A comparison of profitability and cost analyses of tomato cropping systems in greenhouses

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Abstract

This study was conducted in the Mersin province, where greenhouse agriculture is commonly practiced in Turkey. In the study, organic, conventional, and soilless cropping systems were compared economically. The study was conducted by producing tomatoes in greenhouses over a three year period between 2012 and 2014. The best result among the three production systems in terms of production costs and net profit were obtained from the organic cropping system. The average yield in a unit area (ton 1000 m^{-2}) was 22.37 in soilless culture, 19.28 in organic, and 18.55 in the conventional cropping system. Total production cost for a unit area was 13,508.09 US$ in organic growth, 12,694.34 US$ in soilless culture, and 10,744.62 US$ in the conventional cropping system. Net profit for a unit area was 7,314.31 US$ in organic production, 3,278.87 US$ in soilless culture, and 2,608.98 US$ in the conventional cropping system. Results showed that it is possible to grow vegetables economically with alternative production systems. It requires extending and ensuring sustainability of environmentally friendly production systems. Therefore, farmer training about production techniques, and subsidies alternative production systems are important.

Key words: Vegetable growing system. Yield. Production cost. Return.

1. Introduction

The major focus of sustainable agriculture and the promotion of rural development should be to increase food production in a sustainable manner with the intention of enhancing food security and environmental protection. Sustainable agriculture is generally associated with the need for agricultural practices to be economically viable to meet human requirements, to be environmentally positive, and to improve the quality of life.

The objective of sustainability can be met in a number of ways. Sustainability helps to protect soil quality and improve agricultural products' availability (Akinyemi, 2007). Research indicates that possibilities for growing vegetables in alternative systems is less risky for environments with satisfying economic success (Ban et al., 2006).

Today global warming, climate changes, drought, and using groundwater and surface water sources excessively without considering their future; have urged not only scientists and researchers, but also politicians and statesmen towards new departures for production and technology.

Heavy agricultural reliance on synthetic chemical fertilizers and pesticides is having serious impacts on public health and the environment. The society has been increasingly concerned about the environmental damage caused by agricultural activities, especially with regard to health hazards resulting from the use of agrochemicals. Sustainability of conventional agriculture started being questioned, and the agricultural scene experienced changes.

The emergence of market segments interested in differentiated products leads farmers to search for alternative cropping systems, enabling the production of food crops at lower environmental and economic costs (Van Bruggen, 1995; Bettiol et al., 2004). Due to intensive use of agricultural inputs, especially soil resources, natural environment is polluted by conventional production systems. Consequently, human, animal and plant health is threatened. These effects began to spread to the world in an increasingly expanding area. .

The tomato (*Lycopersicon esculentum* Mill.) is one of the most commonly grown fresh market vegetables in the world. The major production countries include China, India, USA and Turkey, and the world production of fresh tomatoes was 163 million tons in 2013 (FAO, 2015).

Tomato production is also very important for Turkey in terms of both domestic consumption and export (Driver et al., 1999). More than a half of the vegetable production in Turkey consists of tomatoes. The amount of production was 11.9 million tons according to the 2014 data.

There are a number of styles and types of greenhouse structures that can be built. In addition, there are a variety of production systems that can be utilized to raise greenhouse tomatoes (Estes and Peet, 1999). Among these, conventional, sustainable, organic, integrated pest management systems, and soilless culture systems (with different ways, such as hydroponic or substrate culture) can be considered.

Greenhouse farmers normally receive higher production costs, which indicates that greenhouse growers need to obtain good prices to be profitable. The fact that the production costs in greenhouses are higher, and that there is a necessity to have technical information based production, requires more information and capital. At this point, organic production is seen as a production system which is sustainable and which derives a higher income especially for the producers who have recently established greenhouses.

The fact that the yield capacity is generally lower, and the production cost is higher in the organic production system than that of the conventional production, slows down the organic production system. It is observed that organic crops, which are sold in markets at a higher price; are not preferred by consumers in lower income groups, but the demand for organic crops is gradually increasing especially in the centers of big cities around the world.

Organic agriculture is characterized by the absence of synthetic fertilizers and pesticides, in addition to the frequent utilization of organic matter sources to maintain soil fertility (Stanhill, 1990; Van Bruggen, 1995). Soilless culture protects agricultural products from soil-borne diseases and pests, therefore eliminating some costs. In this study, the production costs and net profits of tomatoes; which are produced by organic, conventional, and soilless culture systems in greenhouses are compared.

2. Material and Method

According to this study, the experiment results were used to compare three different production systems conducted by Alata Horticultural Research Institute's greenhouses

between the production periods of September to June 2012-2014 in the Mersin province of Turkey. The tests were conducted with F_1 tomato type in three different cropping systems such as conventional, organic, and soilless systems.

Volcanic tufa was used as the growing environment in the soilless production system. Average values of the three-year data obtained from each production system were used in the calculations. The tests were conducted in plastic greenhouses of 1000 $m^{2.}$

While calculating production costs in terms of US$, taken into account the increased US$/TL exchange rate in the last two years, difference to the elimination of the negative effects, the last 30-months average exchange rate value is used.

For calculating the interest on operating expenses, a three-year average current interest was taken into consideration in determining the interest rate of the costs. The rate of the average current interest in three years in which the study was conducted was 7.00%, and the calculation was made for the 9-month period in which the production continued. The production costs in the greenhouse are calculated as variable, fixed, and total costs (Hood et al., 2007).

In this study, the variable costs include labor, fertilizers, chemicals, seedling, energy, certification (in organic production), other growing materials, and marketing costs. In input costs and labor wages, the values at the end of the period were taken into consideration. As managerial costs, 3% of the variable costs were added as expenditure.

Depreciations were calculated using the straight-line method. In fixed costs, there are interest on total initial investment costs, annual initial investment costs, interest on total variable costs, administrative costs and land rent. Fixed costs and variable costs were added and total production costs were obtained. In the study, the gross margin was calculated by subtracting variable costs from the gross output value, and the net profit was calculated by subtracting fixed costs from the gross margin (Estes and Peet, 1999; Hood et al., 2007). Additionally, the Relative Profit was obtained by the Gross Production Value dividing the Total Cost.

In terms of organic greenhouse tomato pricing; transtion costs to organic production, subsidies for producers, financial and technical aids, counselling and engineering services, and certification, packaging-labeling, storage costs have important effect on it.

When these elements of costs are reflected in the price, it is the case that consumers pay much more for organic products than for conventional products. This price difference is of approximately 30-35%. A survey indicated that buyers were willing to pay a 25% price

premium for organically grown vegetables (Estes and Peet, 1999). The average of past years (5 years) was taken into consideration while calculating the prices of organic, and conventional tomatoes.

3. Results and Discussion

While determining the costs of each of the three cropping systems in tomato production in greenhouses, an average value of the data for three years was used. The average variable costs that were calculated according to the cropping system (conventional, organic, and soilless culture) for 1000 m^2 greenhouse land were 8,689.40 US$, 10,919.51 US$ and 10,130.80 US$ respectively (Table 1).

Table 1:Average variable costs for three cropping system in greenhouse (US$ 1000 m^{-2})

	Cropping Systems					
	Conventional		Organic		Soilless culture	
Items	Average cost *	% of Cost	Average cost	% of Cost	Average cost	% of Cost
Labor	1,913.34	17.81	2,508.90	18.57	2,101.77	16.39
Machine labor	129.69	1.21	176.85	1.31	21.86	0.17
Fertilizer	771.96	7.18	1,052.67	7.79	1,052.66	8.21
Chemicals	459.17	4.27	602.68	4.46	118.85	0.93
Seedling	2,500.76	23.27	2,500.76	18.51	2,500.76	19.50
Inspection and certification	0.00	0.00	782.82	5.80	0.00	0.00
Heating (Fuel-diesel)	1,942.43	18.08	1,942.43	14.38	1,942.43	15.15
Bumble bee (Pollinator)	142.48	1.33	142.48	1.05	142.48	1.11
Growing media	0.00	0.00	0.00	0.00	890.48	6.94
Wrapping	204.81	1.91	296.62	2.20	395.06	3.08
Transport	258.35	2.40	347.04	2.57	319.59	2.49
Mulch	189.43	1.76	341.61	2.53	420.20	3.28
Other variable expenses	176.98	1.65	224.66	1.66	224.66	1.75
Total variable cost	8,689.40	80.87	10,919.51	80.84	10,130.80	78.99

*1 US$=2.1532 Turkish Lira

Variable costs in total costs, according to the cropping system showed little change during period of research and proportionally the average was 80.21%. The most important elements of the variable cost were seedlings (20.23%), labor (17.60%), and heating (15.72%).

According to the data that was collected from producers in 2011, the total production cost was 94,550 US$ 1000 m^{-2} in greenhouse tomatoes, and 90,47% of this was variable cost. In this study, especially labor costs (39,94%), marketing costs (18,46%), and heating costs (14,88%) were found as the highest costs in the total production cost.

In another study that was carried out in the same province in 2001, total variable cost was found as 76,787 US$ (82,28%); and labor costs (28,17%), marketing costs (19,76%) and heating costs (18,92%) were found as the most important costs (Laate, 2013). The most important variable cost in greenhouse tomato production consist of labor, marketing, and heating. In addition to this, tomato seedling production is another important variable in Turkey.

The organic system required 35% more labor, due to production being spread out over the growing season (Pimentel et al., 2005). In organic agricultural production, generally more labor is needed. Also, the prices of the organic chemicals which are allowed to be used are rather high. Additionally, there is a necessity of certification and control, and this situation increases the variable costs.

Depending on this, the highest variable cost among the three production systems appeared to be in the organic production. According to the results of research, the organic production system had higher chemical costs, higher labor costs and lower net returns than the other two systems. Both the conventional and IPM systems had relatively the same net returns (Brumfield, et al., 1995).

The growing environment in the soilless culture is regarded as an additional cost element. When each of the three cropping systems were evaluated in terms of variable costs, the organic production system is seen to cause the highest variable costs in a land unit (10,919.51 US$). Labor and certification costs in the organic cropping system increased the total variable cost.Fixed costs eventuated as 2,694.34 US$, 2,588.58 US$, and 2,055.22 US$ for the soilless culture, organic, and conventional cropping systems respectively (Table 2).

Table 2: Average fixed costs for three cropping system in greenhouse (US$ 1000 m^{-2})

	Cropping Systems					
	Conventional		Organic		Soilless culture	
Items	Average costs	% of Costs	Average costs	% of Costs	Average costs	% of Costs
A.Total variable cost	8,689.40	80.87	10,919.51	80.84	10,130.80	78.99
Interest on initial investment cost	304.13	2.83	382.18	2.83	354.58	2.76
Annual initial investment cost	659.53	6.14	891.83	6.60	1,104.06	8.61
Interest on operating capital	608.26	5.66	764.37	5.66	709.16	5.53
Administrative cost	260.68	2.43	327.59	2.43	303.92	2.37
Land rent	222.62	2.07	222.62	1.65	222.62	1.74
B.Total fixed cost	2,055.22	19.13	2,588.58	19.16	2,694.34	21.01
Total production cost (A+B)	10,744.62	100.00	13,508.09	100.00	12,825.14	100.00
Total cost per ton	579.33		700.63		573.40	

While fixed costs resulted closer to each other in the organic and soilless cultures, in the conventional culture they remained at a lower level. Annual initial investment cost was found the highest cost among fixed costs (6.14%-8.61% and average 7.16%), the second highest fixed cost was interest on operating capital (average value: 5.61%).

The rate of other fixed costs remained below 5%. By adding the variable costs and the fixed costs, the total production costs were obtained. The total production cost eventuated as 10,744.62 US$ in the conventional cropping system, 12,825.14 US$ in the soilless culture, and 13,508.09 US$ in the organic cropping system.

The total production costs per ton eventuated as 700.63 US$, 579.33 US$, and 573.40 US$ in the organic, conventional, and soilless culture, respectively. According to the cropping systems, while the total production costs were the lowest in the conventional cropping, they resulted in the highest rate in the organic cropping system.

When each of the three production systems are concluded in terms of amount of production, the average yield taken as 18.55 tones in the conventional system, 19.28 tones in the organic system, and 22.37 tons in the soilless culture (Table 3).

Table 3: The analysis of cost and net profitability (US$ 1000 m^{-2})

Items	Cropping systems		
	Conventional	Organic	Soilless culture
Total production cost (TPC)	10,744.62	13,508.09	12,825.14
Variable cost (VC)	8,689.40	10,919.51	10,130.80
Fixed cost (FC)	2,055.22	2,588.58	2,694.34
Yield (kg)	18,546.67	19,280.00	22,366.67
Cost (per kg of tomato)	0.58	0.70	0.57
Price (per kg of tomato)	0.72	1.08	0.72
Gross production value (GPV)	13,353.60	20,822.40	16,104.00
Gross margin (GPV-VC)	4,664.20	9,902.89	5,973.20
Net profit (GM-FC)	2,608.98	7,314.31	3,278.87
Net profit (per kg of tomato)	0.14	0.38	0.15
Relative profit (GPV/TPC	1.24	1.54	1.26

According to the cropping systems, the amount of production among the years in which the study was conducted varied between 20.33-24.08 tones in the soilless culture, 18.70-19.95 tones in the organic system, and 18.27-18.75 tones in the conventional cropping system. Between the three cropping systems, the highest yield was obtained in the soilless culture, due to not having the negative effects of diseases and pests that result from the soil.

The factors such as the applied cropping system, cultural processes, and growing period contributed to the amount of production in greenhouses. Brumfield, et al., (1995), their research found that maximum marketable yields were obtained using Integrated Pest Management systems, followed closely by the conventional system.

In a study conducted on tomato cropping in the soilless culture and different growing environments of greenhouse, the yields of 25 kg m^{-2} from peat, 23.3 kg m^{-2} from rockwool, and 22.4 kg m^{-2} from spent mushroom were obtained. In the same study, the yields of 20.3 kg m^{-2} from volcanic tufa and 20.0 m^{-2} from the conventional production were obtained (Abak ve Celikel, 1994). In another study conducted in greenhouse production for tomatoes, the amounts of yields varying between 17,58-19.54 tones per 1000 m^{-2} were obtained (Smith et al., 2006).

These results show that comparing to conventional production systems, alternative vegetable production systems are more productive. Even though alternative production systems raise production costs, it is possible to compensate these costs with advantages in product price and environmental goods.

According to the soilless, conventional, and organic cropping systems, the cost of 1 kg of tomato is an average of 0.58 US$, 0.70 US$, and 0.57 US$, respectively. The gross production value was obtained as 13,353.60 US$ in the conventional system, 16,104.00 US$ in the soilless culture, and 20,822.40 US$ in the organic cropping system.

It is important to mention that unit product price in conventional and soilless production systems is 0.72 US$ kg^{-1}, and it is 50% more (1.08 US$ kg^{-1}) in the organic production system.

In terms of net profit, organic production ranked first with 7,314.31 US$. The soilless culture was second in terms of net profit with 3,278.87 US$, and the conventional system was third with 2,608.98 US$. The fact that the yield was higher although the production costs were more in the soilless production system caused a higher gain of net profit than in the conventional production.

The net profit per 1 kg of tomato was 0.38 US$ in organic production, 0.15 US$ in the soilless culture, and 0.14 US$ in the conventional cropping system. The relative profit was calculated as 1.54% in the organic system, 1.26% in the soilless culture, and 1.24% in the conventional cropping system. The relative profitability of the organic production system has been prominent in the cropping system because of the price advantage.

Improvments in agricultural production and studies carried out about this issue show that is possible to make environment friendly and satisfactory production with organic and low input alternative production systems (Ban et al., 2006; Akinyemi, 2007).

A greenhouse facility is an expensive structure to build, equip, and operate while greenhouse tomatoes are expensive to grow, harvest, and handle relative to many other agricultural commodities. High investment and production costs require that volume and/or price must be sufficiently large to ensure economic feasibility.

Shoppers are willing to pay premium prices for tomatoes only if greenhouse tomatoes offer superior quality, value, taste, and freshness relative to alternative products. Recent increases in tomato consumption, greenhouse industry capacity expansion, and increased sales revenue might suggest an optimistic economic future for greenhouse tomato operators.

Greenhouse tomatoes are often sold at a price premium when compared with field-grown tomatoes, but price premiums tend to limit sales volume (Estes and Peet, 1999). Consumer awareness about organic agriculture is still very weak and this point requires further attention. The link between organic agriculture and environment/nature protection is

missing, too. The purchase of organic food is influenced by the level of information and knowledge consumers have in reference to these products (Ban et al., 2006).

4. Statistical Analysis

According to homogeneity analysis results about yield values of each of the three production systems (Sig. 0.109>0.05), groups were found homogeneous in terms of variances at a 95% confidence level. According to one-way variance analysis, differences between group averages were found statistically significant at a 95% confidence level (Table 4, sig. 0.019<0.05).

Table 4: Analysis of one way anova between cropping systems

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24657688.889	2	12328844.444	8.315	0.019
Within Groups	8895933.333	6	1482655.556		
Total	33553622.222	8			

Pairwise comparisons of Tukey's test results as shown in Table 5 related to the tomato greenhouse cropping systems. Mean differences between conventional-soilles culture and organic-soilles culture were found significant. In other words, among alternative cropping systems, soilless culture was found to statistically differ from conventional and organic production systems in terms of productivity.

Table 5: Tukey test results

		Mean Difference		95% Confidence Interval	
(I)	(J)	(I-J)	Sig.	Lower Bound	Upper Bound
Conventional	Organic	-733.333	0.752	-3783.82	2317.15
	Soilles culture	-3820.000	0.020*	-6870.48	-769.52
Organic	Conventional	733.333	0.752	-2317.15	3783.82
	Soilles culture	-3086.667	0.048*	-6137.15	-36.18
Soilles culture	Conventional	3820.000	0.020*	769.52	6870.48
	Organic	3086.667	0.048*	36.18	6137.15

* The mean difference is significant at the 0.05 level

5. Conclusion

Greenhouse cropping is a branch of production whose importance is gradually increasing economically. However, in order to ensure the continuity of this cropping system, customers' demands should be taken into consideration; and a production type that considers the crop quality and the impact it has on human and environmental health should be taken seriously.

Producers should apply methods that decrease the production costs, provide product diversity, and enable them to market their products at a higher price. Organic farming in the world has developed significantly in recent years, but still needs some developments such as consumer attentions, suitable prices, and more production crops.

In Turkey, the production in greenhouses is generally practiced by conventional methods. Alternative cropping systems in greenhouses has recently begun as a sustainable agricultural production approach. Therefore, there is a need for new studies to be conducted regionally in producers' conditions.

Production economy studies should be about various vegetable species in terms of costs and return. Research studies about organic agriculture techniques should be encouraged, and the producers' problems and consumers' trends and demands in this area should be clarified. The studies to be conducted on organic agriculture should cover producers, consumers, and all related components and organizations in a holistic approach.

Producer income is especially affected by productivity, price, and costs in greenhouse vegetable growth. While price is the most important issue which effects producer's income and profitability, productivity follows price as another important issue. These factors can boost income with minimum cost increase.

Therefore, it would be beneficial to check market price movements before making production decisions. It is crucial to farmers to be open to new ideas such as alternative production systems to ensure improvement in productivity and production costs. Farmers should be supported with subsidies about environmentally friendly production systems; and training activities should be conducted about alternative production systems. It could also be beneficial to carry out future studies and alternative production systems at the level of producer conditions.

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