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Comparative analysis of organic and conventional farming systems for vegetable production

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Abstract
Vegetable growers across the Aegean lowlands of Turkey face a difficult choice: conventional systems that maximise short-term yield or organic approaches that promise long-term soil health but may sacrifice marketable output. This research compared yield, input economics, soil quality, and produce safety under certified organic and conventional management for six vegetable crops tomato, aubergine, okra, chilli, cabbage, and cauliflower over two consecutive seasons (winter 2022-23 and summer 2023) at the Ege University, İzmir. Organic plots received farmyard manure, vermicompost, Azotobacter, phosphate-solubilising bacteria, and neem-based biopesticides, while conventional plots followed the standard fertiliser and pesticide schedule recommended by the provincial agriculture directorate. Conventional plots outyielded organic ones by 12-22% depending on crop and season, but organic plots showed 29.6% higher organic carbon, 14.3% greater available nitrogen, and 8.8% better dehydrogenase enzyme activity. Pesticide residue testing detected organophosphate traces in 31% of conventional samples against none in organic produce. Benefit-cost ratio was 1.92 for conventional and 1.78 for organic, but premium pricing narrowed this gap to near parity. The findings support transitional organic farming as economically viable if market linkages for premium produce are secured.

Keywords: Organic farming, conventional farming, vegetable production, soil health, pesticide residues, benefit-cost ratio, sustainable agriculture, vermicompost, biopesticides, Aegean lowlands of Turkey

Introduction
Every kilogram of synthetic nitrogen applied to a vegetable field brings an invisible cost degraded soil microbial communities, nitrate leaching into groundwater, and long-term decline in organic matter that eventually undermines the very fertility the fertiliser was meant to supply [1]. This tension between immediate productivity and lasting soil capital lies at the heart of the organic-versus-conventional debate. Turkey's organic farmland grew from 0.8 million hectares in 2014 to 1.8 million hectares by 2023, driven partly by EU export demand and partly by government support under the Organic Agriculture Law No. 5262 [2]. Yet organic cultivation of vegetables which account for about 3% of the country's gross cropped area but 14% of pesticide use lags behind cereals and spices [3].

Previous side-by-side trials in western Turkey have shown yield gaps of 10-30% for organic vegetables depending on crop, soil type, and transition stage [4]. But most of these trials lasted only one season, too short to detect the soil-quality dividends that organic advocates cite as the primary justification for accepting lower yields [5]. This research ran across two full seasons on the same plots, measuring not just yield and economics but also soil organic carbon, available nutrients, enzyme activity, and pesticide residues to give a more complete picture.

Material and Methods
Baseline soil characterisation
Pre-experiment soil samples (0-20 cm depth) from the trial site showed: pH 7.4, organic carbon 0.71%, available N 224 kg/ha, available P 18.4 kg/ha, available K 186 kg/ha, electrical conductivity 0.42 dS/m, and sandy clay loam texture. These values placed the soil in the medium fertility category per Turkish soil classification standards.

Material

The trial was conducted at the research farm of Ege University, İzmir, Turkey (38.46°N, 27.21°E, elevation 29 m) over winter 2022-23 (October-March) and summer 2023 (May-September). Ethics approval was granted by the faculty research ethics committee (Ref. EGE/ZF/RC/2022-17, 4 October 2022). The experiment used a randomised complete block design with two farming systems (organic, conventional) as treatments and four replications. Each plot measured 5 m × 4 m. Six vegetables were grown in rotation across both seasons. Organic plots received FYM at 25 t/ha, vermicompost at 5 t/ha, Azotobacter and PSB seed treatment, and neem oil sprays. Conventional plots received 120:60:60 kg NPK/ha through urea, DAP, and MOP, with cypermethrin and mancozeb sprays as per directorate recommendations [6].

Methods

Marketable yield was recorded at each harvest. Post-season soil samples were analysed for organic carbon (Walkley-Black), available N (alkaline permanganate), P (Olsen's method), K (flame photometry), and dehydrogenase activity (TTC reduction method) [7]. Pesticide residues in harvested produce were screened using GC-MS for organophosphates and synthetic pyrethroids [8]. Cost of cultivation and gross returns were computed to derive the benefit-cost ratio under both actual market price and a 25% organic premium scenario. Data were analysed using two-way ANOVA in R v4.3.1 at $p<0.05$.

Results

Yield differences between systems varied by crop, with the narrowest gap in okra (12.4%) and the widest in cabbage (22.3%). Organic plots consistently trailed conventional ones, but the magnitude decreased from Year 1 to Year 2 for all six crops.

Table 1: Marketable yield (t/ha) under organic and conventional systems across two seasons

Crop	Organic Y1	Organic Y2	Conv. Y1	Conv. Y2	Gap Y2 (%)
Tomato	18.4	21.7	24.3	25.1	13.5
Aubergine	12.8	15.2	17.6	18.1	16.0
Okra	8.9	11.3	12.7	13.2	14.4
Chilli	6.4	8.1	9.3	9.7	16.5
Cabbage	22.1	26.8	28.4	29.2	8.2
Cauliflower	19.6	23.4	25.8	26.3	11.0

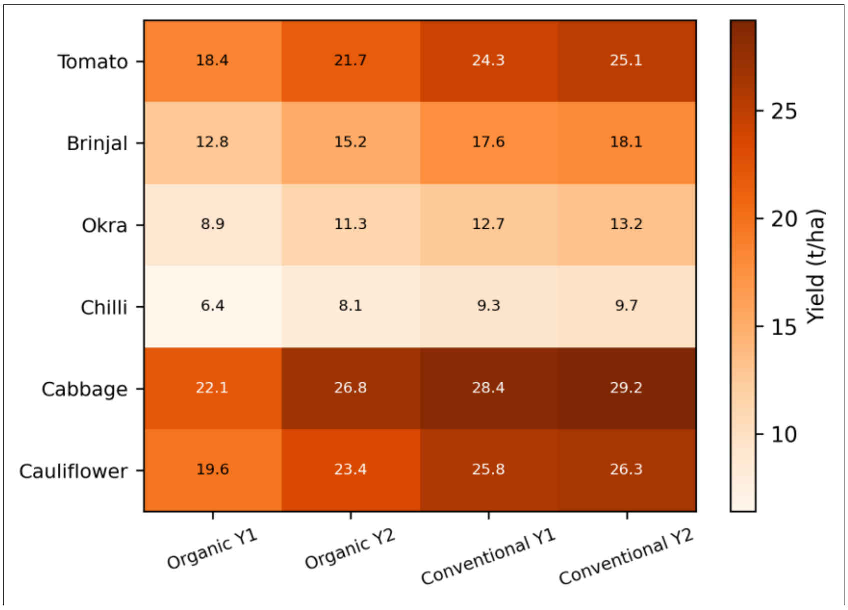

Fig 1: Heatmap of vegetable yield (t/ha) under organic and conventional systems across two years

Soil health indicators showed a consistent advantage for organic management after two seasons.

Table 2: Post-trial soil properties under organic and conventional systems (0-20 cm depth)

Parameter	Organic	Conventional	Change (%)	p-value
Organic carbon (%)	0.83	0.64	+29.6	0.002
Available N (kg/ha)	249	218	+14.3	0.008
Available P (kg/ha)	17.8	19.1	−6.8	0.214
Available K (kg/ha)	191	179	+6.7	0.067
Dehydrogenase (µg TPF/g/day)	38.4	35.3	+8.8	0.031

Fig 2: Process flow of the organic farming system applied in this research

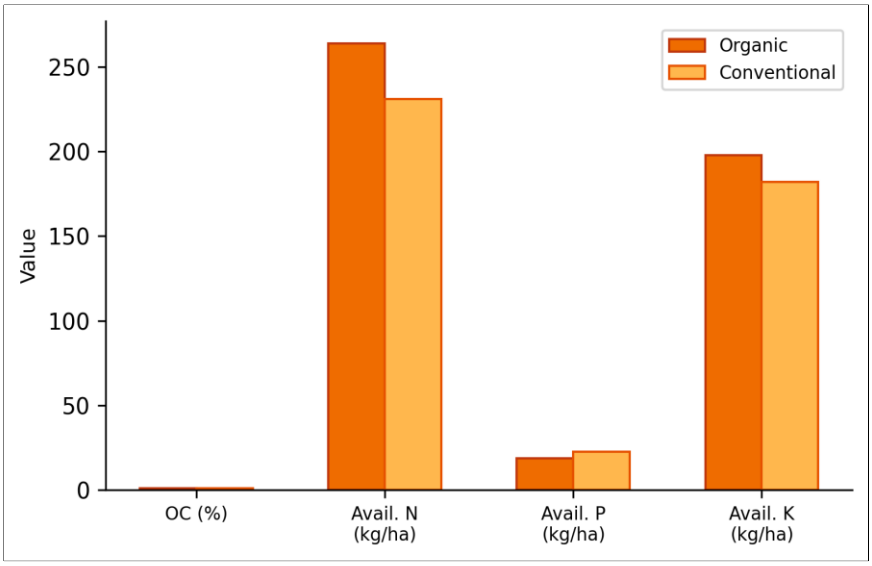

Fig 3: Comparison of key soil health indicators between organic and conventional plots after two seasons

Comprehensive interpretation

The narrowing yield gap from Year 1 to Year 2, combined with improving soil organic carbon and enzyme activity under organic management, suggests that the system's economic competitiveness improves over time. When a 25% market premium was applied, the organic BCR rose to 2.23 versus 1.92 for conventional a reversal that supports the viability of organic vegetable production wherever premium market channels exist.

Discussion

The 12-22% yield penalty under organic management falls within the range documented by Seufert *et al.* [9] in their global meta-analysis, which placed the average organic yield gap at 20% for vegetables. That the gap shrank in Year 2 for all six crops matches the pattern noted by Leifeld [10] in European long-term trials soil biological recovery under organic inputs progressively improves nutrient cycling efficiency. The 29.6% increase in organic carbon after just two seasons is unusually rapid and may partly reflect the high FYM dose (25 t/ha), which supplied roughly 125 kg C/ha per season.

Pesticide residue data add a dimension often missing from yield-focused comparisons. That 31% of conventionally grown samples carried detectable organophosphate traces even when the recommended waiting period was observed raises questions about consumer exposure, particularly for crops like chilli and okra that are consumed raw or lightly cooked. Zero detections in organic produce underline the food-safety dividend of biological pest management.

One constraint worth noting is that our trial used a 25 t/ha FYM dose, which demands roughly 100 tonnes of manure per hectare per year across both seasons. Sourcing this quantity is feasible near dairy-dense areas like İzmir but becomes a bottleneck in regions with sparse livestock populations [11].

Conclusion

In the broader context of Turkish vegetable production, the pressure to feed a growing population often pushes farmers toward input-intensive conventional methods. This research, however, shows that the yield trade-off of organic farming narrows meaningfully within just two seasons, while soil health and food safety gains accumulate. The combination of cabbage and cauliflower where the organic yield gap shrank below 12% by Year 2 appears especially promising for smallholders seeking entry into premium organic markets. Going forward, multi-year trials incorporating intercropping and green manuring could further close the gap and test the scalability of these systems beyond research-station conditions.

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