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AN ANALYSIS ON FACTORS INFLUENCING GOVERNMENT SUPPORTED BUMBLE BEES USE AS POLLINATORS BY GREENHOUSE PRODUCERS' IN THE MEDITERRANEAN COASTAL REGION OF TURKEY

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Abstract. The main objective of this study was to determine the factors affecting the government supported bumble bees use as pollinators by greenhouse producers in the Mediterranean Coastal Region of Turkey. The data used in this study were collected from growers by using a face to face survey. To this end, data was obtained by using simple random sampling method in 80 greenhouse farms in Antalya province. The data were analyzed with the chi-square test which was used to test relationship between variables. The result of the analyses showed that there is a significant relationship between the farms using and non-using bumble bee, considering status registered for greenhouse of farmer, type of growing, type of greenhouse ventilation and the number of people working in greenhouse. Furthermore, the most of farmers believed that use of bumble bees as pollinators in greenhouse tomato production is beneficial. These benefits include the effect of environment and human health and also the economic (marketing, higher price, higher yield, reducing pesticide use and labor use).

Key words: greenhouse production, bumble bees use, subsidy policy, Turkey

INTRODUCTION

Horticultural production is an important part of the agricultural sector in Turkey. Turkish greenhouse production continues to show very fast expansion. In 2003 total greenhouse area was 48 324 ha of which 7011 ha was under glass and 41 313 ha was under plastic. In 2013 total greenhouse area was 61 512 ha of which 8073 ha was under glass and 53 439 ha was under plastic. In 2003 total greenhouse area was 17 131 ha of which 5590 ha was under glass and 11 541 ha was under plastic in Antalya Province. In

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2013 total greenhouse area was 23 980 ha of which 6644 ha was under glass and 17 344 ha was under plastic [TURKSTAT 2014]

Total greenhouse vegetable and fruit production was 6.2 million tons produced on 61 512 ha. About 51.0% of total vegetable production was tomato. Total tomato production was 11.8 million tons in Turkey. About 27.1% of total tomato production was greenhouse tomato [TURKSTAT 2014].

Antalya province is one of the most important agricultural production areas and also, is the center of greenhouse vegetable production in Turkey. Total greenhouse tomato production was 2.1 million tons in Antalya province. Antalya's share in the total greenhouse tomato production of Turkey is 66.6% [TURKSTAT 2014]. Tomato production dominates in the total greenhouse vegetable production. Greenhouse production contributes significant income, employment and export opportunities in Antalya province.

The role of bumble bees in pollination of natural and cultivated plants has been known for a longer time. However, the use of bumble bees as pollinator in glass and plastic greenhouses and rearing bumble bees colonies in captivity for year-round has been introduced in the recent years [Sıralı et al. 2012]. Proper pollination is necessary for optimal fruit set and production. In the past, greenhouse tomato growers have relied on manual pollination, which takes long time to consume. Using bumble bees for pollination is an effective alternative and can completely replace manual pollination. Bumble bees are used, such as tomatoes, peppers, eggplants, melons, raspberries, blackberries and blueberries. In addition bumble bees pollination has many advantages. These advantages are, being active at low temperatures, windy and cloudy conditions, having higher quality and yields fruit in crops, and saving labor in greenhouse [Smith-Heavenrich 1998, HortReport 2002].

Bumble bees are one of the most ecologically and economically important groups of pollinators in temperate regions [Potts et al. 2010]. Commercial suppliers produce bumble bees year-round in both eastern North America and western North America largely for pollinating greenhouse tomatoes [Dogterom et al. 1998]. In the last years the use of bumble bees colonies is more and more widespread in the pollination of protected crops. The results indicated that bumblebees could be used successfully in greenhouses for tomato plant pollination. Bumblebee-pollinated tomatoes gave higher yield, higher number of seeds, better weight-size correlation, higher specific gravity and higher fruit firmness than other pollinating agents; plant growth bio-regulator and plant vibration [Morandin and Winston 2003].

Horticultural sector is characterized by a strong increase in production in the last 20 years in Turkey. In recent years, it has been interested widely for agricultural system in terms of ecological, economic and social sustainability aspects from production to consumption. With the increase of consciousness level related to environment and health in societies, the interest on healthy food has increased. Also, the importance of bumble bees for the pollination of many high-value crops has led to the commercial production. For these reasons, Ministry of Food, Agriculture and Livestock [MAFA] has supported using of bumble bees as pollinators in greenhouse production in Turkey since 2005 in order to ensure greenhouse production activities economically and increase using of bumble bees [Turkish Official Journal 2005]. Subsidy is given for bumble bees using in greenhouse production. A subsidy of €20.76 was paid per colony to farmers who use

bumble bees for pollination in greenhouse production in 2013 year [Turkish Official Journal 2013]. Payments would be done directly to farmers in cash or by transferring to their bank accounts. Farmers who are not registered to Greenhouse Registration System (GRS) can not apply for the support of bumble bees use. Since the beginning of the 2005, bumble bees use has increased approximately two-fold in greenhouse production in Turkey by reason of the bumble bees use subsidy. Also, rapid increase has been shown in the use of bumble bees in greenhouses, while number of colonies were 15 000 in 2001 and reached 200 000 in 2013 year. There is an approximately 13.33 fold increase in number of bumble bees colonies [MAFA 2013].

Bumble bees have been the subject of many important studies in the world, including research on foraging behavior, floral resource competition, pollination, crop yield, economic and its commercial production. Many studies have been made on bumble bees use as pollinators by producers in greenhouse tomato production in many different countries and Turkey [Heinrich 1979, Banda and Paxton 1991, Kevan et al. 1991, Ravestijn et al. 1991, Ravenstijn and Sande 1991, Abak et al., 1995, Dogterom et al. 1998, Ateş 2000, HortReport 2002, Yılmaz et al. 2002, Al-Attal et al. 2003, Morandin and Winston 2003, Velthuis and Doorn 2006, Karaman and Yılmaz 2007, Goulson and Darvill 2008, Survilienė et al. 2009, Gradish et al. 2010, Potts et al. 2010, Gurel et al. 2011, Sıralı et al. 2012] But, this study examined for the first time the factors affecting the government supported bumble bees use as pollinators by greenhouse producers.

Fig. 1. Bumble bee and bumble bee pollinating tomato blossom

MATERIALS AND METHODS

This study was carried out in Antalya province (fig. 2), in the south-west of Turkey within 36º87’ and 37º26’ north latitude and 29º17’and 32º44’ east longitude. Different geographical and climatic characteristics and very favorable ecological conditions increase the variety of crop patterns and greenhouse farms have a very important economical value in the province. Greenhouse farming is mostly concentrated on the south coast of the region. In this area, the coast line plains are surrounded by the Taurus Mountains in the north and by the Mediterranean Sea in the south. A typical Mediterranean climate is seen in the region with dry and hot summers and rainy and mild winters. Annual average temperature and total rainfall are 18.2ºC and 971.7 mm, respectively.

Fig. 2. Research area

Antalya province was chosen as a representative of the Turkish greenhouse industry since it where greenhouse growing is one of the most common economic activities is the centre of greenhouse tomato production in Turkey. Data about the number of farmers growing tomato in greenhouse were obtained from the Food, Agriculture and Livestock Directorate of Antalya. 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, sample size was determined as 80 farmers, the sample size representing the area.

$$n = \frac{N \cdot S^2 \cdot t^2}{(N-1) \cdot d^2 + S^2 \cdot t^2} \tag{1}$$

Where:

n – sample size;
s – standard deviation;
t – t value with a 95% confidence interval (1.96),
N – total farm number in the sample population,
d – acceptable error (5% deviation).

The data used in this study were collected from farmers growing single and double crop tomato in greenhouse. The greenhouse tomato producers were interviewed personally with a questionnaire aimed at analysis of factors influencing use of bumble bees as pollinators. The data were collected in January 2014 with 80 randomly selected greenhouse tomato producers in Antalya province, Serik and Aksu districts and 11 villages in these districts.

Data Analysis. This research was carried out with 80 farmers; collected data was divided into two groups as 58 farmers were using bumble bees and 22 farmers were non-using bumble bees analyzed accordingly. After data collection, the questionnaires were cleaned for errors made during data collection. Summarized and coded data were put into the computer after which analysis of quantitative data was done using the Statistical Package for Social Sciences (SPSS). For objectives of this study, descriptive statistics, namely percentages, means and standard deviation were used to understand the nature of the sample. Chi-square test was used to determine the relationship between the independent variables and the dependent variable. The chi-square (χ^2) test statistic is given in formula (eq. 2) [Koseoglu and Yamak 2008].

$$\chi^2 = \sum_{ij} \frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}} \tag{2}$$

Where:

χ^2 – calculated chi-square value,
O_{ij} – observed frequency value,
E_{ij} – expected frequency value.

In addition to, the farmers' opinions and beliefs about bumble bees use were measured using a likert scale. Farmers chose the following answers which are classified as "5 = strongly agree, 4 = agree, 3 = not sure, 2 = disagree, 1 = strongly disagree".

RESULTS AND DISCUSSION

General characteristics of the farms. Comparing the socioeconomic characteristics of bumble bees used and non-used farms is to understand the nature of the sample. Some basic characteristics of the sampled farms are presented in Table 1. Farm operators averaged year is 44.02 years old for the bumble bees used farms and that of bumble bees non-used farms is 48.32 years. Their experience in greenhouse tomato production was vast in both farms. The educational level of farmers in the bumble bees used farms was higher compared to bumble bees non-used farmers. Sample bumble bees used farms size of the greenhouse was 0.57 ha. On average, they received €16 860.19 of farm income per farm. In contrast, bumble bees non-used farms had 0.55 ha of greenhouse and they received less farm income than bumble bees used farms. The average size of farm family in bumble bees used farms was 5.14 people, higher than the average (4.59 people) in bumble bees non-used farms. The yield of tomato in the bumble bees used farms (108.80 t ha^{-1}) is higher compared to bumble bees non-used farms (94.30 t ha^{-1}). The amount of exported tomato in the bumble bees used farms (16.86 t farm^{-1}) is higher compared to bumble bees non-used farms (12.50 t farm^{-1}). The cost of pesticide used in the bumble bees used farms (€2 848.72 ha^{-1}) which are lower compared to bumble bees non-used farms (€3 231.29 ha^{-1}).

Table 1. Basic characteristics of bumble bees used and bumble bees non-used farms in greenhouse tomato production: descriptive statistics

Characteristics		Bumble bees used farms (N = 58)		Bumble bees non-used farms (N = 22)	
		average	standard deviation	average	standard deviation
Personal characteristics	education level of farmers (year)	7.59	3.79	6.86	3.38
	the age of the farmers (year)	44.02	12.14	48.32	11.72
	experience of farmers (year)	15.45	8.08	15.14	8.74
	family population (person)	5.14	1.55	4.59	1.33
Farm characteristics	farm income (€/farm)	16 860.19	9057.41	16 496.60	11 074.40
	the number of people working in greenhouse (person/farm)	5.69	2.10	5.05	2.68
	total size of greenhouse (ha)	0.57	0.27	0.55	0.38
	size of glass greenhouse (ha)	0.35	0.21	0.25	0.23
	size of plastic greenhouse (ha)	0.22	0.26	0.29	0.23
	number of greenhouse (number/farm)	2.95	1.29	2.59	1.59
	tomato production (tones/farm)	66.78	45.87	50.68	31.69
	tomato yield (tones/ha)	108.80	170.20	94.30	208.90
	amount of exported tomato (tones/farm)	16.86	33.24	12.50	22.13
	amount of government subsidy received by farmer (€/farm)	66.27	62.56	51.02	67.01
	cost of pesticide use (€/ha)	2848.72	1441.96	3231.29	2491.85

The result of the chi-square test analysis according to selected personal characteristics of the farmers and their information-seeking behavior. Table 2 shows that chi-square (χ^2) test of relationships between farmers both bumble bees used and bumble bees non-used farms in greenhouse tomato production and their selected personal characteristics of the farmers and their information-seeking behavior. It was found that 72.50% of the bumble bees used farms while 27.50% of the bumble bees non-used farms in greenhouse tomato production. In another study, this rate was found as 62.25% and 37.75% respectively [Engindeniz et al. 2008].

The study results show that according to χ^2 test applied to find out whether there are any differences in the personal characteristics of farmers' and their information-seeking behavior both government supported bumble bees used and non-used farms, it was found out that there is a significant relationship among the only variable of status registered for greenhouse of farmer. On the other hand, it was found that there is not a significant relationship among the variables of age of farmers and education level, farmer's experience, family population, cooperative membership of farmer, status non-agricultural income of farmer, use of the internet, reading printed materials and participation of farmers in extension activities (tab. 2).

Table 2. Results of chi-square (χ^2) showing associations between using bumble bees of farmers with information-seeking behavior and the selected personal characteristics of the farmers

	Characteristics	Bumble bees used farms (N = 58)		Bumble bees non-used farms (N = 22)		χ^2	*P*
		n	%	n	%		
Personal characteristics	age (year)					1.88	0.39
	23–40	24	41.38	6	27.27		
	41–60	27	46.55	14	63.64		
	61 and over	7	12.07	2	9.09		
	education					0.19	0.65
	primary or middle school	42	72.4	17	77.3		
	high school or university	16	27.6	5	22.7		
	experience (year)					0.19	0.90
	1–5	6	10.3	3	13.6		
	6–14	23	39.7	8	36.4		
	15 and over	29	50.0	11	50.0		
	family population (person)					1.42	0.23
	1–3	7	12.07	5	22.73		
	4 and over	51	87.93	17	77.27		
	cooperative membership of farmer					0.14	0.70
	yes	47	81.03	17	77.27		
	no	11	18.97	5	22.73		
	status non-agricultural income of farmer					0.03	0.85
	yes	25	43.10	10	45.45		
	no	33	56.90	12	54.55		
	status registered for greenhouse of farmer					2.69	0.10*
	registered	33	56.90	8	36.36		
	non-registered	25	43.10	14	63.64		
Information-seeking behavior	use of the internet					0.00	0.93
	yes	19	32.76	7	31.82		
	no	39	67.24	15	68.18		
	reading printed materials					0.58	0.44
	yes	42	72.41	14	63.64		
	no	16	27.59	8	36.36		
	participation of farmers in extension activities					0.03	0.85
	yes	7	12.07	3	13.64		
	no	51	87.93	19	86.36		

* $p < 0.10$

Table 3. Results of chi-square (χ^2) showing associations between using bumble bees of farmers and growing characteristics of the farm

Farm characteristics	Bumble bees used farms (N = 58)		Bumble bees non-used farms (N = 22)		χ^2	*P*
	n	%	n	%		
Farm income					0.54	0.76
Less than €10 000	14	24.14	7	31.82		
€10 000–€19 999	28	48.28	9	40.91		
€20 000 and above	16	27.59	6	27.27		
Size of greenhouse (ha)					0.90	0.63
0.2–0.3	15	25.86	8	36.4		
0.4–0.7	29	50.00	9	40.9		
0.8 and over	14	24.14	5	22.7		
Number of greenhouse					2.91	0.23
1	5	8.62	5	22.73		
2–3	35	60.34	11	50.00		
4–7	18	31.03	6	27.27		
Type of greenhouse					1.73	0.42
Glass	52	89.66	15	68.18		
Plastic	32	55.17	16	72.73		
Glass and Plastic	26	44.83	9	40.91		
Season of growing						
Single crop	54	93.10	17	77.27	4.00	0.04**
Double crop (fall and spring cropping)	4	6.90	5	22.73		
Type of seedling used					0.01	0.89
Grafted	43	74.14	16	72.73		
Non-grafted	15	25.86	6	27.27		
Type of greenhouse ventilation					19.58	0.00***
Sidelong	10	17.2	15	68.2		
Overhead	8	13.8	2	9.1		
Sidelong and overhead	40	69.0	5	22.7		
Situation soil testing made by farmers					1.64	0.19
Yes	22	37.93	5	22.73		
No	36	62.07	17	77.27		
The aim of growing tomato					0.09	0.76
Foreign marketing	19	32.76	8	36.36		
Domestic marketing	39	67.24	14	63.64		
Form of crop marketing					0.31	0.57
Middleman	48	82.76	17	77.27		
Selling directly to exporters	10	17.24	5	22.73		
The number of people working in greenhouse (person/farm)					7.09	0.02**
1–4	15	25.86	12	54.55		
5–7	34	58.62	6	27.27		
8 and over	9	15.52	4	18.18		
Use foreign labor in greenhouse					1.72	0.19
Yes	43	74.14	13	59.09		
No	15	25.86	9	40.91		

*** $p < 0.01$, ** $p < 0.05$

The result of the chi-square test analysis according to characteristics of farm and growing practices of farmer in greenhouse tomato production. Table 3 shows that chi-square (χ^2) test of relationships between farmers both bumble bees used and bumble bees non-used farms in greenhouse tomato production and their selected farm characteristics of the farmers and their growing practices. The study results show that χ^2 test applied to find out whether there are any differences in the farm characteristics and growing practices of bumble bees used and non-used farms. It was observed that there is a significant relationship among the variables of season of growing, type of greenhouse ventilation and the number of people working in greenhouse. Another study found that there is a significant relationship for yield of tomato, knowledge level of farmers about bumble bees using and adoption level of new production technologies of farmers between farmers both bumble bees used and bumble bees non-used farms in greenhouse tomato production [Karaman and Yilmaz 2007]. On the other hand, it was found that there is no significant relationship for farm income, size of greenhouse, number of greenhouse, type of greenhouse, type of seedling used, situation soil testing made by farmers, the aim of growing tomato, form of crop marketing and use foreign labor in greenhouse variables (tab 3).

Table 4. Farmers' beliefs and opinions on bumble bees use

Statements	Mean	Standard deviation
Friendly to the environment and human health	4.93	0.78
The products more preferred in market	4.84	0.72
Have better quality of products	4.69	0.69
Products is more healthier	4.58	0.54
Products are sold at higher prices	4.25	0.95
Increasing tomato crop yields	3.72	1.35
Reducing pesticide use saves money	3.46	1.42
Reducing labor use saves money	3.28	1.64

Understanding beliefs and opinions farmers towards use of bumble bees in growing greenhouse tomato. Table 4 shows that beliefs and opinions towards use of bumble bees of government supported bumble bees used farmers. This study found that according to likert scale results; farmers' have positive opinions about bumble bees use. Also, the most of farmers believed that use of bumble bees as pollinators in greenhouse tomato production is beneficial. These benefits include the effect of environment and human health and also the economic (marketing, higher price, higher yield, reducing pesticide use and labor use). Other studies reported similar scientific findings on beliefs on bumble bees use and impact of bumble bees use farmers' in greenhouse production [Engindeniz et al. 2008, Karaman and Yılmaz 2007].

CONCLUSIONS

The main objectives of this study were to determine the factors affecting the government supported bumble bees use as pollinators by greenhouse producers in the Mediterranean Coastal Region of Turkey. Based on qualitative and quantitative analyses presented in this study, it can be drawing the following conclusions and recommendations.

The results revealed that there is a significant relationship between the farms using and non-using bumble bee, considering status registered for greenhouse of farmer, season of growing, type of greenhouse ventilation and the number of people working in greenhouse. On the other hand, most of farmers believed that use of bumble bees as pollinators in greenhouse tomato production is beneficial. Because the government supported policies applied for bumble bees use in greenhouse production in Turkey, using bumble bees has increased. The aid proposals will be formulated due to the results of the above mentioned analysis, which should contribute to support of greenhouse farms to increase the bumble bees use. Therefore, farmers training about bumble bees use should be given importance and extension programs should be improved in the research area. In addition to, bumble bees support policies and agricultural extension works on this supports should be continued. Consequently, improving of bumble bees use in greenhouse tomato production will further increase the contribution of the horticultural sector to rural development and the Turkish economy.

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ANALIZA CZYNNIKÓW WPŁYWAJĄCYCH NA WSPARCIE RZĄDOWE UŻYCIA TRZMIELI JAKO ZAPYLACZY PRZEZ PRODUCENTÓW WARZYW SZKLARNIOWYCH W ŚRÓDZIEMNOMORSKIM REJONIE TURCJI

Streszczenie. Głównym celem niniejszego badania było określenie czynników wpływających na wspierane rządowo użycie trzmieli jako zapylaczy w szklarniach śródziemnomorskich rejonów Turcji. Dane zostały zebrane od rolników przy użyciu bezpośredniej ankiety, a uzyskano je za pomocą metody losowej z 80 gospodarstw ze szklarniami w prowincji Antalya. Dane przeanalizowano za pomocą testu chi kwadrat, którego użyto w celu sprawdzenia związków między zmiennymi. Z analiz wynika, że istnieje istotny związek między gospodarstwami używającymi i nieużywającymi trzmieli, wziąwszy pod uwagę status zarejestrowanego rolnika, typ uprawy, typ wentylacji w szklarni oraz liczbę osób pracujących w szklarni. Ponadto większość rolników uważa, że użycie trzmieli jako zapylaczy w szklarniowej produkcji pomidora jest korzystne. Korzyści dotyczą wpływu na środowisko, zdrowie człowieka, a także kwestii ekonomicznych (marketing, wyższa cena, większy plon, mniejsze użycie pestycydów oraz siły roboczej).

Słowa kluczowe: produkcja szklarniowa, użycie trzmieli, polityka dotowana, Turcja

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