Comparative Economic Analysis between Chemical Pesticides and Bacterium Using in Apricot Production

K. Peker

Wirtschaftlichkeitsvergleich zwischen der Anwendung von chemischen Pestiziden und Bakterien in der Marillenproduktion

1. Introduction

In Turkey, the apricot (*Prunus armeniaca* L.) is an important fruit in terms of both its chemical composition and its economic value. It is rich in minerals, vitamins and carbohydrates, which make it a healthful product. Being a traditional export product, apricots have an economic value for Turkey due to the sizeable production and Turkey's share in the world market. According to the statistics provided by FAO for the year 2001, Turkey is the largest apricot producer in the world with an average share of about 16 % of the world's fresh apricot production during the years 1990–2000. This figure is about 70 % for dried apricot production (OLGUN et al., 2001).

The use of pesticides in apricot production increases the yield by protecting the crops from diseases, insects and weeds. Despite the high costs of pesticides, farmers in most countries continue to use them in increasing quantities.

Zusammenfassung

Der Gebrauch von Pestiziden in der Pflanzenproduktion kann die menschliche Gesundheit beeinträchtigen und ebenso die Produktionskosten erhöhen. Der Bakterieneinsatz stellt eine gangbare und kosteneffiziente Alternative zur Pestizidanwendung dar. Bakterien als Substitut für Pestizide stellt eine Entwicklung in der Landwirtschaft dar, welche während der letzten Jahre in der Türkei sehr deutlich an Bedeutung gewonnen hat. Was die türkische Marillenproduktion betrifft, ist die Bakterienanwendung neu und befindet sich erst im Versuchsstadium. In der gegenständlichen Untersuchung wurde eine Kosten/Nutzen-Analyse der Anwendung des Bakteriums *Bacillus subtilis* OSU-142 und des Pestizideinsatzes für die Marillenproduktion in der Provinz Malatya erstellt. Von dort stammt mehr als die Hälfte der türkischen Marillenproduktion. Deswegen wurde dieser Raum als Untersuchungsgebiet ausgewählt. Den Untersuchungsergebnissen zufolge errechneten sich Kosten pro Produkteinheit (1 Kilogramm Marillen) von 1,36 $ bei Pestizidanwendung und von 0,94 $ bei Bakterieneinsatz. Jeder für den Pestizideinsatz aufgewendete Dollar bringt einen Erlös von 0,91 $; dieser Wert liegt im Falle des Bakterieneinsatzes in der Marillenproduktion bei 1,31 $.

Schlagworte: Marillen, chemische Pestizide, Bakterien, Umwelt, Kosten/Nutzen-Analyse.

Summary

The use of pesticides in crop production could threaten human health and also increases the production costs. Bacterium is a viable and cost-effective alternative to the use of pesticides. The use of bacterium as a substitute for pesticides is a development in agriculture, which has gained much more importance in recent years in Turkey. It is new and still at the trial stage in apricot production in Turkey. In this study, cost and benefit analysis of the use of bacterium-*Bacillus subtilis* OSU-142 and pesticides in apricot production was performed in Malatya province, which provides more than half of the apricots produced in Turkey, was selected as the study area. According to the study results, the cost per unit of apricot production (one kilogram) was calculated to be $ 1.36 with pesticide application and $ 0.94 with bacterium application. Each dollar of cost produces $ 0.91 of revenue in pesticide use; this figure is $ 1.31 in the case of bacterium use in apricot production.

Key words: apricot; chemical pesticides; bacterium; environment; cost and benefit analysis.

However, continual use of chemical inputs such as pesticides has resulted in damage to the environment, ill health in humans, a negative impact on agricultural production, and reduced agricultural sustainability (PIMENTEL and GREINER, 1997). Numerous short and long-term human health effects have been recorded (WILSON and TISDELL, 2001).

There are substantial differences between farmers' expectations and consumers' inclinations. Consumers usually demand healthful, natural and cheap food, while farmers desire higher yield, higher market prices and farmland conservation. Therefore, it is important to satisfy the consumers without shortchanging the farmers, by employing methods agreeable to both sides. One of the most viable approaches to satisfy both farmers and consumers is the use of bacterium instead of pesticides in agricultural production. Bacterium use has been proven to be an acceptable alternative to pesticides (HUANG et al., 2003). Bacterium use, instead of pesticides, in apricot production in Turkey is at a trial stage. To date, the study of ESITKEN et al. (2002) was the extent of the published research regarding bacterium application in apricots. In that study, the bacterial strain *Bacillus subtilis* OSU-142 was used against shot-hole disease caused by *Wilsonomyces carpophilus* L., which is one of the most destructive diseases on apricot cv. 'Hacıhaliloglu' grown in Malatya, Turkey. The *Bacillus subtilis* OSU-142 tested in this study was reported to have a great potential for antagonistic activity against plant pathogenic bacteria and fungi, as well as a growth-promoting effect. ESITKEN et al. (2002) reported that with the foliar application of *Bacillus subtilis* OSU-142 on apricots, the average increase in yield in 2000 and 2001 was about 30 and 90 % respectively, without a decrease in quality, in comparison with pesticide use. They also suggested that OSU-142 might be used as a biological fertilizer to spray apricots at the blooming stage for a better yield, that it had an antagonistic effect against *Wilsonomyces carpophilus,* and that it could be applied to control shot-hole disease on apricots and other various host species.

The objective of current study was to make an economic analysis between the use of the bacterial strain *Bacillus subtilis* OSU-142 and pesticides in apricot production. In the study, comparable cost and benefit analysis between using *Bacillus subtilis OSU-142* and pesticides in apricot production were performed in Malatya, Turkey.

2. Materials and methods

Malatya province, home to 55.2 % of Turkey's apricot production (OLGUN et al., 2001) was selected as the study area. The original data of the present cost and benefit analysis consisted of both field and questionnaire studies. In the field study, 3 apricot producers were chosen; one in Darende and one in Arapkir (in Malatya), and one in Baskil (in Elazig), all of which are centers of apricot production. The apricot producers were selected based on their supportiveness and willingness to participate in the study. In the farmers' orchards *Bacillus subtilis* OSU-142 was applied on 105 apricot trees in total (35 trees per farmer). Because the bacterium application is neither common nor well known, each of the farmers was only willing to risk 35 trees. The bacterial strain *Bacillus subtilis* OSU-142 was used by the farmers at the blooming stage, what had been suggested by ESITKEN et al. (2002).

The results of the *Bacillus subtilis* OSU-142 application were compared to the weighed averages of the data of pesticide application from the questionnaires completed by the apricot producers in the same geographical area. Questionnaires were filled out with farmers on 120 farms determined by the simple randomized sampling method described in the study of YAMANE et al. (2001), based on the apricot plantation size of the farms in Malatya central district. Cost and benefit method was used in the comparative economic analysis of the bacterium substitution for pesticide use.

3. Results and discussion

3.1 Use of pesticides in apricot production

Although it is not recommended, excessive amounts of chemicals are used in apricot production. According to the data from the questionnaires, 85.7 % of the farmers use pesticides, which are applied as follows:

(i) *Spring application*: Pesticides are applied at the pink bud stage to control stem blight disease, bud caterpillars and scabies.
For diseases: Bordeaux mix or one of the ready-made preparations of copper is used.
For insects: In controlling insects various insecticides are used. Decis, Thiodan, Folidol, Subrex and Arivo are the most commonly used insecticides in the study area.

(ii) *Flower application:* Pesticides are applied against Moniliasis (brown rot) disease. The total amount of

recommended dosage is applied in two parts, the first half given when 5–10 % of the flowers are in bloom, and the second half given when all the flowers are in bloom. The most common fungicides in the study area are Derosol, Benlate, Chovus, Bavistin and Takistin.

(iii) *Fruit stage application:* At this stage the fungicide, Captan, is used against shot-hole disease.

(iv) *Autumn application:* Bordeaux mix (3 %) is used as protection from branch blight and other fungal diseases. However, only 20 % of the farms included in the study employ this application.

3.2 Results of the Bacillus subtilis OSU-142

According to the questionnaire results and the weighed averages of the control group, the fresh apricot yield was 42 kg/tree in the case of pesticide application, while it was 58 kg/tree in the case of *Bacillus subtilis* OSU-142 application in farmer conditions. Thus, the yield increase obtained from the bacterium application is 38.10 % [(58-42)/42 x 100 = 38.10]. The costs related to *Bacillus subtilis* OSU-142 use and pesticide use is given in table 1. As seen from table 1, bacterium use decreased the medication cost at a rate of 58.36 % [((356.59-148.5)/356.58) x100 = 58.36]. The comparable cost and benefit analysis between using bacterium and pesticides in apricot production is given in table 2.

It is seen from table 2 that the cost of a kilo of apricots is $ 0.94 with bacterium application, while it is $ 1.36 with pesticide application. In the same manner, while each dollar of cost produces $ 0.91 of revenue in pesticide use, this figure is $ 1.31 in the case of bacterium use in apricot production.

4. Conclusions

According to the data from the questionnaires, 85.70 % of the apricot producers use pesticides. 80 % of the producers using pesticides, use pesticides three times a year, while the

Table 1: The cost comparison of pesticides and bacterium applications in apricot production in Malatya, Turkey (a hectare of orchard)
Tabelle 1: Kostenvergleich zwischen Pestizid- und Bakterienanwendung bei der Marillenproduktion in Malatya, Türkei (ein Hektar Obstanlage)

	Pesticides					Bacterium				
	Inputs	Amount	Unit	Average price per unit ($)	Cost ($)	Inputs	Amount	Unit	Average price per unit ($)	Cost ($)
1. Before blooming medication	Bordeaux mix or any copper preparation	14	Kg	6.30	88.20					
	Labor	1.2	Hour	0.19	13.30	No application				
	Tractor	1.2	Hour	0.46	32.20					
	Water	3000	Lt.	–	–					
	Sub-total				**133.7**					
2. Blooming	Any fungicide (i.e. Derosol. Benlate. etc.)	4	Kg	6.43	25.72	BA142 (*Bacillus subtilis*)	0,2	Lt.	0.45	90.00
	Labor	1.5	Hour	0.19	17.10	Labor	1.5	Hour	0.19	17.10
	Tractor	1.5	Hour	0.46	41.40	Tractor	1.5	Hour	0.46	41.40
	Water	4000	Lt.	–	–	Water	4000	Lt.	–	0.00
	Sub-total				**84.22**					**148.50**
3. Fruit	Captan (Fungicide)	7.5	Kg	7.25	54.38					
	Labor	1.7	Hour	0.19	19.95	No application				
	Tractor	1.7	Hour	0.46	48.30					
	Water	5000	Lt.	–	–					
	Sub-total				**122.63**					
4. Autumns	Bordeaux mix	7	Kg	4.96	34.72					
	Labor	1.2	Hour	0.19	13.30					
	Tractor	1.2	Hour	0.46	32.20	No application				
	Water	3000	Lt.	–	–					
	Sub-total *				**16.04**					
				Total	**356.59**				Total	**148.50**

* Twenty per cent of the costs were taken into account since only 20 % of the apricot producers carried out Autumn medication

Table 2: Comparative cost and benefit analysis of the bacterium use instead of pesticide in apricot production in Malatya, Turkey (a hectare of orchard)
Tabelle 2: Kosten-Nutzen-analytischer Vergleich zwischen der Anwendung von Bakterien und Pestiziden bei der Marillenproduktion in Malatya, Türkei (ein Hektar Obstanlage)

	Pesticide use		Bacterium use	
Applications	$	%	$	%
1. Pruning	94.73	2.00	94.73	2.09
2. Plowing	154.10	3.25	154.10	3.40
3. Spading or digging	186.92	3.94	186.92	4.13
4. Fertilization	268.47	5.65	268.47	5.93
5. Medication	356.59	7.51	148.50	3.28
6. Sulfuration-drying-Classification packing	1292.72	27.23	1322.20	29.19
7. Total of variable costs (1+...+6)	2353.53	49.57	2174.92	48.02
8. General management costs (3.0 %)	70.61	1.49	65.25	1.44
9. Interest of the capital (23.0 %)	541.31	11.40	500.23	11.05
10. Soil rent	1467.12	30.90	1467.12	32.39
11. Amortization of the establishment costs	168.64	3.55	168.64	3.72
12. Marketing costs	146.72	3.09	152.72	3.37
13. Total production costs (7+8+9+10+11+12)	4747.93	100.0	4528.88	100.0
14. Production (kg)	3444.0		4750.0	
15. Apricot seed income	76.80		80.20	
16. Dried apricot costs ($/kg) (13–15)/14	**1.36**		**0.94**	
17. Total income ($) *	4312.92		5922.70	
18. Benefit/Cost rate (17/13)	**0.91**		**1.31**	

* Apricot price is 1.23 $/kg. plus apricot seed income

rest employ the medication four times a year. Medication is carried out against pests at pink flower bud, flower, and fruit stages, along with a protective application in the autumn. Bordeaux mix or one of any other ready-made copper preparations is commonly used against fungal diseases, while the most common insecticides are Thiodan, Decis, Folidol, Subrex, Bazudin, and Arivo. Although bacterium application is at a trial stage in apricot production, successful results were obtained. The yield increase provided by bacterium substitution for pesticides in the study area is 38.1 %. The medication cost decreased 58.36 %, and the total cost decreased 30.88 %. The medication cost for one year is $ 356.59 for 100 trees, which is average apricot plantation size of farms in the study area, while it is $ 148.50 in the case of bacterium application. The cost of a kilo of apricots was calculated to be $ 1.36 and $ 0.94 in pesticide and bacterium applications respectively. In view of the results obtained from this study, bacterium substitution for pesticides can be suggested as demonstrated HUANG et al. (2003). Yet, before doing this, there is a need to prove these results by more comprehensive studies. Regardless of the stated positive effects of bacterium use, the problems, i.e. the risk of crops being exposed to the other types of pests and diseases, weakness of the produced crop to harvesting and transportation, and difficulty in sulfuration with existing technology, among others, have not been addressed yet. In addition, negative effects of rainfall just after the application, risk aversion of the farmers, suitability of the fruit's appearance, lack of demand for organic production at present, the need for new techniques for organic dried apricot production, and the effect of production increase on prices in the future, are the most important problems to be taken into consideration in this regard.

It can be concluded that the subject of bacterium application in apricot production is an innovation whose application can be possible in the long run only after it is examined in detail.

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Address of Author

Kenan Peker, Selcuk University, Faculty of Agriculture, Department of Agricultural Economics, Konya, Turkey; E-mail: kenanpeker@selcuk.edu.tr

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