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The Effects of Applying Biological Control Measures in Greenhouse Cultivation on the Production Efficiency in Kaş District of Antalya Province, Turkey

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Abstract
Nowadays, in vegetable production, biological pest control practices are recommended to prevent human health and environmental damage even though there has been lacking of economic information. Therefore, the study examined the economic dimension of biological and chemical control measure and aimed to reveal the link between production efficiency and biological pest control practice. Research data were collected from randomly selected 51 farms implemented chemical pest control practice, and 52 farms implemented biological pest control practice by using questionnaire. Cluster analysis was performed to select similar farms from two different groups. Data envelopment analysis (DEA) was used to calculate the efficiency measures such as technical efficiency, allocative efficiency and economic efficiency. Research results showed that farms implemented in biological pest control in pepper production had better technical efficiency and economic efficiency scores comparing to tomato ones, while the reverse was the case for allocative scores. Farms focused only pepper production, implemented biological pest control had better technical efficiency scores compared to chemical ones. Research results also showed that biological pest control in tomato was excessive net profit, biological control costs and pesticide use in greenhouse, while the reverse was the case for pepper. Farmers would increase their technical efficiency if they improve their skills via participating the extension and training programs.

Keywords: greenhouse cultivation, biological pest control, production efficiency, Antalya, DEA

1. Introduction

In the world, physical and chemical degradation has occurred in the soil due to excessive input use. The biological pest control is alternative methods developed for struggling with this problem. Biological pest control is based on the use of organism against harmful organism causing economic losses to reduce with the population density of another organism (GTHB, 2015).

Greenhouses has covered 63.521.430 hectares of land in Turkey. Vegetables have been produced in 1.071.020 hectares of land. %28 of Turkish vegetable production have been produced in Antalya (TUIK, 2016). Environmentally friendly production methods are widely used in the research area. In the research area, biological pest control have been concentrated in three districts, which are Çavdır, Kınık and Ova. Since biological pest control is common and crop diversification is satisfactory level in 3 districts of Kaş, these districts are selected as a research area. The study intended to test the hypotheses of whether biological pest control had any effect on net farm income, or not. The share of pest control costs in total production costs and the effects of agricultural subsidies on farm income were also examined in the study.

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The biological pest control methods, which are used to prevent illnesses and losses that happen in harmful weeds and they are not only appropriate for sustainable agriculture methods, but also sensitive to the environment, human and animal health. In literature many previous studies have focused on microbial factors such as bacteria, virus and fungus causing illnesses on plants and facilities of biological pest control against the harmful organism in one side (Çeliker, 1994; Ulukuş et al, 1997; Aktete et al, 1997; Tozlu, 2008; Öztürk and Ulusoy, 2011; Polat and Coşkuntuna, 2014; Yiğit et al, 1994; Öncüer et al, 1994; Çiftçi et al, 1995; Pal and Gardener, 2006). On the other side, some researches have conducted several studies to explore adverse effects at pesticide to environment and human health (Zengin, 1997; McFadyen, 1998). There have been also some studies that use viruses, bacteria's, rickettsia's, fungus, protozoa and nematodes as microbial war factors against the illnesses and pests (Datnoff et al, 1995; Eken and Demirci, 1997; Kedici and et al, 1998; Gökçe and Er, 2002; Akyazı and Ecevit, 2006; Tozlu et al, 2010; Erdoğan, 2015; Aydın, 2015).

However, the information related to the economic effects of following biological pest control measures on the farms was very limited in literature. Greenhouse farming required intensive healthy technical and economic information about vegetable production. Farmers have faced with risk when making decision related pest control. In general farmers were not comfortable when deciding to apply biological pest control due to emitted scientific information related tradeoff between biological and chemical pest control. In addition, the link between the production efficiency and the application of biological pest control measures was not clear. Therefore, the study examined tradeoff between biological and chemical pest control and the link between the efficiency measures and biological pest control application.

2. Materials and Methods

2.1 Research area

The research was conducted in the Kaş district of Antalya, Turkey. Kaş (pronounced 'Kash') is a district of Antalya Province of Turkey, 168 km west of the city of Antalya. There are 5 villages and 48 villages in Kaş district of Antalya province. The map of the research area is depicted in Figure 1. The total agricultural land in Kaş is 22536 hectares. The irrigable area is 1225 hectares. Irrigated land allocated to cereals (8300 ha), edible legumes (1005 ha), industrial plants (100 ha), oil seeds (1790 ha), tuber plants (10 ha) and fruit (1659 ha). The production area under cover consists of 5,1 hectares of glass greenhouses and 2,8 hectares of plastic greenhouses. It is allocated to tomatoes (0,7 ha), peppers (0,6 ha), aubergine (0,2 ha), and cucumbers (0,1 ha). The tomatoes production is 330,000 tons per year, while that of pepper is 50,000 tons (TUIK, 2016).

Figure 1. Map of Research Area

2.2 Research data

Research data were collected from randomly selected 51 farmers out of 1080 farmers who implemented chemical pest control practice and 52 farmers who implemented biological pest control practice in the villages of Çavdır, Ova and Kınık by using face-to-face questionnaire during the production period of 2015. When calculated the optimum sample size, the precision level and confidence level were 10% and 99%, respectively.

The variables measured in the study were divided into two broad groups such as farmer's characteristics (age, education level, farming and greenhouse cultivation experience and working time at farm), farm characteristics (family size, operational land, tomato and pepper land, prize, yield, farm income, variable cost, fixed cost, total production cost, pesticide and biological control costs).

2.3 Measuring and comparing the economic performance of the sample farms

The classical economic analysis procedure was followed when calculating the annual economic performance of the farms implemented biological pest control and farms implemented chemical pest control. The production value, gross farm income, gross margin and net farm income were used as an indicator for economic performance. Production value was calculated by multiplying the quantity of the produced field and animal product with corresponding prices of products. The rent of the building, which was 5% of the value of building, and the off-farm income were summed to reach gross income. Total production costs were expressed as amounts used per hectare. Total production costs were divided into two groups such as variable and fixed costs. The variable cost included costs for seed and seedling, manure, pesticide, irrigation, electricity, version planting, fuel, marketing, shattering-solarization, frost protection, shading, insect netting, rope, labor and biological control cost. Depreciation, family labor, sharecropper, greenhouse, building, machinery depreciation and building repair were included into fixed costs. Gross margin was calculated by subtracting variable costs from gross production value. Net farm income was found by subtracting total production cost from gross income. The straight-line method was used when calculating depreciation cost.

In this study, farm implemented biological pest control practice were compared to chemical ones in terms of measured variables. Student t test was used to test the mean of two farm group. Before comparison of two different farm groups, the distribution of the continuous research variables was tested whether they were normally distributed, or not by using Kolmogorov Smirnov test.

2.4 Efficiency model for sample farms

Cluster analysis was used to select similar farms form the farm group of implemented biological pest control and farm group of chemical pest control in order to set ceteris paribus conditions. The profile of farm managers, which was created by compounding variables such as age, education, experience on agriculture, the variable of greenhouse production area and the variable of return on equity were included the cluster analysis. Based on the results of the cluster analysis, we determined that 28 biological pest control farms and 18 chemical pest control farms were similar. Then we used them when measuring the efficiency measures and comparing them.

When estimating the production efficiency measures, the relative efficiency approach suggested by Farrell (1957) was adopted in the study. The study focused on the technical efficiency (TE) and its components that were scale efficiency (SE) and pure technical efficiency (PTE). Data envelopment analysis (DEA) procedure was followed to calculate efficiency scores.

Based on the suggestions Charnes et al. (1978) and Banker et al. (1984), we assumed that each farm produced tomato and/or pepper (Yi) using the most important inputs of pest control cost and variable costs excluding pest control cost (xi*). Since the farmers had the more control power over their inputs comparing to their outputs, the input-orientated efficiency model was constructed to estimate the efficiency scores. Input oriented efficiency scores under variable return to scale (VRS) were estimated by running the linear programming depicted below:

Minimum λ., xi* wiT (xi*)

Subject to $-yi + Y\lambda \geq 0$

$xi^* - X\lambda \geq 0$

$\lambda \geq 0$

In the equation, wi, the vector of an input price for i-th farm; T, transpose of function and xi*, input price, wi, with output level, Yi, minimum cost of input level was calculated via linear programming for each farm. This equation revealed the minimum cost under variable return to scale (VRS). Cost efficiency for each farm was estimated by using the formula of (CE) = wiT xi*/ wiT xi. Allocative efficiency was calculated by using the formula of AE= CE / TE (Coelli et all., 1998). DEAP 2.1 package program which was developed by Coelli (1996) was used for the estimation of efficiency measurement.

3. Findings and Discussion

Research result revealed that the typical farmers was 49 years old and they had 6 years of schooling, on average. There were statistically significant differences between the groups in terms of farming experience, greenhouse cultivation experience and working time at farm. The mean family size of biological and chemical pest control was about 4 persons. Comparative analysis showed that the amount of farmland differed associated with farm groups ($p<0,10$). In the research area, the average land allocated to chemical control in tomato and pepper production were 0,8 and 0,6 hectares, respectively, while that

of biological control were 1,6 and 0,4 hectares, respectively (p<0,10). The production value of pepper in chemical control group was greater than that of biological ones (p<0,05). However, the reverse was the case in tomatoes production (p<0,10). Regarding the crop yield, the yields of tomato and pepper in the farm group preferred the chemical control were higher than biological farm group (Table 3.1).
Based on the results of the economic analysis, total production costs for biological and chemical pest control groups were 178544,5 ₺/ha and 142366,6₺/ha, respectively. About by 66% of the total production costs was fixed costs, while 34% of it was variable costs in both biological pest control and chemical pest control. Family labor had the highest share and followed by sharecropper cost, seed and seedling cost and manure cost. There were statistically significant differences among the biological and chemical pest control farmers in terms of biological control costs, insect netting cost and shading cost at farm (p<0,01). But there were not statistically significant differences among pesticide used (Table 3.1).

Table 3.1 Socio- economic characteristics of sample farmers

	Chemical pest control		Biological pest control	
Farmers' characteristics	Mean	Std. Dev.	Mean	Std. Dev.
The age of the farm operator (year)	50,2	8,1	48,2	11,6
Education level of the farm operator (year)	6,9	3,1	6,7	2,9
Farming experience (year)*	23,9	9,4	20,4	12,4
Greenhouse cultivation experience (year) **	22,6	9,2	18,2	10,3
Working time at farm (months per year) *	9,5	1,6	9,9	0,3
Farm characteristics				
Family size (person)	4,1	1,3	3,9	1,2
Farmland (ha)*	0,7	0,8	1,0	2,4
Land allocated to tomato (ha)*	0,8	0,8	1,6	3,0
Land allocated to pepper (ha)*	0,6	0,4	0,4	0,3
Tomato price (₺/kg) **	0,9	0,2	1,2	0,7
Pepper price (₺/kg)	2,3	0,0	2,3	0,0
Tomato yield (kg/ha)	205487,8	16651,0	203064,5	33483,3
Pepper yield (kg/ha) **	133168,4	138578,2	259611,8	391308,0
Tomato production value (₺/ha) ***	126500,0	36518,6	107142,9	12305,6
Pepper production value (₺/ha) **	166483,2	183610,1	74113,0	63241,9
Variable expenses (₺/ha) ***	47937,6	18989,5	59265,0	21151,0
Fixed expenses (₺/ha) **	94429,0	52920,3	119279,5	70952,5
Total production expenses (₺/ha) ***	142366,6	64373,9	178544,5	78010,7
Pesticide and biological control cost (₺/ha) ***	6596,0	9328,1	13262,0	6393,1

***p<0,01, **p<0,05, *p<0,10
1 Euro equals to 3,89 (₺) Turkish Liras in 2017 (CBRT, 2017).

Capital structures of the sample farms were depicted Table 3.2. Total assets of the farms implemented chemical pest control was 1892962,3 (₺/ha), while that of farms implemented biological pest control was 1368784,9 (₺/ha). In addition, the current dept of chemical pest control farms was about twice that of biological pest control farms. There were statistically significant differences between the farm groups in terms of total assets and total liability in the research area (p<0,01). In both groups, the share of the equity was 91% (Table 3.2).

Table 3.2 Capital structures of the sample farms

	Chemical pest control		Biological pest control	
Capital Items	Mean	Std. Dev.	Mean	Std. Dev.
*Noncurrent assets (₺/ha) **	1336293,1	832953,7	1141851,5	869878,3
Total land capital (₺/ha) **	716003,1	373737,7	593160,8	165678,6
Land improvement (₺/ha) **	35800,2	18686,9	29658,0	8283,9
Building capital (₺/ha)	569920,0	745704,7	505457,7	870718,8
Greenhouse capital (₺/ha) *	12607,1	10217,5	11315,9	9609,7
Machinery capital (₺/ha) *	1962,7	2224,1	2259,0	3233,9
*Current assets (₺/ha) **	556669,2	533876,2	226933,4	196179,8
Field inventory-stock (₺/ha)	53196,4	17406,9	60854,1	16219,1
Stock (₺/ha) ***	8913,4	20235,7	1038,8	4727,8
Cash money (₺/ha) ***	460203,6	520102,9	139054,0	193908,5
Borrowed money (₺/ha) ***	34355,9	34600,4	25986,6	24630,5
*Total assets (₺/ha) ****	1892962,3	1107875,8	1368784,9	876281,7
Current Debt (₺/ha) *	185954,9	384487,4	93321,1	177735,1
Equity (₺/ha) **	1707007,4	1006493,8	1275463,8	913527,8
*Total liability (₺/ha) **	1892962,3	1107875,8	1368784,9	876281,7

***p<0,01, **p<0,05, *p<0,10

1 Euro equals to 3,89 (₺) Turkish Liras in 2017 (CBRT, 2017).

Table 3.3 Annual economic performances of the sample farms

Economic variables	Chemical pest control		Biological pest control	
	Mean	Std. Dev.	Mean	Std. Dev.
Crop production value (1) (₺/ha) ***	205776,0	79164,0	255007,2	124958,8
Off farm income (2) (₺/ha)	162,6	1009,9	10714,3	76258,3
Rent value of building (3) (₺/ha)	28496,0	37285,2	25272,9	43535,9
Total agricultural support (4) (₺/ha) ***	1620,1	1052,2	4830,3	101,3
Gross farm income (5=1+2+3+4) (₺/ha) ***	236054,7	85706,8	295824,7	172091,5
Total production cost (6) (₺/ha) ***	142366,6	64373,9	178544,5	78010,7
Net output (7=5-6) (₺/ha)	93688,1	90554,4	117280,2	173263,4
Family labor (8) (₺/ha) ***	47557,9	53040,9	80930,5	69774,4
Agricultural income (9=7+8) (₺/ha) ***	141246,0	84149,7	198210,8	161948,2
Variable costs (10) (₺/ha) ***	47937,6	18989,5	59265,0	21151,0
Fixed costs (11) (₺/ha) **	94429,0	52920,3	119279,5	70952,5
Gross margin (12=1-10) (₺/ha) **	157838,4	78759,5	195742,2	128989,6
Opportunity cost of equity (13) (₺/ha)	93688,1	90554,4	117280,2	173263,4
Net farm income (14=1-4+13) (₺/ha) ***	148129,4	98591,7	139670,1	135622,5
Relative profit (%)***	1,5	1,3	1,5	1,6
Return on asset (%)**	5,1	7,6	9,3	19,0
Return on equity (%)	5,7	8,3	10,0	18,2

***p<0,01, **p<0,05, *p<0,10

1 Euro equals to 3,89 (₺) Turkish Liras in 2017 (CBRT, 2017).

Annual economic performances of the sample farms were depicted Table 3.3. Production value was 230391,596 ₺/ha, on average. Farms implemented biological pest control benefited by 3500 ₺/ha of government support for biological pest control, resulting in gaining high level of gross return comparing to farms implemented chemical pest ($p<0,01$). Regarding the net farm income, farms implemented biological pest control gained higher net farm income than that of farms implemented chemical pest control ($p<0,01$). However, the reverse was the case for gross farm income (Table 3.3).
The efficiency scores reflected different pattern in tomato and pepper production. When comparing the tomato and pepper farms, farms implemented chemical pest control had better technical efficiency scores and economic efficiency scores than that of farms implemented biological pest control, while the reverse was the case for allocative and scale efficiency scores. Regarding the patterns of efficiency scores in sample farms, pepper producer farms implemented biological pest control had better technical efficiency scores comparing to tomato producer farms, while the same was the case for allocative and economic efficiency scores.

Table 3.4 Efficiency scores and some economic performance measurement for tomato and pepper production

	Tomato				Pepper			
	Chemical pest control		Biological pest control		Chemical pest control		Biological pest control	
	Score	Std.Dev.	Score	Std.Dev.	Score	Std.Dev.	Score	Std.Dev.
Technical efficiency (TE)	0,803	0,208	0,553	0,228	0,651	0,298	0,638	0,174
Allocative efficiency (AE)	0,869	0,071	0,919	0,046	0,936	0,081	0,913	0,122
Economic efficiency (EE)	0,691	0,167	0,514	0,228	0,606	0,287	0,582	0,182
Scale efficiency (SE)	0,623	0,270	0,567	0,316	0,805	0,139	0,762	0,122
Pure technical efficiency (PTE)	0,536	0,331	0,372	0,325	0,530	0,301	0,495	0,173

Despite the fact that these tomato producer farms have better biological pest control efficiency scores by chemical pest control, net profit is quite low. Pepper producer farms have better chemical pest control efficiency scores by biological pest control, net profit is high in chemical pest control farms. The technical efficiency of farms in terms of technical efficiency is divided into pure and scale efficiency. For the study area, especially in the biological pest control farms the reason for not being able to provide technical efficiency expressing the skill of the operator pure technical inefficiency. Pure technical inefficiency was the primary cause of scale inefficiency in tomato producers, but these reason for pepper was caused technical inefficiency (Table 3.4).
Based on the result of the scale efficiency analysis, 84,6% of tomato produce chemical pest control farms and 73,3% of biological pest control had increasing returns to scale, while rest of tomato produce farms had constant returns to scale and decreasing returns to scale. However, all the tomato and pepper produce chemical pest control hadn't decreasing returns to scale. Only tomato produce of biological pest control farms had decreasing returns to scale. Pepper producer of biological pest control farms must decrease total produce costs. Pepper producers of biological pest control farms have lower incomes because they are both less productive and excessive costs. On the other side, tomato producers of biological pest control farms have higher incomes because

they are less total production costs according to chemical pest control (Table 3.5).
The results of the efficiency analysis and some economic performance measurement associated by crop were given in Table 3.5. Net farm income of tomato farms were 170020,1 ₺/ha in biological pest control option and 147791,6 ₺/ha in chemical pest control option, even if amount of government support was ignored. To produce this yield, an average of farm income 171969,8 ₺/ha with in biological pest control and 114069,6 ₺/ha with in chemical pest control. Due to biological pest control farms receiving agricultural support, farm income was higher than those of chemical pest control farms. On the other hand, pepper producing farm income was 196227,8 ₺/ha and 197770,7 ₺/ha with respectively biological and chemical pest control.

Table 3.5 Summary of returns to scale results for sample farmers

			Number of the farms		Farm income (₺/ha)		Sum of pesticide cost with biological control cost (₺/ha)		Variable costs excluding biological control cost and pesticide cost (₺/ha)		Net income (₺/ha)	
			N	%	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Chemical pest control	Tomato	CRS	2	15,4	290401,1	283008,7	2358,3	3264,5	4516,7	6104,7	273108,5	211089,1
		DRS	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		IRS	11	84,6	121890,7	52909,7	5676,9	5624,6	421,3	509,5	125006,7	56793,4
		Total	**13**	**100,0**	**147815,4**	**114069,6**	**5166,3**	**5367,0**	**1051,4**	**2384,8**	**147791,6**	**97439,2**
	Pepper	CRS	1	20,0	313973,3	0,0	3750,0	0,0	1575,0	0,0	296471,3	0,0
		DRS	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		IRS	4	80,0	168720,1	37734,2	12107,1	9348,8	2206,8	1737,1	98741,6	194673,6
		Total	**5**	**100,0**	**197770,7**	**72715,9**	**10435,7**	**8917,3**	**2080,5**	**1530,7**	**138287,5**	**190375,4**
Biological pest control	Tomato	CRS	1	6,7	486777,9	0,0	18309,3	0,0	1350,5	0,0	489062,9	0,0
		DRS	3	20,0	440965,6	26143,3	12177,4	490,8	20436,4	19882,5	401410,1	53592,2
		IRS	11	73,3	124956,4	98256,7	12616,2	2466,4	5036,2	10060,5	77909,9	115999,8
		Total	**15**	**100,0**	**212279,6**	**171969,8**	**12908,0**	**2577,7**	**7870,5**	**13113,1**	**170020,1**	**188233,0**
	Pepper	CRS	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		DRS	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		IRS	13	100,0	196227,8	47697,2	16051,2	11487,4	5072,9	8702,7	108279,8	106340,8
		Total	**13**	**100,0**	**196227,8**	**47697,2**	**16051,2**	**11487,4**	**5072,9**	**8702,7**	**108279,8**	**106340,8**

(CRS: constant returns to scale, DRS: decreasing returns to scale, IRS: increasing returns to scale)
1 Euro equals to 3,89 (₺) Turkish Liras in 2017 (CBRT, 2017).

4. Conclusions

Under the light of the research findings, biological pest control farms had disadvantage status due to high production cost. Therefore, these farms' net incomes were lower level comparing to chemical pest control farms, resulting in having lower level of efficiency scores in biological pest control farms. Regarding to productivity, there was no statistically difference between the farms implemented biological pest control and farms implemented chemical pest control in tomato production. However, implementing biological pest control affected the efficiency scores in sample farms. The allocative efficiency of the farms implemented the biological control was higher than that of chemical ones. However, the reverse was the case for economic efficiency scores. If sample farms implemented biological pest control measures reduced their input cost by 49% in tomato production, these farms would become economically full efficient farms.

In addition, 44% of the farms implemented biological pest control measures in tomato was technically inefficient. 62,8 % of the technical inefficiency was sourced by ability of farm managers.

The yield of pepper in farms implemented biological pest control measures was about twice that of farms implemented chemical pest control measures. Due to the fact that farms implemented biological pest control measures in pepper was high biological cost, farms implemented chemical pest control measures had more agricultural income. But the net farms income of these farms was higher than the farms implemented chemical pest control measures by 30%. At the same time, all of these farms was increasing returns to scales, so they need to increase their scale. On the other side, it is clear that government subsidies for environmental protection have eliminated loss of farm income in the research area.

Farmers should focus on the monitoring the input markets, especially input prices. The farmers' education programs may increase the information level of sample farms to reduce their expenditures up to efficient farm level. If farmers manage their farms by taking into account the price level and allocation of resources then they can increase their yield and reduce their input cost. Effective extension services may enhance the farmers' knowledge in managing their farms.

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