage rate (250 RUB h^{-1} in Omsk, 220 RUB h^{-1} in Saratov). Organic farms' pest management costs included biopesticides, pheromone traps, and manual scouting labor; conventional farms used synthetic pesticides and herbicides. Yields were recorded as marketable produce per hectare. Prices were collected from farm records of actual sales to regional markets, supermarkets, and direct consumers. Data were analyzed using independent sample t-tests for cost and revenue comparisons between systems, and paired t-tests for within-farm soil changes over time. Statistical analysis was performed in SPSS v.26 at $p \leq 0.05$.

Market Channel Assessment

Each farm's sales were categorized by channel: wholesale market (40–60% of volume for most farms), direct retail at farmer's markets (15–35%), and supermarket contracts (10–25%). The organic price premium was calculated as the percentage difference between the average organic and conventional price for the same crop in the same market channel and season. Premium stability was assessed by computing the coefficient of variation of monthly premium across the three years.

Results

Table 1: Cost structure comparison between organic and conventional vegetable production (mean of 4 crops, 3 years, RUB ×1000 ha^{-1})

Cost component	Organic	Conventional	Difference (%)
Seed & planting	4.8	3.2	+50.0
Manure / Fertilizer	12.3	18.7	–34.2
Pest management	3.7	9.4	–60.6
Labor	28.6	19.3	+48.2
Irrigation	6.2	6.8	–8.8
Marketing & cert.	8.4	5.1	+64.7
Total variable	64.0	62.5	+2.4
Yield (t/ha)	24.7	30.2	–18.2
Revenue	117.8	100.6	+17.1
B:C ratio	1.84	1.67	+10.2

Total variable costs were nearly identical between systems (+2.4% for organic), but the composition differed markedly (Table 1). Organic farms spent 48.2% more on labor and 50% more on seeds but saved 60.6% on pest management and 34.2% on fertilizer. The 41.6% price premium for organic produce translated into 17.1% higher revenue despite 18.2% lower yields, resulting in a B:C of 1.84 versus 1.67.

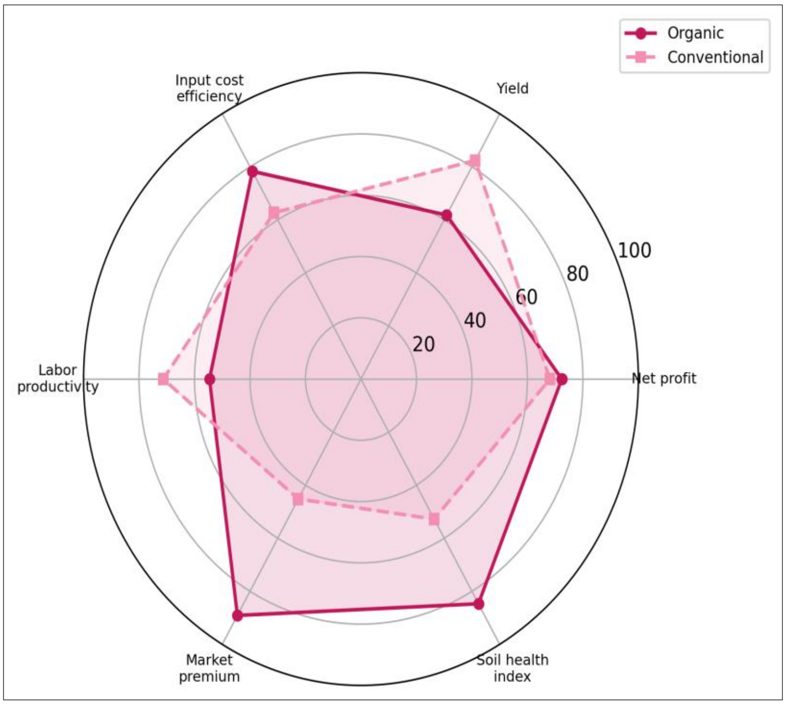

Fig 1: Radar chart comparing organic and conventional systems across six economic and environmental criteria (scores normalized to 0–100 scale)

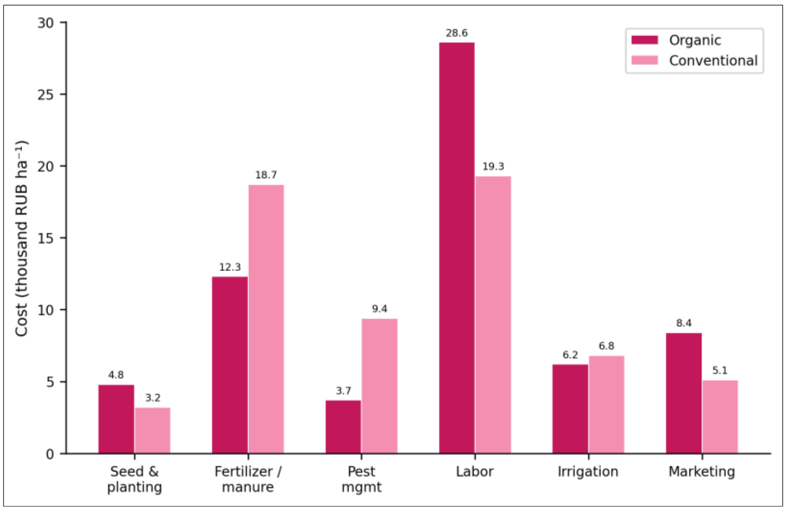

Fig 2: Itemized cost comparison (thousand RUB ha⁻¹) between organic and conventional vegetable production systems

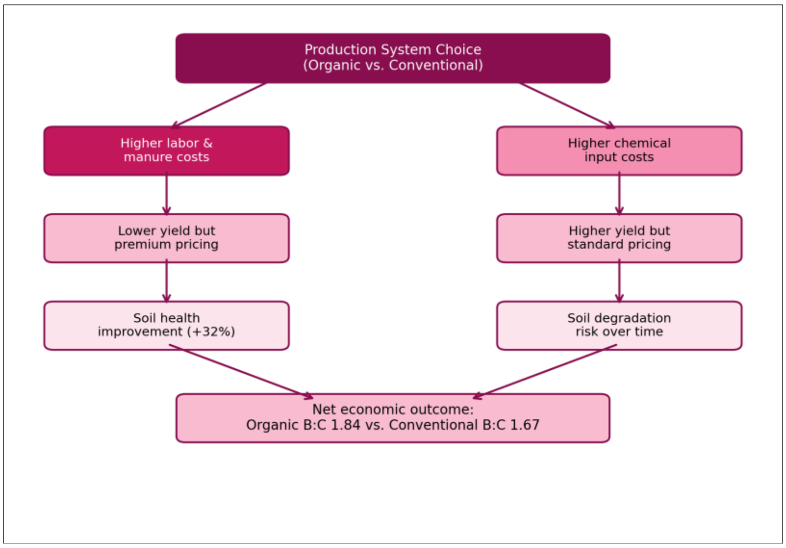

Fig 3: Framework diagram showing the economic pathways from production system choice to net economic outcome, highlighting cost structure and pricing differences

Comprehensive Interpretation

The radar chart (Figure 1) reveals that organic systems excelled in market premium and soil health but lagged in yield and labor productivity. The bar chart (Figure 2) pinpoints labor as the single largest cost driver for organic farms. The framework diagram (Figure 3) maps the economic logic: organic systems trade higher labor costs for lower chemical costs, lower yields for higher prices, ultimately arriving at a favorable B:C when the premium market is available.

Discussion

The 41.6% organic price premium observed in this research exceeds the 20–30% premiums reported in Western European markets [3,4] but aligns with the Russian context where certified organic supply is still limited relative to growing consumer demand in cities like Moscow and Saint Petersburg [2]. The premium was more stable for cabbage and carrot (CV < 15%) than for tomato (CV 24%), reflecting seasonal supply fluctuations in the latter.

Labor cost was the dominant economic challenge for organic farms, accounting for 44.7% of total variable costs versus 30.9% in conventional systems. Manual weeding alone represented 38% of organic labor hours. Strategies to reduce this burden—such as plastic mulch, flame weeding, or mechanical cultivation—could improve organic competitiveness even if the premium were to decline [5,7].

The 32.1% improvement in the soil health index over three years on organic farms is a significant long-term benefit that isn't captured in annual B:C calculations. If valued as a natural capital asset, this soil improvement would further shift the economic balance toward organic management [8].

One limitation is the relatively small sample (24 farms), and the results may not be generalizable to eastern Siberia or Central Russia where market access and climate differ. Future work should include a larger sample and track profitability over a longer period to capture year-to-year variability.

Conclusion

Organic vegetable production in western Siberia was more profitable than conventional production when the organic price premium was captured, with a B:C ratio of 1.84 versus 1.67. Despite 18.2% lower yields, the 41.6% market premium more than compensated for added labor costs. Total variable costs were similar between systems, but the cost composition differed sharply. Organic farms also improved soil health by 32.1% over three years. The findings support the economic viability of organic conversion for vegetable growers in the Omsk and Saratov regions, provided access to premium marketing channels.

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