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# Organic Hazelnut Farming Techniques: A Review

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ABSTRACT

Growing environmental and human health awareness due to increased concerns caused by intensive agriculture, has resulted a trend toward organic farming. Organic farming first started in the mid-1980s worldwide, introduced in Türkiye during 1989–1999 with raisin, fig and apricot, and then hazelnut was included in these products. In our country, total of 21.418,57 tons of organic hazelnut production occurs on 12.129,24 ha in 18 provinces. Considering the entire hazelnut production area, organic production is quite low. Organic hazelnut production requires daily monitoring of mechanical control and cultivation measures in the orchard. In addition to this intensive labor, the extraordinary increase in agricultural inputs in the recent period may explain such a low production amount. However, given the recent environmental disasters in the world, human and environmental friendly production systems such as organic agriculture should be encouraged in order to restore the natural balance that has been significantly damaged.

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## Introduction

Producers and consumers in many countries, especially in high-income developed countries, have started to produce green products by making a point of not to disturb the natural balance, not to pollute the environment, not to cause toxic effects on human and other living things, and this production system is referred as "Organic Farming." Some organisms definitions of organic farming emphasize the concept of sustainability. The general concept of sustainable agriculture not only indicates the protection of natural resources in the long term and ensuring their productivity, but also emphasize on an economically, socially and ecologically balanced agricultural system (Demiryürek, 2004; Özyazıcı et al., 2010).

Organic farming has been among the rising values in recent years due to the rise in ecological and health awareness with the increasing education level (Aksoy, 2002; Altındişli, 2002; Onoğur, 2002). The growing demand for organic agricultural products leads to an increase in the trade volumes of organic products. Therefore, governments, non-governmental organizations and producers aim to develop organic farming through regulations cover organic agricultural products to improve their market share of organic products (Vatansever Deviren and Çelik, 2017).

In other words, organic farming is a certified production method in which all stages from production to consumption are controlled and recorded, is a sustainable productivity-based approach that does not threaten the environmental and human health, protect soil fertility and food security via organic and green fertilization, rotation, soil preservation, improved resistant plant materials and biological control without using artificial inputs such as chemical fertilizers and pesticides (Başaran et al., 2018; Okçu and Karabulut, 2019). Along with the demand for organic products worldwide and in our country, the production areas allocated to organic agriculture are also increasing (Turan and Dere, 2005; Demirtürk, 2011; Demirtürk et al., 2017; Çalışkan et al., 2019).

Organic products, which are included in the shopping bags of many consumers in the world, continue to increase rapidly both in terms of production area and market size (Ilgar, 2017). According to 2017 data announced in 2019, 97 billion dollars of organic product sales were realized in the world. Recent publications reported that organic production and total area of organic farming increased in the most countries, reaching 70 million ha with 2.9 million producers (FIBL and IFOAM, 2019).

In parallel with this growth, the first studies on organic agriculture in our country were started in 1983-1984. Organic production has been made with products for export purposes until today, and with this production technology, export opportunities for new products could not be provided mostly. Intensive agriculture has led to higher agricultural yields and better welfare, but it has also resulted in problems about environment, food supplies, and agricultural workers. Conventional agriculture aims to obtain the highest yield from a unit area and thus, improving the yield and production has been the target of agricultural programs, research and funds (Turan and Dere, 2005).

Organic agriculture in our country introduced in line with the demands from abroad, especially Europe, and over time, organic products started to be demanded in the domestic market. Many studies and market researches show that the demand for organic products is in an increasing trend both in the domestic and international markets. Data on organic agriculture certified according to the legal regulations valid in Türkiye are collected by the Ministry of Agriculture and Forestry and published as official data. According to the published report in 2019 and harboring the data for 2018 and before, although there are fluctuations in organic farming areas in our country, an increasing trend is observed in general. The main factors causing fluctuations are changes in the data collection system, rapid decline in natural hazelnut harvesting and government supports. According to 2018 data, organic production was carried out on 626,885 ha, and 213 products were certified as organic in our country, which has a wide range of products (Bilen and Çilekli, 2019).

Organic hazelnut production in Türkiye started in 1989-1990 in line with the demand from foreign companies (Akdoğan and Demirtürk, 2018; Aydın Eryılmaz and Kılıç, 2019). Today, many companies are working to increase production in Western Central and Eastern Black Sea regions. One of the most important reasons for choosing the regions is the suitable ecology for hazelnut growing (Turan and İslam, 2020a). Growing the crops in its ecology has great advantages in terms of plant health and contributes to organic agriculture.

The transition of producers to organic hazelnut production was realized as a result of high prices, purchase guarantee, technical, and cash assistance provided by companies. Organic hazelnut sales price is based on market value plus 10%. Due to the recent increase in input prices, this difference is considered low among growers (Kılıç Topuz and Bozoğlu, 2021) and is not sufficient to compensate the labor performed. Growers seek alternatives to eliminate the low yield caused by organic practices. The supply of organic fertilizers to meet nitrogen deficiency and cost-effective organic insecticides against hazelnut weevil are among major problems.

Several studies on organic hazelnut production have been carried out to date (Turan and Dere, 2005; İslam and Turan, 2006; Turan et al., 2007; Turan et al., 2009; Özyazıcı et al., 2010). However, unfortunately, studies addressing all aspects of organic hazelnut production and including recent developments are extremely limited. The present study, therefore, was carried out to re-evaluate cultivation practices in organic hazelnut production stages, to reflect new developments and to suggest possible solutions.

## Cultivation Practices

Organic farming in Türkiye started in the Aegean region with raisin and fig in the 1984-1985 production season, and spread to different regions with the participation of products such as dried apricot and hazelnut (Turan et al., 2009). Organic hazelnut production started in the 1989-1990 production season in response to the demand of foreign companies. A total of 21,418.57 tons are produced on 12,129.24 ha in 18 provinces (Table 1). In addition, 2020 data of the Ministry of Agriculture and Forestry showed that there is a production amount even in places where not declared as organic hazelnut production areas (RG, 2011; TOB, 2021). The possibility that these products in small quantities may have been brought from outside the provinces where they are registered should not be overlooked. Therefore, there is a need for a re-evaluation of the relevant data and their legal status. On the other hand, Table 1 shows that the average enterprise size is 673.85 ha and the production amount per enterprise is 1.189,92 tonsha$^{-1}$.

Table 1 Provinces producing organic hazelnuts in 2020, production area (ha), and quantities (tons)

| No | Country | Production area | Production quantity |
|---|---|---|---|
| 1 | Artvin | 2.013.69 | 3.744.41 |
| 2 | Bartın | 105.18 | 322.16 |
| 3 | Bilecik | 0.35 | 0.10 |
| 4 | Bolu | 2.03 | 2.03 |
| 5 | Çanakkale | 0.05 | 0.01 |
| 6 | Düzce | 659.04 | 2.255.51 |
| 7 | Giresun | 185.95 | 171.00 |
| 8 | İstanbul | 0.05 | 0.04 |
| 9 | Kırşehir | 0.01 | 0.01 |
| 10 | Kocaeli | 0.98 | 0.62 |
| 11 | Konya | 0.01 | 0.15 |
| 12 | Ordu | 2.860.48 | 4.425.55 |
| 13 | Rize | 631.83 | 743.54 |
| 14 | Sakarya | 570.20 | 1.252.25 |
| 15 | Samsun | 2.721.91 | 4.333.49 |
| 16 | Tokat | 2.39 | 1.12 |
| 17 | Trabzon | 1.176.26 | 1.606.17 |
| 18 | Zonguldak | 1.198.83 | 2.590.97 |
| Total | | 12.129.24 | 21.418.57 |

Source: TOB, 2021

**Plant Nutrition Technique**

Leaf and soil samples should be taken after the second half of July, 10 and/or 15 days before harvesting starts. If fertilization recommendations are to be made based solely on soil analysis, samples should be taken in autumn, a few months before fertilizer is applied to the orchard. As a result of this analysis, the nutrient requirement should be determined according to the condition of the plant and the amount of plant nutrients available in the soil (Güçdemir, 2012; Özkutlu, 2020; Anaç et al., 2020). To maintain sustainable organic hazelnut farming, legume planting, green manure, farm manure from the same enterprise and/or local sources, and hazelnut manure compost can be used (Turan and Dere, 2005; Turan et al., 2009; Şenol, 2019). In organic hazelnut orchards, Rhizobium bacteria living symbiotically with legume plants grown as green manure should be used. Farm manure should be evenly distributed onto strip in the ring form with a width of 50-60 cm branch projection of the shrub every 3-4 years in autumn or early spring and mixed with the soil (İslam et al., 2018; Özkutlu, 2020).

Hazelnut plant grows well in soil with a pH value between 5-7 and can produce plenty of crop. However, especially the soil of the Eastern Black Sea Region where hazelnut is cultivated is acidic. The acid character of the soil may prevent the uptake of certain elements. Therefore, physical, chemical and biological properties of soil can be improved by liming. The amount of lime to be added to the soil is determined according to the results of soil analysis. Lime is evenly distributed onto strip in the ring form with a width of 40-50 cm branch projection at a soil depth of 5-10 cm between November-February every 3-4 years (Turan and Dere, 2005; Turan et al., 2009).

Another method of adding organic matter to the soil in the absence of farm manure is green manuring. Green manure crops for hazelnut orchards are vetch, wild peas, and oats, which should be sown onto strip in the ring form with a width of 40–50 cm branch projection on sloping lands in autumn, and in all gardens on flat lands, and should be mowed and mixed with the soil before flowering in the first months spring season (Figure 1).

Figure 1. Application of nitrogen fertilizer and lime to the crown projection

This practice should be continued for several consecutive years in areas with low soil organic matter, and also hazelnut husk should be turned into compost and spread on the branch projection and laid at a depth of 5-10 cm (Özkutlu, 2020). In addition to these fertilizers, organic hazelnut producers use NPK-containing commercial fertilizers licensed for organic agriculture (Turan and Dere, 2005). For example, such as amino acid, cupper 5 force produced by Gübretaş I.C (Ekotar, Mersin), and algovital plus (IMO, İzmir) produced by Vit Verim İnşaat L.C. (İstanbul).

**Pruning, Thinning, and Removal of Sucker Shoots and Weed Control**

In the hazelnut orchards; diseased, old, dry branches and/or twigs that are directed into the hazelnut shrub must remove to ensure that the shrub having flat form crown. The distance between the shrubs should not be less than 4-5 m. In order to maintain this distance, the shrubs should be removed when necessary and the number of branches in each shrub should be reduced to 4-6 to ensure the best utilization of sunlight, ventilation and plant nutrients (İslam and Serdar, 2020).

In addition, shading will be prevented by cutting fruit trees and other border plants that are common in hazelnut orchards. Hazelnut plants tend to produce a lot of roots and sucker shoots (Figure 2). They develop abundantly every year on the roots of main branches and share the nutrients of the shrub as well as cause the branches to become dense and prevent ventilation and sunbathing (İslam et al., 2018). For this reason, the root and sucker shoots should be removed twice a year, in the fall and late May early June periods. In general, pruning in hazelnuts is done in the fall, when vegetation stops and the leaves fall to a large extent. On the other hand, recent studies have considered that pruning can be performed for 12 months (Turan et al., 2009). For example, bottom shoot cleaning, branch thinning, pruning of disease and insect infected-branches. However, these pruning practices must be carried out under the supervision of specialized technical staff. In order to weed suppression in hazelnut orchards, it is necessary to weeding at least once a year. Although weed control is generally done with a weed hook in organic hazelnut production, organic herbicides containing fatty acid, clove oil, acetic acid and garlic extract (Kolören and Lanini, 2018) and flame weeding are also used (Turaloğlu, 2019).

**Control of Diseases And Pests**

***Pests***

*Hazelnut weevil* [*Curculio nucum* L. (Coleoptera: Curculionidae)]

Hazelnut weevil has no effective natural enemies. However, some birds are known to be predators of adult form. *Beauveria densa* Link. (Hypocreales: Clavicipitaceae) was identified as an entomopathogenic fungus that infects larvae found in soil (TOB, 2017).

Figure 2. Before and after pruning of hazelnut

Figure 3. Hazelnut worm

Mechanical control against this pest can be carried out by collecting fallen fruits and hoeing the garden soil. Thus, insect density can be reduced, but care must be taken not to damage the plant roots when hoeing. The economic damage threshold must be determined and a decision must be taken accordingly (Figure 3). After early morning counts, if there are at least 2 or more adults per 10 shrubs and the nuts have reached the size of lentil, control can be considered (first week of May). Against this pest, repellent mixture (sulfur + lime + ash; 3:1:1) can be used by applying from the trunk to the bottom of the shrub, and a dose of 2 $mlha^{-1}$ of spinosad, a virus preparation, is recommended (Ruşen et al., 2005).

*Ambrosia beetles in hazelnuts (Xyleborus dispar* F. and *Xylosandrus germanus* B.), *(Xyleborinus* saxesenii R. (Coleoptera: Curculionidae)]

Cultivation activities such as pruning and fertilization in hazelnut orchards should be carried out in accordance with the appropriate technique, and trees should be kept healthy. Contaminated branches containing overwintered adults should be cut and removed from hazelnut orchards and disposed until March at the latest. In addition, hazelnut orchards should not be established in places with high ground water and cultivation activities should be carried out together with all neighboring gardens (TOB, 2017).

As a biotechnological control, it is possible to apply a successful control against this pest with the method of mass trapping. Accordingly, traps should be hung according to label information. In biotechnological control, traps should be checked periodically and replaced immediately when the attractant (ethyl alcohol) in the traps depleted. This is extremely important, because if the attractant is not renewed as soon as it is finished, the insects heading toward the traps remain untargeted and can infect the branches close to the traps (Figure 3). In addition, traps should be hung to represent the garden and should never be hung along the borders (TOB, 2017; Güncan, 2020).

*Hazelnut Cone Mites* [*Phytoptus avellanae* Nalepa (Acarina: Phytoptidae) *Cecidophyopsis vermiformis* (Nal.) (Acarina: Eriophyidae)]

Mechanical control is a highly effective method against hazelnut cone mites. During the leafless period in winter, the hazelnut cones should be collected and left somewhere in the garden (Figure 5). They should never be burned or buried. The inside of the cones is also a shelter for other beneficial mites and insects. Since hazelnut cone mites move too slow and are rapidly affected by unfavorable environmental conditions, they cannot leave the cones and die because they cannot find food in the dried cones (TOB, 2017).

Figure 4. Damage of bark beetle in hazelnut (Atıf Yok)

Figure 5. Damage of hazelnut cone mites

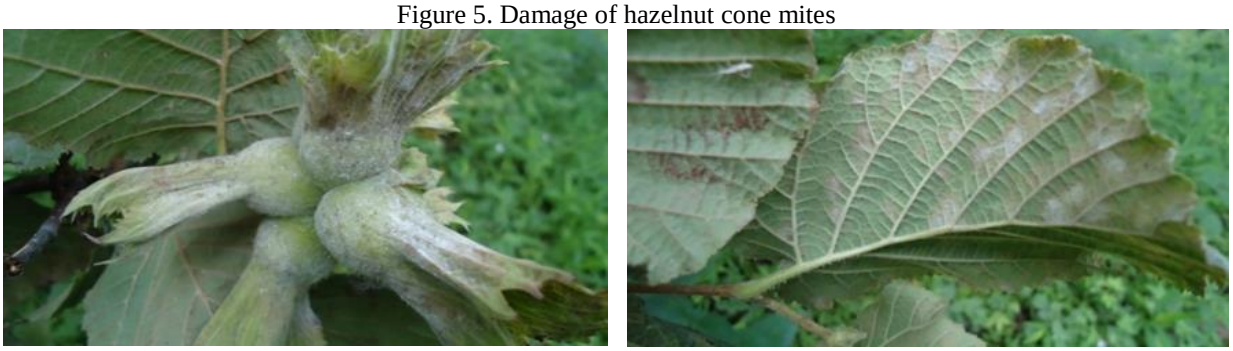

Figure 6. Damage of powdery mildew

***Diseases***

*Powdery mildew Phyllactinia guttata (Wallr. Et. Lev.) Fr. and Erysiphe corylace arum* U. Braun & S. Takam.

Cultivation measures: To reduce the infection source, fallen leaves and diseased plant residues should be collected, infected sucker shoots should be cut and disposed (Figure 6). Pruning and weed control should be emphasized to reduce humidity in the garden and to ensure better air circulation and adequate lighting (Kolören, 2020).

Spraying time should consider followings: If the disease appears for the first time in the garden, it is necessary to start spraying as soon as the symptoms occur (Sezer, 2020). If the disease was observed in previous years, the first spraying should be done after the leaves reach their normal size before the symptoms appear (TOB, 2017), and liquid sulfur should be used.

*Hazelnut bacterial blast (Xanthomonas arboricola pv. corylina*)

Cultivation measures: the soil of hazelnut orchards should be at normal depth and rich in plant nutrients, orchard areas should not have high level of ground water and water retention capacity, appropriate fertilization and accurate timing and technique of cultivation activities should be maintained. When establishing an orchard, healthy saplings should be used and planting can be done in the fall, and/or winter. Plant materials for propagation should not be taken from the infected trees. Diseased shoots and branches should be cut 60-100 cm below the infected part and removed from the garden and disposed by burning. Pruning in diseased gardens should be done in summer and winter (TOB, 2017). Tools used in pruning should be disinfected in accordance with organic farming regulations when moving from one shrub to another (Turan et al., 2009).

**Post-harvest Applications in Hazelnut**

***Harvest***

Hazelnut husk should be harvested when the humidity falls below 30%, and early harvest should be avoided. Associated with early harvest, both the physical properties and chemical development of hazelnut are insufficient. In early harvested hazelnuts, especially the yield and the rate of whitening in the hazelnut kernel is low, the amount of wrinkles increases, the taste becomes bland and the storage life is shortened. In organic hazelnut farming, the ripening nuts should be waited to fall or growers should manually shake the branches and drop the nuts and collect them from the ground. However, since the land in the 1st Standard provinces (Ordu, Giresun, Trabzon, Rize and Artvin) where hazelnut production is made, is too sloppy, branch harvesting may be allowed in some areas without waiting for the nuts to fall to the ground. In this case, it is absolutely necessary to comply with the harvesting ripening criteria (Turan and İslam, 2020b).

Large mesh sacks and/or large baskets should be used when transporting the harvested hazelnuts to the threshing floor. Baskets and sacks used in traditional hazelnut harvesting should never be used in organic hazelnut harvesting. If use, they must be disinfected properly before use. Harvesters must disinfect their hands if they are going to harvest organic hazelnuts immediately after harvesting hazelnuts produced with conventional methods (Turan and Dere, 2005).

***Threshing***

The harvested hazelnuts should be brought to the threshing floor on the same day and laid in a layer of maximum 10-15 cm thick. In sunny weather, mixing

process should be done daily with a wooden shovel and after 3-4 days of withering, manure should be separated with the help of haymaker. Hazelnuts separated from the manure should be laid on a jute cloth/canopy in the soil blend or directly on disinfected concrete with a maximum thickness of 5 cm. The cleaning agents used in these disinfection processes should be complied with the rules permitted by the organic farming regulation. The hazelnuts brought to the threshing floor should be mixed at least 2-3 times every day in sunny weather and then cleaned from dust, soil, and empty hazelnuts by passing through a fan. Broken and damaged organic hazelnuts should be removed by hand and the dried hazelnuts should be placed in jute sacks early in the morning or in the evening when the air is cool (Turan and İslam, 2020b).

***Storage***

The warehouses where organic hazelnuts will be placed should not allow mixing or contamination with other products and substances that are not in compliance with the organic farming regulation. Insulation materials and cooling equipment used in warehouses for organic hazelnuts should be selected considering these regulations. In cases where separate storage is not possible, measures should be taken to prevent the mixing of organic and conventional products and the adequacy of these measures should be checked by the public authority. Storage conditions should be provided with pressure, temperature, and gases approved by the authorized institutions. During the storage of organic products, pesticides and spraying methods that will cause the product to lose its organic properties should never be used (Turan and Dere, 2005; Turan et al., 2009). In the warehouses where these conditions are met, the humidity of the unshelled hazelnuts should not be exceeded 7%, the kernels 5% and the total humidity 12%. Storage temperature should be arranged between 5-10 °C and atmospheric humidity between 50-60%. Packages containing unshelled hazelnut or hazelnut kernels should be placed on wooden pallets in warehouses and no more than 10 packages should be stacked on top of each other. Loading and unloading should not be carried out in unsuitable climatic conditions and without taking the necessary precautions (Turan et al., 2020c).

## Conclusions

Organic hazelnut production in Türkiye started in the early 1990s and has developed in line with the demand of foreign companies. In organic hazelnut production studies, it is seen that organic-based preparations are insufficient to meet the nitrogen need of the soil and to control against some pests, especially nut weevil. Solving these problems requires growers to devote more time to applying mechanical control methods in the orchards. This constitutes one of the most important problems that increase the cost of organic hazelnut production. The fact that the market value of organic hazelnuts is not very high may lead growers to have difficulties in their choices and/or to withdraw from organic production. Thus, funds for organic hazelnut production should be increased to a level that will cover the costs, and large-scale national projects should be developed to overcome challenges in plant nutrition and pest control.

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