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Biological control in pest management in Turkey: Comparison of the attributes of participant and non-participant greenhouse farmers in government-subsidized biological control practices

Hasan Yilmaz*[1] Zuhal Asli Tanc [1]

[1] Isparta University of Applied Sciences, Faculty of Agriculture Sciences and Technology, Department of Agricultural Economics, Isparta, Turkey

* Corresponding author: *hasanyilmaz@sdu.edu.tr* | Contact Number: *+90 (246) 211 85 99*

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Abstract

The adoption of biological control methods is increasing in crop production due to concerns and awareness of consumers about food safety and pesticide residue conundrum. Biological control methods are a key component in pest management practices as they minimize the usage of pesticides, hence create less environmental and health problems. Biological control practices have been supported in Turkey since the year 2010 to ensure economical greenhouse production and to reduce the consumption of pesticides for sustainable agricultural production. This solved the pesticide residue conundrum in fresh fruits and vegetables both domestically consumed and exported. The main objective of this study was to compare the attributes of the participant and non-participant farmers in government-subsidized biological control practices for pest management in greenhouse pepper cultivation. The data used in this study were collected from 84 greenhouse growers by using a face-to-face interview in Kaş district, Antalya province, in the Mediterranean coastal region of Turkey. The results show a statistically highly significant ($p<0.05$) relationship between the government-subsidized biological control implemented farms and non-implemented farms with respect to age of farmers, educational level, retirement status of farmers, number of workers, use of agricultural credit, greenhouse working experience, pepper yield, type of greenhouse covering, type of greenhouse ventilation, crop production system, internet usage, farmers association membership, and so on. The results also show that farmers believe biological control practices improve crop quality and yield as well as improve the environment and human health. The agricultural extension agencies and government subsidy policy played an important role in motivating farmers to intensify biological control practices on their farms.

Introduction

Greenhouse production of vegetables is an important part of the agricultural sector and crop production in Turkey and continues to show a promising pace of development. The total greenhouse vegetable production realised was 7.3 million tonnes cultivated on 73717 ha of land. According to TURKSTAT, (2017) about 6.43% of the total greenhouse vegetable produced in Turkey was sweet pepper in 2016. Antalya province is one of the most important crop production areas. It is the centre of greenhouse vegetable production in Turkey. The total greenhouse sweet pepper production was 3.6 million tonnes in Antalya province making it 48.88 % of the total greenhouse sweet pepper production in Turkey (TURKSTAT, 2017). Greenhouse vegetable production is very

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Figure 1: Location of Kaş, Antalya

important economic venture in Antalya province. It contributes significantly to income, employment and export opportunities. Tomato and pepper production dominate in the total greenhouse vegetable production.

Increased environmental consciousness by consumers has led to the need for sustainable agricultural production systems with essential components including Good Agricultural Practices (GAP) and Integrated Pest Management (IPM) (Pretty and Bharucha, 2015). Concerns about quality and safety of food consumers have compelled both public regulation authorities/bodies to put stringent standards on pesticide residues in foods. Ahangama and Gilstrap (2007) opined that although IPM is a sustainable and effective method of pest control, pesticides should be used only as a last resort in other to ensure food safety and access to international market. One of the major components of IPM is biological pest control. In biological pest control, natural enemies of the pest are introduced to the population density of the pest to feed on them. The natural enemies used in biological pest control are mostly predatory insects or nematodes (Bale et al. 2018). Public worry about the safety of food and issues associated with pesticide residues in food has made the concept of IPM in general a biological pest control more importantly from both economic and ecological viewpoints (Erkılıc and Demirbas, 2007).

Biological control of pest as an industry has not seen the needed growth and development although it is one of the oldest methods of pest control. Nevertheless, it is of late being considered as a primary pest control method in several crops production and managed ecosystems (Sharma et al. 2013). Biological control of pest is a key component of pest management. Biological practices in greenhouse production are a solution to the challenge of sustainable and safe food production. Meeting food safety requirements using current agricultural production techniques cannot be achieved. For this reason, biological control and organic production is recommended as a solution to the challenge of sustainable food production with less or no pesticide residues and lower use of inputs (Ciccarese and Silli, 2016). IPM practice was first introduced in Turkey in 1970 with cotton production and later was applied in apple, hazelnut, wheat, vines and production of other such crops (Isin and Yildirım, 2007). Biological control application initially began by trials carried out on 10 ha of pepper grown in greenhouses in 2002 in Antalya Province of Turkey. Amblyseius swirskii Athias-Henriot, Orius laevigatus Fieber, Aphidius colemani Viereck, and Phytoseiulus persimilis Athias-Henriot have been used in practice for biological control of pests in pepper production. (Topakcı and Kececi, 2017). However, the usage biological control method for pepper production at the greenhouse has not been effective due to obsolete greenhouses and more so the insignificant result it's able to achieve (EC, 2013). Biological control applications in greenhouse crop production result in maximum economic returns and sustainable pest control leading to no harmful effects on human health and the environment (FAO, 2017). To realize this, supportive and enabling policies together with institutions are required. For this reason, the Ministry of Agriculture and Forestry (MAF) in Turkey has provided an area-based support to greenhouse growers. The ministry subsidy for growers introducing biological control agents in greenhouse production is 3 500 TL and those using sticky traps and pheromones in greenhouses is 1 100 TL per hectare (1US dollar was equal to 3.65 Turkish Lira as at 2017) (TOJ, 2017). Growers who are not registered to

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Table 1: The result of the chi-square test analysis according to selected personal characteristics of the growers and their information-seeking behavior

Characteristics	Biological control implemented farms		Biological control non-implemented farms	
	Mean	S.D	Mean	S.D
Age of grower (years)	43.76	7.65	53.24	10.08
Level of education (years)	8.07	3.17	6.12	0.72
Greenhouse growing experience (years)	22.07	7.35	30.93	10.03
Biological control experience(years)	4.10	1.28	-	-
Household size	4.50	0.83	4.55	1.09
Number of employees worker	4.00	1.72	3.67	1.56
The rate of farm association membership	97.62	-	47.62	-
The rate of grower working non-agricultural	11.90	-	21.43	-
The rate of agricultural credit use	11.90	-	2.38	-
The rate of internet use	76.19	-	38.10	-
Size of the greenhouse (hectare)	0.61	0.35	0.37	0.18
Number of greenhouses	3.50	1.49	2.95	1.03
Pepper production (tons/farm)	78.06	53.61	34.24	19.36
Pepper yield (ton/hectare)	131.70	20.04	93.60	15.10

Greenhouse Registration System (GRS) cannot apply for the support of biological control. Biological controlled areas have increased after government subsidy of the biological control expenditures of growers; these areas reached 1 270.1 ha in 2015. Currently, biological control fields constitute about 5% of the total protected areas in Antalya.

The aim of this study was to compare the attributes of participant and non-participant greenhouse farmers in government-subsidized biological control practices in pest management of greenhouse pepper cultivation for sustainable food production in the Mediterranean coastal region of Turkey.

Materials and Methods

Experimental site: The study area was confined to Kaş district of Antalya province in the Mediterranean Coastal Region of Turkey. Antalya province is one of the most important greenhouse production regions in Turkey. Kaş district was purposively selected for the study because it has the largest number of greenhouse sweet pepper growers, and the government supported biological control project was first introduced in Kaş. It is situated in the westernmost part of Antalya province between mountains and the Mediterranean Sea (Figure 1). The climate is warm and temperate. The winter months are much rainier than the summer months. Annual average temperature and total rainfall are 18.3 °C and 909mm, respectively. The driest month is August, with an average of just 2mm precipitation. Most of the precipitation falls in January, averaging 221 mm. With an average of 26.5 °C, July is the warmest month. January is the coldest month, with temperatures averaging 11.0 °C. The population shows a remarkable demographical increase in recent years. District centre population increases while village populations are constant. Kaş population of around 7 000 inhabitants and increases to about 20 000 people during the summer season. The economy in the district of Kaş is dominated by greenhouse production, tourism and fishing. Greenhouse production strikes as the main occupation of the local workforce thus the main revenue-generating activity for local livelihoods. The production is mainly characterized by out of season vegetables and especially green peppers. In 2017 total green pepper production was 32 430 tonnes produced on 324.3 ha in greenhouse pepper area in Kaş district. The green pepper produced in Kaş district meets 14.6 % of Antalya's province total production. (TURKSTAT, 2017).

Data Collection: Purposive sampling technique was used for the sample selection of this study. The main goal of purposive sampling was to focus on the characteristics of a population that were of interest and best enable the answering of the research questions. A well-structured questionnaire was developed and administered to farmers via face-to-face interview. Simple random sampling method was used to determine the sample size of the research (Yamane, 2001) Sampling size was determined using Eq. 1. According to calculations, the sample size was determined as 84 growers, the sample size representing the area;

$$n = \frac{N * S^2 * t^2}{(N-1) * d^2 + S^2 * t^2} \qquad \text{(Eq 1)}$$

Where, n= Sample size; s= Standard deviation; t= t value with 95% confidence interval (1.96), N= Total number of farms in the sample population and, D= Acceptable error (5% deviation).

Data Analysis

All data collected from the study were analysed using SPSS (version 19) software. Moreover, descriptive statistics (frequencies, percentages, means, and standard deviations) were used for data analysis to accomplish the objectives of the study. Also, the chi-square test was used to ascertain the relationship between participant and non-participant farmers in the biological control practices. The differences between the groups depending on the normality of the data and selected variables were also to establish. The chi-square (χ2) test statistics is given in formula (Eq.2) (Koseoglu and Yamak, 2008).

$$\chi^2 = \Sigma_{ij} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \qquad \text{(Eq 2)}$$

Where:

X^2 =calculated chi-square value

O_{ij}= observed frequency value

E_{ij}= expected frequency value

Results and Discussion

General characteristics of the farms

The mean age of the growers in biological control implemented farms is 43.8 years and non-implemented farms 53.2 years. This confirms what is commonly said that the age of the growers in biological control implemented farms is younger compared to the non-implemented farms. With respect to experience in greenhouse growing, the participants had, on average, 22.1 years of experience in biological control implemented farms and non-implemented farms are 30.9 years. Also, the participants had, on average, 4.1 years of experience in biological control. The size of the greenhouse in biological control implemented farms was 0.61 ha, higher than (0.37 ha) in the non-implemented farms. The educational level of growers in the biological control implemented farms was higher compared to non-implemented farms. The rate of internet use of growers in biological control implemented farms was 76.2%, higher than the rate (38.1%) in the non-implemented farms. The yield of pepper in biological control implemented farms (131.7 t ha-1) is higher compared to that grown the non-implemented farms (93.6 t ha-1). The rate of farmer uses agricultural credit in biological control implemented farms was 11.9%, higher than the rate (2.4%) in the non-implemented farms.

Personal characteristics of the farmers: Result of the chi-square test

Table (2) shows that chi-square (χ2) test revealed a relationship between the two groups and by selected personal characteristics of the farmers and their information-seeking behaviour in greenhouse cultivation. With respect to the farmers age ($p \leq 0.01$), educational level ($p \leq 0.05$), retirement status ($p \leq 0.10$), greenhouse farming experience ($p \leq 0.01$), engagement in agricultural extension activities ($p \leq 0.05$), internet use ($p \leq 0.01$), farmers association membership ($p \leq 0.01$) and agricultural credit use by farmers ($p \leq 0.10$), the result of the statistical analyses showed a significant relationship between the growers who applied the biological control practices and those who did not.

The above personal characteristics of the farmers also showed an increase in farmers' participation in government-subsidised biological control practices. This was an indication that the personal characteristics of the farmers influenced the farmers quest participate in the government sponsored biological control practices.

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Table 2: Results of chi-square showing relationships between groups by selected personal characteristics

Characteristics	Biological control implemented farms		Biological control non-implemented farms		Total	
	N	%	N	%	N	%
Personal characteristics						
Age of the grower						
Younger than 45	22	52.38	10	23.81	32	38.10
45 and older	20	47.62	32	76.19	52	61.90
$\chi 2 = 7.269$, $p \leq 0.01$						
Educational level						
Primary school	19	45.24	34	80.95	53	63.10
Middle school	8	19.05	2	4.76	10	11.90
High school or university	15	35.71	6	14.29	21	25.00
$\chi 2 = 3.896$, $p \leq 0.05$						
Family population (person)						
1-5	20	47.62	20	47.62	40	47.62
5 and over	22	52.38	22	52.38	44	52.38
$\chi 2 = 0.000$, $p = 1.000$						
Retirement status of grower						
Yes	1	2.38	5	11.90	6	7.14
No	41	97.62	37	88.10	78	92.86
$\chi 2 = 2.872$ $p \leq 0.10$						
Status non-agricultural income of growers						
Yes	5	11.90	9	21.43	14	16.67
No	37	88.10	33	78.57	70	83.33
$\chi 2 = 1.371$, $p = 0.242$						
Greenhouse growing experience (year)						
Less than 25	23	54.76	11	26.19	34	40.48
25 and over	19	45.24	31	73.81	50	59.52
$\chi 2 = 7.115$, $p \leq 0.01$						
Farm Association Membership						
Yes	41	97.62	20	47.62	61	72.62
No	1	2.38	22	52.38	23	27.38
$\chi 2 = 26.403$, $p \leq 0.01$						
Farm records keep						
Yes	32	76.19	30	71.43	62	73.81
No	10	23.81	12	28.57	22	26.19
$\chi 2 = 0.246$, $p = 0.620$						
Agricultural credit use						
Yes	5	11.90	1	2.38	6	7.14
No	37	88.10	41	97.62	78	92.86
$\chi 2 = 2.872$, $p \leq 0.10$						
Information-seeking Behavior						
Participation to agricultural extension						
Yes	6	14.29	1	2.38	7	8.33
No	36	85.71	41	97.62	77	91.67
$\chi 2 = 3.896$, $p \leq 0.05$						
Internet use						
Yes	32	76.19	16	38.10	48	57.14
No	10	23.81	26	61.90	36	42.86
$\chi 2 = 12.444$, $p \leq 0.01$						
The aim of Internet use						
Agricultural	9	28.13	8	50.00	17	35.42
Agricultural and social media	23	71.88	8	50.00	31	64.58
$\chi 2 = 2.231$, $p = 0.135$						

Table 3: Results of chi-square showing relationships between groups by selected personal characteristics

Characteristics	Biological control implemented farms		Biological control non-implemented farms		Total	
	N	%	N	%	N	%
Greenhouse size (hectare)						
0.1-0.4	19	45.24	22	52.38	41	48.81
0.4 and over	23	54.76	20	47.62	43	51.19
$\chi2 = 0.429$, $p = 0.513$						
Pepper yield (ton/hectare)						
1-120	7	16.67	38	90.48	45	53.57
120 and over	35	83.33	4	9.52	39	46.43
$\chi2 = 45.997$, $p \leq 0.01$						
Type of greenhouse covering						
Glass and plastic	6	14.29	1	2.38	7	8.33
Plastic	36	85.71	41	97.62	77	91.67
$\chi2 = 3.896$, $p \leq 0.05$						
Number of greenhouses						
1-3	13	30.95	15	35.71	28	33.33
3 and over	29	69.05	27	64.29	56	66.67
$\chi2 = 0.214$, $p = 0.643$						
Type of greenhouse ventilation						
Side and roof ventilation	38	90.48	27	64.29	65	77.38
Side ventilation	4	9.52	15	35.71	19	22.62
$\chi2 = 8.230$, $p \leq 0.01$						
Status of greenhouse insurance						
Yes	4	9.52	3	7.14	7	8.33
No	38	90.48	39	92.86	77	91.67
$\chi2 = 0.156$, $p = 0.693$						
Number of employees worker						
1-3	39	92.86	31	73.81	70	83.33
3 and over	3	7.14	11	26.19	14	16.67
$\chi2 = 5.486$, $p \leq 0.01$						
Crop production systems						
Double	21	50.00	7	16.67	28	33.33
Single	21	50.00	35	83.33	56	66.67
$\chi2 = 10.500$, $p \leq 0.01$						
Situation soil testing made by growers						
Yes	10	23.81	18	42.86	28	33.33
No	32	76.19	24	57.14	56	66.67
$\chi2 = 3.429$ $p \leq 0.10$						
Type of crop sell						
to trader	38	90.48	34	80.95	72	85.71
to exporter	4	9.52	8	19.05	12	14.29
$\chi2 = 1.556$, $p = 0.212$						

Characteristics of the farms: Result of the chi-square test

The table (3) shows the chi-square ($\chi2$) test results relationship between the two groups (with and without biological control practices) and by selected characteristics of the farms in greenhouse production. The empirical evidence revealed that there was a significant relationship between the growers who applied biological control practices and those who did not in terms of yield of pepper ($p \leq 0.01$), type of greenhouse covering ($p \leq 0.05$), type of greenhouse ventilation ($p \leq 0.01$), number of workers ($p \leq 0.01$), crop production systems ($p \leq 0.01$) and condition of soil tested by growers ($p \leq 0.10$). This was an indication that farms in greenhouses with better condition and basic facilities was favourable for

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Table 4: Analysis of growers' beliefs and opinions about the application of biological control

Statements	Mean
Reduce pesticide use	4.83
Useful for human health	4.72
Better quality products are produced	4.32
Increase crop productivity	3.69
Products are more easily marketed	3.57
Useful for the environment and natural enemies of pests	3.52
Reduce production costs	3.22
Products are sold at a higher price	2.71

Likert scale: 1 = strongly disagree, 5 = strongly agrees

the success of biological control practices subsidised by the government. This result also attests to the challenges faced by the ministry of agriculture and forestry that used to financially support biological pest control practices in the study area but was not successful as a result of the poor nature of the greenhouses which were used (EC, 2013).

Growers' opinion and perception on biological control
Biological pest control practice is economical as compared to other methods of pest management however, its adoption and implementation in a new environment is slow (Bale et al, 2008). This could be because of many reasons of which this study revealed an economic reason. Nonetheless biological pest control practice is the prospect of pest management due to its sustainability, economical and ecologically friendliness (Sharma et al, 2013). Table (4) presents the results of questions asked the growers concerning their beliefs and opinions on the application of biological control practices in greenhouse production. Using Likert scale results, the study found out those growers had positive opinions about the application of biological control practices in greenhouse production. Most of the growers believed that application of biological control practices in greenhouse pepper production was beneficial economically (better quality products are produced, increase crop productivity, products are more easily marketed and reduction in production costs) and to the environment and human health (reduce pesticide use, useful for human health, useful for the environment and natural enemies of pests). The statistical analyses showed that contrary to the expectations, growers that had adapted biological pest control practices could not sell their pepper at a higher price (mean: 2.71).

Conclusions

The biological control can play an important role in achieving the goal of sustainable agriculture in research area. Biological pest control method is an accepted innovation among greenhouse farmers in Kaş district even with its shortcomings. However, creating more awareness to farmers in greenhouse production and lots of government investment in biological control practices is significant for food safety, sustainable agriculture, easy access to international market, minimum risk to human health and favourable environment. To achieve this, more research is needed in terms of the effects of government supported policies implementation and its practicality to influence the full acceptance of biological pest control by farmers in Turkey. Also, growers must be educated on the importance of biological control practices of pest management and sustainable greenhouse production practices. The training should be focused on minimizing environmental risks, safe food production, the use of sustainable farming techniques, maximizing the effects of beneficial organisms and identification of natural enemies in biological pest control practices. Agricultural extension agencies and subsidy policy of governments are needed in motivating the growers if the expansion of biological control practices is to be realised.

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Conflict of Interests

The authors hereby declare that there are no conflicts of interest.

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