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AN ECONOMIC COMPARISON OF PESTICIDE APPLICATIONS FOR PROCESSING AND TABLE TOMATOES: A CASE STUDY FOR TURKEY

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Abstract: In many circumstances, pesticides are the only effective means of controlling disease organisms, weeds, or insect pests. Yet, pesticides are toxic and potentially hazardous to humans, other animals and organisms, and the environment. Therefore, people who use pesticides or regularly come in contact with them must understand the relative toxicity, potential health effects, and preventative measures to reduce the exposure to the products they use. Today, farm-level costs include the costs of the pesticides, and their application. This study was conducted to analyse the farm-level economics of pesticide use on the processing and table tomato growing in selected regions of Turkey. Data was collected from 59 processing tomato farmers and 30 table tomato farmers. These farmers were willing to have their data recorded. According to the results of the study, the average usage concerning the active ingredient of pesticides for the processing and table tomatoes were 4,825.02 and 5,273.86 g/ha. Average pesticide and pesticide application costs of the processing and table tomatoes were determined to be $445/ha and $502/ha, respectively. The breakeven yields for the processing and table tomatoes were calculated to be 3,708 and 3,138 kg/ha, repectively.

Key words: economic feasibility, input use, pesticide, pesticide economics, tomato growing

INTRODUCTION

Originating in South America, the tomato (*Lycopersicon esculentum)* was spread around the world following the Spanish colonization of the Americas. Many tomato varieties are now widely grown, often in greenhouses in cooler climates. The tomato fruit is consumed in diverse ways, including consuming it raw – as an ingredient in many dishes, sauces, and drinks. While it is botanically a fruit, it is considered a vegetable for culinary purposes, which has caused some confusion. The fruit is rich in lycopene, which may have beneficial health effects.

Successful crop production requires that crop pests and diseases be managed so that their effects on the plants are minimized. The management of crop diseases is directed at preventing the establishment of diseases and minimizing the development and spread of any diseases that become established in the crop. Managing pest problems is directed at preventing pest populations from becoming too large and uncontrollable. The presence of pests and diseases are a fact of crop production. Growers must use all available options and strategies to avoid serious pest and disease problems (Savidov 2004).

Production of the processing and table tomatoes would be impossible without fungicides and insecticides to control diseases and insects. Preventative applications of pesticides must be made to avoid or reduce losses from diseases, insects, and weeds. Growers must meet quality standards set for tomatoes by each processor. Extreme damage from diseases and insects can render tomatoes unusable. High value products require tomatoes to be free from blemishes caused by diseases and insects and to be a u niform red color. Uneven color results from defoliation or heavy weed infestations. Tomatoes failing to meet quality standards for whole peel products may be used for lower value soft products (Janssen *et al*. 1999).

Chemical control forms the prime and foremost method for managing insect pests of agricultural and horticultural crops. Prolific use of chemical insecticides significantly curtailed the insect pests in the past but in due course it resulted in, insects developing resistance to insecticides, environmental degradation, and an increase in the cost of cultivation. To overcome these unfavorable situations, Integrated Pest Management (IPM) strategies were advocated.

Recently, the Turkish Ministry of Food, Agriculture, and Animal Husbandry has encouraged IPM in the region. Yields of the processing and table tomato may be reduced by a myriad of insect and diseases pests. The IPM is a systems approach for reducing pest damage to tolerable levels using a variety of techniques such as natural enemies, genetically resistant plants, sound cultural practices, and when appropriate – chemical pesticides. The IPM approach is based on proper pest identification, periodic scouting, and on the application of pest management practices during the precise stage of the crop's development where a lack of control actions would result in significant economic losses (Engindeniz and Engindeniz 2006). The term, Integrated Pest Management, is used to

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describe an evolving process where cultural, biological, and chemical controls are included in a holistic approach of pest and disease control. Key components of effective pest and disease control programs include: sanitation, crop monitoring, cultural control, resistant cultivars, biological control, and chemical control.

In recent years, many studies have included the economic analysis of pesticide applications for tomato growing in Turkey (Akgungor *et al*. 1999; Tanrivermis 2000; Koc *et al*. 2001; Karsavuran and Cetin 2002; Demirci *et al*. 2005; Engindeniz 2006; Hayirlioglu 2007). Similarly, many studies have included the economic analysis of pesticide applications for tomato growing in different countries of the world (Trumble *et al*. 1992; Walgenbach and Estes 1992; Clark *et al*. 1998; Taylor *et al*. 2001; Nault and Speese 2002; Yardım and Edwards 2003; Alimi and Ayanwale 2004; Hosamani 2009). Nonetheless, there is still need for study, especially at the farm-level.

The purposes of this study was to determine the amount and types of pesticides used on those processing and table tomato grown in Izmir, Turkey, and to analyse the farm-level economics of pesticide use. Growers' views toward using pesticides, growers' use of IPM practices, and pesticide use problems that the growers had, were also determined.

MATERIALS AND METHODS

Materials

This study was conducted in the Bergama, Torbali, and Odemis districts of Izmir, Turkey. Izmir is situated in the western part of Turkey between 38°15′N and 27 and 28°30′E. Izmir has a Mediterranean climatic. The entire river basin has rather similar average annual temperatures for the warmest month (July) and the coldest month (January). The annual precipitation is about 550 mm and the average relative humidity is 63%.

The Bergama, Odemis, and Torbali districts provide approximately 70% of the total tomato production of Izmir. Two villages were selected from every district for this study. The six selected villages were visited, and the number of tomato farmers was determined. The total number of farmers was 768. Instead of all the farmers taking part in the research, it was decided to use the sampling method. Using proportional sampling, the sample size was calculated as 86 farmers (Newbold 1995). The data were from the production period of 2008. The data were collected from 59 farmers growing processing tomatoes and 30 table tomato farmers who used pesticides on tomatoes growing in the field. In 2008, 59 farmers produced the processing tomatoes, and 30 farmers produced table tomatoes. Three farmers produced both the processing and table tomatoes. These farmers were willing to have their data recorded. Yield data and observations were recorded throughout the production period. Thus, income and expense data were collected on time.

Processing and table tomatoes were grown for the spring season production of 2008. Plants were transferred into the field in April, 2008. The farmers' processing tomato production area varied between 0.3 and 12 hectares. The average processing tomato production area was calculated to be 2.88 hectares. The farmers' table tomato production area varied between 0.5 and 17 hectares. The average table tomato production area was 3.76 hectares. Harvest started in June and continued until October, 2008. The processing tomato varieties grown were: Brixy, Alta, Shasta, Chicago, Chibli, and Hypeel. The table tomato varieties grown were Zeus, Selinus, Folcon, Epona, and Dona.

Methods

In this study, the cost items of processing and table tomato production was classified into variable costs and fixed costs. The variable costs associated with the growing of processing and table tomatoes were all inputs that directly related to the production of the processing and the table tomatoes, and which covered the costs of labor, fertilizer, pesticide, seedling, electricity, transport, *etc*. Variable costs were calculated by using current input prices and labor costs. Variable costs also included the interest on varaible costs. Interest on the total variable costs was calculated by charging a simple interest rate of 9% (annual savings deposits interest rates on the US dollar). But, the interest on the total variable costs was calculated for six months and the interest rate was 4.5%, since the tomato production and tomato marketing period were approximately six months.

In this study, fixed costs included administrative costs, land rent, keeper fee, and land tax. Administrative costs can be estimated to be 2–7% of the total gross production value or 3–7% of the total costs (Kiral *et al*. 1999; Mulayim 2001). In this study, administrative costs were estimated to be 3% of the total variable costs. This method was applied in most of the previous studies (Engindeniz 2006; Engindeniz and Engindeniz 2006; Engindeniz 2007; Engindeniz 2008). Fixed costs plus variable costs equal the total production costs. The total costs were subtracted from the total gross revenue to calculate the net revenue.

In this study, breakeven yield was also estimated for the production of the processing and table tomatoes. Breakeven analysis is a useful farm manegement tool because it allows for the calculation of various combinations of prices and yields to cover anticipated costs. Breakeven analysis can also be used to calculate the breakeven price or yield required to cover variable costs (short-term production decisions). If anticipated receipts are greater than anticipated variable costs, the enterprise should be continued. Any loss would be equal to some amount between the difference in the total costs (variable costs plus fixed costs) and variable costs. If the anticipated receipts are less than the variable costs, losses would be minimized by not continuing the enterprise. In this situation, losses would be limited to the amount of fixed costs that would have to be absorbed. The breakeven yield is the minimum yield required to cover all costs at the anticipated price per unit. The breakeven yield is computed as follows (Greaser and Harper 1994; Engindeniz and Engindeniz 2006):

breakeven yield = anticipated total costs/anticipated price

RESULTS

Pesticide applications

The sources of information which influenced farmers in their application of pesticides were very diverse. Pesticide dealers were the source of information for 59.3 and 56.7% of the processing and table tomato farmers. It also turned out that 13.6 and 16.7% of the processing and table tomato farmers rely on their own experience. The rest of the processing and table tomato farmers; 27.1 and 26.6%, had contact with neighbors, extension workers, mass media, and agricultural faculties, respectively. Mass media, *i.e.* extension literature and television/radio did not play an important role as an information source.

Age, education level, and the tomato growing experience of farmers all affected the use of pesticides in the growing of the processing and table tomatoes. Age, education level, and growing experience (in years) of the processing tomato farmers varied between 27 and 80,5, and 15,3 and 20, respectively. The average age, education level, and growing experience of farmers were 47.34, 6.48, and 9.02. Age, education level, and growing experience (in years) of table tomato farmers varied between 33 and 65,5, and 11,3 and 25, respectively. The average age, education level, and growing experience of farmers were 49.93, 6.25, 8.80.

Tomatoes are subject to attack by a large number of insect pests from the time the plants first emerge in the seed bed until harvest. Aphids, flea beetles, leafminers, and spider mites threaten young plant-bed tomatoes. In the field, flea beetles, aphids, leafminers, stink bugs, and fruitworms cause minimal damage to the foliage. However, severe damage may result either from their feeding on the fruit or from their spreading of certain diseases.

Some common tomato pests are stink bugs, cutworms, tomato hornworms and tobacco hornworms, aphids, cabbage loopers, whiteflies, tomato fruitworms, flea beetles, red spider mites, slugs, and Colorado potato beetles. When insects attack tomato plants, the tomato plants produce the plant peptide hormone – systemin, which activates defensive mechanisms, such as the production of protease inhibitors to slow the growth of insects. The hormone was first identified in tomatoes, but similar proteins have been identified in other species since.

Many diseases can affect tomatoes during the growing season. Important diseases of tomato include bacterial canker, bacterial spot, bacterial wilt, blossom-end rot, blotchy ripening or gray wall, catface, double streak virus, early blight, fruit cracks, fusarium wilt, gray leaf spot, late blight, puffiness, sclerotinia, powder mildew, tomato spotted wilt virus, and tobacco mosaic virus (Gleason and Edmunds 2006). Most fungus and virus diseases can be controlled with fungicides and proper sanitation and sterilization of soils. Several virus diseases and insects affect tomatos, but at the same time, several chemicals are available to control these pests.

The most frequent insect pests mentioned by farmers were white flies, tomato moth, cutworms, bollworms, wireworms, and aphids. The most frequent acar pests and fungus pests mentioned by farmers were spider mites and bacterial spot, fusarium wilt, early blight, and downy mildew, respectively.

The most commonly used insecticides were: diazinon (Basudin), imidacloprid (Confidor), chlorpyrifos-ethyl (Durspan), cyromazine (Trigard), spinosad (Laser), indoxacarb (Avaunt), acetamiprid (Neoplan), dichlorvos (Izol-DDVP), alphacypermethrin (Zeplin), and lambda-cyhalothrin (Caretta). The most commonly used fungicides were: metalaxyl+mancozeb (Ridomil), mancozeb (Manzep, Tri-miltox), propineb (Antrocol), copper oxychloride (Hektas), and copper salts of fatty and rosin acids (Tenn-Cop). Abamectin (Agrimec) was the most commonly used acaricide. Herbicides used were trifluralin (Treflan) and metribuzine (Sencor). Pesticides used on tomato and the amount of the active ingredients are given in table 1.

Two crop protection handbooks were prepared by the Turkish Ministry of Food, Agriculture, and Animal Husbandry, in 2002 and 2009 (Anonymous 2002; Karaca *et al*. 2009). Pesticides needed to be used, and appropriate pesticide amounts for different crops were made clear in these books. Then, a book for farmers about how to control pests and diseases of tomato was prepared by the Turkish Ministry of Food, Agriculture, and Animal Husbandry in 2011 (Anonymous 2011). Based on the recommendations in these books, tomato growing farmers appeared to use some pesticides to excess (Table 1); for example: chlorpyrifos-ethyl (Dursban), acetamiprid (Neoplan), diazinon (Basudin), lambda-cyhalothrin (Caretta), spinosad (Laser), imidacloprid (Confidor), metalaxyl mancozeb (Ridomil), and copper salts+mancozeb (Tri-Miltox).

Climatic conditions play a large part in whether the pest or disease is going to become a problem. The best way to manage the build up of pests and diseases is to practice IPM. The IPM is a sustainable approach for managing pests. It is an approach which combines biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. When it comes to tomato growing, IPM practices include crop rotation, scouting, and biochemical or microbial agents (Bauske *et al*. 1998; Anonymous 2008).

In this study, it was determined that some farmers used different IPM techniques. For example, 32 processing tomato farmers and 13 table tomato farmers used yellow sticky cards to prevent insects. To prevent problems, cultural techniques such as, soil testing and crop rotation were used by 43 processing tomato farmers and 19 table tomato farmers. But, nobody use a monitoring program, record keeping or biological controls.

The average usage per hectare concerning the active ingredients of insecticides, fungicides, herbicides, and acaricides in the processing and table tomato production was determined to be: 1,319.32 g and 1,435.72 g, 1,830.91g and 2,048.43 g, 1,526.64 g and 1,703.31 g, 148.35 g and 86.40 g, respectively. In a previous study done in Izmir, Turkey, the average usage per hectare concerning the active ingredients of insecticides, fungicides, acaricides, and herbicides was 228 g, 1,367 g, 9 g, and 1,007 g, respectively (Engindeniz 2006). In a study conducted in the South Marmara Region of Turkey, the average usage per hectare concerning the active ingredients of insecticides,

Table 1. Pesticide use on the processing and table tomatoes listed according to active ingredient pesticide type

	Pesticides	Active substance	% of active substance	What the pesticide was used for	Pesticide application area [ha]		Pesticides used [g/ha]*		Pesticides needed to be used [g/ha] *, **
					the processing tomato	table tomato	the processing tomato	table tomato	
Insecticide	Basudin 60 EM	diazinon	63	white flies, aphids	50.1	29.4	2,053.6	1,720.1	2,000
	Confidor SL 200	imidacloprid	35	white flies, aphids	26.8	22.5	1,186.5	1,025.1	1,000
	Dursban 25 WP	chlorpyrifos-ethyl	48	white flies, wireworms	20.3	16.9	2,051.6	2,023.4	2,000
	İzol-DDVP 550 EC	dichlorvos	55	white flies, aphids	9.8	12.7	1,858.5	1,922.5	2,000
	Caretta 5 EC	lambda-cyhalothrin	5	white flies, cutworms	13.0	9.5	562.4	526.8	500
	Laser	spinosad	48	tomato moth	15.2	7.4	188.3	202.8	200
	Avaunt	indoxacarb	7.2	tomato moth	18.7	15.8	387.2	391.5	400
	Neoplan 20 SP	acetamiprid	20	white flies, aphids	12.4	9.3	324.8	299.3	300
	Zepplin 100 EC	alphacypermethrin		cutworms, bollworms	17.8	8.7	458.7	472.5	500
	Trigard 75 WP	cyromazine	75	white flies, aphids	3.8	2.7	172.6	188.4	200
Fungicide	Antrocol WP 70	propineb	70	early blight, Fusarium wilt	87.6	55.8	1,749.2	1,509.1	2,000
	Hektas	copper oxychloride	50	downy mildew	15.3	20.1	2,567.9	2,878.7	3,000
	Ridomil Gold MZ 68 WP	metalaxyl+mancozeb	68	downy mildew	22.1	15.7	2,582.6	2,496.3	2,500
	Manzep M 45	mancozeb	80	downy mildew	9.8	6.6	748.3	787.5	800
	Tri-Miltox Forte	copper salts+mancozeb	41	downy mildew	8.5	5.6	1,276.4	1,258.4	1,200
	Tenn-Cop 5 E	copper salts of fatty and rosin acids	5.14	early blight, bacterial spot	23.8	19.5	1,821.5	1925.8,	2,000
Acaricide	Agrimec EC	abamectin (avermectin)	1.2	spider mites	152.4	99.5	165.8	97.9	250
Herbicide	Treflan	trifluralin	48	weed	126.3	89.2	2,001.5	1,882.6	2,000
	Sencor WP 70	metribuzine	70	weed	16.1	9.6	418.6	442.5	500

*active substance; **recommendations of Turkish Ministry of Food, Agriculture, and Animal Husbandry fungicides, and herbicides was 1,128 g, 465 g, and 680 g, respectively (Cetin and Vardar 2008). In studies done in Tokat and Canakkale, Turkey, the average usage per hectare concerning the active ingredients of fungicides and herbicides was 7,760 g and 1,200 g, 2,640 g and 450 g, respectively (Esengun *et al*. 2007; Turhan *et al*. 2008).

During pesticide applications, farmers should take measures in order to protect themselves. When the farmers in our study were asked whether they take any measures during the applications, 76.3 and 73.3% of the processing and table tomato farmers stated that they use personal protective equipment. They stated that they wear: only masks, both masks and gloves, mask and a protective costume or only a protective costume. They stated that they take some other measures, such as not smoking, wearing glasses, not eating or drinking, wearing protective head covering and boots, etc. When they were asked whether they take any particular measures after the application of pesticides, 88.1.% and 86.7% of the processing and table tomato farmers stated that they take certain measures. The measures they took after pesticide applications were: a bath and changing clothes or only eating yogurt.

The main problems of the processing and table tomato farmers concerning pesticide applications, were high pesticide prices, inefficient pesticides, lack of the pesticide subsidy, the farmers' education level, and low tomato prices and income.

Yield

The yield of the processing tomatoes varied between 55,000 and 125,000 kg/ha. The average yield was determined to be 71,740 kg/ha. The yield of table tomatoes varied beetween 45,000 and 110,000 kg/ha. The average yield was determined to be 67,092 kg/ha. There were no statistically significant differences between the processing and table tomatoes as determined by one-way ANOVA.

Tomato production per hectar varies from region to region in Turkey. For example: in similar studies done in Tokat, Ankara, Canakkale, Izmir and the South Marmara Region of Turkey, the average yield was determined to be 97,000 kg/ha (Esengun *et al*. 2007), 51,080 kg/ha (Tatlidil *et al*. 2005), 74,640 kg/ha (Turhan *et al*. 2008), 74,420 kg/ha (Engindeniz 2007), and 45,360 kg/ha (Cetin and Vardar 2008).

However, in similar studies done in Iran, Ghana, and Nigeria, the average yields were calculated to be 57,643 kg/ha (Moghaddam and Monda 2011), 53,000 kg/ha (Robinson and Kolavalli 2010), and 17,798 kg/ha (Adeniyi 2011), respectively.

Costs

Total costs of tomato production consist of variable and fixed costs. The average variable costs of the processing and table tomatoes were calculated to be $7,173/ha and $7,640/ha, respectively (Table 2). Labour and machinery costs, electricity costs, seed-seedling costs, and land rent formed 39.7, 15.3, 13.9, and 12.4% of the total production costs of the processing tomatoes, respectively. Labour and machinery costs, electricity costs, seed-seedling costs, and land rent formed 40.9, 13.9, 13.5, and 11.9% of the total production costs of table tomatoes, respectively. Pesticide and pesticide application costs formed 6.2 and 6.5% of the total production costs of the processing and table tomatoes, respectively.

In similar studies done in Tokat, Ankara, Canakkale, Izmir, and the South Marmara Region of Turkey, the total production costs and the share of pesticide costs in the total costs were $15,914/ha and 7.5% (Esengun *et al*. 2007), $6,203/ha and 2.3% (Tatlidil *et al*. 2005), $5,325/ha and 1.9% (Turhan *et al*. 2008), $3,410/ha and 3.8% (Engindeniz 2007), $3,471/ha and 10.2% (Cetin and Vardar 2008), respectively.

Marketing

Generally, the processing tomatoes are marketed to processing factories. Some farmers also market to dealers, brokers, wholesalers, and retailers. Table tomatoes are marketed to brokers, wholesalers, retailers, and fresh fruit-vegetable marketing cooperatives. On the other hand, for smaller farmers, direct sales at their farm, farmers markets, or at roadside stands are all viable options. The processing and table tomatoes are marketed in wood boxes, or in bulk.

In this study, 83% of the processing tomato farmers (49 farmers) produced on contract, for companies. The processing tomatoes were marketed to processing factories (79%), dealers-brokers (12.6%), wholesalers (8%), and farmers markets (0.4%). Table tomatoes were marketed to dealers-brokers (74.9%), wholesalers (22.4%), farmers markets (0.8%), and processing factories (1.9%).

The prices farmers received for the processing tomatoes varied between $0.05/kg and $0.15/kg. The average processing tomato price was calculated to be $0.12/kg. The prices that farmers received for table tomatoes varied beetween $0.11/kg and $0.29/kg. The average table tomato price was calculated to be $0.16/kg. There were statistically significant differences between the processing tomatoes and table tomatoes, as determined by one-way ANOVA.

Gross margin and net profit

The average gross margin and net profit obtained from the processing tomatoes was determined to be $2,513/ha and $1,436/ha, respectively. Furthermore, the average gross margin and net profit obtained from table tomatoes was determined to be $4,207/ha and $3,095/ha, respectively (Table 3). Under the circumstances, table tomato farmers have it better. But, they must endure a price and quality risk.

Breakeven yield

According to our results, the average pesticide and pesiticide application costs of the processing tomatoes and the average processing tomato price were $445/ha and $0.12/kg, respectively. Therefore, the breakeven yield was calculated to be 3,708 kg (445/0.12 = 3,708). This means that the increase in yield has to be 3,708 kg/ha for this pesticide to prove economical.

The average pesticide and pesiticide application costs of table tomatoes and the average table tomato price were $502/ha and $0.16/kg, respectively. Therefore, the break-

Table 2. Total costs of the processing and table tomato production ($/ha)

Cost items		The processing tomato	[%]	Table tomato	[%]
Labour and machinery costs	ploughing	620	8.7	667	8.7
	seedling production	93	1.3	101	1.3
	planting	362	5.0	361	4.7
	fertilization	137	1.9	145	1.9
	hoeing	425	5.9	455	6.0
	irrigation	137	1.9	152	2.0
	pesticide application	118	1.6	124	1.6
	harvest and packing	701	9.8	769	10.1
	transport	257	3.6	352	4.6
	total	**2,850**	**39.7**	**3,126**	**40.9**
Input costs	seed-seedling	998	13.9	1,031	13.5
	fertilizer	448	6.3	479	6.3
	pesticide	327	4.6	378	4.9
	peat	31	0.4	32	0.4
	viol	10	0.1	18	0.2
	electricity	1,097	15.3	1.064	13.9
	others	73	1.0	119	1.6
	total	**2,984**	**41.6**	**3,121**	**40.8**
Interest on variable costs		262	3.7	281	3.7
A. Total variable costs (1+2+3)		6,096	85.0	6,528	85.4
B. Fixed costs	administrative costs	183	2.5	196	2.6
	land rent	888	12.4	913	12.0
	keeper fee	4	0.1	–	–
	land tax	2	0.0	3	0.0
	total	**1,077**	**15.0**	**1,112**	**14.6**
Total costs (A+B)*		7,173	100.00	7,640	100.00

*difference is not statistically significant ($p > 0.05$)

Table 3. Gross margin and net profit obtained from the processing and table tomatoes

Items	The processing tomato	Table tomato
Production quantity (kg/ha)*	71,740	67,092
Average tomato price ($/kg)**	0.12	0.16
Gross production value ($/ha)	8,609	10,735
Variable costs ($/ha)	6,096	6,528
Total costs ($/ha)**	7,173	7,640
Gross margin ($/ha)	2,513	4,207
Net profit ($/ha)**	1,436	3,095

*difference is not statistically significant ($p > 0.05$)
**difference is statistically significant ($p < 0.05$)

even yield was calculated to be 3,708 kg (502/0.16 = 3,138). This means the increase in yield has to be 3,138 kg/ha for this pesticide to prove economical.

The breakeven yield for tomato growing was also calculated in previous studies done in different regions of Turkey. In studies done in Ankara (Nallihan), Izmir (Torbali), the Middle Sakarya River Basin, and the South Marmara Region, the breakeven yield was calculated to be 1,040 kg/ha (Tatlidil *et al*. 2005), 2,014 kg/ha (Engindeniz 2006), 1,367 kg/ha (Tanrivermis 2000), and 3,932 kg/ha (Cetin and Vardar 2008).

DISCUSSION

Many consumers often do not like to buy vegetables that show insect damaged or that have disease spots. For this reason farmers tend to use a lot of pesticides on vegetables from the beginning of the season. Using pesticides increases the cost of production. It is also harmful to the environment as well as leaving toxic residues on products. With the government campaign for a cleaner environment, there are other consumers who are more conscious about the vegetables they eat. Such consumers are willing to pay a higher price for slightly damaged vegetables because then it is clear that the use of pesticides was low, and so residues are low. For some time, vegetables have been grown with a high use of pesticides. But, consumers are becoming more and more aware of the effects of pesticides on their health, and on the environment. The practice of using reduced amounts of pesticides when growing vegetables is gaining a lot of attention.

The majority of the farmers selected varieties that were less susceptible to pests and believed that their pesticide-use practices were not a threat to their groundwater. Most farmers believed that they would lose more than half of their yield if pesticides were not available to control pests. But, farmers use an excess amount of most pesticides when growing the processing and table tomatoes according to the results of this study. Excessive pesticide use causes ground and surface water contamination, and unacceptable levels of pesticide residues in foods. Therefore, IPM practices are particularly important for growing the processing and table tomatoes, since excessive pesticide use is common, and farmers have depended heavily on pesticides.

In Turkey, consumers have indicated an increasing concern regarding the use of pesticides in food production. An alternative method of pest control is IPM with minimized pesticide applications, to produce a safe and profitable crop. Because of the continuing concern about food safety, chemical contamination, and other detrimental effects from chemical use, the government has mandated that all cropland should be farmed using IPM practices. To reach this end, IPM must be clearly defined and the current level of IPM use in the region determined. Applicable research and technology can then be identified and educational needs and appropriate distribution methods determined to promote IPM to target farmers.

Farmers must be informed about: the selection and usage of pesticides, accurate and efficient use of pesticide application, machinery, effects of the pesticides on the environmental and human health, and precautions to be taken before and after the pesticide application. Farmers use licenced pesticides for crop protection in Turkey. The Turkish Ministry of Food, Agriculture, and Animal Husbandry has banned the manufacture, sale and use of the toxic pesticide endosulfan since 2007. Because methyl bromide (used for soil fumigation) has been banned in Turkey since 2008 under the Montreal Protocol, researchers are working with farmers to develop new growing methods. In Turkey, pesticide subsidy per hectare for farmers, is currently not practised. Pesticide subsidy should be provided to farmers who use IPM techniques or to farmers who use pesticides which are harmless to the environment and human health. In 2012, biological control subsidy was offered by the Turkish Ministry of Food, Agriculture, and Animal Husbandry. The farmers who use beneficial insects for biological control receive \$169 ha^{-1}, and farmers who use pheromone traps receive a \$169 ha^{-1} subsidy. Furthermore, farmers who use organic production methods receive \$197 ha^{-1}, and those farmers who use good agricultural practices receive a \$140 ha^{-1} subsidy.

Private and state owned accredited residue laboratories should be established in order to regularly carry out pesticide residue analyses for agricultural products. There should be more multidisciplinary research studies on the economic analysis of pesticide use in agricultural production, the economic benefits of IPM applications, and studies identifying threshold levels of economic damage.

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