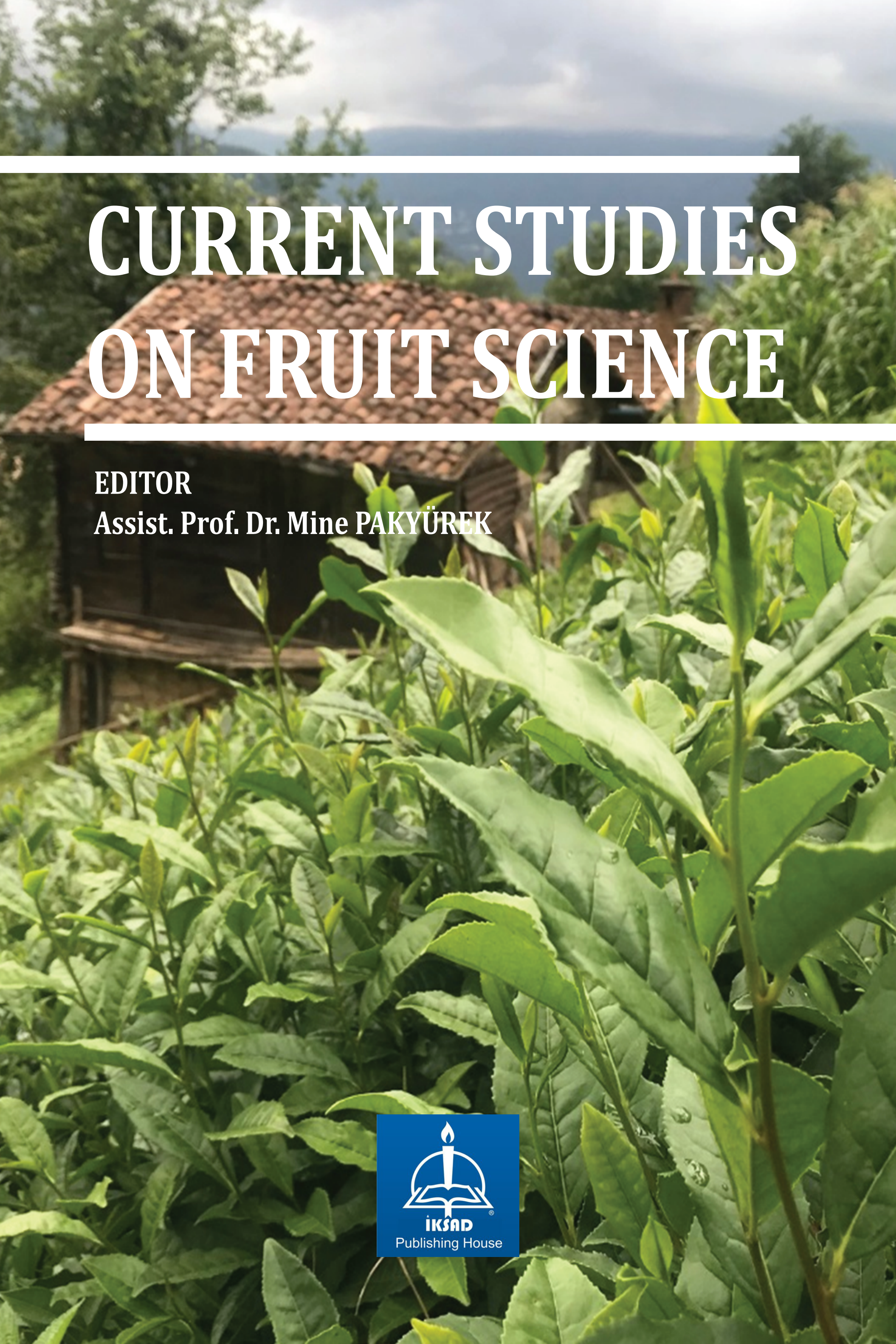

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PREFACE

Nowadays, the important of health and healthy food has been significantly increase around the globe. Undoubtedly, the global epidemic (Covid-19), which started two years ago has badly affected all the countries in the world. Fruits have an important place in human nutrition owing to fact they contain an excellent amount of minerals and vitamins. Regular fruit consumption has recently become one of the essential conditions for a healthy diet in order to strengthen the immune system. Based on the statements made by the World Health Organization in this regard, the United Nations declared 2021 as the "International Year of Fruits and Vegetables". In this way, it is planned to raise awareness about the nutritional and health benefits of consuming more fruits and vegetables.

Because of the increase in fruit consumption during the epidemic, the importance of sustainable fruit production has been substantially increased. The main condition for leaving a healthier world to future generations is to not pollute the basic production resources such as soil and water, with synthetic pesticides and fertilizers. Economic use of available water resources is also extremely important in sustainable fruit production. The climate change we have been experiencing in recent years also complicates sustainability in agricultural production. The fruit growing sector is directly affected by climate changes. It also affects the fruit supply process in many ways, such as product quality, access to safe and healthy food. The fruit production sector contributes to improve of biodiversity, ensuring sustainability over the world and enhancing the livelihoods of farmers and workers. In this regard, our book involves novel production techniques were used currently and the advanced studies that contributed for sustainable fruit growing.

I would like to thank all the authors for their efforts and valued works contributed to the formation of this book. Hopefully, our book will be beneficial to researchers and specialists who are interested in fruit growing and breeding.

Sincerely Yours

Mine PAKYÜREK

CHAPTER 1

AN OVERVIEW OF STRAWBERRY (*Fragaria* spp.) CULTIVATION IN TURKEY AND IN THE WORLD

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INTRODUCTION

Strawberry is a plant that can be grown in a wide variety of climates all over the world, and it is a berry-like fruit consumed by everyone due to its fragrant, delicious, aromatic properties and beautiful appearance. There are different types of strawberries that grow especially in temperate climates around the world. Being an important component of our natural environment, Strawberry is a berry-like fruit belonging to the genus *Fragaria*, from the family Rosaceae. Its closest relatives, *Duchesnea Smith* and *Potentilla L. Fragaria*, have six ploidy chromosomes, while the most common species in the world, *Fragaria vesca*, has 14 chromosomes and is a diploid plant. Moreover, it is reported that *F.* × *ananassa* is a hybrid of *Fragaria chiloensis* (L.) Duch and *Fragaria virginiana* Duch. Besides, there are 13 diploid and 12 polyploid species of *Fragaria* currently. Therefore, although most strawberry species are perfect flowered, some are dioecious. In addition, male flowers consist of pistillate plants that do not produce viable pollen and function only as females, while some are staminate male plants that do not bear fruit and serve only as pollen sources. Wild Fragaria (Rosaceae) species occur across the northern hemisphere and disjunctly in southern South America (Fig. 1). As is known, *F. vesca* is the most widely used species in Asia, Europe and America. Other species are clustered in different ecogeographies such as Europe-Siberia, North China and Manchuria, Indo-South China, Japan and America. Besides, although it is native to the Pacific Northwest region of North America, *F.* × *ananassa* is cultivated all around the world

(Hancock, 2020). In some records, it has been reported that strawberry cultivation was carried out in the world, especially in Europe in the 1324s and in Turkey in the late 1700s and early 1800s (Yılmaz, 2009). It is also indicated that the homeland of the strawberry is South America (Chile). The awareness of berry fruits is as old as human history. Wild strawberries are among the plants used for human consumption. It is possible to come across wild strawberries and similar berry fruits in almost every region of our country. These fruits have become a part of people's cultural and commercial life (Arslan, 2006). In addition, due to the fact that strawberry is a herbaceous but perennial berry type that is suitable for early season and has good export and domestic sales opportunities, it has become a species that is increasing its prevalence in the world day by day due to the ease of breeding studies compared to other fruit species (Ertürk et al., 2015). Conventional strawberry production in Turkey started in the 19th century in the Marmara (Arnavutköy/Istanbul) and Western Black Sea (Ereğli/Zonguldak) regions, and during its cultivation woodland strawberries (*F. vesca*) were generally used and it was consumed as marmalades or jams due to its unique aroma (Kaşka, 1997). However, traditional strawberry cultivation started in the Mediterranean region in the early 1960s under the leadership of Arife Karaoğlu (Tarsus Regional Soil and Water Research Institute). Then modern strawberry cultivation was started in the 1980s by Prof. Dr. Nurettin Kaşka. Çiltar (Dr. Ali Türemiş and Dr. Ömer Taşkıran), a private nursery company, started commercial production of frigo plants. Afterwards, Mehmet Yaltır, the owner of Yaltır Nursery Company, and especially the technical director of the company (Mehmet Ali Ünlü) and his team played an important role in the use of frigo plants for strawberry growing, as well as in the dissemination of strawberry cultivation with modern techniques (Kafkas, 2016). The first strawberry cultivation in Turkey started with local varieties selected from wild strawberries and grown up till today in provinces such as 'Ereğli' in Zonguldak, 'Arnavutköy' in Istanbul, and 'Karşıyaka' in İzmir. The fruit of latter variety was not as aromatic as the 'Ereğli' variety. However, this variety was the only freshly consumed variety called 904 in the Aegean coastal region of Izmir. The 'Arnavutköy' variety was an aromatic local variety of Istanbul and suitable for both fresh consumption and the jam industry, whereas the local 'Ottoman' variety was the most aromatic local variety among the known and grown strawberries grown in Central Anatolia around Ankara. The Ottoman variety is male sterile, its fruits are small, its yield is very low, it is pink in color and very soft. European varieties started to be used in strawberry cultivation in the 1960s due to close relations and migrations with European countries. In the Marmara region, Bursa was famous for the 'Madame Moutot' strawberry variety brought from Bulgaria and successfully grown from 1940 to 1960. The first modern culture in strawberry growing started with 'Macheraus Frühernte' in Tarsus/İcel Soil Conservation and Irrigation Institute. In the 1970s, the first adaptation studies were carried out at the Yalova Atatürk Horticultural Research Institute using foreign varieties such as 'Madame Moutet', 'Gorella', 'Pocahontas', 'Suprise des Halles', 'Tioga', 'Aliso'. ‘Cambridge 0422' and 'Pocahontas' were the main varieties found in the region (Kaşka et al., 1979; Yılmaz, 2009; Kaska, 2002).

Modern farming methods such as annual agricultural systems, tall nurseries, large plant beds, drip irrigation, fertilization and black plastic mulch technology introduced in the 1980s have been used. Strawberry farmers in Turkey collaborated with research scientists and increased production efficiency. In the development of strawberry cultivation and technology in Turkey, Çukurova University scientist Prof. Dr. Nurettin Kaşka has conducted many experiments in various ecological regions such as Ankara (Central Anatolia), Antalya (Mediterranean coast), Sultanhisar (Aegean), Adana (Mediterranean), Yalova (Marmara) and Dalaman (Aegean coast). The researchers compared the winter and summer planting systems of the frigo plants of Aliso, Tioga, Pocahontas, Cambridge 0422 and Ottoman varieties, taking into account the 3-year production periods. Due to the sandy soil, the highest yield was obtained from the Antalya region, and the lowest from the Ankara region. The results of these adaptation studies using European and American strawberry varieties have reported that strawberry cultivation regarding these varieties is carried out in various regions in Turkey (Kaska, 2002; Kafkas, 2016). The aim of this study is to offer new perspectives for the future of strawberry cultivation by analyzing academic studies on strawberry production in the world and in Turkey, the place of strawberry in the world market, new varieties of strawberry and strawberry breeding, cultural practices, harvesting and post-harvest processes.

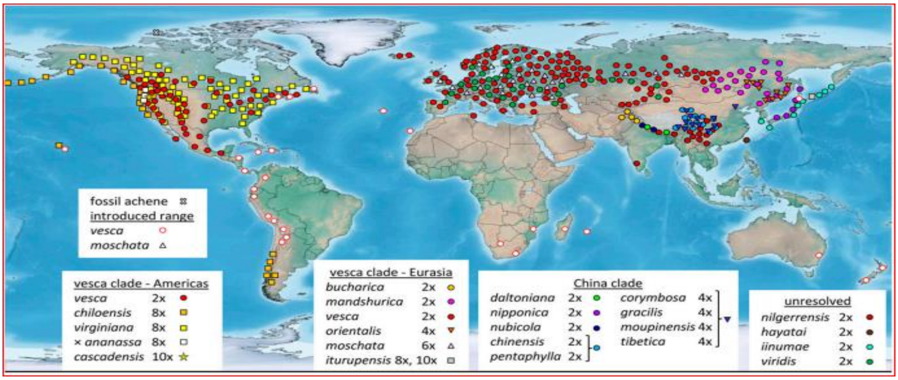


Figure 1: Approximate geographic distribution of *Fragaria* species and ploidy. Due to uncertainty over species boundaries, the six endemic Chinese species are designated as diploids (*F. chinensis*, *F. pentaphylla*) or tetraploids (*F. corymbosa*, *F. gracilis*, *F. moupinensis*, *F. tibetica*). Data sources include the GBIF data portal, the "Wild Strawberry" Dimensions of Biodiversity US-China project website, published distribution maps, and base map (Liston, et al., 2014).

STRAWBERRY CULTIVATION IN TURKEY AND IN THE WORLD

In Turkey, varieties registered by the Ministry of Agriculture such as 'Aliso', 'Cruz', 'Dorit' (216), 'Douglas', 'Pajaro', 'Tioga', 'Tufts', 'Vista', 'Yalova-15', 'Yalova-104' in Turkey, 'Yalova-110', 'Redlands Hope', 'Kabarla', 'Sweet Charlie', 'Cal Giant 3', 'Festival', 'Camino Real', 'Albion', 'Ventana', 'Marbling', 'Ebru', 'Kaşka', 'Sevgi', 'Palomar' were used. In addition, 'Camarosa' has been used as the most popular commercial variety for many years due to its high yield, larger and firmer fruits and strong plant characteristics. In recent years, 'DPI-Rubygem', 'Florida Fortuna' ('Radiance'), 'Florida Festival', 'Sabrina', 'Sabrosa', 'San Andreas', 'Sweet Ann', 'Kabarla' varieties have become popular. In addition, varieties such as 'Crystal', 'Camarosa', 'Amiga', 'Sweet Charlie' are cultivated in coastal areas, and 'Cristal', 'Fern', 'Aromas', 'Albion', 'Sweet Ann', 'San Andreas' ', 'Monterey', 'Portola' are grown in the last season in the Central Anatolia region. As well as 'Florida Festival', 'Florida Fortuna', 'DPI-Rubygem' varieties, 'Sabrina' and 'Sabrosa' are also known as common varieties. ‘Festival’ is preferred for its high fruit quality, while ‘Rubygem’ is thought to be very sweet and tasty and having pleasent aroma mostly preferred by Turkish consumers. ‘Florida Fortuna’ is the most common cultivar for early production areas. Its yield is high under optimum conditions, however, it is highly susceptible to soil-borne diseases. ‘Amiga’ does not have great taste, it is still produced because of its exceptional fruit firmness characteristics. Cultivation is done using mostly short-day commercial cultivars however day-neutral cultivars are used less. Day-neutral cultivars are grown especially in high elevation and northern climates. In Turkey, as a result of a few cross-breeding programme a few Turkish cultivars were obtained. The first breeding programme was started by Ataturk Horticultural Central Research Institute and ‘Yalova-15’, ‘Yalova-104’, ‘Eren 77’, ‘Ata 77’, ‘Erenoğlu 77’, ‘Hilal 77’, ‘Dorukhan 77’, ‘Doruk 77’, ‘Bolverim 77’ cultivars developed from this program by Dr. Onur Konarlı and Dr. Burhan Erenoğlu (Yılmaz, 2009). In another cross-breeding programme the cultivars ‘Kaşka’, ‘Sevgi’ and ‘Ebru’ were developed from the Çukurova University by Prof. Dr. Nurettin Kaşka, Prof. Dr. Sevgi Paydaş Kargı and Prof. Dr. Ebru Kafkas while ‘Seyhun’ and ‘Ceyhun’ from Yaltır company and cooperation with University of Çukurova (Kafkas, 2016). Strawberries are grown both in open field (80%) and in low and high tunnels (20%). Operating costs are minimal as the high tunnels are passively heated and cooled. High and low tunnels are used for earliness and to protect plants from frost damage. Today, greenhouse production systems are much more preferred due to climate change. The reason for this is that producers prefer plastic high tunnels as they are less expensive and help them control the ecological conditions relatively. Moreover, we can list the reasons why producers prefer high tunnels as follows; They prefer them for reasons such as high yields, earliness, long shelf life, low humidity on the leaves and fruit compared to the low tunnel, and less fungal diseases such as *Botrytis* (Kadir et al., 2006; Santos et al., 2010; Belasco et al., 2013). The raised bed annual system is a common practice. Black plastic mulch coverage and drip irrigation and fertigation applications are also common. Although annual growing method should be used in strawberry cultivation, some growers keep their plantings for a second or a third year. Consequently, yield and fruit quality is significantly reduced in the second year and the incidence and severity of soil-borne fungal diseases increases. Covers are used to passively protect plants against the frost damage. As for the pollination, bumble bees are commercially available and work well in high tunnels, but they are expensive. For this reason, most of the growers prefer honeybees to bumble bees in Turkey (Paydas et al., 2000). As of 2019, in global strawberry production, China ranks first with 3.2 million tons, the USA ranks second with 1 million tons, and Mexico ranks third with 861 thousand tons. Being the leading strawberry producer, China meets 36.2% of the total global strawberry production. As in terms of the amount of production, China is the leader in terms of production areas as well with 126 thousand/ha. Poland ranks second with 50 thousand hectares and Russia is in the third place with 31 thousand hectares.

According to the world trade data for strawberries by Trade Map, the export amount of fresh and frozen strawberries in the world in 2020 was 1.6 million tons. As compared to the previous year, there was a 3.8% decrease in Spain, which ranked first, and 2.0% in the USA, which ranked third, on the other hand, an increase of 7.6% was experienced in Mexico, which ranked second. In 2020, the amount of fresh and frozen strawberry import in the world was 1.7 million tons. The USA, which was the largest importer, experienced an increase of 3.1% compared to the previous year; Germany, being the second largest importer experienced an increase of 3.0% while the third largest importer, Canada experienced an increase of 3.3%. Turkey's foreign trade of strawberries is carried out in two ways as fresh and frozen strawberries. As most of the strawberries produced are consumed domestically, only 8.8% of the total strawberry production was exported in 2020. Being the fourth largest strawberry producer in the world, Turkey comes twelfth in terms of exports. Strawberry exports in 2020 increased by 14.7% compared to the previous year and was 47.912 tons (Table 1 and Figure 2). Strawberry exports have doubled in the last five years. Strawberry imports, on the other hand, vary from year to year, but do not have a significant volume. The strawberry market continues to expand due to the excessive increase in consumer demand for fresh strawberries in Europe in recent years. In order to meet this increasing demand, many companies, both inside and outside Europe, are expanding their production areas in order to produce varieties that can adapt to different climates and are suitable for different production methods.

Table 1: World Strawberry Data (kiloton)

Years	2015	2016	2017	2018	2019	Change(%)
Land (thousand/ha)	377	366	371	395	396	0,4
Yield (ton/ha)	59,2	61,7	57,3	60,0	56,3	-6,1
Production	8.221	8.045	8.242	8.561	8.885	3,8
Import	1.481	1.516	1.561	1.580	1.702	7,7
Export	1.518	1.580	1.556	1.577	1.680	6,6

Source: FAO,[1] /Trade Map (27.05.2021), shows the change in the last two years of which [2]/Data is available.

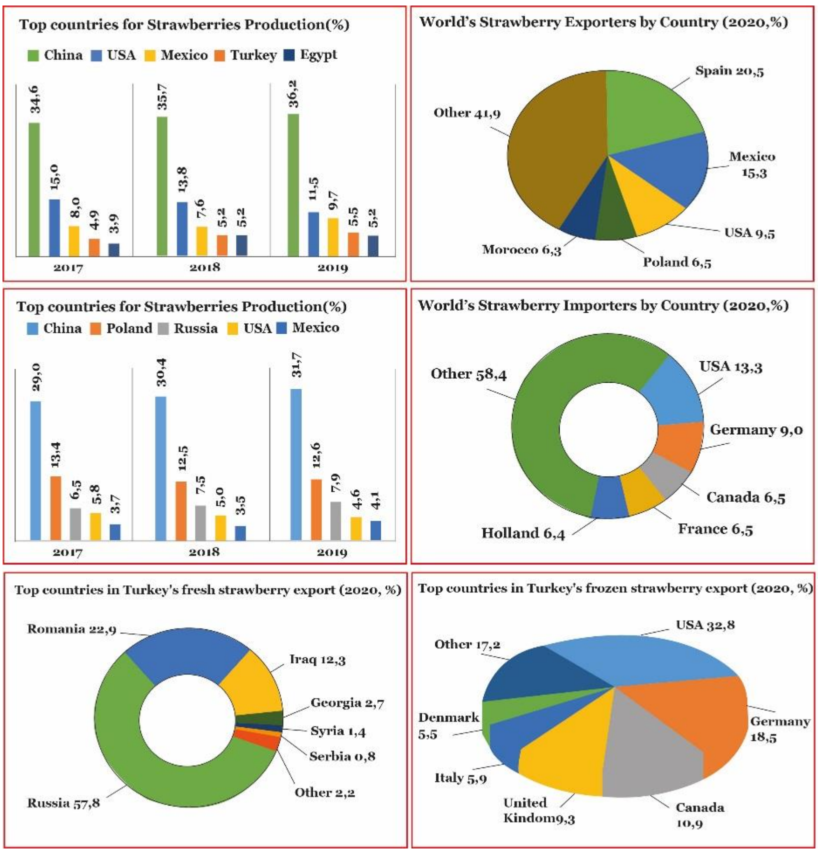


Figure 2: Strawberry production by country, Turkey's fresh strawberry production, strawberry production areas, exports and imports, and top countries in frozen strawberry exports (TUIK, 2020).

Consumers in the world and especially in European countries can find fresh strawberry fruit for almost four seasons. Especially the Southern regions of Europe, for example the Huelva area, which is called Andalusia in Spain, covers almost the 70% of the entire EU demand. In addition, fresh strawberries come onto the European market from Italy, Greece and Turkey, as well as from Morocco, Egypt and Tunisia. Some products are also supplied from other Central African countries (Kenya). Moreover, Greece and Turkey are making efforts to meet the market demand in many eastern and Middle Eastern countries, especially in Russia, in order to increase the market network of fresh strawberries. With the new developments in biotechnology, genetics and plant physiology in breeding studies, important progress has been made in obtaining new strawberry varieties all over the world. At the same time, since genetic resources in the world are integrated with new genomic and molecular knowledge and technologies, they have also provided significant convenience in strawberry breeding. In this context, strawberry breeding studies are carried out in the world through national or international groups or private companies. Seasonal fresh strawberry production in Europe begins in April and July with sheltered and open field production in northern Italy, southern France and Germany. Again in Europe, mostly in summer, fresh strawberry production is carried out by Germany, Poland and other northern countries. As in Turkey, mainly the mountainous areas of Italy are used so that the autumn production can be met. Belgium and the Netherlands, which are among the European countries, differ from all other European countries since they use soilless agriculture in cultivation and are able to produce throughout the year in greenhouses with highly modern automation systems. In order to meet this ever-increasing consumer demand in Europe, producer countries are using high-yield varieties and high-yield production methods. By the way, Turkey is the one of the largest agricultural producer in the world. It is followed by Spain, Poland, Germany and Italy. Undoubtedly, the main feature appreciated by the consumer today is the taste and therefore the demand for organic strawberries are increasing (Mezzetti et al., 2018).

Table 2: Strawberry Data of Turkey (kiloton)

Years	2015/16	2016/17	2017/18	2018/19	2019/20	Change (%)[1]
Fruit orchards (1000 da)	-	154	154	161	161	-0,1
Yield (kg/decare)	-	1.667	1.728	1.690	1.812	7,2
Production	376	415	400	441	487	10,4
Domestic use	306	342	314	350	388	10,9
Consumption Per Person (kg)	3,9	4,3	3,9	4,3	4,7	9,4
Import (ton)	2.654	559	982	3.738	1.855	-50,4
Export (ton)	35.139	32.285	48.970	52.356	53.345	1,9

Source: TUIK (27.05.2021), [1]/TEPGE calculations show the change in the last two years of which [2]/Data is available.

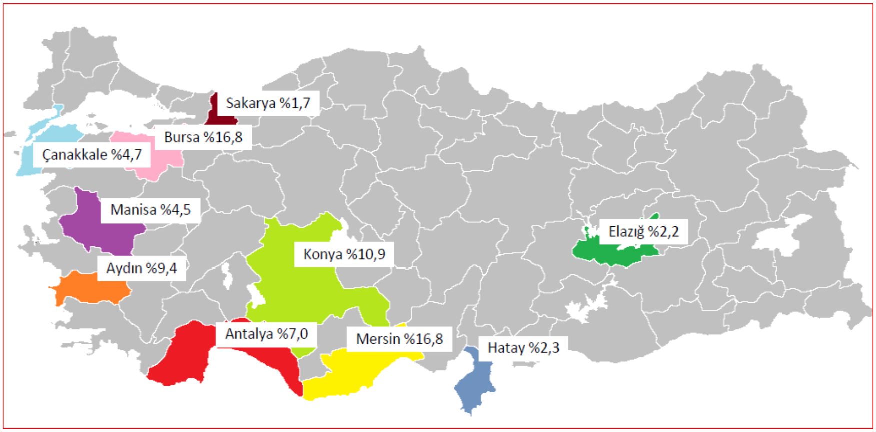


Figure 3: Production Areas for Strawberry in Turkey (TUIK, 2020)

As can be seen in Table 2 and Figure 3, when the strawberry orchards in Turkey in 2020 are examined; Mersin, which has a share of 26.8%, ranks first with 48 thousand decares, Bursa ranks second with 30 thousand decares, and Konya ranks third with 20 thousand decares. Strawberry production areas increased by 16.5% in 2020 compared to 2016 and reached 179 thousand da. The number of production areas increased by 11.7% in 2020 compared to 2019. As seen in Figure 4, Mersin ranks first with 188 thousand tons of strawberry production in 2020, Aydın ranks second with 68 thousand tons, and Konya ranks third with 51 thousand tons. In 2020, compared to the previous year, the amount of production increased by 11.6% in Mersin, 0.4% in Aydın and 17.2% in Konya. According to the first estimation of Turkish Statistical Institute, Strawberry production of 546 thousand tons in 2020 is expected to increase by 18.2% and reach 646 thousand tons in 2021.

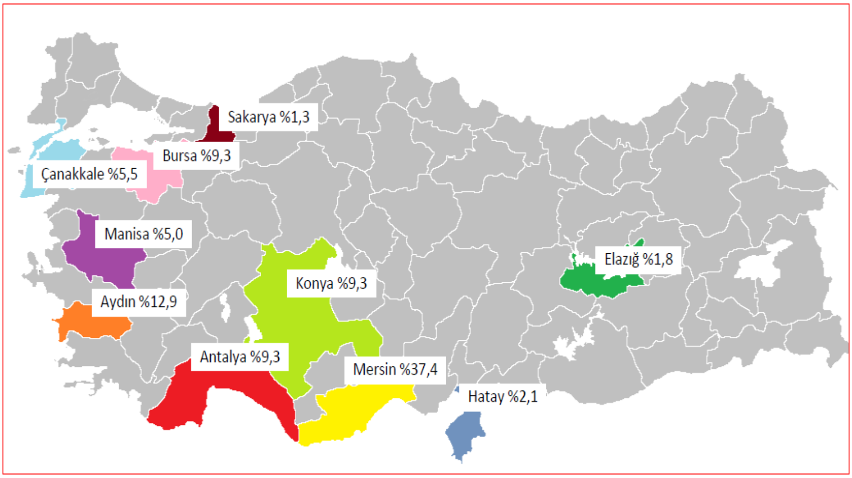
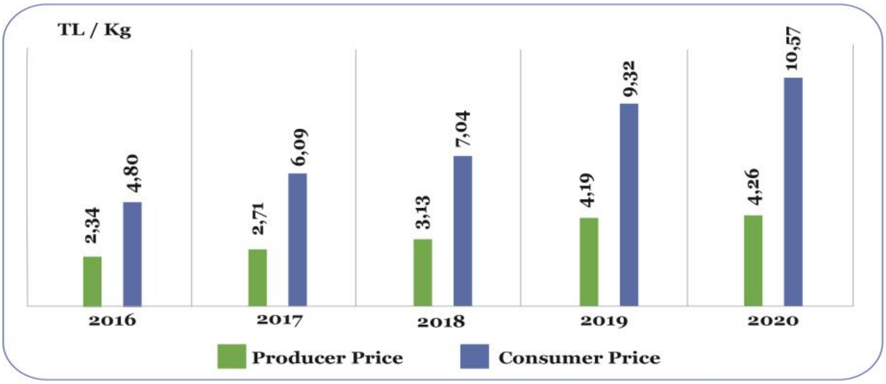


Figure 4: Strawberry production (TUIK, 2020)

According to the countries, Turkey's strawberry export was 47,917 tons in 2020. In the first 4 months of 2021, it was 27,914 tons. During the first four-month period, Turkey exported about 12,543 tons to Russia with a rate of 44%, and about 4,129 tons to Iraq with a rate of 14%. Strawberry import in Turkey in 2020 was about 3 thousand tons. According to the countries, Turkey's strawberry import is approximately 785 tons in the first 4 months. Egypt imported 95% of strawberries. As seen in Figure 5., the changes in strawberry producer and consumer prices in Turkey are given. Accordingly, the producer price of strawberries, which was 5.02 TL/kg in May 2021, increased by 2.3% compared to the previous month and by 19.4% compared to the same month of the previous year. In May 2021, the consumer price of strawberries was 15.10 TL/kg. Consumer price increased by 4.4% compared to the previous month and by 23.1% compared to the same month of the previous year. When the difference between producer and consumer prices in the last 5 years is reviewed, it is seen that the difference was 105.1% in 2016 and reached 148.1% in 2020.



Source: TUIK (27/05/2021)

Figure 5: Changes in producer and consumer prices of strawberry in Turkey

Encourage Policies on Strawberry Cultivation in Turkey: Within the frame of the "Communiqué on Agricultural Support Payments" dated 2020, the support for diesel fuel was 15 TL/da. The support for fertilizer was increased from 4 TL/da to 8 TL/da with the change made in March 2021. The amount of support for strawberries cultivated regarding the organic agriculture was 100 TL/da for individual certification and 50 TL/da for group certification. Regarding the good agricultural practices support, while the ones producing under greenhouses with individual certification received 150 TL/da and group certification received 75 TL/da; those producing in open fields with individual certification received 50 TL/da and group certification received 25 TL/da. Soil analysis support is determined as 40 TL per analysis, with 1 analysis for each 50 decares of land for the lands of more than 50 decares. A support of 400 TL/da is given to the producer using certified saplings. In 2020, an increase of 91.4% was achieved in the total amount of support given for the production of 1 kg of strawberries compared to 2016. Strawberry cultivation, which is the most important one among the berry-like fruits, has shown a continuous increase in the last 50 years in our country. Due to its high adaptability, strawberry is one of the most common fruit species in the world. In our country, strawberry cultivation is possible from the sea level to 2000 m. In addition to its high adaptability, a very rich biodiversity also plays an important role in the cultivation of strawberries in a very wide area. However, ecologies with warm temperate climates have more importance in terms of strawberry cultivation. Although strawberry cultivation is carried out almost everywhere in Turkey, the large part of production takes place in the Mediterranean, Aegean and Marmara regions. Turkey's foreign trade of strawberries is carried out in two ways as fresh and frozen strawberries. As most of the strawberries produced are consumed domestically, only 8.8% of the total strawberry production was exported in 2020. Being the fourth largest strawberry producer in the world, Turkey comes twelfth in terms of exports Strawberry exports in 2020 increased by 14.7% compared to the previous year and was 47.912 tons (Table 1 and Figure 2). Strawberry imports, on the other hand, vary from year to year, but do not have a significant volume. Consumption per capita has varied between 3.9-4.7 kg/year in the last 5 years and was determined as 4.7 kg/year in 2019. The qualification rate for the 2019-2020 marketing year is 112.2%. Considering that 90% of the strawberries produced in our country are consumed fresh, the use of postharvest technologies should become a necessity. The use of the most effective method by updating the current methods used in strawberry preservation in line with new trends is important for both the producer, the consumer and the country's economy.

CULTURAL PRACTICES IN STRAWBERRY PRODUCTION

If the soilless culture is not taken into account, there are two main production methods used in strawberry production: hill planting and mulching system. The use of mulch in strawberry cultivation is considered to be very important in terms of weed control and increasing the yield of strawberries. The hill system for growing strawberries is most commonly used for day neutral strawberries. Short-day varieties are grown in California, Florida, Italy, and Spain where the winters are mild and the summers are hot. Short-day varieties are also used in climates characterised by cold winters and short summers, such as Europe and northern North America. Most of the strawberries in the world are cultivated in open fields, but currently strawberry cultivation in tunnels and greenhouses has been increasing rapidly. In some regions, such as the Turkish Mediterranean Region, Southern Spain and the United Kingdom, almost all of the hectares of strawberries are grown under tunnels. In other places, such as Turkey, Belgium, the Netherlands, and Japan, greenhouses are the most popular for off-season production. Strawberry production is increasing day by day in Mexico, Eastern USA and Canada (Kafkas, 2016; Hancock, 2020). Until recently, methyl bromide and chloropicrin chemicals were fumigated into the soil to combat diseases caused by soil-borne pathogens. However, with the idea that these chemicals play a role in the depletion of the ozone layer, the use of these chemicals was banned in 1987 with the Montreal Protocol approved by the United Nations. Since methyl bromide/chloropicrin fumigation application, chloropicrin and metam sodium applications damage the ozone layer and soil microorganisms, wood vinegar (pyrolysis acid), a natural product, has been used in organic agriculture in recent years, which plays an active role both in improving soil structure and in combating soil-borne fungal diseases. Due to the rapid population growth, agricultural lands have been used extensively to meet the nutritional and shelter needs of the people recently, resulting in soil exhaustion and soil pollution. The technological developments affect the agricultural sectors in the world as well. For this reason, developed countries has started to perform natural and different applications in order to ensure the sustainability of agricultural production areas, to reduce soil pollution, to restore the flora and fauna of agricultural soils, and to improve soil chemistry. One of these applications is the use of wood vinegar (Oğuz and Oğuz, 2021). Based on photoperiodic requirements for flower induction, strawberries are classified as short-day, long-day and day-neutral. Currently, most cultivated strawberries are short-day cultivars. In recent years, utilization of day-neutral cultivars increased in commercial strawberry growing because of their importance for extending production season length. Complex flowering habits of the cultivated strawberries delayed to obtain knowledge on their flowering physiology. Some aspects of flowering physiology of strawberries still remain unclear. Therefore, even today this subject is being emphasized. Comprehensive knowledge on flowering physiology of short-day, long-day and day-neutral strawberries and factors affecting flowering physiology will increase growing achievement of them and make important contribution to the development of strawberry production. Strawberries are planted in winter or autumn regarding their varities, whether they are neutral or short-day. Day-neutral varieties are preferred as they flower at an early stage. At the same time, neutral varieties are produced both in the open field and in tunnels for earliness in many parts of the world. Strawberries are planted in autumn in open fields in regions with mild winters. In places with harsh winters, they are planted in greenhouses and tunnels to get the last-season product, or they are planted in the open field in spring to extend the fruiting season. Due to the cyclical nature of neutral varieties, it is ensured that the vegetative development of the plant is completed with plucking the first flowers and that way it is provided that it will yield more in the future periods. Short-day plants grown in matted rows are usually planted in early spring. In the first year, the flowers of the plant are removed by plucking. The aim here is to allow the plant to develop a strong system and to encourage runner production. Short-day varieties are planted in a hill system either in summer or in late autumn/early winter, depending on the producer's purpose and climatic conditions. In regions with mild winters (lowest 0-10°C) and mild summers (high below 30°C), strawberries are usually planted in summer to be planted again the following spring. Typical summer planting dates range from early August to mid-September (Yılmaz, 2009; Demirsoy et al, 2012; Hancock, 2020). As known, hydroponics started to become widespread for the first time in the 1970s. The reason for this is that the chemical treatment of the soil is often very expensive, causing farmers to seek new methods. It is observed that hydroponics has become increasingly common all over the world. Nonetheless, hydroponics is used mostly in Mediterranean countries such as Spain, Turkey and Italy. Strawberry is one of the most popular fruits in the world. However, in terms of strawberry growing, traditional agriculture poses serious problems due to yield and plant loss caused by soil-borne plant pathogens. Since the chemicals used for the treatment of the soil may be greatly harmful, hydroponic strawberry production has been preferred by the producers. This method not only provide protection from diseases and pests, but also significantly increased yield and fruit quality. Hydroponic strawberry cultivation has showed effective results in areas where climatic conditions are suitable but soil is not. Currently, the most important reasons for the rapid spread of hydroponics in greenhouse strawberry cultivation are that soil-borne diseases and damaging effects of pests. For this reason, producers achieve higher yields and improve the quality of their production with proper fertilization and water management thanks to hydroponics (De Cal et al., 2005; Şahin and Kendirli, 2012; Palencia et al., 2016; Demirsoy and Serçe, 2016; Martinez et al. 2017). In recent years, Rubygem, Sabrina, Festival, Albion are the most widely used varieties under greenhouse regarding hydroponics. Cocopeat is generally used as a nutrient medium in hydroponics. Cocopeat is a medium made out of coconut husk and is suitable for use in agriculture especially in hydroponics as it is made free from sand. As Cocopeat is 100% organic, has a pH of 5.7 – 6.5 and high water holding capacity, it is an ideal substance for to be used in agriculture. During the greenhouse cultivation of hydroponic strawberries, approximately 12 thousand seedlings are planted per decare in a way that 13 seedlings are planted diagonally using 15 cm spacing in each Cocopeat container. Planting starts in October, generally the first harvest is done in December. The harvesting process continues until mid-June. With a good garden management and a correct plant nutrition program, generally around 10 tons of product can be obtained from a decare. Producers have been producing more consciously recently. Nevertheless, producers continue to produce as they still make a profit despite the continuous increase in input costs. Especially in greenhouse production, they use Bumblebees to increase pollination and fertilization. Using bumblebees both increases product quality and contributes to natural production by not using chemicals. Earliness and high yield are very important issues in greenhouse strawberry cultivation as the initial cost is high. Strawberry production, which is normally made during the season for 6 months, can be extended up to 12 months with hydroponics. For this reason, fresh strawberries can be placed to the market for 12 months by means of greenhouse cultivation of hyroponic strawberries. The productivity and efficiency can be 4 times higher in hydroponics rather than traditional agriculture when strawberries are well cared. Producers in the Mediterranean Region have been producing hydroponic strawberries in greenhouses recently, despite the high initial cost. They prefer it due to the consumers with the highest willingness to pay and the high market demand (Demirsoy et al., 2017). In addition, in greenhouse hydroponic strawberry cultivation, it has been determined that frigo seedlings are advantageous in terms of yielding and tubed seedlings are advantageous in terms of earliness (Adak and Pekmezci, 2011). Likewise, it has been stated that frigo seedlings are advantageous in terms of productivity and tubed seedlings are advantageous in terms of early maturing (Nafiye and Pekmezci, 2012; Oğuz and Oğuz, 2021). Two main types of mulch are used in growing strawberries: straw and plastic. Straw is generally used with matted row system. As it is known, black and white mulches are used in strawberry production. However, according to the researches, the healthiest results in the use of plastic mulch were obtained from black mulches. Biodegradable plastic mulches have recently come to market, but have not yet been widely adapted (Goldberger et al., 2019). The aim here is to keep the fruit fresh in mild winters, to keep roots warm in harsh winters, to control weeds that will occur in the soil, and to conserve soil moisture by reducing evaporation of water. Thus, it provides a positive contribution to the yield by stimulating the root growth. Strawberry irrigation practices vary greatly depending on climate, soil structure and cultural systems. Especially in recent years, due to the decrease in water as a result of climate change, new projects are being designed about what will be the most ideal irrigation system in the future using economical irrigation or limited irrigation systems in irrigation applications. Researchers have focused on methods of obtaining maximum yield, especially by using limited irrigation systems. For this reason, gypsum blocks and tensiometers are used to conserve the soil moisture in the root zone of the strawberry, which is the basic principle in irrigation. It is reported that soil moisture content should be kept above 50% available water regarding the water loss caused by evaporation in the leaf area resulting from the change in climatic conditions and temperature data as the strawberry plant develops (Gavilán et al., 2015; Morillo et al., 2015). Strawberry plant grows best in sandy loam soil; on very light soil with a pH of 6.5-7.0. Increasing the yield and fruit quality of strawberries can be achieved by fertilizing regularly and in appropriate amounts at appropriate times. Especially fertilization is one of the factors that increase the yield in strawberry cultivation (Kaşka et al., 1988; Seferoğlu and Kaptan, 2010). There are many changes in fertilization practices in strawberry cultivation due to geographical, ecological and cultural differences. In general, nitrogen (N) is applied most frequently and in the largest amount, followed by potassium (K) and phosphorus (P). Typical N fertilization rates are in the range of 110-450 kg ha-1, with lower rates used in perennial systems and higher rates in annual systems. However, these values will definitely be valid after soil and leaf analysis (Geisseler, 2014; Hanson, 2015). In their study in which they investigated the effect of K fertilization on strawberry based on samples taken from the leaves, they determined that all plant nutrients except nitrogen decreased during the harvest period. According to the same research result, it was stated that excess potassium causes small fruits in strawberry and 40 mg/kg K was recommended for strawberry according to the Bray II method, and it was also stated that it was more appropriate to take and analyze leaf samples in spring to determine the nutrition of the strawberry plant (Kara, 1996). The use of herbicides is the most preferred method for weed control because manual weeding is a laborious operation. Herbicides are the most widely used type of pesticide today, as weeds are an important factor limiting productivity in many crops. The main goal of agricultural chemical application techniques is to control plant diseases, pests, and weeds and achieve the goal with maximum efficiency of agrochemicals and minimum effort to ensure minimum pollution. The uniform agrochemical application has been shown to be effective in removing weeds and but also it is a labor-intensive and time-consuming practice. Hydraulic sprayers are generally used for uniform agrochemical applications. A great number of broadleaf weeds and grasses cause problems in all production areas. There are significant regional differences in weed populations, but some of the most significant perennial weed pests are Bermuda grass (*Cynodon dactylon*), bindweed (*Convolvulus arvensis*), Canada thistle

(*Cirsium arvense*), hedge bindweed (*Convolvulus sepium*), horse nettle (*Solanum carolinense*), horsetail (*Conyza canadensis*), quackgrass *Agropyron repens*), red sorrel (*Rumex acetosella*) and yellow nutsedge (*Cyperus esculentus*). Some of the most troublesome annual broadleaves are little annual sowthistle (*Sonchus oleraceus*), burclover (*Medicago polymorpha*), cheat or chess (*Bromus* spp.), chickweed (*Stellaria media*), common groundsel (*Senecio vulgaris*), filaree (*Erodium* spp.), lambsquarters (*Chenopodium album*), mallow (*Malvia parviflora*), pepper grass (*Lepidium* spp.), prickly lettuce (*Lactuca serriola*), purslane (*Portulacca* spp.), ragweed (*Ambrosia* spp.) and sweet clover (*Melilotus* spp.). Some of the most noxious annual grasses are barnyard grass (*Echinochloa cruz-galli*), bluegrass (*Poa annua*), crabgrass (*Digitaria* spp.), autumn panicum (*Panicum dichotomiflorum*), foxtails (*Setaria* spp.) and wild barley (*Hordeum leporinum*). Several different classes of herbicides are available to strawberry growers. Growers usually use as pre-emergent herbicides such as Examples are napropamide and DCPA (dimethyl 2,3,5,6-tetrachloro-1,4-benzenedicarboxylate) which control a number of annuals and some broad-leaved weeds. Also, they use as post-emergent herbicides such as sethoxydim and fluazifop-butyl, which control actively growing grasses, and 2,4-dichlorophenoxyacetic acid (2,4-D), which is used to control broadleaf weeds after renovation. All of these herbicides have restrictions on where they can be used and when (Hancock, 2020; Dessalegn et al., 2021; Liu et al., 2021). Despite an extended use of chemical soil fumigation, it has been estimated that current yield losses in the area caused by soil fungal pathogens (SFPs) are around 10%. There are no strawberry-resistant cultivars against these pathogens, and therefore their control has relied upon reducing pathogen inocula by soil disinfestation with fumigant agrochemicals (1,3-dichloropropene, chloropicrin, or metam sodium) applied by injection or emulsified in irrigation water. To increase its effectiveness, the soil is covered for several weeks with polyethylene plastic sheets, which maintains the concentration of fumigants in the soil for a longer duration and reduces gas emissions into the atmosphere (López et al 2016; Talavera et al., 2018). It is ensured that the plants develop in a more protected area against environmental conditions. Heated or unheated closed ecosystems can be used. For example, low tunnels are generally 60-70 cm high and have a planting peg inside. These tunnels are simply constructed by bending a steel wire which is 140-170 cm long and 5 mm in diameter until it looks like a cresent moon and placing them into the soil at spacing of 1-1.5 m. High tunnels, on the other hand, have a base width of at least 4 m and a height of at least 2 m, and are made of half-moon-shaped steel or by using 6 m long thin water pipes. Hoops are assembled by inserting pipes to the ground with 5 wires at 1.5 m spacing. UV-blocking plastic films are used as cover material in low and high tunnels. Glass or plastic is used as cover material in greenhouses. Since greenhouses are higher and wider than tunnels, a very suitable environment is created for the aeration and development of plants. It is very easy to care for and harvest the plants inside, and there are suitable spaces as well to carry out processes such as heating and cooling. Low and tall plastic tunnels and greenhouses are becoming more popular for season extension and off-season production, especially in areas with mild winters. They are often accustomed to accelerate ripening by 3–4 weeks. Also, they can be accustomed to produce autumn and winter crops. Protected systems are also valuable in rain protection and disease control (Yılmaz, 2009; Orde et al., 2018; Hancock, 2020). Most strawberry producers harvest their own products for commercial use in local and retail markets. The majority of fresh market fruit is harvested by hand on a 2-3 day cycle, except during extremely hot weather. Fruits are not harvested or less is harvested in heavy rain conditions. However, producers harvesting in rainy weather do not have a problem with the humidity if they have cold storage. Although fruits can be picked later in the day, producers generally prefer to start early in the day and finish harvesting by midday. Most of the fruits to be marketed as fresh are harvested at the three-quarters colored in order to extend the storage life of the strawberries. Attention should be paid that the stems remain attached to the fruits during harvest until consumed. In commercial enterprises, the operations of sorting and packaging of fresh fruits is done in the field. Strawberries used for industrial processing (juice, jam, marmalade, ice cream, etc.) are usually collected in large containers and then sorted and packaged in processing units. The containers used to bring fresh fruits to the market in the world vary considerably. Usually plastic containers are used. The hingeless lidded and transparent ones of these plastic storage containers are preferred. Small-scale producer generally use paper and wood-based materials to emphasize the naturalness of their products. Storage container sizes also vary widely around the world. Although Quarts are commonly used by small producers in North America, large-scale producers often use containers packed eight to a cardboard tray, or pints packed 12 to a tray. In Europe, fruits are packaged in metric containers of 125, 250 and 375 g. The number of pickers needed to adequately harvest a field varies widely depending on crop load and cultural system. Experienced pickers can harvest three to four flats of 8 quarts per hour on matted rows, making 10 to 25 pickers necessary per hectare. In annual hill fields, a good picker can harvest 6–10 trays of pints per hour, and about five pickers per hectare are generally needed. In Hokkaido, Japan, three to four pickers are needed per 300 m^2 tunnel. After harvest, the containers of fresh fruit are palletized in a barn and then commonly forced-air cooled. Forced-air cooling involves the channelling of refrigerated air through pallets of fruit (Kader, 2002). A pressure gradient is developed across the two sides of a stack of fruit by a fan pulling cold air (as low as −3°C) from the room through the spaces in and around the boxes. To minimize fruit dehydration, the fan is stopped when the flesh temperature is within a few degrees centigrade of the target and the cooler is maintained at above 90% relative humidity. After cooling, fruit are generally kept in a holding room at 2°C and high humidity until shipping. Polyethylene wraps are often used around pallets of fruit in order to prevent water loss; but, these can interfere with heat transfer and therefore are not applied until the fruit are fully chilled. To prevent condensation, the pallets are wrapped before they are taken out of cold storage. There are many studies on harvesting robot. The first example of harvesting robot can be shown in Kondo's (1988) research on a machine vision system for the localization of fruit. In this research, it is stated that there are two systems for connecting the vision sensor to the robot. The first is the vision-based robot manipulator and the other is the independent manipulator. It has been found that one of the methods in order to obtain accurate three-dimensional locations of fruits is the stereo camera with vision sensors. It has been stated that this method will be used to locate relatively low plants such as tomatoes. The process of recognizing the fruits of tall trees such as sour fruits and accurately detecting their location has been found to be difficult. It has been determined that the reason for this is that the sensor is at a longer distance from the fruit and sends fewer pictures to recognize it. A research to determine the location of the fruit and detect the stems has been conducted by strawberry harvesting robot. Two cameras were used in this research. The first one is used to capture images of 8-10 strawberries and the other is used to determine their XYZ coordinates. Image segmentation was performed based on the OHTA color space. In this way, it is ensured that the fruit is picked by robotic hand. Experimental results determined the error rate in determining the location of the fruit to be 7% and the accuracy of robotically picking the fruit without any damage as 5%. A strawberry-harvesting robot was evaluated in a field test. In the study, a robot consisting of a cylindrical manipulator, end-effector, machine vision unit, travelling unit and storage unit was used. In order to overcome the problems such as low work efficiency, low success rate, unstable illumination encountered in the previous studies, a lighting unit was developed to harvest at night. For the identification of the fruit, the degree of maturity of the fruit was defined. It is determined that the success rate of fruit detection was 60% with the machine vision unit. The success rate of the system is 34.9% (Kondo et al., 1988; Feng et al., 2008; Hayashi et al., 2010; Kahya and Arın, 2014).

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CHAPTER 2

INVESTIGATIONS ON YIELD AND DRIED FRUIT QUALITY OF SARILOP FIG CLONES FOR FURTHER REGISTRATION

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INTRODUCTION

Fig is a functional food item that is utilized from its seed to its milk, with its high calorie value, minerals and nutrients in terms of human health (Vinson, 1999). It is in the *Moraceae* family of the *Urticales* order. There are more than 1400 species in this family. *Ficus* genus includes approximately 700 species (Watson and Dallwitz, 2004; Caliskan, 2012). The most important in this genus is *Ficus carica* L., called as Anatolian fig (Ozbek, 1978). Sarılop is the most valuable dried fig variety of Turkey that increases our contribution in production and exports. As in many fruit types, natural mutations in figs can cause clonal differences. There are clonal differences in fig cultivation in Büyük Menderes and Küçük Menderes Basins. Sapling productions are done by rooting the cuttings taken randomly from trees of these different clones. In order to maintain the superiority in production and export, it is necessary to benefit from the clonal variation in Sarılop. Also, it is necessary to use superior types in production. The sought parameters in high quality dried figs are defined as thinness of the fruit flesh thickness, being soft, having bright- colour, being light-colored and not having any damage (Aksoy et al., 1987; Aksoy et al., 2001). It is stated that it will be possible to access to the market with a low scrap rate, high quality, clean and abundant product supply to access to the market by the researchers (Elbek and Ozkaya, 1997; Anac et al., 1991; Kusaksiz, 1999).

There are studies carried out for the purpose of developing fig variety. These were carried out by determining the variety standards in general and the selection of high quality clones among the local fig varieties (Eroglu, 1982; Mars et al., 2001; Kuden and Tanriver, 1998; Kutlu and Aksoy, 1997; Aksoy et al., 1992).

There are many morphological and pomological characters used to select superior genotypes in selection studies. Since the breeding studies are spread over a long period, the data collected for the characters is quite high and it takes time to recover. Quality parameters representing the superior genotype should be determined accurately in the weighted-rankit process steps. In determining these characteristics, it is important to examine them through principal component analysis and to establish a standard. In this way, selection studies that seem more comprehensive and complicated are standardized. Thus, the selection of the superior genotype becomes easier by conducting the studies more healthily and reducing the workload (Tekintas et al., 2015).

Studies to determine the current clonal variation in the Sarılop fig variety were carried out by Eroğlu (1982); It was initiated in 1978-79 within the scope of the "Fig Selection Research Project". First 157 individuals were selected. In 1979, individuals were controlled and a clone selection parcel plantation was created in 1982 with 86 clones in the parcel of the Fig Research Institute. Aksoy et al. (1994) selected 25 clones from 86 clones in their research and created the second clone selection parcel at the same institute. Later, no studies have been carried on these clones to date and the work based on registration has been left unfinished. The disadvantageous characteristics of Sarılop (wide ostiole opening, splitting state, sun-scalded, ostiole-end cracks, excessive scrap rate), climate factors thought to change (global warming, precipitation, temperature, drought). The establishment of breeding plots with random types and non-homogeneous production brought the issue to the fore again that clonal variation should be used in Sarılop variety. This research was planned in order to complete the lack of work based on registration in the parcel consisting of 25 Sarılop clones, which were selected in 1994 (Aksoy et al., 1994) and established in 1997, but the registration phase was not initiated. The performances of the clones in terms of dry fruit quality and yield were compared using the correct methodology in order to give the selected superior clones a variety feature, to select the correct base material in production, to protect and maintain the selected material.

1. MATERIAL AND METHOD

Location of the Experiment Area: This research, which was conducted between 2015 and 2016, was carried out on the parcel consisting of Sarılop clones planted with 6x6 m row and row distance in 1997, selected in 1994 (Aksoy et al., 1994), located in the Fig Research Institute.

Climate of the Trial Area: The trial area shows the characteristics of the Mediterranean climate. Mediterranean climate type is hot and dry in summers and warm and rainy in winters. During the fig production season; air relative humidity average values were 55.7 % in 2015 and 54.6 % in 2016; total precipitation was 802.7mm in 2015 and 509.7mm in 2016; average maximum air temperatures varied between 33.5^{o}C (2015) and 34.2^{o}C (2016).

Trial Plan; In the research, 25 Sarılop fig clones (11, 18, 19, 20, 21, 28, 31, 32, 34, 37, 43, 45, 50, 58, 59, 61, 63, 64, 66, 69, 71, 74, 75, 82, 83; code no) were used.

Studies on dried fruit quality features; materials for the studies were taken by marking 3 trees with homogeneous development belonging to each clone. In this research conducted in 2015 and 2016; pomological analyzes were carried out on a total of 75 trees belonging to clones. The studies were carried out on representative samples of 3kg dried fruit that were collected 20 days after the first harvest and dried on plastic mat.

Average fruit weight of dried fig fruit samples; 10 fruits were weighed with a precision scale sensitive to 0.01 grams and the average fruit weight was calculated in grams via dividing by the number of fruits. *Composition of dried fruit samples*: 10 fruits belonging to each clone were passed through a meat grinder. 25 g of the obtained fruit paste mixture was weighed and made up to 100 ml with distilled water. The mixture kept for one day was mixed in the blender and a fruit juice mixture was obtained. Hanna HI2211 pH meter was used for pH measurements of the fruit juice. The amount of soluble dry matter in water (TSS) (%): was determined by measuring the fruit juice mixture with a refractometer (Aksoy, 1981). *Titratable acidity (in terms of (%) citric acid):* It was determined by titration method. 10ml sample taken from the fruit juice mixture was titrated until its pH reached 8.1 with 0.1 N NaOH solution. Acid measurements were made. It was evaluated in terms of citric acid commonly found in figs. Mettler Toledo-DG-115-SC automatic tirator instrument was used in the titration. *Dried fruit* *skin color C.I.E*. Measured with Minolta CR-400 Chromometer color meter from both sides of the fruit according to the L*a*b* scale. The values obtained in skin color (color of dried fruit) in terms of L*a* b* have been formulated. It was made on 3kg dried fruit samples taken 20 days after the first harvest. *Scrap fruit ratio* (%), sun-scalded fruit (%) and ostiole-end crack fruit ratio (%) were determined (Aksoy et al., 1987). *Ostiole-end crack in dried fruit*; It is the ratio of cracking to fruit size. Ostiole-end crack condition; It has been classified as more than 1/3 (>1/3) crack amount and expressed as % (Aksoy et al., 1987). Extremely damaged, mechanically damaged, insect-defeated, wormy, very dark colored fruits were evaluated as scrap and expressed in % (Anac et al., 1992; Irget et al., 2005*). In sun-scalded fruits*, the fruit surface is stretched, hard and smooth like leather. If sunscald covers more than 1/3 of the fruit, the fruits are included in the burnt group and calculated as % (Aksoy et al., 1987; Kusaksiz, 1999; Irget et al., 2005). *Yield*; Within the scope of the experiment, the parameters related to the yield were evaluated only in dried fruit samples on the basis of clones. In this context, yield values per tree and yield per trunk cross section were taken. Yield values were taken during the whole harvest period with weekly harvests. In this way, average yield values per tree of the clones were calculated (kg/ tree). In the period after the leaf fall, the tree trunk diameter (cm) was calculated from the height of approximately 75cm from the soil surface (the height is assumed from where the tree generates a crown), and the calculated area was calculated as the yield (g/ cm^2) according to the trunk cross-sectional area by dividing the total yield per tree (Tan et al., 2013).

Evaluation of Data; The data obtained on the properties of the clones were evaluated by Principal Component Analysis (PCA). Principal component analysis; In terms of many characteristics examined, it is used to express the variance structure of the X variable set with k variables (k< p) and new variables that are linear components of these variables instead of p original variables (Ozdamar 2004; Sangun, 2007).

For this purpose; in dried fig fruits taken from clones; average fruit weight (g), soluble solids content (TSS) (%), titratable acidity (%), yield per tree (kg/ tree), harvest time (days), unit yield per trunk cross-sectional area (g/ cm^2), ostiole-end crack condition (>1/3), scrap amount (%), sun-scalded fruit ratio (%), color 'L' values were taken as variables. In the other evaluation phase of the experiment, the main parameters which are the basis of the weighted rankit method were determined in order to compare the parameters that came to the fore as a result of the principal component analysis and the clones. As it is used in similar selection studies, in order to determine the most superior clones within the scope of the research,"Weighed-Rankit" method which is suggested and has been modified for this research by Michelson et al. (1958) has been taken as a basis. As a result of the analysis of principal components in dried fruit samples; Scrap amount (%), yield per tree (kg / tree), ostiole-end crack (> 1/3), sun-scalded fruit ratio (%), average fruit weight (g) color 'L' variables came to the fore. These main parameters have been used as the main evaluation criteria for weighed rankit. Class ranges in the weighted rating method were created according to the data obtained from the study. As a result, the score the clones received for each dried fruit weight rankit criterion was calculated. According to the class range they entered, the qualification class scores of the clones were multiplied by the relative scores and the points they got for each criterion were calculated. then these weighted rating scores calculated for each criterion were collected. The clones scoring higher than the total scoring were highlighted.

2. RESULTS

In terms of analysis of variance on fruit weight, pH, water soluble dry matter and titratable acidity data; In 2015, no statistical difference was found between the clones in terms of pH, solubility and titratable acidity values. However, average fruit weight was significant among clones. Clone number 18 took the first place with 23.93g in terms of average fruit weight. This clone was followed by 28 (22.79 g) and 32 (22.96 g). As a result of the variance analysis performed on the pH, water soluble dry matter and titratable acidity values of the Sarılop clones in 2016, no statistical difference was found. As a result of the variance analysis performed on the average fruit weight values of the Sarılop clones in 2016, a statistical difference was found between the clones. In terms of average fruit weight values, clone 82 took the first place with 22.33g value (Table 1).

Composition of dried fig fruit samples: In 2015, clones were evaluated in terms of pH, total soluble solids, titratable acidity values of the compositions of dried fruit samples. The pH range of the clones varied between 4.42 (K.50) and 4.90 (K.63). Water soluble dry matter content (%); It ranged from 59.50 (K.71) to 69.20 (K.82). Titratable acidity values (%) among the clones varied between 0.68 (K.11) and 1.33 (K.19). In 2016, the pH ranges of the clones changed between 4.37 (K.66) and 5.25 (K.63). The clones ranged from 51.07 (K.34) to 66.92 (K.31) in terms of the amount of water soluble dry matter. In terms of titratable acidity values, K.66 took the first place with (1.26). In the evaluation made over the years, it was determined that the fruit weights, water soluble dry matter and titratable acidity of the clones were higher in 2015 (Table 1).

Skin color of dried fruit: As a result of the variance analysis performed on the exterior color L, a, b values of the dried fruit characteristics of the Sarılop clones in 2015, statistical differences were detected among the clones in only L color value. In the L color value, clone 82 took the first place as the lightest clone with a value of 73.64. In the clones, the a color values ranged from 8.37 (K.82) to 10.97 (K.37). The b color value was ranged from 24.51 (K.18) to 26.48 (K.37) (Table 2). Differences between averages are shown in separate letters. According to the results of the analysis of variance on the exterior color L, a, b values of 2016, belonging to the dried fruit characteristics of the Sarılop clones; It was determined that there are statistically significant differences between clones in terms of all color values. In L color value, K.75 took the first place with 76.06 color value and became the lightest clone. Among the clones, clones 21 (6.68) and 19 (6.67) took the first place in terms of a color value. In the evaluation made; It was determined that the clones numbered 28 (25.51), 58 (25.48) and 74 (25.55) took the first place in b color values. L color value was found important in 2016. a and b color values in clones, on the other hand, ranked first in 2015 and were found to be significant over the years (Table 2).

Table 1: Average values of dried fig fruit quality criteria of clones for 2015 and 2016

Clone No	Average fruit weight (g)				pH		TSS (%)		TA (%)		
	2015		2016		2015	2016	2015	2016	2015	2016	
K.11	18,1	f	19,39	b-f	4,86	4,8	59,7	64,3	0,68	0,76	bc
K.18	23,9	a	14,42	ı	4,56	4,86	61,4	63,4	0,77	0,68	bc
K.19	20,4	b-f	14,83	hı	4,44	4,73	62,4	62,6	1,33	1,03	ab
K.20	21,9	a-d	16,93	e-ı	4,73	5,09	61	62,2	0,78	0,61	c
K.21	21,5	a-d	16,75	f-ı	4,67	4,81	61	62	0,89	0,75	bc
K.28	22,8	ab	17,49	d-h	4,47	4,66	61,5	62	0,71	1,03	ab
K.31	19,9	b-f	20,25	abc	4,65	4,96	62,1	66,9	0,94	0,63	c
K.32	23	ab	19,32	b-f	4,78	4,83	60	62,5	0,82	0,76	bc
K.34	22,2	abc	16,46	ghı	4,81	5,14	61,1	51,1	0,72	0,5	c
K.37	21,9	a-d	19,24	b-f	4,69	5	62,3	62,3	0,98	0,72	bc
K.43	20,4	b-f	19,05	b-g	4,67	5,13	62,6	62,7	0,9	0,53	c
K.45	20,5	b-f	20,62	abc	4,57	4,8	59,9	62	1,09	0,83	bc
K.50	20,8	a-f	17,4	d-h	4,42	4,91	64,2	64,5	1,19	0,66	bc
K.58	21,1	a-f	19,41	b-f	4,67	4,77	62,2	65,6	0,95	0,77	bc
K.59	22	a-d	19,93	a-d	4,68	4,81	60,4	65,3	0,85	0,78	bc
K.61	18,3	ef	19,14	b-g	4,67	4,7	61,9	65,6	0,88	0,8	bc
K.63	21,2	a-e	19,5	b-e	4,9	5,25	60,2	62,8	0,71	0,52	c
K.64	19,6	c-f	20,28	abc	4,76	5,05	61,8	58,4	0,7	0,51	c
K.66	19,8	b-f	18,18	c-g	4,62	4,37	61,2	62	1,02	1,26	a
K.69	21,7	a-d	18,5	c-g	4,63	5,02	60,8	61,1	0,98	0,59	c
K.71	18	f	18,39	c-g	4,67	4,81	59,5	65,5	0,86	0,72	bc
K.74	19,2	c-f	17,46	d-h	4,45	4,91	61,1	64,3	1,21	0,64	c
K.75	19,1	def	21,7	ab	4,57	4,99	61,7	66,3	0,92	0,71	bc
K.82	20,8	a-f	22,33	a	4,52	5,14	69,2	59,5	1,17	0,52	c
K.83	22,3	abc	20,85	abc	4,53	4,96	61,7	61,6	1	0,75	bc
Std Error	1,12		0,96		1,1	0,15	2,06	3,95	0,15	0,14	
P	0,02		<0,0001		0,07	0,07	0,68	0,88	0,16	0,04	
Average of years											
2015	20,8	a			4,64	b	61,75		0,92		
2016	18,7	b			4,9	a	62,62		0,72		
Std Error	0,26				0,03		0,64		0,03		
p	<0,0001				<0,0001		p=0,329		<0,0001		

** Statistical comparisons were made using LSD multiple comparison test at 5% significance level. Differences between averages are shown in separate letters.*

Dry fruit quality: As a result of the variance analysis performed on the dried fruit quality values of the Sarılop clones in 2015, only the scrap amount values were found to be statistically different between the clones. Ostiol-end crack fracture amounts varied between 0-4% among the clones. Ostiol-end cracked fruit ratio was not found in clones 37, 58, 59, 66, 75 and 82. When the clones are evaluated as the amount of scrap; Clones 28 (22%) and 34 (23%) were in the first group with the least amount of scrap. It was determined that clone 83 in the last group had the most scrap (71%). Sun-scalded fruit ratios of clones; It varied between 10% (K.43) and 41% (K.74). As a result of analysis of variance on dried fruit quality values in 2016; statistical differences were found between clones in terms of ostiol-end cracked fruit and scrap amount. No fruit with an ostiol end crack was found in clone 19. In terms of scrap amount, K.21 (30%) and K.34 (29%) were in the best group among the clones with the least scrap rate. In 2016, it was determined that the rate of ostiol-end cracked and scrap fruit was higher than in 2015 (Table 3). Clones yield values; In the evaluation made as a result of variance analysis, all yield values were found to be statistically significant among clones. In terms of fruit set ratios, it was determined that among the clones, the clone with code 82 had the highest fruit set with 73%. This clone was followed by clone 83 with 70% fruit set rate. In the evaluation made in terms of yield per tree, it is seen that the yield per tree of clone 82 (27.08 kg / tree) is also high. This is followed by clone with code 83 (25.83 kg / tree). However, clone 83 was identified as the clone with the longest harvest period. 59 (35 days) in terms of short harvest period; The clones with the earliest harvest time of 45 and

58 (36 days) ranked first. It is seen that clone no 45 takes the first place with 48.15 g/ cm^2 in terms of yield values according to body cross-sectional area. This clone is followed by clone 74 with a value of 44.38 g/ cm^2.

Table 2: The average skin color values of the dried fruit characteristics of the sarlop clones for 2015 and 2016

Clone No	L				a			b		
	2015		2016		2015	2016		2015	2016	
K.11	65,76	c-g	68,13	f-j	9,81	6,1	a-d	26,3	24,01	bcd
K.18	61,04	h	67,7	f-j	10,91	6,64	ab	24,51	24,56	ab
K.19	63,82	fgh	67,31	hıj	10,69	6,67	a	24,96	24,58	ab
K.20	64,72	d-h	71,49	b-g	10,25	5,56	c-g	25,21	25,39	ab
K.21	63,55	gh	69,07	e-j	10,67	6,68	a	25,4	25,25	ab
K.28	64,97	c-h	70,3	c-ı	10,04	6,22	abc	24,98	25,51	a
K.31	64,68	d-h	71,22	b-h	10,34	5,4	c-h	26,09	25,06	ab
K.32	68,02	b-e	71,32	b-g	9,81	5,17	c-ı	25,92	24,65	ab
K.34	66,19	c-g	71,34	b-g	9,76	4,92	f-j	25,17	24,23	a-d
K.37	66,14	c-g	69,81	d-ı	10,97	6,08	a-d	26,48	24,97	ab
K.43	65,74	c-g	67,6	g-j	9,81	6,1	a-d	24,89	24,26	a-d
K.45	67,79	b-f	67,17	ıj	9,63	5,92	a-f	25,46	24,02	bcd
K.50	64,07	e-h	73,48	a-d	10,59	4,5	hıj	25,35	24,15	a-d
K.58	63,88	fgh	72,63	a-e	10,18	5,4	c-h	24,65	25,48	a
K.59	66,27	c-g	71,65	b-f	10,32	5,11	d-ı	25,84	24,29	abc
K.61	68,16	bcd	71,01	b-ı	9,31	5,59	b-g	25,6	24,61	ab
K.63	68,31	bcd	74,07	abc	10,08	4,27	ıj	26,08	24,31	abc
K.64	68,83	bc	73,77	a-d	8,96	4,78	g-j	24,86	24,33	abc
K.66	67,32	b-g	74,35	ab	9,15	4,58	g-j	25,46	24,38	ab
K.69	67,19	b-g	74,47	ab	9,97	4,22	ıj	25,61	24,48	ab
K.71	66,39	c-g	65,64	j	10,02	6,01	a-e	25,02	22,93	cd
K.74	70,43	ab	71,53	b-g	8,98	4,98	e-j	26,38	25,55	a
K.75	68,39	bcd	76,06	a	9,66	3,95	j	26	24,15	a-d
K.82	73,64	a	65,19	j	8,37	6,02	a-e	26,04	22,83	d
K.83	67,17	b-g	72,26	a-e	9,29	5,18	c-ı	25,48	24,63	ab
Std Eror	1,42		1,4		0,43	0,37		0,45	0,5	
P	0,0002		<0,0001		0,069	<0,0001		0,1455	0,0321	
Average of years										
2015	66,49	b			9,9		a	25,51	a	
2016	70,74	a			5,44		b	24,5	b	
Std Error	0,34				0,09			0,1		
p	<0,0001				<0,0001			<0,0001		

** Statistical comparisons were made using LSD multiple comparison test at 5% significance level. Differences between averages are shown in separate letters.*

Table 3: Average values of Sarılop clones for 2015 and 2016 dried fruit quality

Clone No	Ostiole-end crack ratio (>1/3) (%)		Scrap ratio (%)		Sun-scalded fruit ratio (>1/3)(%)	
	2015	2016	2015	2016	2015	2016
K.11	3	3 e-ı	25 fg	47 ghı	36	14
K.18	1	2 ghı	24 fg	43 hıj	36	28
K.19	2	0 ı	29 fg	72 bc	29	43
K.20	2	3 c-ı	36 def	66 b-e	27	26
K.21	3	0 hı	25 fg	30 k	23	38
K.28	3	3 d-ı	22 g	38 ıjk	15	29
K.31	1	4 b-ı	30 fg	38 ıjk	37	27
K.32	1	3 d-ı	28 fg	35 ıjk	14	28
K.34	4	6 bcd	23 g	29 k	26	28
K.37	0	4 b-ı	48 bc	61 def	27	27
K.43	2	11 a	33 efg	51 fgh	10	25
K.45	4	4 b-h	45 cd	35 ıjk	28	41
K.50	1	5 b-f	43 cde	66 b-e	36	29
K.58	0	6 bc	27 fg	56 efg	23	29
K.59	0	6 bcd	35 def	49 gh	13	21
K.61	1	3 c-ı	54 bc	64 c-f	21	27
K.63	3	7 b	25 fg	43 hıj	13	27
K.64	2	6 b-e	29 fg	34 jk	27	28
K.66	0	3 d-ı	58 b	67 bcd	29	18
K.69	1	3 c-ı	35 def	62 c-f	17	34
K.71	1	5 b-g	43 cde	69 bcd	29	27
K.74	1	7 b	52 bc	45 g-j	41	33
K.75	0	4 b-ı	24 fg	67 b-e	13	32
K.82	0	2 f-ı	45 cd	76 ab	30	20
K.83	1	2 ghı	71 a	86 a	32	22
Std Error	1,02	1,24	4,2	4,92	7,56	6
P	p=0,1821	p<0,0001	p<0,0001	p<0,0001	p=0,2074	p=0,3623
Average of yeras						
2015	2	b	37	b	25	
2016	4	a	53	a	28	
Std Error			1,12		1,43	
P	<0,0001		<0,0001		p=0,1002	

** Statistical comparisons were made using LSD multiple comparison test at 5% significance level. Differences between averages are shown in separate letters.*

As a result of the variance analysis performed on the yield values of the Sarılop clones according to the fruit set rate in 2016, yield per tree and trunk cross section; There was no statistically significant difference between the yield values per body cross section between the clones. It was determined that there are differences between clones in terms of fruit set ratio and yield per tree, which are other yield parameters. As a result of the analysis of variance on the yield values of the Sarılop clones in 2016 according to the fruit set rate, yield per tree and trunk cross section; There was no statistically significant difference between the yield values per body cross-sectional area between the clones. Other yield parameters were found to differ between clones in fruit set ratio and yield per tree. When the fruit set rates of clones in 2016 are examined; 11, 50, 58, 66, 69 and 82 (87%); 74 and 83 (88%); K.71 was in the top group with the best value with 89%. In terms of yield values per tree; among the clones, it was determined that clone 83 ranked first with 29.35 kg / tree value. This clone was followed by clone 82 with a yield value of 28.06 kg / tree. However, the harvest times of these two clones appear to be quite long (47 days). Clone 74 had the longest harvest period with 48 days. Clone number 45 followed a stable course in both years with the shortest harvest period. Trunk cross-sectional area (TCA) evaluation; among the clones, the yield values per body cross-sectional area varied between 26.46 (K.21) -44.92 (K.59) g / cm^2. When the fruit set ratios of Sarılop clones in 2015 and 2016 are examined; it has been observed that there is a difference between the years. Trees have higher fruit set in 2016. In the evaluation made between years; It was found that yield values per tree were high in 2016, but in terms of harvest times, the harvest times of clones were longer in 2016 (Table 4).

The data obtained according to the principal component analysis and weighted grading method in order to evaluate the clones in the experiment as dried quality characteristics are given below. For this purpose, the pomological quality criteria taken from dried fig samples were averaged as of 2015 and 2016. Principal component analysis was performed on the average data obtained (Table 5). The first 4 components constituted 74% of the total variance of all characters in 2015 and 2016 dried fig fruits belonging to the Sarlop Clone Selection. This value showed the highest degree of correlation between analyzed characters. In other words, these first four components explain 74% of the overall variance. Other components make up 26% of the total variation. The first component has 28% of the total variation. The second main component made up 22% of the total variation, the third component 13%, and the fourth component 11%. The most important features affecting the first four basic components in principal component analysis; generally, scrap amount, yield per tree, ostiole-end crack condition, sun-scalded fruit ratio, average fruit weight and color "L" values. It made the highest contribution to the first four components (Table 5).

In dried fruit principal component analysis evaluations; Generally, scrap amount, yield per tree, ostiole-end crack condition, sun-scalded, average fruit weight and skin color “L” values were taken as the distinguishing parameters in general variation. Especially using pomological criteria, these principal component analysis data, which were obtained in order to determine the differences from each other, are given in Table 6 as the weighted grading data arranged in dried fig fruits by taking the averages of 2015 and 2016. The weighed rankit criteria for dried fig fruits were divided into 6 groups (amount of scrap, yield per tree, ostiole-end crack condition, sun-scalded, average fruit weight and skin color "L" values).

Table 4: Averages of 2015 and 2016 yield values of clones

Clone No	Fruit set ratio (%)		Yield (kg/ tree)		Harvest period (day)		TCA (g/cm^2)	
	2015	2016	2015	2016	2015	2016	2015	2016
K.11	47 e-h	87 a	11,32 j	14,61 f-ı	42 c-g	46 c	34,5 a-g	39,55
K.18	55 b-g	61 bcd	14,55 f-j	17,78 e-ı	40 fgh	42 e	23,93 g	27,65
K.19	56 b-g	46 e	14,56 f-j	18,41 e-ı	39 gh	41 e	29,7 d-g	34,13
K.20	55 c-g	70 b	20,62 bcd	25,61 a-d	41 d-g	38 h	33,27 b-g	37,51
K.21	44 gh	25 f	15,44 e-j	13,86 hı	41 efg	40 g	33,68 b-g	26,46
K.28	46 fgh	66 bc	12,33 hıj	14,83 ghı	39 gh	40 g	29,89 d-g	32,32
K.31	66 abc	70 b	11,76 ıj	11,92 ı	40 e-h	39 g	41,15 a-d	35,08
K.32	66 abc	67 bc	14,08 f-j	14,51 ghı	41 d-g	43 d	30,35 d-g	29,26
K.34	67 abc	66 bc	12,86 f-j	16,34 e-ı	41 efg	41 f	30,63 d-g	34,88
K.37	63 a-d	47 de	19,01 cde	20,96 c-f	45 ab	46 b	43,69 abc	44,72
K.43	62 a-e	67 bc	16,67 c-g	25,5 a-d	40 fgh	43 d	24,49 fg	32,87
K.45	36 h	68 bc	16,42 d-ı	13,13 ı	36 ı	38 ı	48,15 a	37,24
K.50	62 a-f	87 a	23,74 ab	26,12 abc	37 hı	39 h	38,65 a-e	39,66
K.58	37 h	87 a	14,05 f-j	20,2 c-g	36 ı	41 f	26,95 efg	32,5
K.59	63 a-d	55 cde	16,6 d-h	22,15 b-e	35 ı	42 d	36,72 a-f	44,95
K.61	68 abc	54 cde	15,49 e-j	18,24 e-ı	40 fgh	43 d	33,06 b-g	36,75
K.63	62 a-e	46 e	16,72 c-f	21,07 c-f	39 gh	43 d	30,61 d-g	36,39
K.64	37 h	57 b-e	12,37 g-j	15,72 f-ı	44 b-e	46 b	32,61 b-g	37,89
K.66	47 d-h	87 a	20,93 bc	24,91 a-d	43 b-f	46 b	31,92 c-g	33,69
K.69	37 h	87 a	16,97 c-f	19,99 d-h	43 b-f	39 h	27,17 efg	30,41
K.71	61 a-f	89 a	12,27 ıj	15,96 f-ı	41 efg	40 g	24,64 fg	29,22
K.74	47 d-h	88 a	16,35 d-ı	17,35 e-ı	44 a-d	48 a	44,38 ab	43,18
K.75	20 ı	66 bc	19,63 b-e	25,73 a-d	42 b-g	39 h	32,53 b-g	39,25
K.82	73 a	87 a	27,08 a	28,06 ab	45 abc	47 b	40,19 a-d	32,09
K.83	70 ab	88 a	25,83 a	29,35 a	47 a	47 b	29,88 d-g	31,23
Std Er	5,57	5,08	1,52	2,16	1,17	0,18	4,34	4,44
P	p<0,0001		p<0,0001		p<0,0001		p=0,0130	0,244
Average of years								
2015	54 b		16,69 b		41 b		33	
2016	69 a		19,71 a		42 a		35	
Std Er	1,67		0,38		0,23		0,86	
p	<0,0001		<0,0001		<0,0001		p=0,1177	

** Statistical comparisons were made using LSD multiple comparison test at 5% significance level. Differences between averages are shown in separate letters.*

Table 5: Eigenvalues values in dried fig fruits and% variation values calculated with the first 4 components according to the 2015 and 2016 average of the Sarılop Clone Selection

	Principal Components			
	1	**2**	**3**	**4**
Scrap ratio (%)	0,88	-0,079	-0,087	-0,12
Yield (kg/tree)	0,794	0,301	-0,157	0,051
>1/3 Ostiole-end crack (%)	-0,541	0,396	0,326	0,194
Sun-scalded fruit ratio (%)	0,031	-0,749	0,438	-0,175
Fruit weight (g)	0,257	0,694	-0,131	0,248
Skin color "L"	0,359	0,633	0,399	-0,04
Eigenvalue	2,791	2,208	1,265	1,093
Variation (%)	27,908	22,084	12,646	10,932
Cumulative Variation (%)	27,908	49,992	62,638	**73,571**

Extraction Method: Principal Component Analysis. a. 4 components extracted.

Each group consists of different relative scores in order of importance. Class interval values were created by dividing into five groups according to the minimum and maximum data obtained from Sarlop clones. Accordingly; the total weighed rankit scores of the clones in the dried fig fruits of 2015 and 2016 were calculated. The total weighted rankit scores of the clones in dried fig fruits are given in Figure 1. According to these scores, the clone with code 71 got the lowest score (430), while the clone with code 82 got the highest score (860).

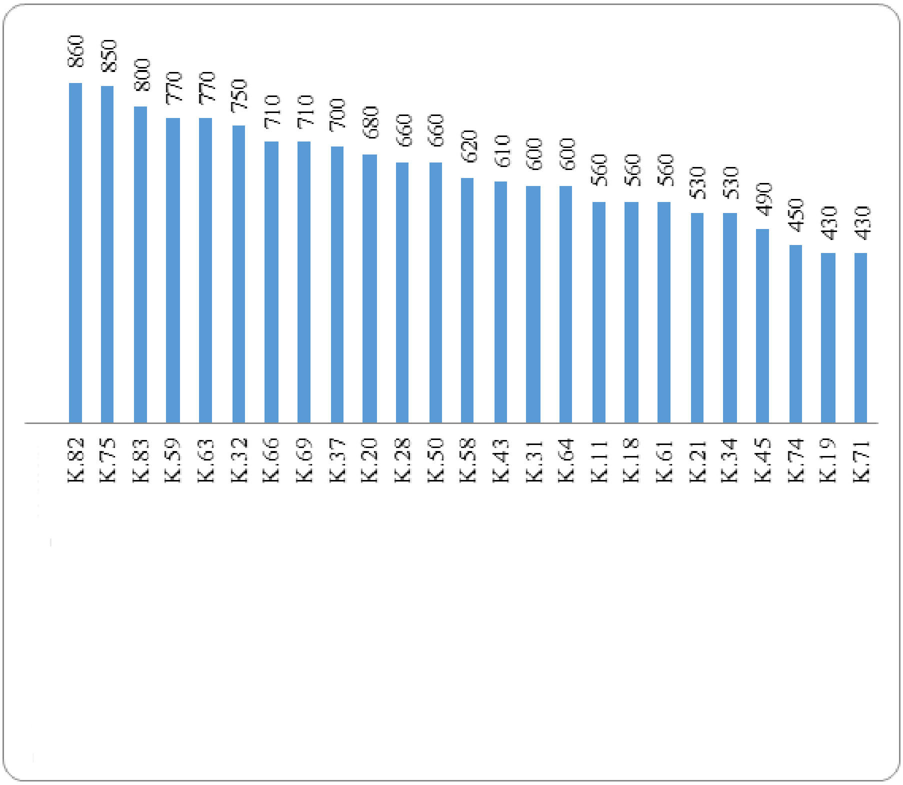

Figure 1: The weighed rankit scores of the clones in dried fig fruits according to the average of 2015 and 2016.

Table 6: Weighted rankit values of dried fig fruits according to the average of 2015 and 2016 for the Sarlop clone selection

Characteristics	**Relative scores (%)**	**Classes and scores of the characteristics**	
Yield (kg/tree)	25	>24,47	10
		21,32-24,47	8
		18,16-21,31	6
		15,00-18,15	4
		11,84-14,99	2
Average Fruit Weight (g)	20	>20,80	10
		20,01-20,80	8
		19,21-20,00	6
		18,41-19,20	4
		17,60-18,40	2
		25,78-36,27	10
		36,28-46,77	8

Scrap ratio (%)	15	46,78-57,27	6
		57,28-67,77	4
		>67,77	2
		16,93-20,96	10
		20,97-25,00	8
Sun-scalded fruit ratio (%)	15	25,01-29,04	6
		29,05-33,08	4
		>33,08	2
		0,90-2,03	10
		2,04-3,17	8
Ostole-end cracks ratio(>1/3)	15	3,18-4,31	6
		4,32-5,45	4
		>5,45	2
		>70,68	10
		69,11-70,68	8
Skin color "L"	10	67,53-69,10	6
		65,95-67,52	4
		64,37-65,94	2
TOTAL SCORE	**100**		

DISCUSSION AND CONCLUSION

As the length of the harvest period is regarded as an advantage in table fig production, drying in the sun is considered as a disadvantage. As a result of the analysis of variance to determine the difference between the clones; statistical differences were found. It was determined that clone 45 (with the earliest harvest period in 2015 and 2016) differed from the others for the shortest period. Aksoy et al., (1994), although clones 37 and 45 are not in the first place in terms of fruit size, they have determined that they are superior clones due to the completion of the total quality and ripening periods in a short time. Climate is one of the most important external factors for dried fig cultivation. Insufficient winter precipitation will negatively affect plant growth, and the increase in relative humidity in July, August and September, when the harvest period takes place, also negatively affects yield and quality. In the harvest period of 2019, when the application was made, the rainfall amount and relative humidity of the Sarılop fig variety were close to the optimum climatic values, which positively affected the yield and quality. Fig cultivation is strongly affected by climatic conditions. For this reason, 70% of the world's fig production is concentrated in the countries on the Mediterranean coast (Arpaci, 2017).

Aksoy et al.(1994); in order to determine the dried fruit characteristics of the clones, average fruit weight (g), fruit color, fruit firmness, ostiol end crack and sunscalded fruit ratio were examined. Kuşaksız (1999), the average fruit weight, color, firmness, ostiol end crack, ostiol width, scrap, black throat, sealed, sunscalded fruit, bright greenish yellow glow, alcohol-soluble color and moisture were emphasized as dried fruit quality characteristics.

In this research; average dried fruit weight (g), pH, TSS, TA, dried fruit skin color L parameter, dried fruit quality (ostiole end crack, scrap, sunscalded fruit rate) were evaluated. Dried fig size is the major factor in marketing especially for direct consumption (İrget et al., 2008).

Average dried fruit weight of clones in 2015; 23.93g (K.18) to 18.04g (K.71); In 2016, the value ranged from 22.33 g (K.82) to 14.42 g (K.18). As a result of the analysis of variance, it was determined that there were differences between the clones in terms of average dried fruit weight values in both years.

Aksoy et al (1994), found the average fruit weight of Sarılop clones in the range of 9.77 (K.63) to 20.01 (K.43). Kusaksiz (1999) found the fruit weights of different Sarılop clones in the range of 13.90 (K.63) - 17.22 (K.83) g.

In the analysis of variance in pH and water-soluble dry matter (TSS) values of dried fruit samples, no statistical difference was found between clones in both years. As a result of the analysis of variance in the amount of titratable acidity, it was determined that there was a difference between clones in 2016. It was determined that clone K.66 (1.26) took the first place, followed by clones K.19 and 28 (1.03).

In a research carried out in Aydın Germencik Sarılop fig orchards; It was determined that 16.5% of the composition of dried fruits consists of water and 83.5% of dry matter (Aksoy et al., 1987). Tan et al., (2013) determined the amount of water-soluble dry matter in dried fruit as 71%, the highest value in 2011.

L color parameter value in dried fruit expresses the lightness and darkness of the outer skin. As a result of the analysis of variance, it was determined that there were differences between the clones in terms of L color values in both years. Among the clones, L color values were found to be lighter in 2016. Aksoy et al. (1987), color values of Sarılop clones; 49.8% (light), 39.3% (medium) and 10.9% (dark). Kusaksiz, (1999) evaluated the fruit color class values in dried fruit in five different classes, from light color (5) to dark color (1) subjectively in different Sarılop clones. Sahin (2003) states that 48.11 L color values are obtained in the darkest colored fruits and 63.71 L color values in the lightest colored fruits. Irget et al. (2005), L color value in dried fruit is 45.49- 56.36, Tepecik (2010); Color parameter L from 57.20 (2008) to

70.98 (2007); Tan et al. (2013); they stated that the color L value is between 48.7 (2008) and 71.2 (2012). Tepecik (2010), in his doctoral research; Demir (2005) stated that Sarılop dried fruit L color parameter changed as 66.6±2.2 in the north direction and 63.4±2.9 in the south direction. Premium dried figs are identified by the brighter color of the fruit. Light-colored dried figs are better marketed (Sedaghat and Rahemi, 2018). Ozkul et al. (2021); It was determined that the best dry fruit weight in Sarılop was 20.72 g/piece in B7 application. This was followed by B5 with 19.82 g/piece.

Cracking is a physiological phenomenon and it is the cracking of the skin around the ostiol (mouth) in figs as a result of the fruit peel not developing parallel to the fruit flesh. It is mostly associated with air humidity (Ulkumen et al., 1948). Another reason for fruit cracking is the high fertilization rate of the ovules in the fig fruit. The skin, which cannot keep up with the development of a large number of seeds, cracks. it has been stated that this cracking occurs in the form of cleavage on the cheek and before maturation (Obenauf et al., 1978).

As a result of the analysis of variance; ostiole end crack amount values were found significant among the clones in 2016. 37, 58, 59, 66, 75 and 82 in 2015; in 2016, no ostiole end crack was observed in clones 19 and 21. clone 19 also had the highest rate of sunscalded fruit in 2016. In 2016, more ostio-end cracked fruit rate was found.

It is the amount of ostiole end cracked fruit, which is an undesirable situation that causes a decrease in the quality of figs, the transmission of diseases and an increase in the scrap rate. Aksoy et. al., (1994) determined that clones 11 and 64, 63 and 82 were resistant to cracking. They stated that clones 83 and 45 were the most susceptible to cracking. Kusaksiz (1999); among the clones, clone 63 ranked first with 87% solid fruit rate, clone 83 had mild cracks (<1/3 fruit size) rate (23%), severe cracks (>1/3 fruit size) rate (30%) stated that it is in the first place in terms of. Anac et. al., (1991) and Aksoy et al., (1987); it is stated that the rate of ostiole end cracked fruits decreases in trees where the rate of sunscalded fig increases with the effect of current climatic conditions during the ripening season. Anac et al. (1992); 0.7-48.2%, Irget et al.(2008); ostiole end cracking class 1-2%; Tan et al.(2008); they state the ostiole end crack fruit rate between 6-14% on average. Ozkul et al. (2021), when the dried fig fruit was examined as scrap cracked and normal fruit, the difference between the blocks for the highest B7 application was found to be 74.49%, followed by the B5 application. In Bk control application, the highest scrap rate is 52.53%, the lowest scrap rate is 17.28% in B3 application.

It is a desirable feature that the scrap rate in dried figs is low and the amount of marketable product is high. It has been determined that the air relative humidity averages by years are above the average of many years during the fig production season in 2015 and 2016. These data are approximately 5-6 points above the 45-50% humidity range, which is the optimum air relative humidity demand of figs. High air relative humidity is effective in increasing the amount of industrial figs. As a result of the analysis of variance, significant differences were determined in the scrap amount values between the clones in both years.

In 2016, the amount of scrap was determined to be higher. K.34 is the clone with the least amount of scrap in both years, and K 83 is the clone with the highest amount of scrap.

Ferguson et al.(1990) reported that the highest scrap rate (27%) among fig varieties grown in California was found in Calimyrna (Sarılop). Aksoy et al.(1994); Among the Sarılop clones, 63 (92%) has the highest scrap rate, and clones with code number 21 (1%) and 20 (2%) are the clones with the lowest scrap rate. No scrap fruit was detected in 6 Sarılop clones, which were examined in this research on clones in 1992. In 1993, it is reported that the rates changed between 2% (K.37) - 92% (K.63). Kusaksiz (1999) found the highest scrap rate in clone 83 (7%) and clone 61 (5%). Scrap rate was higher in 1995. In the survey and fertilization studies of the Sarılop fig variety in the Büyük and Küçük Menderes basins, Anac et al.(1992); 13- 89%, Aksoy and Bulbul (1995); 12-33%, Hakerler et al.(1999); 29-30%, Sahin (2003); 5-31 %, Irget et al. (2005); 11-31%, Ertan et al.(2009); They indicate the rate of scrap (unmarketable) fruit varying between 2-4%. Sunburn is a feature that negatively affects quality. In the research, those with sunscalded fruit area larger than 1/3 were taken. As a result of the analysis of variance, no statistically significant difference was found between the clones in terms of sunscalded rate in both years (2015-2016). Aksoy et al.(1994); stated that 82 (69%), 37 (68%) and 75 (51%) clones took the first three places in Sarılop clones in terms of resistance to sunburn. Kusaksiz (1999), It is indicated that clone 63 had the highest rate of suncalded fruit with 31%, clones 53 (19%), 83 (17%) and 37 (16%)

formed the last group and had the least sunscalded fruit. indicated that it is in the fruit group. Aksoy et al. (1986); It has been reported that the rate of excessive suncalded fruit in Sarılop fruits collected from different regions varies between 11.7% and 41.2%. Belge et al.(2012), in their research investigating the causes of untimely defoliation in fig trees; It has been determined that there are statistical differences in terms of sunburn parameters according to years and locations. Aksoy et al. (1987); In the research conducted in the Germencik region, an average of 3.7% in table fruit and 27% in dry fruit, Anac et al. (1992); 33- 86% non-sunscalded (0) fruit class, < 1/3 of the fruit surface with moderate sunscalded 8-38%, and > 1/3 of the fruit surface showing severe suncalded 4 - 54%, Irget et al., (2005); 1-2%; Tan et al.(2009); sunscalded varies were between 7 -17%.

During the fig production season, 802.7 mm of precipitation was recorded in 2015 and 509.7 mm in 2016. The precipitation amount in 2016 is below the total annual precipitation demand of figs. The precipitation in 2015 had a positive effect on the yield in 2016. The low precipitation in 2014 may have triggered the low yield in 2015. The fact that the annual shoots on which fruits were formed in 2015 were shorter supports this view.

As a result of the analysis of variance in the yield values of the clones in the research, it was determined that there were statistical differences between the clones in both years (2015-2016). Although the main factor on fruit set was fertilization, different fruit set were observed in Sarılop clones transplanted with male fig fruits obtained from the same source.

In 2015, the highest fruit set occurred in clone 82 with 73%. The fact that the yield of clone 82 is high (27.08 kg / tree) and the unit yield per trunk cross-section area (40.19 g / cm2) supports this. In 2016, the fruit set rate of clone 83 (88%) was the highest. It was determined that the yield amount of this clone (29.35 kg/tree) and the yield (31.23 g/cm2) according to the trunk cross-sectional area were also high. However, both clones (K.82 and K.83) are the clones with the longest harvest period (47 days). As a result of the analysis of variance, fruit set values in both years were found to be important in determining the difference between clones. In both years, clones 82 and 83 were in the first group with the best value, followed by clones 50 and 71 with the best value. The long harvest period for table fruit is advantageous as it will extend the time to market for the product. In the production of dried figs, precipitation is not desired, especially during the harvest and drying period. Since figs are affected by changing climatic conditions, a short harvest period is desired for dried figs. In the research, it was determined that clone 59, which stands out with its superior properties of dried fruit, had a shorter harvest period than clones 82, 75 and 83.

It is stated that the fruit set rates in Sarılop vary between 25-63% (Aksoy et al., 1987). In a research conducted with the Sarılop (Calimyrna) variety in California, it was reported that the fruit set rate was 87% (Crane, 1948). Kusaksiz (1999); In his study on different Sarılop clones between 1995-1996; Fruit set rates of clones vary between 40-52% depending on years, fruit quantity and quality. Aksoy et al.(1994); Although clones 37 and 45 are not in the first place in terms of fruit size in Sarılop clones, they are superior clones due to the completion of their total quality and maturation periods in a short time. Ozkul et al.(2021), total dry fruit yield was 11.34 kg / tree with highest B7 application and lowest 6.91 kg / tree with B3 application. The highest yield per decare was 476,29 kg in B7 application.

In order to determine the superrior clones in terms of dried fruit quality characteristics, the amount of scrap taken in 2015 and 2016 (%), yield per tree (kg/tree), ostiol end cracked (%), sunscalded fruit (%), average dried fruit weight, skin color "L", TA (titratable acidity (in citric acid)) (%), yield per trunk cross-sectional area (g/cm^2), harvest period (day), dry matter amount (TSS) (%) parameters are the main components used as a variable in the analysis.

The purpose of principal component analysis has been defined as expressing a large number of variables with fewer new variables, which are linear components of them, and helping to summarize and interpret the data obtained as a result of the studies (Sharma, 1996, Tatlidil, 1996, Ozdamar, 2004; Sangun, 2007). As a result of Principal Component Analysis, it is revealed which variable or variables each principal component predominantly represents (Sharma, 1996). As a result of the evaluation, the variables expressing 74% of the total variation in dried fruit were scrap amount, yield per tree, (>1/3) ostiol end crack status (1st main component), sunscalded fruit (%), average fruit weight (g) and the skin color "L" (the highest contributor to the 2nd principal component). In other words, it has been revealed that there may be differences between the clones examined in terms of dried fruit characteristics with regards to these parameters. With these prominent variables, dry fruit weighted grading quality characteristics steps were created. Evaluation result, clones 82 (860), 75 (850), 83 (800), 59 and 63 (770), 32 (750), 66 and 69 (710), 37 (700), 20 (680) It took its place in the top ten by taking the total weighted rankit points in parentheses. At the and of the PCA and weighed rankit method; 82, 75, 83 and 59 code no of clones are surpass the others. Altough there are general differences in terms of pomological characteristics in Sarılop clones, all the data determined are agreement with literature data reported for Sarılop.

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CHAPTER 3

STUDIES ON LOCAL FETHİYE KAYA FIG CLONES AND OTHER FIG GENOTYPES IN FETHİYE AND SEYDİKEMER DISTRICTS OF MUĞLA PROVINCE

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INTRODUCTION

As in many fruit species, natural mutations can cause clonal differences in figs (Ayar, 2018; Ayar et al., 2018 and 2019). Muğla Region is one of our provinces with a high fig population. There are genotypes that emerged as a result of natural mutations in the region and have not been screened until now. There is also Fethiye Kaya fig, which is widely found and produced in the Fethiye Region. Local people declared that this fig has black, white and purple types and they are not alike. Especially the black Fethiye kaya fig has superior properties in terms of drying as well as being used for table use. Other fig genotypes in the region were included in this study, which was carried out in 2020 in order to determine the general characteristics of the black-colored Fethiye Kaya fig types in Fethiye and Seydikemer Districts. With the study, the general situation of the fig existence in the region was revealed.

In the research, the general characteristics of the fig genotypes for table fresh fruit and drying in the region were evaluated according to the criteria of IPGRI variety feature certificate by making pomological analysis and morphological measurement (Ayar et al., 2018; Anonymous, 2003).

Hepaksoy (2004) states that the most commonly used method for the identification of cultivars and clones of a species is morphological and pomological features.

1. MATERIAL AND METHOD

In this research, black colored (2, 4, 5, 6, 10, 14, 17, 23); white colored (1, 11, 19 and 27) and purple colored (3, 7, 9, 12 and 18) Fethiye Kaya fig clones and other fig genotypes (25, 29, 30, 31, 32) were used. The numbers in parentheses are the numbers given in the marking of trees.

Black colored Fethiye Kaya fig; it is generally a genotype with small ostiol witdth and high drying quality. While the fruits are green, they have red scales around the ostiolum. Generally, there are 50-250 years old trees in the region. It generally multi-stemmed (generally old trees) and very large, spreading/ semi-erect trees. Small or medium yielding, usually ancestral figs with a retrospective history are the most common figs. When the fruits ripen, the skin turns dark purple-black. Fruit flesh thickness becomes thinner as it matures. There are red-purple colors in the fruit inner (pulp) and fruit inner fles. The fruit pulp inner color of the fruit is purple or dark red. Some genotypes have a unique aroma (such as sour cherry) (Figure 1).

Figure 1: While black colored Fethiye Kaya fig maturing

The purple colored genotypes generally have poor dried quality. They are more suitable as a fresh table fig for evaluation. The skin of the fruit is generally thick, the skin ground color is yellow-green, and the fruit skin ground color ground over colour: (irregular patches) is purple. (Figure 2 (a)).

White-colored genotypes are generally medium-sized and their fruit internal colour (pulp) changes from amber to red. The pulp flavour are medium sweet. Generally, as a dried is consupted (Figure 2 (b)).


(a)

(b)

Figure 2: Purple (a) and white (b) Fethiye Kaya genotypes

Within the scope of the project, from Fethiye Chamber of Commerce and Industry, Seydikemer Chamber of Agriculture and from muhtars who know the region well, have been received guidence. From Fethiye Chamber of Agriculture and District Directorate of Agriculture and Forestry, and selection studies were held in Fethiye and Seydikemer Districts of Muğla Region between 20.07.2020-17.09.2020 (Figure 3). In the selection studies carried out; 32 trees in total are marked. While marking the trees, the passport information in the fig collection form was recorded for each marked tree.

25 fresh fruit, 30 leaves and 1 kg dried fruit samples were taken from each marked tree.

The pomological evaluations of fig genotypes according to the criteria in the cultivar feature certificate are given in Tables 1, 2, 3 and 4.

In the evaluation; The average fresh table fruit weights of the fig genotypes were determined in the range of 12.46 (genotype 10)-37.84 g (genotype 7).

It was determined that the number of dried fruits per kilogram ranged from 51 (genotype 3) to 133 (genotype 31). Black-colored Fethiye Kaya genotypes generally have more fruit per kilogram than purple and white-colored types. This highlights that the dried fruits are smaller. Fresh table fruit weights were also found to be smaller than other figs.

Dried fruit skin color L value parameter was determined in the range of 27.93 (genotype 30)-60.23 (Genotype 11). This value, which expresses the lightness and darkness in the fruit skin color, becomes lighter as the color increases. The value decreases in dark colored genotypes. It was determined that the color parameter of fresh table fruit pulp inner colour a changed in the value range of 6.46 (genotype 32)-17.08 (genotype 23). The increase in this value in the color of fresh table fruit indicates that the redness in the pulp internal colour is excessive (Table 1).

(a) (b) (c) (d) (e)

Figure 3: Selection studies in Seydikemer (a), Central of Fethiye (b), İncirköy(c) Dodurga (d), Kayadibi (e)

Table 1: Some pomological features of fig genotypes

Genotypes	Average fresh table fruit weight (g)	Number of dried fruits per kilogram	Dried fruit skin color			Fresh table fruit pulp internal colour		
			L	**a**	**b**	**L**	**a**	**b**
18	20,77	89	34,27	8,18	4,05	30,89	8,84	8,23
4	25,30	102	29,27	4,87	17,57	30,89	8,84	8,23
1	35,86	63	32,3	1,02	-1,98	35,62	7,88	12,24
2	27,32	96	32,3	1,02	-1,98	28,07	14,54	6,5
3	28,59	51	33,08	1,9	-1,31	34,69	10,16	9,06
5	19,54	76	30,14	1,06	-1,45	27,64	14,01	7,4
26	14,13	91	30,86	0,98	-2,21	27,2	15,68	6,49
17	17,79	106	30,24	0,94	-2,57	26,66	15,52	6,94
21	16,09	128	30	1,22	-1,71	31,4	9,41	7,67
6	21,57	97	31,46	0,91	-1,25	27,91	16,01	6,78
27	30,34	58	45,94	10,63	9,56	39,8	13,77	12,62
19	23,68	72	52,22	8,02	15,88	35,77	11,25	9,2
23	20,51	91	29,53	0,79	-1,69	30,07	17,08	7,69
28	19,69	122	30,82	0,84	-1,85	31,3	16,02	7,85
25	20,36	83	29,24	1,74	-1,18	33,86	12,68	8,29
9	32,83	68	46,4	10,61	10,91	41,06	7,5	13,4
14	28,55	86	33,17	0,7	-2,36	37,56	10,47	10,65
29	25,68	63	31,03	0,63	-2,48	30,08	11,47	8,61
10	12,46	123	30,75	0,89	-2,74	27,78	11,95	5,41
12	20,95	85	50,07	8,03	13,07	32,83	10,42	9,57
11	21,78	76	60,23	5,57	18,63	30,77	12,53	7,76
30	21,03	90	27,93	0,78	-2,74	36,05	11,79	11,07
31	28,20	133	28,44	0,68	-3	36,58	11,83	10,33
32	15,10	102	29,68	0,85	-2,21	34,62	6,46	8,54
7	37,84	60	46,31	9,12	8,33	37,37	10,22	13,68

Table 2: Evaluation of fruit samples obtained from fig genotypes

Genotypes	Fruit lenticels quantity	Fruit lenticels colour	Pulp flavour	Pulp internal colour	Pulp juicness	Fruit inner cavity	Colour formation in the flesh
18	medium	white	strong	red	little juicy	very small	absent
4	scarce	white	aromatic	dark red	juicy	very small	intense colour formation
1	medium	white	nötr	amber	little juicy	small	absent
2	medium	white	aromatic	dark red	juicy	very small	intense colour formation
3	medium	white	strong	red	little juicy	very small	light coloration
5	scarce		aromatic	red	juicy	very small	light coloration
26	scarce	white	strong	dark red	little juicy	very small	light coloration
17	scarce	white	aromatic	dark red	little juicy	very small	intense colour formation
21	medium	white	little flavour	kehribar	little juicy	very small	absent
6	scarce	white	aromatic	red	juicy	very small	absent
27	scarce	white	little flavour	amber	little juicy	very small	absent
19	scarce	white	little flavour	amber	little juicy	small	absent
23	scarce	pinkish	aromatic	dark red	little juicy	very small	intense colour formation
28	scarce	white	strong	dark red	little juicy	very small	light coloration
25	medium	pinkish	strong	red	little juicy	very small	absent
9	medium	white	little flavour	red	little juicy	very small	absent
14	medium	white	little flavour	amber	little juicy	very small	absent
29	scarce	white	little flavour	amber	little juicy	very small	absent
10	scarce		aromatic	dark red	juicy	very small	intense colour formation
12	numerous	white	nötr	amber	little juicy	very small	light coloration
11	scarce	green	little flavour	dark red	little juicy	small	absent
30	medium	white	little flavour	amber	little juicy	very small	light coloration
31	scarce	white	little flavour	amber	little juicy	very small	absent
32	medium	white	little flavour	amber	little juicy	very small	absent
7	numerous	white	strong	amber	little juicy	small	absent

The fruit lenticel quantity (spot on the fruit skin) of the fruits taken from the fig genotypes was found to be sparse or medium, the lenticel color was generally white, and the fruit pulp inner color was dark red or amber. Fruit inner cavity was not found. In terms of colour formation in the flesh, besides the genotypes with no color, the genotypes with intense colour formation in the flesh were also encountered. In terms of sensory taste (pulp flavour), generally sweet or distinctly sweet types were encountered. In terms of pulp juiciness, the types are generally in the little juicy class (Table 2).

The evaluations of uniformity of fruit size, liquid drop at the ostiol and colour of liquid drop at the ostiole, ease of peeling, fruit ribes (logitudinal ridges on the fruit suface), and fruit skin cracks are given in Table 3. In the evaluation, it was determined that the fruits of the genotypes were uniform, the fruit skin was easily peeled, the fruit was clearly prominent, and the fruit minute skin craking was insignificant in general (Table 3).

Evaluations on the amount of fruit skin ground colour, fruit skin ground over colour, firmness of the fruit skin, TA (%) (Titratable acidity amount), fruitlets size (achene) taken from the types are given in Table 4. The fruit skin ground colour and ground over fruit skin colour of the genotypes are generally black. Firmness of the fruit skin is medium hard. TA value was found in the range of 0.182-0.612. The TSS value was found in the range of 16.18 (genotype 2)-29 (genotype 25). Genotypes differ in fruitlets size and generally have a moderate amount of fruitlets in terms of kernel quantity (Table 4). Studies carried out according to leaf characteristics are given in Tables 5 and 6. In the study; although genotypes differ in terms of leaf dentation, leaf margin, density of hairs or spicules on lower and upper surface and leaf shape, it was determined that the leaf color of genotypes is generally dark green. The number of lobes is generally 5; shape of lobes is spatulate (narrow at the base and wider at the top). There were differences between genotypes in terms of veining status and the shape of the base (petiole sinüs) (Table 6).

Table 3: Evaluations of some quality parameters in fruits

Genotypes	**Uniformity of fruit size**	**Liquid drop at the ostiole**	**Colour of liquid drop at the ostiole**	**Easy of peeling**	**Fruit ribes (logitudinal ridges on the fruit suface)**	**Fruit skin cracks**
18	uniform	present	transparent	easy	prominent	minute cracks
4	uniform	absent		easy	prominent	minute cracks
1	variable	absent		easy	intermediate	minute cracks
2	uniform	absent		easy	prominent	scarce longitudinal cracks
3	variable	absent		easy	prominent	scarce longitudinal cracks
5	uniform	absent		easy	intermediate	scarce longitudinal cracks
26	uniform	absent		easy	intermediate	scarce longitudinal cracks
17	uniform	present	pinkish	easy	intermediate	scarce longitudinal cracks
21	uniform	absent		easy	intermediate	scarce longitudinal cracks
6	uniform	absent		easy	intermediate	scarce longitudinal cracks
27	uniform	absent		easy	prominent	minute cracks
19	uniform	absent		easy	intermediate	minute cracks
23	uniform	absent		easy	intermediate	minute cracks
28	uniform	absent		easy	prominent	minute cracks
25	variable	absent		easy	intermediate	scarce longitudinal cracks
9	uniform	absent		easy	prominent	minute cracks
14	uniform	present	transparent	easy	prominent	scarce longitudinal cracks
29	uniform	present	transparent	easy	prominent	craced skin
10	uniform	present	pinkish	easy	prominent	scarce longitudinal cracks
12	uniform	absent		easy	prominent	minute cracks
11	uniform	present	dark red	easy	prominent	minute cracks
30	uniform	absent		easy	prominent	scarce longitudinal cracks
31	uniform	present	transparent	easy	prominent	scarce longitudinal cracks
32	uniform	present	transparent	easy	prominent	minute cracks
7	uniform	present	transparent	easy	prominent	minute cracks

Table 4: Evaluations of some quality parameters in fruits

	Fruit skin ground colour	Fruit skin ground over colour	Firmness of the fruit skin	Titratable acidity (% citric acid)	Fruitlets size	Amount of fruitlets	Total soluble solids (%)
18	yellow green	purple	medium	0,317	medium	medium	23,88
4	black	black	medium	0,378	large	low	18,05
1	light green	green	medium	0,310	large	medium	16,30
2	black	black	soft	0,612	medium	medium	16,18
3	light green	purple	medium	0,182	medium	medium	21,98
5	black	black	soft	0,427	small	medium	20,35
26	black	black	medium	0,332	medium	medium	26,85
17	black	black	medium	0,344	large	high	22,98
21	black	black	medium	0,205	medium	high	25,73
6	black	black	medium	0,313	medium	medium	22,45
27	light green	light green	medium	0,467	small	high	21,63
19	green	green	medium	0,300	medium	medium	22,80
23	black	black	soft	0,336	medium	medium	26,28
28	black	black	medium	0,421	medium	medium	21,30
25	black	black	medium	0,425	medium	medium	29,00
9	yellow green	purple	medium	0,412	medium	medium	25,37
14	black	black	medium	0,197	large	medium	20,73
29	purple	black	soft	0,292	medium	medium	24,78
10	black	black	medium	0,262	medium	medium	22,17
12	green	purple	medium	0,420	medium	medium	22,68
11	yellow	green	medium	0,316	medium	medium	28,93
30	black	black	soft	0,333	medium	low	25,70
31	black	black	soft	0,465	small	medium	25,03
32	black	black	medium	0,440	small	medium	28,20
7	yellow green	purple	medium	0,376	large	high	19,84

Table 5: Evaluations of leaf characteristics

Genotypes	Leaf margin dentation	Leaf margin	Density of hairs or spicules on leaf surface		Leaf colour	Leaf shape
			lover	upper		
18	lobes sides completely dented	crenate	medium	medium	dark green	base calcarate, lobes linear
4	no dentation	undulate	sparse	none	dark green	base cordate, five lobed, lobes spatulate
1	only upper margins dented	serrate	medium	none	dark green	base cordate, five lobed, lobes spatulate
2	only upper margins dented	dentate	medium	none	ligth green	base cordate, three-lobed
3	only upper margins dented	crenate	sparse	none	dark green	base cordate, five lobed, lobes spatulate
5	only upper margins dented	dentate	medium	none	dark green	base truncate
26	no dentation	crenate	medium	none	dark green	base calcarate, lobes latate
17	no dentation	undulate	sparse	none	dark green	base cordate, five lobed, lobes spatulate
21	no dentation	undulate	sparse		dark green	base calcarate, lobes latate
6	no dentation	undulate	sparse	none	dark green	base truncate
27	no dentation	undulate	sparse	none	dark green	base cordate, three-lobed
19	no dentation	undulate	none	none	dark green	base calcarate, lobes lyrate
23	no dentation	undulate	sparse	none	dark green	base cordate, five lobed, lobes spatulate
28	no dentation	undulate	sparse	none	ligth green	base cordate, five lobed, lobes spatulate
25	only upper margins dented	undulate	sparse	none	dark green	base truncate
9	no dentation	undulate	sparse	none	dark green	base truncate
14	only upper margins dented	undulate	sparse	none	dark green	base truncate
29	no dentation	undulate	none	none	ligth green	base truncate
10	no dentation	undulate	none	none	ligth green	base truncate
12	only upper margins dented	crenate	none	none	ligth green	base truncate
11	only upper margins dented	undulate	medium	none	dark green	base cordate, five lobed, lobes spatulate
30	only upper margins dented	undulate	sparse	none	dark green	base cordate, three-lobed
31	only upper margins dented	undulate	sparse	none	dark green	base decurrent
32	only upper margins dented	undulate	sparse	none	dark green	base truncate
7	only upper margins dented	crenate	none	none	dark green	base cordate, three-lobed

Table 6: Evaluations of leaf characteristics

Genotypes	Number of lobes	Shape of lobes	Leaf venation	Shape of leaf base (petiole sinus)
18	5	(spatulate)-(narrow at the base and wider at the top)	apparent	cordate
4	5	(spatulate)-(narrow at the base and wider at the top)	apparent	calcarate
1	5	(spatulate)-(narrow at the base and wider at the top)	unapparent	decurrent
2	5	(latate)-(winder lobes)	slightly apparent	cortade
3	5	(spatulate)-(narrow at the base and wider at the top)	unapparent	calcarate
5	5	(spatulate)-(narrow at the base and wider at the top)	unapparent	truncate
26	5	(latate)-(winder lobes)	unapparent	calcarate
17	5	(latate)-(winder lobes)	unapparent	calcarate
21	5	(spatulate)-(narrow at the base and wider at the top)	slightly apparent	calcarate
6	5	(spatulate)-(narrow at the base and wider at the top)	slightly apparent	truncate
27	3	(spatulate)-(narrow at the base and wider at the top)	unapparent	cordate
19	5	(linear)-(more slender and regular in shape)	apparent	calcarate
23	5	(latate)-(winder lobes)	slightly apparent	cordate
28	5	(latate)-(winder lobes)	slightly apparent	calcarate
25	3	(linear)-(more slender and regular in shape)	unapparent	truncate
9	3	(spatulate)-(narrow at the base and wider at the top)	unapparent	truncate
14	5	(spatulate)-(narrow at the base and wider at the top)	unapparent	truncate
29	5	(spatulate)-(narrow at the base and wider at the top)	unapparent	truncate
10	5	(latate)-(winder lobes)	slightly apparent	truncate
12	5	(latate)-(winder lobes)	unapparent	decurrent
11	5	(latate)-(winder lobes)	slightly apparent	cordate
30	3	(latate)-(winder lobes)	slightly apparent	cordate
31	5	(spatulate)-(narrow at the base and wider at the top)	slightly apparent	decurrent
32	5	(spatulate)-(narrow at the base and wider at the top)	slightly apparent	decurrent
7	5	(spatulate)-(narrow at the base and wider at the top)	slightly apparent	cordate

Table 7: Morphological measurements made on leaves

Genotypes	Leaf length (cm)	Leaf width (cm)	Length of central lobe (cm)	Petiole length (cm)	Petiole thickness (mm)	Degree of leaf lobation/incision ratio (%)	Leaf area (cm^2)
1	24,46 a	18,74 a-d	16,75 a	9,81 a	4,45 ab	0,68 ab	463,02 a
2	19,39 c-f	19,31 ab	13,92 b	6,52 def	4,30 bcd	0,50 j	381,13 b
3	20,34 cd	18,80 a-d	12,17 c	8,37 b	4,36 ab	0,56 f-ı	384,40 b
4	15,58 mn	15,23 ıjk	12,04 cd	5,17 gh	3,68 b-e	0,54 g-j	239,43 j
5	18,01 f-j	17,26 d-g	11,90 c-h	5,98 fg	3,74 b-e	0,51 ıj	312,28 e-h
6	17,68 g-k	17,96 b-e	11,86 cde	7,23 b-e	3,87 b-e	0,58 efg	321,76 c-h
7	16,98 ı-m	14,87 jk	11,86 cde	5,05 gh	3,89 b-e	0,60 def	253,11 ıj
9	19,75 c-f	17,58 c-f	11,64 c-f	5,96 fg	4,05 b-e	0,60 c-f	349,05 b-f
10	14,81 n	15,39 h-k	11,50 c-f	4,69 h	3,08 e	0,50 j	231,61 j
11	18,40 e-ı	16,44 e-j	11,45 c-g	7,20 cde	4,21 bcd	0,65 abc	306,90 f-ı
12	19,46 c-f	16,86 e-ı	11,32 c-h	7,31 bcd	3,26 cde	0,44 k	331,31 b-g
14	20,07 cde	17,41 c-f	10,90 d-ı	7,96 bc	4,00 b-e	0,57 efg	350,67 b-f
17	16,14 k-n	16,69 e-ı	10,85 d-ı	5,77 fgh	5,39 a	0,59 d-g	274,40 hıj
18	16,41 j-n	16,46 e-j	10,82 d-ı	7,25 b-e	3,79 b-e	0,71 a	273,11 hıj
19	15,93 lmn	14,42 k	10,75 e-ı	6,55 def	3,40 b-e	0,68 ab	234,45 j
21	19,35 c-g	19,04 abc	10,48 f-j	5,56 fgh	4,37 abc	0,59 d-g	370,07 b-e
23	17,55 h-l	16,99 e-h	10,19 g-k	6,11 efg	3,26 cde	0,51 hıj	303,63 f-ı
25	18,04 f-j	15,65 g-k	10,13 g-k	5,39 fgh	3,23 de	0,60 def	284,57 g-j
26	19,31 d-g	19,04 abc	9,69 ı-l	7,67 bcd	3,83 b-e	0,55 f-j	369,68 bcd
27	19,24 d-h	16,24 f-j	9,29 jkl	7,37 bcd	4,17 bcd	0,64 bcd	316,39 d-h
28	19,14 d-h	19,66 a	9,17 kl	7,43 bcd	3,83 b-e	0,57 efg	381,58 b
29	21,08 bc	17,80 b-f	8,96 kl	7,52 bcd	3,64 b-e	0,56 e-h	377,82 bc
30	20,54 b-e	15,82 e-k	8,47 lm	5,18 fgh	3,65 b-e	0,60 c-g	337,66 b-h
31	19,41 c-f	16,19 f-j	8,46 lm	5,76 fgh	3,92 b-e	0,56 f-ı	319,32 d-h
32	22,51 b	19,72 a	7,36 m	9,69 a	4,13 b-e	0,62 cde	449,11 a
St. Error	0,60844	0,59856	0,452636	0,426742	0,385681	0,196399	20,2322
P	>0,0001	>0,0001	>0,0001	>0,0001	0,0388	>0,0001	>0,0001

The variance evaluation table of the leaf data of fig genotypes is given in Table 7. In the statistical evaluation, leaf length, leaf width, length of central lobe, petiole length, degree of leaf lobation/incision ratio and leaf area were found to be statistically significant. Leaf lengths 14.81 (genotype 10)-24.46 (genotype 1) cm; leaf widths 14.42 (genotype 19)-19.72cm (genotype 32); length of central lobe 7.36(genotype 32) - 16.75cm (genotype 1); petiol lengths 4.69 (genotype 10)-9.81cm (genotype 1); petiol thicknesses 3.08 (genotype 10)-5.39cm; (genotype 17); degree of leaf lobation/incision rate was 0.50% (genotypes 2 and 10)- 0.71 (genotype 18) and leaf area was determined in the range of 231.61 (genotype 10)- 463.02cm2 (genotype 1).

2. RESULTS and DISCUSSION

Fethiye Kaya fig is grown at different altitudes of Muğla Province Fethiye and Seydikemer Districts and has different soil groups and soil characteristics. The presence of figs in general; it is more concentrated in regions such as Kayadibi, İncirköy, Üzümlü, Seydikemer, Dodurga, Saklıkent and Kayacık. The texture of the soils where the genotypes are found is generally sandy-loam. These are Mediterranean (terrarosa) soils and non-calcareous brown forest soils. It has been determined that the number of fruits and taste of these figs grown in brown soils with good aggregation are better.

When the presence of figs in the region was evaluated, it was determined that the fruits were generally small in genotypes. Genotypes 3, 27, 7, 1, 29, 9, 19, 5 and 11 entered the middle class (medium) in terms of the number of dried fruits per kilogram, taking place between 61-80 pieces. Genotypes 4, 32, 17, 28, 10, 21 and 31 were included in the group with more than >100, that is, very small fruit. Other genotypes are in the group with small fruits (81-100 units) (Table 8) (Anonymous, 2003; item 89)

Table 8: Number of dried fruits per kilogram

Number of dried fruits per kilogram	very large	<45
	large	46- 60
	medium	61- 80
	small	81-100
	very small	>100

It was determined that the black genotypes from the Divrek Kara fig clone, which is indicated with the number 25 in the region, generally have a higher number of dried fruits per kilogram. In other words, its fruits are smaller than the fruits of Divrek Kara.

The black genotypes in the region are generally less sweet than the purple and white genotypes. In addition, black figs have a unique aroma.

Trees in the region are generally low and moderately productive. The reason for being less efficient; may be the limited number of covered gardens and the fact that the producer does not give due importance to or does not know how to caprification. In addition, another factor is that suitable maintenance conditions have not been established since figs are generally found in the region as a border tree.

The presence of figs in the region, from past to present, has been collected; fresh table fig and as a dried fig are soled in local markets or stored as a dried fig. Drying is done locally. The figs, which are dipped in boiling hot water within knitted wooden baskets. Leaves of trees such as laurel and myrtle are also put into the hot water. Then the figs are dried layer by layer and kept in a cool place by sprinkling flour among them.

Tobacco fields have replaced the fig orchards in the plain, which is known as the fig garden, which is stated to have been widely produced in historical records (Anonymous, 2020). However, dipping and drying have not been forgotten in the region because it is a time-honored tradition of many years and is still being carried out. Divrek Kara (registered variety) (Figure 4) has been registered by The Directorate of Fig Research Institute in 2019. It is a very important alternative for the presentation to the black dried fig market. The added value of black figs is higher. Because, especially in America and Europe, consumers have started to prefer black fig types due to the high antioxidant value in dark-colored food products. (generally contains 3 times more antioxidant activity than white varieties) (Ayar, 2019; Anonymous, 2019; Konak et al., 2017).

Figure 4: Divrek Kara fig variety

Although large fig varieties are generally preferred in the market, it is stated that in line with the change in demands of foreign market; snack figs which are also called cherry figs, small- black figs, and the ones sold in a cup, are also in demand today. The reason why Fethiye Kaya fig is especially popular in the UK market is the qualification of being small in size, both fresh and dried, which makes it suitable for the export of snack figs. As a matter of fact, it has been noted that the region has a great potential. (Anonymous, 2021).

We have valuable figs that exist in tourism regions but are about to disappear due to rapid construction. Fethiye Kaya fig genotypes are one of these fig gene resources that have a history and are tried to be kept alive with traditional methods. With the increase in demand for black figs, its importance has begun to be understood better. Aydın Fig Research Institute has been carrying out a selection project project in the region in cooperation with Fethiye Chamber of Commerce and Industry and Seydikemer and Fethiye Chamber of Agriculture. The genotypes that stand out in the project will be spread by establishing closed gardens in the region with the cooperation of sapling production. Studies were started without wasting time, especially for the dissemination of the black Fethiye Kaya Fig.

Figs are a very valuable treasure for Turkey. All our fig assets that cannot breathe and are stuck in tourism regions should be researched, evaluated and taken under protection before they become extinct. In this study, within the scope of the “Fig Selection in Muğla Province” project; The data obtained is for one year and the study continued in 2021. The genotypes to be selected as a result of the evaluation of the two-year data; It will be evaluated in terms of yield and quality characteristics with a new clonal selection study to be carried out in Aydın conditions. As a result of the research the determined superior genotypes will be registered and given the variety feature, and the fig will be taken under protection in the plant gene bank.

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CHAPTER 4

PISTACHIO PRODUCTION IN SİİRT/ERUH AND THE SOCIO-ECONOMIC STATUS OF PRODUCERS

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INTRODUCTION

Pistachio is one of the agricultural products with high economic value in the South-eastern Anatolia region of Turkey. Pistachio was first introduced to agricultural culture by Hittite civilization in Southern Anatolia. Pistachio was first transported to Rome in the First Century A.D. by the Syrian Governor Viltellius, and then taken from Rome to Spain. Thus, while pistachio spread in the Mediterranean Region, it also spread in Iran, Afghanistan and India (Özbek, 1978).

While it was originally thought to be the canter of pistachio in Syria and Mesopotamia, it has been reported that wild forms of this species also grow in Central Asia by researchers such as Popov, Morozov and Tsherniakovskaya (Ayfer, 1959).

Of the species in the genus *Pistacia*, only *Pistacia vera* L. (Pistachio) has gained economic value and is used in trading.

The production of Iran, which ranks first in pistachio production, is 462,358 tons. The production of the USA, which is in the second place, is 365,574 tons. The production of Turkey, which ranks third, is 143,250 tons (Figure 1) (Anonymous, 2020a).

The production of China, which ranks fourth in pistachio production, is 98,232 tons. The production of Syria, which is in the fourth place, is 43.323 tons.

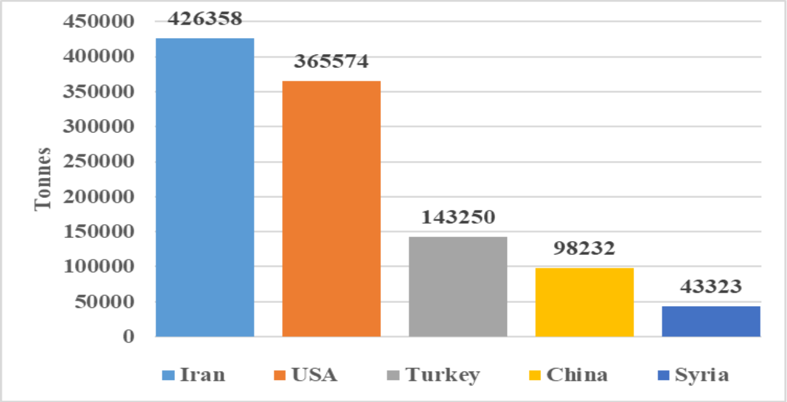

Figure 1: World Pistachio Production (2016-2019 years) (Tonnes)

Considering the last 6 years' pistachio production in Turkey, there are large fluctuations (Figure 2) (Anonymous, 2021a).

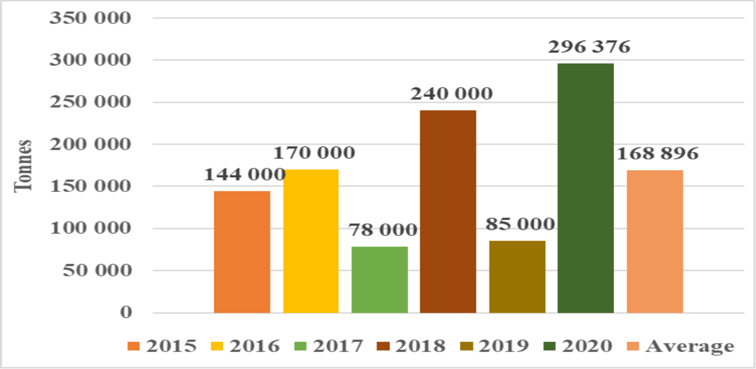

Figure 2: Pistachio Production in Turkey (2015-2020 years) (Tonnes)

The most important reason for this is that we are producing with Uzun pistachio variety, which is one of the varieties with high alternate bearing. Another reason is that our pistachio orchards are not irrigated.

While pistachio production in Siirt was 2 thousand tons in 2002, it increased to 25.624 tons by 2020 (Anonymous, 2021b).

Siirt variety of pistachio is grown intensively in Siirt region in Turkey. This variety is productive and fruit quality is superior. A lot of research has been done and projects have been concluded so far.

Atlı et al. (2011) determined that the most suitable pistachio rootstock - cultivar combination was *P. khinjuk* - Siirt and *P. atlantica* - Siirt for irrigated conditions. They determined that with these combinations, a yield of 300 kg per decare can be obtained in irrigated conditions, 100 nut weight is 153 g, kernel rate is 45.4% and nut splitting rate is 97.8%.

It was determined that the Siirt variety yielded 3 years earlier than the long-fruited varieties, and the yield and fruit quality were higher than the long-fruited varieties (Tekin et al., 2001; Atlı et al., 2003; 2011).

The flowering of the Siirt variety in Gaziantep started on April 16, ended on April 25, and the harvest was done on September 24. The average yield per tree (19 years old) was 4.70 kg/tree, and the yield per decare was determined as 155.2 kg/da. They found that the 100 nut weight of the Siirt variety was 133.80 g, the hulled kernel rate was 42% and the nut splitting rate was 88% (Tahtacı et al., 2007).

Arpacı et al., (1995), have obtained yields of 262 kg/da from Siirt variety and 190 kg/da from Uzun variety in the pistachio orchard planted in irrigated conditions at 1x7 m spacing.

It was determined that the Siirt variety yielded 74.94 kg/da in 8x8 m plots planted in dry conditions, 97.34 kg/da in 6x8 m plots and 132.62 kg/da in 4x8 m plots. 100 nut weights in Siirt variety in 4x8 m, 4x6 m and 8x8 m, respectively; The nut splitting rates were 136.56 g, 135.67 g and 139.21 g, respectively; It was determined as 96.78%, 93.33% and 97.33% (Arpacı et al., 1997).

Atlı et al., (1997) determined that the beginning of flowering of Siirt cultivar in 1996 in Gaziantep occurred on April 22, full bloom on April 29, end of flowering on May 3, early ripening on August 12 and harvest on Sept. 25. They determined the nut splitting rate of Siirt variety as 98.6%, the weight of 100 nut as 135.1 g, and the kernel rate as 45.80%.

Fruit and tree characteristics of 43 genotypes of Siirt cultivar were determined in Pervari district of Siirt. Nut weights were found to be 1.21-1.93 g on average, kernel weights of 0.46-0.81 g and yields varied between 31.5% and 49.0% (Öztürk, 2006).

As a result of a research, in the Siirt variety; nut splitting was 98%, kernel rate was 45%, and 100 nuts weight was 135.1 g. It has been observed that the beginning of flowering is April 22, full flowering is April 29, the end of flowering is May 3, early ripening is August 12, and the harvest date is September 25 (Atlı et al., 1999).

Studies have been carried out in different provinces to establish a database in order to determine the socio-economic status of pistachio producers and make plans about them.

Fruit growing in 41% of agricultural lands in Gaziantep, and the share of pistachio production in fruit growing; It is 62%. Pistachio is produced by 26% of the farmers in the province. It has been calculated that the economic land size will be 48 decares for the living of a family of 5 people. It has been determined that 55% of the pistachio producers have a land size of 51 decares and more of land (Çalışkan et al., 2007b).

Şen and Sandal (2015) found the production cost of pistachios to be 1.035 TL under irrigated conditions and 650 TL under non-irrigated conditions in Gaziantep. They determined that 150 kg/da yield was obtained from irrigated pistachio orchards and 90 kg/da yield was obtained from non-irrigated pistachio orchards. It has been reported that the minimum amount of orchard that the producers will make a living should be 9 decares for irrigated conditions and 15 decares for non-irrigated conditions.

Sandal and Yurddaş (2019) found the production cost of pistachio to be 1.263 TL under irrigated conditions and 869 TL under non-irrigated conditions in Şanlıurfa. They determined that 150 kg/da yield was obtained from irrigated pistachio orchards and 90 kg/da yield was obtained from non-irrigated orchards. It has been reported that the minimum amount of orchard that the producers can make a living should be 9.3 decares for irrigated conditions and 15.9 decares for non-irrigated conditions.

With our study, it was aimed to reveal the effects on the phenological and pomological characteristics and yield of pistachios grown at different altitudes, irrigated and non-irrigated conditions in the Eruh region of Siirt province, and also to determine the socio-economic conditions of the producers and to establish a database for those who will work in the future and to provide support to the authorities.

1. MATERIAL AND METHOD

1.1. Material

3 trees were selected from 4 pistachio orchards, 18-20 years old, planting spacing of 6 x 6 meters, in 4 different heights of the village in Eruh district of Siirt province. A total of 12 trees were used as material.

The altitude of Çeltiksuyu village is 790 meters. Siirt variety was grafted on it using pistachio seedlings. It is cultivated without irrigation. Chemical fertilizers are not used and around 1 ton of manure is given per decare per year.

The altitude of Ekinyolu village is 810 meters. Siirt variety was grafted on it using pistachio seedlings. It is cultivated without irrigation. Chemical fertilizers are not used and around 1 ton of manure is given per decare per year.

The altitude of Bayramlı village is 930 meters. Siirt variety was grafted on it using pistachio seedlings. It is cultivated without irrigation. Chemical fertilizers are not used and around 1 ton of manure is given per decare per year.

The altitude of the village of Gölgelikonak is 960 meters. Siirt variety was grafted on it using pistachio seedlings. There is limited irrigation in the garden. Chemical fertilizers are not used, and 200 litres of water are given to each tree 4 times during the summer months. Irrigation was started in the first week of July and irrigation was done every 20 days. About 1 ton of manure was given per decare.

1.2. Method

1.2.1. Phenological Observations

Beginning of Blooming: When the stigmas of the flowers in the female inflorescences turn 5% cream green, it is accepted as the date of the beginning of blooming (Atlı and Kaşka, 2003).

Full Blooming: The date of full bloom was accepted when 70% of the stigmas of the flowers in the female inflorescences turned cream green (Atlı and Kaşka, 2003).

End of Blooming: The date when all of the stigmas of the flowers in the female inflorescences are light brown is accepted as the end of blooming (Atlı and Kaşka, 2003).

Blooming Period: The blooming period was determined by the sum of the time between the beginning of blooming and the end of blooming.

Early Ripening: The early ripening period is determined as the period when the hull turns from green to pink-white and when we squeeze the nut with our finger, the hull starts to scavenge (Atlı and Kaşka, 2003).

Harvest: From the beginning of September, the orchards were checked and harvested when the hull colours of the fruits in the cluster were pink, pinkish red as an example.

1.2.2. Yield (kg)

During the harvest period, the fruit clusters on the trees were collected by plucking, and the fresh fruit weights per tree were calculated by removing the grains that filled the fruit from the cluster stems. In addition, 1 kg of fresh fruit was taken from each orchard and dried, and the amount of dried fruit per tree and decare was calculated (Arpacı et al., 2014).

1.2.3. Pomological Evaluations of Fruits

Fruit samples taken from the trees in the orchards were dried and analysed in 3 replications, and the weight of 100 nuts (g), splitting ratio and kernel ratios (%) were calculated in these fruits (Tahtacı et al., 2007) (Figure 3 and Figure 4).

Figure 3: Fresh Fruit Samples from Selected Pistachio Orchards

100 Nut Weights (g)

100 nut weights of the fruits were determined as both fresh and dried fruits, dry hulled and shelled.

Figure 4: Dried Fruit Samples from Selected Pistachio Orchards

Fruit samples were taken and weighed in 3 replications, wet hulled and wet shelled, and weighed again after drying, and the data were taken.

Number of Nuts in 100 Grams of Fruit (pieces)

Nut counts were determined by weighing 100 g samples from dried hulled and shelled pistachio fruits with 3 replications.

Kernel Rates (%)

While determining the nut ratios of pistachio fruits in the gardens, 100 grams of dry hulled nut (D-HN) and dry shelled nut (D-SN) samples were taken with 3 replications, the kernels were removed and weighed, and the kernel ratios were found.

Nut Splitting Rates (%)

Dry pistachio nuts were taken as 3 replications, split nuts were counted in 100 nuts, and splitting rates were determined.

1.2.4. Pistachio Production Cost

Considering the production factors in the pistachio orchard, the production costs of one decare of land were calculated (Çalışkan et al., 2007a).

1.2.5. Socio-Economic Status of Producers

A survey was conducted with 100 producers in 11% of the 900 producers in Eruh. According to the questionnaire prepared by Çalışkan et al., (2007b), data on the social and economic structure were obtained by conducting a face-to-face survey with the producers.

1.2.6. Evaluation of Data

Statistical analyses of the obtained data were made according to the randomized blocks experimental design with 3 replications, and the differences between the averages were compared with the LSD test at the 5% significance level (Düzgüneş et al., 1983). Analyses were performed with the Jump statistical program (SAS Institute Inc., Cary, NC).

2. RESULTS AND DISCUSSION

2.1. Phenological Observations

Phenological observations of pistachio trees were made in the orchards of selected villages (Table 1).

Table 1: Blooming Period in Selected Pistachio Trees

Villages	Beginning of Blooming	Full Blooming	And of Blooming	Blooming Period (days)	Early Ripening	Harvest
Çeltiksuyu	8.04.2021	12.04.2021	15.04.2021	7	01.08.2021	07.09.2021
Ekinyolu	7.04.2021	11.04.2021	15.04.2021	8	01.08.2021	07.09.2021
Bayramlı	10.04.2021	14.04.2021	17.04.2021	7	06.08.2021	10.09.2021
Gölgelikonak	11.04.2021	14.04.2021	18.04.2021	7	10.08.2021	14.09.2021

2.1.1. Beginning of Blooming

The earliest flowering was observed in the garden in Ekinyolu village on 07.04.2021, and the latest in the garden in the Gölgelikonak village on 11.04.2021 (Table 1). The beginning of flowering was 3-4 days earlier in Çeltiksuyu and Ekinyolu villages than in Bayramlı and Gölgelikonak villages. This is due to the fact that the altitudes of Çeltiksuyu and Ekinyolu villages are lower than Bayramlı and Gölgelikonak villages and the temperature is high.

Tahtacı et al. (2007), who studied with Siirt variety in Gaziantep, determined that the beginning of flowering was April 16. This date is 5-9 days later than the flowering date in our study. The gardens in Eruh bloomed early due to the fact that the temperature in Siirt region is higher than that in Gaziantep region and the vegetation starts early.

2.1.2. Full Blooming

The earliest full blooming orchard in Ekinyolu village was observed on 11.04.2021, and the latest full blooming orchards in Bayramlı and Gölgelikonak villages were observed on 14.04.2021 (Table 1).

Full blooming was 2-3 days earlier in Çeltiksuyu and Ekinyolu villages compared to Bayramlı and Gölgelikonak villages. This is due to the fact that the altitudes of Çeltiksuyu and Ekinyolu villages are lower than Bayramlı and Gölgelikonak villages and the temperature is high.

Tahtacı et al. (2007), who studied the Siirt variety in Gaziantep ecology, determined that the full blooming date is 20 April. This is 6-9 days late the full bloom date in our study. The gardens in Eruh bloomed early because the temperature in Eruh is higher than in Gaziantep.

2.1.3. End of Blooming

The end of blooming was determined for the first time in Çeltiksuyu and Ekinyolu villages on 15.04.2021, and lastly in the selected orchard on 18.04.2021 in Gölgelikonak (Table 1).

The end of blooming was 2-3 days earlier in Çeltiksuyu and Ekinyolu villages than in Bayramlı and Gölgelikonak villages. This is due to the fact that the altitudes of Çeltiksuyu and Ekinyolu villages are lower than Bayramlı and Gölgelikonak villages and the temperature is high.

Tahtacı et al., (2007) worked with Siirt variety in Gaziantep ecology, determined that the end of blooming date is 25 April. This date is 8-10 days later than the end of blooming date in our study. The last blooming of the orchards in Eruh was also early due to the fact that the temperature in Eruh region is higher than in Gaziantep region and the vegetation started earlier.

2.1.4. Blooming Period

The longest blooming period was 8 days in the orchard in Ekinyolu village, and it was 7 days in other villages (Table 1).

Blooming periods were generally short in all orchards. Atlı and Kaşka (2003) determined that female pistachios bloomed in Gaziantep within 11 days. They reported that this period will be shortened or prolonged in relation to the temperatures during the flowering period. The high temperatures in Eruh shortened the flowering period.

2.1.5. Early Ripening

The earliest ripening on the fruits was observed on 01.08.2021 in the gardens of Çeltiksuyu and Ekinyolu villages, followed by 06.08.2021 in Bayramlı village, and the latest ripening was observed on 10.08.2021 in Gölgelikonak village.

Early ripening date of Siirt variety was determined as 21 August in Gaziantep (Tahtacı et al., 2007). In our study, it took place between 1-10 August. Since Eruh region is warmer than Gaziantep, early ripening was earlier.

2.1.6. Harvest

The earliest harvest was made in the orchards in Çeltiksuyu and Ekinyolu villages on 07.09.2021, followed by the orchard in Bayramlı village on 10.09.2021, and the latest harvest was made on 14.09.2021 in the orchard in the Gölgelikonak village.

Tahtacı et al. (2007), who worked with the Siirt variety in Gaziantep, determined the harvest date as September 24. In our study, the harvest took place on 7-14 September. Since the temperature in Eruh region is higher than Gaziantep region, the harvest was earlier.

Atlı et al., (1997) harvested the Siirt variety on September 25 in Gaziantep. The phenological observation dates in this study were also 1-2 weeks later than in our study.

2.2. Yield

2.2.1. Pistachio Yield Per Tree (kg/tree)

In 2020, the highest dry shelled nut (D-SN) yield per tree was 9,157 kg in the orchard in the Gölgelikonak village. The lowest yield in the orchard in the Çeltiksuyu village with 6,780 kg. The yield values of the villages of Ekinyolu (6,973 kg) and Bayramlı (7,523 kg) are also among the values of these two villages (Table 2).

Table 2: Dry Shelled Yield Per Tree of Orchards (kg/tree)

Villages	2020	2021	Average
Çeltiksuyu	6,780 b	3,717 ab	5,248
Ekinyolu	6,973 b	4,107 ab	5,540
Bayramlı	7,523 b	3,550 b	5,537
Gölgelikonak	9,157 a	4,833 a	6,995
LSD %5	**1,510**	**1,130**	

In 2021, the highest dry shelled nut (D-SN) yield per tree was 4,833 kg in the orchard in the Gölgelikonak village. The lowest yield in the orchard in the Bayramlı village with 3,550 kg. The yield values of the villages of Çeltiksuyu (3,717 kg) and Ekinyolu (4,107 kg) are also among the values of these two villages (Table 2).

In the average of D-SN yield values per tree (in 2020 and 2021), the village of Gölgelikonak (6,995 kg) with a limited irrigation garden took the first place, followed by Ekinyolu (5,540 kg), Bayramlı (5,537 kg) and Çeltiksuyu (5,248 kg), which were not irrigated, respectively (Table 2).

Tahtacı et al. (2007), who studied the Siirt variety in Gaziantep ecology, under non-irrigated conditions, determined that there was a dry nut yield of 4,700 kg per tree in an 18-year-old orchard. This result is in agreement with our dry-conditioned orchards.

2.2.2. Pistachio Yield Per Decare (kg/da)

Yield per decare in 2020, the maximum yield was 256.4 kg in the orchard in the Gölgelikonak village and the lowest yield was 189.8 kg in the orchard in the Çeltiksuyu village. The yield values per decare of the Ekinyolu (195.3 kg) and Bayramlı (210.7 kg) villages were also found was between the values of the two villages (Table 3).

In 2021, yield per decare was found in the orchard village with 135.3 kg, and the lowest yield in Bayramlı village with 99.4 kg. The yield values per decare of Ekinyolu (115.0 kg) and Çeltiksuyu (104.1 kg) villages were also found was between the values of the two villages (Table 3).

Table 3: Dry Shelled Nut Yield Values per Decare of Orchards (kg/da)

Village	2020		2021		Average
Çeltiksuyu	189,8	b	104,1	ab	147,0
Ekinyolu	195,3	b	115,0	ab	155,1
Bayramlı	210,7	b	99,4	b	155,0
Gölgelikonak	256,4	a	135,3	a	195,9
LSD %5	**42,1**		**31,8**		

The average yield per decare (2020 and 2021) was obtained in the orchard with limited irrigation in the Gölgelikonak village (195.9 kg). This was followed by Ekinyolu (155.1 kg), Bayramlı (155.0 kg) and Çeltiksuyu (147.0 kg) villages, which had unirrigated gardens (Table 3).

Tahtacı et al., (2007) who studied the Siirt variety in Gaziantep under non-irrigated conditions, obtained 155.2 kg/da dry nuts yield from an 18-year-old orchard. Arpacı et al., (1997) obtained a yield of 132.6 kg/da from Siirt variety in Gaziantep under non-irrigated conditions. These results are in agreement with our gardens in non-irrigated conditions.

Atlı et al., (2011) obtained 320 kg/da yield from Siirt variety in irrigated conditions in Akçakale. This result is better than our orchard under irrigated conditions. The reason for this is that the soil and growing conditions in Akçakale are better and the planting spacing is 6x4 meters.

2.3. Pomological Assessments

2.3.1. 100 Nut Weights (g)

The highest weight of 100 Fresh Hulled Nuts (F-HN) was determined in the orchards in the Gölgelikonak village with 266 g, followed by the orchards in Bayramlı (238 g), Çeltiksuyu (234 g) and Ekinyolu (224 g) villages, respectively. The highest weight of 100 Fresh Shelled Nuts (F-SN) was 158 g in the orchards in the Gölgelikonak village, followed by orchards in Bayramlı (146 g), Çeltiksuyu (145 g) and Ekinyolu (142 g) villages, respectively (Table 4).

The highest weight of 100 Dry Hulled Nuts (D-HN) was 135 g in the orchards in the village of Gölgelikonak, followed by orchards in Ekinyolu (127 g), Bayramlı (125 g) and Çeltiksuyu (124 g) villages, respectively (Table 4).

Table 4: Dry and Fresh 100 Nuts Weight Values of Pistachio (g)

Villages	F-HN *	F-SN **	D-HN ***	D-SN****
Çeltiksuyu	234 b	145 b	124	100 b
Ekinyolu	224 b	142 b	127	103 ab
Bayramlı	238 b	146 b	125	102 b
Gölgelikonak	266 a	158 a	135	110 a
Average	240,5	147,8	127,8	103,8
LSD %5	**18,9**	**11,1**	**N.S.**	**6,9**

* F-HN: Fresh - Hulled Nuts ***D-HN: Dry - Hulled Nuts
**F-SN: Fresh - Shelled Nuts ****D-SN: Dry - Shelled Nuts

D-SN 100 Nut weight was determined the highest in the orchards in the Gölgelikonak village with 110 g, followed by the orchards in Ekinyolu

(103 g), Bayramlı (102 g), Çeltiksuyu (100 g) villages, respectively (Table 4).

Moisture loss (weight loss) when hulled nuts were dried was 46.9%, and shelled nuts were 29.8% (Table 4).

Atlı et al., (1997) determined that the dry hulled 100 nuts weight of Siirt variety was 135.1 g in Gaziantep. Tahtacı et al., (2007) determined the weight of hulled 100 nuts of Siirt variety to be 133.8 g in Gaziantep. Arpacı et al., (1997) determined that the dry hulled 100 nuts weight of Siirt variety was 135.7 g in Gaziantep. All three studies are in agreement with our dry-conditioned orchards.

2.3.2. Number of Nuts in 100 Gram Nuts (pieces)

Dry Hulled Nut (D-HN) The highest number of nuts in 100 g nut sample was determined in the orchards in Bayramlı and Çeltiksuyu villages with 81, while it was determined as 79, that is, the largest nuts in Ekinyolu and Gölgelikonak villages (Table 5).

Dry Shelled Nut (D-SN) The highest number of nuts in 100 g nut sample was determined in Çeltiksuyu with 100, Bayramlı with 98, followed by the orchard in Ekinyolu (97 pieces) village, and the lowest number of nuts was determined as 91 in the orchard in Gölgelikonak village, the largest nuts were formed in this orchard (Table 5).

The average number of nuts in D-HN 100 g nut was 80 and 96.5 in D-SN nut.

Table 5: Number of Nuts in 100 g Dried Pistachio Fruits in Orchards (pieces)

Villages	D-HN *	D-SN **
Çeltiksuyu	81	100 a
Ekinyolu	79	97 ab
Bayramlı	81	98 a
Gölgelikonak	79	91 b
Average	80	96,5
LSD %5	**N.S.**	**6,4**

*D-HN: Dry - Hulled Nut N.S.: Not Significant
**D-SN: Dry – Shelled Nut

2.3.3. Kernel Rates (%)

The highest Dry Hulled Nut (D-HN) kernel ratio was obtained from the orchard in the Gölgelikonak village with 47.5%, followed by the orchards of Bayramlı village with 43.1%, Çeltiksuyu village with 41.8% and Ekinyolu village with 41.4% (Table 6).

Table 6: Pistachio Kernel Ratio in Orchards (%)

Villages	D-HN*	D-SN**
Çeltiksuyu	41,8	50.2 b
Ekinyolu	41,4	49.1 b
Bayramlı	43,1	49.5 b
Gölgelikonak	47,5	54.3 a
Average	43,5	50,8
LSD %5	**N.S.**	**1,9**

The highest Dry Shelled Nut (D-SN) kernel ratio was obtained from the orchard in the village of Gölgelikonak with 54.3%, followed by Çeltiksuyu village with 50.2%, Bayramlı village with 49.5% and Ekinyolu village with 49.1% (Table 6). The average D-HN kernel ratio was 43.5%, and the D-SN kernel ratio was 50.8%.

Atlı et al., (1997) determined in their study that the kernel rate of Siirt pistachio variety was 45.8% in Gaziantep. Tahtacı et al., (2007) determined that the kernel rate of Siirt variety was 42.0% in Gaziantep. Both of these studies are in agreement with our dry-conditioned orchards.

2.3.4. Nuts Splitting Rates (%)

The highest nut splitting rates were found in Gölgelikonak orchard with 97.3%, Ekinyolu village with 81.3% and Çeltiksuyu village with 75.3%, the lowest splitting rate was found in Bayramlı village with 70.7% (Figure 5).

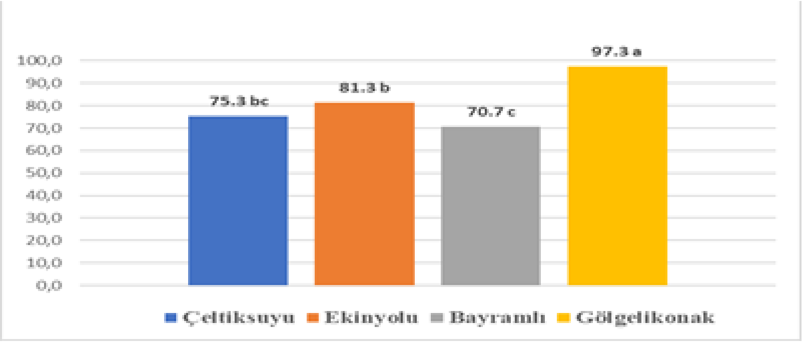

Figure 5: Pistachio Nuts Splitting Rates (%)

Atlı et al., (1997) determined that the splitting rate of Siirt pistachio cultivar in Gaziantep was 98.6%. Arpacı et al., (1997) determined that the splitting rate of Siirt variety was 93.3% in Gaziantep. These two results are in harmony with our irrigated garden. Tahtacı et al., (2007) also determined that the splitting rate of Siirt variety was 88.8% in Gaziantep. This study is also in agreement with our orchards in non-irrigated conditions.

2.4. Production Cost of Pistachio

In this study, the production cost in one decare pistachio orchards in 2021 was determined according to the information obtained from the farmers in Eruh (Table 7).

The total production cost of one decare of unirrigated pistachio orchard was calculated as 1.786 TL (Table 7). The average tree yield (in 2020 and 2021) in our 3 unirrigated orchards is 5,442 kg, and the garden planting spacing is 6x6 meters. Considering that the number of trees per decare is 27.8, 151.3 kg of pistachios will be obtained from 1 decare. It has been stated that 1 kg of pistachio Siirt variety is traded for 71 TL in Gaziantep Commodity Exchange (Anonymous, 2021c).

Gross income from 1 decare will be 151.3 x 71 TL = 10.743 TL, and net income will be 10.743 – 1.786 = 8.957 TL (943 $).

In our country, the poverty line for a family of four is 8.003 TL in June and 96.036 TL on an annual basis (Anonymous, 2021d). Since the average number of individuals in the family in Eruh is 8, the poverty line will be 192,062 TL. Accordingly, a pistachio producer in Eruh will need 192,062 TL / 8,957 TL = 21.4 decares of unirrigated pistachio orchard in order to make a living.

The total production cost of one decare of limited irrigated pistachio orchard was calculated as 2,369 TL (Table 7).

Table 7: Pistachio Production Cost Chart (year 2021)

Transaction explanation	Process group	Cost element	Number of transactions	Quantity	Quantity unit	Price (TL)	Process (TL/da)
Tillage	1. tillage	Plow	1	1	da	75,00	75,00
	2. tillage	Cultivator	1	1	da	50,00	50,00
	3. tillage	Cultivator	1	1	da	50,00	50,00
	4. tillage	Cultivator	1	1	da	50,00	50,00
Pruning	Labor	Pruning Labor	1	1,5	Hour	150,00	225,00
Fertilization	Manure	Manure	1	1.000	kg	0,35	350,00
Agricultural fighting	Pesticide	Other	1	0,025	kg	880,00	22,00
		Other	1	0,05	kg	360,00	18,00
		Other	1	0,1	kg	320,00	32,00
İrrigation	İrrigation	Tanker + water cost	1	22,4	Ton (m^3)	24,10	540,00
Grinding and hoeing	Tillage	Grinding hoeing	1	1	Hour	100,00	100,00
Harvest and drying	Labor	harvest work	1	1	Hour	230,00	230,00
Marketing		Transport.	1	1	Hour	20,00	20,00
Other + Guard	Other	Other	1	1	da	200,00	200,00
Total costs (restricted irrigation)							1.962,00
Total of costs (non-irrigation)							1.422,00
Normal interest (5%) of total expenses (restricted irrigation)							98,10
Normal interest (5%) of total expenses (non-irrigation)							71,10
General administrative expenses (Total costs 3%) (restricted irrigation)							58,86
General administrative expenses (Total costs 3%) (non-irrigation)							42,66
Bare land value (normal interest from 5%) (restricted irrigation)							250,00
Bare land value (normal interest from 5%) (non-irrigation)							250,00
Grand total of production costs (restricted irrigation)							**2.368,96**
Grand total of production costs (non-irrigation)							**1.785,76**

It was determined that the average tree yield (in 2020 and 2021) in the limited irrigated garden we selected in Eruh was 6.995 kg and the garden planting spacing was 6x6 m. Considering that the number of trees per decare is 27.8, 195.9 kg of pistachios will be obtained from 1 decare. It has been stated that 1 kg of pistachio Siirt variety is traded for 71 TL in Gaziantep Commodity Exchange (Anonymous, 2021c). The gross income to be obtained from 1 decare will be 195.9 x 71 TL = 13.909 TL, and the net income will be 13,909 - 2.369 = 11.540 TL (1.215 $).

It is stated that the poverty line for a family of four in Turkey is 8.003 TL in June and 96.036 TL on an annual basis (Anonymous, 2021d). Since the average number of individuals in the family in Eruh is 8, the poverty line will be 192,062 TL. Accordingly, a pistachio producer in Eruh will need an irrigated (restricted) pistachio orchard of 192,062 TL / 11,540 TL = 16.6 decares in order to support his family.

Çalışkan et al. (2007) calculated that 48 decares of unirrigated pistachio orchard would be sufficient for a family of 5 in Gaziantep. In our study, there was a difference because the number of individuals in the family was 8 and the pistachio growing conditions were different.

The cost of 1 decare wheat with 400 kg yield per decare is 857 TL (Anonymous, 2021e). The average purchase price of one kg of wheat is 2.55 TL (Anonymous, 2021f). The family of 8 people from Eruh, who grows wheat, needs to plant 1178 decares of wheat in order to have an income at the poverty line. This is the proof that pistachio cultivation is the most suitable form of agriculture to reduce subsistence problems.

Şen and Sandal (2015) found the production cost of pistachios to be 1.035 TL under irrigated conditions and 650 TL under non-irrigated conditions in Gaziantep. They determined that 150 kg/da yield was obtained from irrigated pistachio orchards and 90 kg/da yield was obtained from non-irrigated pistachio orchards. Sandal and Yurddaş (2019) found the production cost of pistachio to be 1.263 TL under irrigated conditions and 869 TL under non-irrigated conditions in Şanlıurfa. Although the years in which these two projects were concluded are different, they are in harmony with our project.

Table 8: Pistachio Production in Siirt and Eruh (2021 Year)

Pistachios	**Eruh**	**Siirt**	**Percent %**
Number of Trees at Fruiting Age - Number of Pieces	1.382.843	7.061.748	19,58
Number of Trees at Non-Fruiting Age - Number of Pieces	412.605	2.630.414	15,69
Area of Collective Orchards – Decares	59.000	320.600	18,40
Production Amount – Tons	5.504	25.624	21,48
Yield - kg/tree	4	4	

19.58% of the pistachio production in Siirt comes from Eruh district (Anonymous 2021a) (Table 8). The average yield per tree was 4 kg in both Siirt and Eruh. In addition, the productivity rate of Eruh district was higher than Siirt in general. In this situation, it is concluded that the climatic conditions in Eruh district are more suitable for pistachio cultivation.

In Eruh, the average yield per tree was 5.4 kg in the non-irrigated orchards we chose, and the average yield was 7.0 kg in the orchard with limited irrigation. It has been determined that the average yield in Eruh will increase by 57% in case of limited irrigation.

2.5. Socio-Economic Status of the Producers in Eruh

When we take the average of the results we have obtained as a result of the survey we have done with our pistachio producers, the result is 32,820 TL of the average agricultural income of our producers.

It is stated that the poverty line for a family of four in Turkey is 8.003 TL in June and 96.036 TL on an annual basis (Anonymous, 2021d). Since the average number of individuals in the family in Eruh is 8, the poverty line will be 192,062 TL. The net income to be obtained from an unirrigated pistachio orchard is 8.957 TL. Accordingly, a pistachio producer in Eruh will need an unirrigated pistachio orchard of 192,062 TL / 8,957 TL = 21.4 decares in order for his family to be able to make a living at the poverty line.

In order to raise the average agricultural income of our producers (32,820 TL/year) to the poverty line (192.062 TL/year), practices, activities and supports that will increase their income by 5.9 times must be planned. Our producers stated in our survey study that 46% of the population is 11-50 decares of pistachio orchards, which contradicts the calculations we have obtained. In other words, our producers are below the hunger limit because they do not know their annual income exactly or they say it incompletely in the surveys.

Considering the amount of land where our producers grow pistachios, it is understood that they produce on 11-50 decares, which makes up

46% at most. It is seen that the lowest segments are the producers who produce on an area of 201-250 decares, which constitutes the 1% segment, and also produce on an area of more than 250 decares, which constitutes the 1% segment.

In our cost calculations, it has been deduced that a pistachio producer in Eruh should have 21.4 decares of dry pistachio orchard or 16.6 decares of irrigated (restricted) pistachio orchards in order to provide for his family. In this case, producers who do not have 21.4 decares or 16.6 decares of irrigated (restricted) pistachio orchards should be supported to increase the amount of their gardens above these levels. As can be seen in our study, pistachio is a product suitable for Eruh ecology and with a high economic return. Directing the producers to pistachio cultivation will solve the problem of livelihood in the region.

3. CONCLUSION AND RECOMMENDATIONS

3.1. Conclusion

- Blooming of Siirt pistachio variety in Eruh, orchards at different altitudes started on 7-11 April, blooming ended on 15-18 April. Blooming took a total of 7-8 days. Harvest took place on 7-14 September.

- In the average of dry shelled nut (D-SN) yield values per tree (years of 2020 and 2021), the village of Gölgelikonak (6,995 kg) with limited irrigation took the first place, followed by the unirrigated Ekinyolu (5,540 kg), Bayramlı (5,537 kg) and

Çeltiksuyu (5,248 kg) villages respectively.

- In the average of the D-SN fruit yield values per decare, the Gölgelikonak village (195.9 kg) with a limited irrigation orchard took the first place, followed by the unirrigated Ekinyolu (155.1 kg), Bayramlı (155.0 kg) and Çeltiksuyu (147.0 kg) villages respectively.

- The average yield per tree (2020 -2021) in the non-irrigated orchards we selected in Eruh was 5.4 kg, and the average yield in the irrigated (limited) orchard was 7.0 kg. It has been determined that the average yield in Eruh will increase by 57% with limited irrigation.

- Fresh hulled nut (F-HN) 100 nuts weight was highest with 266 g in the orchards in the Gölgelikonak village, followed by the orchards in Bayramlı (238 g), Çeltiksuyu (234 g) and Ekinyolu (224 g) villages, respectively.

- Fresh shelled nut (F-SN) 100 nuts weighed the highest with 158 g, in the orchard in Gölgelikonak, followed by Bayramlı (146 g), Çeltiksuyu (145 g) and Ekinyolu (142 g), respectively.
- Dry hulled nut (D-HN) 100 nuts weight was highest with 135 g in the orchard in the village of Gölgelikonak, followed by the orchards in Ekinyolu (127 g), Bayramlı (125 g) and Çeltiksuyu (124 g) villages, respectively.
- The highest weight of D-SN 100 nuts was 110 g in the orchard in the Gölgelikonak village, followed by the gardens in Ekinyolu

(103 g), Bayramlı (102 g), Çeltiksuyu (100 g) and villages, respectively.

- When the fruits were dried, the moisture loss (weight loss) of hulled nuts was 46.9%, and shelled nuts were 29.8%.
- The highest number of nuts in the D-HN 100 g nut sample was found in the gardens of Bayramlı and Çeltiksuyu villages with 81, while it was 79 in Ekinyolu and Gölgelikonak villages.
- The highest number of nuts in 100 g D-SN sample was determined in the villages of Çeltiksuyu with 100 and Bayramlı with 98, followed by the orchard in Ekinyolu (97 pieces) village, and the lowest number of nuts was determined as 91 in the orchard in the village of Gölgelikonak.
- The average number of nuts in the D-HN 100 g sample was 80, and 96.5 in the D-SN sample.
- The highest D-HN kernel ratio was obtained from the orchard in the Gölgelikonak village with 47.5%, followed by the gardens of Bayramlı village with 43.1%, Çeltiksuyu village with 41.8% and Ekinyolu village with 41.4%.
- The highest D-SN kernel ratio was obtained from the orchard in the Gölgelikonak village with 54.3%, followed by Çeltiksuyu village with 50.2%, Bayramlı village with 49.5% and Ekinyolu village orchard with 49.1%.
- Average D-HN kernel rate was 43.5% and D-SN kernel rate was 50.8%.
- The highest nut splitting rate was obtained from the orchard in the

Gölgelikonak village with 97.3%, followed by the Ekinyolu village with 81.3% and the Çeltiksuyu village with 75.3%, the lowest splitting rate was found in the orchard in the Bayramlı village with 70.7%.

- Total production cost of one decare of unirrigated pistachio orchard is calculated as 1.786 TL, yield per decare is 151.3 kg, sales price of pistachios is 71 TL and net income of one decare pistachio orchard is 8.957 TL (943 $).
- The total production cost of one decare of limited irrigated pistachio orchard is 2.369 TL, the yield per decare is 195.9 kg, the selling price of pistachios is 71 TL and the net income of one decare pistachio orchard is 11,540 TL (1.215 $).
- It has been determined that a pistachio producer in Eruh will need 21.4 decares of unirrigated or 16.6 decares of irrigated (restricted) pistachio orchards in order to support his family.
- The average number of family members of the farmers is 8, the average age of the farmers is 46, 56% of them are at primary school or below, 92% of them are operating on their own land, they do not employ workers, they would irrigate if possible, they regularly pruned, 19% of them used farm manure 81%.
- It has been determined that the average agricultural income of the family is 32,820 TL, 26% of the pistachio orchards are 5-10 decares, 46% are 11-50 decares, and the annual average cost of the gardens is 11,465 TL.

3.2. Recommendations

- Average yield per tree (2020 -2021) was 5.4 kg in unirrigated orchards, and 7.0 kg in irrigated (restricted) orchards. It has been determined that the average yield in Eruh will increase by 57% with limited irrigation.
- *P. khinjuk* (Buttum) rootstock should be used in new orchards, Siirt variety should be grafted, irrigation should be done. State support should be increased, technical staff should lead.
- In Eruh, a pistachio producer must have a pistachio orchard of 21.4 decares of unirrigated or 16.6 decares of irrigated (restricted) in order to support his family.
- In order for the producer family to make a living, they must plant 1.178 decares of wheat in dry conditions (Anonymous, 2021e and Anonymous, 2021f). This shows how profitable the pistachio production is.

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CHAPTER 5

THE PERFORMANCE OF THE SOME STANDARD APPLE CULTIVARS GRAFTED ON MM106 ROOTSTOCK IN YUKSEKOVA (HAKKÂRI) ECOLOGICAL CONDITIONS

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INTRODUCTION

Apple (*Malus comminus L*), which is in the genus *Malus* and has a widespread area in the world with its tolerance to ecological conditions (Hyson, 2011), is one of the most produced and economically important fruit species (Hyson, 2011). Apple cultivated for approximately 4000 years can be grown economically in every region except for very high cold and low altitude areas in Anatolia (Ozcagiran et al., 2005). However, in recent years, the amount of the production has been increasing day by day with the adoption of the modern fruit growing, especially in apples in our country. For this reason, apple is one of the most produced fruit species in Turkey (Anonymous, 2019). But, the fact that the growing still carried out with traditional habits in many regions causes problems in terms of the fruit yield and quality. The principal aim in modern growing is to obtain more and higher quality products per unit area, the selection of the suitable rootstock and cultivar for the region and purpose is the most important factor and has a significant importance in terms of the growing's widespreading.

The combination of the rootstock and cultivar can affect the vegetative and generative growth of the tree, thus the yield and quality. The rootstock significantly affects the cultivar's performance at the same time its performance may also vary depending on the ecological characteristics of the region. Because, the potential of a fruit species or a cultivar to be grown in the region, the yield level and fruit quality are limited by the ecological characteristics of the region (Ercisli, 2008). The performances of the many apple cultivars have been determined by the studies in regions that differ in terms of the climatic characteristics in Turkey. However, Starking and Golden Delicious are still the most produced apple varieties in our country. This is an indication that there is a lack of the adaptation and performance determination studies in terms of the regions in the apple cultivars such as Granny Smith, Fuji, Gala group, Red Chief, Jersey Mac, Pink Lady and Breaburn. The successful fruit growing starts with the selection of the suitable cultivar for the ecology. The high quality apple cultivars have been obtained by the breeding studies (Balta ve Kaya, 2007). Ecological conditions can affect on the phenological and pomological characteristics of the fruit and their pollination biology. For this reason, it is not possible to obtain applicable results for all fruit growing regions by studies on the limited number cultivars in a region. The researches need to be carried out with certain methods in the different regions (Ozbek, 1977). In the some regions, the significant economic damages may occur due to the cultivar grown without the adaptation studies. The determination of the regional adaptations of the cultivars is very important for the development of the fruit growing in our country.

The aim of the study planned with this thought is to determine the performance of Golden Delicious, Granny Smith, Fuji, Mondial Gala and Red Chief apple cultivars grafted on semi-dwarf MM106 apple rootstock in Yuksekova (Hakkari) ecological conditions and is to contribute to the growing’s widespread of the cultivar or cultivars, which have the highest performance in the region.

1. MATERIAL and METHODS

1.1. Plant Material

This research was carried out in 2017 and 2018 years on the 5-year-old apple trees of Golden Delicious, Granny Smith, Fuji, Mondial Gala and Red Chief cultivars grafted on MM106 rootstock in Akçalı village of Yuksekova (Figure 1).

Figure 1: The study area and orchard

In order to determine the performance of the cultivars, 10 trees were evaluated for each cultivar for two years and their phenological, morphological and pomological characteristics were examined.

1.2. Phenological Characteristics

The bud swelling and bursting were determined by recording the dates when the buds began to swell and burst on the trees. The period when 10% of the flowers opened was accepted as the first blooming, the period when 80% of the flowers opened was considered as full blooming and the period when 80% of the petals of the flowers fell was accepted as the end of the flowering, and the dates were recorded. Harvest time was determined by considering the harvest criteria such as the fruit colour and fruit size. The number of the days from full blooming to harvest date (FBHDN) was determined by calculating the days in between the full blooming and harvest time on the trees (Figure 2).

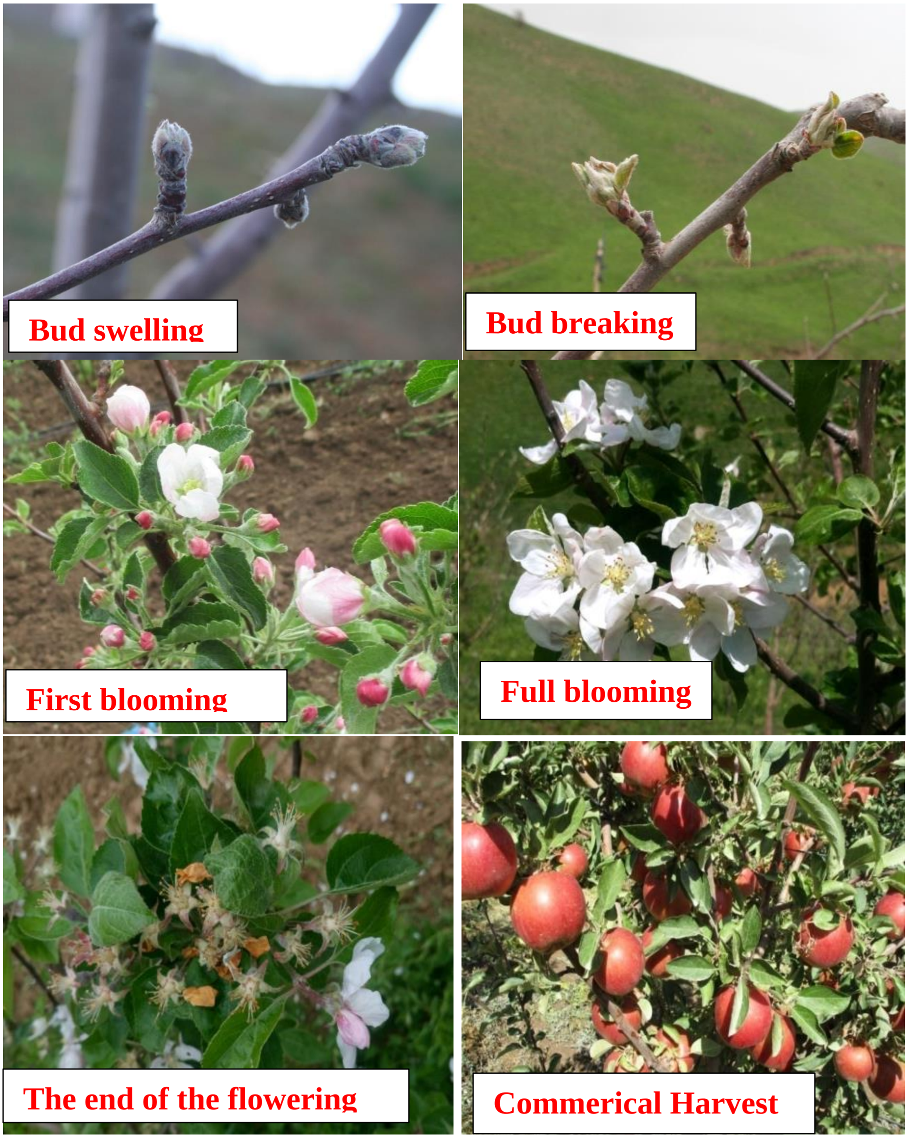

Figure 2: The phenological stages on the cultivar in the study.

1.3. Morphological Characteristics

Tree height, shoot length, and shoot diameter were measured with a digital caliper with a precision of 0.01 mm. Shoot growth was determined by measuring shoot diameter (mm) and shoot length (cm) at 14 days intervals from onset to the end of the vegetation period. Shoot growth curves were formed by measuring ten shoots from ten trees representing each cultivar. Canopy width and height were measured to determine tree canopy volume. For canopy width, two measurements were made in the north-south and east-west directions in the central part of the tree canopy, and the average of these was taken. The canopy height was determined by measuring the distance between the point where the first branches formed and the top of the canopy with meters. By using these measurements, the canopy volume values were calculated with the formula $V=\pi r^2.h/2$ (Yildirim and Celik, 2003). In the formula, V: volume, π: constant value, r: radius, h: height.

1.4. Pomological and Chemical Characteristics

For, yield per trunk cross-sectional area, firstly, the trunk diameter was measured 15 cm above the graft union with a digital caliper with a sensitivity of 0.01 mm. The trunk cross-sectional area (cm^2) was calculated by using the formula $TCSA= \pi.r^2$. Then, yield per tree (kg/tree) was determined by weighing the all fruit of the tree. The yield per trunk cross-sectional area was determined by dividing the yield per tree by the trunk cross-sectional area.

In 20 fruits randomly taken from trees representing each cultivar, the weight of each fruit was measured with a digital scale (Radwag, Poland) with a sensitivity of 0.01 g and the fruit weight was determined by taking the average and expressed as g. For the fruit firmness, the fruit peel was cut at three different locations on the equatorial region of the fruit and measured as kg with the 11.1 mm tip of the penetrometer (Effegi brand, model FT-327; MoCormick Fruit Tech, Yakima, WA). Fruit color values (L*, a*, b*) were determined with Konica Minolta CR-400 brand colorimeter. Chroma [C*= $(a^{*2}+b^{*2})^{1/2}$] and hue angle ($h^{\circ}= \tan^{-1} b^{*}/a^{*}$) values were calculated by using L*, a*, b* color values (McGuire, 1992; Hung et al., 1993).

The fruit was shredded with a blender and made homogeneous, and the obtained homogenate was passed through a cheesecloth and fruit juice was obtained. Sufficient amount of juice was dropped into a digital refractometer (PAL-1, McCormick Fruit Tech., Yakima, Wash.) for the measurement of SSC and the value on the screen was recorded as%. pH was measured with a pH meter (Hanna, model HI9321).

For titratable acidity (TA) measurements, 10 ml of the obtained juice was taken and 10 ml of distilled water was added on it. Then, samples were expressed in terms of malic acid (g malic acid 100 ml-1) based on the amount of NaOH spent in titration with 0.1 N sodium hydroxide until pH 8.1 was reached.

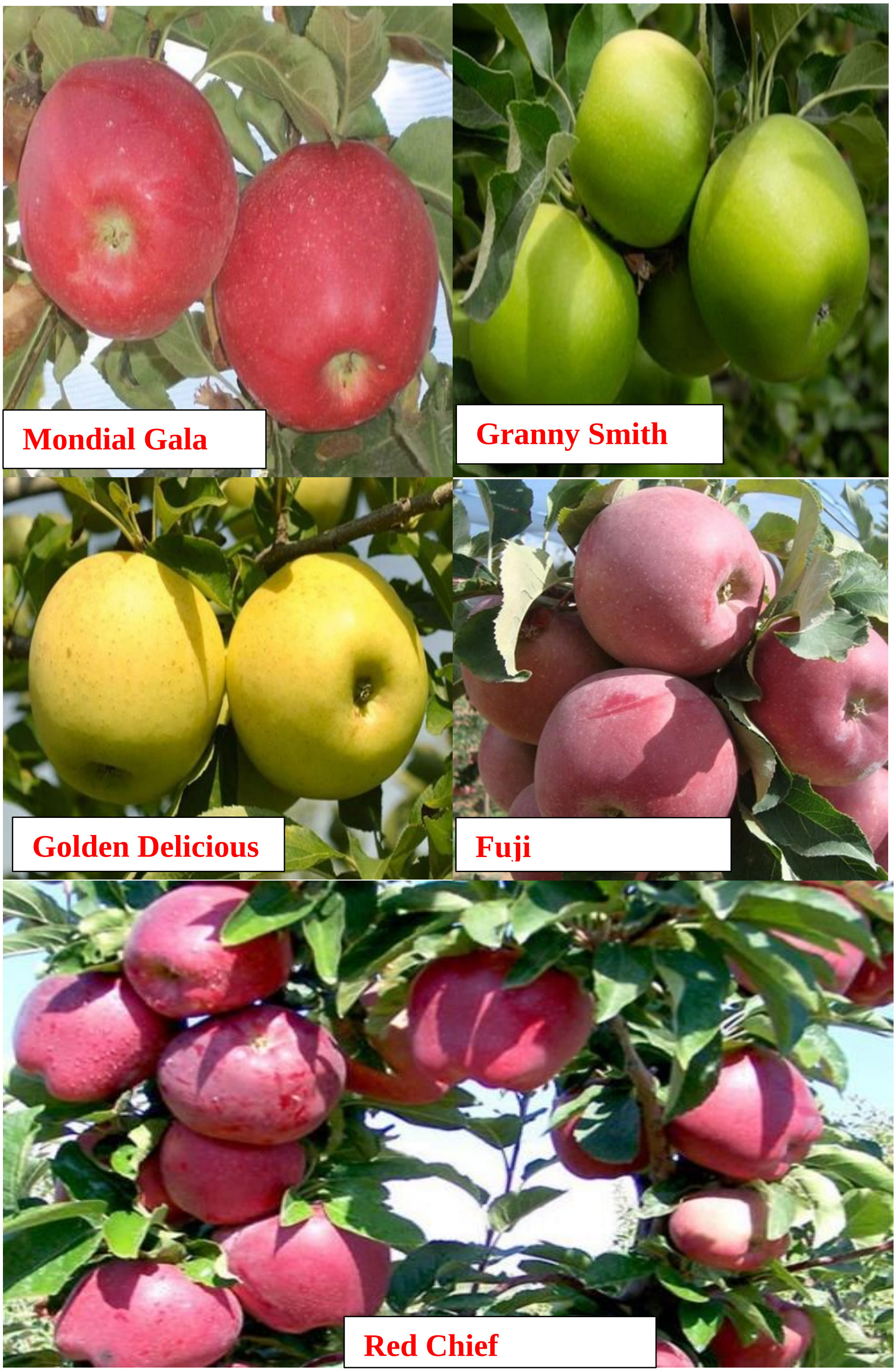

Figure 3: The apple cultivars in the study

1.5. Statistical analyzes

After the obtained data were analyzed by variance analysis, the significance level between values was determined by the Tukey multiple comparison test. Statistical analyzes were performed in the SAS package program (SAS 9.1 version, USA). The significance level was considered as $\alpha = 5\%$ in statistical analysis and interpretation of the results.

2. RESULTS and DISCUSSION

2.1. Phenological Characteristics

The economically growing potential in a region of the fruit species or cultivars shows parallelism with the ecological characteristics of the region. The phenological characteristics such as the sprouting, blooming and harvest in the fruit trees may vary depending on climatic factors, especially temperature. The blooming and harvest time in apples can affect fruit yield, quality and marketability. In order to avoid the damage from late spring and early autumn frosts, the blooming and harvest time are significant critically in the selection of the cultivars according to the region. In the study, there were significant differences between the cultivras in terms of the phenological observations depending on the climatic changes that occurred in the region in 2017 and 2018 years. The blooming took place between 14th -19th May in the first year, and between 29 April and 7 May in the second year. In both years of the study, the trees of Mondial Gala were bloomed earlier while Granny Smith was the latest blooming cultivar. The trees of Golden

Delicious and Red Chief cultivars bloomed at the same time, but the blooming in Fuji took place one day after these cultivars. The effect of the climate factor at the harvest time differed depending on the years. However, there were differences between the cultivars in terms of the harvest time. The difference between the cultivras in terms of the effective temperature total is effective in this result. The harvest date in cultivars showed parallelism with blooming and the number of days from full blooming to harvest. Monial Gala cultivar with the earliest blooming and the lowest number of days from the full blooming to the harvest was harvested earlier while Grany Smith was harvested at the latest (Table1). It can be said that the difference in the phenological characteristics over the years is particularly due to ecology. The most effective factor in this regard is temperature, and especially high temperatures during the flowering period cause a shortening of the flowering period (Shoemaker, 1952). The flowering time and period may vary depending on many factors such as the cultural practices, ecology, rootstock and cultivar (Facteau et al., 1986). In studies conducted in different regions, it has been reported that the flowering and harvest time in apples varies depending on the cultivar and region, the flowering time varies between 14th April and 4th May (Baytekin, 2006; Ceylan, 2008; Unuvar, 2014) and the harvest is between 5th August and 7th November (Erdogan and Bolat, 2002; Soylu et al., 2003; Ceylan, 2008; Unuvar, 2014). It has been reported to be that the period from the full blooming to the harvest varies depending on ecological conditions on regions, this period is between 102 -197 days in Karaman (Unuvar, 2014), 118 - 164 days in Niğde (Ceylan, 2008), 146 -166 days in Corum (Culha, 2010), 98 - 161 days in the Eastern Anatolia Region (Vurgun, 2012), 90 - 158 days in Van (Kaya and Balta, 2013), 89 - 162 days in Erzurum (Karsı, 2016), 89 - 187 days in Samsun (Ozturk and Ozturk, 2016). When the phenological results obtained in the different studies were compared each other, it was observed that there were differences depending on altitude, cultivar, cultural practices and ecology.

Table 1: The phenological characteristics of the apple cultivars

Phenological characteristics	**Mondial Gala**	**Granny Smith**	**Golden Delicious**	**Fuji**	**Red Chief**
	2017				
Bud swelling	23rd April	25th April	27th April	26th April	29th April
Bud brusting	30th April	2nd May	3rd May	3rd May	5th May
First blooming	14th May	19th May	18th May	17th May	18th May
Full blooming	18th May	25th Mayıs	24th May	22nd May	24th May
The end of the flowering	26th May	31st May	30th May	28th May	29th May
Harvest date	17th September	30th October	21st October	25th October	19th October
FBHDN	122	158	150	156	148
	2018				
Bud swelling	29th March	31st March	2nd April	1st April	3rd April
Bud bursting	3rd April	5th April	6th April	6th April	7th April
First blooming	29th April	5th May	7th May	6th May	7th May
Full blooming	5th May	16th May	17th May	18th May	15th May
The end of the flowering	19th May	23rd May	24th May	24th May	22nd May
Harvest date	12ndSeptember	29th October	17th October	27th October	13rd October
FBHDN	130	166	153	162	151

FBHDN: Number of days from full blooming to harvest date.

3.2. Morphological Characteristics

Tree size: Tree size is one of the most significant factors affecting fruit yield, quality and cultural processes such as pruning and harvesting. Tree size can be controlled with the use of the dwarf rootstock (Ozkan and Yildiz, 2009). However, there may be differences depending on the cultivar in tree size. The fact that Ozongun et al. (2016) reported that tree growth in apple differed between cultivars and Mondial Gala cultivar grafted on MM 106 rootstock produced more vigorous trees than Granny Smith cultivar. In the study, the effects of the cultivar on the vegetative growth of the tree were observed by considering the tree height, canopy volume and shoot development, and when the results obtained were evaluated, the tree vigor changes depending on the cultivar. Mondial Gala and Granny Smith cultivars showed greater tree growth, and the trees of Red Chief and Fuji cultivars had lower vegetative growth (Table 2). In previous studies have shown that there were significant differences in the tree growth vigor between cultivars. (Robinson et al., 1991; Sen et al., 2000; Yıldırım and Celik, 2003; Simsek, 2007; Tas, 2008; Sensoy, 2013). However, it was determined that there were differences between the studies in terms of the vegetative growth values. It is thought that these differences were due to the cultivars and rootstocks used in the studies, the age of the tree, the ecological characteristics of the region where the studies was carried out, the pruning and training method and the nutritional status of the trees.

Table 2: The morphological characteristics of the apple cultivars

Morphological characteristics	Mondial Gala	Granny Smith	Golden Delicious	Fuji	Red Chief
Tree height (cm)	299.45a	311.55a	299.15a	268.55b	279.95b
Canopy volume (m^3)	4.10 a	3.00b	3.22b	2.63bc	2.21c
Shoot length (cm)	59.49b	80.59a	46.57c	64.08b	67.15b
Shoot diameter (mm)	6.20b	8.09a	5.94b	6.63b	7.56ab
Per tree yield (kg)	12.30a	5.19b	11.88a	11.14a	4.38b
TCSA yield (kg/cm^2)	0.44a	0.18b	0.36a	0.43a	0.19b

TCSA: Trunk Cross Section Area. The differences among the means indicated with the same lowercase letter in the same line were not significant ($p < 0.05$)

3.3. Pomological and Chemical Characteristics

Yield: Considering the yield values per tree and trunk cross-sectional area in the study, it was found that there was no difference in fruit yield between Mondial Gala, Golden Delicious and Fuji cultivars and the highest yield was obtained from these cultivars' trees. Again, the lowest yield values were recorded in Red Chief and Granny Smith cultivars (Table 2). In studies conducted in different regions, it was determined that the yield in apple varied depending on the cultivar and region, and in the studies, the yield per tree was between 3.9-27.74 kg (Kuden and Kaska, 1995; Jonsson and Tahir, 2004; Baytekin, 2006; Culha, 2010) and the yield per trunk cross-sectional area varied between 0.21 and 2.19 kg/cm^2 (Soylu and Erturk, 1999; Dousti, 2010; Kucuker, 2010). In our study, the yield per tree varied between 4.38 and 12.30 kg, and the yield per trunk cross-sectional area ranged between 0.18 and 0.44 kg/cm^2 (Table 3). The yield of the apple tree can be vary depending on the ecology, nutritional conditions, cultural practices, training system, rootstock and cultvar. The amount of the crop obtained per unit area in apples is also significantly affected by cultural processes such as disease and pest control, soil cultivation, fertilization, irrigation and pruning, apart from rootstock and cultivar (Arikan et al., 2015).

Fruit size: Fruit size is one of the most important criteria affecting quality and marketability. The fruit size may vary depending on ecological conditions and cultural practices, but the cultivar is the main factor affecting to the fruit size (Zadrevec et al., 2013). In the study, the fruit size varied depending on the cultivar. There was no difference in the fruit size between Fuji and Red Chief cultivars and the biggest fruit were harvested from these cultivars'trees. There was no statistical difference between the other three cultivars, and it was observed that these cultivars'fruit were smaller (Table 3). However, Ozongun et al. (2016) reported that the bigger fruit were obtained in Granny Smith cultivar compared to Mondial Gala under Isparta conditions on the same rootstock (MM106). On the other hand, Altuntas et al. (2012) and Ozkan et al. (2012) reported that the cultivar was effective on fruit size, and Zadrevec et al. (2013) have suggested that the cultivar effect is significant, but in its effect, the differences may occur depending on the year.

Fruit flesh firmness: The fruit flesh firmness, which decrease as a result of the breakdown of cell wall components such as pectin substances, hemicellulose and cellulose (Wang et al., 2015) and the decrease in turgor pressure in the cell (Mannozzi et al., 2018), is a significant quality characteristics that determines the post-harvest life of the fruit (Ozturk et al., 2012; Cheng et al., 2020). Kucuker and Aglar (2021), who reported that the softening of the fruit occurs with the increase in ripening in apples, suggested that the cultvar does not affect on fruit flesh firmness. In the study, it was determined that the fruit flesh firmness values were higher in the fruit of the Granny Smith cultivar, and there was no difference between the values of the other four cultivars (Table 3). The fact that Ozongun et al. (2016) reported that the fruit flessh firmness varied depending on the cultivar and that the fruit flesh firmness values in Granny Smith were higher than Mondial Gala.

Fruit colour: When the fruit color values were examined, it was determined that the L* and b* values were higher in the cultivars with yellow fruit skin upper ground color, and the a value was higher in the red cultivars. In addition, it was determined that the hue angle values of the cultivars with red fruit skin color (Mondial Gala, Fuji and Red Chief) were lower than the cultivars with yellow fruit skin color (Granny Smith and Golden Delicious) (Table 3). As a matter of fact, Baytekin ve Akca (2011), stated that the fruit color may vary depending on the ecological conditions and cultural practices, but that the color is cultivar characteristic. They reported that and the L* and b* values are higher in cultivars with yellow and greenish-yellow, but a* value are higher in cultivars with red.

SSC, titratable acidity and pH: The SSC/acid ratio, which is used as a harvest criteria in fruit and affects the quality of the fruit, increases as the maturity progresses due to an increase in SSC and a decrease in acidity. However, this rate varies depending on the cultivar (Karakurt, 2006; Vurgun, 2012; Senyurt et al., 2015). Consistent with this explanation, there were significant differences between cultivars in terms of SSC, titratable acidity and pH values. The titratable acidity content of Red Chief fruit, which have the highest SSC and pH values, was lower than the fruit of the other cultivars. In terms of the titratable acidity, there was no statistical difference between Mondial Gala, Golden Delicious and Fuji cultivars, and the highest value was recorded in Granny Smith cultivar (Table 3). Kucuker and Aglar (2021), who reported that SSC increased and titratable acidity decreased with the progression of the maturity, suggested that SSC, titratable acidity and pH values varied depending on the cultivar and titratable acidity content was lower in Red Chief cultivar.

Table 3: The pomological and chemical characteristics of the apple cultivars

Pomological characteristics	Mondial Gala	Granny Smith	Golden Delicious	Fuji	Red Chief
Per tree yield (kg)	12.30a	5.19b	11.88a	11.14a	4.38b
TCSA yield (kg/cm^2)	0.44a	0.18b	0.36a	0.43a	0.19b
Fruit weight (g)	161.91b	158.19b	164.76b	174.85a	172.16a
Fruit firmness(kg)	7.50b	8.07a	7.50b	7.50b	7.20b
Fruit Colour L^*	45.54b	65.40a	76.58a	48.76b	36.20c
a^*	35.52a	-19.09d	-4.12c	22.94b	28.22a
b^*	17.61bc	41.30a	50.85a	22.79a	12.58c
Croma	40.56b	45.45a	51.32a	33.66b	30.78b
Hue angle	27.82c	115.04a	94.43a	46.50b	23.65c
Soluble solids content	16.53ab	13.08b	18.88a	13.58b	18.95a
Titratable acidity	0.65bc	1.00a	0.73b	0.81b	0.39c
pH	4.02b	3.81b	4.00b	3.81b	4.57a

The differences among the means indicated with the same lowercase letter in the same line were not significant ($p < 0.05$).

3.4. Shoot and Fruit Growth

In the shoot length and shoot diameter measurements made to determine the shoot development, it was observed that in all cultivars shoot development was fast the first stage while the shoot development slowed down in the last stage and there were differences in shoot growth ratio among the cultivars. When the shoot lengths were examined, the first stage (the rapid growth stage) was completed on 15th July in Mondial Gala and Red Chief, on 1st July in Golden Delicious and on 29th July in Granny Smith and Fuji cultivars and the shoot length rate gradually slowed down after this stage. (Figure 4). Atay (2007) stated that the fruit diameter values increase during the growth period and the growth is in the form of a single sigmoid curve. Sen (2008) reported that the rapid shoot growth was observed in the May-June period in all the cultivars, the growth was also observed in the May-July period, but the growth rate slowed down compared to the previous period, and the growth stopped in the period from July to the end of the vegetation period. Guleryuz et al. (2001) found that the fruit diameter increased faster than fruit height until harvest. In the measurements made at certain intervals in order to monitor the fruit development in the cultivars, the fruit width and fruit length were examined in three stages according to their daily growth ratio. The fruit development was slow in the first and last stages and fast in the middle stage. Although the fruit growth differed depending on cultivar, it was observed that the fruit length and fruit width increased continuously during the growing period in all cultivars, and the fruit width developed faster than the fruit length. When the fruit development stages were examined, it was determined that the fruit of all cultivars grew by forming a single (simple) sigmoid curve (Figure 4). When the the results of the study were compared with the literature above, they were similar in terms of both shoot and fruit development curves while the growth values determined during the development process were found to be different. It is predicted that this difference is due to the ecology, rootstock, cultivar and cultural processes.

CONCLUSION

As a result, Mondial Gala is superior in terms of the precocity, but as late cultivars are more advantageous in the region in terms of the storage and marketing, these cultivars, which will not be affected by early autumn frosts, can be recommend. It is possible to say that Mondial Gala, Golden Delicious and Fuji cultivars with high yield are better in terms of the precocity than the other cultivars. Fuji and Golden Delicious cultivars may be suggested for Yuksekova (Hakkari) ecological conditions due to their phenological, pomological and morphological characteristics.

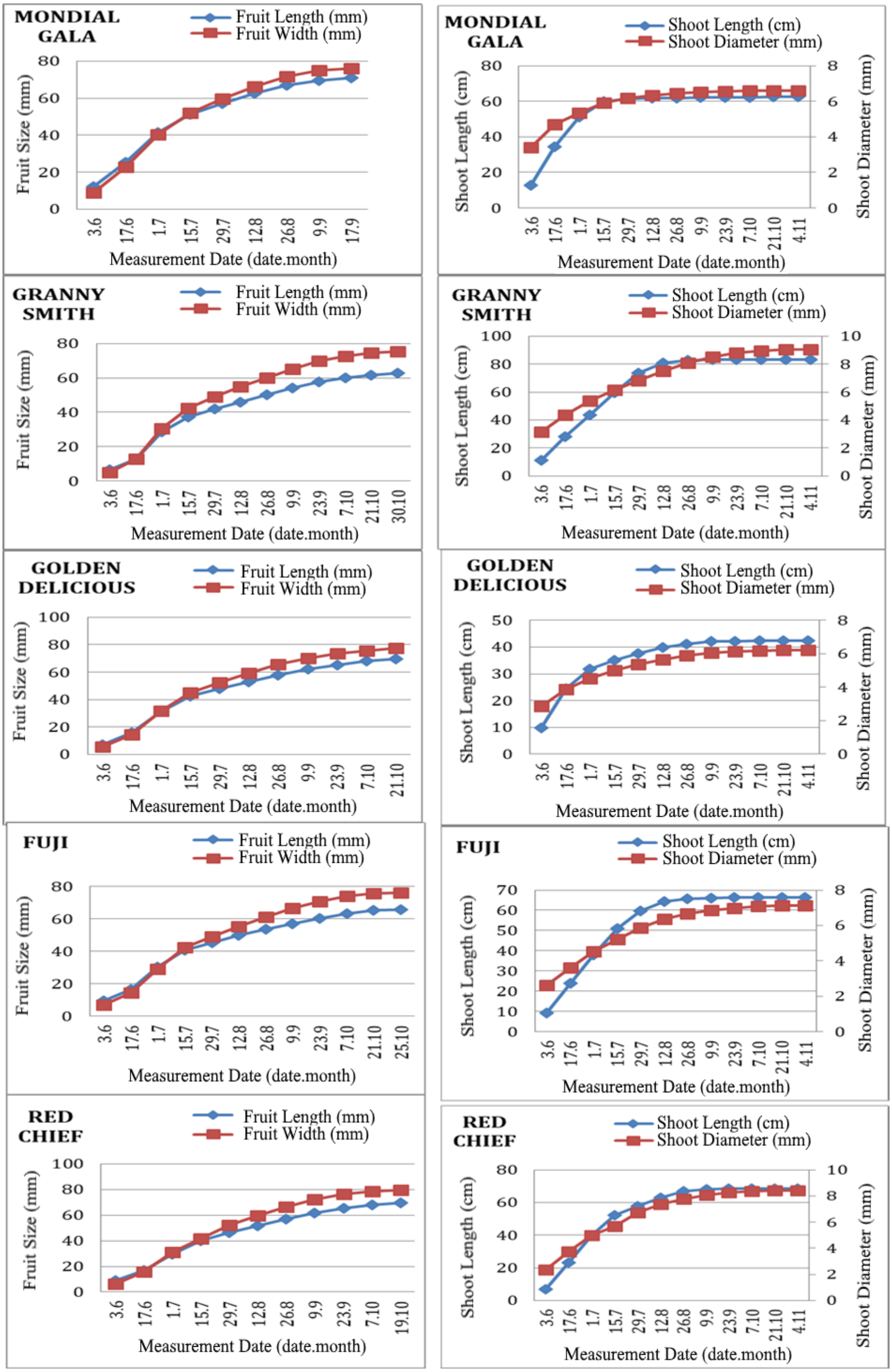

Figure 4: Shoot and fruit growth curves

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CHAPTER 6

THE HISTORICAL LOCAL PEAR AND APPLE CULTIVARS YÜKSEKOVA (HAKKÂRI) ECOLOGICAL CONDITIONS

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INTRODUCTION

Anatolia is an important region in terms of the genetic richness due to its ecological conditions suitable for horticultural growing, being on migration routes and being an area where many civilizations have lived. The genetic richness of a country is an important advantage in terms of the obtaining of the cultivar that is suitable consumer preferences and different climatic conditions and is resistant diseases and pests (Agaoglu et al., 1995). Although Turkey is one of the the most important countries in the world in terms of plant genetic resources, the plant genetic resources are in danger of the decreasing or even disappearing due to environmental and other pressures in the regions where they are located. Their protection is mandatory in terms of the securing of the plant production. Since the genetic resources have developed resistance to many pressure conditions during the growing process, they are in the insurance and key position in overcoming the problems we face today (Karagoz et al., 2010). Today, the breeders are constantly looking for new sources of the hereditary material, since the modern cultivars with high yields but narrow genetic bases lack genes for resistance to environmental stresses (diseases, pests, cold and drought, etc.). In this respect, the plant genetic resources are used directly or as intermediary species to transfer quantitative characters in long-term programs and qualitative characters in short or medium-term programs. However, the sustainable use depends on good evaluation of the plant genetic resources. Improving the use of the plant genetic resources for food and agriculture can be achieved by determining all properties of the material during its preservation (Sehirali and Ozgen, 1987). Turkey, which has very rich genetic resources and is among the homelands of apple and pear, has very suitable ecological conditions for apple and pear cultivation and the commercial cultivars adapted to ecological conditions are grown in almost all regions of the country. However, the local apple and pear cultivars that have survived until today are the important cultural and genetic riches of the country.

These local cultivars, which are especially appreciated for their taste and flavour, offer genetic richness with their morphological and pomological characteristics. So these local apple and pear cultivars should be accepted as a cultural inheritance and transferred to the future. In addition, this genetic richness creates important alternatives in terms of the cultivar breeding suitable for different soil and climatic conditions, and the cultivar developing suitable for different domestic and foreign market demands (Akcay et al., 2009; Bostan and Acar 2009). However, In recent years, the opinions that it would be more beneficial to preserve local apple and pear cultivars as breeding materials, rather than demanding them in the market and generating a lot of income, have been suggested (Senyurt et al., 2015). In Turkey, which has a very large fruit growing culture, the many studies have been carried out to reveal the quality characteristics and their importance by determining the phenological, pomological and technological characteristics of the local apple (Ozrenk et al., 2011; Kirkaya et al., 2014; Vurgun and Aslantas, 2015; Coskun and Askin; 2016) and pear (Yarilgac and Yildiz, 2001; Uzunismail, 2010; Karadeniz and Corumlu, 2012; Polat and Bagbozan, 2017; Oturmak et al., 2017) cultivars.

However, there are many regions in Turkey that are rich in apple and pear local cultivar potential and have not been explored yet. In the study, it was aimed to determine the phenological, pomological, morphological and chemical properties of local pear (Mellaki, Sirya, Kurisi, Hirmiyatirmehi, Hirmiyapayizi, Hirmizer) and apple (Talesevk, Sekersev, Sevasor, Sevazer) cultivars in Yuksekova (Hakkâri) region.

2. MATERIAL and METHODS

2.1. Material

The trees of the local pear (Mellaki, Sirya, Kurisi, Hirmiyatirmehi, Hirmiyapayizi, Hirmizer) and apple (Talesevk, Sekersev, Sevasor, Sevazer) cultivars, which have been growth in the form of scattered and orchards for a long time in Yesiltas (37° 27' 0.402" North, 44° 4' 41.672" East) and Daglica (37° 21' 53.35" North, 44° 3' 37.679" East) villages of Yuksekova district, constitute the material of the study. Yuksekova, where the continental climate is dominant, it is in the "hot humid continental (Dsa)" climate class in summers according to Köppen-Geiger' climate classification (Peel et al., 2007). Yesiltas and Daglica villages, where is altitude of 1340-1565 meters, have microclimate climate characteristics with the effect of the mountains and the Avasin river, and therefore the subtropical climate fruit species such as pomegranate, fig, olive and persimmon can be grown in the region. The soil of the region consists of the fertile soils in colluvial structure consisting of the sediments carried by the surface waters, rivers and streams.

Figure 1: The study area and orchard

2.2. Methods

In the study carried out in 2018 and 2019 in order to determine the characteristics of the historical local apple and pear cultivars in Daglica and Yesiltas (Yuksekova) villages, 10 trees were determined for each cultivar, and the morphological, phenological, pomological and chemical characteristics of these trees and their fruit were determined by analysis and measurements as indicated following.

Morphological characteristics: The tree's age (years) was determined by counting the branches back in the trees or according to the statement of the orchard owner. Tree height (cm) was measured at the end of the growing season with a tape measure and the soil surface was considered as 0 (zero). Canopy width (cm) and height (cm) were measured to determine tree canopy volume. For canopy width, two measurements were made in the north-south and east-west directions in the central part of the tree canopy, and the average of these was taken. The canopy height was determined by measuring the distance between the point where the first branches formed and the top of the canopy with meters. By using these measurements, the canopy volume values were calculated with the formula $V=\pi r^2.h/2$ (Yildirim and Celik, 2003). In the formula, V: volume, π: constant value, r: radius, h: height. The periodicity tendency was evaluated by considering the research results and the opinion of the breeder together. The tree habitus is grouped as upright, semi-upright and splay while the growth vigor of the trees grouped as weak, semi-vigorous and vigorous. The tree trunk circumference (cm) was measured by meters at the beginning and end of the vegetation, 5 cm above the grafting area**.** Shoot length (cm) was measured with meter on ten shoots from ten trees representing each cultivar in the dormant period. The shoot diameter (mm) was measured with a digital caliper (0.01 mm sensitive) on ten shoots from ten trees representing each cultivar in the dormant period. Leaf characteristics (leaf length and leaf width) were measured by digital caliper (sensitive to 0.01 mm) by randomly taking 10 mature leaves from each cultivar.

Phenological characteristics: The bud swelling and breaking were determined by recording the dates when the buds began to swell and burst on the trees. The period when 10% of the flowers opened was accepted as the first blooming, the period when 80% of the flowers opened was considered as full blooming and the period when 80% of the petals of the flowers fell was accepted as the end of the flowering, and the dates were recorded (Orman, 2005). Harvest time was determined by considering the harvest criteria such as fruit colour and fruit size. The number of the days from full blooming to harvest date

(FBHDN) was determined by calculating the days in between the full blooming and harvest time on the trees. Leaf yellowing is when 70% of the leaves begin to turn yellow (Tekintas et al., 2006); the leaf drop is taken as the period in which the leaves turn yellow and fall 90%.

Yield: For, yield per trunk cross-sectional area, firstly, the trunk diameter was measured 15 cm above the graft union with a digital caliper with a sensitivity of 0.01 mm. The trunk cross-sectional area (cm^2) was calculated by using the formula TCSA= $\pi . r^2$. Then, yield per tree (kg/tree) was determined by weighing the all fruit of the tree. The yield per trunk cross-sectional area was determined by dividing the yield per tree by the trunk cross-sectional area.

Pomological characteristics: The following measurements and analyzes were made by taking 20 fruit from the trees representing each cultivar. The fruit weight was measured with a digital scale (Radwag, Poland) with a sensitivity of 0.01 g and the fruit weight was determined by taking the average and expressed as g. For the fruit firmness, the fruit peel was cut at three different locations on the equatorial region of the fruit and measured as kg with the 11.1 mm tip of the penetrometer (Effegi brand, model FT-327; MoCormick Fruit Tech, Yakima, WA). Fruit color values (L*, a*, b*) were determined with Konica Minolta CR-400 brand colorimeter. Chroma [$C^* = (a^{*2}+b^{*2})^{1/2}$] and hue angle ($h^\circ = \tan^{-1} b^*/a^*$) values were calculated by using L*, a*, b* color values (McGuire, 1992; Hung et al., 1993). Fruit volume (ml) was measured by using a measuring cylinder. The measuring cylinder was filled halfway with distilled water and the fruit were left in it without splashing water. The amount of the water rise was recorded as volume. This process was repeated one or more times, and the water lost in the cylinder was completed each time (Kaya, 2008). The thickness of the fruit skin (mm) and flower pit width and depth were measured by the digital caliper (sensitive to 0.01 mm). Fruit length (mm) was found by measuring the longest distance between the fruit's stem pit and flower pit, and the fruit width (mm) was found by measuring the widest part of the fruit in the equatorial region with a digital caliper sensitive to 0.01 mm (Kaya, 2008). The fruit shape index, which is obtained by dividing the fruit length (mm) by the fruit diameter (mm), is accepted as flat if it is between 0.81-0.92, round if it is between 0.93-1.04, and as long as 1.05 and above (Guleryuz and Ulkumen, 1972). The kernel's number (piecs/fruit) was determined by counting the fruit's kernel. The sensory observations, taste, aroma and juiciness of fruits were determined by sensory observations; classified as moderate, good, very good.

Chemical characteristics*:* The fruit was shredded with a blender and made homogeneous, and the obtained homogenate was passed through a cheesecloth and fruit juice was obtained. Sufficient amount of juice was dropped into a digital refractometer (PAL-1, McCormick Fruit Tech., Yakima, Wash.) for the measurement of soluble solids content (SSC) and the value on the screen was recorded as%. pH was measured with a pH meter (Hanna, model HI9321). For titratable acidity (TA) measurements, 10 ml of the obtained juice was taken and 10 ml of distilled water was added on it. Then, samples were expressed in terms of malic acid (g malic acid 100 ml-1) based on the amount of NaOH spent in titration with 0.1 N sodium hydroxide until pH 8.1 was reached.

3. RESULTS and DISCUSSION

In the study that was carried out to determine the characteristics of the historical local pear and apple cultivars in Yüksekova region, six local pear cultivars and four apple cultivars were determined among the promising cultivars grown in the region. The results for Mellaki (Table 1), Sirya (Table 2), Kurisi (Table 3), Hirmiyatirmehi (Table 4), Hirmiyapayizi (Table 5) and Hirmizer (Table 6) pear and apple Talesevk (Table 7), Sekersev (Table 8), Sevasor (Table 9) and Sevazer (Table 10) cultivars were presented in following tables.

3.1. The Characteristics of the Local Pear (*Pyrus comminus* L.) Cultivars

Tree growth: The tree sizes of the local cultivars, which are important genetic resources, is a significant characteristics in breeding studies to control vegetative development. In the study, it was determined that the tree height was larger in the Kurisi local pear cultivar in both years, and the smallest trees belonged to the Hirmiyatmehi cultivar. The smallest values in terms of the canopy volume were recorded in Hirmiyatmehi and the highest values were recorded in Hirmizer cultivars. It was observed that the trees occurred longer shoots in the Hirmizer cultivar while the shoots were shorter in the Kurisi cultivar. In both years of the study, it was determined that the cultivar with the more vigorous shoots in terms of shoot length and shoot diameter was Hirmizer, and the shoot growth was weaker in Kurisi cultivar. The factors such as rootstock, cultivar, pruning, plant density and nutritional status have important effects on the control of the tree size (Mitchem and Actives, 2007). As a result of the fact that the trees, which are the material in the study, were local cultivars and especially the pruning was not applied properly, the vegetative development of the trees was upright and vigorous. Indeed, in the studies conducted in Van (Bostan and Sen, 1991) and Marmara region (Buyukyilmaz and Bulagay, 1983) where a more conscious cultivation is carried out, it has been reported that the vegetative development of the local pear cultivars was relatively low.

Bud breaking and blooming: The bud swelling in the local pear occurred earliest in Hirmiyatirmahi and Hirmizer, and latest in Hirmiyapayizi cultivars. The bud breaking was the earliest in the Hirmizer, and the latest in Kurisi and Hirmiyapayizi cultivars. Hirmizer was the earliest blooming cultivar in both years, and the blooming started later in Kurisi, Sirya and Hirmiyapayizi cultivars. Although the blooming period varied depending on the cultivar, it lasted 9-15 days in 2018 and 7-10 days in 2019 with the effect of the ecological factors. The blooming period in cultivars was 2–5 days shorter in 2018. In similar studies conducted in the different ecologies, it was found that the blooming period of the local pear cultivars (Mehrani, Istanbul, Queen, Kabak, Hacihamza, Cermayil, Ankara and Honey) was 7-12 days (Guleryuz, et al., 2001); It was determined that the bud breaking was between 15th March -1st April (Uzunismail; 2010), the first blooming was between 20th March - 10th April, and the full blooming was between 28th March – 18th April. Again Karadeniz and Corumlu (2012), in Corum province İskilip district, 10 local pear cultivars bloomed between April 15th-21st, on the other hand, Osmanoglu et al. (2013) determined that the bud breaking in some standard pear cultivars in Bingöl ecology was between 14th March-23rd April, the first blooming was between 17 March-26 April, the full blooming was between 24th March-1st May, and the end of flowering was between 28th March-4th May. The blooming time and period may vary depending on the cultivar, rootstock, ecology and cultural practices. As a matter of fact, it can be said that the difference between the phenological characteristics over the years is entirely due to the ecology. Especially the temperature is the most effective factor in this direction, and the high temperatures during the blooming period shorten the blooming period (Shoemaker, 1952). The earliest harvested cultivar in the first year of the study was Hirmiyatmehi (15th -30th August), this cultivar was followed by Hirmizer (22nd-30th August), Mellaki (10th-28th September), Hirmiyapayizi (11st-25th October), Sirya (13rd-27th October) and Kurisi (17th-27th October) cultivars respectively.

Harvest time: In both years of the study, Hirmizer, Hirmiyatmehi at the earliest and Kurisi at the latest reached harvest maturity. In both years of the study, Hirmizer, Hirmiyatmehi at the earliest and Kurisi at the latest reached harvest maturity. Mellaki pears were harvested between 15th-30th November in Ercis (Van) conditions (Askin and Oguz, 1992), at the same time the in similar studies were reported that local pears were harvested between 31st July – 15th September in

Trabzon (Uzunismail, 2010) , 1st August – 30th October in Erzincan (Guleryuz et al., 2001), 15th July – 24th October in Artvin (Serdar et al., 2007). The number of the days from full blooming to harvest date (FBHDN) that varied depending on the cultivar and year was found to be between 103 (Hirmiyatirmahi) - 158 days (Kurisi) in 2018, and between 105 (Hirmizer) -162 days (Sirya) in 2019. FBHDN in local pear cultivars varied between 121-147 days in Van ecological conditions (Bostan and Sen, 1991), and between 122 and 167 days in Trabzon (Uzunismail, 2010). The differences between the results obtained in the similar studies may be caused by altitude, cultivar, cultural practices and ecological properties.

Yield: Yield, which is an important criterion in growing, can vary depending on the ecological factors, cultivar, rootstock and cultural practices such as pruning and training (Musacchi et al., 2011). In the local cultivars, the yield per unit area is low due to unsuitable growing conditions and the lack of the attention to cultural practices, but the yield per tree is high in these cultivars due to the bigger tree structure. The yield per tree in the standard cultivars is 45 kg on semi-dwarf rootstocks and 90 kg on the classical vigorous pear rootstocks (Anonymous, 2021). In the study, as the local pear trees were generally one by one, the yield value could not be obtained per unit area and the yield was determined as yield per tree and per trunk cross-sectional area. The significant differences occurred between cultivars in terms of yield, which varied depending on the year. The highest yield was obtained with Hirmizer, Hirmiyapayizi and Mellaki cultivars in both years, the lowest yield value was recorded in Sirya cultivar. In the study, it was determined that the yield per tree in the local pears varied between 50-85 kg, but in the study conducted in Bahcesaray (Van), it was reported that the yield varied depending on the cultivar and growing conditions, and the yield per tree was between 60-120 kg (Orman and Yarilgaç, 2016). It is thought that the difference in the yield of the local pears is due to cultivar, rootstock, the tree's age, location, pruning, training, nutritional status and ecological factors.

Fruit size: Fruit size, which is one of the most important factors affecting consumer preferences in terms of the marketing, is the property of the cultivar, and also affected by factors such as ecology, location, nutritional status and rootstock. The fruit size of the local cultivars is smaller as a cultivar characteristic. However, the ecological conditions of the region where it grows, the failure of the cultural practices to be fulfilled and the nutritional deficiencies in the tree are effective in the small fruits. In the study, it was observed that there was no effect of the year on fruit weight, but there were differences between cultivars. Fruit weight ranged from 44.4 g (Sirya) to 230.3 g (Mellaki). In previous studies, the effect of the cultivar on fruit weight was significant, It has been reported that, in the local pear cultivars, the fruit weight was between 89 and 368 g in Bitlis region (Yarilgac and Yildiz, 2001), 46 and 98 g in Van (Orman et al., 2005) and 58 and 209 g in Malatya (Bayindir et al., 2019). However, the fruit weight was 420 g in Kieffer, 400 g in Passe Crassane, and 382 g in Deveci in standard cultivars (Akcay et al., 2009). The significant differences between the local and standard cultivars in terms of the fruit weight can be explained by the effect of cultivar and growing conditions.

Fruit flesh firmness: Fruit flesh firmness is an important quality characteristic that affects the post-harvest life of the species or cultivar, and thus the marketing period. Pears and apples are superior to many other fruit types in terms of Fruit flesh firmness, and therefore their post-harvest life and marketing periods are longer. Although fruit flesh firmness is the characteristic of the cultivar, and it can vary depending on the ecology and cultural practices. In the study, fruit flesh firmness changed depending on the cultivar. The fruit flesh of Mellaki cultivar was softer (2.1 kg) and the eating maturity was earlier, at the same time Sirya was the cultivar with the hardest (5.23 kg) fruit. When the fruit flesh fimness values were evaluated according to the UPOV descriptor, it was seen that the fruits had a very soft (between 3.70-5.76 kg) structure. This situation can be explained by the fact that the fruit was harvested in the period of the eating maturity in the study. Bayindir et al., 2019 reported that the fruit flesh firmnes of the local pears in Malatya was 4.90 - 9.92 kg/cm2, that is, they were in the medium and hard category. However, Ozrenk et al. (2010) reported that the fruit flesh firmness of the local pears was between 3.07 and 13 lb, at the same time Yarilgac and Yildiz (2001) reported that they were between 4.70 and 10.24 lb, that is, they were in the soft category.

SSC and titratable acidity: SSC and titratable acidity, which are used as harvest criteria in fruit, are important properties in terms of the eating quality in fruit. In parallel with maturity, the amount of SSC in the fruit increases, but the acidity decreases. SSC ratio was between 12.8 and 15.7, and titratable acidity ratio was between 0.04% (Mellaki) and 0.58% (Şirya) in Yuksekova local pear cultivars. Compared to previous studies, it was observed that the SSC ratio of Yuksekova local pear cultivars was within reasonable limits, but the acidity ratio was relatively lower. Ozrenk et al., (2010) reported that in the local pear cultivars grown in Van region, the fruit's SSC ratio was between 8.7% and 15.7%, and the acidity was between 1.8% and 20.4%, at the same time Bayindir et al., (2019) reported that the SSC ratio was between 11.3% - 19.3% in Malatya. It is thought that the factors such as tyhe cultivar difference, fruit maturity degree and ecological differences may be effective in obtaining different results in studies.

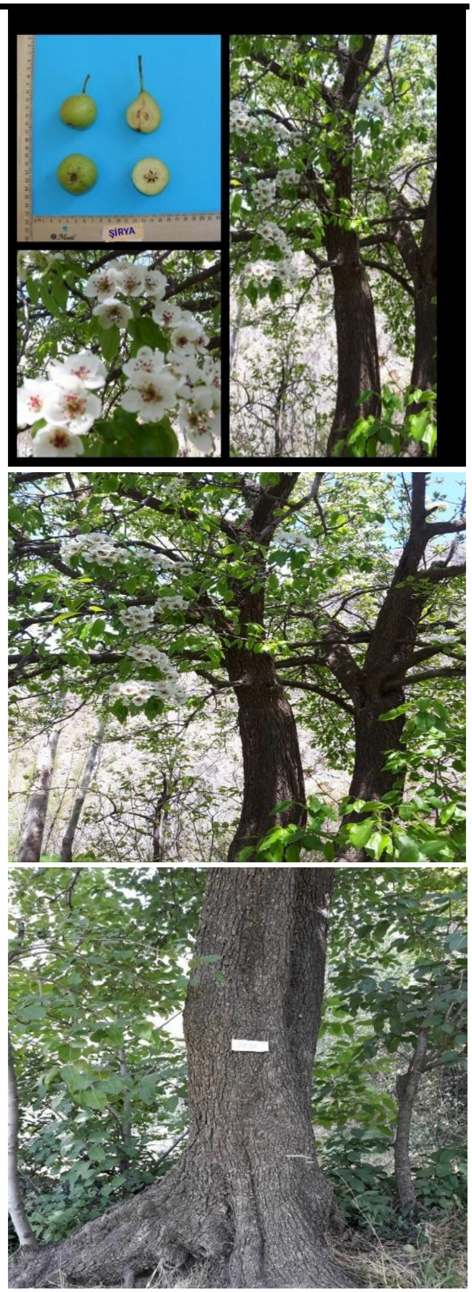
Table 1: The characteristics of "Mellaki" local pear cultivar.

Morphological characteristics	
Tree age (year)	90-100
Tree height (cm)	772
Canopy volume (m^3)	47.22
Canopy shape	Splay
Trunk circle (cm)	78.50
Tree growth vigor	Vigorous
Shoot length (cm)	36.16
Shoot diameter (mm)	6.19
Leaf length (mm)	84.05
Leaf width (mm)	46.02
Periodicity tedency	Partial
Phenological characteristics	
Bud swelling	10-20 April
Bud breaking	17-27 April
First blooming	2-11 May
Full blooming	8-17 May
The end of the flowering	20-27 May
Harvest date	10-28 September
FBHDN* (day)	125-134
Leaf drop	5-17 November
Yield	
YPTCSA** (kg/cm^2)	0.14
Yield per tree (kg/tree)	80.78
Pomological characteristics	
Fruit weight (g)	232.84
Fruit length (mm)	83.33
Fruit width (mm)	73.87
Fruit volume (ml)	1.09
Fruit shape index	Long
Flower pit width (mm)	20.26
Flower pit depth (mm)	8.84
Kernel number	9
Fruit stalk length (mm)	43.89
Fruit skin thickness (mm)	0.54
Fruit flesh firmness (kg)	2.10
Fruit colour a*	-10.11
b*	40.21
L*	78.25
Chroma	45.52
Hue angle	104.60
Chemical and sensory characteristics	
Soluble solids content (%)	12.71
Titratable acidity (%)	0.03
pH	5.51
Juiciness	Good
Taste	Sweet
Aroma	Very good

*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

Table 2: The characteristics of "Sirya" local pear cultivar.

Morphological characteristics	
Tree age (year)	90-100
Tree height (cm)	846
Canopy volume (m^3)	92.50
Canopy shape	Splay
Trunk circle (cm)	95.00
Tree growth vigor	Vigorous
Shoot length (cm)	51.88
Shoot diameter (mm)	5.90
Leaf length (mm)	61.52
Leaf width (mm)	34.81
Periodicity tedency	No
Phenological characteristics	
Bud swelling	14-22 April
Bud breaking	22-24 April
First blooming	4-15 May
Full blooming	13-20 May
The end of the flowering	23-30 May
Harvest date	13-27 October
FBHDN*(day)	148-162
Leaf drop	5-15 December
Yield	
YPTCSA** (kg/cm^2)	0.09
Yield per tree (kg/tree)	52.14
Pomological characteristics	
Fruit weight (g)	50.10
Fruit length (mm)	40.24
Fruit width (mm)	41.82
Fruit volume (ml)	37.10
Fruit shape index	Basipetal
Flower pit width (mm)	11.68
Flower pit depth (mm)	6.82
Kernel number	7
Fruit stalk length (mm)	27.78
Fruit skin thickness (mm)	0.74
Fruit flesh firmness (kg)	5.07
Fruit colour a*	15.09
b*	40.41
L*	67.87
Chroma	43.19
Hue angle	110.60
Chemical and sensory characteristics	
Soluble solids content (%)	13.64
Titratable acidity (%)	0.56
pH	3.39
Aroma	Good
Juiciness	Very good
Taste	Sweet



*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

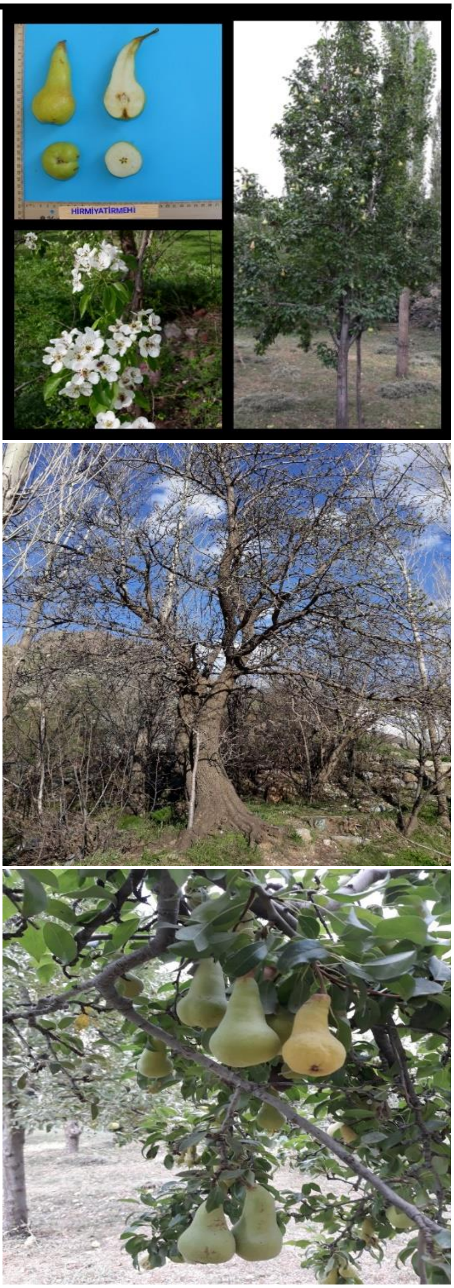
Table 3: The characteristics of "Kurisi" local pear cultivar.

Morphological characteristics		
Tree age (year)		90-100
Tree height (cm)		893
Canopy volume (m^3)		68.02
Canopy shape		Semi-upright
Trunk circle (cm)		55.82
Tree growth vigor		Vigorous
Shoot length (cm)		33.21
Shoot diameter (mm)		5.50
Leaf length (mm)		72.66
Leaf width (mm)		47.06
Periodicity tedency		No
Phenological characteristics		
Bud swelling		15-25 April
Bud breaking		25-30 April
First blooming		7-14 May
Full blooming		16-22 May
The end of the flowering		25-30 May
Harvest date		17-27 October
FBHDN*(day)		154-158
Leaf drop		11-20 December
Yield		
YPTCSA** (kg/cm^2)		0.14
Yield per tree (kg/tree)		80.78
Pomological characteristics		
Fruit weight (g)		232.84
Fruit length (mm)		83.33
Fruit width (mm)		73.87
Fruit volume (ml)		208.17
Fruit shape index		Long
Flower pit width (mm)		20.26
Flower pit depth (mm)		6.42
Kernel number		9
Fruit stalk length (mm)		43.89
Fruit skin thickness (mm)		0.54
Fruit flesh firmness (kg)		2.30
Fruit colour	a*	-10.11
	b*	40.21
	L*	78.25
	Chroma	45.52
	Hue angle	104.60
Chemical and sensory characteristics		
Soluble solids content(%)		12.71
Titratable acidity (%)		0.03
pH		5.51
Juiciness		Good
Taste		Sweet
Aroma		Very good

*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

Table 4: The characteristics of "Hirmiyatirmehi" local pear cultivar.

Morphological characteristics	
Tree age (year)	85-95
Tree height (cm)	714
Canopy volume (m^3)	42.01
Canopy shape	Splay
Trunk circle (cm)	69.79
Tree growth vigor	Vigorous
Shoot length (cm)	35.02
Shoot diameter (mm)	6.02
Leaf length (mm)	56.42
Leaf width (mm)	23.80
Periodicity tedency	No
Phenological characteristics	
Bud swelling	8-16 April
Bud breaking	16-22 April
First blooming	1-10 May
Full blooming	7-19 May
The end of the flowering	19-26 May
Harvest date	15-30 Agust
FBHDN*(day)	103-108
Leaf drop	5-16 November
Yield	
YPTCSA** (kg/cm^2)	0.11
Yield per tree (kg/tree)	58.36
Pomological characteristics	
Fruit weight (g)	123.03
Fruit length (mm)	108.79
Fruit width (mm)	54.22
Fruit volume (ml)	107.01
Fruit shape index	Long
Flower pit width (mm)	13.50
Flower pit depth (mm)	8.12
Kernel number	6
Fruit stalk length (mm)	29.00
Fruit skin thickness (mm)	0.57
Fruit flesh firmness (kg)	3.80
Fruit colour a*	-13.20
b*	41.33
L*	69.36
Chroma	44.38
Hue angle	106.91
Chemical and sensory characteristics	
Soluble solids content (%)	13.12
Titratable acidity (%)	0.15
pH	4.24
Juiciness	Very good
Taste	Sweet
Aroma	Very good



*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

Table 5: The characteristics of "Hirmiyapayizi" local pear cultivar.

Morphological characteristics	
Tree age (year)	90-100
Tree height (cm)	759
Canopy volume (m^3)	66.87
Canopy shape	Splay
Trunk circle (cm)	73.35
Tree growth vigor	Semi-vigorous
Shoot length (cm)	36.01
Shoot diameter (mm)	5.42
Leaf length (mm)	58.17
Leaf width (mm)	29.93
Periodicity tedency	No
Phenological characteristics	
Bud swelling	18-26 April
Bud breaking	16 April-6 May
First blooming	8-15 May
Full blooming	16-22 May
The end of the flowering	26-30 May
Harvest date	11-25 October
FBHDN*(day)	146-152
Leaf drop	1-8 October
Yield	
YPTCSA** (kg/cm^2)	0.14
Yield per tree (kg/tree)	81.6
Pomological characteristics	
Fruit weight (g)	117.75
Fruit length (mm)	63.05
Fruit width (mm)	51.03
Fruit volume (ml)	103.91
Fruit shape index	Long
Flower pit width (mm)	13.8
Flower pit depth (mm)	7.03
Kernel number	4
Fruit stalk length (mm)	33.28
Fruit skin thickness (mm)	0.78
Fruit flesh firmness (kg)	2.48
Fruit colour a*	-17.21
b*	43.82
L*	64.75
Chroma	47.12
Hue angle	111.56
Chemical and sensory characteristics	
Soluble solids content (%)	13.86
Titratable acidity (%)	0.17
pH	4.24
Juiciness	Very good
Taste	Sourish
Aroma	Moderate

*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

Table 6: The characteristics of "Hirmizer" local pear cultivar.

Morphological characteristics	
Tree age (year)	85-95
Tree height (cm)	743
Canopy volume (m^3)	96.85
Canopy shape	Splay
Trunk circle (cm)	97.50
Tree growth vigor	Vigorous
Shoot length (cm)	66.85
Shoot diameter (mm)	6.27
Leaf length (mm)	55.02
Leaf width (mm)	29.42
Periodicity tedency	No
Phenological characteristics	
Bud swelling	7-15 April
Bud breaking	16-25 April
First blooming	28 April-7 May
Full blooming	9-19 May
The end of the flowering	21-30 May
Harvest date	22-31 Agust
FBHDN*(day	105-110 gün
Leaf drop	1-20 November
Yield	
YPTCSA** (Kg/cm^2)	0.16
Yield per tree (kg/tree)	83.35
Pomological characteristics	
Fruit weight (g)	72.19
Fruit length (mm)	64.00
Fruit width (mm)	51.16
Fruit volume (ml)	66.67
Fruit shape index	Long
Flower pit width (mm)	12.32
Flower pit depth (mm)	5.56
Kernel number	8
Fruit stalk length (mm)	29.85
Fruit skin thickness (mm)	0.52
Fruit flesh firmness (kg)	2.40
Fruit colour a*	-11.24
b*	50.63
L*	71.46
Chroma	51.99
Hue angle	102.64
Chemical and sensory characteristics	
Soluble solids content (%)	14.92
Titratable acidity (%)	0.79
pH	4.55
Juiciness	Vey good
Taste	Sweet
Aroma	Vey good

*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

3.2. The Characteristics of the Local Apple (*Malus comminus* L.) Cultivars

Tree growth: Considering the data of the tree height and canopy volume made to determine tree vigorous in the study, it was determined that the tree vigorous was lower in Sevasor local apple cultivar, and the most vigorous growth was observed in Sekersev cultivar. However, Sevasor had the most vigorous shoots in terms of the shoot length and shoot thickness, the shoot growth was relatively weak in Talesevk and Sekersev cultivars. Tree vigor in apples may vary depending on the cultivar (Yildıirim and Celik, 2003), rootstock and cultural practices such as pruning, fertilazation and irrigation (Robinson et al., 1991). In the study conducted in Van ecological conditions (Kaya, 2008), it was determined that the tree height was between 2 and 10 m in local apple cultivars, and the cultivar, cultural practices and growing conditions had an effect on tree growth.

Bud breaking and blooming: The phenological characteristics of the local apple cultivars, as in pear, varied depending on the year and cultivar. Blooming in the trees occurred later in 2019 compared to 2018. In the study, the earliest bud swelling and breaking, thus the blooming occurred in Talesevk and Sekersev, and the latest was in Sevasor cultivars. Although the blooming period varied depending on cultivar, it lasted for 10-14 days in 2018 and 9-15 days in 2019 with the effect of the ecological factors.

Harvest time: Harvest maturity in the cultivars showed parallelism with blooming, such that the earliest blooming Talesevk cultivar was harvested between 8^{th}-22^{nd} September, and the harvest in the latest blooming Sevasor was performed between 10^{th}-18^{th} October. Kazankaya et al. (2009) have reported in the local apple cultivars in the Van Lake basin, the bud breaking was 18^{th} -23^{rd} April, the first blooming was 9^{th} –16^{th} May, the full blooming was 17^{th} -23^{rd} May. In our study, it can be said that the beginning of the vegetation in local apple cultivars, in which 2018 data were taken into account, was earlier in Hakkari than in Van ecological conditions, so the harvest was done earlier. It can be thought that this difference is due to the the ecology and cultivar. Again, in studies conducted in the different regions, it was determined that the full blooming of the local cultivars was between 4^{th} April and 26^{th} May in Rize (Aygun and Ulgen, 2009), 23^{rd} April - 6^{th} May in Ordu (Yarilgac, 2009) and 13^{rd}-30^{th} April in Corum (Corumlu, 2010), and harvest was between 7^{th} August - 10^{th} October in Van (Balta and Kaya, 2009), 5^{th} August - 26^{th} October in Rize Aygun and Ulgen, 2009) and 10^{th} July -30^{th} October in Corum (Corumlu, 2010). In the study, it was determined that FBHDN was at least 119-130 days (Talesevk) and at most 145-154 days (Sevasor) in 2018, and 116-124 days (Talesevk) and 149-154 days (Sevazer) in 2019. In previous studies, it has been determined that the number of days from apple full blooming to harvest was between 95 - 156 days in Van (Kaya, 2008), 89-187 days in Samsun (Ozturk and Ozturk, 2016).

Yield: Considering the yield per tree and yield per trunk cross section, it was seen that the effect of the year on yield was not significant, however, there were significant differences in yield between cultivars. Talesevk was the most productive cultivar at the same time the lowest yield was recorded with Sevasor cultivar. Yield per tree was 51-85 kg, and yield per trunk cross-sectional area varied between 0.08 and 0.16. Although the cultivar has an effect on the differences in yield, the factors such as the age, size and nutritional status of the trees may have been effective. Indeed, Balta et al (2015) reported that the yield in the local cultivars, which may vary depending on the age and size of the genotypes, was in the range of 8-200 kg.

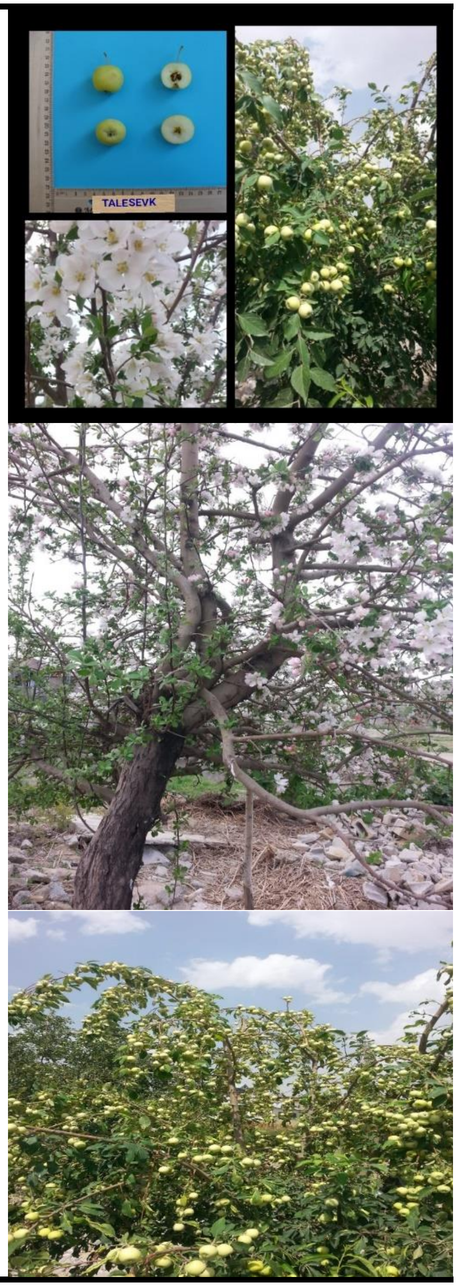
Fruit size: Fruit size, which is a significant criterion in terms of the marketing in apples, is a cultivar-specific property and differs depend on the cultivar. The significant differences occurred between cultivars in terms of fruit size in the study. The biggest fruit (132 g) were harvested from the trees of Sevasor and the smallest (15 g) from the trees of Talesevk cultivars. Consistent with our results, the fruit weight of the local apple cultivars was between 32.29 g and 138.25 g in Van ecological conditions (Kaya and Balta, 2009), 23.95 g and 168.5 g in Bitlis (Sen et al., 1992), and 54-206 g in Artvin (Serdar et al., 2007).

Fruit flesh firmness: It was observed that the fruit of the local apple cultivars in Yuksekova region were softer when compared to both standard cultivars and local apple cultivars from different regions. Such that, the fruit flesh firmness ranged between 7.3 lb (Talesevk) and 10.4 lb (Sevazer) in the study, whereas Kazankaya et al. (2009) reported that it is between 15 lb (Elstar) 19 lb (Starkrimson D) in standard cultivars and 12 lb (Sour Va-II) and 25.55 lb in local cultivars.

SSC and Titratable acidity: In the local apple cultivars, the SSKM value was determined between 10.8% (Talesevk) and 13.1% (Sevasor), and the amount of titratable acid was between 0.21% (Sevasor) and 0.96% (Şekersev). In previous studies, it was determined that the ratio of SSC in the local apple cultivars was 10.0 and 15.4% in Van (Ozrenk et al., 2010), 10.6% and 19.2% in Erzincan (Vurgun and Aslantas, 2015), and 12.6% and 15.2% in Trabzon (Islam et al. al., 2009). On the other hand, Kaya (2008) found that the titratable acidity ratio in local apple cultivars grown in Van ecological conditions was between 0.12 and 3.58% (Kaya, 2008). It is thought that the differences between SSC and acidity ratios are due to the differences in the characteristics such as cultivar, region, cultural practices, ecological conditions and the maturity level in the studies.

Table 7: The characteristics of "Talesevk" local apple cultivar.

Morphological characteristics	
Tree age (year)	90-100
Tree height (cm)	955
Canopy volume (m^3)	144.58
Canopy shape	Splay
Trunk circle (cm)	82.6
Tree growth vigor	Vigorous
Shoot length (cm)	46.39
Shoot diameter (mm)	6.29
Leaf length (mm)	66.8
Leaf width (mm)	29.2
Periodicity tedency	No
Phenological characteristics	
Bud swelling	8-18 April
Bud breaking	19-25April
First blooming	27 April-5 May
Full blooming	10-17 May
The end of the flowering	18-27 May
Harvest date	5-22 September
FBHDN*(day)	116-130
Leaf drop	5-16 November
Yield	
YPTCSA** (kg/cm^2)	0.15
Yield per tree (kg/tree)	83.85
Pomological characteristics	
Fruit weight (g)	12.97
Fruit length (mm)	27.81
Fruit width (mm)	29.49
Fruit volume (ml)	12.83
Fruit shape index	Basipetal
Flower pit width (mm)	12.51
Flower pit depth (mm)	4.07
Kernel number	9
Fruit stalk length (mm)	18.43
Fruit skin thickness (mm)	0.62
Fruit flesh firmness (kg)	3.35
Fruit colour a*	-13.10
b*	45.46
L*	77.57
Chroma	45.41
Hue angle	106.01
Chemical and sensory characteristics	
Soluble solids content (%)	11.03
Titratable acidity (%)	0.35
pH	3.53
Juiciness	Good
Taste	Sweet
Aroma	Moderate



*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

Table 8: The characteristics of "Sekersev" local apple cultivar.

Morphological characteristics	
Tree age (year)	85-95
Tree height (cm)	990
Canopy volume (m^3)	150.31
Canopy shape	Splay
Trunk circle (cm)	Gövde Çevresi
Tree growth vigor	Vigorous
Shoot length (cm)	52
Shoot diameter (mm)	5.93
Leaf length (mm)	66.74
Leaf width (mm)	35.01
Periodicity tedency	No
Phenological characteristics	
Bud swelling	13-22 April
Bud breaking	23 April-3 May
First blooming	4-12 May
Full blooming	14-22 May
The end of the flowering	24-29 May
Harvest date	5-23 October
FBHDN*	119-128
Leaf drop	5-15 December
Yield	
YPTCSA** (kg/cm^2)	0.15
Yield per tree (kg/tree)	80.45
Pomological characteristics	
Fruit weight (g)	28.70
Fruit length (mm)	35.82
Fruit width (mm)	41.75
Fruit volume (ml)	37.00
Fruit shape index	Basipetal
Flower pit width (mm)	13.61
Flower pit depth (mm)	6.57
Kernel number	10
Fruit stalk length (mm)	15.98
Fruit skin thickness (mm)	0.71
Fruit flesh firmness (kg)	3.54
Fruit colour a*	-17.13
b*	44.90
L*	72.74
Chroma	48.08
Hue angle	110.87
Chemical and sensory characteristics	
Soluble solids content (%)	11.03
Titratable acidity (%)	0.93
pH	3.13
Juiciness	Good
Taste	Sweet
Aroma	Moderate

*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

Table 9: The characteristics of “Sevasor” local apple cultivar.

Morphological characteristics	
Tree age (year)	85-95
Tree height (cm)	706
Canopy volume (m^3)	58.62
Canopy shape	Splay
Trunk circle (cm)	56.10
Tree growth vigor	Vigorous
Shoot length (cm)	55.02
Shoot diameter (mm)	6.70
Leaf length (mm)	65.75
Leaf width (mm)	35.93
Periodicity tedency	No
Phenological characteristics	
Bud swelling	15-23 April
Bud breaking	24 April-3 May
First blooming	6-13 May
Full blooming	17-25 May
The end of the flowering	26-31 May
Harvest date	7-21 October
FBHDN*	143-154
Leaf drop	7-19 December
Yield	
YPTCSA** (kg/cm^2)	0.08
Yield per tree (kg/tree)	53.75
Pomological characteristics	
Fruit weight (g)	131.32
Fruit length (mm)	56.57
Fruit width (mm)	65.36
Fruit volume (ml)	146
Fruit shape index	Basipetal
Flower pit width (mm)	20.18
Flower pit depth (mm)	6.47
Kernel number	10
Fruit stalk length (mm)	26.25
Fruit skin thickness (mm)	0.74
Fruit flesh firmness (kg)	3.87
Fruit colour a*	31.47
b*	24.58
L*	55.77
Chroma	41.55
Hue angle	40.53
Chemical and sensory characteristics	
Soluble solids content (%)	12.43
Titratable acidity (%)	0.19
pH	3.92
Juiciness	Very good
Sweet	Sourish
Aroma	Very good

*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

Table 10: The characteristics of "Sevazer" local apple cultivar.

Morphological characteristics	
Tree age (year)	85-95
Tree height (cm)	902
Canopy volume (m^3)	138.49
Canopy shape	Splay
Trunk circle (cm)	83.73
Tree growth vigor	Vigorous
Shoot length (cm)	47.16
Shoot diameter (mm)	6,09
Leaf length (mm)	53.61
Leaf width (mm)	32.63
Periodicity tedency	No
Phenological characteristics	
Bud swelling	13-22 April
Bud breaking	23April-1 May
First blooming	3-12 May
Full blooming	14-22 May
The end of the flowering	20-39 May
Harvest date	5-23 October
FBHDN*	141-154
Leaf drop	5-15 December
Yield	
YPTCSA** (kg/cm^2)	0.09
Yield per tree (kg/tree)	51.35
Pomological characteristics	
Fruit weight (g)	89.17
Fruit length (mm)	60.26
Fruit width (mm)	59.16
Fruit volume (ml)	105.33
Fruit shape index	Basipetal
Flower pit width (mm)	13.19
Flower pit depth (mm)	5.83
Kernel number	10
Fruit stalk length (mm)	31.83
Fruit skin thickness (mm)	0.68
Fruit flesh firmness (kg)	4.70
Fruit colour a*	-18.40
b*	41.88
L*	72.22
Chroma	45.75
Hue angle	113.72
Chemical and sensory characteristics	
Soluble solids content (%)	12.63
Titratable acidity (%)	0.22
pH	3.64
Juiciness	Good
Taste	Sweet
Aroma	Good


*FBHDN: Number of days from full blooming to harvest date.
** YPTCSA: Yield per trunk cross-sectional area

CONCLUSION

It has been observed that Yesiltas and Daglica vilages (Yuksekova-Hakkâri) have suitable ecology in terms of the local pear and apple fruit cultivars the growing. From these local cultivars, there are the cultivars with characteristics that can be standard cultivar. This study aimed to determine local apple and pear with superior characteristics in the region, as well as to increase the growing and recognition of them. It has been observed that Mellaki, Hirmiyatmehi and Hirmizer local pear cultivars will be promising cultivars in terms of pomological, morphological, phenological and chemical analyzes and it has been concluded that they will be candidates to be standard cultivars. Sevasor and Sevazer cultivars can be considered as promising cultivars due to their best pomological and disease resistant characteristics. In Yuksekova (Hakkari) ecological conditions, the widespreading the growing of the cultivars we have determined in the region and the determining of the different cultivars specific to the region by making more extensive adaptation trials will undoubtedly contribute to the fruit growing and economy of the region.

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CHAPTER 7

EVALUATIONS ON INVESTIGATING OF OPPORTUNITIES USING OF PLANT GROWTH-PROMOTING BACTERIA IN TURKEY'S TEA CULTURE

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INTRODUCTION

Tea from the *Angiospermea* division, *Dicotyledonea* class, *Theaceae* or *Camellia* family in botany; It is called *Camellia sinensis* L. O Kuntze. The growth height of the tea plant, which has three different varieties (var. *sinensis*, var. *assamica* and var. *cambodiensis*), varies according to the varieties and the cultural practices applied together ecology in which it was grown (Kacar, 2010).

This type of fruit, which is used for its leaves and has become widespread in tropical-subtropical climate regions; It likes high relative humidity climates where rain is plentiful and temperature is sufficient so that it can form regular shoots. These climatic characteristics are very important, especially with the desired shoot growth and high quality N requirement. In places with sufficient temperature and humidity (such as South India, Sri Lanka, Java, Sumatra and Kenya), shoot formation is observed throughout the year, while in places with temperature and humidity differences between seasons (North and Northeast India, Northeast China and Japan, S. In the cool regions of Africa, Georgia, Azerbaijan, Iran's Caspian Sea coasts and Turkey) shoots occur intermittently in the tea plant. During the cold seasons, the plant enters the resting period in these countries. In order for the tea plant to be grown economically in a region, the average temperature should not fall below 14^{o}C, the soil pH level should be between 4.5-6.0 and a rainfall of over 1200 mm during the growing season is needed.

In Turkey, in the Eastern Black Sea Region, in the areas on the Hopa (Artvin) and Tirebolu (Giresun) lines, a different intensity of tea culture is dominant in the coastal areas. The most characteristic feature of Turkish tea cultivation, which is the livelihood of approximately 250,000 families in the country, is that it can still be grown without the use of pesticides.

The product obtained by processing young and fresh shoots consisting of two leaves and a bud with different methods is one of the most important beverages in the world today. Tea, which is reported to contain more than 2000 chemical components; It is very beneficial for human health thanks to many substances such as polyphenols, alkaloids, amino acids, carbohydrates, proteins and minerals. The amount of these substances is also affected by the way the tea process. (Yashin et al., 2015). Tea is mainly consumed in different beverage forms such as "black" (fermented), "green" (unfermented) or "oolong" (semi-fermented). These process patterns differ from country to country. Thus; South-East Asia, namely India and Sri Lanka, and eastern and southern Africa, Kenya, Malawi, Tanzania, Uganda and Mozambique, are the main producers of black tea, while China and Japan mainly produce green tea (Kacar, 2010).

Tea cultivation, like other forms of plant production, needs continuous mineral nutrition, especially the uninterrupted supply of N, P, K, Mg and S. Especially, since they can affect the content of polyphenols and N-containing compounds, these nutrients can improve the quality of tea. (Hara and Lua 1995). Since tea cultivation only focuses on taking a higher amount of shoots, the use of very high amounts of N fertilizer causes negative effects on both the quality of the made of tea and the environment. Choosing the most appropriate fertilization rate will contribute positively to both healthy and economical tea production and the environmental impact of agriculture. Therefore, It is important to optimize the efficiency of fertilizer use in order to maximize both quality and profitability sustainably in tea cultivation. (Gebrewold, 2018).

In studies on the nutritional status of tea plantations in Turkey; It has been determined that the soils are highly acidic, have sufficient or high nitrogen content, the available phosphorus level carries a serious risk due to high acidity, and the potassium content is weak in 1/3 part. (Eyüpoğlu, 1999, 2002, Adiloğlu and Adiloğlu, 2006). In addition, in another study conducted on the soils of the Rize region, where tea plantations are the most dense, it was determined that at least half of the soil samples were found to be at high risk (<10ppm Fe) in terms of Fe deficiency (Şendemirci and Korkmaz, 2008, Özyazıcı et al., 2011), as well as in terms of Zn content. Also, missing levels were determined (Muftüoğlu et al., 2010, Özyazıcı et al., 2015).

In line with the above-mentioned evaluations on tea cultivation in Turkey, the first study on the possibilities of using plant growth promoting bacteria, which has been studied extensively in the world for the last two decades, was initiated in 2007 in order to carry out balanced, sustainable-nature-friendly fertilization activities. As a first step, firstly, by isolating, diagnosing, characterizing and laboratory tests (oxidase, catalase, nitrogen fixation, sucrose, phosphate solubilization, amylase and ACCD tests) of beneficial bacteria in the tea plantations in

Rize and its surroundings, which cover the first degree tea growing areas in Turkey, first of all, It is aimed to establish the first trials in pots. In the second step, bacterial strains evaluated as biological fertilizer candidates were used in single or multiple formulations in the presence of different carriers both in pots and in the field, and their activities regarding both vegetative growth parameters and leaf enzyme contents were determined. Therefore, this study aimed to evaluate the results of biological fertilizer research in tea cultivation in Turkey.

1. Soil Sampling, Isolation and Identification of Bacteria

These research series; It started with soil sampling (total 580 acidic tea rhizospheric soil samples in 62 locations) in tea plantations in Rize and Trabzon provinces (40^{o} 50 - 41^{o} 20 N - 38^{o} 49 - 41^{o} 28 S) between 2007 and 2016 (Figure 1 and 2). Rhizobacterial isolates in soil samples were identified using FAME profiles (Only strains with the similarity index (SIM) $\geq$0.3 were considered a good match) (Poonguzhali et al 2006 and Çakmakçı et al., 2010).

Figure 1: Soil sampling from the tea rhizosphere for bacterial isolation (Original-by Y. ERTÜRK).

Figure 2: Locations of bacterial isolation (Giresun, Trabzon and Rize Provinces)

2. Nitrogen Fixation and Phosphate Solubilisation

Isolation and purification of N_2-fixing strains were carried out in an N-free solid malate-sucrose medium (NFMM) modified from Döbereiner 19899. Modified NFMM medium per liter distilled water (sucrose, 10.0 g; L-malic acid, 5.0 g; $MgSO_4$, H_2O, 0.2 g; $FeCl_3$, 0.01 g; NaCl, 0.1 g; $CaCl_2.2\ H_2O$, 0.02 g; K_2HPO_4, 0.1 g; KH_2PO_4, 0.4 g; $Na_2MoO_4.H_2O$, 0.002 g) with 18 g agar for solid mediumwas used for isolation. The medium adjusted to pH 7.2 with 1 N NaOH prior to agar addition and was then sterilized at 121 ºC for 20 min in an autoclave (Xie et al., 2003). N-free medium was used in order to obtain nitrogen fixing PGPR (Piromyou et al., 2011). Phosphate solubilization activity of the bacterial isolates was detected on Pikovskaya (1948) and National Botanical Research Institute's phosphate growth medium (NBRIP-BPB). NBRIP-BPB contained (per liter): glucose, 20 g; $Ca_3(PO_4)_2$, 10 g; $MgCl_2\ 6H_2O$, 5 g; $MgSO_4\ 7H_2O$, 0.25 g; KCl, 0.2 g; $(NH4)_2SO_4$, 0.1 g, and BPB, 0.025 g. To compare the reproducibility of the halo formation, pH indicator bromophenol blue was supplemented phosphate growth medium. Phosphate solubilization was was carried out according to the described procedure already (Çakmakçı et al., 2010a). In studies, a total of 1428 colonies were selected from the acidic tea rhizosphere. Over 1428 rhizoplane bacteria were randomly selected from agar-solidified trypticase soy broth, and identified using fatty acid methyl ester (FAME) profiles. The MIDI system identified (SIM > 0.3) 56.4% (805 out of 1428) of the bacteria isolated from the rhizosphere of tea and 38.9% (556 out of 1428) of the bacteria fixed nitrogen and 31.2% (446 out of 1428) solubilized P from insoluble calcium phosphate on NBRIP medium (Table 1).

Table 1: Diversity of culturable P-solubilizing and N2-fixing bacteria in the acidic tea rhizosphere soils (Çakmakçı, 2019)

Taxonomic identification	Order	Bacterial strain FAME identification	Number of isolates	N2-fixing isolates	P-solubilizing isolates
Alphaproteobacteria	*Rhizobiales*	*Rhizobium radiobacter*	8	6	4
		Rhizobium rubi	1	1	1
		Phyllobacterium rubiacearum	2	1	1
		Roseomonas fauriae	6	5	4
		Ochrobactrum anthropi	2	2	1
	Rhodobacterales	*Paracoccus denitrificans*	2	2	1
Betaproteobacteria	*Burkholderiales*	*Burkholderia cepacia*	11	8	7
		Burkholderia pyrrocinia	4	4	3
		Ralstonia eutropha	3	2	2
		Ralstonia pickettii	1	1	1
		Ac. xylosoxidans denitrificans	6	5	3
		Acidovorax facilis	3	1	3
		Acidovorax konjaci	1	1	

		Alcaligenes faecalis	16	9	8
Gammaproteobacteria	*Xanthomonadales*	*Lysobacter enz. enzymogenes*	15	12	10
	Pseudomonadales	*Pseudoxanthomonas sp*	5	4	3
		Stenotrophomonas acidaminiphila	10	6	6
		Stenotrophomonas maltophilia	36	28	21
		Pseudomonas alcaligenes	7	5	4
		Pseudomonas agarici	5	3	2
		Pseudomonas aurantiaca	2	1	
		Pseudomonas chlororaphis	3	2	1
		Pseudomonas fluorescens	39	28	26
		Pseudomonas mucidolens	1	1	
		Pseudomonas putida	28	22	19
		Pseudomonas pseudoalcaligenes	1	1	
		Pseudomonas stutzeri	3	3	1
		Pseudomonas syringae maculicola	3	3	2
		Pseudomonas atrofaciens	3	2	1
		Pseudomonas sp.	7	4	3
		Acinetobacter calcoaceticus	15	9	7
		Acinetobacter lwoffii	5	3	2
	Alteromonadales	*Pseudoalteromonas tetraodonis*	1	1	1
		Aeromonas hydrophila	1	1	1
	Enterobacteriales	*Cedecea davisae*	1	1	1

		Enterobacter intermedius	2	1	1
		Citrobacter freundii	2	1	2
		Ewingella Americana	2	1	1
		Erwinia crysanthemi	3	1	3
		Hafnia alvei	4	3	4
		Photorhabdus luminescens	5	4	3
		Proteus vulgaris	5	4	3
		Rahnella aquatilis	3	2	2
		Providencia alcalifaciens	1		1
		Serratia fonticola	4	3	3
		Serratia marcescens	4	4	3
		Serratia plymuthica	2	2	1
		Pantoea agglomerans	3	3	3
Firmicutes	*Bacillales*	*Bacillus amyloliquefaciens*	2	1	
		Bacillus atrophaeus	10	9	8
		Bacillus badius	1	1	1
		Bacillus alcalophılus	2	1	1
		Bacillus cereus	78	55	28
		Bacillus coagulans	8	2	5
		Bacillus globisporus	1	1	
		Bacillus laevolacticus	20	17	12
		Bacillus licheniformis	27	23	18
		Bacillus lentus	4	2	1
		Bacillus megaterium	37	28	25
		Bacillus mycoides	11	7	4
		Bacillus parabrevis	1	1	1

		Bacillus pumilus	26	20	16
		Bacillus simplex	6	3	2
		Bacillus sp	14	8	7
		Bacillus sphaericus	26	13	8
		Bacillus subtilis	24	20	16
		Bacillus thuringiensis	2	1	
		Paenibacillus alvei	1	1	1
		Paenibacillus azotofixans	2	2	1
		Paenibacillus larvae	3	2	2
		Paenibacillus lentimorbus	6	4	3
		Paenibacillus macquariensis	7	5	6
		Paenibacillus polymyxa	20	17	12
		Paenibacillus validus	14	11	8
		Brevibacillus choshinensis	12	8	5
		Brevibacillus centrosporus	8	4	3
		Brevibacillus parabrevis	3	2	1
		Brevibacillus reuszeri	9	3	4
		Geobacillus stearothermophilus	1	1	1
		Kurthia gibsonii	1	1	1
		Kurthia sibirica	11	3	
Actinobacteria	*Actinomycetales*	*Arthrobacter pascens*	2	1	1
		Arthrobacter agilis	4	3	2
		Arthrobacter aurescens	3	1	1
		Arthrobacter crystallopoites	1	1	1
		Arthrobacter citreus	2	1	2

		Arthrobacter globiformis	6	5	4
		Arthrobacter mysorens	4	1	2
		Arthrobacter viscosus	13	6	5
		Kocuria rosea	6	4	4
		Micrococcus lylae	5	4	4
		Micrococcus luteus	11	6	7
		Brevibacterium liquefaciens	4	2	1
		Microbacterium chocolatum	1	1	1
		Rhodococcus erythropolis	11	8	6
Bacteroidetes	*Flavobacteriales*	*Chryseobacterium indologenes*	5	3	3
Others[a]	32		32 18	18	13 13
No library match			192		
Unidentified[b]			431		
Total			1428	556	446

[a]Others includes the genera: *Brevundimonas, Methylobacterium, Rhodobacter, Xanthobacter, Comamonas, Kingella, Variovorax, Xanthomonas, Raoultella, Yersinia, Photobacterium, Clostridium, Enterococcus, Sporosarcina, Staphylococcus, Cellulomonas, Curtobacterium, Nocardia, Bergeyella, Flavobacterium Sphingobacterium*, N2-fixing and P-solubilizing bacteria in these genera were only detected once or twice. [b]Isolates named with a similarity index < 0.3.

3. Use of Single Bacteria

The bacteria isolated from the soil samples taken from the tea plantations of the Eastern Black Sea region, after being identified and characterized, were first applied to the plants belonging to different tea clones in the pots and their activities were evaluated (Fig 3, 4).

Figure 3: Different clonal tea plants treated with microbial inoculants in pots (Original-by Y. ERTÜRK).

In the study carried out in pots in Rize conditions, a total of 25 different isolates were applied to plants belonging to Hayrat and Fener-3 tea clones, especially *Burk. pyrrocinia* 64/4, *P. polymyxa* 28/3, *Bb. reuszeri* 10/5, *Bacillus sp*. 29/4, *Radiobacter* 2/7, *A.x. denitrificans* 16/4, *C. freundii* 3/7, *Ps. putida* 53/5, *P. macquariensis* 38/2, *Pseudoxanthomonas sp.* 8/3 *Ps. maculicola* 41/2, *M. luteus* 3/5 and *P. lentimorbu*s 47/8 bacterial strains were found to have high-level positive effects on vegetative growth parameters, especially in plants (Çakmakçı et al., 2010b), Similarly, 25 different bacterial isolates (*Bacillus simplex* 6/4; *Paenibacillus polymyxa* 2/5; *Paenibacillus validus* 22/1, *Staphylococcus simulans* 36/1;*Brevibacillus centrosporus* 66/4; *Paenibacillus polymyxa* 66/6; *Pseudomonas putida* 35/4; *Burkholderia cepacia* 65/6; *Bacillus subtilis* 52/1; *Pseudomonas fluorescens* 48/1; *Rhodococcus erythropolis* 4/8; *Pantoea agglomerans* 5/8; *Bacillus cereus* 27/6; *Bacillus pumilus* 35/6; *Chryseobacterium indologenes* 21/5; *Bacillus megaterium* 42/4; *Brevibacterium liquefaciens* 28/5; *Bacillus sphaericus* 57/3; *Pseudomonas putida* 27/3; *Pseudomonas sp.*30/5; *Alcaligenes faecalis* 47/11; *Stenotrophomonas* *acidaminiphila* 4/7; *Stenotrophomonas maltophilia* 60/5; *Paenibacillus polymyxa* /3; *Rhodococcus rhodochrous* 66/9) and Fener-3, Muradiye 10 and Tuğlalı tea clones were applied to pots containing plants by dipping and injection methods. Bacterial activity varied according to the selected bacterial species, tea clones and the parameters considered. Indeed, according to 2-year results, *P. agglomerans* 5/8, *B. pumilus* 35/6 *Al. faecalis* 47/11, *S. maltophilia* 60/5 and *Pb. validus* 22/1 Fener 3 tea clones were the most effective isolates, and the most effective promoters of leaf yield and vegetative growth in Tuğlalı tea clone were *Br. reuszeri* 10/5, *Bacillus sp.* 29/4, *Rh. radiobacter* 2/7, *Ps. syringae maculicola* 41/2, *C. freundii* 3/7, *Ps. syringae* 8/4, *Ps. putida* 29/2 and. While *Pb nitrogenofixans* 66/12 isolates, maximum leaf yield and stem growth in Muradiye 10 clones were determined by *K. sibirica* 3/5, *B. subtilis* 39/3, *Pb. azofixans* 66/12, *Pb. lentimorbus* 47/8, *Ps. putida* 53/5 and. It was obtained by *Rh radiobacter* 2/7 vaccinations (Çakmakçı et al., 2010c). In another study, plants of the Tuğlalı type were used. The most effective isolates on vegetative growth parameters in plants belonging to the brick tea clone, *Br. Reuszeri* 10/5, *Bacillus sp*. 29/4, *Rh. radiobacter* 2/7, *Ps. Syringae maculicola* 41/2, *C. freundii* 3/7, *Ps. syringae* 8/4, *Ps. putida* 29/2 and there were *Pb. azotofixans* 66/12 isolates (Ertürk et al., 2010).

In another study conducted to determine the effects of 11 different PGPR isolates on the yield of Fener-3 (2-years-old) seedlings; *Arthrobacter citreus* 48/4, *Roseomonas fauriae* 27/2 and *Kocuria rosea* 69/2 isolates, stem diameter of tea seedlings, *Bacillus sphaericus* 65/9, *Rhizobium radiobacter* 11/2 and *Roseomonas fauriae* 58/5 together with NPK fertilizer applications can statistically increase the seedling height found to be increased. Branch+leaf weight; increased significantly in inoculations of *Roseomonas fauriae* 58/5, *Arthrobacter citreus* 48/4 and *Rhizobium radiobacter* 11/2, especially in mineral fertilizer applications, compared to the control. The highest leaf yield was obtained from mineral fertilizer applications, followed by *Roseomonas fauriae* 58/5, *Arthrobacter citreus* 48/4 and *Rhizobium radiobacter* 11/2 inoculations (Erturk et al., 2011).

In Muradiye 10 clones, one of the Turkish tea clones; In another study carried out to determine bacteria that can be used as biological fertilizers, 26 different bacterial isolates selected according to laboratory test results were maintained for 3 years using barnyard manure, 3 different mineral fertilizers and control. According to the experimental results, most of the isolates used stimulated tea growth and increased the leaf macro and micro element contents. According to the research results, especially *Bacillus simplex* 6/4, *Paenibacillus validus* 22/1, *Bacillus megaterium* 42/4, *Chryseobacterium indologenes* 21/5, *Pantoea agglomerans* 36/2, *Bacillus cereus* 27/6, *Brevibacillus centrosporus* 66/4, *Paenibacillus polymyxa* 66/ 6, *Pantoea agglomerans* 5/8, *Burkholderia cepacia* 65/6, *Pseudomonas alcaligenes* 27/1, *Paenibacillus polymyxa* 24/3, *Pseudomonas sp.* 30/5 and *Brevibacillus choshinensis* 2/5 isolates increased all vegetative growth parameters including leaf macro and micro element content, stem diameter, seedling height, stem growth and leaf yield in Muradiye

10 clone. It has been determined that the bacteria tested in this study can reduce the need for chemical fertilizers and have the potential to be used as biological fertilizers in organic and improved agricultural applications (Çakmakçı et al., 2012).

In plants belonging to Hayrat clone, another Turkish tea clone, 22 different bacterial isolates (*Bacillus simplex* 6/4, *Brevibacillus coshinensis* 2/5, *Paenibacillus validus* 22/1, *Brevibacillus centrosporus* 66/4, *Paenibacillus polymyxa* 66/6, *Pseudomonas putida* 35/4, *Burkholderia cepacia* 65/6, *Bacillus subtilis* 52/1, *Pseudomonas fluorescens* 48/1, *Pantoe agglomerans* 5/8, *Chryseobacterium indologenes* 21/5, *Bacillus saphaericus* 57/3, *Pseudomonas sp.* 27/3, *Alcaligenes faecalis* 47/11, *Stenotrophomonas acidaminiphilla* 4/7, *Stenotrophomonas maltophilia* 60/5, *Paenibacllius polymyxa* 24/3, *Rhodococcus rhodochrous* 66/9, *Bacillus subtilis* RC63, *Bacillus megaterium* RC07, *Pseudomonas fluorescens* RC77, *B. subtilis*) were applicated.

At the end of the study, in terms of both vegetative growth parameters and leaf nutrient contents, *Bacillus simplex* 6/4, *Brevibacillus coshinensis* 2/5, *Paenibacllius polymyxa* 24/3, *Brevibacillus centrosporus* 66/4, *Paenibacillus polymyxa* 66/6, *Bacillus subtilis* 52/1, *Stenotrophomonas maltophilia* 60/5, *Burkholderia cepacia* 65/6, *Chryseobacterium indologenes* 21/5, *Stenotrophomonas acidaminiphilla* 4/7 and *Rhodococcus rhodochrous* 66/9 strains showed positive contributions compared to both positive (fertilizer dose) and negative control (0: no application) groups. (Çakmakçı et al., 2013).

4. Use of Different Carriers with Multiple Bacterial Isolates

In the formation of biological fertilizer formulations in which two or more isolates are used together are preferred rather than single isolates. However, combining two or more bacterial strains in a formulation may cause adverse effects in some cases, the opposite of the desired extra effect. In this respect, it is important to perform efficacy tests with single bacterial strains. Taking into account the laboratory tests of the isolates that are effective in these tests, the main goal is to create the right formulations, taking into account the plant's species, ecological demands and the cultural applications it needs. Though PGPR have a very good potential in the management of biological fertilizer, it could not be used as cell suspension under field conditions. Hence, the cell suspensions of PGPR should be immobilized in certain carriers and should be prepared as formulations for easy application, storage, commercialization and field use. To develop a successful PGPR formulation, rhizobacteria should possess

a. High rhizosphere competence
b. High competitive saprophytic ability
c. Enhanced plant growth
d. Ease for mass multiplication
e. Broad spectrum of action
f. Excellent and reliable control
g. Safe to environment
h. Compatible with other rhizobacteria
i. Should tolerate desiccation, heat, oxidizing agents and UV

radiations (Jeyarajan and Nakkeeran, 2000; Nakkeeran et al., 2006) Furthermore; characteristics of an ideal formulation;

a. Should have increased shelf life

b. Should not be phytotoxic to the crop plants

c. Should dissolve well in water and should release the bacteria

d. Should tolerate adverse environmental conditions

e. Should be cost effective and should give reliable control of plant diseases

f. Should be compatible with other agrochemicals

g. Carriers must be cheap and readily available for formulation

development (Jeyarajan and Nakkeeran, 2000; Nakkeeran et al 2006). Since the shelf life of bacteria varies according to the bacterial species, carriers and particle sizes, different carriers and different bacterial combinations were included in the trial in this study series to determine the most accurate combination of bacteria x carrier(s) in tea cultivation. In the study to determine these formulations; established with potential PGPR isolates; five pieces formulations (F1: *Bacillus atrophaeus* RC11+ *Bacillus megaterium* RC07+ *Pseudomonas fluorescens* RC77; F2: *Bacillus subtlis* RC63+ *B. megaterium* 21/4; F3: *B. subtlis* 36/10+ *B. megaterium* 42/2+ *P. fluorescens* ;F4: *B. subtilis*, 39/3+ *B. megaterium* 42/4+ *P. fluorescens* 9/7; F5: *B. subtilis* RC521 + *B. megaterium* 42/4+ *P. fluorescens* 9/7) 7 organic and inorganic were developed in solid carrier (tea waste, peat, perlite, leonardite, zeolite and vermiculite) and liquid carrier-based formulations were made. Experiments were carried out in four replications (each with five rooted seedlings) under natural soil conditions, according to a completely randomized trial design. In this study, the growth and survival of PGPR formulations in the carrier material were evaluated. The productivity of the biofertilizers was variable and varied depending on the inoculant strain, carriers and growth parameters evaluated. The effective bacteria and carrier formulations tested consistently yielded growth and productivity equal to or higher than the applied chemical fertilizers. (Cakmakci et al., 2014). The study; in the pots of one of the Turkish tea clones, Hayrat tea clone; mineral fertilizer, a commercial biological fertilizer and organic and inorganic origin solid (tea residue, peat, perlite, leonardite, zeolite and vermiculite) and nitrogen fixer and phosphate solvent microorganism-based five different biological fertilizer formulations (F1: *Bacillus atrophaeus* 55/6 + *Bacillus megaterium* 63/1 + *Pseudomonas fluorescens* 9/7;F2: *Bacillus simplex* 6/4+*Bacillus subtlis* B2/8 + *Pseudomonas putida* 3/10;F3: *Bacillus pumilus* 35/6 + *Paenibacillus polymyxa* 2/2 + *Pseudomonas sp* .27/3; F4: *Bacillus pumilus* RC19 + *Paenibacillus polymyxa* RC35 + *Pseudomonas putida* 29/2; F5: *Bacillus lentus* 29/6 + *Paenibacillus polymyxa* RC14 + *Pseudomonas putida* RC06) developed in liquid carriers to evaluate the effect of tea growth and enzyme activity of tea leaf was carried out. In the study, which continued for two years under natural conditions in Rize, a randomized plot design with five replications, seven carriers, eight applications and four saplings in each replication, was preferred. It has been determined that the bacterial formulation efficiency varies according to the inoculated strain, carrier material and the parameters discussed, as in previous studies. The biological fertilizer formulation promoted growth in Hayrat Turkish tea clone, including stem growth, plant height, stem diameter, leaf yield, chlorophyll and antioxidant content, leaf area, oxidative, catalytic, hydrolytic and antioxidant enzyme activity. It has been determined that the bacterial combinations tested in the research can promote plant growth, reduce the need for chemical fertilizers, and have the potential to be used as biological fertilizer in organic and sustainable agriculture applications (Çakmakçı et al 2016).

Biological fertilizer isolates candidate isolated from tea plantations in the acidic soils of the Eastern Black Sea region were applied in multiple formulations by combining multiple isolates, especially those with positive efficacy in single use, taking into account their performance in laboratory tests. In this context; 7 different bacterial formulations for plants belonging to 10 tea clone Tuğlalı 10 (BF1: *Bacillus subtilis* RC28 + *Paenibacillus polymyxa* RC05 + *Pseudomonas fluorescens* RC77; BF2; *Bacillus subtilis RC63* + *Paenibacillus polymyxa* 24/3 + *Pseudomonas* RC05; + *Paenibacillus polymyxa* 28/3 + *Pseudomonas fluorescens* 51/2; BF4; *Bacillus megaterium* 12/1 + *Paenibacillus polymyxa* RC35+ *Pseudomonas fluorescens* 48/3) combinations of BF1, BFIV, BFV, BFVI and BFVII significantly increased vegetative growth parameters such as shoot growth and leaf yield compared to the control (Çakmakçı et al., 2017). In another study conducted on two years old seedlings belonging to Pazar-20 tea clones; 5 different bacterial formulations (F1, F2, F3, F4 and F5) were applied in triplicate with 7 different carriers. Of the formulations, especially F1, F2 and F5 gave the highest values in vegetative development parameters. In terms of the carriers used, the liquid carrier produced the highest average values (Ertürk et al., 2021).

The results summarized above provided positive contributions to many vegetative growth parameters in parallel with the applications made with different tea types/varieties in different locations. However, the activity; it is reported that it may differ depending on the bacterial formulation content, application method, carrier and the type/cv of tea palnt used. (Chakraborty et al., 2006; 2013; Bai et al., 2014; Dutta et al., 2015; Princy et al., 2015; Dutta and Takur, 2017).

5. CONCLUSION

Investigation of isolates specific to the region in tea growing locations in Turkey is very important, especially in terms of obtaining formulations that will assist the Integrated Nutrient Management (INM) strategy. For this purpose, the results of the studies conducted in the region between 2007-2016 and summarized above; showed that bacterial inoculations can significantly increase the growth and development parameters of the tea plants. It is also clear that this group of microorganisms, known as PGPR, offers great potential for new and more sustainable product management applications. However, human beings have understood very little of this potential. In this respect, there is more researches to be done on PGPRs. Many areas such as being able to be used as a biological fertilizer, stimulating plant growth even under stress conditions imposed by adverse ecological conditions, and supporting the fight of plants against diseases and pests are also very important for tea cultivation. With this; it should also be noted that the effectiveness of inoculants varies greatly depending on the bacterial isolates in the formulation and the application technology.

In fact, studies have determined that the type of carrier that can be used with formulations can be significantly effective. Indeed, these factors create enormous potential for global food security, the sustainability of crop production and making agricultural systems resilient to climate change.

Figure 4: The effects of some isolates on vegetative growth in plants belonging to different tea clones (Original-by Y. ERTÜRK).

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CHAPTER 8

HARVEST, STORAGE AND POST-HARVEST TECHNOLOGIES OF JAPANESE PLUM

(*Prunus salicina* Lindl.)

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INTRODUCTION

Plums have the second-highest production rate with 12.601.312 tons after peach and nectarine (25.737.841 tons) among the stone fruit species in the world (FAO, 2019). As seen in Figure 1a, world plum production has increased significantly especially in 2018-2019. When we analyze it based on countries, China (6.995.738 tons), Romania (692.670 tons), Serbia (558.930 tons), Chile (465.280 tons), Iran (359.176 tons), United States of America (340.010 tons), Turkey (317.946 tons), Italy (215.020 tons), France (205.110 tons), and Ukraine (181.140 tons) are the top ten countries in terms of plum production, respectively (FAO, 2019). As can be seen, China alone meets more than half of the world's plum production (Figure 1b).

Generally, plum species are classified into three groups according to the gene centers such as Euro-Asian, North American, and East Asian plum species (Özvardar and Önal, 1990; Butac et al., 2010). *Prunus domestica*, *Prunus spinosa*, *Prunus insititia*, and *Prunus cerasifera*, are widespread in Euro-Asian species while *Prunus nigra*, *Prunus munsoniana*, and *Prunus americana* are classified as North-American plum species. In addition, *Prunus salicina*, *Prunus simonii* and *Prunus ussuriensis* are mentioned as East-Asian plum species (Özbek, 1978; Butac, 2020). Among these different species, *P. salicina* and *P. domestica* are major commercial species in worldwide. After these, *P. cerasifera* is used as an important rootstock in the world and also for fresh consumption in green fruit stage only in Turkey.

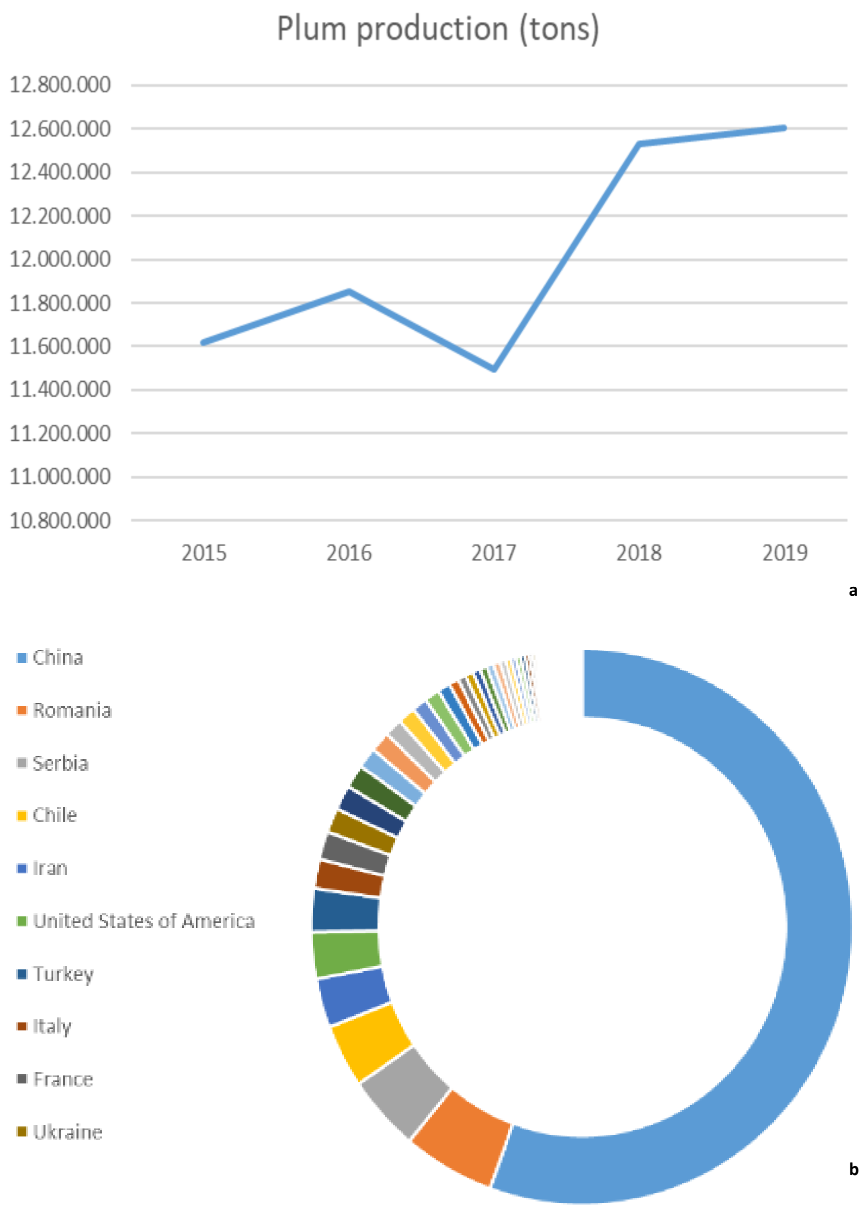

Figure 1a: World plum production quantity between 2015-2019. **1b.** Top ten plum producer countries (FAO, 2019).

Japanese plum (*Prunus salicina* Lindl.), belongs to Prunus genus, Prunoideae subfamily and Rosaceae family, has the biggest production value for fresh consumption in plum species in worldwide. Plum breeding studies were started by Luther Burbank in 1875, his varieties are still available and have been used not only in production but also in hybridization combinations.

Along with production increases, studies on breeding new varieties with different harvest times, high quality and suitable for long term postharvest storage have gained importance (Bellini and Nencetti 1998; Minas et al., 2015: Ruiz et al., 2016; Çavdar et al., 2017).

As well as, increasing production levels have led to development of pre-harvest, harvest and post-harvest storage technologies. In this context, studies on harvesting, storage and post-harvest process in Japanese plums and the latest technologies used are discussed in detail.

1.CLIMACTERIC CATEGORY, HARVEST, OPTIMUM STORAGE CONDITIONS AND QUALITY CRITERIA

As we know, fruits and vegetables have traditionally been classified according to differences in respiration pattern and ethylene physiology; climacteric or non-climacteric (Biale, 1964; McMurchie et al., 1972). This situation has diversified for Japanese plums and is examined under three main headings: climacteric, non-climacteric and suppressed-climacteric (have low ethylene production) (Abdi et al., 2017). Most Japanese plum cultivars show climacteric (Santa Rosa, Gulfruby, Beauty) or suppressed-climacteric (Black Diamond, Shiro, Rubyred, Late Santa Rosa, Casselman, Roysum, Angeleno) patterns, while few of them have non-climacteric (Sweet Miriam) tendency (Jobling et al., 2003; Díaz-Mula et al., 2009; Minas et al., 2015; Abdi et al., 2017; Farcuh et al., 2019).

Harvest starts at early-summer and continues to mid-autumn according to the varieties and regions. The harvest time of Japanese plums is determined by organoleptic characteristics, firstly color then texture, firmness, soluble solids concentration, titratable acidity, taste, days after full bloom, and aroma are important harvest parameters (Robertson at al., 1991; Abdi et al., 1997; Crisosto et al., 2004; Valero et al., 2007; Singh et al., 2009; Singh and Singh, 2013). When fruit ripens, color changes begin with chlorophyll degradation on fruit skin and pulp, then variety-specific coloration occurs, such as yellow, purple and crimson (Srivastava, 2002; Crisosto and Mitchell, 2003; Crisosto and Kader, 2000). In addition, harvest maturity of each variety change according to climacteric profile's that mentioned above as tree-ripe and commercial ripe (Infante et al., 2011), while some cultivars come to optimum harvest maturity 25-85 days after pit hardening (Abdi et al., 1997).

Plums can be easily perishable and depending on the cultivar, storage life changes between only two to six weeks at 0 °C storage (Abdi et al., 1997; Pérez-Marín et al., 2010). Although storage at 0-2 °C is beneficial in prolonging post-harvest life, it may lead to the development of chilling injury symptoms such as reddish discoloration, external browning and consequent loss of quality (Manganaris et al., 2008;

Guerra et al., 2008). Polyamine, calcium, 1-methylcyclopropene (1-MCP) and heat treatment successfully are used prior to cold storage to preserve quality longer than low temperature alone (Valero et al., 2002a, 2002b, 2003; Martínez-Romero et al., 2003; Velardo-Micharet et al., 2017).

The important quality criteria in Japanese plums are size, color, firmness, soluble solids content (SSC), titratable acidity (TA), and antioxidants (Manganaris et al., 2008). Among these, fruit size stands out as the most important factors affecting the marketing process while fruit firmness is one of the most important factors affecting post-harvest process. Other features are firstly important parameters in terms of consumer preferences and nutritional values then post-harvest physiology. Fruit size depends on the cultivar, rootstock, environment, and cultural practices such as, water status of tree, fruit thinning, and hormone treatments (Crisosto et al., 1997; Stern et al., 2007; Intrigliolo et al., 2010; Erogul and Sen, 2015). Fruit firmness is major factor limiting the post-harvest and shelf-life, as mention above some practices can support this limitation.

2.POST-HARVEST DISORDERS

Post-harvest disorders analyzed under two main headings: physiological and pathological disorders. Chilling injury (CI) or internal breakdown (IB) which contains flesh browning, flesh bleeding, flesh translucency, black pit cavity, flavor lost, and mealiness symtopms is the most important physiological disorder, while brown rot (*Monilinia laxa*), grey mould (*Botrytis cinerea*), and rhizopus rot (*Rhizopus stolonifera*) are significant fungal pathological disorders (Mitchell and Kader, 1989; Crisosto et al., 1999; Manganaris et al., 2008; Gonçalves et al., 2010; Zhang et al., 2010).

2.1. Physiological Disorders

Development of physiological disorders have been related to oxidative injury, antioxidant levels at harvest time, and changes their concentrations during storage in fruit species (Sala and Lafuente, 2000; Diamantidis et al., 2002; Sing, 2010). CI is effected by different pre-harvest and post-harvest factors such as cultivar, harvest maturity, storage conditions, nitric oxide, oxalic acid, salicylic acid, putrescine, and 1-MCP treatments (Taylor et al., 1995; Ward and Melvin Carter, 2001; Perez-Gago et al., 2003; Crisosto et al., 2004; Singh and Singh, 2009; Sing, 2010; Erbaş and Koyuncu, 2019). CI symptoms often occur in cold and long term storage below 7.5 °C (Palou et al., 2003). Although the genetic background of CI has been determined in peach (Brummell et al., 2005), that is an important stone fruit, there are no studies on this subject in Japanese plums and it is stated that more detailed studies on this subject should be done.

As mentioned above different CI symptoms occurs depending on genotype. Flesh browning and mealiness are highly seen as the major CI symptoms in cv. Autumn Giant (Perez-Gago et al., 2003), while only mealiness is important in cv. Fortune (Manganaris et al., 2008). In another study with the Fortune cultivar, flesh browning, translucency symptoms, and lack of juiciness were observed (Crisosto et al., 1999).

The range of CI symptoms depended on storage conditions and post-harvest treatments on cv. Autumn Giant and showed lower symptom when stored at 1 day at 20 °C (Perez-Gago et al., 2003). There were no CI symptoms observed in Angeleno, Black Amber and Fortune cultivars when stored for 5 weeks at 0 °C, while Howard Sun, Show Time and Friar cultivars showed CI symptoms within 4 weeks at 0 °C (Crisosto et al., 1999). Effects of dipping fruits before storage into different concentrations of oxalic acid, salicylic acid, putrescine, and nitric oxide solutions were tested on CI symptoms of Black Diamond cultivar. Salicylic acid was found the best treatment for delaying CI and also decay rate (Erbaş and Koyuncu, 2019).

2.2. Pathological Disorders

As a result of highly perishable fruit characteristic, Japanese plums are liable to fungal postharvest diseases especially brown rot (*Monilinia laxa*), grey mould (*Botrytis cinerea*), rhizopus rot (*Rhizopus stolonifera*). These postharvest diseases, which cause significant economic losses, can be controlled by fungicides, chitosan, edible coatings or wax coating, natural antagonists or biocontrol agents, salicylic acid, vapour of some medicinal plants such as thymol, and irradiation (Northover and Cerkauskas, 1998; Liu et al., 2002; Svircev et al., 2007; Zhang et al., 2010; Gonçalves et al., 2010; Hussain et al., 2013; Salem et al., 2016; Erbaş and Koyuncu, 2019).

However, since some studies have determined that the use of essential oils has a toxic effect on fruits, attention should be paid to the application doses in the use of such compounds (Speranza and Corbo, 2010; Lopez-Reyes et al., 2013). On the other hand, effect of *Aureobasidium pullulans* PL5 and tebuconazole against *M. laxa* on postharvest fruits (cv. Angeleno) under cold storage conditions were studied and compared to the control, the incidence of *M. laxa* was reduced by 43% in fruits treated with *A. pullulans* PL5 (Zhang et al., 2010). As in this study, the fact that natural agents are more effective than fungicides are important in terms of protecting consumer health as well as storage life.

3.POST-HARVEST TECHNOLOGIES

3.1. 1-Methylcyclopropene (1-MCP)

1-Methylcyclopropene (1-MCP) is an ethylene inhibitor gas that uses in horticultural crops which shows climacteric patterns. Beneficial effects of 1-MCP in lateness on ripening and prolonged postharvest life have been indicated in lots of horticultural crops (Watkins, 2006). Different forms of 1-MCP such as powder, tablet and paper containing 1-MCP are used successfully in plums (Erkan and Eski, 2012; Velardo-Micharet et al., 2017; Lin et al., 2018) and, furthermore using forced-air cooling (FAC) during 1-MCP application was found an energy saving method (Minas et al., 2013).

When examined studies on plums, 1-MCP application delays softening of fruit flesh and changes on skin color, reduces darkening during storage and protects flesh firmness (Argenta et al., 2003; Martínez-Romero et al., 2003; Salvador et al., 2003; Luo et al., 2009; Ozkaya et al., 2010; Bae et al., 2011; Stanger et al., 2016; Velardo-Micharet et al., 2017; Uysal et al., 2020). In addition, 1-MCP is used alone as well as with controlled atmosphere, modified atmosphere packaging, natamicin, chlorine dioxide, UV-C irradiation on different plant species (Jiang et al., 2015; Ozkaya et al., 2016; Xu and Liu, 2017; Uysal et al., 2020; Bi et al., 2022).

Using new application technology for 1-MCP as called "forced-air cooling" for storing Japanese plum cultivars at higher than normal cold storage temperatures to avoid CI, was tested by exposing 0.5 $\mu L\ L^{-1}$ 1-MCP at 0°C for 24 h. After treatment, storage at 10°C were found a promising method for avoiding CI of low-acid plums (Minas et al., 2013).

Combined effect of the harvesting time with or without 1-MCP treatment and the postharvest storage in three different temperature regimes (0°C, 8°C and dual temperature, 0/8°C) were tested on Songold Japanese plum variety. In line with the results of the study, 1-MCP reduced the color changes (L* and b*) and firmness loss, so using 1-MCP allows us to market the fruit at a later ripening stage and to store it at a higher temperature without loss of quality (Velardo-Micharet et al., 2017).

3.2. Edible coatings

Edible coatings play a role as physical barriers on the fruit surface and diminish its permeability to water vapour, CO_2, and O_2 (Mishra et al., 2010; Valero et al., 2013; Kumar et al., 2017). Coated fruits also show low ethylene production rate (Valero et al., 2013; Kumar et al., 2017).

Whey protein, carboxymethyl cellulose (CMC), hydroxypropyl methylcellulose, versasheen (carbohydrate-based polymer from waxy maize starch), alginate, aloe jel, gellan gum, and gum arabic are the most used and important edible coatings for preserving the internal physiology and fruit quality parameters, reducing postharvest losses on plums (Reinoso et al., 2008; Eum et al., 2009; Valero et al., 2013; Choi et al., 2016; Kumar et al., 2017; Martínez-Romero et al., 2017; Panahirad et al., 2019; Bal, 2019; Fawole et al., 2020). Besides, carnauba wax and chitosan reduce fruit decay on plums under postharvest conditions (Gonçalves et al., 2010; Bal, 2013).

Chitosan coating was investigated on cv. Santa Rosa and fruits were coated with 2% chitosan, then stored at 1 ± 1 °C under 90 ± 5% relative humidity (RH). Results showed that coating had an important effect in keeping fruit firmness, delaying respiration and ethylene evolution rates, weight loss, and retarding the color change as compared to non-coated fruits (Kumar et al., 2017).

Thakur et al. (2018), was investigated the possibility of rice starch-ι-carrageenan (RS-ι-car) composite coating blended with sucrose fatty acid esters (FAEs) on enhancing the shelf life of *P. salicina*. This coating was found to be effective for reducing respiration rate, endogenous ethylene production, and weight loss and prolongs the shelf life and some quality parameters.

3.3. Controlled Atmosphere (CA)

Controlled atmosphere (CA) storage is a storage system that allows to increase fruit quality by reducing fruit metabolism and is used to extend the storage life of horticultural crops. Response of fruit crops under CA is effected by cultivar, maturity stage, storage temperature, and pre-storage chemical treatments (Saltveit, 2003). Like 1-MCP and edible coatings, CA is also used in combinations with different post-harvest technologies.

Using CA storage alone generally reduced softening but increased brown rot in cv. Angeleno (Menniti et al., 2006). Another study with cv. Angeleno, combined effects of controlled atmosphere(CA), normal atmosphere (NA) and 1-MCP treatment were investigated. After treatment with 625 ng g^{-1}1-MCP, fruit were stored in normal NA and CA (1% O_2-3% CO_2) conditions at 0 ºC and 90±5% RH. The combination of 1-MCP and CA storage prolonged storage life of compared to other treatments (Erbaş and Koyuncu, 2019).

Storage of Black Amber fruits for 56 days at 0-1 °C under 1% O_2 + 3% CO_2, 2.5% O_2 + 3% CO_2 conditions were reduced CI and oxidative stress (Singh and Singh, 2013). In addition, CA storage of cv. Laetitia were observed on 5% O_2 + 10% CO_2 condition and this treatment retarded ethylene production (Maré et al., 2005). Combining CA (2 kPa

O_2 + 2 kPa CO_2) with 1-MCP (0.6 μL L^{-1}) on the same cultivar showed delaying CI and ripening (Steffens et al., 2014).

3.4. Modified Atmosphere Packaging (MAP)

Modified atmosphere packaging (MAP) is the other important post-harvest technology which has been successfully use to sustain fruit quality and to extend the storage period (Erkan and Eski, 2012). Using MAP provides lower O_2 and higher CO_2 conditions, and thereby controls ethylene synthesis, respiration rate, and decay (Mattheis and Felman, 2000; Rocha et al., 2004; Erkan and Eski, 2012). Like 1-MCP, edible coatings, CA, and MAP is also used in combinations with different post-harvest technologies.

Storage of cv. Angeleno with using MAP at 1 ± 1 °C with 90% RH and MAP at 1 ± 1 °C with 90–95% RH protected fruit quality for 35 and 60 days, respectively (Briano et al., 2015; Peano et al., 2017). In the Golden Globe variety, storage 35 days at 2 °C with 90% RH under MAP storage, controlled changes in color and reduces softening (Díaz-Mula et al., 2011). Like Golden Globe the storage of cv. Friar at 0 °C for 45 days under MAP delayed color changes, reduced weight loss and CI symptoms (Cantín et al., 2008).

Erkan and Eski (2012), studied the effect of 1-MCP and 1-MCP+MAP combination on cv. Autumn Giant and Black Beauty. 1-MCP+MAP treatment have shown positive effect on prolonging storage with best fruit quality.

3.5. Gamma irradiation treatment

Gamma irradiation is another important post-harvest technology especially for using to reduce antimicrobial activity (Tiryaki and Maden, 1991; Marquenie et al., 2002; Koçak and Bal, 2017). Besides this effect of using gamma irradiation (alone and/or combined with edible coatings), it reduces respiration rate, weight loss and preserve some quality parameters (Hussain et al., 2013; Salem et al., 2016). This technique is also suitable and healthy alternative to chemical post-harvest treatments (Hussain et al., 2013). Especially 1-1.5 kGy doses successfully use for Japanese plums (Hussain et al. 2013; Salem et al., 2016). Combined 1 kGy gamma irradiation with 3% chitosan positively effect on reducing disease incidence of cv. Kelsey (Salem et al., 2016).

3.6. Heat treatments

Heat treatment has beneficial effects for extending shelf-life and reduced wound-induced (Lurie, 1998; Serrano et al., 2004). Treating plums with heat (45 °C) and stored at 2 °C for 28 days improved firmness and decreases flesh deformation (Valero et al., 2002b).

CONCLUSION

Japanese plums are one of the most produced plum species in the world. It is understanding from the studies, storage and shelf life can be extended with many post-harvest technologies. Efforts to be made to combine different technologies, either alone or in combination with other technologies, will prolong the storage and shelf life. In this way, consumers will be able to reach good quality Japanese plums in the long term and both consumption and production will be encouraged accordingly.

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CHAPTER 9

LIFE CYCLE ASSESMENT OF FRUIT PRODUCTION

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INTRODUCTION

The information we use faster and more in all areas of life is the output of science. This century, which is the output of science, is actually the Information Age. In order to be able to show the right approaches in agriculture, industry, economy, in all areas of life, it is necessary to reveal known knowledge more clearly. So as to ensure sustainability in fruit growing, we need to be aware of the importance of the fruit life cycle, which is the basis of vitality.

Sustainability is meeting the needs of today with the needs of the future. Sustainability is a life cycle with economic, social and environmental effects, just like agriculture. The life cycle is a concept that includes the value chain. The life cycle includes production, consumption, environmental protection and improvement. Therefore life is the basis of the life cycle (Gökkür, 2019a).

The term sustainability means using the limited resources of the environment effectively to leave a better world for future generations. The relationship between nutrition and environment is important for societies to lead a healthy life. To combat both undernutrition and overnutrition, culturally acceptable, accessible, affordable, sustainable nutrition systems should be developed (Akay and Demir, 2020).

Environmental problems that arise with industrialization, on the one hand, rise of the concept of sustainable development, on the other hand, to make the production-consumption chains more sustainable, new techniques and It paved the way for the birth of evaluation methods.

Life Cycle Analysis (LCA) is a method developed for this purpose. This method is known as an effective evaluation technique that guides the decision makers about what to do in order to make the production, consumption, waste, recycling processes, in other words, the life cycle of the product (Yıldırım, 2014).

In this chapter, a new life cycle will be created by mentioning the parameters that affect the life cycle of fruit trees and neglected to be added to the cycle.

1.Effects of Climate Change on The Life Cycle of Fruit Trees

Changing climates, melting of glaciers, rising sea level, increasing temperatures, increasing diseases and pests, and ecological systems being affected directly or indirectly by all these changes with the change of all life in the world are the biggest disaster of the last century (Özçatalbaş, 2014). Climate change is the variation of weather conditions over various regions within a specified period of time, which affects all living things, usually as a result of human activities. This differentiation is actually a long-term change in climatic parameters such as precipitation, temperature, humidity, evaporation, wind speed, sunshine duration and pressure (Gökkür, 2017). With climate change, the life stages of all living things are changing. The change of life stages also means the deterioration of the life balance in the World (Gökkür and Şahin, 2020). One of the factors affecting the life cycle is climate change. Every unusual weather event observed due to climate change affects the life cycles and literally seeps into the cycle.

Since fruit growing is a perennial agricultural activity, it is highly affected by global warming. The chilling requirement necessary to obtain quality products with fruit set and balanced flowering in fruit growing varies depending on the species. In studies using dynamic models that calculate the amount required for winter chilling, it has been determined that there may be sudden decreases in winter temperatures that may threaten production for warm and temperate regions, and sudden increases in cold regions (Beppu and Kataoka 1999; Luedeling et al., 2011; Tıraşcı and Erdoğan, 2021).

Agricultural production is primarily affected by changes in climate parameters such as temperature, precipitation and humidity, in other words, climate change. Along with climate change, the increase in summer and winter temperatures in some parts of the world will cause decreases in agricultural production due to the insufficiently of plants to adequately meet the need for chilling times. Breeding studies should be increased for the development of drought-resistant varieties with low chilling requirement. In some fruit species, under extreme cold conditions, the leaves of the trees become brown, their shoots turn brown, their trunks freeze. Depending on the severity of the cold, this may result in the death of the tree (Gökkür, 2019c).

Due to climate change, increasing temperatures in recent years and irregular precipitation many parts of the world are faced with the risk of drought of varying severity from time to time. The fact that the precipitation does not fall before the irrigation season due to climate change, less fruit set in the trees as a result of the flower shedding due to excessive precipitation during the flowering period, and the fact that the plants cannot adequately meet the chilling requirements due to the increase in temperature cause changes in yields over the years.

Extreme temperatures cause the increase of harmful microorganisms in the soil, slow down photosynthesis, and as a result, plant growth and pollination ability are reduced (Bayraç and Doğan, 2016). The excessive moisture that occurs during the pollination times of some fruit trees prevents pollination by sticking the pollen dust together. The hot and drier winds that will occur during this period will dry the stigma and reduce pollination and fruit formation. In some fruit species, the effect of heat decreases in high humidity, but an environment suitable for some diseases occurs. Insufficient relative humidity and arid conditions adversely affect the transformation of flowers into fruit. If the relative humidity is low, the water requirement of some fruit trees in the soil increases (Ayaz and Varol, 2015; Gökkür, 2019c). Varieties that consume less water should be developed.

Furthermore the bees that take part in pollination serve a great deal to plant production. In recent years, pollination is interrupted due to the adverse weather conditions experienced during the flowering period and the inability of pollinators to fulfill their duties (Topal et al., 2016).

Because the decrease in precipitation will negatively affect the yield, it will cause a decrease in the incomes obtained from agriculture. Since flower bud formation in fruits begins from the previous year, precipitation decreases affect the yield and quality of the next year. According to the phenological period of the plant, hail damage can cause flower and fruit drop, quality loss in fruit, and diseases due to wounds in the plant. Cracking in some fruit species on account of excessive precipitation, diseases in the root regions of plants because of groundwater elevations, and yield decreases owing to flower shedding can be seen. It should not be ignored that the phenology and climate demands of each variety within the species are different (Gökkür, 2019c).

Increasing the use of drought-resistant species and varieties in agricultural areas, ensuring the production of plants that need less irrigation water and preparing water management plans are necessary for sustainable agricultural production.

Due to climate change, there is an increase in diseases and pests in some regions. This situation can create many environmental threats such as the use of more pesticides and the pollution of our soil and fresh water resources. In fruit growing, it is necessary to know the life cycles of diseases and pests that affect the fruit type and to fight before the stages of the cycle occur.

When agricultural production is high, the decrease in sales revenues is one of the important problems. Besides with climate change, the agricultural sector is affected by changes in climate parameters such as precipitation, humidity and temperature, more positively or negatively than other sectors. Since the producers determine the next year's production decision according to their post-harvest income, the cycle between production amount and demand prevents price standardization in agricultural products (Gökkür, 2019b). In many parts of the world due to climate change, economic losses occur due to yield reductions in fruit production. This situation will cause a change in the food supply and demand balance. Price management in fruit growing is one of the most important factors for the sustainability of the life cycle.

The most important factor affecting the life cycle of fruit trees is climate change. Therefore, climate change must be added to the life cycle of fruit trees.

It is inevitable that climate change will create a pressure that negatively affects the survival of genetic resources. As a result of the pressure on endangered species with important genetic characteristics in the development of cultivars used in agriculture, cultivars, local cultivars, wild relatives and wild plant species constituting vegetative genetic resources will be directly adversely affected and the possibility of extinction will increase (Newton et al., 2008, Özgen et al., 2015). Climate change negatively affects the varieties of some fruit species. Using new breeding studies of varieties conserved in field gene banks will benefit the protection of the life cycle of fruit species.

2.Economics of Fruit Production

As well as the agricultural sector is important in terms of supplying raw materials to agriculture-based industries, it is also an important market for other industries. Agro-based industries contribute to the economy by processing agricultural products, assisting their conservation and transportation, and expanding their marketing opportunities (Bayramoğlu and Gündoğmuş, 2008). While the agricultural sector, which has felt the effects of artificial intelligence, internet of things and Industry 4.0 technologies until recently, is gradually becoming digital; after the Covid-19 epidemic, topics such as rising food prices, access to food, breaks in the food supply chain and food crisis became important agenda items all over the World (Çetin and Yücesoy, 2020). Sometimes government interventions can be made in order to ensure environmental and food security, unemployment, foreign exchange inflow, production of raw materials for industrial products, protection of the domestic market from foreign products, and increasing the welfare of producers and consumers (Şahinöz, 2010; Çetin and Yücesoy, 2020). For these reasons within the framework of socio-economic goals, all states have intervened directly or indirectly in the agricultural sector (Çetin and Yücesoy, 2020).

For the region to be established in fruit growing, feasibility studies should be carried out on primary issues such as soil structure, climate characteristics, infrastructure opportunities, irrigation, marketing and economic conditions. If the region is suitable for fruit growing, species and cultivar recommendations should be made accordingly (Karamürsel et al., 2016).

For a long-term agricultural production planning, it is necessary to take into account the parameters of the market, such as cost and income, as well as the agricultural product development period. The time to market of a product can be determined in relation to the product development period.Varieties of fruit species are the result of production preparation combined with long research and development activities (Elbert, 2011; Yüce et al., 2019).

Previously the purpose of marketing the product should be determined. Problems and alternative costs (opportunity cost) in agriculture should be considered together with the marketing objective. Planning and Evaluation Phases must be included in this model. The plants used in production constitute our main food source. These plants are the raw material of the model. Production is essential for obtaining raw materials. Research and Development (R&D) studies and Market Research are required for sustainable production. Product supply agreements made by some growers with consumers are also part of this model. In order to reduce operating costs and increase farmer welfare in rural areas, the minimum land size should be determined according to the regions. For farmers whose land size is not economical, many options such as cooperation with other farmers, incentives for renting land can be offered. Land rental problem is another important problem encountered in production. Agricultural land to be leased must be for at least four years or longer. If the farmers do not have to worry about being removed from the area where they will produce, they can plan their production every year. Necessary arrangements must be made for this (Gökkür, 2019a).

Some producers decide on the plant pattern they will grow according to the current market conditions and traditionally. However, this situation is not very suitable for the existing infrastructure of the network, the hydraulic characteristics of the channels and the water supply capacity.

Planning the irrigation in accordance with the real-time and optimum irrigation conditions and the development periods of the plants is necessary for the protection and sustainability of our water resources (Kılıç, 2010).

Gökkür (2019a), in his research, reports that Goal Setting Process (Feasibility Studies, Profitability Studies, Export, Internal Market, Competitiveness, Fight Against Poverty, Climate Change, Ensuring Food Security), Determination of Needs (Costs, Cost Reduction Techniques (Reducing Input Consumption and Conservation of Natural Resources), Research and Development Activities, Breeding Studies to Develop New Varieties), Strategic Planning (Effective Management of Operations and Technological Innovations in Agriculture, Determination of New Policies in Agriculture), Effective Use of Resources (Increasing Agricultural Lands by Consolidation or Common Use, Efforts to Spread Water-Saving Technologies in All Sectors), Agricultural Product Management Practices in Agriculture and Livestock, Storage, Marketing and Sales, Recycling (Using Cracked or Hail Damaged Fruits As Fertilizer) in The New Life Cycle Model for Sustainability Agriculture must be present.

Product life cycle costing is one of the techniques that agricultural enterprises can use as a strategic cost management tool. The product life cycle cost method enables agricultural enterprises to continuously gain competitive advantage in a global competitive environment. The product life cycle cost method covers all of the costs that may arise during the life cycle of a product. The sum of the costs of a product during its life cycle can be compared with the incomes that the product will bring to the agricultural enterprise throughout its life cycle. As a result, the real profitability of the agricultural enterprises will emerge. The product life cycle cost method aims to manage these costs. Costs need to be calculated and managed by planning. Therefore, the focus should be on why costs arise. Activities that cause costs should be planned and costs should be kept under control (Caner, 2011).

From a marketing point of view, the life cycle of the product can be analyzed in four stages. At each stage of the product, the life of the product should be evaluated according to different criteria. Accordingly, it should be considered as start up, growth, maturity and decline stages. While the sales volume is low at the start-up stage, the sales tend to increase in the growth stage of the product. After the product is placed in the market, sales tend to decrease in the maturity stage, while sales decrease in the decline stage of the product (Pazarçeviren and Celayir, 2019). The lifespan of fruit trees curve and the product life cycle stages curve show a similar trend (Figure 1).

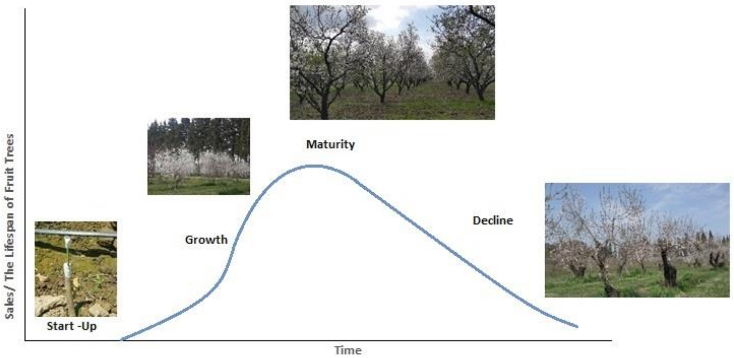

Figure 1: The product life cycle stages curve (Kaygusuz, 2011; Salih GÖKKÜR).

Depending on the stage in the life cycle of the trees in fruit growing, there may be periods when it produces less and sometimes more. The periods in the life cycle, which are part of the plant's life cycle, are linked to the plant's life income return.

Countries should increase their infrastructure investments for the development of post-harvest technologies in order to meet the demand for fruit at the desired level and quality, taking into account the demands of national and international markets for the types of fruit they produce (Gül and Akpınar, 2006).

3.New Life Cycle Assesment

Due to the dependence of agricultural production on natural conditions, there are fluctuations in yield and production from year to year (Gül and Akpınar, 2006). Life cycle analysis is a system that evaluates all the environmental effects of a product or process, from the supply of raw materials from nature until all wastes are returned to nature. This assessment includes all impacts to air, water and soil during product processing, energy consumption, raw material production, shipping, use and post-use waste disposal. The environmental effects are evaluated on the basis of natural resource consumption such as acidification, eutrophication, climate change, toxic emissions, depletion of the stratospheric ozone layer (ISO, 1998; Üstün Odabaşı, 2020).

Stages of Life Cycle Analysis (ISO, 1998; Üstün Odabaşı, 2020)

1. **Purpose and Scope:** At this stage, the purpose, content, boundaries and level of elaboration of the study are defined.

2. **Inventory Analysis:** The energy, water, raw material usage and related environmental emissions that will occur within the scope of the system are determined.

3. **Impact Analysis:** The potential effects of energy, water, raw material use and environmental emissions determined in the inventory stage on human health and environmental values are evaluated.

4. **Interpretation:** The results of the inventory and impact analysis stages are evaluated and a product, process or service is selected among those that are compared. Estimates and existing uncertainties made during this selection are clearly indicated within the scope of life cycle analysis.

The term Life Cycle actually contains more than the first meaning that comes to mind. All life events are interconnected. Demand is necessary for the sustainability of fruit growing, and production is necessary to meet the demand. In the Planning of Agricultural Production, it is necessary to determine all the requirements for Cultivation. These requirements include all cultural activities in the field as well as all harvest, pre-harvest and post-harvest activities. Life Cycle is actually a comprehensive concept that includes the Value Chain.

Standardization has been achieved in fruit production with the use of rootstock. The use of rootstock in fruit cultivation positively affects the product quantity, quality, development, resistance to diseases and pests, and ability to different climatic and soil conditions of the grown variety

(Kuckuck, 1979; Güleryüz, 1987; Güleryüz, 1993). The life cycle in fruit growing starts with the Research and Development activities and variety breeding processes related to the supply of the product to be grown. The process of deciding on the types and varieties of fruit to be grown in fruit growing is the next step. Karık and Tunçtürk, (2019) stated in their study that as the cultivation, breeding and cultivar development studies of different species continue, the number of varieties registered will increase over time. Thus, while the number of standard production materials required by different types of producers increases, quality production will be developed.

The life cycle of fruit trees consists of seed, sprouting seed, sprout, sapling, young tree, mature tree with flowers, pollination, mature tree with fruits, fruits with seeds (Figure 2).

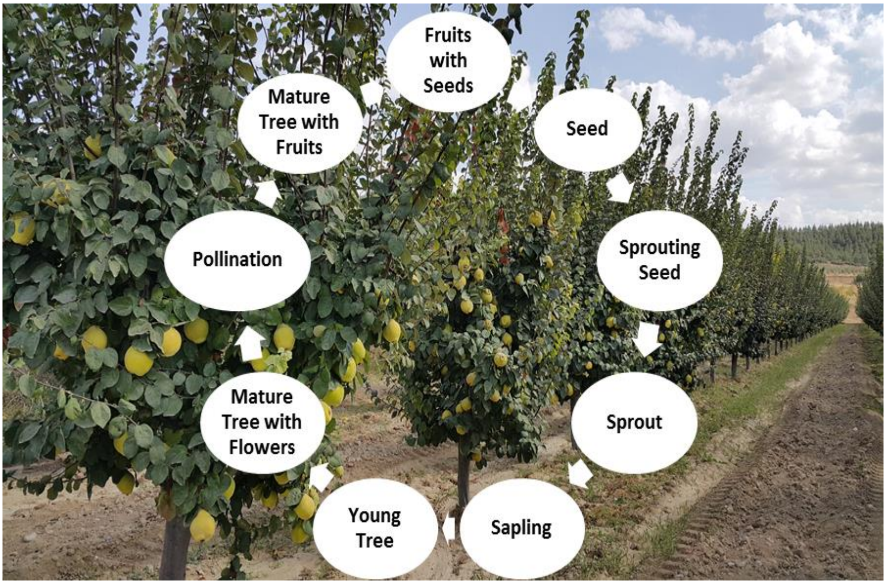

Figure 2: Life cycle of fruit trees.

The soil takes place in agriculture with its fertile part (very rich in minerals and moisture for the development of the plant). The methods chosen during the stages of preparing the soil for planting, development and harvesting determine the lifespan and efficiency of soil (Kılıç, 2020). The wrong agricultural practices of the farmers during the production periods in the field cause various environmental problems (Munoz et al., 2008; Kılıç, 2020). Activities related to making the land suitable for cultivation are actually a part of the life cycle of fruit growing.

Opportunity cost in agriculture suggests other best alternative for fruit growing. The selections that may result in changing the fruit type or fruit variety in cultivation are part of the life cycle in fruit growing. Being successful in sustainable fruit growing is possible by being aware of the fact that all the factors affecting the life cycle are parts of the cycle. Demirer (2011) noted that life cycle analysis is a structure that includes different life cycles. In this framework, examining a product or process for all life cycles becomes possible only with certain simplifications. Life cycle analysis deals with the environmental aspects of products and processes. These environmental effects are evaluated on the basis of natural resource consumption such as climate change, depletion of the stratospheric ozone layer, eutrophication, acidification, and toxic emissions.

In recent years, completely natural fertilizers obtained from plant residues have been started to be used in agriculture, taking into account factors such as the protection of soil structure, the protection of underground water resources and nature. The collection of wastes and recycling them to nature as fertilizer is the main key to the life cycle. The fertility of the soil can be increased by using the compost to be obtained from the evaluation of fruit wastes. The use of fruit residues as fertilizer in agriculture can make significant contributions to increasing the income level of farmers. The water source is part of the life cycle. The part of the irrigation water used in fruit growing that does not mix with groundwater can be collected in the tanks and used for irrigation of ornamental plants.

The stages of fruit processing post-harvest are also part of the life cycle. Because in order to grow for fruit, it must be demanded according to the consumption type. In addition energy efficiency should be considered in the storage of post-harvest fruits.

Low energy consumption in agricultural activities ensure the protection of the environment and the continuity of the life cycle. Due to the fact that the solar panels used to obtain energy from solar energy cover the agricultural lands, shrinkage in the areas where fruit cultivation will be made in the future. To solve this problem, agrivoltaic systems can be used. Agrivoltaic systems allow the simultaneous use of farmland to produce crops and produce photovoltaic (PV) electricity (Figure 2). These systems can be used in areas where dwarf fruit cultivation will be preferred in the future. Furthermore, the decrease in fruit growing areas due to the increasing use of agricultural land for biofuel production threatens the life cycle of fruit growing. Agricultural lands to be used for biofuel production should be moved to regions that are not suitable for fruit growing. Efforts to reduce the negative effects of agricultural inputs on climate change and the environment with optimum use of natural resources and energy must be included in the life cycle analysis.

Figure 3: Image of agrivoltaics systems for pear orchards (Image: KU Leuven, URL-1).

Despite the decrease in the production areas in fruit growing, the increase in the yields obtained from per unit area is an indicator that our farmers have adopted technological innovations. The use of new technologies in fruit production enables fruit species to reach more people. Smart farming technologies are also part of the life cycle of fruit growing.

CONCLUSION

The life cycle is actually the cycle of existence. Life is a chain of interconnected events. All activities related to fruit growing are part of the life cycle.

The new life cycle in fruit growing should include the following processes:

The lifespan of fruit trees (which consists of seed, sprouting seed, sprout, sapling, young tree, mature tree with flowers, pollination, mature tree with fruits, fruits with seeds), choosing locations for fruit trees, climatic requirements, types of soil for growing fruit trees, land preparation, the existence of supply and demand for seedlings, plant spacing and planting distances, rootstocks for fruit trees, varieties, pollination, ecosystem interactions, plant propagation methods for fruit trees, natural resources consumptions of the fruit trees, irrigation, fertilization, pesticides, pruning, fruit thinning, farm equipment and agricultural machinery, fuel required for field operations, emissions to atmosphere from combustion of the fuel, energy consumption for agricultural activities, harvest methods, cold storages, farm laborers, transport of agricultural products, supplier, producers (farmers), merchant, industries, street hawkers, retail chains, middleman, wholesalers, food suppliers, neighborhood market, grocery stores, greengrocer, exporters, consumer, natural disasters (drought, climate change, change in plant diseases and pests, insufficiency of water resources, floods, floods, hail, frost damage, epidemic diseases like covid-19), consuming different agricultural products due to water scarcity, turning towards different agricultural products due to changing habits

In fruit growing, interspecies relationships can be effective in the spread of diseases and pests. The cycles of diseases and pests should be taken into account in the planning related to the cultivation of different fruit species in the same land in fruit growing areas.

Today, with the developing technology, the traceability of all activities affecting fruit growing can be beneficial in the assesment of the life cycle of fruit growing. The most important thing to note is that systems that store data have a high memory capacity.

Furthermore, by the use of modern technology, the changes in the life cycles of varieties of fruit species depending on climate change can be monitored with cabins consisting of various heating systems.

Climate change, the spread of epidemics all over the world, food security endangered by the use of agricultural lands for other purposes, can overcome all problems with new production plans that will be formed by recognizing that there are many cycles in the life cycle. The protection of agricultural lands can be ensured by increasing the number of orchards created with perennial plants. In fruit growing, sustainable production can be achieved by planning the production according to the life cycle. It should not be overlooked that the life cycle in fruit growing is a big concept that includes many cycles.

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CHAPTER 10

TEA AGRICULTURE in TURKEY

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INTRODUCTION

Tea (*Camellia sinensis* (L.) O. Kuntze) is a valuable plant belonging to the *Theaceae* family. Its known homeland is China (Weisburger, 1997). Tea is the most preferred beverage in the world following water. It is obtained from processing the leaves harvested from different varieties of this plant using different methods. The popularity of tea is related to its aroma, taste, and medicinal benefits (Lin et al., 2003). Tea is rich in polyphenol compounds and possesses numerous pharmacological properties including those which are antidiabetic, antimicrobial (Koech et al., 2013), antioxidant (Karori et al., 2007; Kerio et al., 2013; Yazıcı, 2016; Yazıcı and Göksu, 2017) and anti-aging (Khan and Mukhtar, 2007).

The tea plant is grown between the 42nd latitude in the northern hemisphere and the 27th latitude in the southern hemisphere. The majority of the tea producing countries are located in the continent of Asia where China, India, Sri Lanka are the major producers. Tea producer countries in Africa are located in the tropical region and include Kenya, Malawi, Rwanda, Tanzania, and Uganda. Apart from these regions, some quantities of tea are also being produced in South America (Argentina, Brazil and others), the Near East (Iran and Turkey) and the CIS (Russia and Georgia) (Majumder et al., 2010). The top three countries in world tea production are China (2.473 million tons), India (1.325 million tons), and Kenya (440 thousand tons). Turkey ranks 6th after Sri Lanka (350 thousand tons) and Vietnam (260 thousand tons) with a production of 234 thousand tons (Faostat, IGG, ITC). In terms of world annual tea consumption, Turkey ranks first (4 kg/person). In world tea exports, Kenya, China, Sri Lanka, India, and Vietnam occupy the highest ranks while Turkey ranks 31st with 3,968 tons (Anonymous, 2019a; Majumder et al., 2010).

Of the world's tea production, 58% consists of black tea, 30% of green tea, and the remaining 12% of oolong tea, white tea, instant tea, and other tea products. Although there are many different tea types, black and green tea production holds the biggest share in the world tea trade. According to the FAO reports, tea consumption continues to increase in the world, however, the share of black tea in consumption is in a decrease and the ratio and market shares of other tea types, especially green tea, are increasing. The most important green tea-producing countries in the world are China and Japan while the largest producers of black tea are India and Kenya. The largest producers of oolong tea are China and Taiwan while a very important part of the white tea market is in the hands of China (Anonymous, 2020b).

Today, in addition to black, green, oolong, and white tea produced by traditional methods, some other tea and tea-by-products produced using new technologies continue to take their place in the international tea trade. Due to the competitive conditions in the beverage industry, these novel tea products and value-added products obtained from tea that were developed to add individuals who do not consume tea and tea products to the consumer profile, have an important share in the international market. The majority of tea traded until the 1960s were marketed as bulk black tea. Today, on the other hand, a transformation is underway both in terms of product range and in consumption with novel popular tea products including packaged bulk tea, teapot bags, cup tea bags, granulated tea, pressed tea, flavored tea, decaffeinated tea, instant dissolving tea, and ice teas. However, almost all of the tea produced in Turkey is consumed in the domestic market, and the export ratios are generally low due to both the quality differences and high costs. The biggest tea export product is the bulk black tea (Anonymous, 2019c).

It is of great importance to increase the product quality for Turkey to be more involved in the international tea trade and to be able to compete in the world market by creating brand products. To produce quality dry tea, it is necessary to take measures to improve the quality of the tea plant, the main raw material source. Due to the fact that all tea plantations in Turkey are established by sowing seeds, the yield and especially quality of the harvested tea leaves show differences. This may cause problems in obtaining a high-quality standard and homogeneous production and negatively affect exportation.

Therefore, studies on developing high-yield and quality clones for the renewal of the tea gardens and to obtain novel tea products with high added-value and marketabilty in the world will play an important role in the development of the Turkish tea industry.

1. HISTORICAL BACKGROUND OF TEA AGRICULTURE IN TURKEY

The recognition of tea by the Turks dates back almost to the same period with that of the European nations. The recognition of tea as a beverage in Istanbul dates back to the 1600s. The rapid spread of tea drinking in the Ottoman period also initiated attempts to grow tea in the country, and tea saplings brought from China by İsmail Pasha, the Minister of Commerce of the time, were planted in Bursa in 1888. However, the fact that the ecological conditions of the region are not suitable for growing tea caused this attempt to fail (Anonymous, 2019c; 2020a).

The later initiatives related to tea farming in Turkey had developed after 1917. In the delegation sent to Batumi to conduct investigations, mentioning the high amount of money paid for tea imports, Ali Rıza Erten explained that tea plants can be grown in the coasts of the Eastern Black Sea, which have a similar ecology, and suggested that tea cultivation should be carried out in the Rize region. However, due to the events that have priority emerged after World War I, Ali Rıza Erten's report was not taken into consideration at that time (Anonymous, 2019c).

Unemployment, migration, and economic problems experienced in Turkey after World War I made it necessary to create a source of income and new business areas for the people of the region. To solve these problems, according to the report prepared in 1917, Law No. 407 dated 16 February 1924 on the cultivation of hazelnuts, oranges, tangerines, lemons, and tea in Rize province and Borçka district came into the force. Agricultural Engineer Zihni Derin was assigned to carry out the tea production activities initiated according to this law. With the positive results of the work carried out from 1924 to 1937, 20 tons of tea seeds were imported from Batumi in 1937, 30 tons in 1939, and 40 tons in 1940, and the activities on establishing tea garden facilities were initiated. In 1938, the first tea product was harvested (135 kg) and 30 kg of dry tea was produced (Anonymous, 2019c).

The first tea factory in Turkey was established in the Fener district of Rize province in 1947 with a capacity of 60 tons/day. The name of the factory, which was later changed to Zihni Derin Factory, was established in 1950 at an economical scale. Since the amount of tea produced in Turkey could not meet the domestic consumption in the first years, the tea deficit was met by imports. However, in 1964, tea production was able to meet domestic consumption and tea imports were halted. After this date, albeit in a low amount, tea exports have started.

For many years, tea agriculture in Turkey was carried out by the Ministry of Agriculture while the purchase, processing, and marketing of harvested tea leaf were carried out by the Ministry of Customs and Monopoly. In 1971, it was decided that tea farming and tea marketing should not be carried out under the responsibility of different Ministries from that day forward, and, accordingly, the General Directorate of Tea Institution (ÇAYKUR) was established. From 1971 to 1984, ÇAYKUR continued its activities in a monopoly position in accordance with the country's agricultural policy. The tea business, which was maintained under a state monopoly until 1984, was liberated with the "Tea Law" dated 1984 and No. 3092, and ÇAYKUR was removed from the monopoly position. With this law, the production, processing, and marketing of tea were liberated and, thus, tea was opened to the private sector. Article 1 of the Law states that real and legal persons can establish and operate harvested tea leaf processing and packaging factories and that they can purchase harvested tea leaves they need directly from the producers, and this policy has been followed until today. This change made in 1984 has been one of the most important changes seen so far in the history of tea production in Turkey (Anonymous, 2019b; Anonymous 2019c; Anonymous, 2020a; Üstün and Demirci, 2013).

As of today, as a result of the regulations and developments from the past to the present, tea has become a valuable and strategic agricultural product that significantly affects the social, economic, and environmental aspects of the lives of the people of the Eastern Black Sea Region in Turkey.

2. THE IMPORTANCE OF TEA AGRICULTURE IN TURKEY

Tea is an important product that significantly affects the lives of people and farmers in the Eastern Black Sea Region of Turkey, in the evaluation of own resources, in creating employment, in supplying raw materials to other industries, and with its high added value. Tea is an important source of income for its producers in Turkey, as well as in other countries where it is cultivated. Tea is a strategic industrial plant with a high potential to create new added values in the economy, allowing the rough lands consisting of high slopes and mountainous regions to be brought into the economy.

In Turkey, tea is cultivated in the provinces of Rize, Trabzon, Artvin, Giresun, and Ordu (Figure 1,2). Of the total tea production areas in Turkey, 67% are located in Rize, 20% in Trabzon, 11% in Artvin, and 2% in Giresun and Ordu. Rize is the most important province in tea production and has a 68% share in Turkey's total harvested tea leaf. This is followed by the province of Trabzon with a share of 19.6%. The total share of Artvin (10%), Giresun (2.3%), and Ordu (0.1%) in production is 12.4%. In Turkey, in the Eastern Black Sea Region, approximately 214,183 producers working in the tea agriculture sector on an area of approximately 800,000 decares are engaged in tea farming in the form of small family businesses, and 80.0% of the producers have tea gardens of 5 decares and smaller. The area owned by these producers constitutes 56% of the total tea cultivation area (Anonymous, 2019b,c; Anonymous, 2020a,b).

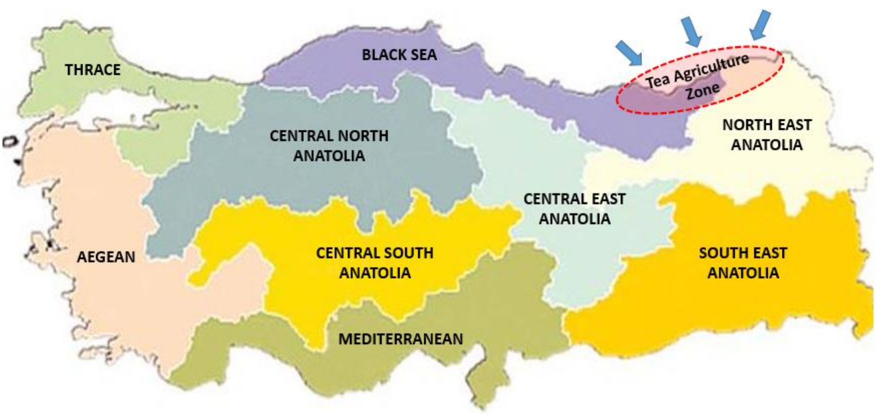

Figure 1: Agricultural zones of Turkey including the tea agriculture zone (shown with striped-red oval circle in the upper right side of the map) (Yazıcı and Turgay, 2021)

The total amount of harvested tea in Turkey in 2020 was 1.450,556 tons. From this harvested tea, 297,000 tons of dry tea was produced. Of the harvested tea, 46.75% was processed by the private sector and 53.25% was processed by ÇAYKUR. There are 207 tea factories engaged in production in the tea sector. Of these, 47 are factories of ÇAYKUR whereas 160 are tea factories owned by the private sector. Of these factories, 119 are located in Rize, 26 in Trabzon, 12 in Giresun, and 3 in Artvin (Anonymous, 2020a; Anonymous, 2020c).

Table 1: Tea production in Turkey, cultivation area distribution and the number of farmers (Anonymous, 2020c)

Years	Number of Farmers (person)	Area (decare)	Harvested Tea (Ton)
2006	203 431	766 136	1 121 206
2007	203 901	765 808	1 145 321
2008	199 231	758 257	1 100 257
2009	200 798	758 513	1 103 340
2010	202 494	758 641	1 305 566
2011	205 312	758 895	1 231 141
2012	206 724	758 566	1 250 000
2013	207 660	764 255	1 180 000
2014	208 464	760 494	1 266 311
2015	209 084	762 073	1 327 934
2016	209 086	763 609	1 350 000
2017	209 086	821 079	1 300 000
2018	209 087	781 334	1 480 534
2019	212 692	785 693	1 407 448
2020	214 183	786 813	1 450 556

The biggest tea production in Turkey is black tea production, and significant developments have been recorded in organic black tea production. The production of green tea, white tea, and oolong tea types, however, which have undergone significant developments in the world and of which their production has increased, has not yet reached the desired levels (Table 2). However, in recent years, important studies have been carried out to produce these teas with high added values.

Table 2: Dry tea production amounts in Turkey by years (Anonymous, 2019)

Product	2016	2017	2018	2019
Black Tea (tons)	129.330	94.660	130.731	134.985
Organic black tea (tons)	4.487	4.996	5.779	6.056
Green Tea (tons)	206	125	37	16
Organic Green Tea (tons)	39	9	1.4	10
White tea (kg)	130	210	225	57

Figure 2: A view of tea orchards in Turkey

4. PROBLEMS OF TEA AGRICULTURE IN TURKEY AND POSSIBLE SOLUTION SUGGESTIONS

It is of great importance for Turkey to increase the quality of tea to take a greater place in the international tea business and to be able to compete in the world market by creating branded products. All of the tea gardens in Turkey were established by sowing seeds. The fact that tea plantations are established with seeds in Turkey causes the leaves harvested in these cross-pollinated plants to differ in terms of yield and especially quality (Yazıcı et al., 2016). This may cause problems in obtaining a high-quality standard and homogeneous production and negatively affect exportation. Therefore, studies have been focused on the development of quality and standard tea varieties and the renewal of tea gardens with these varieties in recent years in Turkey. Because another important problem of tea cultivation in Turkey is the aging of tea gardens and their loss in terms of yield. Considering all these problems, studies have been initiated to establish national tea gene pools in Turkey, to identify tea variety candidates with high yield and quality, suitable for different production processes such as black, green, white, and oolong tea, with high commercial value and high competitivity in the world market. Within the scope of these studies, two large tea gene pools were established as a result of the selection studies carried out in the tea plantations in Turkey. Also, studies have been initiated within the scope of renewing the tea gardens with high-quality tea varieties.

Another problem seen in tea plantations in Turkey is the inability to obtain the target yield and quality from the unit area due to the deficiencies in cultivation techniques such as fertilization, pruning, disease and pest control, and the decrease in soil fertility due to inappropriate applications. The most important problem with the soil in tea production areas is the low pH level. Rehabilitation of acidic soils is an important problem worldwide. In general, the tea plant develops optimally in soils with pH between 4.5 and 6.0. When the pH in the soil drops below 4 for any reason, the tea plant cannot develop normally and quality harvested tea leaves cannot be obtained. In this case, it becomes impossible to grow quality products. There were no problems in the lands where tea was grown at the beginning of tea cultivation in Turkey. However, as a result of unilateral and excessive use of ammonium sulfate fertilizer recommended for tea plants for many years, the pH of the soils where tea cultivation has been carried out has gained excessive acidity over time. The pH level was below 4 in only 0.12% of the soils in Turkey's tea plantations in 1960. In 1989, it was observed that the pH decreased below 4 in 84.57% of the soils. Although there is a current slight improvement in soil pH, this improvement cannot be regarded as sufficient (Taban and Namlı, 2019; Anonymous, 2019c; Anonymous, 2020a). Therefore, it is important to improve tea gardens and increase productivity in Turkey.

Tea-growing areas in Turkey are very rich in terms of organic matter. However, because of dense planting and no spacing between rows in tea gardens, cultural processes such as hoeing cannot be carried out in tea gardens and organic matter accumulates on the soil surface. Therefore, even if the soils where tea cultivation is carried out are rich in organic matter, they are far from showing the expected benefits since they do not undergo mineralization. Therefore, it has been recommended that the newly established tea gardens should be adopted leaving the distances between the rows where cultural practices such as hoeing can be effectively done.

Soil fatigue takes place as a result of deterioration in the biological balance of the soil in time in monoculture farming areas and as a result, the yield decreases. Tea, like other plants, needs macro and micronutrients. To be able to grow efficient and high-quality tea, the macro and micronutrients needed by the plant must be at sufficient levels in the soil and the plant must ingest these nutrients. It has been known that, in the gardens where tea cultivation has been carried out for many years in Turkey, the soils have become poorer in terms of nutrients and nutrient deficiencies have occurred in the soils.

Therefore, it is necessary to determine the missing nutrients by making soil and plant analyses in tea plantations and fertilize accordingly (Taban and Namlı, 2019).

Since a significant part of the areas where tea cultivation is carried out in Turkey are sloping lands, mechanized farming practices in tea farming remain to be very limited. However, the increase in labor costs in recent years has increased the demand for agricultural mechanization, especially pruning. Agricultural machinery is used for pruning, harvesting, and soil cultivation in many countries that carry out tea agriculture in the world. The number of agricultural machineries specialized in tea has remained limited in Turkey. At this point, existing gardens and tea gardens to be newly established or renewed should be planned in accordance with mechanized agriculture to facilitate the interrow soil cultivation, fertilization, and pruning processes.

Since the tea plant is a perennial shrub/tree, it needs regular pruning and maintenance on the branches. Tea plant pruning is the most important cultural practice that directly affects productivity and quality. Therefore, pruning has taken its place as a mandatory and indispensable cultural measure in world tea agriculture. In tea-producing countries in the world, different pruning (light, medium, heavy pruning), and flat-top pruning methods have been adopted. While pruning in tea gardens in Turkey is applied for rejuvenation, especially in tea gardens with advanced age, every year at the end of the harvest seasons, light trimming of the branches, called flat-top pruning, is also carried out to maintain the productivity of the tea plants. To rejuvenate the tea gardens, 1/10 of the area is pruned and controlled every year within the scope of the pruning project currently implemented by Turkey's ÇAYKUR in the tea gardens.

In many leading countries in tea production in the world, some pesticides are used against diseases and pests within the scope of conventional production and good agricultural practices. In tea cultivation in Turkey, a natural sustainable production model without the use of pesticides is taken as the basis as tea diseases and pests are not intense and at a negatively economical level in the gardens. Disease and pest management in Turkey has been reported to be the most advantageous area of tea production. Again, the use of herbicides in tea gardens is not allowed due to its harmful effects on the environment and the product. To maintain and preserve a sustainable ecosystem against diseases and pests in Turkey, measures are taken with cultural processes and biological control methods.

5. THE STRENGTHS OF TEA AGRICULTURE IN TURKEY

- It is important for R&D studies in the region that Recep Tayyip Erdoğan University (RTEU), which is a specialized university in tea agriculture, is located in Rize, where 67% of tea is grown. RTEU Tea Specialization Coordinatorship has initiated important projects for the solution of the above-mentioned problems.
- It is an important advantage to have two Tea Research Centers and a Tea Research Institute in the province of Rize. A trilateral protocol was signed between “RTEU Tea and Tea Products Application and Research Center”, “Ministry of Agriculture and Forestry” and “Atatürk Tea and Horticultural Research Institute” and the project for the renewal of tea gardens has been initiated.
- Black, white, green and oolong tea types will be developed as a result of the project entitled " Establishment of tea plant gene pool and determination of commercial tea variety candidates " carried out in partnership with RTEU and Atatürk Tea and Horticultural Research Institute. Within the scope of this project, two Tea Gene Pools have

been established to host at least 2000 tea genotypes and will make significant contributions to Sustainable Tea Agriculture in Turkey.

- Organic tea production has also been encouraged in Turkey in recent years, and studies have been carried out for successful organic tea cultivation in a wider area. The implementation of organic farming and certified production models in tea cultivation in suitable regions as ecosystems are important developments for sustainability.
- The presence of academicians and ÇAYKUR experts in the region in the fields needed for tea cultivation can provide on-site training activities.
- ÇAYKUR and private companies have been meticulous about the tea harvest and post-harvest processes in recent years, and this has increased the product quality.
- In Turkey, the use of pesticides is prohibited in tea cultivation, and this provides an advantage in marketing in terms of residues in tea compared to other countries.
- Turkey is one of the countries that will be least affected by the climate change that threatens the world's tea agricultural lands, due to its geographical location.
- Considering the structure of world trade and the state of demand in the tea sector, it is predicted that there are potential opportunities in the export of Turkish tea as organic black and green tea.

CONCLUSION

In addition to its contribution to the country's economy in Turkey, tea is also important as the most consumed beverage following water. Tea is an indispensable part of the social life in Turkey and Turkey is the highest tea-consuming country in the world. Turkish tea is produced without using any chemical pesticides and additives in the fabrication stage and it should be introduced to the world markets and export opportunities to world markets should be investigated. Studies should be focused on product diversification, advertising promotion, and increasing consumption by improving the possibilities of introducing the product to the market. Accurate information about international tea markets should be obtained and technological developments should be closely followed. To increase Turkey's tea exports, it is necessary to take and implement measures to increase the quality and reduce the cost, to purchase harvested tea leaf and to produce dry tea in accordance with the standards, and to give importance to R&D studies. Realization of the policies and practices in this direction, addressing the structural problems, providing new initiatives with the cooperation of the public and private sectors are of great importance for the future of tea.

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CHAPTER 11

POSSIBLE EFFECTS of CLIMATE CHANGE on TURKISH TEA and FUTURE PROSPECTS

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INTRODUCTION

Climate change can be defined as the changes in climatic conditions as a result of human activities that directly or indirectly disrupt the composition of the global atmosphere. Particularly in recent years, factors including high population growth rate, misuse of resources, industrialization, and urbanization negatively affect the balance of the nature, leading to environmental problems (Selçuk, 2009; Tümer, 2019). One of these problems is climate change. Climate change can be explained as the overheating of the earth as a result of the fact that various gases, especially water vapor (H_2O), methane (CH_4), and carbon dioxide (CO_2), known as the greenhouse gases, prevent the rays coming from the sun to return to the atmosphere after reflection (Cabuk, 2011; Muoki et al., 2020). Today, global climate change is one of the most emphasized environmental problems. It has been predicted that the climate change process will accelerate as a result of the increase in the accumulation of greenhouse gases in the atmosphere due to the destruction of forests, the use of fossil fuels, the increase in industrial wastes, human-induced effects such as chemicals and pesticides used in some agricultural activities (Bütüner, 2019).

Climate change occurring as a result of global warming seriously threatens the agricultural systems all around the world. Climate change exhibits its negative effects as the emergence of pests and diseases, extreme weather conditions including long-period droughts, heavy rains, hailstones, and frosts. These events have become increasingly frequent and negatively affect agricultural production including rain-fed tea cultivation (Maoki et al., 2020).

Climate change has negative effects on temperature and precipitation, which are the most important factors in plant development. The most important climatic factors for the tea plant are temperature, precipitation, and humidity. The increase in maximum temperatures, irregular or insufficient precipitation and a loss in humidity in the vegetation period that coincides with the summer months lead to water stress, consequently, to the disruption of the water balance of the tea plant. This is called the agricultural drought and yield loss becomes inevitable. Tea is a plant that is highly affected by extreme climatic events.

The countries that have the largest tea production scale including China, India, Kenya, and Sri Lanka have been carrying out various tea cultivation methods for many years under varying geophysical conditions in these regions. However, tea production in all of these countries has been negatively affected recently due to the substantial effects of extreme climatic conditions on regional economies and the livelihood of dependents. It has been thought that the effects of these climatic changes will increasingly continue in the near future. In this manner, novel strategies are of great importance to minimize the negative effects of these climatic changes to reduce production risks and maintain sustainable tea production in these major tea producer countries. It has been argued that the increase in temperatures caused by global warming may extend the tea production area to new regions and ecosystems, causing a possible extension in the growing and flushing period (Anonymous, 2019).

The origin of tea, *Camellia sinensis* (L.) O Kuntze, are areas of monsoon climates with a warm, wet summer and a cool, dry (or less wet) winter. However, as a result of the dispersal of the plant, tea cultivation now covers an area ranging from Mediterranean-type climates to the hot humid tropics (Carr, 1972). Turkey is located in the northernmost region where tea is grown in the world. The effects of global warming have been seen more intensely in countries with warmer monsoon climates where tea is cultivated, such as Kenya, Sri Lanka, China, and India (Anonymous, 2019). Climate change projections for Turkey show that these effects can also be seen in Turkey if precautions are not taken. However, it has been predicted that countries with a subtropical climate, such as Turkey, where tea can be grown, will be less affected by the risk of climate change compared to the tropical regions.

1. THE EFFECT OF CLIMATE CHANGE ON WORLD TEA PRODUCTION

The tea plant is grown in a wide range of areas in the world. It is grown between the 42nd latitude in the northern hemisphere and the 24th latitude in the southern hemisphere. The optimum climatic conditions for the tea plant are moderate temperature and moderate humidity. Climate is the most important factor that directly affects yield, quality and production distribution. Therefore, the favorable climate factor should be taken as the basis in tea cultivation.

Climate change occurring as a result of global warming is currently one of the most important global environmental problems. In numerous countries in Asia and Africa, regional economy is based on agriculture. Tea cultivation is the main livelihood option for millions of people in these countries. In recent years, tea production volume has substantially decreased in some of these countries due to biotic and abiotic stress factors associated with climatic changes.

It has been argued that climate change will prolong the dry seasons in these tea production areas, leading to warmer temperatures and/or heavy rainfalls (Wijeratne, 1996; Eitzinger et al., 2011). The data collected at KALRO-TRI for more than 58 years showed that the annual temperature has increased 0.016°C per year while annual rainfall decreased by 4.82 mm per year over the same period (Cheserek et al., 2015). This has caused a continuous increase in soil water deficit (SWD). A large annual SWD, especially in January, February and March causes significant fluctuations in yearly tea production (Bore, 2008; Bore,2016).

China is the leading tea producer country in the world. It has been seen that climate change shifted the timing of the seasons in India and China. It has been determined that the climatic events, of which their effects have become more evident in the last 10-15 years in China, lead to negative changes in the quality of tea. For the coming decades, it is predicted that there will be negative changes in tea quality and a decrease in yield by 40-55% due to climatic changes. In Yunnan, the onset of the monsoon season has fallen earlier, leading to a shorter dry season. The Intergovernmental Panel on Climate Change (IPCC) argues that, in the next five decades, the end of the East Asia monsoon season will be pushed back. Also, the data collected in China between 1980 and 2011 showed that a later end to the monsoon season strongly indicates a decrease in tea yield (Nowogrodzki, 2019). Moreover, as a result of the collected data, IPCC argued that climate change will increase monsoon precipitation, leading to an earlier onset, and a delayed end, and consequently, the monsoon season will be prolonged in many regions (Stocker et al., 2013). It has been stated that these changes in weather patterns may negatively affect the rural regions in China where the main economic source and livelihood is tea cultivation. This chain of events will ultimately affect tea markets and tea consumers globally (Nemec-Boehm et al., 2014).

Following China, India is the second global tea producer, and more than 80% of the tea produced is consumed within the country. It has been reported that changes in environmental conditions can adversely affect tea quality in India. The intensity of climate change has substantially increased the effects of this change has been already seen in many tea producer countries of the world including India. A long-time trend analysis (approximately 100 years) revealed that the rainfall in North East India has decreased by more than 200 mm along with the increase in minimum temperature in the region. The effects of climate change on these tea cultivation areas have been reported in various regions in

India. The effects of climate change are already loud and clear in a large area in India across the agrarian state of Assam, including its tea-growing regions. The Assam region, which accounts for 17% of India's total tea production, is a low-altitude tropical region and the weather conditions comprise high humidity and high temperatures throughout the year, however, it is under the influence of heavy monsoon rains during the summers. It has been reported that the Assam region is at risk of climate change. In this region, heavy rain causes loss of organic matter, loss of soil fertility, a decrease in the water holding capacity in the soil, excessive water exposure of root systems, and reduced microbial activities, making arable lands barren and unproductive. Soil fertility is expected to decrease in the coming years if high soil erosion and landslides continue on the slopes, especially on the hills of Darjeeling (Anonymous, 2019).

The studies on the effects of climate change on tea production in Sri Lanka showed that except for the ones at higher elevations, tea plantations will be negatively affected. The negative effects of climate change are mainly associated with high temperatures and dry weather conditions and these negative effects overweigh the beneficial effects of the increase in CO_2 in those regions. The positive effects at two higher elevations are associated with the prevalence of lower temperatures than that of optimum for tea (approximately 22 ^oC). However, the potential benefits of the increase in CO_2 at high elevations can be reduced by dry weather conditions and possible changes in pest and disease incidences (Wijeratne, 1996; Anonymous, 2019).

Maps generated in a GIS environment using climate data from the Kenya Meteorological Services predicted that the mean air temperature for the region would increase by about 2% by 2025 and by 11% by 2075 if no action is taken (Muoki et al., 2020). The total area of land suitable for tea cultivation within the current growing areas in Kenya will decrease. This is mainly associated with rainfall distribution rather than the level of precipitation received. The increase in mean air temperatures beyond the threshold of 23.5°C is also regarded as possible. Also, the suitability of tea-growing areas is expected to decrease by 22.5% by 2075 whereas an increase in the suitability of 8% is expected by 2025. Tea depends greatly on the weather for optimal growth in Kenya. Tea is cultivated in higher altitudes in the East and West of the Great Rift Valley, between 1400 and 2700 m amsl, where annual rainfall ranges between 1800 and 2500 mm (Muoki et al., 2020). The studies revealed a negative effect of global warming on the production and quality of tea, especially in terms of an increase in temperature, unpredictable rainfall trends, and the increasing frequency of extreme weather conditions including hail storms, drought, and frost (Boehm et al., 2016; Ahmed et al., 2019; Muoki et al., 2020). It has been reported that stress, especially drought, comprises 14–20% of the loss in yield and 6– 19% in plant mortality (Cheruiyot et al., 2007).

Climate change not only leads to changes in temperature, precipitation, relative humidity, the number of rainy days, and annual sunny days, it also affects some other basic parameters of tea production including soil pH, moisture content, soil organic matter, nutrient availability, pest and disease management, the ecological conditions around cultivation areas, and therefore, the production volume and economy. Studies show that climate change will be an important problem for tea producers all around the world. It is estimated that the areas where tea is grown in the world, especially in East Africa, may decrease by 55% by 2050 (Anonymous, 2019).

2. THE EFFECT OF CLIMATE CHANGE ON TEA PRODUCTION IN TURKEY

In Turkey, tea is cultivated only in the Eastern Black Sea Region due to suitable climatic conditions. Tea is an important source of income for its producers in Turkey as well as in other countries where it is grown. Tea is a strategic industrial plant with a high potential to create new added values in the economy, allowing the rough lands comprising high slopes and mountainous regions to be brought to the economy.

With a production of 234 thousand tons of dry tea, Turkey ranks 6th in the world, after China, India, Kenya, Sri Lanka, and Vietnam (Anonymous, 2019). In Turkey, there are approximately 214,183 producers working in the tea agriculture industry in an area of approximately 800,000 decares in the Eastern Black Sea Region. Tea is an important agricultural product that affects the lives of regional producers in terms of social, economic, and commercial aspects (Anonymous, 2020).

Compared to other countries, it is seen that Turkey is the northernmost region where tea is grown. Depending on the climatic conditions in this region, tea, which enters a mandatory resting period for 6 months in winter, has three shoot periods. In some years, due to the high temperatures seen in spring, the first harvest starts earlier and a fourth harvest period can also be seen.

Negative effects of climate change can be seen in Turkey as in the rest of the world. These effects especially include irregular rains, high temperatures, changes in the harvest period, increases in pests and diseases, decreased soil quality, and an increase in extreme climate events.

2.1. Harmful effects of irregular rains

The most important climatic factors in tea cultivation are temperature, humidity and precipitation. It is important that the precipitation is light and regular, especially during the active growth period of the tea plant. During the growth period of the plant, the average precipitation should be approximately 1200 mm, and the annual total precipitation should be 2000 mm or higher. Outside of these limits, desired yield and quality cannot be obtained for the tea plant. Rapid and excessive rainfall is an undesirable event in tea agriculture.

In recent years, with the effect of climate change, the rainfalls in the region of tea plantations in Turkey have become more irregular, and the increase in the intensity and frequency of excessive rainfall poses a risk for tea, which requires regular precipitation throughout the year as the most basic climate demand of the plant. According to regional climate model predictions, the changes in winter precipitation in the mid-term future in the Eastern Black Sea Region, where tea is cultivated in

Turkey, is predicted as a slight decrease or no substantial changes in other seasons, leading to a change in precipitation distribution in the rainy region and an increase in precipitation variability (Figure 1). Also, considering the topography of the region, the high probability of precipitation in the form of showers may increase the risk of flooding and overflows, as well as trigger effective and frequent mass movements, which may lead to land degradation (Turp et al., 2014).

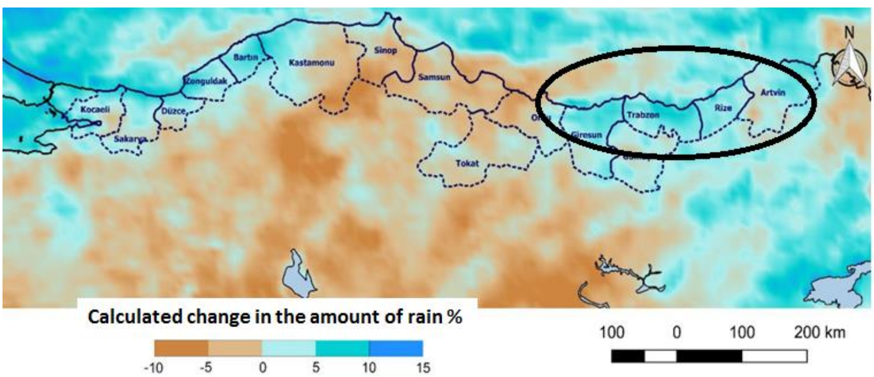

Figure 1: The projection of the expected changes in the annual total precipitation averages in the 2021-2050 period according to the 1991-2012 reference period in the Eastern Black Sea Region of Turkey (shown as striped black circle in upper right side of the map), where tea is grown (Karapınar et al., 2020)

A second rainwater problem caused by climate change is that irrigation water may be needed during the vegetation period of the tea as a result of the excessive rainfall in a period but not regularly throughout the year in the region where tea cultivation is carried out in Turkey. Tea cultivation is carried out in Turkey without irrigation. Because the amount of rainfall during the vegetation period is sufficient for the tea plant. However, it has been predicted that the low rainfall levels during the vegetation period, caused by climate change, will bring the irrigation water need of the tea cultivation areas to the agenda in the future (Figure 2).

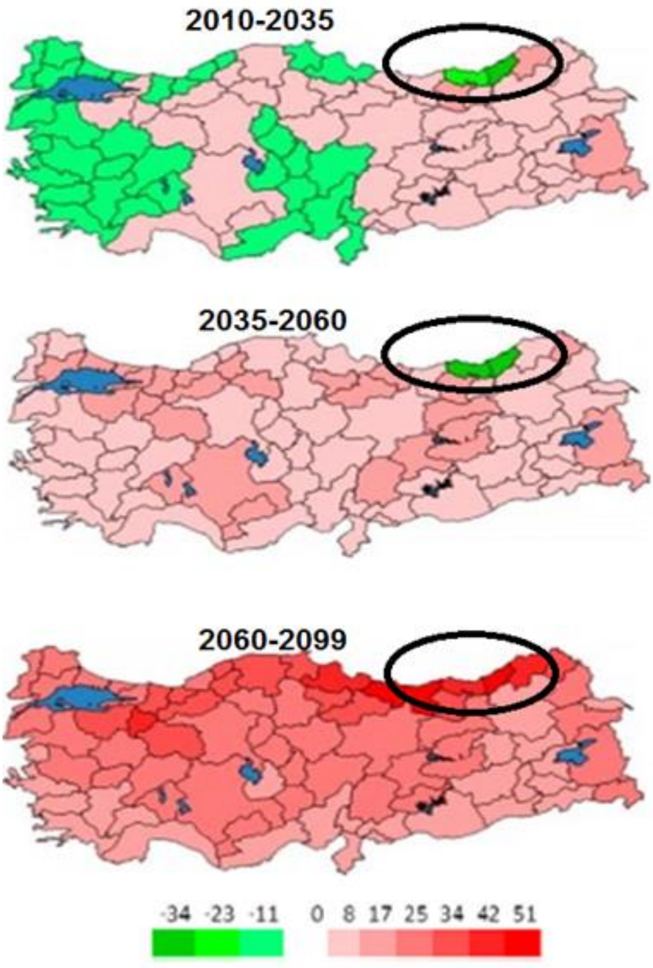

Figure 2: The yearly projection of the changes in irrigation water needs inTurkey in the Eastern Black Sea regions (shown as striped black circle in upper right side of the map) where tea is cultivated (Dudu and Çakmak, 2018).

2.2. Harmful effects of high temperatures

In addition to the water, It has been known that, in the tea plant, the temperature also directly affects the growth, development, and consequently yield and the quality of tea. The temperature range that tea requires to grow under optimum conditions is between 13 and 32°C. Under the conditions of Turkey, a dormant period takes place under 12 ^{o}C for 6 months (October-March) and the growth stops. Also, temperatures above 32 ^{o}C stop photosynthesis and negatively affect the plant's growth.

With climate change, it is expected that the number of extremely hot days, the frequency, and continuity of heatwaves will increase for Turkey. Also, it is predicted that the increase in average temperatures, which are expected to be higher in summer seasons throughout Turkey, may lead to a decrease in yield in the areas where tea is grown (Figure 3).

According to the 1991-2012 reference period, it is predicted that the average temperature in Turkey will increase in the range of 0.15-1.20 ^{o}C for the 2021-2050 period. Also, it has been estimated that there will be an increase in the number of days without precipitation and an increase in the frequency of dry periods (Karapınar et al., 2020). An increase of 4-6 ^{o}C in the average temperature which is predicted for the end of the century may have a negative effect on tea production in Turkey especially in the areas close to the coast. On the other hand, it is also predicted that the high-altitude areas that are currently not suitable for tea cultivation may become more suitable for tea cultivation.

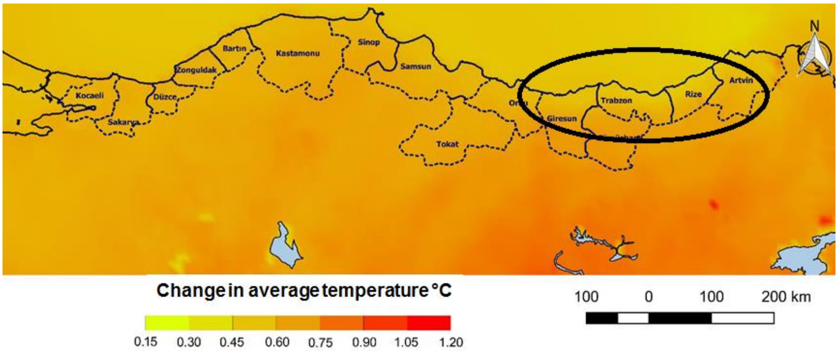

Figure 3: The projection of expected changes in average temperatures for the period 2021-2050 in the Eastern Black Sea Region of Turkey (shown as striped black circle in upper right side of the map) according to the 1991-2012 reference period (Karapınar et al., 2020)

2.3. Changes in The Harvest Period

In Turkey, a dormant period of 6 months takes place in the tea plant due to the low temperature and short days due to the fact that Turkey is located in the northernmost region (42 latitude) where tea cultivation is carried out. In the conditions of the Eastern Black Sea Region in Turkey, the plant buds out generally after the second week of March. The development of the buds continues until the end of April and at the end of April or at the beginning of May, the shoots become ready to be collected. The shoot collection cycle consists of three or four periods per year. There are periods of rest between the periods of the shoot. The shoot collection process starts in May and continues until the end of October.

As there are no seasonal changes in the equatorial region, tea is collected during all 12 months of the year in countries such as Kenya and Sri Lanka, and there are no dormant periods. Since there are no significant differences in the number of shoot periods despite these different ecological conditions, there are four shooting periods in countries close to the equator including Kenya and Sri Lanka, whereas there are three shooting periods in Turkey.

The increase in average temperatures in the tea-growing region in Turkey due to climate change may cause shifts in the phenological periods of tea, as well as a change in harvest periods due to earlier shoots and earlier harvesting. Examining the data on the harvest dates of tea on a yearly basis in Turkey, it was determined that the harvest dates shift to earlier periods, especially in years when the temperatures started to increase earlier (Table 1). It has been known that the tea harvest in Turkey starts from mid-May and continues until mid-September. However, as seen in Table 1, the first tea harvest started in April in some years. It was determined that the first harvest date, especially in 2008 and 2013, occurred in an earlier period, compared to other years. Examining the meteorological data of these years, it was seen that the maximum and minimum temperature averages were higher than those of the other years.

Table 1: Changes in harvest dates by years in Turkey (Anonymous, 2020)

Years	Firs Harvest	Second Harvest	Third Harvest
2003	29 May	16 July	4 September
2004	21 May	17 July	7 September
2005	21 May	7 July	31 August
2006	20 May	8 July	21 August
2007	22 May	9 July	28 August
2008	27 April	1 July	19 August
2009	20 May	9 July	2 September
2010	20 May	7 July	24 August
2011	26 May	17 July	4 September
2012	14 May	5 July	24 August
2013	27 April	1 July	19 August
2014	20 May	9 July	2 September
2015	20 May	7 July	24 August
2016	26 May	17 July	4 September
2017	5 May	3 July	21 August
2018	25 April	19 June	13 August
2019	10 May	01 July	27 August
2020	19 May	07 July	01 September
2021	17 May	08 July	31 August

High temperatures seen in early spring in Turkish climatic conditions may cause shifts in the harvest periods leading to early harvests, a higher number of harvests as in other tea growing countries, and an increase in processed fresh tea capacity. However, the decrease in precipitation and the increase in temperature may cause negative effects on tea quality.

2.4. Increase in Pests and diseases

In many leading tea-producing countries, some pesticides are used against diseases and pests within the scope of conventional production and good agricultural practices. In tea cultivation in Turkey, a natural sustainable production model without the use of pesticides in tea orchards is taken as a basis. Since tea diseases and pests are not intense and economical in tea gardens, and disease and pest management is stated as the most advantageous area of tea production. Also, the use of herbicides in tea gardens is prohibited due to their harmful effects on the environment and the product. However, examining the countries where the effects of climate change are more visible, it was predicted that, in the future, climate change may pose a threat to tea by causing the reproduction and spread of existing or new tea pests in Turkey.

2.5. Decreased Soil Quality

An increase in temperature speeds up the microbe depletion of soil organic matter while reducing the time needed to release nutrients from chemical fertilizers. Intense daily precipitation may lead to severe flooding or landslides, which remove fertile topsoils (Han, 2016). The problems mentioned above seen in the world's tea cultivation areas will also be seen in Turkey as the effects of climate change become more intense. Also, the most important soil-related problem in tea cultivation areas in Turkey is the low pH level. The rehabilitation of acidic soils is an important global problem. If precautions are not taken, extreme rainfalls that will be seen as a result of climate change will increase the soil acidity even more.

2.6. The increase in extreme climatic events

Climate extremes and variations, such as drought, flood, and very cold or hot weather, will cause serious problems for tea production and sustainable development. Due to its unpredictable nature, it would be the most significant factor affecting the yearly tea production.

CONCLUSION

It should be remembered that, apart from its possible direct effects, climate change can pose a threat to tea cultivation by leading to an increase in extreme meteorological events, warmer and less rainy climatic conditions, a decrease in water resources, an increase in drought severity, deterioration of water and soil quality, deterioration of ecosystem, a decrease in biological diversity, a shift in ecological areas, a decrease in tea production and quality, an increase in pests and diseases, problems with fertilization, pesticides, and sustainable tea cultivation problems, and cause the development and spread of existing or new tea pests. Therefore, it is important to take the necessary precautions against climate change in tea agriculture in Turkey as is the case in the world's tea agriculture. In this context, the necessary actions to be taken against the observed and predicted effects of climate change to make the tea product supply sustainable include the conservation of gene resources, breeding, and selection of cultivars that are resistant to drought, heat, frost, pest, and diseases, soil management, ecosystem management, disease and pest management, water management, waste management, renewal and rejuvenation of old and infertile tea gardens, planning studies on infrastructural improvements for short, medium and long terms and to urgently determine necessary agricultural policies on this problems.

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CHAPTER 12

THE OLIVE (*Olea europaea* L): BRIEF DESCRIPTION and GROWING in CANAKKALE

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INTRODUCTION

The olive, known to be one of the oldest cultural plants in the world, belong to the *Olea* genus of the *Oleaceae* family. There are more than 30 species of the genus *Olea*. Among these species, the species that can be cultured is the *Olea europaea* L. species that is widely spread in the Mediterranean and Aegean region and the only species economically significant worldwide. It is known that *Olea europaea* L. has been cultivated for 6000 years and originated Southeast Anatolia and Syria in the Near East region (Fabbri et al., 2009; Ünal, 2011; Gündoğdu and Seker, 2020; Gundogdu and Nergis, 2020). Although the Mediterranean basin is thought first for olive cultivation, this perennial evergreen species can be grown economically in the region between 30–45 north and south latitudes. Moreover, the climate characteristics of areas where olive civilization is vital are astronomically analogous, and some differences are significant. These differences define the growth conditions of olive while affecting the fruit size and fruit flesh ratio. Olive varieties differ by region and section according to climate, geomorphologic and soil characteristics. Some varieties are more convenient for olive oil production, whereas others are consumed as table olives. Due to inadequate statistics, it is not precisely stated that numerous olive varieties cultivate globally. Nevertheless, it is estimated that there are further than 4000 olive varieties (Ozturk et al., 2013; Efe et al., 2021).

Olive Production in the World

The area of olive production (*Olea europaea* L.) is more than 10 million hectares worldwide. According to FAO data (2019), olive production in the world was 19,4 million tons in between the 2018-2019 seasons. Major table olive producer countries are Spain, Italy, Morocco, and Turkey, in which Turkey ranks 4th with 1.525.000 tons (FAO, 2019) (Table 1). It is estimated that the number of olive varieties cultivated in Turkey is over 400 (Ozturk et al., 2013).

Table 1: Area harvested, Yield and Production for Olive in the World.

Area	Area harvested (ha)	Yield (hg/ha)	Production (tonnes)
Spain	2.601.900	22.926	5.965.080
Italy	1.139.470	19.256	2.194.110
Morocco	1.073.493	17.813	1.912.238
Turkey	879.177	17.346	1.525.000
Greece	903.080	13.599	1.228.130
Egypt	89.942	120.088	1.080.091
Portugal	359.950	27.699	997.040
Tunisia	1.606.909	5.457	876.877
Algeria	431.634	20.127	868.754
Syrian Arab Republic	693.227	12.180	844.316
Total	**10.578.561**	-	**19.467.119**

Olive Production in the Turkey

Olive is cultivated in 36 provinces in Turkey in the Marmara, Aegean, Black Sea, Mediterranean and South East Anatolia regions; 110 olive varieties grown in Turkey are “registered” (Ozturk et al., 2013). Production in Turkey in the year 2020 was 1.316.626 tonnes; however, table olive cultivation in Turkey was 513.140 tonnes and 2.334.583

decares in 2020. According to TUIK data (2020) the provinces which are the most common table olive producers are in Manisa, Bursa, Aydın, Mersin, Osmaniye, Balıkesir, Hatay, Antalya and İzmir (TUIK, 2021) (Table 2).

Olive oil cultivation in Turkey was 803.486 tonnes and 6.536.185 decares in 2020. According to TUIK data (2020) the provinces which are produced olive oil the most common in Manisa, Balıkesir, İzmir, Aydın, Gaziantep, Hatay, Muğla, Antalya, Çanakkale and Osmaniye (TUIK, 2021) (Table 3).

The most cultivated olive varieties for both oil and table olive production are Ayvalık, Gemlik, Domat, Hanim Parmagi in the North Aegean Region; Gemlik, Domat, Karamürsel Su, Samanlı, Edincik Su varieties in the Marmara region; Memecik, Uslu, Domat, Yamalak Sarisi, Erkence, Manzanilla, Tavsanyuregi varieties in South Aegean region; Butko, Otur, Sati varieties in the Eastern Black Sea region; Tavsanyuregi, Cilli (Buyuk Topak Ulak), Yamalak Sarisi, Gemlik varieties in Western Mediterranean; Sari Ulak, Halhali, Buyuk Topak Ulak (Cilli), Trilye, Edremit varieties in the Eastern Mediterranean; Kilis Yaglik, Halhali, Nizip Yaglik varieties in the South East Anatolia region (Efe et al., 2021; Seker et al., 2012; Seker et al., 2013).

Table 2: Area harvested (daa), Production (tonnes) and Yield per tree (kg tree^{-1}) Table Olives in Turkey.

Area	Area harvested (daa)	Production (tonnes)	Yield per tree (kg tree^{-1})
Manisa	559.479	166.775	14
Bursa	442.209	115.072	10
Aydın	258.838	45.179	10
Mersin	214.392	33.375	7
Osmaniye	77.186	31.703	16
Balıkesir	105.304	22.658	11
Hatay	117.655	13.684	5
Antalya	66.753	12.204	10
İzmir	100.159	11.014	6
Denizli	26.715	9.133	15
Total	**2.334.583**	**513.140**	–

Olive groves are usually planted in some areas of the Aegean, Marmara, Mediterranean, Eastern Black Sea and South East Anatolia regions. Olive is cultivated extensively in the southern coast of Marmara Region particularly in Gemlik, Mudanya, İznik, Edincik and Erdek vicinity as mono-cultivar. Olive is cultivated together with other agricultural activities in the vicinity of Karamürsel, Golcuk, Yeniçiftlik, Bandırma, Yalova, Marmara Island, Biga, Eceabat, Lapseki, Gökçeada Bozcaada, Ayvacik, Ezine, Bayramic and Gallipoli. A large production of the table olives are produced in the Marmara region, and almost 80% of these are known as the Gemlik variety (Ünal, 2011; Efe et al., 2013; Gündoğdu, 2018).

Table 3: Area harvested, Production and Yield per tree Olives for oil in Turkey.

Area	Area harvested (daa)	Production (tonnes)	Yield per tree (kg tree^{-1})
Manisa	523.749	187.494	20
Balıkesir	732.285	107.916	12
İzmir	865.934	83.861	5
Aydın	1.283.081	75.526	4
Gaziantep	431.240	53.735	6
Hatay	439.143	53.528	5
Muğla	977.774	43.808	3
Antalya	120.857	42.081	14
Çanakkale	308.060	40.087	9
Osmaniye	83.074	31.089	17
Total	**6.536.185**	**803.486**	–

Olive Production in Çanakkale

The distribution of olive orchards in Çanakkale is determined by temperature conditions. For this reason, olive cultivation is carried out in all districts except Çan and Yenice districts. Çanakkale table olive production was 2.723 tonnes on an area of 18.674 decares. Table olive production was Ayvacik and Bayramic districts bordering the Aegean Sea are the first, as seen in table 4 and 5 takes the order.

Table 4: Area harvested, Production and Yield per tree Table Olive in Çanakkale.

Area	Area harvested (daa)	Production (tonnes)	Yield per tree (kg tree^{-1})
Ayvacik	5.500	695	8
Bayramiç	80	0	0
Biga	2.000	341	9
Bozcaada	355	82	7
Eceabat	2.209	254	5
Ezine	3.100	400	10
Gelibolu	1.100	315	8
Gökçeada	1.970	264	6
Lapseki	1.650	262	8
Merkez	710	110	10
Total	**18.674**	**2.723**	–

Çanakkale is one of the important high quality olive oil production centers in the world. While the huge amount of the olives produced in Çanakkale is used for olive oil production, the small amount that is left is used to supply local table olive demand. Olive groves for oil production in Çanakkale is 308.060 decare and olive fruit production for olive oil is 40.087 tonnes. Olive cultivation for oil is most common Ayvacık, Bayramiç and Biga districts in Çanakkale (Table 5) (TUIK, 2021).

Table 5: Area harvested, Production and Yield per tree Olives for oil in Çanakkale.

Area	**Area harvested (daa)**	**Production (tonnes)**	**Yield per tree (kg tree^{-1})**
Ayvacık	108.560	16.163	9
Bayramiç	40.450	3.438	7
Biga	578	48	8
Bozcaada	1.410	158	7
Eceabat	14.697	4.341	10
Ezine	114.600	12.430	8
Gelibolu	615	318	8
Gökçeada	5.600	509	5
Lapseki	3.700	497	8
Merkez	17.850	2.185	8
Total	**308.060**	**40.087**	–

As an olive variety, Ayvalık (Edremit) olive cultivar for oil are dominant. There are also Gemlik, Domat and recently registered Hanim Parmagi varieties are also observed in the olive orchards. There is also a local type of Koroneiki, a special olive called "Gökçeada Olive" or "Ladolia". In addition, Ascolana, Manzanilla and Hojiblanca varieties brought from Spain and Italy began to be seen in the region. Arbequina and Arbosana varieties have been used to establish new dwarf orchards.

The vast majority (67%) of olive trees in Çanakkale were grafted cultivars on wild type trees. The newly established orchards with cuttings constitute 33% of the province (Ilgar, 2016).

Olive oil quality in Çanakkale

When the olive oils obtained in the olive groves of Ayvacik, Ezine and Bayramic regions are investigated, it is seen that olive oils that obtained from Çanakkale have high quality. In many scientific studies, it was determined that olive oils obtained from different regions of Çanakkale (different locations of Ayvacik, Ezine, Bayramic) in terms of oleic acid, which is the most important fatty acid component of olive oil, are above 65%. It was determined that not only aldehyde, terpene and C_6 compounds were more higher in the volatile compounds of olive oils that belong from these locations, but also other olive oil quality characteristics were higher than other locations (Nergis, 2019; Doğan, 2019; Yazıcıoğlu Çeri, 2019; Gündoğdu ve Kaleci, 2016; Gündoğdu ve Şeker, 2020; Gündoğdu ve Nergis, 2020). In addition to conditions such as variety, harvest time or fruit maturity etc. the main reasons for the high quality properties in olive oil characteristics (fatty acid composition, volatile compounds composition, etc.), It is thought that the high oxygen content from Mount Ida combined with the cool winds from the North Aegean Sea and the iodized air make it stand out with its unique aromas.

CONCLUSION

As a conclusion, olive oil production is the main purpose for olive cultivation due to Ayvalik olive cultivar is the major cultivar of the olive groves in Çanakkale. Olive oils, produced by the local producers, trade as boutiques or wholesale to traders and cooperative companies after the producers left some amount for their own consumptions. In addition, large fruits that selected after harvest period are used for green and black pickled olives that supply local demands.

Çanakkale is one of the important olive producing regions of Turkey. Although it is grown as a second crop in some regions (such as Biga, Lapseki, Bayramiç), it is the main source of income for families in some regions (Ayvacik, Küçükkuyu, Eceabat, Ezine).

When the cultural processes applied during the cultivation are not enough and on time, the desired quantity and quality product cannot be reached.

The main reasons for this situation are briefly summarized below:

- Olive cultivation is mostly based on conventional agriculture in the region. In addition, the number of producers engaged in uncertified organic agriculture in order to avoid the certificate fee is quite high. However, unfortunately, they cannot gain advantage from the marketing benefits of organic agriculture by aiming only to reduce inputs with such a production.
- Some producers ignore disease and pest control in order to avoid production inputs. It is common practice to abandon the production completely and unfortunately only visit the olive

groves during the harvest. On the contrary, some producers not only increase their inputs by over-pest untimely but also causes olive or olive oil production with high pesticide residues.

- Each olive grove is a unique field and has different needs with its soil. Nutrition problem, which is the most basic of these needs, can be solved by soil and leaf analysis. Unfortunately, a significant part of the producers fertilize with hear-of-the-know information without determining the needs. In particular, unconscious fertilization will cause both the pH balance and organic matter level of the soil to deteriorate and some nutrients to have an antagonistic effect.
- Especially since pole harvesting breaks the branches that will bear fruit in the next year, it is necessary to harvest by machine. Despite that; it would be beneficial to do this with the tools and equipment to be selected considering the conditions on a provincial basis. Different machine types are recommended for table olives and olives for oil on sloping lands. Establishing mechanization companies or unions, especially in machine harvesting, will both reduce operating costs and reduce production costs.
- The period that the olive tree needs is especially the period from seed hardening to early harvest. Complementary irrigation during this process; It will prevent yield loss due to droughts due to climate change.
- Many farmers mistakenly believe that when the harvest starts more later, oil yield will higher. However, harvesting the fruit in

the over-ripe period both increases the damage of the olive fly (*Dacus oleae*) and affects the quality of the product directly and negatively. With the delay of the harvest, the oil ratio in olive fruits remains constant at a certain rate, and moisture loss increases. In addition, as the fruits ripens, desired aldehydes and C_6 compounds that give olive oil its green aroma and phenolic compounds that make olive oil unique are reduced.

- During the harvest period, keeping the harvested olives in sacks for a long time in olive oil factories causes the fruits in the bags to overheat, increasing the peroxide level and acidity in the olive oil produced, as well as causing the production of organoleptically defective olive oil. In order to prevent this situation, olive fruits harvested by making an appointment with olive oil factories should be turned into olive oil on time, within 24 hours at the latest.
- Harvested olives should be stored away from light, temperature, air, humidity and plastic after they turn into olive oil. In particular, factors such as sunlight, including a light and temperature source, cause components such as phenolic compounds and chlorophylls, which protect olive oil against oxidation, to decompose and cause the quality to deteriorate rapidly. Storing olive oil in containers that are not suitable for food, such as plastic, causes harmful chemicals such as BPA found in plastics to dissolve into olive oil. In addition, olive oil has a structure that absorbs every odor in its environment.

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CHAPTER 13

POMEGRANATE (*Punica granatum* L.) PRODUCTION AND BREEDING

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INTRODUCTION

With the rapid increase in the world population, the variety and production amounts of agricultural products have also increased. Therefore, there has been a rapid increase in the amount of pomegranate production both in the world and in Turkey. Pomegranate fruit is included in functional foods due to its vitamin C, antioxidant and phenol compounds. Functional foods have gained a lot of importance today because they are healthy. Pomegranate is composed of *Punica granatum* L. and *Punica protopunica* Balf f. species, which is in the *Punica* genus in the Punicaceae family. *Punica protopunica* Balf. f. is an endemic plant and is found on the island of Socotra in Yemen. *Punica granatum* L. is a species that is grown for its fruit, has 2 n=16 chromosomes, and has some ornamental forms. These ornamental forms are *P. granatum* var. nana Pers., *P. granatum* var. florae luteo, *P. granatum* var. flore albo-plena and *P. granatum* var. Striata and their chromosome number is 2n=18 (Yılmaz, 2007).

Pomegranate, which is a subtropical climate fruit, is grown in regions from temperate to tropical climates. It is widely cultivated between 27-40 latitudes in the Northern and Southern Hemispheres. The places where it is naturally grown and cultivated in the world are regions with hot summers and mild winters (Kurt et al., 2013). Pomegranate is a type of fruit that is resistant to arid climates, gives regular fruit every year and can adapt to different soil conditions. (Ozguven et al., 2000). Levin (1994), in their studies, reported that the most important growing area of pomegranate is the Mediterranean Basin. Its homeland is located between the South Caucasus and Northeast Anatolia (Janick, 2007 and Pakyürek et al., 2020). Quality pomegranate cultivation is carried out in Turkey, Italy and Spain in the Mediterranean; in China, Turkmenistan, Afghanistan, India, Iran and Japan in Asia continent; in Morocco, Tunisia, Algeria and Egypt in North Africa and in the United States, especially in California, (Stover and Mercure, 2007). Pomegranate is a fruit highly rich in phenolic substances, flavonoids and antioxidants and is very beneficial for human health (Emer and Pakyürek, 2019). In Turkey, pomegranate fruit is consumed as table and fruit juice. It is also used as raw material to obtain products such as animal feed, pectin, tannin, oil, vinegar, medicine, dye, ice cream, liquor, wine, jelly, cake and dessert (Vardin et al., 2004; Poyrazoğlu et al., 2002; Seeram et al., 2006). Pomegranate is one of the oldest types of fruit and has been seen as a sacred fruit in many religions throughout history. Studies have reported that the amount of juice of pomegranate fruit is 76-85.5% and the amount of aril is 60-80% (Vardin, 2000; Kaplan, 2014). Pomegranate fruit has high potassium, calcium, magnesium content and sugar content. Especially glucose and fructose constitute a large part of the sugar content. Turkey's total agricultural area is 231.451,337 decares, and 15.37% (35,587.493 tons) of this area is fruit, beverage and spice plants. Turkey's pomegranate production was 600,021 tons in 2020 (Table 1). There was a 12-fold increase in the amount of pomegranate production from 1990 to 2020 (TUIK, 2021) The number of trees on which pomegranate is produced is 15,882,000. Average yield per tree is around 40 kg.

Table 1: Pomegranate Production Quantity (tons) of Turkey

Year	1990	2000	2010	2015	2020
Product Quantity	50.000	59.000	208.502	445.750	600.021

TÜİK, 2021

When we look at the pomegranate production according to the regions in Turkey, 59.76% of the pomegranate production is provided by the Mediterranean region. This is followed by the Aegean region with 26.76% and the South-eastern Anatolia region with 11.86% (Table 2). When we look at the pomegranate production by provinces, the highest pomegranate production is in Antalya, followed by Muğla, Mersin, Adana, Denizli, Hatay, Gaziantep, Aydın, İzmir, Adıyaman and Şanlıurfa.

Table 2: Distribution of Turkey's Pomegranate Production Quantity by Regions.

Regions	Product Quantity (ton)	Product (%)
Mediterrenian	358.588	59.76
Aegean	160.564	26.76
Southeastern Anatolia	71.158	11.86
Marmara	5.591	0.93
Middle East Anatolia, West Anatolia and Northeast Anatolia	3.180	0.53
Black Sea	940	0.16

TÜİK, 2021

There has been an increase in pomegranate orchard facilities in Turkey due to the taste and benefits of pomegranate fruit for human health. One of the most important reasons for this increase is due to the production of productive and quality varieties as a result of breeding studies. There are two types of blooms in pomegranate trees, type A and type B. Since the female organ is not functional in type A blooms, the male organ is functional, this type of flowers only has positive effects on pollination. Since B type blooms are in hermaphrodite bloom structure, fruit yield in pomegranate is provided with this type of blooms. Blooming begins in April in subtropical regions and in May in temperate climatic regions.

1-POMEGRANATE VARIETIES AND PROPAGATION

Important local pomegranate varieties grown in Turkey are; Hicaznar, Silifke aşısı, Katırbaşı, Çevlik, Fellahyemez, İzmir 26, İzmir 23, İzmir 1513, İzmir 2, İzmir 1261, İzmir 1265, Bey narı, Kuş narı, Ekşi Göknar, Suruç, Suruç tatlısı, Suruç karası, Devedişi, Evci, Boncuk, Gök Güllesi, Caner and Zivzik pomegranate. Wonderful and Early Wonderful varieties of foreign pomegranate varieties are also grown in our country. Wonderful pomegranate variety is a variety that makes up more than 90% of pomegranate gardens in America. (Chater and Garner, 2018). Stover et al., (2007) reported that there are more than 500 pomegranate varieties in the world. If we look at the characteristics of some important pomegranate varieties;

Hicaz: It is the most cultivated pomegranate variety in Turkey. It is a variety used in all regions where pomegranate is grown. It is suitable for repository and storage. Aril and fruit peel colours are quite dark. Fruit shape is flat, aril efficiency is medium and taste is sour (Yılmaz, 2007).

Suruç: It is cultivated in the South-eastern Anatolia region. It is of high quality and is consumed as a table. The thickness of the fruit peel is quite thin, the taste is sour and the aril colour is red. Its fruits are large, weighing up to 1000 grams. It is a productive variety. Yields are between 2-2.5 tons per decare. It is an export variety.

Katırbaşı: It is a very productive variety grown in the Siverek region of Şanlıurfa. Trees tend to grow vigorously. The shell thickness is thin, the aril color is dark pink, the aril hardnes is high and the fruits and arils are large. The taste is sour and the seeds are medium hard.

Silifke Aşısı: It was obtained as a result of selection study in Silifke district of Mersin province. Its fruits are quite large. The colour of the aril is pink-red, the colour of the fruit peel is red-yellow, the taste is sour, and the seeds are hard.

Pomegranate can be propagated by cuttings, grafting and seed, Mainly, pomegranate is mostly propagated by wood cuttings. It is easy to propagated with wood cuttings and the success rate is very high. Wood cuttings are taken from one-year branches, 20-30 cm long, and planted in rooting pans with 1-2 bud of the cuttings under the soil. Pomegranate seeds also germinate easily, but seedling is not preferred much because of the heterozygote form. Propagation by grafting is applied to change the variety.

2-CLIMATE

Pomegranate is grown in high quality in regions with hot summers and mild winters. For this reason, it is grown in subtropical, tropical and certain parts of temperate climate. It is a fruit with high temperature demand. When the total temperature is insufficient, losses in fruit yield and quality are observed. In terms of low temperatures, trees can generally withstand temperatures of -10 and -12 ^{0}C. 100-150 hours of cooling is sufficient. Pomegranate cultivation is carried out up to an altitude of 1000 meters above sea level, and a very productive and high-quality agriculture is carried out at an altitude of approximately 250-600 meters. Annual precipitation demand is 500 mm. Irrigation should be done in the summer period. Precipitation close to harvest causes fruit cracking. In regions with high humidity in summer, fruit quality is adversely affected, and quality cultivation is carried out in areas with low humidity during the fruit maturity period. Excessive irrigation should be avoided.

3-SOIL

The pomegranate plant can be grown in different soil conditions. It is cultivated in quality in soils with good drainage, permeable, deep, sandy, aerated and high in organic matter content. It is mid-resistant to salt. It can grow in alkaline and acidic soils. Ground water should be at least 1 meter deep, and deeper is better.

4-IRRIGATION

In order to increase yield and quality in pomegranate cultivation, it is necessary to irrigate at the right time and in sufficient quantities. The age of the tree, the region of cultivation, the irrigation method used and the soil structure are important in the preparation of the irrigation program. Regular irrigation should be done, otherwise the yield and quality will be adversely affected and the cracking rate of the fruit will increase. While controlling the soil moisture, soil is taken from 0-30 cm depth from the soil surface and compacted by hand. If there is enough water in the soil, the compacted soil will stick and will not disperse. If the opposite is the case, this informs us that it is time for irrigation. It is most accurately done by using a humidity measuring instrument such as a tensiometer. With the manometer in the tensiometer, the retention power of water in the soil is measured in centibar. The necessity of making use of water and fertilizer at the highest level gave the drip irrigation system and fertilizer applications (fertigation) with this method prominence. The necessity of applying the drip irrigation method has emerged due to the fact that the efficiency of water application in drip irrigation systems is 90-95%, the water use efficiency of plants increases and it is considered as one of the basic conditions for sustainable agriculture (Bozkurt-Çolak, et al., 2014). In order to reduce fruit cracking, irrigation should not be done about two weeks before the pomegranate harvest.

5-PRUNING

Pruning in fruit trees is generally done to control tree size, increase fruit yield and quality, and reduce the effects of diseases and pests. (Sauls, 2002; Yıldırım et al., 2010). If the lighting is good, shoot formation, flower and fruit formation will increase and the fruits will be evenly distributed on the tree. Pruning is done in single-stem or multi-stem shapes in pomegranate tree. If pruning will be done with a single stem, the stem of the planted sapling is cut between 50-60 cm and 3-4 branches that come out in different directions from below the cut place are left as the main branch. Thus, the tree is given the shape of an open vase (or centre). If multi-stem cultivation will be done, 5-6 of the bottom shoots are left as stems, the next year, the best 3-4 of these left shoots are selected and the others are cut. Thus, a multi-body shape is given. Topping is also done in the form of multi-stem pruning. In Pomegranate, pruning is done in the form of shape pruning, yield pruning and rejuvenation pruning. The pomegranate tree bears fruit after 2 years of age. Generally, after the age of 5, it becomes fully productive. The trees are long-lived. In yield pruning, bottom shoots, shoot branches, diseased and damaged branches are cut. If the canopy is dense, the branch should be removed from the middle part of the tree to increase ventilation and sunbathing. There is a decrease in yield after the age of 20 in the pomegranate tree. In this period, rejuvenation pruning should be done. In rejuvenation pruning, old stems are cut from the bottom and new shoots are formed from the cut.

6-FERTILIZION

Soil and leaf analysis should be done to determine the nutritional elements needed by the pomegranate plant. Fertilizing program should be prepared according to the analysis results. Leaf samples should be taken during the fruit ripening period (end of August-early September) in pomegranate fruit. To represent the garden, samples should be taken from different parts of the land and from different directions of the tree, from the leaves that are close to the middle of the branches that are underage and have grown in the spring of the same year and that have completed their development. The age of the tree, the soil structure and the yield of the tree should also be taken into account in the preparation of the plant nutrition program. About 2.5 tons of well-burned animal manure per decare can be given to soils with low organic matter content every few years. According to the need, fertilizers containing nitrogen, phosphorus, potassium, iron, zinc, manganese and copper should be given. El-Rhman, (2010), in his study on Manfaluty pomegranate variety, reported that 1% zinc sulfate ($ZnSO_4$) applied from the leaves reduced fruit cracking to a high extent, and that fruit cracking rate was 50% less with controlled irrigation with this fertilizer application. If the deficiency continues, foliar fertilizer application can also be made to support the fertilizer application from the soil. Nitrogen fertilizers can be applied between March and June by dividing in months, while phosphorus and potassium fertilizers can be applied in winter.

Figure 1: Wonderful pomegranate variety

7-POMEGRANATE PESTS

Pests that cause damage to pomegranate plants: Carob moth, Mediterranean fruit fly, citrus mealybug, pomegranate aphid, pomegranate whitefly, orange moth, dried fruit beetles, tree yellowworm, pomegranate leafroll mite, lemon rat, root-knot nematodes. Important pomegranate pests:

Carob moth (*Ectomyelois ceratoniae*): Carob moth causes a decrease in the commercial value of pomegranate fruits. The fruits become wormy and then rot and the market value of the fruit decreases. The outer shell of the damaged fruits becomes brown and damage occurs in the form of rotting of the fruit. The pest lays its eggs in the flower calyx of the fruit. Its larvae enter the flower calyx of the fruit and cause damage to the fruit grains. In the cultural measures of the carob moth, the dropped fruits should be collected, and different fruit species that could be hosts should not be grown in the garden (Pala et al., 2004). For good chemical control, pruning should be done in a way that the inside of the tree canopy can get air, and frequent planting should be avoided.

Mediterranean fruit fly (Ceratitis capitata): The pest spends the winter in the soil or in the fruits left on the tree. It causes the pomegranate fruits to fall prematurely. It reduces the market value of the fruit. The larvae feed on the arils in the fruit and cause the fruit to rot. In its cultural struggle, dropped pomegranate fruits should be collected and removed from the garden and fruit species that can be host should not be grown in the garden. Mediterranean fruit fly damages many vegetables, fruits and ornamental plants. The hosts that it harms in Turkey are fruits such as pomegranate, peach, citrus fruits, persimmon, apricot, plum, apple, fig, quince, banana, loquat (Uygun et al., 2010). Mediterranean fruit fly exit control should be done by hanging attractive traps before the fruit ripens in the pomegranate orchards in late July and early September.

Citrus mealybug (Planococcus citri): There are over 60 species of mealy bugs in the world (Ben-Dov, 1994). Adult females are elongated oval in shape and covered all over the body with a layer of white thin waxy strands. It causes damage in the places where the fruits meet with the stem and the fruits come into contact with each other and in the flower calyx of the pomegranate fruits. Mealy bugs sucks the leaves and fruit stems which reduces the fruit quality and causes early drop of fruits with weakened stem bottoms and also fumagin formation (Lodos 1986). Biological Control: Cryptolaemus motrouzieri Muls. (Col.: Coccinellidae) predator insect and Leptomastix doctiilopii How (Hym.: Encyrtidae) parasitoid are the most important natural enemies (Soylu et al., 1977; Kansu et al., 1980; Yiğit et al., 1994).

Pomegranate aphid (Aphis punicae): Pomegranate aphids damage fresh shoots, leaves, flowers and fruits by sucking the sap of the plant. In the spring, their numbers are quite high. It causes the formation of fumagin, which adversely affects plant growth. The higher the humidity, the higher the population density. In the cultural control of the pest, excessive irrigation, nitrogen fertilization and frequent planting should be avoided, pruning should be done every year and weed struggle should be given importance.

Pomegranate Whitefly (Siphoninus phillyreae): They lay their eggs in groups on the underside of leaves. Adults are transparent and yellow in color and their movements are quite slow. It causes damage by sucking under the leaves of the pomegranate plant. In cases where it is intense, they cause the formation of fumagin. In the cultural control of the pest, excessive nitrogen fertilizer application and irrigation should be avoided. Weed control should be applied and pruning should be done regularly.

8-POMEGRANATE DISEASES

Diseases that cause damage to pomegranates: Brown spot disease, Trunk gum disease, Aspergillus, Coniella, Penicillium and Trichoderma fruit rot, Eutypa dieback disease, Fusarium dry rot disease. The most important diseases seen in pomegranate:

Brown Spot Disease (Alternaria alternata): This is a fungal disease which is seen to increase with the warming of the weather in the spring. It causes damage to newly formed shoots, leaves, flowers and fruits due to rain, dew formation and excessive irrigation during the shoot development period. Damaged fruits lose their market value. Since the disease will increase in humid conditions, frequent planting and excessive pruning should be avoided. The tree should be exposed to the sun and therefore ventilated with a balanced pruning. Pomegranate fruit rot is usually caused by Alternaria alternata fungal pathogens, which enter the fruit during and after flowering (Munhuweyi et al., 2016).

Trunk Gum Disease (Phytophthora sp.): It lives in plant residues in the soil in humid conditions. Root and stem infections are mostly in winter and spring, and fruit infection occurs in autumn. The disease increases in heavy textured soils with poor drainage. Surface irrigation and bowl irrigation should not be applied. root collar and trunk should not get wet so it should be done with the drip irrigation method. seedlings should not planted deep in garden establishment. Fruits should not be injured in the collection and packaging process, and wet fruit should not be collected. Before planting, the root and stem of the seedlings should be soaked in 1.5% bordeaux fungicide preparation.

Aspergillus Fruit Rot (Aspergillus niger): It is a fungal disease that causes damage to pomegranate fruits and is more common in the fruit ripening period. It prevents the preservation of pomegranate fruit as it causes the fruits to rot. First, the fruit peel softens, and then the inside of the fruit takes on a black appearance. In the cultural measure, pruning should be done in a way that there is air circulation in the garden. Frequent planting, surface irrigation and bowl irrigation should be avoided.

9- POMEGRANATE BREEDING

If we look at the reasons for plant breeding, it is to increase the yield and quality of plants, to enhance resistance to stress, environmental factors, pests and diseases and to remedy. Inherited variations in plants occur through hybridization, mutation and ploidy. Selection breeding in plants is the oldest of plant breeding methods, it takes place in two ways, natural and artificial selection. Natural selection consists of individuals who best adapt to the environment and climatic conditions, that is, to the environment they are in, and continue their own generation. Heredity, variation and selection are important in natural selection. Heredity ensures the continuity of genetic characters, and variety provides the population richness of different characters. The continuity of the most suitable one of the different characters to the natural conditions is realized by selection. Artificial selection, on the other hand, is the process of selection as a result of controlled breeding of plant species and varieties with certain desired characteristics, obtained by humans. Researchers decide which desired properties of the plant will be preserved. New varieties are obtained through the registration of individuals that are found as a result of selection breeding and that have superior characteristics that are tolerant to some diseases and adverse soil conditions with yield, quality. Pakyürek et al., (2020) reported that selection and clone selection studies were carried out by many researchers in pomegranate. In order to increase the production of pomegranate, there is a need to obtain new varieties and therefore to accelerate the breeding studies. Mutation breeding in plants is hereditary changes. Mutations can be beneficial or harmful. Extreme temperature changes, some chemicals, ultraviolet rays and x-rays can cause mutations. While mutations can occur naturally, artificial mutations are also used to provide variation in fruit growing. In 1950, positive results were obtained in apples in mutation studies. It is aimed to prevent some undesirable features by preserving the positive features in artificial mutations (Sagel et al., 2002). Two genetic structures are combined with hybrid breeding in plants. Hybridization is done in two ways, naturally and under controlled conditions. Many pomegranate varieties have been obtained as a result of selection and hybridization breeding studies. Aksoy, (2017), in Kamilbey 35, Tezeren 35, Efenar 35 and Dr. Ercan 35 pomegranate varieties were applied open pollinated, self-pollinated and cross pollinated, and as a result of hybridization studies, the highest fruit set was finded to Kamilbey 35 × Dr. Ercan hybried varieties. Yazıcı et al., (2016) conducted hybridization studies on Hicaznar x Hicaznar; Hicaznar x Fellahyemez and Hicaznar x Ernar varieties, and compared a total of 67 hybrid individuals with their parents in terms of fruit characteristics and tree characteristics. In addition to the formation of new varieties with hybridization breeding, it is also ensured that some desired positive characters are obtained in the new individual. Since classical breeding studies take many years, it is very important to use molecular markers in addition to these methods in fruit breeding studies. Thus, more effective, quick and reliable results are obtained. With the use of molecular markers, results will be obtained in a short time, unlike long-term fruit breeding studies. With the combination of molecular marker studies and classical breeding studies, faster and more accurate results will be obtained in pomegranate breeding.

CONCLUSION

In recent years, there has been a significant increase in the amount of pomegranate production in Turkey as well as in the world. The amount of pomegranate production in Turkey has increased 12 times from 1990 to 2020 (TUIK, 2021). Pomegranate fruit type, which has a very high economic value, should be grown to provide the highest yield and quality. At first, a garden should be established with healthy, certified saplings that are true to its name. Planting distances should be determined according to the variety to be planted, soil structure and climate characteristics. It is useful to keep the planting distance wide in very humid areas. In order to increase yield and quality in pomegranate cultivation, modern cultivation techniques should be applied. Correct technical application methods should be explained to pomegranate growers to reduce the mistakes made by producers in pomegranate care practices. A conscious and effective struggle should be made against diseases and pests that cause economic damage in pomegranate, and good agricultural practices should be included in this struggle. Pesticides with no residual effect must be applied to increase the amount of pomegranate export. Pruning should be done by experienced teams who know the job. Before preparing a pomegranate fertilization program, soil and leaf analyses should be done and the amount of fertilizer to be given according to the results of this analysis should be calculated and applied. In summer period, irrigation should be done in a controlled manner and excessive irrigation should be avoided. The amount of yield per decare and fruit quality will increase in pomegranate cultivation as a result of the correct implementation of all these applications. Pomegranate breeding studies should be accelerated, the pomegranate production season should be extended by the use of molecular markers together with selection, hybridization and mutation breeding methods, and new pomegranate varieties resistant to cold, drought and diseases should be obtained. In addition to these; packaging, processing, storage and providing cold transportation chain of pomegranate fruit should be paid attention, otherwise; there will be a very high loss of pomegranate fruits, especially those sent to distant markets. Pomegranate fruit losses in transportation and storage should be minimized, and the number of cold storage rooms should be increased. The benefits of pomegranate fruit for human health should be explained through advertisement and publication studies, and the amount of pomegranate fruit consumed per capita should be increased. The number of agricultural supports to pomegranate producers, the number of producer organizations and producer cooperatives should be increased. With the implementation of all these practices, yield and quality will increase in pomegranate fruit production, and as a result, a significant increase will be achieved in our export amount by cultivating the desired varieties in the world market.

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