

LUCRĂRI MECANICE ȘI UTILAJE AGRICOLE FOLOSITE ÎN PLANTAȚIILE DE FISTIC DIN PROVINCIA SIIRT, TURCIA

ASSESSMENT OF AGRICULTURAL PRACTICES AND MACHINERY USE IN PISTACHIO NUT ORCHARDS IN SIIRT PROVINCE OF TURKEY

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Abstract

As is the case in all type of orchards, agricultural practices should be done on regular and timely basis in Pistachio orchards to get abundant and high-quality products. The agricultural practices applied mainly in pistachio orchards include tillage, irrigation, pruning, fertilization, plant protection, harvesting and post-harvest handling and processing. In this study, the use of machinery and the problems encountered in the application of agricultural practices in pistachio orchards were evaluated in Siirt province of Turkey. Study data were collected with the structured questionnaires during the face-to-face farmer interview, which was conducted in 165 pistachio farms in 2019. The sample size was determined by Stratified sampling method. For analysis of the data, descriptive statistics methods and Chi-square test were employed. It was revealed that the mechanization applications and problems encountered in pistachio production were connected with the processes from soil cultivation to harvest and post-harvest. The results showed that the use of machine power in the pistachio farms in Siirt province is very limited with tillage, spraying and transportation. It was also revealed that the orchard acreage had a statistically significant relationship with the machinery use for almost all agricultural practices except tillage and irrigation methods.

Cuvinte cheie: lucrări mecanice în livezi, tăierile pomilor, combaterea dăunătorilor, recoltarea nuciferelor.

Key words: tillage in orchards, pruning trees, pest control, nut harvesting.

1. Introduction

Pistachio (*Pistacia vera* L.), which is a subtropical plant belonging to the *Anacardiaceae* family, is one of the most important export and strategic agricultural product in the world. It is mainly grown in Middle Eastern (e.g. Iran, Turkey, Syria, and Greece), some European (e.g. Italy) and American (e.g. U.S.) countries (Kamali and Owji, 2016). The U.S. and Iran are known as the global leaders in the production and the cultivation of pistachios. Turkey and Syria follow the U.S. and Iran in pistachio production (Shahbandeh, 2020). In Turkey, South-eastern Anatolia Region has the largest pistachio production areas. The total pistachio production of this region consists of 95% of the total production of Turkey.

It is known that performing farm activities in a timely manner is very important in agricultural production because it optimizes the biological efficiency of the crop and reduces risks from environmental and managerial factors. Also, reducing labor demand and input costs in agricultural production has an important role in increasing agricultural productivity (Rahman et al., 2011). As well as in all agricultural production labor-intensive areas, pistachio growers have many challenges related to the needs of cultivation activities during production because the majority of tree fruit production operations have been conducted in traditional farming system and are still highly dependent on human labor (Wilkinson, 2005; Firouzi et al., 2017). Agricultural production has been mechanized in developed countries to enhance farmers' income and make agriculture more appealing because mechanized farming requires less labor than traditional farming (Singh, 2006; Rahman et al., 2011).

Agricultural machineries have been widely used in field crops. But in recent years, it is seen that it has been also used in horticultural crop farming. Therefore, analysis of agricultural practices and machinery use in orchards will be critical for the successful implementation of agricultural mechanization technologies (Miyazaki, 2000; Goyal et al., 2014; Khandetod, 2019). To decide the right level of mechanization for the jobs to be done, the main agricultural activities, the current level of mechanization and the main issues in pistachio production must be analyzed in detail. Consequently, it is very important to know how agricultural activities are conducted in pistachio orchards, the nature and size of the

enterprise and current status of agriculture machineries used in pistachio growing farms in order to politically develop “appropriate mechanization technologies”, because the selection of agricultural equipment is affected by many factors such as the nature and size of the enterprise, the profitability and access to finance, the economic status of the region, the accessibility to a range of equipment options at local level, the ownership (individual, shared or cooperative) of equipment.

The purpose of this study is to determine the machinery use in agricultural practices and problems encountered in pistachio nut production from soil cultivation to harvest in Siirt province of Turkey, and to investigate the relationships between the existing land properties of the orchards and the machinery use in agricultural practices.

2. Material and methods

This study was conducted in Siirt province, which is located in the southeastern Turkey, in order to determine the machinery use level in the application of agricultural activities in the enterprises growing pistachio, and the main issues encountered during the application of agricultural activities in pistachio orchards. Data were collected from pistachio growers in the study region by face-to-face interviews with structured questionnaire in September 2018 to April 2019. In the survey study, information was gathered on land size and soil properties of pistachio growing enterprises, the main methods and equipment used in the applications of agricultural activities (tillage, irrigation, pruning, fertilization, plant protection, harvesting and product transportation), the main problems and constraints during the applications of agricultural activities. Study farms were randomly selected from the 3,431 pistachio growing enterprises in the study area. Sample size was calculated according to stratify random sampling method (Yamane, 1967), using the formulas given in Eq. 1 and Eq. 2. The farms were stratified into three size groups, regarding the pistachio acreage. i.e. less than 1 ha, 1-3 ha and more than 3 ha.

$$n = \frac{(\sum Ni \times Si)^2}{N^2 \times D^2 + \sum Ni \times Si^2} \quad 1$$

$$D^2 = \frac{d^2}{t^2} \quad 2$$

where n represents the required minimum sample size, N denotes the target population size as Ni, Si, d and t indicate the size of the i'th stratum, the standard deviation of the i'th stratum, margin of error on the population mean, and t statistics at a given confidence level, respectively.

The sample size was calculated to be 165 (broken by 35, 72 and 58 for the first, second and the third strata respectively) at 95% confidence interval considering the margin of error of 5%. Basic descriptive statistics methods were used to summarize data and present the results. Also, the chi-squared test was employed to assess the relationships between the land properties and the machinery usage in studied farms. Data analysis was performed using SPSS statistical software (IBM Corp. 2013).

3. Results and discussions

3.1. Tillage practices

Number of tillage per year, tillage time and tools used in tilling of the pistachio orchards are given in Table 1. When considering overall surveyed orchards, approximately 98% of respondents stated that they tilled their orchards at least two times a year. During the survey, it was observed that the tillage practices were mostly carried out at autumn and spring period and mouldboard plough was the most common agricultural equipment, followed by field cultivator and power tiller. Most common use of mouldboard plough, resulting in “clean cultivation,” eliminating weed vegetation throughout the orchard, shows that pistachio production has still been conducted according to traditional production systems in the region. Similarly, Özpınar and Çay (2018) stated that mouldboard plough was the most common agriculture implement in Mediterranean region. Also, De Leijster et al. (2020) reported that the mainstream floor management of Mediterranean organic orchards was conventional tillage, which involves a tillage frequency of 3 to 5 times a year withholding natural vegetation to grow and therefore causing biophysical land degradation. In orchards, tillage practices are mainly applied to control weeds, incorporate manure or fertilizer spread on the soil surface, and mix crop residue plant into the soil. However, deep tillage by mouldboard is deleterious to tree roots and soil moisture relations and should be avoided except in serious cases of soil compaction. Therefore, it is very important to select the best tillage technique in order to reduce costs in terms of working times and fuel needs and maintain a suitable productive level of

crops and soil fertility (Liu et al., 2013). Morugán-Coronado et al. (2020) reported that there was a need to spread scientific knowledge to initiate a change towards sustainable orchards including cover crops and reduced or no-tillage (avoiding bare soil during long periods) to overcome the loss of soil, soil organic matter (SOM) and nutrients.

Regarding the relationship between the land properties of the pistachio orchards (size, slope, stoniness and texture of the land) and the equipment used in tillage (Table 8), chi-square test revealed that while there was no significant relationship between size, slope and stoniness of the land and the choice of tillage system, the tillage method used in pistachio orchards had a significant relationship with the type of soil texture ($p < 0.01$). Distribution of tillage methods across soil texture types showed that reduced tillage systems (non-mouldboard tillage type) was used more in sand-textured soils compared to silt and clay textured soils. Similarly, Alskaf et al. (2020) stated that soil texture type had a substantial influence on the choice of tillage method, noting that in a wet year, ploughing heavy clay soil is a necessity to help in drainage.

When asked about the most important problems encountered in tillage, more than the 70% of respondents stated that they had problems in obtaining tools and equipment. This result shows that developing the sharing farm machinery models can be important for farmers with limited purchasing power.

3.2. Fertilizer applications

Table 2 shows the fertilizer type, the fertilizer application method, and the machinery use in fertilizer application in the surveyed pistachio orchards. From Table 2, it is seen that about 90% of the responders used the nutrients such as mineral fertilizers, manure and compost to improve soil fertility and crop yield. When asked about the fertilizer type, it was observed that the most common fertilizer types preferred by the pistachio growers were livestock manure (10.3%), mineral fertilizers (33.3%), and both manure and mineral fertilizers (46.1%). In the study area, the methods of fertilizer application used by farmers was determined to be hand broadcasting (42.5%), broadcasting equipment (4.2%) and ring fertilization (43.0%). Fertilizer application method is an important point for improving plant growth and increasing crop yield at a minimum environment and soil pollution and/or degradation. Therefore, proper application of fertilizers to the soil continues to become increasingly important in achieving the highest crop response at a minimum cost. Similarly, several researchers (e.g. Larco et al., 2013; Han et al., 2017; Cui et al., 2020) pointed out that inefficient fertilizer application techniques might not only reduce the proportion of applied fertilizer uptake by trees but also lead to wasting money, excess vigor, soil acidification and contamination of groundwater.

When asked about the way of fertilizer application, 95.8% of respondents answered that they did not use any machinery during fertilizer application. However, mechanized fertilizer application may result in more efficient nutrient uptake and labor savings. Therefore, it is necessary to provide farmers' adoption of fertilizer application machines in region.

The chi-square test results indicated that the machinery use in fertilizer application showed statistically significant relationships with the acreage ($P < 0.01$) and the slope of the land ($P < 0.05$), but no significant relationships with the type of soil texture and the stoniness of land (Table 8). Respondents with larger pistachio orchard acreage were more likely to use fertilizer application machinery compared to those with smaller orchard acreage. Also, the rate of machinery use in fertilizer application was higher in non-sloped orchards compared to sloping ones. When asked about the problems encountered during fertilizer application, it was found that about 40% of respondents indicated the lack of equipment as one of the main problems in fertilizer application.

3.3. Pest control

In pistachio orchards as well as all agricultural lands, chemical sprayers are mostly used for pest control. When asked about the use of chemicals in pest control, 72.2% of responders answered "yes" and 27.3% "no" and approximately 90% of growers, who used chemical, stated that they sprayed their orchards at least two times a year (Table 3). The results of the survey indicated that while about 46% of responders reported that they used backpack sprayers (mechanical and air-assisted sprayer) for application of pesticides, 4.8% and 6.7% of respondents stated that they used the frame power sprayer with wheels and the tractor operated sprayer, respectively. 3.6% and 19.6% of growers used the frame power sprayer with wheels and the tractor operated sprayer in addition to backpack sprayers, respectively (Table 3). The type of sprayer used in pesticide application showed a statistically significant relationship with land size, but no significant relationship was detected with the soil texture and the stoniness and sloppiness of the land (Table 8). Distribution of the type of the sprayer across the acreage of pistachio orchards showed that backpack sprayer was the mostly used equipment in pest control in the orchards less than one hectare as the frame power sprayer with wheels or tractor operated sprayers were most widely used in the orchards larger than three hectares. Powell et al (1999) stated that although labor-intensive, backpack or knapsack sprayers were relatively light and could be taken places where mounted

sprayers are difficult to use because they worked well in small orchards or small fruit garden areas. When asked about the main problems encountered in spraying, about 70% of growers stated that they had lack of knowledge on chemical application for pest control, indicating the need for agricultural extension and education services in chemical application in pest control. Mohammadrezaei and Hayati (2015) reported that agricultural extension services had the main role in the integrated pest management (IPM) adoption by farmers. Also, the authors stated that those pistachio growers who have more benefited of those services had more IPM adoption.

3.4. Pruning

The process of pruning targets the removal of defective, dead, flimsy, non-productive and unwanted tissues from the plants. Selection of the right tools for pruning is important to make pruning easier and more pleasant. Table 4 shows the percentage distribution of equipment used in pruning in the surveyed farms. It is obvious that 65.4% of the pistachio growers used pruning hook and saw together. Then, this was followed by only hand hook (17.8%) or hand saw (8.5%). Survey results indicated that the use of powered pruning machines (8.4%) was lower than that of hand pruning tools (65.4%). Similarly, Polat et al. (2001) reported that pruning was done by hand and saw in South-East Anatolia region of Turkey. They recommended that new technical pruning systems must be applied in the farms with larger orchard acreages due to lower labor need or cheaper than hand pruning tools. Chi-square analysis results showed a statistically significant relationship between the type of pruning equipment and pistachio orchard acreage ($P < 0.01$), as was no significant relationship with the soil and land properties such as texture, stoniness and sloppiness (Table 8). Results showed that hand pruning tools were significantly more preferred in the farms with smaller orchard acreages than in the farms with larger orchards.

3.5. Irrigation

Table 5 presents the percentage distribution of the irrigation methods applied in the surveyed orchards. The survey results indicated that about 58% of the pistachio orchards were not irrigated, and common irrigation method applied in the irrigated orchards was wild flood irrigation method (22.4%). It was seen that drip irrigation method, which reduce production costs by increasing the water utilization efficiency, was very low (5.8%). In a study conducted on "determination of irrigation tendency of Siirt regional pistachio growers", Aydın and Saltuk (2018) observed that the traditional production concept was more common in the adoption of irrigation among Pistachio growers in the region. When asked about the main irrigation problem, more than the 50% of respondents stated that they did not have sufficient water resources for irrigation. Similarly, Aydın and Saltuk (2018) reported that about 78% of the agricultural lands in Siirt region were non-irrigated land and they lack of irrigation water sources.

3.6. Harvest

Pistachios grow in grape-like clusters on the tree and each cluster may have thirty to fifty nuts. Pistachio nuts are harvested manually as clusters that can easily be separated from branches by bending them back or by traditional methods of shaking the limbs of the tree with a pole. In addition, mechanical harvesting techniques are used in harvesting Pistachio nuts (Crane and Dunning, 1975; Kaska, 1995; Polat et al., 2007; Ferguson et al., 2011). The percentage distribution of harvesting methods applied in the surveyed orchards is presented in Table 6. The survey results indicated that the more than half of the growers harvested their products by picking nut clusters by hand. Similarly, several researchers (Polat et al., 2001; Polat et al., 2007) stated that in Turkey pistachio nut trees were generally harvested by traditional methods of shaking of the limbs of the tree with a pole, by hand or by shoving. Whereas, this type harvesting of pistachio nuts is time consuming. It is stated that the 43.33% of total labor in pistachio nut production was used for harvesting operations (Polat et al., 2001). The authors stated that suitable equipment, which will used for mechanical harvesting of pistachio nut, should be developed in order to reduce the cost of production and labor, and prevent wasting time. The chi-square test results indicated that harvesting methods of pistachio nuts were significantly affected by the land size of orchards and the relationship between harvesting method and the other properties of land such as slope, stoniness and texture was not significant. It was seen that hand harvesting method (picking nut clusters by hand) was used at a higher rate in small orchards and the harvesting method of shaking the tree with a pole is preferred in larger orchards. When asked about the most important problems encountered during the harvest, limited access to labor and higher harvesting costs were reported to be the most important problems by more than half of the growers. Similarly, Polat et al. (2001) reported that harvesting costs and labor problems were very high in pistachio harvesting in the South Eastern Anatolia region of Turkey since harvesting was completely performed manually.

3.7. Transportation

Harvested pistachio nuts are packed using sacks, basket or plastic field bins and then transported to processing areas by trucks or trailers. The percentage distributions of transport equipment used in the surveyed orchards are presented in Table 7. According to the results, about 90% of the growers transported the harvested clusters in sacks to processing area by hand (49%) or trucks (41%). Similarly,

Ak et al. (2016), who discussed the current status and the future perspective of pistachio production and industry in Turkey, reported that the harvested pistachio nut clusters were put in sacks and brought to drying yards where they were spread out and left to dry in the sun. Chi square test results in Table 8 revealed that the transportation method of harvested pistachio nuts to processing areas had a statistically significant relationship with orchard acreage, but not significant with the soil and land properties. Distribution of the transportation method across the orchard acreage showed that type of transportation was greatly determined by the acreage that pistachio nut sacks are transported to processing areas on hand in small farms, as trucks were used in medium to larger farms (Tables not presented).

4. Conclusions

In this study, common agricultural practices and mechanization use in pistachio nut production was evaluated in Siirt province of Turkey. The results of the study showed that pistachio nut production has still been conducted according to traditional production systems in the region and the use of machinery is limited to tillage, pest control and transportation. According to the Chi square test, while there was a significant relationship between the tillage method used in pistachio orchards and the type of soil texture, the methods used during fertilization, chemical application, pruning, harvest and transportation had a statistically significant relationship with orchard acreage. From the study conducted, it was seen that reduced tillage systems (non-mouldboard tillage type) were used more in sandy-textured soils compared to silty and clayey textured soils. Respondents with higher pistachio orchard acreage were more likely to use the machinery for almost all agricultural practices.

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Tables and Figures

Table 1. The percentage distribution of the number of tillage per year, tillage time and equipment used in tillage in the surveyed farms

Variables	Options	Response percentage (%)
The number of tillage per year	1	2.4
	2	50.3
	3	34.5
	4	12.7
Tillage time	*Spring	6.6
	Spring and Autumn	66.4
	Spring, Autumn and Summer	26.0
Equipment used for tillage	Mouldboard plough	9.1
	Mouldboard plough+cultivator	69.1
	Mouldboard plough+cultivator+power tiller	2.4
	Cultivator	14.5
	Cultivator+power tiller	1.2
	Power tiller	3.6

Table 2. The percentage distribution of fertilizer type, fertilization method, and machinery use in fertilizer application in the orchards

Variables	Options	Response percentage (%)
Fertilizer application	Yes	89.7
	No	10.3
Type of fertilizers	No fertilizer application	10.3
	Livestock manure	10.3
	Mineral fertilizer	33.3
	Livestock manure +mineral fertilizer	46.1
Methods of fertilizer application	Not fertilizer application	10.3
	Broadcast by hand	42.5
	Broadcast by machine	4.2
	Ring placement around the tree	43.0
Use of machinery in fertilizer application	Yes	4.2
	No	95.8

Table 3. The percentage distribution of Chemical application, the number of chemical application per year, and the machinery used in chemical application in the orchards¹

Variables	Options	Response percentage (%)
Chemical application for pest control	Yes	72.7
	No	27.3
The number of chemical application per year	1	9.1
	2	40.6
	3	30.3
	4 and more than 4	7.2
Tool and machinery used in chemical application ¹	BMS	37.0
	BAS	3.6
	FPS	0.6
	FPAS	4.2
	TOS	0.6
	TOAS	6.1
	BMS+BAS	6.1
	BMS+FPS	1.2
	BMS+FPAS	2.4
	BMS+TOAS	17.2
	BMS+BAS+TOAS	2.4

¹BMS, Backpack mechanical sprayer; BAS, Backpack air-assisted sprayer; FPS, Frame power sprayer with wheels; FPAS, Frame power air-assisted sprayer with wheels; TOS, Tractor operated sprayer; TOAS, Tractor operated air-assisted sprayer

Table 4. The percentage distribution of tool used during pruning in the orchards

Variables	Options	Response percentage (%)
Type of equipment used in pruning	Hand hook	17.6
	Hand saw	8.5
	Powered saw	1.2
	Hand hook+hand saw	65.4
	Hand hook+hand saw+powered saw	5.4
	Hand hook+hand saw+powered saw+pneumatic pruning machine	1.8

Table 5. The percentage distribution of irrigation methods applied in the orchards

Variables	Options	Response percentage (%)
Irrigation methods	No-irrigation	57.6
	Flood irrigation	22.4
	Basin irrigation	6.7
	Furrow irrigation	5.8
	Drip irrigation	2.0
	Basin+furrow irrigation	1.2
	Flat+drip irrigation	3.0

Table 6. The percentage distribution of harvesting methods applied in the orchards

Variables	Options	Response percentage (%)
Harvesting methods	Picking nut clusters by hand (A)	78.2
	Shanking limbs with a pole (B)	1.8
	A+B	19.0

Table 7. The percentage distribution of transport equipment used in the orchards

Variables	Options	Response percentage (%)
Transport equipment	Plastic bin	3.6
	Sacks	41.8
	Basket	0.6
	Truck	0.6
	Plastic bin+sacks+basket	9.1
	Plastic bin+trucks	3.6
	Sacks+trucks	40.7

Table 8. Observed p values for Chi square tests between independent and dependent variables related to agricultural practices and machinery usage in pistachio nut orchards

	The size of land	The slope of land	The stoniness of land	The soil texture of land
Equipment used for tillage	0.361ns	1.070ns	0.814ns	12.638**
Usage of machinery in fertilizer application	10.553**	6.187*	0.183ns	2.166ns
Use of machinery in chemical application	33.804**	6.361ns	5.785ns	7.578ns
Usage of machinery in pruning	14.863**	6.544*	0.936ns	0.464ns
Irrigation method	2.651ns	8.875ns	5.856ns	11.002ns
Harvesting method	9.714**	3.314ns	1.745ns	7.461ns
Transport method	34.98**	3.929ns	4.079ns	7.728ns

*, p<0.05; **, p<0.01; ns, not significant