RECENT HEADWAYS IN POMOLOGY

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Institution of Economic
Development and Social
Researches Publications®
(The Licence Number of Publicator: 2014/31220)
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USA: +1 631 685 0 853
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Iksad Publications – 2021©

ISBN: 978-625-7562-09-6
Cover Design: İbrahim KAYA
June / 2021
Ankara / Turkey
Size = 16x24 cm

CONTENTS

PREFACE

Climate change has the potential to influence the production and quality of fruits. The reduction in production of fruits, is a result of several factors, i.e., environmental, physiological and biological, but the impact of environmental and climatic factors are comparatively significant. The climatic parameters have affected the average growth and development, influenced the quality of fruit production, frequently changing weed, pest, and disease incidences. Several physiological mechanisms are involved in the stress tolerance of fruits plants. To alleviate the harmful effects of environmental stresses, plants increase the production of various compatible osmolytes.

This book summarizes the importance of fruits crops, the present improvements, and future directions for enhancing yield and nutritional quality under environmental stress conditions and climate change scenarios. Recent agricultural technologies that have significantly increased food supply have had inadvertent, detrimental impacts on the environment and ecosystem services, highlighting the need for more sustainable agricultural production. In light of the possible impact of climate change, researchers should emphasize the development of environmental resistant crops. Further, it needs to be initiated to define the present limits to these resistances and the feasibility of manipulation through advanced genetic and molecular techniques. Advanced technology has the potential positive impact on the agriculture sector. It minimizes adverse effects of agricultural practices, environment and human health, improves productivity and food security. In this context, we studied the recent trends of technology that could provide benefits for sustainable fruit growing.

I would like to thank all the authors who contributed to the formation of this book with their valued works. Hope the book will be useful to readers and researchers who are interested in the subject.

Sincerely Yours

Mine PAKYÜREK

CHAPTER 1

THE EFFECTS OF ALTITUDE AND VARIETIES ON PERFORMANCE OF PISTACHIO (*Pistacia vera* L.) GRAFTING ON BUTTUM (*Pistacia khinjuk* L.) TREES

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INTRODUCTION

Pistachio fruit, which has a high yield to its producer, is an important plant food that is the most preferred among the hard-shelled fruit species around the world. An average of 83.4% of the total pistachio production in the world is provided by Iran, America and Turkey. Turkey ranks third in the world in the number of pistachio trees and pistachio production (FAO, 2019).

World Pistachio production is 1.005.436 tons and 150.000 tons (14.9%) of that number is produced in Turkey (Ertürk et al., 2015). *Pistacia* species known as Wild Pistachio are spread almost all over Turkey. Melengiç is the most common one in terms of number and distribution area, followed by Buttum and Atlantic Gum (Bilgen, 1973; Türker, 2003). Pistachio varieties commonly grown in Turkey are Uzun, Siirt, Kırmızı, Halabi and Ohadi varieties.

While the cultivation of many fruit species is limited in the Southeastern Anatolia region, Pistachio is widely cultivated in this region due to its unique ecological conditions and it can be grown easily even in both arid and soil conditions where other fruit species are difficult to grow. In our country, there are approximately 42 million pistachio trees and 26 million of these are in the yield age (Ertürk et al., 2015) and the cultivation of this fruit is increasing day by day (Özbek, 1978, Ayfer et al., 1990; Balta, 2002). Pistachio is pomologically divided into three parts, which are long (Uzun, Halebi, Sultani), oval (Siirt, Kırmızı) and round (Ohadi, Kerman). Pistachio is grown in stony, rocky, calcareous and arid soils that are poor in nutrients. It can be grown economically in regions with long, hot and dry summers and relatively cold winters (Özbek, 1978; Tekin et al., 2001).

The homeland of pistachio is Turkey, the Caucasus, Iran and the high region of the Near-East. At the same time, it is the most important gene source and development center in the formation of cultural varieties. Pistachio is a plant species that needs hot and dry weather in summers and very cold climates in winters. It can be easily grown in barren, rocky and calcareous areas where many other cultivars cannot easily grow.

In our country, the number of Pistachio trees bearing fruit in 2014 is 39.329.512, the yield per tree is 2 kg, and Pistachio cultivation is carried out on an area of approximately 2,823,338 decares (Ertürk et al., 2015). *Pistacia terebinthus*, *Pistacia khinjuk*, *Pistacia atlantica*, and *Pistacia vera* rootstocks are used in pistachio cultivation in our country (Köroğlu, 1999). Naturally, in the chip budding of the melengic rootstocks at different periods, 10% grafting success was achieved when the trees were at rest, 20% grafting success was achieved in the grafting made at the time of awakening, and finally, 60% grafting success was achieved in the flowering period while the shoot lenght was 45 cm for all these three conditions. (Kaşka et al., 1990). In a study that grafted Siirt, Ohadi and Uzun cultivars on Melengic rootstock by chip budding method; It was stated that 65% of the graftings vaccinations made between the months of spring (April-May) and 33% of the graftings vaccinations made between the end of July and the middle of August were achieved (Çağlar, 1994). In a study conducted in

Şanlıurfa; In the T-budding, vaccine, the highest grafting success was obtained in *Pistacia vera* x Siirt grafting with 95%, and the lowest grafting success was obtained in Pistacia khinjuk x Siirt graftings with 40%. He noted that among the rootstocks, Pistacia vera 78%, Pistacia atlantica, 65% and Pistacia palaestina 64%, the highest grafting success was obtained from Siirt variety with 79% and the lowest success rate was obtained from Kırmızı variety with 61% (Kandemir, 2004).

Five Pistachio (Pistacia vera L.) varieties (Siirt, Kırmızı, Uzun, Atlı, Uygur) were grafted in seven different locations (Döküktaş, Göktepe, Nuh, İncirli, Hacı Mehmet, Dayılar, Sürücüler) that are located at different altitudes on Buttum (Pistacia khinjuk L.) rootstocks in Hizan District. Buttum trees aged between 15-20 years, which were pruned in preparation for grafting before grafting, were inoculated with the T budding method and their grafting success, shoot development and performance of the cultivars were followed.

1. MATERIAL AND METHOD

This research was carried out in the district of Hizan (Bitlis) between the altitudes of 900-1600, Dayılar (1250-1350 m), Göktepe (1320-1400 m), İncirli (1450-1500 m), Noah (980-1100 m), Sürücüler (1550-1600 m), Döküktaş (1250-1400 m) and Hacı Mehmet (950-1000 m) locations in 2019-2020 (Figure 1). In the first year, Buttum (*Pistacia khinjuk*) population in the region was determined, the trees in the locations to be grafted were marked, and inoculation was made with the T budding method in the third week of June, which is the stagnant period (Figure 2).

In the first year of the graftings, it was observed that the success rates of the grafts in the locations and the success rates in the varieties differed. Therefore, five different pistachio cultivars were inoculated in different locations. Graftings were carried out repeatedly in the same locations in 2019 and 2020. Siirt, Uzun, and Kırmızı varieties were grafted as female varieties, while Uygur and Atlı varieties were grafted as male varieties (Figure 3).

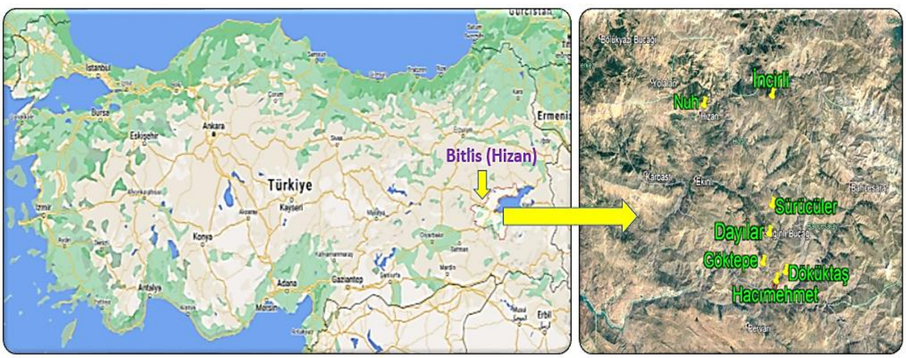

Figure 1: Location map of the study area.

Figure 2: Images of grafts made.

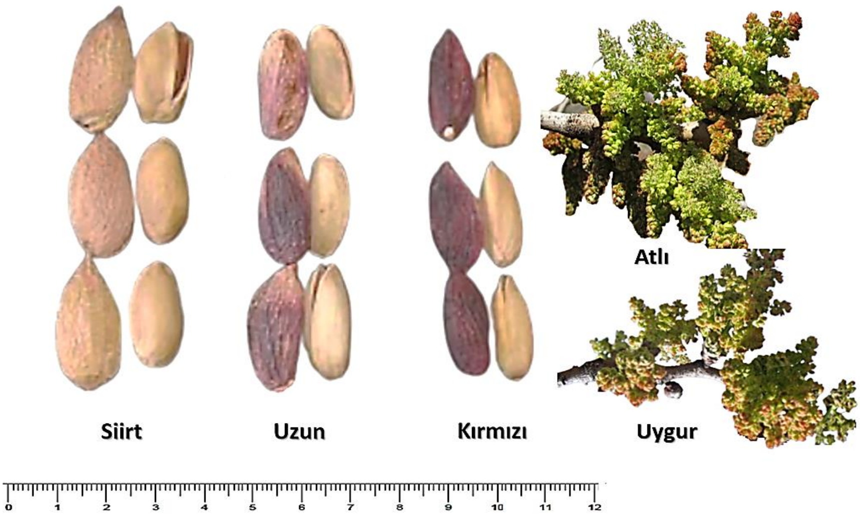

Figure 3: Varieties used in the research.

100 inoculations of each variety were made and the locations are quite scattered and hilly. Genotypes determined to be between 15-20 years of age were preferred for grafting. In the coming years, it is planned to continue grafting of all rootstocks in the region under the coordination of the Bitlis Provincial Directorate of Agriculture and Forestry. In the Hizan region, the Buttum (*Pistacia khinjuk*) population is spread over a wide area and there are tens of thousands of trees in the appearance of a scattered forest. The average annual temperature of Hizan district is 11.0 ºC, the average highest temperature in the summer months is 32 ºC, and the average lowest temperature in the winter is -15 ºC. In general, continental climate prevails, and microclimate features are observed in some locations. The annual average precipitation is 853 mm (Anonymous 2021a,b,c).

2. RESULTS and DISCUSSION

In the first year of the graftings, the lowest success rate was obtained in the Kırmızı variety in the Sürücüler location with 39%, while the highest rate was obtained in the Siirt variety in the Dayılar location with 94%. The average success rate on the basis of 1st year varieties was 65-81%. In the second year, on the basis of varieties, the lowest success rates in grafts were obtained in the Red variety at the Sürücüler location with 38%, while the highest rate was obtained in the Atlı variety in the Hacı Mehmet location with 96%. The average success rate on the basis of varieties in the 2nd year was 61-82%. It has been determined that the average success rates of the 1st and 2nd years in the locations are 59-84% (Table 1).

Due to the fact that the area where the shoot development is studied is a mountainous, rugged and scattered wide area, it could not be taken in the vaccinations made in 2019, and the shoot length values obtained at the end of the vegetation in 2020 were expressed as mean and standard deviation. Differences were observed on the basis of male cultivars and female cultivars in different locations. The longest shoot growth in Hacı Mehmet location was observed in Uygur variety from male varieties, in Kırmızı variety with 44.52 and Siirt variety with 44.22 from female varieties in the same location. While the shortest shoot growths was determined in Atlı variety in Döküktaş location from male varieties, it was determined as 6.08 cm in Siirt variety in Nuh location in female varieties. Average shoot development was determined as 22.58 cm (Table 2).

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While the longest shoot growths were determined as 44.78 (Uygur), 42.61 cm (Kırmızı) and 42.65 cm (Siirt) in Döküktaş location, the shortest shoot growths were determined as 6.71 cm (Siirt) and 7.02 (Atlı) cultivars. Average shoot growths was determined as 23.59±6.53 cm (Table 2).

In Göktepe location, the longest shoot growth were determined as 42.05 cm (Uygur) and 38.05 cm (Siirt), while the shortest shoot growths were determined in 8.06 cm (Uzun) and 8.11 (Atlı) cultivars. Average shoot growths was determined as 25.45±4.28 cm (Table 2).

While the longest shoot growths in Hacı Mehmet location were determined as 48.30 cm (Uygur), 44.52 cm (Kırmızı) and 44.22 cm (Siirt), the shortest shoot growths were determined in 13.64 cm (Siirt) and 19.24 (Atlı) cultivars. Average shoot development was determined as 30.11±5.54 cm (Table 2).

While the longest shoot growths in İncirli location were determined as 40.74 cm (Uygur) and 33.58 cm (Siirt), the shortest shoot growths were determined in 7.54 cm (Uzun) and 8.33 (Uygur) variety. The average shoot growth was determined as 25.55±3.80 cm (Table 2).

Table 1: Grafting success rates of pistachio cultivars at different altitudes (%)

Type	Siirt ♀		Uzun ♀		Kırmızı ♀		Uygur ♂		Atlı ♂		Average	
Location / Altitude	1 year	2 years	1 year	2 years	1 year	2 years	1 year	2 years	1 year	2 years	1 year	2 years
Dayılar / 1250-1350 m	94	88	92	78	70	70	83	79	81	82	**83**	**80**
Döküktaş / 1250-1400 m	84	78	72	72	68	65	73	71	68	63	**73**	**70**
Göktepe / 1320-1400 m	92	80	88	73	72	71	94	91	71	74	**83**	**78**
Haci Mehmet / 950-1000 m	50	45	81	72	53	41	62	52	90	96	**67**	**61**
İncirli / 1450-1500 m	73	75	70	70	75	68	81	79	76	70	**75**	**72**
Nuh / 980-1100 m	88	82	82	80	80	72	92	93	73	91	**84**	**84**
Sürücüler / 1550-1600 m	43	40	46	42	39	38	79	82	88	96	**59**	**59**
Average	**75**	**70**	**76**	**70**	**65**	**61**	**81**	**78**	**78**	**82**	**75**	**74**

Table 2: Shoot length values of vaccinations made (cm)

Type	Shoot Development (cm)	Dayılar	Döküktaş	Goktepe	Hacı Mehmet	İncirli	Nuh	Sürücüler	Average
Siirt ♀	Max	42.54	42.65	38.05	44.22	33.58	42.55	29.91	**23.48±7.12**
	Min	9.18	6.71	8.33	13.64	8.56	6.08	7.22	
	Average	25.52 ± 8.21	24.13±8.55	23.17 ± 7.21	28.50 ± 6.24	20.59 ± 5.57	24.14 ± 5.89	18.15 ± 8.25	
Uzun ♀	Max	34.45	33.56	28.08	38.57	26.28	33.87	24.52	**17.73 ± 4.40**
	Min	11.02	7.41	8.06	15.64	7.54	7.33	7.21	
	Average	22.51 ± 4.57	20.04±4.33	18.41 ± 3.51	26.5±7.10	16.50±3.22	20.22 ± 5.02	15.54 ± 3.07	
Kırmızı ♀	Max	42.85	42.61	30.57	44.52	26.81	42.34	21.07	**21.95 ± 4.87**
	Min	10.07	6.54	9.34	14.66	8.56	6.38	6.37	
	Average	26.57 ± 6.02	24.44±7.08	19.51 ± 3.21	29.00±4.11	17.01 ± 3.75	24.08 ± 6.10	13.5 ± 3.84	
Uygur ♂	Max	43.58	44.78	42.05	48.30	40.74	44.45	30.27	**26.97±4.22**
	Min	17.08	12.14	9.66	20.07	8.33	12.09	7.36	
	Average	30.18 ± 5.10	28.27 ± 5.82	25.57±3.71	34.02±5.02	24.09±3.22	28.32±4.20	18.55 ± 2.48	
Atlı ♂	Max	38.14	35.46	34.58	46.21	31.45	35.47	29.22	**22.79 ± 4.54**
	Min	10.27	7.02	8.11	19.24	9.58	7.57	7.56	
	Average	24.27±5.01	21.07 ± 6.87	21.10 ± 3.77	32.54 ± 5.22	20.58±3.24	21.45 ± 4.01	18.20±3.70	
Average		**25.81±5.78**	**23.59 ± 6.53**	**25.45±4.28**	**30.11 ± 5.54**	**25.55 ± 3.80**	**23.64±5.04**	**16.78±4.27**	**22.58 ± 4.35**

In Nuh location, the longest shoot growths were determined as 44.45 cm (Uygur), 42.34 cm (Kırmızı) and 42.55 cm (Siirt), while the shortest shoot growths were determined as 6.08 cm (Siirt) and 7.57 cm (Atlı). The average shoot growth was determined as 23.64±5.04 cm (Table 2). While the longest shoot growths were determined as 30.27 cm (Uygur) and 29.91 cm (Siirt) in the Sürücüler location, the shortest shoot growths were determined as 6.37 cm (Kırmızı) and 7.36 (Uygur) cultivars. Average shoot development was determined as 16.78±4.27 cm (Table 2).

Kandemir (2004), in the prestudy of his research, investigated the effect on the success of grafting by grafting Siirt variety on *P. vera* rootstock on three different days. According to his study, 83% grafting success was achieved in the first day after the buds were removed, 68% grafting success was achieved in the second day grafting, and 30% grafting success was achieved in the third day grafting. The results obtained from T-budding applied on different rootstocks are similar to the studies performed by Arpacı et al., (1997) and Kandemir (2004). Arpaci et al. (1997) noted that *P. atlantica* showed the best development in terms of shoot development, while the weakest development was in plants grafted on *P. vera* rootstock. Kandemir (2004), reports that the best development is in the shoots grafted on the *P. vera* rootstock, followed by *P. khinjuk*, *P. atlantica* and *P. palaestina*, respectively.

Kaşka et al. (1990) stated in their study that due to the high air temperature in T-budding, the grafts formed the top bud and the shoots remained between 5-7 cm. Kandemir (2004), in his research, reports that the top bud begins to form in August, and the shoot length varies between 7-31 cm. Çağlar (1994) stated that Uzun variety gave the longest exile on melengiç rootstock and there was no significant difference between Ohadi and Siirt varieties in terms of shoot length. It has been reported by different researchers that the success rate, seedling yield and shoot development in grafts differ depending on the seedling, cultivar, time of making, the grafting method used, the altitude, the ability of the person, the climate and soil factors in the environment (Kaşka, 1990; Kazankaya, 1996; Türker, 2003; Kandemir, 2004; Şen et al., 2006).

It was determined that the success of the grafting ranged from 38-96% in Atlı variety, and the lowest success in the Kırmızı variety with the highest grafting success. It was determined that the lowest success of the graft was gained in the Sürücüler location, where the altitude was the highest. It was observed that the shoot length of the male cultivars Uygur was longer, the shoot length varied between 6-48 cm, and the shoot development of the female cultivars Kırmızı and Siirt followed a parallel course. It has been revealed that the increase in altitude in different locations has a negative effect on shoot growth. According to the results obtained in the study, it was determined that the grafting success rate varies depending on many factors, and the increase in altitude negatively affects the grafting success rate and shoot development.

CONCLUSION

It has been observed that the grafting on the north side of the rootstocks in the evening or early morning is important in the success of the grafting. In addition, pruning in preparation for grafting in autumn and preventing excessive wound opening on the rootstock at the time of grafting can increase the success of the graft. Among the female varieties, which are the subject of the study, Siirt and Kırmızı varieties can be recommended to the region for inoculation grafts, and as pollinator, Uygur was recommended as the most suitable variety for the region.

Inoculation of the inert buttums will accelerate the increase of pistachio production. It has been observed that in the villages of Nuh (Ballı) and Döküktaş, which have low altitudes, the success of grafting increases between at 950-1200 meters altitude and negative altitude effects occur at altitudes exceeding 1250 meters, and this is effective in all stages of the working processes of this paper. It is expected to make significant contributions to the production in the region by grafting Siirt variety as the main variety and Uygur variety as pollinator to the buttum trees that are located in the areas with an altitude of approximately 950-1200 meters in the Eastern and Southeastern Anatolian region. Buttum trees, which have been grafted before, start to yield fruit and albeit very little, from the third year. It is expected that the production that will be obtained will contribute to the family budget, the economy of both the region and the country.

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CHAPTER 2

REPRODUCTION OF WALNUT TREES

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INTRODUCTION

Due to its high protein and valuable oil content, walnut fruit has become an increasingly important food in human nutrition. Walnut is a strategic fruit that can be consumed directly and processed into many products. It is included in the FAO list as a priority product to be grown in the world (Gandev, 2007). The cultivation of walnuts will be possible with the reproduction of high-quality varieties.

Since walnut (*Juglans regia* L.) is more difficult to propagate than most fruit species, old and reliable propagation technologies around the world are being developed through studies of new methods for producing grafted planting material. The most widely used propagation method in the production of walnut trees today is the grafting method. The most commonly used technique in grafting is patch budding. Examples of other methods used are English grafting, chip bud grafting, indoor grafting and hot callusing. Hot callusing has been used successfully in the reproduction of walnut varieties in recent years. Another walnut propagation method is called epicotyl grafting. Poor callus formation directly affects the success of walnut in the fusion phase after grafting. Due to the anatomical structure of the walnut, the high concentration of phenolic compounds in its vegetative part and the problems arising as a result of their oxidation, it does not make it possible to reproduce with cutting. In layering method reproduction, it is not used much in practice due to the difficulty of application as well as the low reproduction speed. Moreover, the tissue culture reproduction method is also not a widely used method in reproduction because the desired final success cannot be achieved at all.

In walnut cultivation, propagation is done by two different methods, which are vegetative and generative methods. Propagation by seed in walnut cultivation is generally used in breeding studies, obtaining new types and varieties, afforestation on the roadside, afforestation of forest areas and rootstock in propagation with grafting. When reproduction is mentioned, it should come to mind to obtain new plants with the same characteristics of the variety desired to be reproduced. In this respect, seed propagation, which is the oldest known propagation method, is a method that we cannot use in the reproduction of varieties in walnut cultivation. Because walnuts are heterozygous because they are monoecious, show dichogamy tendency and pollination is by the wind. The new plant consisting of walnut seeds may not completely carry the characteristics of the mother plant. Concurrently, another negative aspect is that the trees propagated by seeds give fruit late. In today's walnut cultivation, the most practical propagation method is grafting. The success of the layering propagation method, which is one of the vegetative propagation methods, is partial and its use is not as common as other methods. In addition to the difficulty of reproduction by layering method, the low reproduction speed makes the method impractical. Reproduction by tissue culture, which has been the most emphasized and theoretically the fastest propagation method in recent years, has been tried on walnuts as well as many fruit species but has not been widely put into practice. (Millikan, 1971; Woodroof, 1979; Li et al., 1984; Sharma et al., 1984; Ozalin and Kozubaev, 1988; Germain, 1990; Tsurkan, 1990; Kantarcı and Jacob, 1990; Karadeniz, 1993; Rongting and Pinghai, 1993; Alnabulsi, 1995; Kazankaya, 1996; Şen et al., 2006).

1. GENERATIVE REPRODUCTION

The seed propagation method in walnut cultivation is generally used to obtain rootstock. In addition, it is used to obtain new varieties in breeding studies and to propagate by seed in roadside or forest plantations. For whatever purpose, each of the processes of obtaining, drying, preserving, folding and sowing the seeds required for reproduction is extremely important. Therefore, it would be useful to examine these stages separately. In order for the germination to be good and the seeds obtained to develop rapidly, the seeds to be used in reproduction should be full, rich in nutrients and fully developed. Seeds used in reproduction should be taken from healthy and well-developed trees. Seeds should not be taken from trees where diseases such as anthracnose occur and insects damage their leaves. Seeds should not also be taken from trees that have poor nutritional conditions, are dehydrated or grow in dehydrated environments, have a sunburn and are damaged by cold. Larger seeds tend to form larger seedlings. Seeds should be separated from the green skin immediately after the fruits are harvested, washed well with clean water and dried in a shaded place (Woodroof, 1979; Şen et al., 2006).

As with all temperate fruit species, walnut seeds also need a period of rest (Table 1). In order for regular germination to occur, the seeds must be folded for a certain period of time. For this, the seeds should be kept in a low temperature and humid environment between 0-8 °C, in cool basements, ordinary warehouses, or cold storages for 8 weeks. The bottom boards of the chests to be used for folding should be in such a way as to allow excess water to flow, and there should be a layer of coarse gravel in the lowest layer, a thin layer of sand sprinkled on the gravel, and walnuts should be placed on the top (Figure 1).

Table 1: Some features related to fruit size, cooling needs and germination of seeds in different walnut types.

Species	Seed the size of (Fruit number / 100 g)	Chilling need (day)	Optimum cooling temperature (° C)	Germination rate (days)	Seed viability (Year)
J. californica	16	-	-	-	-
J. cinerea	3-9	90-120	5	45	-
J. hindsii	7-18	60-120	-	30	3-5
J. nigra	4-22	60-120	5	25	-
J. nigra	11-22	60-120	-	30	3-5
J. (paradox)	11-14	60-80	-	25	3-5
J. (Royal) hybrid	11-18	60-100	-	25	3-5
J. regia	7-11	30-60	5	20	1-3
J. rupestris	17-24	90	7	14	-

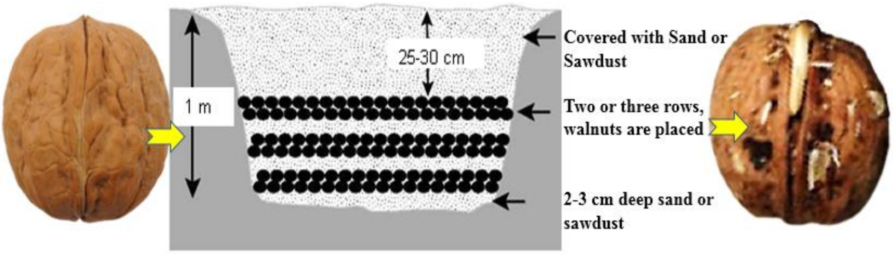

Figure 1: Folding the walnut.

The purpose of folding;

- ✓ Keeping the seeds in a moist environment and washing the inhibitors.
- ✓ Eliminating the mechanical anti-germination effect of the shell by

softening the hard shell.

- ✓ To make the seed swell by taking water and transport the spare nutrients to the growth points.
- ✓ By eliminating the cooling needs of the seeds, it helps to have regular germination and seedling development.

Sometimes it is possible to meet the structural resting needs of seeds such as GA_3 by using growth regulators instead of folding. In order to achieve this, the walnut kernels should be removed as a whole without being damaged and kept in a 25-100 ppm hormone solution for 6-12 hours. If the seeds have not been folded, early sowing will yield more positive results than late sowing. Therefore, if walnut seeds are planned to be sowed directly in the garden or nursery, this should be done in October-November. The sowing depth of the seed can vary between 3-10 cm depending on the size of the seed, the structure of the soil, the moisture condition in the soil, the soil temperature, the presence of squirrels and rodents, crows and birds in the environment. Seeds germinate during the first growing season. If seeds are improperly folded or the seedbed is left dry, they may not germinate until the second year. Likewise, the hard shell of the walnut can form a mechanical barrier against germination. This effect of hard bark against germination can be removed by cracking and mechanical or chemical abrasion. The hard shell can be abraded by treating it with chemicals such as HCL, H_2SO_4, NaOH and KOH for certain periods of time, and the hard shell can also be abraded by rasping. In order to achieve good seedling growth after germination of seeds, care needs to be followed carefully. The most important work to be done in the seedling plots during the development period is weed control. In order to control weed, herbicides can be used, as well as mulching (Şen et al., 2006).

2. VEGETATIVE REPRODUCTION

When it comes to vegetative propagation of walnut trees, the first method that comes to mind is the grafting method. Walnuts cannot be propagated by rooting practically, because the rooting ability of walnuts is quite low (Erdoğan, 2006; Reil et al., 1998). For such reasons, many researchers have conducted studies on the reproduction of walnuts by grafting. The impracticality of propagation by immersion, the very low rooting rate of the plant in propagation by cuttings, and the large investments required for propagation with tissue cultures significantly limit the propagation of walnuts by vegetative methods other than grafting.

Reproduction by Grafting

The grafting of walnuts presents significant difficulties compared to the grafting of other fruit species.

- ✓ Walnut needs higher temperature for callus formation
- ✓ The rootstock has a thick crust and creates an air pocket under the bud to be used during graftings;
- ✓ During the cleft grafting, there is more bleeding than the cuttings.

These issues reduce the grafting success rate in walnuts.

In cleft grafts, if the graft is made in the early period, the xylem sap flow formed in the grafting areas prevents the formation of callus between the rootstock and the scion and the establishment of a connection between the vascular bundles, thus preventing fusion in the graft. Covering the grafting site with a polyethylene cover, covering it with paraffin, painting it with white paint or wrapping it with pit moss has effects that increase the success rate in graftings. The amount of nitrogen, carbohydrate, water-soluble dry matter, juglone, flavone, structural hormones and starch in rootstocks and scions affect the rate of retention and eruption in grafts. In addition, the age of the rootstock and scion used, its maturity, the time of grafting, the graft bond used, paste, paraffin, ambient temperature, humidity, lighting and the environmental conditions of the seedlings after grafting have a direct effect.

In its general definition, grafting can be understood as the joining of two plant parts, taking advantage of the regeneration of their tissues. One of these two plant parts belongs to the variety we want to reproduce and is called a scion or bud according to the structure of the part. Walnut is the hardest to graft among the hard-shelled fruit species. This is because walnut grafting requires a higher temperature for callus formation. Callus formation in walnuts starts at 17°C, reaches the optimum level at 27°C and stops when the temperature reaches 38°C. In this regard, if the spring grafting is delayed until the outside temperature reaches 27°C, the success rate will increase even more. If the shoot grafting is to be done in February or March, which is the beginning of the awakening period in walnut grafting, the grafting must be done indoors and the ambient temperature and humidity must be adjusted in order to provide the required temperature. If the grafts are to be made outdoors, it may be necessary to heat the graft area in order to ensure rapid cell division and fusion. With the increase in the temperature in the graft region, cell division and differentiation will begin, and the success of the graft will increase in walnuts. The shoots of walnut varieties should be taken and stored in November and December before the severe winter cold starts. Walnut cleft grafting should be delayed until the first shoots take their full size in the spring development period. The top of the seedling rootstock should be cut 20-25 days before inoculation to prevent excessive bleeding. Cuts should be made 3-5 cm above the grafting area. As the grafting season progresses, the bleeding of the cuttings on the rootstocks will decrease (Prataviera et al., 1983; Eriş and Barut, 1989; Ronting and Pinghai, 1990; Lagerstedt, 1981; Şen, 1986; Eriş and Barut, 1989; Tsurkan, 1990; Hartman et al., 1990; Şen et al., 1995; Kazankaya, 1996).

Many factors affect the success of the graft. The grafting blade should be very sharp, the scions should be cut and stored well during the rest period, and the scions should also be kept in wet cotton cloth during grafting to prevent drying out. If the rootstock and scion are of the same thickness, the whip graft and cleft graft, when the scion is thinner than the rootstock, the modified cleft graft, when the rootstock is thicker than 2.5 cm, the splitting or bark graft are the most commonly used methods. For novices, whip graft, bark graft and cleft graft are the most effective grafting methods commonly used. The shoots that will emerge from the rootstock should be cut three to four weeks after grafting, every 5-6 days. In order to obtain correct seedlings, grafted seedlings must be labeled. In order for the grafting to be successful, there should be enough temperature to encourage callus formation in the grafting area, the joint area of the scion and rootstock bud should be prevented from drying out, and the cambium of the rootstock and shoot should be overlapped. The cambium is a layer of cells located between the bark and the woody layer of the stem. Since this cell layer is capable of dividing, it produces wood tissue on the one hand and living inner bark on the other, and ensures the transverse development of the trunk. The cambium, which has such a development feature, heals the wood by forming callus tissue in the graft area. The cambium that carries out these activities in the graft region belongs to both the rootstock and the scion. Callus cells formed by both cambium mix during growth and provide the union between rootstock and scion. With the completion of fusion, the differentiated callus cells will form a new cambium and vascular bundles. The greater the contact area of the rootstock and the scion, the higher the success rate of the graft (Figure 2). In this regard, if possible, the rootstock and scion should be close to each other in diameter. If there is no fusion in the graft site due to reasons other than physical conditions and environmental factors, this situation is expressed as incompatibility. The first reason that comes to mind in a rootstock-scion mismatch is the lack of genetic closeness. Diseases, on the other hand, are accepted as the second cause of conflict. The callus tissue forms the cambium after grafting. Cells damaged during grafting turn brown and die. Living cells behind the dead cells divide within 24 hours and begin to form callus. The callus tissue formed on the rootstock and scion move towards each other and begin to form the first callus bridges within 5 days. Callus cells penetrate into the brown tissues damaged during grafting and break up these tissues. Differentiation begins in the callus tissue within 2-3 weeks. Then lignification begins and fusion is completed (Walter, 1978; Lagerstedt, 1980; Lagerstedt, 1984; Szöke, 1990; Atefi and Avanzota, 1995; Atefi, 1995; Kazankaya, 1996; Kazankaya et al., 1997; Karadeniz et al., 1997; Şen et al., 1997; Gandev, 2007; Gandev, 2014).

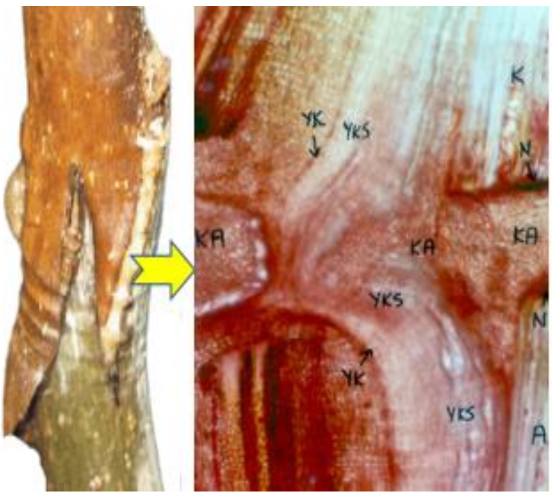

Figure 2: The appearance of fusion, Callus (KA), Scion (K), Rootstock (A), New Xylem (YKS) and Necrotic Layer (N) 40 days after grafting.

After the callus has formed at the graft area, the high summer temperatures that will occur may be harmful to the fresh tissue in the graft area. Therefore, the grafting area may need to be protected. For this, this protection work can be done by shading the graft, wrapping the graft with a reflective material such as an aluminum layer, or applying white paint to the graft site. With the decrease in light intensity, that is, with the increase in the amount of shadow, the growth of shoot length and diameter is greater. In addition, normal shading is more successful in terms of seedling yield than excessive shading or those left in the open (Table 2, 3, 4) (Kazankaya, 1996).

Table 2: The effect of environments on height development in exiles

Development Environment	June (cm)	July (cm)	August (cm)	September (cm)	October (cm)	Light Intensity (Lux)
Tulle Drape	13.24	14.10	14.50	14.70	14.79	18750
Tulle + Polyethylene cover	13.00	14.05	14.50	15.10	15.10	5900
Hair Cover	13.08	14.88	15.00	15.12	15.13	4500
Transition Room	15.54	17.09	17.89	18.93	18.93	501
Open Space (control)	12.50	12.61	12.64	12.67	12.68	57000

Table 3: Effects of media on diameter development in shoots

Development Environment	June (cm)	July (cm)	August (cm)	September (cm)	October (cm)	Light Intensity (Lux)
Tulle Drape	4.10	4.23	4.42	4.49	4.50	18750
Tulle + Polyethylene cover	4.20	4.60	4.70	4.78	4.80	5900
Hair Cover	4.10	4.47	5.68	4.88	4.90	4500
Transition Room	4,01	4.64	4.70	4.81	4.93	501
Open Space (control)	4.20	4.28	4.30	4.31	4.33	57000

Table 4: Saplings of Different Shaded Environments Effects on Yield

Development Environments	Live Sapling (%)	Lasting Sapling (%)	Sapling Efficiency (%)	Light The severity
Tulle Drape	61	78	48	19678
Tulle + Polyethylene cover	85	87	74	6114
Hair Cover	60	79	47	4412
Transition Room	72	88	63	504
Open area	36	80	29	58707

It is noted that calluses are not formed in walnuts inoculated at temperatures below 21°C. The most important thing to do after grafting is to prevent moisture loss by wrapping the graft area tightly with a moisture-proof material. The material to be used for this purpose is rubber grafting tape, plastic film, or adhesive tapes, provided that it is painted over later. The cutting time of the shoot to be made depends on the conditions of the season, especially considering the temperature. The shoots should be cut when they are at full rest before the buds begin to swell. But the cutting of the shoots must be done before the buds begin to swell. The best scion can be made from the vigorously growing shoots of the previous year. When scions are cut, the cutting surfaces are covered with any material, bound and labeled to prevent moisture loss. It is very important to take the grafts out of the warehouse and transport them to the garden, to protect them from excessive heat and light during the grafting process, and to prevent them from drying out. It is seen that the grafting made at the end of the resting period and at the beginning of the awakening period in walnuts are higher in terms of seedling yields and seedling growth compared to the grafting made during the resting period or the flowering period. A successful graft is possible with a good timing of grafting. Many factors are affecting the grafting time, such as temperature, rootstock, scion, weather, latitude, soil layer and air drainage. Frost may occur in areas with low altitudes, and early vegetation and late frosts may have a negative effect (Woodroof, 1970; Atefi, 1997; Achim, 2001; Hartmann et al., 2002).

Bud take and sprouting rates in different grafting methods differed according to the cultivars. In the graft study conducted with different grafting methods and varieties, the chip budding seems to be the most successful and the omega grafting is the most unsuccessful. When the situation is analyzed on the basis of varieties, it is understood that Yalova 2 and 60 TU 1 give more successful results than the others. Regardless of the variety, while the chipped bud stood out in March; In

July, a chipped bud and a patched bud, in September, a tongued, chipped bud, a patched bud; More successful results were obtained in lingual grafts in November. In the evaluation made without considering the methods, it was observed that the April grafts gave more successful results on average. Considering the three grafting methods in November, the most successful results were obtained in 13 AD 01, 13 AD 02 and Altınova types (Table 5-7) (Kazankaya, 1996).

Table 5: Retention and Application Rates in March Period Grafts

Standard Kinds	Retention Rate		
	Lingual	Omega	Chipped
Yalova 1	42	25	86
Yalova 2	80	45	88
Yalova 3	80	-	80
Yalova 4	90	-	76
KR 1	54	44	94
KR 2	42	57	75
24 KE 15	56	44	80
24 KE 25	44	42	76
60TU-1	80	35	80
Kaplan	89	14	86
Bilecik	75	33	78
Şebin	30	-	92
13AD01	44	28	60

Table 6: Graftings in November Period Graft Effects of His Methods

Standard Diverseprivate	Retention Rate (%)		
	Lingual	Patch	Chipped
Yalova 1	64	8	60
Yalova 2	74	14	56
Yalova 3	74	8	56
Yalova 4	72	4	56
Kaplan	84	26	76
Bilecik	80	16	60
Altinova	82	36	76
13 AD01	94	70	94
13 AD02	94	58	88

Table 7: Graftings According to Periods Effects of Methods on Retention Rates

Grafting Method	Retention Rate (%) March	Retention Rate (%) July	Retention Rate (%) September	Retention Rate (%) November
Lingual	62	34	74	80
Chip Budding	81	77	70	67
Patch	35	82	76	27
T Budding	5	38	22	-
Omega	-	-	15	-
Retention Rates by Dates	7 March	21 March	April 4	18 April
	31	89	72	78

Grafting propagation is classified into three different parts according to the purpose of making it, which are variety replacement grafts, seedling growing grafts and repair grafts. Sap flow sap from the cut or injured parts of trees, or in other words, the occurrence of bleeding is closely related to root pressure. Especially in the early spring periods when the soils are too humid and the night and day temperatures change irregularly, the sap flow, which is bleeding, occurs in an annoying way. Bleeding is a big problem, especially when grafting walnuts. Because when there is bleeding in the junction area, either no or very little callus is formed. Since this amount will not be sufficient for the fusion of the graft area and the rootstock merger, the graft is usually unsuccessful. In order to prevent bleeding, the rootstock can be cut 1-30 days before the grafting period. The easiest way to protect the graft from heat is to reflect the heat coming to the grafting area. In order to do this, the grafted plant is painted from the top to the bottom in the south and west directions, where the temperatures are the highest.

Cleft Grafting: This type of grafting consists of attaching a piece of wood (branch) with more than one bud on the rootstock and fusing it. The later the resting scions are attached to the rootstock, the higher the success rate will be.

Whip Grafting: The whip grafting method can be easily recommended to beginners due to its ease of application. This grafting method is used for grafting small seedlings that are 1-2 years old. In this method, it is recommended that the diameters of the rootstock and the scion are slightly different from each other or to be the same diameter. Chipping of rootstock and scion occurs by cutting both of these two diagonally. The best cambium contact is achieved by overlapping the crosssectional surfaces in such a way that they close each other. In general, it is good to have at least two buds on the scion. It is noted that the grafts in walnuts that are made in March and September are equally successful (Figure 3).

Figure 3: Application methods of Whip and Tongue Graft

Wipe Grafting: Wipe Tongue grafting is another form of whip grafting. This graft is more widely used than the whip graft. In this method, there is a tight connection between rootstock and scion even before callus formation. Because in this graft, rootstock and scion are partially intertwined. It is the type of grafting that provides the best cambial contact, especially in cases where the rootstock and scion are of the same diameter. Wipe grafting is best applied to rootstocks and scion less than 2 cm in diameter. It can also be applied to larger diameter bodies if required. A diagonal-shaped long cross-section surface is formed on the rootstock and the shoot. Then, starting just above the pith in the center of this cross-section surface, making a short cut parallel to the stem axis, a tongue is formed on each rootstock and scion. Finally, the rootstock and the scion are combined in such a way that these sections pass into each other. Therefore, the cambium contact of rootstock and scion is very important (Figure 3).

Wedge Grafting: This method of grafting can be more easily applied mainly to seedlings around 1 cm in diameter. In this method, a deep V is opened on the rootstock by hand or machine. The scion is hewn to fit into this V and placed in its place on the rootstock. It is then tied nicely with the graft tie. In order to get the best results from the wedge graft, the rootstock and the scion should be of the same diameter (Figure 4).

Side Grafting: When the rootstock diameter exceeds 2 cm, it is easier to use the side graft as it will be difficult to make the wedge graft. For this purpose, the scion is hewn starting from one side so that it becomes thinner towards the tip in the form of a wedge. In the rootstock, a shallow diagonal wound is made in accordance with the scion and the scion is placed there. Thus, the cambium of the rootstock and the scion will meet on both sides (Figure 4).

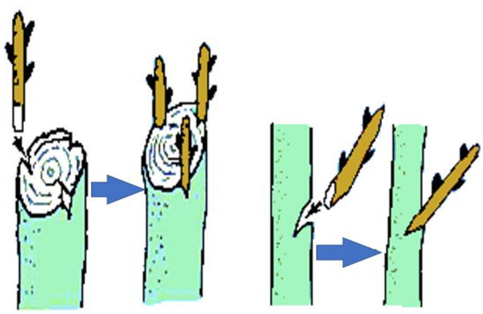

Figure 4: Application of wedge and side grafts.

Cleft Grafting: It is the oldest known grafting method and is widely and successfully used in the reproduction of walnut varieties. It is a grafting method that is used for grafting stems or branches of large trees, usually thicker than 2.5 cm in diameter. In this graft, more than one scion can be used according to the diameter of the rootstock or branch to be used as rootstock. In this graft, the scion is chiseled into a wedge. The rootstock is cut from the upper end of the diagonal-shaped section surface down and towards the center in an acute-angle V shape, rather than in the middle as in the wedge graft. The greater the depth of the angle, the better the yield, as more cambium contact will be achieved. After the scion is placed on the prepared place on the rootstock, it is tied with a graft so that the entire grafting area is closed. This grafting method can be applied to small seedlings, as well as to rootstocks with a diameter of 7-8 cm or larger. It would be appropriate to use the normal cleft graft, especially for grafting wild walnut trees for the purpose of cultivating (Figure 5).

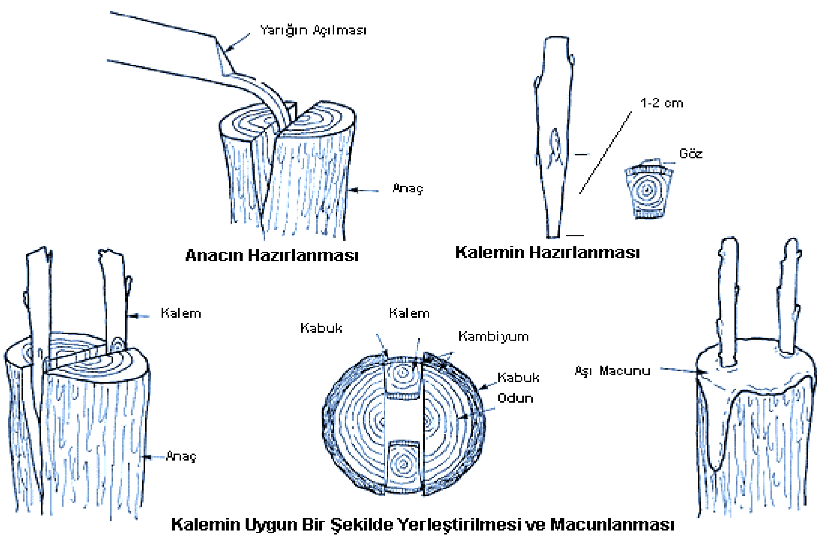

Figure 5: Preparation of the Cleft Graft (In Turkish).

Veneer Grafting: This method consists of placing the carved scion on the rootstock to fit a notch on the outside of the rootstock to be used as rootstock. In this graft, since there is no gap in the placement of the scion to the rootstock, there is no danger of drying out and the graft will be perfectly fused and combined, as it provides good cambium contact. Another advantage of this graft is that it is one of the methods that allows many scions to be attached around thick branches.

Strip Grafting (spiked bark grafting): It is one of the grafts applied under the bark, and the scion is prepared as in the modified split graft. Two vertical cuts are made on the rootstock with the top cut off or on the branch with the cut end, wide enough to meet the thickness of the scion without damaging the wood. By removing the bark strip between the two cuts, the scion is placed here and the removed bark strip is closed on the scion. Then the whole graft area is tied with a graft tie. In this graft, more than one scion can be used, depending on the thickness of the rootstock (Figure 6).

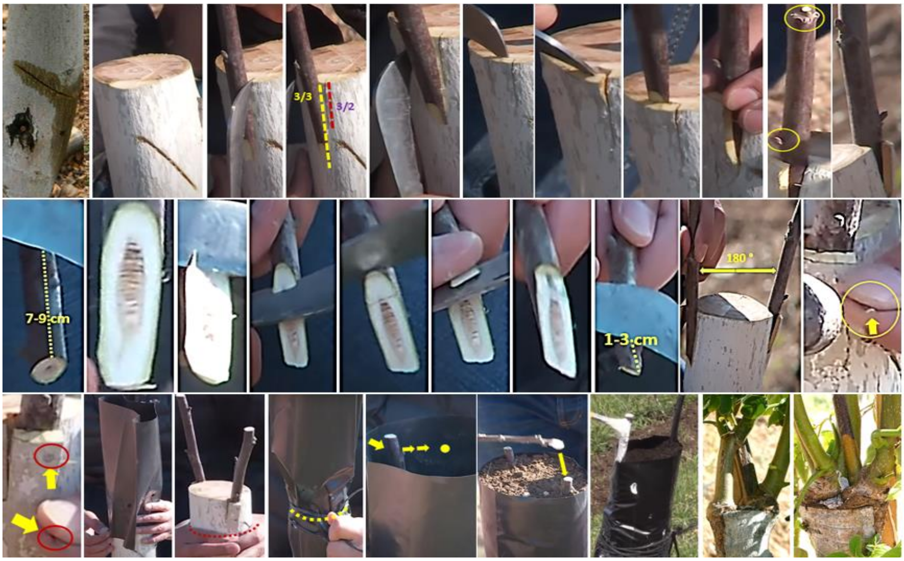

Figure 6: Application of strip grafting (spiked bark grafting).

Bark Grafting: It is a grafting method that is easy to do and has a high take-rate. The bark of the cut rootstock or branch is cut vertically so as not to damage the wood. The shell is opened from this cut to both sides to prepare a place for the scion and then the scion is placed there. If the rootstock is thick enough, multiple scion can be attached and then tied nicely with a rubber band or any grafting tie. Exposed cut surfaces should be well sealed with grafting paste or other material, as with other grafts. The time of execution is between 15 July and 15 August.

Bud Grafting: This method of grafting uses only one bud instead of a scion with more than one bud on it. This graft can be given at any time when the crust is removed. Usually, the time to do it is in the second half of the summer term. Thus, sufficient temperature will be provided for the rootstocks to grow and thicken a little, for the buds to be used for this graft to mature better, and for the formation of callus necessary for the take of the graft (Figure 7).

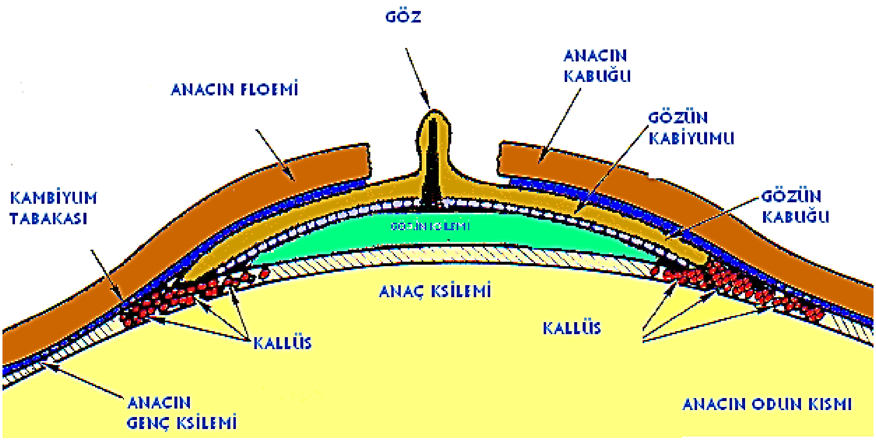

Figure 7: Coalescence in Bud Grafting.

T Budding: This type of graft is also called "shield budding" because of the shape of the shelled bud. This name comes from the appearance of the cut made on the rootstock. In scions with a diameter of 0.4-0.7 cm, the length of the shell carrying the graft maybe 2-3 cm. It is very important that the bud is cut as quickly and perfectly as possible and attached to the rootstock. Thus, the possibility of dusting and drying of the cambium will be reduced during the fitting and binding of the bud. It is noted that the T bud graft has been used correctly or in reverse and has been equally successful. The top of the rootstock is not cut during the budding. Attaching the bud is a critical process. The Attaching process should be done in a way to ensure tight contact and good fusion between the bud shield and the rootstock, and the graft should be tied in such a way that the bud remains open. After grafting these buds should not appear until the following spring. Rootstocks are usually cut in early spring. During the development period, all shoots that may emerge from under the graft bud should be cut without delay. The cuttings cut during the resting period for bud grafting should be kept at rest until the time of grafting (Figure 8).

Figure 8: T budding.

T budding is not recommended for trees with thick bark, such as walnuts, due to the difficulty of preventing an "air pocket" under the bark.

Patch Budding: As with the T grafting, patch budding can only be done during the developmental period when the shell is well removed. Patch grafting consists of removing the bark of equal size from the rootstock and the scion, placing the bark containing the bud to be grafted onto the rootstock and tying it. The tying should be done carefully and with the bud open. Putting the edges of the patch to prevent drying will increase the success rate. Ideal rootstocks for patch-bud grafting are seedlings 1-2 cm in diameter (Figure 9).

Figure 9: Patch budding.

Bark-Patch Budding: This grafting method can be applied from late June to mid-September. In this method, the shoot of the development period is used and it is requested that the scions from which the buds will be taken are at least 1.2-1.5 cm in diameter. The bud on the 1.2-1.5 cm diameter scion is cut with a double-edged knife. The narrow strip of bark opposite the bud is removed. The sides of the bud patch are loosened. A rootstock with a diameter of at least 2.5 cm is selected where the bud is attached, and the grafting area is cut with a double-edged knife. With a vertical cut, the parallels are joined, the edges are slightly lifted and left. By opening the caps on the rootstock, the main patch carrying the bud is placed on the rootstock with slow movements from side to side. This method can be made on the branches of large trees and used as a flip graft. When the rootstock is crossed for patch grafting, a 2.5-3.5 cm wide strip is removed between two parallel sections. With the cut on both sides of the graft bud on the scion, the sides of the shoot are straightened. Then the bud is scratched around the bud with a double-edged knife and if the time has come, the bark carrying the bud is easily removed. This bud is placed under the bark on the rootstock where the strip is removed. In this method, the bark carrying the bud is removed from the scion in the form of a ring and placed in the same way as the rootstock (Figure 10).

Figure 10: Bark patch budding.

Chip Budding: This grafting can be thought of as a method of grafting, in which only a bud is grafted instead of a scion. Unlike the T budding, the chip bud can usually be done when the crust is not lifted. Chip budding is generally better applied to large trunks and especially to trees with thick bark, such as walnuts, than T budding. A bud that we want to use in the graft is removed from the grafting stick in such a way that it carries a piece of wood under it, and it is placed in place of the same size chip removed from the rootstock with a similar cut. If the graft bud bar and rootstock to be used in the application of this graft are of the same thickness, the application and fusion of the graft will be more perfect. The chip budding is limited to the rest period. This grafting can be done with buds at rest, in April-May when the outdoor conditions are suitable, that is, when there is sufficient temperature outside, as well as during the active growth period and at the end of the growth period. materials such as putty and graft bond will be used less. In this respect, it is an advantageous grafting method. Callus formation and graft fusion will occur in 2-4 weeks, depending on the variety and environmental temperature (Figure 11).

Figure 11: Chip budding.

Green-Wood Grafting: When making budding in walnuts, it is to make the graft by finding a leaf piece together with the bud. The bud to be used in the graft; It is cut together with a leaf and a piece of bark 5-7 cm long. Leaves belonging to the rootstock, which will prevent the grafting, wrapping and light of the grafting, should be removed from the grafting area. The grafting can be done on the annual shoot or, if the bark is not very thick, on the shoot of the previous year. In our hot regions, cooler directions may be preferred to avoid excessive heat damage. The following spring, after the growth of the grafted shoot has begun, the remaining part of the rootstock is cut just above the grafting area and putty to prevent water loss.

Green-Wood Chip Budding: The grafting period for this method applied in cold regions is the end of June-early July. The rootstock suitable for this graft should be 6-7 cm above the root collar and 1.5-2.0 cm thick. The branches and leaves on the rootstock up to 20-25 cm above the place to be grafted are cleaned. The place in the rootstock is prepared by drawing around the prepared scion piece. Two cuts are made on the body, parallel and perpendicular to each other. Then these lines are combined with two sections that will be parallel to each other and this time to the ground. However, these incisions are made not from the end of the vertical cuts, but a little below. The scion piece should be placed in the place of this removed shell and in such a way that it completely covers the cambium. 2-3 weeks after grafting, the top of the rootstock is cut and the bud is forced to shoot. Since there will be a strong development in the grafted shoot in the spring, it is useful to connect the shoot to the stake. If the weather goes well and the grafting is done well, it will be possible to achieve 90% success in the reproduction of the walnut with this graft.

Bench (Indoor) Grafting: Plants grown in small containers or rooted on the surface are used as rootstock. Grafting is usually done on benches or rows and is suitable for intensive production. These grafts can be made by hand as well as with different types of developed machines. For this purpose, chip budding and wipe grafting are widely used. Because these grafts are easily learned, mechanized can be made quickly and it is possible to produce softwood trees with these grafting methods. Walnut seeds prepared on the table in autumn are exposed to 24-27°C for rapid callus formation. During this period, the buds belonging to the scion should remain at rest and should not start to grow. In this respect, grafted seedlings are stored under cold storage conditions until spring planting, in order to keep the scion buds resting after the callus stage of the graft. If the grafting time is not well-adjusted and the grafted plants are to be planted outside before or late; may be exposed to the negative effects of environmental factors. However, it may be possible to gain profit and efficiency from this grafting in a properly selected location and with suitable environmental conditions.

Although the term "bench grafting" is used in this method, it should be understood under this heading that grafts (Figure 12) Whip, wipe, Chip budding that are usually made in the building during the rest period. Some of these indoor conditions may be greenhouse conditions, laboratory conditions and basement conditions. The important thing is that the graft can be made in an environment where some factors that are effective in the fusion and consolidation of the graft can be provided in a controlled manner. Indoor grafting has some obvious advantages over outdoor grafting. It is possible to provide high humidity in indoor grafting. More grafted plants can be obtained from the unit area. In indoor reproduction, less soil and nutrient elements will be needed compared to outdoors, and it will be possible to prepare an environment in the desired size and quality, and it is possible to obtain well-developed rooted seedlings. The seedlings will reach the planting site with their root systems relatively less damaged. Since the grafting process is done during the rest period, the idle labor force in the winter will be evaluated. The selection of the rootstock and the scion is very important for the success of the bench grafting. The humidity of sawdust to be used as grafting medium, placing grafted rootstocks in sawdust, controlling the ambient temperature, transporting boiled grafts to the nursery and care of grafted seedlings in the nursery are other important factors affecting success. The diameter of the seedlings 3-8 cm above the root collar should be 0.6-1.2 cm. The selection of cuttings is an important process in grafting walnut trees. The shoots from which the scion will be made should be 12-15 cm long. The shoots to be cut are not from mature trees; They should be taken from trees that are 3-4 years old, young and well developed. After the rootstock and scion are ready for grafting, the task is to combine the rootstock and scion using any grafting method. It is noted that the success rate of this grafting technique is as high as 75-90%.

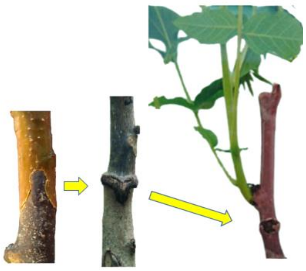

Figure 12: Omega graft.

Figure 13: Preparation of cotyledon graft.

Cotyledon Grafting: Cotyledon grafting has some advantages and disadvantages compared to conventional grafting methods. In this method, there is no need to grow the seedling to be grafted for two or more years. Small diameter scions can be used easily. The cotyledon grafting method requires less experience than conventional grafting methods. In other words, this graft can be easily made by inexperienced people. In this grafting method, ligation of the graft site is usually not necessary (Fig. 13). Therefore, there will be no cost of grafting, labor will be reduced, and as a result of simple and quick grafting, the costs will be relatively low. In hardwood fruit trees, the formation of a good graft zone is provided more quickly. Walnuts such as perlite, peat, sphagnum, or pit moss that is folded and ready to germinate are taken, placed in a humid environment and allowed to germinate. However, it is recommended to bud between the time the cotyledon leaves are fully opened and the fully grown leaves of the growing shoot are ready for approximately full extension (Gandev and Arnaudov, 2011; Gandev, 2014).

Swap in Walnut Species (Reverse Graft): It is difficult to give an economic walnut production example since a quality walnut cannot be produced directly from the seed. Since trees grown from seed do not provide uniformity in quality, yield and fruit, time and economic losses are experienced. Elimination of this negative situation of the walnut existence can be surrounded by trees consisting of productive standard varieties within 2-4 years by grafting it with a few certain items. In the walnut trees that are inefficient or that have aged and started to lose their economic life, the tree can be made productive and high quality by changing the variety. Thus, the economic life of the trees is extended. As a result, a walnut garden established with old or wrong varieties will be made productive and of high quality in a short time and will be brought to the economy. Strip graft and cleft craft are successfully applied in reverse grafting.

Propagation By Cutting: Reproduction of hard-shelled fruit species on their own roots will be less costly than grafted rootstocks. This method will eliminate the incompatibility problem in walnuts and will reveal the availability of clonal rootstocks. Propagation by cuttings, which is one of the vegetative propagation methods, is the easiest, cheapest and quickest way to propagate especially fruit species whose cuttings are easy to root. However, it does not seem economically possible to propagate walnuts with cuttings due to the current cutting technique and the existing rooting stimulating substances.

Layering Method: The immersion reproduction method, which is one of the vegetative propagation methods, is a method used practically in the propagation of fruit species that develop in bush type. However, the immersion method has no practical value for walnuts.

Tissue Culture: It is a form of reproduction made in order to ensure the efficient development and differentiation of plant tissues on sterile nutrient media. For this purpose, different propagation techniques such as meristem culture, shoot tip culture, in vitro micrografting, embryo culture, anther culture, callus culture, cell culture are used. For this, plant tissues are disinfected, planted in nutrient media prepared in sterile conditions, grown in climate rooms under artificial light at certain temperatures, transferred at certain intervals and rooted and acclimatized to outdoor conditions. It has advantages such as high reproduction coefficient, obtaining virus-free plants, ease of quarantine, plant breeding, increasing the efficiency of biotechnological methods and protecting plant gene resources. Due to the heterozygous structure and opening of hard-to-root plants, there is no problem in propagation by seeds. One of the most important factors affecting the rapid production of walnut varieties in tissue culture is the difficulties in rooting micro shoots, the darkening that occurs as a result of the oxidation of phenols from the cutting surface and the losses that occur during staggering. not reflected.

CONCLUSION

In walnut cultivation, propagation is done by two different methods, which are vegetative and generative. Although the oldest, easiest, fastest and cheapest propagation method known is seed propagation, this method is a method that we cannot use directly in walnut cultivation. Propagation with seeds are generally used for breeding purposes, obtaining new types and varieties, afforestation on the roadside, afforestation of forest areas and rootstock for propagation by grafting. The most practical propagation method used in walnut cultivation is propagation by grafting. When optimum conditions such as suitable grafting method, time, temperature, rootstock, scion and environment are provided in nursery conditions and indoors, the grafting method is the most appropriate propagation method. In addition, grafting of high-quality varieties to walnut trees that have fallen out of yield, aged or have completed their economic life has recently become widespread. Although some types of layering propagation methods, which is one of the vegetative propagation methods, are not common, they have been tried on walnuts and successful results have been obtained. However, in addition to the difficulty of implementation of this method, the low reproduction speed makes the method impractical. Propagation with cuttings, which is practical and economical in many fruit species whose cuttings are easily rooted, could not be applied sufficiently in walnut cultivation due to the very low rooting rate. Reproduction by tissue culture, which has been the most emphasized and theoretically the fastest propagation method in recent years, has been tried on walnuts as well as many fruit species but has not been widely practiced.

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CHAPTER 3

PROPAGATION OF FRUIT TREES

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INTRODUCTION

Fruit growing activities begin with the production of fruit seedlings. Fruit tree sapling production can be done by sexual and asexual methods. Sexual (seed) reproduction is not preferred in fruit growing due to the foreign pollination of most of the fruit species and the prevalence of dichogamy in some. Asexual reproduction includes reproduction with apomictic embryos, by layering, separation, cutting and grafting. (Kaşka ve Yılmaz, 1987).

In horticulture, maintaining the desired characteristics of parent plants plays an important role in plant reproduction. Depending on the species, different techniques can be applied to optimize a nursery production system and solve the challenges. For example, in almonds (*Prunus dulcis* Mill.), the failure of new vegetative buds to grow in spring due to *non-infectious bud failure* (NBF) is seen as an important problem in fruit growing. In this context, good nursery practices, the right plant materials should be used with the right methods, and many issues should be clarified (Roberto and Colombo, 2020).

Vegetative production in seedling production is an economically important production method used in the reproduction of many fruit species and rootstocks. Vegetative production, which is carried out by using the organs of plants such as roots, branches, and leaves, allows plants to be produced as a clone. The bulkiness, longevity and durability of the trunk, especially in woody plants, in organs; It depends on adequate air and humidity conditions, proximal and distal positions, aboveground and underground parts, and the successive development of adventitious roots (Jenik, 1994). Vegetatively propagated rootstocks create specific and the same effects on the variety. Thus, it is possible to provide a complete standardization in fruit production and marketing with sample and standard rootstocks.

In recent years; in addition to the pandemic conditions, the increase in the food needs of the growing population, and the development of laboratory facilities, opportunities such as micro-propagation and micro inoculation in fruits have increased. In the research, tissue culture and propagation of fruit trees were also examined.

In line with that information; the basic principles of sexual and asexual reproduction techniques in fruit trees have been revealed, and the studies on the subject have been examined.

1. GENERATIVE (SEXUAL) PROPAGATION

1.1. Morphological, Biological and Physiological Characteristics of Seeds

In the botanical sense, a seed is a matured seed ovule containing the embryo formed without or as a result of fertilization. Seeds are divided into three types according to the tissue in which nutrients are stored; Seeds with endosperm, seeds without endosperm and seeds not classified. The protective layers of the seed consist of the seed coat, nuclei and endosperm residues and sometimes the fruit parts.

These layers are mechanically protective covers of the embryo. In this way, seeds can be processed without damage, can be transported over long distances and stored for a long time. In addition, the seed coat controls germination. In seed that have two seed coats, the inner one generally is rather soft and delicate, while the outher protective layer is hard and thick. Sometimes this crust has thickened and hardened brown color. The inner layers of the seed coat are thin, permeable and membranous. Sometimes there are residues of endosperm and nuclei in the inner layers. In some plants, the fruit parts are stuck to the seed.

The seed propagation method is used in fruit growing to obtain rootstock and new varieties. In general, since the seed has a heterozygous structure, the new plants that will emerge may show different characteristics than the parent plant (Jain, 1976). Plants with different morphological and physiological characteristics are formed from that type of seeds. In addition, since these types of plants will have different ecological demands, difficulties are encountered in determining the graftage.

The most important condition for success in propagation with seeds is to know the hereditary structures of the plant from which the seed will be taken. Some trees may be diploid and some may be triploid. Differences can be seen in plants obtained from seeds with triploid structures. In addition, while many seeds are obtained from diploid fruits, the number of seeds to be obtained from triploids is low.

Another problem in seed propagation is the inability to find the seed, namely parthenocarpic. The most important issue in this regard will be the need to reproduce tree species, hybrids, or biologically seedless selections (Burr and Burr, 2000).

The issue of male infertility also causes a number of problems. Three types of male sterility were observed among 1063 cultivars and clones obtained from *Castanea crenata, C. mollissima, C. sativa, C. seguinii* and other species and their interspecific hybrids. The flowers of the first type were anthers, the second type developed anthers and pollen grains, but the pollen did not germinate. Male fertility of the cytoplasmically male sterile *C. crenata X C. sativa* clone belonging to SI was restored by open pollination. A breeding plan is proposed to use male infertility in the production of hybrid varieties (Omura and Akihama, 1980).

Physical dormancy caused by hard and impermeable seed coats is observed in some plants. For example; In stone fruit types, this shell is abraded mechanically or by acid. Another type of dormancy is physiological dormancy. In these cases, the need for cooling should be met or the dominant abscisic acid (ABA) effect should be broken. Abscisic acid (ABA) is a growth-inhibiting dormine, which is synthesized in leaves and is densely found in flesh, seed coat, and endosperm.

Physiological dormancy can also occur for an internal reason such as an immature embryo. In some seeds, germination is restricted by physical or physiological rest. Germination is provided by methods such as mechanical abrasion, salcification, soaking in hot/cold water, folding and a combination of all these methods. Gibberelic acid can be applied to seeds with long-term cooling desire (Kolarova et al., 2010). Gibberelic acid (GA_3) is a hormone that is synthesized at young growth points in plants and is also densely found in embryos, seeds, and fruits, causing cell elongation (Gupta and Chakrabarty, 2013).

Apomixis is the formation of an embryo from diploid cells without fertilization. The most important example is nucellar embryos in citrus fruits. The seeds containing these embryos are called apomictic seeds. Apomictic seed formation has also been detected in apple and mango.

1.2. Propagation Application on Seeds

Taking seeds from fruit trees varies according to the type and variety. For this reason, the fruits to be planted should be examined in different groups. For example; It is easier to buy seeds in stone fruit types than others. The seeds of the fully matured fruits are divided and the flesh is taken immediately after harvest. The point to be considered here; If the seed is to be purchased from industrial establishments that process this type of fruit, it should be ensured that high temperature or chemical applications are not applied. These practices have negative effects on the germination power and speed of seeds. The maintenance, irrigation, fertilization, pruning, pest and disease control of the fruit tree from which the seed will be taken directly affects the quality of the seed.

The most preferred method to eliminate the dormancy caused by the embryo is to store the seeds at appropriate temperatures. In this method, which is called folding, the seeds are kept for a certain period of time in a humid, cold and airy medium, the development of the embryos and their desire to dormant (Alkan et al., 2015).

Cold stratification is the process of keeping moist seeds between 0 and 10°C for a certain period of time before germination. In this application, seeds taken to a humid medium such as perlite, sand, or peat should remain at an average of 4°C for a certain time according to their type or variety, and then they should be planted. Cold strafication times vary according to the species and variety. The medium should not be too watery, the material should be sprayed with fungicide against fungal diseases.

In hot strafication, the seed is kept in a pre-humidified medium medium at a temperature of 21-24°C. During the application, which lasts 4-12 weeks, the temperature is stabilized between 18 and 19°C. In nature, the seed lives in this period during the summer of the year following fertilization. This phenomenon indicates that the seeds will germinate successfully in the spring. There are different applications in the propagation of fruit trees by seeds. Some of these are given in Table 1.

Table 1: Germination applications in some fruit seeds

Type	Application
Carya illinoinensis	Either the seed is sown in autumn without any treatment, or it is sown in the spring after being kept in a cold medium for 90 days (Ghazaeian, 2012).
Juglans regia	The hard-shelled seed, which is obtained by removing the fruit skins, is planted in moist sand after 12-20 weeks of cold stratification.
Prunus cerasifera	The flesh of the fruits is cleaned and washed and planted after 2 weeks of hot and 18 weeks of cold folding.
Rosa sp.	It is planted in the spring after 8 weeks hot, 8-12 weeks in cold stratification.
Eleagnus grandiflora	It is planted in the fall or after the acid treatment, 4 hours hot 8-12 hours cold stratification is applied and planted in the spring.
Pistacia vera	It is transplanted after 60 to 80 days in cold stratification.
Amygladus sp.	It is transplanted after 30 to 40 days in cold stratification.
Castanea sp.	It is transplanted after 90 to 100 days in cold stratification.
Prunus avium* and *P .mahaleb	The peel is abraded and it is planted after 100-120 days in cold stratification. (Çekiç, 1996; Çetinbaş & Koyuncu, 2005).

In the past, the producer used to get the seed needed for the next planting period from the product of that period. Although this method is still applied especially in underdeveloped countries, today modern seed production has become a very specialized industry all over the world. Commercial seed production from annual garden plants to vegetable and flower species is an intensive industry specialized. Seed companies (commercial seed sources) produce the seeds of the varieties developed as a result of breeding studies without creating genetic confusion (paying attention to the isolation distances determined according to the species and varieties against uncontrolled pollination). This production is carried out in large quantities in a healthy way with high germination capacity by using the right techniques in suitable ecological conditions (for example, without precipitation and low humidity conditions during the harvesting period). The harvested seeds are first cleaned (removal of foreign matter and other plant seeds). Various applications (enhancing germination and facilitating cultivation) can be applied to these seeds before planting. At every stage of the production process, seeds are passed through various tests (such as germination tests). Finally, the seeds are properly packaged and stored to maintain quality until use (Table 2).

Table 2: Seed production and processing procedure

Process	Aim
Genetic selection	**Breeding superior varieties**
Seed production	**Seed germination potential and high yield production**
Seed cleaning	**Separating seeds from fruit, non-seeds removing material and foreign seeds**
Seed applications	**To facilitate sowing or in seeds improve germination**
Packaging and storage	**To the marketed or by the manufacturer maintaining seed quality until use**
Seed tests	**To provide quality controls**

1.3. Factors Affecting Seed Conservation

Deterioration of seeds is the loss of strength first, then normal germination capacity, and finally vitality. Storage conditions that reduce seed spoilage are conditions that slow down respiration in the seed and other metabolic events without harming the embryo. The first among these conditions are the low moisture content of the seed, the low storage temperature and the combination of the storage atmosphere. The humidity-temperature relationship is of great importance in practice. In general, every 0,5-1% increase in seed moisture in the range of 4-16% and every 5^{o}C increase in storage temperature between 0-50^{o}C reduces the storage life by half.

With the increased moisture content of the seed, various problems arise. When the moisture content of the seed is high, insects become active and reproduce, fungi become active, warming occurs, and so germination will be started.

2. VEGETATIVE (ASEXUAL) PROPAGATION

The propagation of plants with specialized vegetative organs that can form roots and shoots at different ages or that can merge and develop with another plant is called asexual reproduction. In other words, vegetative organs such as root, shoot, stem, or leaf are used for asexual propagation (Ağaoğlu et al., 2010). The new plant obtained by this propagation method is exactly the same as the parent plant if it has not undergone any mutation. However, some mediumal conditions such as climate, soil, and diseases may cause changes in the appearance or fruits of the plant. Examples of plants that are asexually propagated from a single plant is called clones (Soylu, 2003).

The vegetative method can be used for many reasons. If any of the commercially grown varieties are propagated by seed, genetic expansion occurs and the valuable characteristics of the variety are lost. For example; The high quality of the peach or strawberry is made so that it can be kept as a clone, as is the color of the flowers. In plants that are formed without seeds and have fruits called parthenocarpic fruits, reproduction by seeds cannot be made. Fruit species and varieties that cannot produce viable seeds can only be reproduced by asexual methods. Each of the plants that develop from seeds has a different genetic structure. Horticultural plants that can lose their superior characteristics by showing high genetic expansion due to foreign fertilization and heterozygosity when propagated by seed can only be preserved by asexual reproduction. Due to the hard and impermeable seed coat of some species, germination takes a very long time.

However, it is easily possible to obtain new plants by asexual reproduction (Ağaoğlu et al., 2010; Dumanoğlu, 2021).

The controlled production of plants of special value is called propagation. Thus, the continuity of the plants with the desired qualities will be ensured. In order for the reproduction processes in plants to be successful; to have sufficient knowledge about the properties and structure of the plant to be reproduced, it is necessary to decide on the most suitable method for the plant to be reproduced and to work cleanly, carefully, and carefully while applying the reproduction technique.

2.1. Cutting

In order to obtain a new plant, the pieces prepared by cutting the roots, stems, branches and leaves of the plants are called 'cutting'. New plants are obtained by providing the cuttings to form roots and shoots under suitable mediumal conditions. Most of the fruit types such as quince, pomegranate, tea, olive, berry, vine, fig and berry can be propagated directly by cuttings. In addition, clonal rootstocks used in fruit growing and American grapevine rootstocks used in viticulture and the propagation method with cutting are widely used in the reproduction of ornamental plants (Ağaoğlu, 2010). Since the propagation method with cutting is easy and practical, it is a method that has advantages over other vegetative propagation methods. Therefore, the production of many types and varieties of seedlings that can be reproduced with cutting is provided directly by this production method (Ünal et al., 1992).

Cuttage is the name given to the rooting of any vegetative part of the plants under suitable conditions. The new plant formed in this way has all the characteristics of the main plant (Özgüven and Ak, 1993). Reproduction by cutting is one of the most cost-effective and simplest methods of asexual reproduction methods. Because replication with cutting is a very easy, cheap, and quick method (Barut, 2008).

Cuttings are grouped according to plant type and purpose of use.

Basic Cuttings: They are 10-90 cm long branch pieces depending on the type of plant. Rooting takes place in a shorter time due to the large wound surfaces on the bottom of these cuttings and the abundance of nutrients. Ordinary cuttings prepared in 2-4 m length are called pole cuttings.

Wood Cuttings: It is a type of cutting that is prepared 10-25 cm in length than 1 or 2 years old branches in winter resting, which is more resistant to unfavorable mediumal conditions and does not deteriorate quickly. It is used for the reproduction of figs, kiwi, quince, olive, pomegranate, mulberry, some plum varieties, and vines. On the other hand, it is very difficult to propagate hard-core fruits such as peaches and cherries, soft seeds such as apples and pears, and hard-shelled fruits such as pistachios and walnuts with wood cuttings.

Semi-Wood Cuttings: They are summer cuttings that are partially wooded, usually leafy, partially wooded towards the end of the growing season. Fruit types such as olives, citrus fruits, tea, and large-leaf ornamental plants such as rhododendrons, green azaleas for all seasons can be easily reproduced with semi-wood cuttings. Since semi-wood cuttings are leafy, rooting should be done in humid conditions to prevent water loss.

Softwood Cuttings: They are cuttings prepared in leafy form at the beginning of summer from the fresh spring shoots of the deciduous species that have not yet become lignified. They have the feature of rooting more easily than wood cuttings. These cuttings are 7-12 cm long and are prepared from shoots that are not very soft and brittle.

Leaf Cuttings: Leaf blade can be taken alone or with a leaf stem or can be used as cutting in parts to be cut from the leaf.

Root Cuttings: It is a form of reproduction made with root pieces cut from the roots of the main propulsion. Some varieties of quince, hazelnuts, apples, and plants such as blackberries that have the ability to make root shoots can be propagated in this way.

In the USA, semi-wood cuttings from Enis and Casina hazelnut varieties were purchased. In this study on the rooting of these cuttings, the effects of IBA and Agrobacterium rhizogenes applications were examined. As a result of the research, it was determined that bacterial applications significantly increased root formation compared to control applications (Bassil et al., 1991).

In the study of Kuden et al. (1993) on fig cuttings, the effect of cutting time, indolbutyric acid (IBA) application and rooting medium on rooting were investigated. As a result, it was stated that there was a rooting varying between 0% and 90%.

Şenel (2002), investigated the effect of cutting period, planting shape and rooting medium on rooting rate and root quality in Black Mulberry and White Mulberry cuttings in his study conducted under Isparta conditions. In his study, the average rooting rate was found between 2.22% and 71% in black mulberry cuttings and between 3.33% and 50% in white mulberry cuttings with a dose of 5000 ppm IBA hormone dose. The same researcher applied 10-100 ppm IAA, IBA and NAA as growth regulators on White Mulberry and reported that the applications stimulated callus and root formation in all conditions. In addition, it has been determined that it encourages rooting even when rooting does not occur under normal conditions (Şenel, 2002).

The highest rooting rate in cherry cuttings was obtained from 65% green cutting and 70% to 250 ppm IBA + AgrobacteriumrubiA- 16 application in semi-woody cuttings (Eşitken et al., 2003).

Babaoğlu and Kalyoncu (2006), in their study, M9 green tip cuttings are known in fogging system, different air relative humidity medium, different dose applications of Indol-3-Butyric Acid (IBA) and coarse agricultural perlite (0.0-5.0 mm) rooting medium. On the contrary, it has been demonstrated that a highly successful rooting can be achieved (Babaoğlu & Kalyoncu, 2006).

In a study investigating the effect of IBA on the reproduction of 5 pomegranate types selected in Hatay by cuttings, 1000 ppm IBA application was found to be insufficient, although it positively affected the rooting rates and other properties of the cuttings. For this reason, it is recommended to increase the IBA concentration (Polat and Çalışkan, 2006).

Sarıtaç (2008), investigated the rooting and development performance of nine different fruit clonal rootstock cuttings in pumice and zeolite mediums and the root blueprint formation in the anatomical structures of the rooted cuttings of these rootstocks. According to the results of the experiment, the highest rooting was observed in cuttings of Pixy rootstock (87.7%) planted in zeolite medium in late spring, while the lowest rooting (1.1%) was in cuttings planted in the zeolite medium of M9 rootstock in early spring. While there was no rooting in both periods of MaxMa and GF677 rootstocks, rooting was not observed in the cuttings planted in the pumice medium of M9 rootstock in early spring. While the most different diameter increase and best shoot development were seen in SL64 rootstock planted in a pumice medium in late spring, the best root development was found in MM111 rootstock planted in zeolite medium in late spring. In the anatomical examination, the earliest root stub formation was seen in M9, MM106 and Quince A rootstocks at the 3rd week.

Dvin et al. (2011) investigated the effect of rooting media with IBA doses on the rooting of MM 111 apple rootstock with wood cuttings. The researchers obtained the highest rooting rate with 37% in cocopite + perlite medium and at a dose of 2500 mg / l IBA. In this study, the maximum root length was found in cocopite + perlite medium and at a dose of 1500 mg / l IBA.

Edizer and Demirel (2012) Marianna GF 8-1, St. Julien, Garnem, applied control (0), 2000, 3000, 4000 ppm doses of IBA to SL-64 clone rootstocks and they were planted in perlite medium in the mist unit and examined the rooting properties of clonal rootstocks with green cuttings. According to the research findings; St. At 3000 ppm IBA application in Julien, Marianna GF 8-1 and SL-64 clone rootstocks, 90,00%; In the Garnem clone rootstock, in 4000 ppm IBA application, 86.67% rooting occurred.

Tezel et al. (2016) in their study on determining the effect of different cutting diameter and different IBA (Indolebutyric acid) concentrations on rooting in jujube; Wood cuttings purchased in January; cutting length was adjusted to 15 cm and three different cutting diameters (2-4 mm, 5-7 mm, 9-11 mm) were used in the study. Three doses of IBA hormone (0,2500 ppm and 5000 ppm) were applied to the cuttings. Perlite was used as a propagation medium and the rooting medium was disinfected with methyl bromide before planting. Although it was insignificant, the highest rooting rate was obtained as 2.22% from 5000 ppm hormone dose with 6-8 mm cutting diameter.

2.2. Grafting and Budding

Graftage is to combine and fuse two plant parts and to allow them to grow and develop like a single plant. The part that will form the upper part or the crown of the new plant and the part that will form the lower part or the root of the variety is called rootstock. All processes to obtain new plants by combining and fusing two vegetative plant parts are called 'grafting' (Çelik et al., 1998).

Grafting is a technique that combines and fuses two plant parts so that they can grow and develop like a single plant. Two separate parts are needed for grafting. The above-ground part of the new plant, that is, the part that forms its crown, is called 'variety', and the part that forms the root system is called 'rootstock'. According to the time it is made, graftings are divided into two as exile and stagnant. In addition, according to the way it is made, and generally divided into two grafts (Yılmaz, 1994; Karadeniz, 1997; Karadeniz, 1998; Hartmann et al., 2011).

The success rate of some grafting is very high, and some are very low, depending on many factors. Plant species and variety to be grafted, ie genetic structure, incompatibility, environmental conditions such as temperature and relative humidity during and after graftage, and cultural processes, age and development of the rootstock, time, type, polarity, irrigation, the moisture level in the soil, proper combination, skill, virus contamination, insect pests and diseases, graft type and pastes used for wound closure, growth-regulating agents and other chemicals, brooding-bleeding (exudation), oxygen status, nutrient conditions, used in grafting cleanness of materials, selection of scions, time of collection and storage are factors that affect graftage success (Tekintaş, 1991; Tekintaş et al., 1991; Karadeniz et al., 1993; Şen et al., 1994; Yılmaz, 1994; Karadeniz et al., 1997; Karadeniz, 2003; Karadeniz, 2006; Hartmann et al., 2011; Zenginbal, 2017).

Grafts should be done at the appropriate time of the year. The buds of the variety to be grafted must be in a dormant state during the graftage period. For this reason, the majority of cuttings are given in the spring when growth begins. Grafts should be taken after the resting period, in the period before the start of cultivation, stored at low temperature and placed on the rootstock in the spring (Ellialtıoğlu, 2013).

The part attached to the main body consists of a single bud Bud sticks are made with a small shell and a single bud on it. There are many types of bud grafting (budding) according to the way they are made. Bud graftings can be administered starting from the new growth period in the spring until the end of growth in the autumn. The chip bud grafts can be applied when the bark is not separated from the wood (Ellialtıoğlu, 2013).

In apple graftage, it is stated that the rate of callus formation increases with temperature between 4 ° C and 32 ° C after grafting, and no callus occurs below 0 ° C and above 40 ° C (Hartmann et al., 2011).

In order to increase the success of the grafting, the grafting area should be kept at the desired temperature. For this, grafting integration rooms have been developed and graftings have been started to be given indoors. In addition, graftings have begun to be administered in buildings with glass and plastic covers. Today, seedlings are produced in low and high plastic and glass-covered structures in many modern sapling facilities. However, greenhouse sapling production has not developed sufficiently in the sapling enterprises of our country, and the production of vegetables and flowers in the greenhouse has improved.

The success of grafting and the quality of seedlings will be positively increased with the production of greenhouse seedlings in the nursery facilities spread to almost every region of our country. In addition, the cost of seedlings will be reduced and economical sapling production will be realized. For this, structures with glass and plastic cover systems should be used in the nursery business that produces and will produce modern seedlings (Zenginbal, 2015).

Çelik et al. (2006) grafted the cuttings belonging to the "Hayward" kiwi variety to the 3-year-old seedling rootstocks of the same variety on May 15 in Samsun province field conditions. In the study, they tried Reverse T, T, chip bud and machine and chip bud graftss. As a result of the research, they obtained the highest grafts retention (98.34%), graft application (91.67%), graft shoot length (58.07 cm) and graft shoot diameter (6.84 mm) from hand-applied chip bud grafts. Researchers state that the performance of the graftage machine that makes the chip bud grafts is good, but there is too much time spent for graftage and low grafts success.

Karamürsel and Kalyoncu (2011) compared apple sapling production in the greenhouse and outdoors. For this purpose, 'RedChief', 'Breaburn' and 'Mondial Gala' apple cultivars were grafted onto M9 and MM106 rootstocks by budding methods with tongues and chips. As a result of the research, they found the grafting rate of 82% in the greenhouse, 69% in the outdoor environment, 146 cm in the greenhouse, 84.86 cm in the outdoor environment, 10.71 mm in the greenhouse, and 6.84 mm in the outdoor environment. They found more growth of the 'Mondial Gala' variety seedlings grafted on MM 106 rootstock in the greenhouse and outdoors. In terms of grafting retention rate, while the tongue-based grafting (82%) was found to be more successful than the chip grafting (64%), there was no difference in terms of sapling length, shoot diameter and length. They determined the rate of first-class seedlings as 95.35% in the greenhouse environment and 66.74% in an outdoor environment. In terms of rootstocks, the rate of 1st class standard seedlings was 72.77% in M9 rootstock and 88.31% in MM106 rootstock; In terms of cultivars, they found 'Mondial Gala' 88.11%, 'Braeburn' 86.06% and 'RedChief' 67.46%.

Salih and Said (2012) grafted 'Redblush' grapefruit variety (*Citrus paradisi* Macf.) to 12-month-old sour orange (*Citrus aurantium* L.) seedling rootstocks in their study in Sudan. As a result of the research, they determined that the graft tape significantly affected the graft retention rate, graft shoot length and number of leaves. In all parameters examined, the highest results were obtained from rubber and Cellotape graft bonds, and the lowest results were obtained from graft bonds consisting of plastic strips. On the other hand, they obtained the highest results in greenhouse conditions and the lowest results in outdoor conditions in all parameters they examined.

Zeb et al. (2017) in their study to determine the most appropriate grafting and type of grafting in kiwi, tried tongue-and-chip bud graftings at 5 different times (January 10, January 25, February 9, February 24 and March 11). They state that they obtained the maximum leaf area (101.73 cm2) and graft retention rate (77.93%) from the tongue graft. In addition, in the bilateral interaction, they found that the scalloped grafting made on February 9 had significant effects on the number of leaves, shoot number, graft shoot diameter and graft retention rate, while it had insignificant effects on the number of days until grafting, leaf area, graft shoot length and grafting rate. As a result of the research, they suggest that the tongue grafting should be done in the middle of February in the production of kiwi seedlings in the SwatValley region of Pakistan, which has microclimate characteristics in terms of agriculture.

2.3. Layering

It is one of the vegetative propagation forms in which the branches of the mother plant are buried in the soil in different ways without separating them from the plant, rooting from the buried place, cutting and cutting from the mother plant. This type of reproduction is used in fruit species and varieties that are difficult to produce with cuttings.

The layering method is an economical propagation method used commercially in some fruit species (apple clone rootstocks, pear clone rootstocks, currant, gooseberry, quince, blackberry, fig, some grapevine species, pecan and guava) especially suitable for this method such as hazelnuts. Many clones that cannot be easily reproduced with cuttings can be rooted thanks to the layering method. In addition, it is an alternative method in species where this method can be applied when it is desired to get rid of the difficulties of propagation with graftss (Hartmann et al., 1990; Barut, 2012).

It is done by bending the branches coming out of the rootstock towards the soil, immersing them in the soil so that the shoot tip is out, and cutting them off from the mother plant after rooting. It can be easily applied to plants in the form of bushes, which shoot profusely from the root collar and bend easily, such as cranberry (*Cornus*) and berry (Özbek, 1977; Ellialtıoğlu, 2013).

The ends of one-year-old shoots are immersed in pits opened at a depth of 5-10 cm and covered with soil. Rooting occurs at the tips of the shoots that are bent and immersed in the soil. The rooted structures formed are planted in the garden in autumn or spring. It is commonly applied to currants, purple and black raspberries, and vines grown in phylloxera-free areas.

It is performed by apical bud the top of the plant from the soil surface during the resting period and rooting the bottom parts of the newly developed fresh shoots by covering them with soil in spring.

It is a form of immersion by placing the whole or a certain branch of the mother plant horizontally in a shallow trench and then covering it with soil. It is applied on vine, blackberry, cranberry and apple rootstocks.

It is used for the reproduction of tropical and subtropical plants where branches such as figs and citrus fruits are difficult to bend and bend. This layering method is applied on one-year-old branches in spring or partially lignified shoots towards the end of summer. Wounds are opened in various shapes on the branch to be rooted, slightly moistened rooting medium is wrapped around the wound. The area where the rooting medium is wrapped is completely covered. After the desired amount of rooting occurs and the plant enters the resting period, the rooted shoot or branch is separated from the plant and taken into the pot.

Some researchers have stated that the superior aspects of simple layering compared to top dip are the high rooting rate on the shoots, the size and root development of the seedlings at the end of the season that can be planted directly. Although the seedling yield per unit area is higher than the top layering, it has also been noted that the seedlings obtained at the end of the year should be grown for one year before planting (Achim et al., 2001). When the new season bottom shoots reach 60-90 cm in length and 8-10 mm in diameter, layering is usually started in June. Weakly developed shoots are cut off. Thus, both dilution and a sample sapling are obtained (Roversi et al., 2008).

Leaves are plucked at the bottom of the shoots at 20-30 cm, and they are closed with materials such as sawdust and peat or their mixtures in different proportions. The closed part should not be more than half of the shoot length. It is stated that the bottom parts of the shoots can be closed 2 or 3 times, but it is more practical and requires less labor if the process is done in one go. In order to prevent the dispersion of the closed material, it is surrounded by a plate all around. It is humidified and the ambient humidity is checked regularly. Success in this method depends on fertilizing the soil every year and strengthening the rootstocks and maintaining a constantly moist environment in the rooting zone (Fischbach, 2009; Soylu, 2012).

In another study examining the effects of hormones on hazelnut top layering, lanolin paste containing 0 (control), 750, 1000 and 1500 ppm IBA doses and 1000 ppm IBA + 1000 ppm NAA was applied to the strangulated part of the shoots 15 cm above the soil surface. Rooting rates were determined 6 months after the application, rooted shoots were planted in nursery plots and survival rates were determined at the end of the 4th month from planting. Hormone applications significantly increased rooting percentage, root length, root fresh and dry weight and survival rate compared to control. The highest results were obtained at a dose of 750 ppm in the EC-24462 genotype and 1000 ppm in the EC-24463 and EC-24567 genotypes (Pandey, 1996).

It is very suitable for the production of seedlings by the top layering method, for the creation of single stem cultivation systems that will facilitate the application of technical and cultural processes and mechanization. It has been noted that by means of propagation by top immersion, trees that do not produce bottom shoots can be obtained through disbudding application during the seedling production stage and thus bottom shoot elimination can be made. When the primary meristematic tissue and a piece of wood tissue, together with the buds and bud in the nodes below the main (skeletal) branches on the trunk, were cut with the help of a knife and separated from the trunk, the seedlings did not produce bottom shoots in the following years (Smith and Erdoğan, 2001).

It is known that adventitious roots in woody plants may generally consist of young parts of "secondary phloem", as well as from "cambium" tissue, "vascular rays" or core parts. Auxins promote cell division in these tissues and cell groups take on a root tip appearance. In histological studies in hazelnut, root tip primordium formation, which is the beginning of adventitious roots in the shoots originates from phloem cells (phloem parenchyma) close to the cambium and breaks the sclerenchyma ring and comes out of the cortex tissue. A conductive tissue system is formed in the new root outline and is connected to the nearest conductive tissue system. Externally applied synthetic auxin IBA is slowly degraded by enzyme systems that degrade auxin, promoting rooting (Rodriguez et al., 1988; Koyuncu, 1997; Beyhan, 2016).

2.4. Tissue Culture

Tissue culture in plants; It is used to reproduce plants that cannot be easily reproduced by traditional methods, to establish somaclonal resistance against plant diseases, to study for breeding purposes, to select resistant individuals, to preserve gene resources, to purify plants from diseases, to obtain biochemical products (secondary metabolites). Tissue culture is a very important clonal propagation method in many species, especially in vegetable production. With tissue culture, clonal cleaning can be performed to obtain a large number of new propagation material, to preserve genetic material in vitro and to produce grafted seedlings with high plant health.

In particular, the cultivation of woody plants, namely fruit trees, with these methods is more difficult than herbaceous plants. It is extremely important to establish the necessary protocols for the sterilization of these plants. In addition, determining the hormone combinations required for proliferation is important for mass production. In this context, the relevant literature on woody plants has been examined in this section.

Lauri et al. (2001), in study carried out to develop a regeneration protocol from shoot tips in apricot, almond, peach, and plum species; Cultures in the medium added to 2 mgl-1 BAP, 0.2 mgl-1NAA and 250 mgl-1 cefotaxime were incubated in the dark for 30 days. These shoots were then transferred to an auxin-free medium containing 0.5 mgl-1 GA3. In the histological study, adventitious shoot formation from callus was observed in M55 almonds.

Miguel et al. (1996) examined the effects of young and mature explants in their foliar regeneration studies carried out in almonds. Surface sterilization was completed by leaving 5-6 cm long shoots taken in March in 70% alcohol for 2-3 seconds and in 10% Ca(OCl)2 solution for 30 minutes. MS medium was found to be more effective in adventitious shoot development than modified QL medium. TDZ + auxin (IBA, IAA, 2,4-D) combinations were successful for foliar shoot development, but no shoots were formed when BAP was used instead of TDZ. When used from young leaves as explants, higher concentrations of TDZ were required and a better regeneration rate (38-40%) was obtained.

In studies on *Prunus* species, calcium hypochlorite (Ca(OCl)2) is sometimes preferred instead of sodium hypochlorite. Matt and Jehle (2005), 10 x 20 min in cherry buds; Channuntapipat et al. (2003), 7% x 15 min in almond buds; Miguel et al. (1996) performed surface sterilization using $Ca(OCl)_2$ with 10 x 30 min applications on new shoots of almond.

Yıldırım (2006) reported that the most successful cytokinin application was 1 mgl-1BAP in in vitro shoot propagation studies of Hacıhaliloğlu apricot cultivar and TDZ and kinetin were not effective in shoot multiplication.

Srinivasan et al. (2005) made a compilation of studies on fruit species in the genus Prunus, on topics such as micro propagation, micro ascension, somatic embryogenesis, organogenesis and molecular genetics. In these subjects, sample results were compiled from studies on almond, apricot, cherry, sour cherry, nectarine, peach and plum fruit species. In Prunus species, micro propagation is mainly used for virus elimination and rootstock propagation, the main propagation material is shoot tip and nodal cuttings, BAP is the most commonly used cytokine for shoot propagation, and the appropriate concentration differs according to genotype. information is given as it is difficult.

Grant and Hammatt (1999), in their research to determine the effect of the number of subcultures on shoot and root development in micropropagation of F12/1 cherry rootstock and M9 apple rootstock, used shoot tips as starting material and performed surface sterilization in 10% solution of commercial bleach. For shoot propagation, modified

MS medium containing 1 mgl-1 BAP, 0.1 mgl-1 GA3, 0.1 mgl-1 IBA and 126 mgl-1 Phlorogluquinol was used. MS medium supplemented with 3 mgl-1 IBA was used for rooting. In both rootstocks, it was reported that the duration of subculture affected shoot and root development, but the number of subcultures was not.

Demiral and Ülger (2008), in their study on in vitro propagation of Gisela-5 cherry rootstock, used apical and lateral buds to initiate culture. Surface sterilization of buds; The fungicide solution was completed in several steps using different concentrations of NaOCl, alcohol and sterile water. In cultures using MS medium, different amounts and combinations of BAP and IBA were tested in the shoot propagation stage, and different NAA concentrations in the rooting stage. In the propagation stage, the best number of shoots was 2.9 with 1.0 mgl-1 IBA +0.75 mgl-1 BAP; The best shoot length with 1.7 cm was obtained from 2.0 mgl-1 IBA + 1.0 mgl-1 BAP applications. The best rooting rate was found in the application of 6 mgl-1 NAA with 93%.

Sedlak et al. (2008), in their study on the in vitro propagation of P-HL series dwarf cherry rootstocks, culture was started with shoot tips in active development. The effect of 0.2, 0.75, 1.0, 1.5 and 2.0 mgl-1 BAP concentrations added to the MS broth by filter sterilization on the end rootstock of the series was investigated. The concentration of 1.5 mgl-1 showed the highest shoot number (7.7-10.9 shoot/explant) in the end rootstock has given. It has been reported that the highest dose of BAP (2 mgl-1) has a negative effect on shoot proliferation and development.

The resulting shoots were rooted in MS medium containing 2.5 mgl-1 IBA. Researchers have determined that the use of antibiotics (200 mgl-1 Cefotaxime) is effective against bacterial contamination.

Aka-Kaçar et al. (2001) investigated the effects of different gel builders and different pH levels on the in vitro propagation of Damil, Edabriz, Gisela-5 and Maxma cherry rootstocks using MS medium. It was tested using agar 7 mgl-1, agargel 5 mgl-1 and phytagel 3 mgl-1 concentrations and the pH level was adjusted to 5.0, 5.7 and 6.2. In cultures started using shoot tips of growing trees, MS medium supplemented with 1 mgl-1 BAP was used. Considering the general average of all rootstocks, the best shoot reproduction was obtained from agar gel (5.8 shoots/explant), the highest shoot length was obtained from phytagel (2.5 cm). The pH levels had different effects on shoot growth and the best results were obtained at pH 6.2 (3.6 shoots/explants).

CONCLUSION

The rapid increase in the population in recent years, the health problems caused by urbanization, enviromental pulliton (pandemic conditions, etc.) reveal the food needs of people. In this context, fruits, which are good sources of fiber, are very important for our nutritional habits with their nutritional and vitamin valuations (retinoic acid, ascorbic acid, iron, calcium and potassium etc.). In order to meet this need of people, it is necessary to know the details of fruit growing.

In sapling production, vegetative production is an economically important production method used in the reproduction of many fruit species and rootstocks. Vegetative production, which is carried out by using the organs of plants such as roots, branches and leaves, allows plants to be produced as a clone. Vegetatively propagated rootstocks produce certain and identical effects on the variety. Thus, it is possible to provide full standardization in fruit production and marketing with exemplary and standard rootstocks true to its name.

Based on all this information, it was aimed to detail the various applications applied to some fruit species and varieties, and their effects on rooting were examined by supporting the literature. In this way, the necessary data for the rapid production of seedlings of different species were revealed. Positive results will be revealed by testing how generative and vegetative applications in fruit growing can be more effective, the method to be used in future studies, different doses/combinations of growth regulator applications and application times.

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CHAPTER 4

GREENHOUSE CULTIVATION OF FRUITS IN THE MEDITERRANEAN REGION OF TURKEY

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INTRODUCTION

As the world population increases, the food demand increases accordingly. However, due to climate change and natural disasters experienced recently, it has become increasingly difficult for people to access safe and sufficient food. Turkey is in a very fortunate position as compared with its neighbours in terms of fruit growing due to its ecological structure and agricultural strategic position.

Production is gradually decreasing in horticultural crops in the Mediterranean Region, especially in provinces such as Mersin, Adana, Antalya and İzmir, for reasons such as misuse of agricultural lands, covering fertile lands with concrete, opening large enclosed gardens regardless of how they are used, lack of knowledge in plantation establishment and management, mistakes made in variety and rootstock selection, insufficient quantity and quality of the product per unit area. Due to these and similar reasons, greenhouse cultivation has become a popular trend nowadays. There has been a significant increase in greenhouse fruit growing in Mediterranean countries such as Spain, Italy and Greece recently. This is because these countries aim to increase their market share by taking a step forward in terms of the advantage of earliness. As it known, the Mediterranean Region of Turkey has a large number of species and varieties, especially in terms of fruit growing. However, despite this richness, it cannot be said that Turkey has taken the advantage of earliness as well as Spain and Italy.

Supposing that Turkey is able to use the advantage of its climatic and ecological features and geographical proximity to export markets properly and effectively in terms of greenhouse fruit growing, it is in a better position in many aspects than Spain, Italy and Greece, especially in terms of tropical and subtropical fruit growing. Regarding the production of tropical fruits in Turkey, there is a chance to grow the fruits in some locations of the Mediterranean Region with microclimate characteristics. Although these locations are mainly found in Antalya and Mersin provinces, some parts of Adana and Hatay provinces can also be included in these locations.

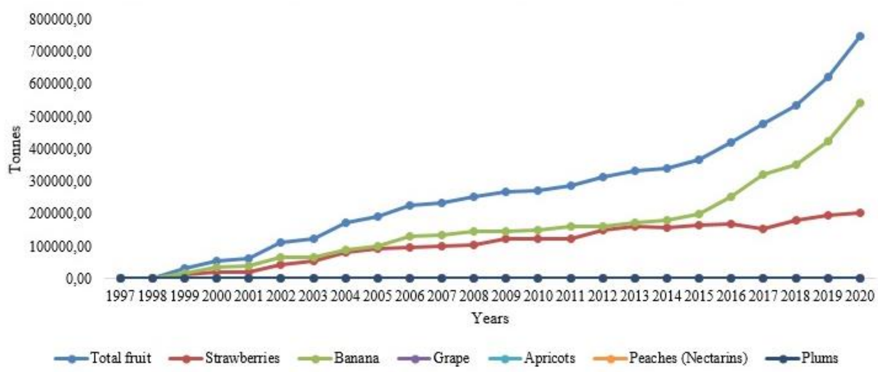

Figure 1: Fruit production for land under protective cover, 1997-2020 (TUIK, 2020)

As can be seen in Figure 1, the production of banana and strawberry has shown the highest increase in terms of greenhouse fruit growing in Turkey. According to data taken from TUIK, total greenhouse fruit production was 30.753 tons in 1999, while this production reached 747.988 tons in 2020. In other words, the total greenhouse fruit production has increased by 717.235 tons in 21 years. The production of banana and strawberry in greenhouse is quite high within this rate.

While banana production was 15.995 tons in 1999, it reached 542.809 tons in 2020. Greenhouse cultivation of banana has increased by 526.814 tons in 21 years. On the other hand, strawberry production in greenhouse was 14.758 tons in 1999, while it increased to 203.206 tons in 2020. Greenhouse cultivation of strawberry has increased to 188.448 tons in 21 years. According to data taken from TUIK, greenhouse cultivation of grape increased from 350 tons to 1.114 tons in 2020. Grape has become a remarkable fruit in terms of the total greenhouse fruit production as it has increased by 764 tons in the last 10 years (TUIK, 2020). In recent years, a considerable increase has been observed in the production of fruits such as plum, apricot, peach (nectarine), loquat, and other tropical and subtropic fruit species such as avocado, papaya, pitaya, dragon, mango, passiflora growing under greenhouses. As can be seen from this graph, while the banana production has the largest number, it was followed by strawberry production. At the same time, recently, as mentioned above, the tendency of grape and other temperate fruit species to be grown under greenhouse has increased due to earliness and high profitability.

Strawberries, bananas and grapes are commercially being grown under greenhouses, however the cultivation of fruit species such as apricot, plum, avocado, papaya, dragon fruit and mulberry have been increased recently. As known, in addition to earliness, the basic principle of greenhouse fruit growing is that to offer fresh fruit to the market at high prices by controlling the climatic conditions when there is no product in the market. Moreover, as greenhouse farming techniques are one of the most important practices that increase productivity and profitability, it requires more knowledge and experience. Therefore it may be preferred by some manufacturers. Especially in the Mediterranean Region, Mersin, Antalya, Adana and Hatay provinces are very advantageous in terms of marketing in fruit growing, and conscious producers have realized this so that they can gain more money from greenhouse production. For example, as stated above, Spain is a country that takes the advantage of earliness in greenhouse fruit production. For this reason, considering the proximity of the Mediterranean Region countries to the European market network, there has been a significant increase in the production of temperate, tropical and subtropic fruit species, mainly bananas and avocados, in greenhouse conditions in Mersin, Antalya, Adana and Hatay provinces.

Apart from the fruit species mentioned above, some producers, who have taken ecological advantage especially in Mersin, have started to produce tropical and subtropical fruit species such as Guava, Mango, Passiflora, Pitaya, and dragon fruit. In addition, as the demand for these fruits both in our country and throughout the world is increasing, the opportunity of markets increases as well. This study aims to make a general evaluation of greenhouse fruit growing in the Mediterranean Region, which has a very high advantage in terms of earliness and profitability, which has an ecological superiority compared to other regions of Turkey.

1. GREENHOUSE CULTIVATION OF PLUM

As is the case, earliness in greenhouse fruit growing and catching up with the domestic and foreign markets provides very important advantages to the producers. For example, cultivating Japanese plum varieties such as Black Diamond, Black Amber and Black Star, which are among the temperate fruit species, under greenhouse provides significant earliness and profitability for the producers. Producers benefit from placing Japanese plums into market, especially in May.

These varieties are usually expected to be put on the market in June, however, by placing them on the market one month earlier, it is aimed to manage the market-based congestion that occurred on regular days and find buyers in the market offering higher prices, which increase the significance of greenhouse plum cultivation once again. For this reason, it obliges producers to be selective in choosing both variety and rootstock in terms of greenhouse plum cultivation. In recent years, varieties such as Early Queen and Black Splendor are generally preferred in greenhouse plum growing. The reason for this is that the harvest time of Early Queen is usually about a month earlier than the Black Splendor, which is beneficial in terms of marketing. At the same time, in order not to create a gap in the market, in addition to the Early Queen, the Black Splendor is also used by producers due to its ripening in the first week of June. The aim is to increase the economic income levels of the producers by introducing products to the market at regular intervals throughout the production season. Recently, within the Greenhouse Early Queen plum garden facility; gardens are created by using the method of dorsal plantation in heavy soils with high water table and planting two rows of main variety and one row of Black Amber pollinator at a distance of 1.5 x 4 m. Since, among the plum varieties, the Black Splendor develops weaker than the Early Queen, for high density planting, it is more profitable than other plum varieties. For this reason, during greenhouse plum growing, it is seen that Black Splendor is planted using 4 x 1 m and 4 x 0.5 m spacing with two rows of main variety and one row of Pioneer. As it has been known recently, dwarf growing and therefore high density planting method in fruit growing has become very important due to the high yield per unit area. In these varieties, Myrobolan 29 - C are used as rootstocks, as they are suitable for heavy soils and form 20% smaller crown than seedling rootstocks. Especially with the density planting method, 4 x 0.5 m spacing is preferred. In addition, with the correct garden management, plant nutrition and irrigation schemes, Black Splendor varieties can produce 5 - 5.5 tons of products per decare in the 4th year. When high density planting is taking into consideration; during pruning, leaving a weak branch on the main trunk rather than a thick branch and thinning fruits is an important method for obtaining high quality and productive fruit.

In conclusion, earliness in the greenhouse plum growing, leaving a weak branch rather than a thick branch when pruning and training, choosing the right pollinator type, using bumble bees, dorsal plantation, setting the roof and gutter heights in the greenhouse correctly, plant nutrition and garden management in accordance with the technique are the significant factors associated with a profitable greenhouse plum cultivation.

Figure 2: Greenhouse plum growing in Mersin-Silifke

2. GREENHOUSE CULTIVATION OF APRICOT

Turkey is one of the leading countries in terms of apricot production in the world. However, Turkey tends to increase greenhouse apricot production in order to enlarge its potential by extending its harvest season and to place apricots growing in greenhouses into the markets throughout the world earlier. In particular, provinces such as Hatay, Adana, Mersin and Antalya, which have the potential to grow fruit under greenhouse in the Mediterranean Region, are starting to grow new apricot varieties with characteristics such as dwarf growing, lower chilling requirements, early maturing, high yielding and without fertilization and pollination problems. Since the initial investment cost in greenhouse fruit cultivation is very high, it is very important that the fruit type to be grown will yield early and fructify within short span of time. During the cultivation of apricot in greenhouse, in order to create a garden with the apricot varieties having the above characteristics, approximately 200 saplings are planted per decare at a distance of 2 x 1.5 m. V-shaped planting is used with an angle of 60 degrees parallel to the soil. Pruning and training system is very important in greenhouse apricot cultivation like in other fruit productions. The fundamental principle is to avoid leaving thick branches, removing old branches and encourage new growth. Besides, it is extremely important to cut thick branches in the autumn and thinning green branches during the period of shoots. The aim here is to make use of light as much as possible especially for trees under greenhouse. During greenhouse apricot growing, when the trees reach their 3rd and 4th year, the lower branches do not receive sufficient sunlight, so the expected coloration and homogeneous maturation of the fruits cannot be achieved. In order to prevent this, aluminium foils are coated on the base of the fruit trees, allowing the lower branches of the fruit trees to receive more light. As a training system of greenhouse apricot growing, three main branches are left in the first year. Then, fruit branches are formed on these and fruit production is expected in the early period. During greenhouse cultivation of apricots, the production is carried out and plentiful supply is expected to be produced from the second year. Then, it is aimed to produce a yield of 2-2.5 tons or more per decare in the 3rd and 4th year. In the greenhouse cultivation of apricots, Precoce de Tyrinthe and Ninfa apricot varieties which are self-pollinating are widely used. In addition, in recent years, Spanish Mikado variety is preferred in greenhouses due to its early maturing and lower chilling requirements. For Mikado, Myrobolan 29 - C is generally used as rootstock. As in plum production, in greenhouse apricot cultivation, dorsal plantation is preferred in heavy soils.

In conclusion, for apricots to be grown under greenhouse, varieties with dwarf growing, weak branch formation in pruning, early maturing, lower chilling requirements and high yielding and without pollination and fertilization problems are preferred.

Figure 3: Greenhouse Apricot growing in Mersin-Kale Village

3. GREENHOUSE CULTIVATION OF NECTARINE AND PEACH

Peach is one of the fruits that can easily adapt to various climatic conditions. For this reason, it is aimed to extend the growing season by means of greenhouse cultivation and thus to increase the profit share of the producers by placing products to the market earlier. Hence, while growing nectarine and peach under greenhouse conditions, criteria such as lower chilling requirements, dwarf growing, early maturing, ease of fertilization and pollination are preferred. Needless to say, early maturing is the most important criterion. The most common provinces in the Mediterranean region are Mersin, Hatay, Adana and Antalya for greenhouse peach growing. Since the initial investment costs in greenhouse peach and nectarine production are high, it is extremely important that the varieties can achieve higher yields in the second and third years, starting from the first year. It is intended that about 2-2.5 tons of fruit per decare and 8-10 kg per tree are produced in the second year. Provided that the variety and rootstock are selected correctly and garden management, plant nutrition activities are performed, the production can be up to 3 tons. However, fruit thinning is absolutely necessary in order to obtain high quality and large fruits. For greenhouse peach and nectarine growing, varieties which require chilling of 150 hours or lower are generally preferred. Trees should be planted between rows using 75 cm x 4 m spacing. Approximately 240-280 trees are planted per decare. Gutter height is very important in terms of greenhouse cultivation of peach. As the height of the gutter in greenhouse is 4 - 4.5 m, it increases the development of the volume of the crown, so that the trees receive plenty of light and the yield is increased as the trees grow volumetrically. Factors such as light intensity and air circulation in the greenhouse are extremely important in all kinds of greenhouse fruit growing as they directly affect efficiency. In greenhouse peach and nectarine production, V-shaped planting is used with an angle of 60 degrees parallel to the soil. The aim here is to make the leaves create more carbohydrates by getting more light and also to provide advantages in controlling pests and diseases by facilitating the circulation of the air within the greenhouse.

Figure 4: Peach fruits in greenhouse

Earliness is extremely important in terms of marketing in greenhouse nectarine and peach production. In general, introducing peaches to the market at high prices in the first week of April in the Mediterranean region is economically preferred by producers. In greenhouse fruit growing, especially in the first years, producers increase their profit margins by intercropping vegetables together with nursery stocks. In recent years, especially fig peach production has become popular in terms of greenhouse cultivation. The peach variety called as fig peach, Chinese flat peach, Flat Paraguayan peach is preferred by the producers in greenhouse peach production for its disease and pest resistance unlike the other varieties and lower chilling requirements. For this variety, Nemaguard and Rootback are used as rootstocks. At the same time, Flored and Filomena peach varieties, which are generally grown in the Mediterranean region, are used in the production of nectarine and peach under greenhouse. Producers prefer these varieties because their chilling requirements are ranging from 120 to 150 chill hours and they mature early. As well as Flariba N2-117 and Flavela N2-36 varieties, which require chilling ranging from 80 - 120 chill hours and mature early, Spanish Patagonia varieties with lower chilling requirements and early maturing have also been preferred recently. Especially the commercial value of Patagonia variety is high due to its long shelf life and its yellow flesh.

In conclusion, as in other fruit types, earliness, lower chilling requirements and high yielding are the most important factors that affect the preferences for producers regarding peach and nectarine production.

4. GREENHOUSE CULTIVATION OF HYDROPONIC STRAWBERRY

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, Rubigen, 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).

Figure 5: Strawberries in greenhouse (ROA Biotechnology)

In conclusion, using the method of hydroponics in greenhouse cultivation of strawberries has increased the productivity and has provided the opportunity to put fresh strawberries to the market for almost 12 months. At the same time, it has provided protection from soil borne diseases and pests as well as improving the plant nutrition.

5. GREENHOUSE CULTIVATION OF BANANA

The bananas originated in Southeast Asia. Their origin is placed in Southeast Asia, India and islands between India and Australia. The first bananas are believed to have been cultivated by fishermen as fishing nets were made out of banana leaves. Bananas were firstly discovered in India dating back to the year 600-500 BC. Bananas have a high nutritional value and provide benefits for health because they are rich in many bioactive compounds such as phenolic, carotenoids and biogenic amines. In addition to the fact that most of these compounds have antioxidant properties, it has been reported that they are also effective in protecting the human body from some oxidative stress (Singh et al., 2016).

Banana plant was first brought to our country in 1750 by a rich Egyptian family to Alanya as an ornamental plant. When it is found out that the banana, which was mostly grown as an ornamental plant in those years, can yield fruit; commercial banana plantations started for the first time towards the end of the 1930s. Today, bananas are produced in our country especially in Anamur, Bozyazı, Gazipaşa and Alanya districts and under greenhouse conditions both in Mersin, Antalya, Hatay, Adana provinces and in many coastal districts. Banana cultivation is carried out in more than 130 countries, especially in tropical countries and in subtropical regions with Mediterranean coasts (Aurore et al., 2009). Regarding greenhouse banana cultivation, there has been a great increase recently in Mersin due to the fact that the producers are able to bear the input costs in a short time despite the high initial investment cost. Turkish banana production meets half (51%) of country's demand. Turkey's most important banana production center is Mersin regarding that it produces 72.2% of Turkeys' banana production (Akova and Şahin, 2018). In addition, with the increasing population in Turkey and the understanding of the importance of bananas in human health, there has been an increase in banana consumption. This increase prompt producers to grow bananas under greenhouses, so that they can control of climate, which is the most important factor in banana cultivation. In addition, according to the researches, it is found out that at the end of the development phase of the mother plant when bananas produce 15 leaves in warm climates and 5 leaves in colder climates, baby plants are started to be produced (Turner et al., 2016) and that the total leaf number was found to be higher in greenhouse cultivation (28.2) than in open- field (20.8) .

Figure 6: Greenhouse banana growing in Antalya

In the same research, it was observed that for bananas growing under greenhouses the period between the time that the stem appears and the harvest has decreased to 41.4 days and there was an increase of up to 14 kg compared to open- field cultivation (Gübbük and Pekmezci, 2004). Besides yield and earliness, Selli et al. (2012) found that the condition of the greenhouse and open-field is a significant factor in terms of the flavour of the fruits. When to be produced in greenhouse, the banana variety "Azman" is preferred more than other varieties, since its resistance to cold and therefore its level of abiotic stress tolerance is much better than the others (Emekli et al., 2009; Nafiye et al., 2012).

For bananas, steel construction greenhouses with a roof height of 7 - 7.5 meters are generally used. Banana plants are generally planted in the greenhouse using 3 x 1.7 m spacing. Especially in the Mediterranean region, if the surface of the greenhouse is built on the east and west side regarding the topography, it is most affected by the sun, gaining and storing heat throughout the day (Bağçetinçelik, 1985). As a result, the most important problems encountered in banana cultivation can be summarized as follows; In Turkey, it is necessary to accelerate the breeding of new varieties such as Azman variety or the breeding suitable for the region. The method of dorsal plantation should be preferred in banana gardens that will be created in heavy soils with high water table and poor permeability. A correct and effective plant nutrition program should be followed. Balanced and adequate irrigation methods must be applied. Harvest time should be determined correctly and post-harvest practices should be improved. In order to increase the efficiency per unit area, a correct greenhouse management should be provided. It is imperative to adopt the organized production model from production to marketing.

In conclusion, regarding the global trade of bananas, Turkey's banana industry has a very low chance of competing with other producer countries due to the price disadvantage. At the same time, it is very important to manage banana production in order not to affect the banana sector from international agreements.

6. GREENHOUSE CULTIVATION OF GRAPE

In addition to growing bananas, strawberries, plums and peaches under greenhouses, one of the alternative production methods is grape cultivation. In recent years, greenhouse cultivation of grape in the Mediterranean region has become one of the branches increasing its profitability by adding high value and by introducing grapes to the market earlier. Thus, Early Cardinal, Ergin Çekirdeksizi, Perlette, Trakya İlkeren, Uslu, Yalova Pearl, Yalova Misket and Prima varieties are produced under greenhouses due to their early maturing and lower chilling requirements. American grape-vine rootstocks are generally used. Most of the grape greenhouses in the Mediterranean Region were high-roof greenhouses where vegetables were produced before. However, new greenhouses are also being created specifically for grape production. Grape cultivation is even carried out in glass greenhouses, and both plastic and glass greenhouses. Since the roof height is not very high in the old greenhouses growing vegetables, the grapes planted in these greenhouses bring along some problems due to the low greenhouse roofs, lack of light and poor air circulation. In greenhouses for grapes, grape-vines are planted using 1.5 x 2 m, 2 x 4 m or 4 x 6 m spacing. 4 or 2 grape-vines are occasionally attached to each ridge pole. For this reason, depending on the planting density, 250 - 500 grape-vines are planted per decare. Higher greenhouses with a side height of around 3-3.5 meters are generally used. The grape greenhouse is generally built with a slope roof and a slant height of 2.50 m and a crest height of 3.70 m. Side and roof ventilations are available in greenhouses. The polyethylene cover used in the greenhouse is 0.3 mm thick and consists of UV and IR (Polat et al., 2007). The height of the roof and gutter in the grape greenhouses and the heating, ventilation system and planting frequency in the greenhouses significantly affect the amount of grapes and earliness to be obtained per unit area. For example, in order to increase efficiency per unit area, a 4-planting system has been preferred recently. In addition, some studies have shown that Prima and Trakya İlkeren grape varieties growing in greenhouse can achieve high yield per unit area and reach a quality level as high as in the open-field (Tangolar et al., 2017). Producers report that from the 3rd and 4th year of planting in the greenhouse, they contribute to economic yield and that 35-50 tons of grapes can be obtained from approximately one decare.

In greenhouse vine growing, there can be common diseases such as Downy Mildew, Gray Mold and Powdery Mildew as well as pests like Grape Moth. However, supposing that the summer pruning is performed, proper vineyard management is followed, and effective plant nutrition programs are managed, these problems are not likely to occur. One of the most important issues that producers should pay attention to in greenhouse grape growing is the early harvesting. Since some producers think that they will sell at high prices and harvest early accordingly, the market value of the grape is decreased. In greenhouse grape cultivation, especially during the flowering stage, the temperature inside the greenhouse should not be below +7 ° C. If the temperature in the greenhouse decreases during cold weather, high potential yield losses may observed. For this reason, having a day-night temperature of 10-27 ° C during the flowering stage will provide useful results. Greenhouse grape growing is one of the production models with very high initial cost, as in all greenhouse fruit growing. For this reason, it is important to provide manufacturing-based government support to producers on greenhouse construction and costs of plants in the beginning. When greenhouse grape cultivation and greenhouse tomato cultivation which are widely produced in the Mediterranean Region are compared, as the grape production requires less labor and less input compared to tomato production, as its harvest ends in late May and as there is no need for a significant labor force during the hot weather in the greenhouse, greenhouse grape cultivation is preferred more and more each day. However, as in all productions, it is absolutely necessary to create production planning and make sure that the production is balanced in terms of marketing (Özkan et al., 2005).

In conclusion, since the initial investment cost of greenhouse grape production is high in the first years and profitability will be achieved after the 4th and 5th years in the long term, during this period, the input costs are tried to be reduced by producing secondary products such as beans and pepper by means of intercropping in the greenhouse.

Figure 7: Greenhouse grape growing in Mersin-Kale Village

7. GREENHOUSE CULTIVATION OF LOQUAT

Loquat is a tree species that is originated in China, Japan and India and is in the family *Rosaceae*. In Turkish it may also called as *Eriobotrya japonica* and medlar. It is a subtropical fruit that has been produced in the Mediterranean region in Turkey for about 150-200 years. Greenhouse cultivation of loquat shows a rapid development in the region due to both its earliness and obtaining high quality fruit. It can grow even in plastic greenhouses that are not very high. In addition to this, high density planting, wire system and drip irrigation systems are conducted regarding the greenhouse cultivation of loquat (Kaşka, 2019). With the high density planting system 100 loquat seedlings can be planted within a decare. In general, the average yield of a 4-year-old tree under homogeneous conditions is 2-3 tons per decare. Although the first harvest varies depending on the climatic conditions, loquat is ready for harvest in the middle of January and in the first weeks of February.

In addition, the harvest is expected to continue until March and April. The product finds buyers offerring higher prices in the markets even at the end of April due to the large size of its fruits and the absence of black spot disease in greenhouse cultivation. As the fruit characteristics of the Round Pit Belly are superior among the Loquat (*Eriobotrya japonica*) varieties, the use of this variety in the food industry is more preferred by the producers regarding greenhouse cultivation. However, in the open field, varieties such as Yuvarlak Çukur Göbek, Hafif Çukur Göbek, Uzun Çukur Göbek, Gold Nugget and Akko XIII are widely produced in the Mediterranean Region (Bayrakdar, 2020). Especially in Antalya, some producers have started to use the variety called Cyprus. Since this variety is meaty and matures very early, its taste and flavor is superior to other varieties and has stunted growth; it has become a preferred variety in recent years. In addition, the loquat variety, locally called Cyprus, can be planted in greenhouses using 1.5 x 3 m spacing, and approximately 200 saplings per decare can be planted. In addition to earliness in the production of loquat fruit under greenhouses, one of the most important advantages is that it provides the opportunity to produce without being infected with black spot disease (*Venturia* *inaequalis*) and other fungal diseases, since it is produced in a closed environment.

Figure 8: Greenhouse loquat growing

In conclusion, greenhouse loquat cultivation is preferred by producers in damaged banana greenhouses or old vegetable greenhouses because of its high profit rate, as it provides a 1-1.5 month earliness and finds buyers offering higher prices when there is no fresh fruit in the market.

8. GREENHOUSE CULTIVATION OF AVOCADO

In the early 1970s, 4 important avocado cultivars Fuerte, Hass, Bacon and Zutano were brought from California through FAO for commercial avocado production in Turkey. These varieties were tested in ecological conditions of Antalya, Dalaman Muğla, Alata Mersin, Adana and İskenderun Hatay. In summary, avocado has been produced in Turkey for about 50 years. Approximately 75-80% of avocado production in Turkey is produced in Antalya, 15-20% in Mersin and 2-5% in other provinces (Muğla and Hatay). It is believed that the future of greenhouse avocado production can be quite profitable in Turkey due to its ecological advantages in the Mediterranean Region and geographical proximity to the European market. Turkey has a great advantage in terms of the cost of heating in avocado production under greenhouse, especially in the region between the provinces of Hatay and Muğla compared to other regions. At the same time, Turkey has a higher chance of competing with Mediterranean countries such as Spain and Italy (Bayram and Aşkın, 2006). Greenhouse avocado cultivation has become popular recently. Greenhouse cultivation is preferred for avocado growing due to the fact that it is a tropical plant and is heavily affected by climate change in subtropical regions and that the climate factor can be controlled under greenhouses. As known, although the high cost of greenhouse partially restricts greenhouse cultivation, conscious and capable producers have started to produce avocado under greenhouse regarding the government support for greenhouse fruit growing and its high profit rate. It is preferred by producers to transform especially banana greenhouses into avocado greenhouses as they loss of productivity due to soil degradation. In recent years, Pinkerton and Wurtz varieties are preferred in greenhouses. Because of their semi-dwarf nature However, Pinkerton variety is preferred more by the producers due to the high fruit quality and market demand. Owing to the fact that the branches of the avocado plant are sensitive and are easily affected by winds and that plants does not break in the greenhouse environment, the avocado plant develops better under greenhouse. Pinkerton variety increases the profitability and preferability of this variety with the introduction of avocados to the market in the 3rd, 4th and 5th months when there is no fresh one in the market. The fact that the producers offer fresh avocados to the market in May and June creates the opportunity to sell at very high prices.

Figure 9: Avocado fruits (Photo taken from ntv.com.tr)

Besides, Pinkerton variety provides a significant advantage in terms of filling the avocado market gap in May and June and offering fresh avocados to the market for about 12 months. Since the Pinkerton variety is dwarf, 100 saplings are planted in the greenhouse using 2.5 x 4 m spacing between rows and above rows. Two-year-old seedling of Pinkerton avocado yields 10-12 fruits. When effective plant nutrition and correct garden management are implemented, the weight of each Pinkerton fruit reaches 260 - 280 gr. Each tree yields 150-200 kg of fruit in the 3rd and 4th year. For this reason, approximately 15-20 tons of product can be obtained from a decare. Bumblebees or honey bees must be used in greenhouses for pollination to increase efficiency in avocado production. In addition, the method of dorsal plantation is recommended in heavy soils with high water table.

In conclusion, early maturing varieties with characteristics of high yield and dwarf growing are preferred by the producers in terms of the production of avocados under greenhouse. New varieties with these features need to be breeded.

CONCLUSION

We can summarize the issues to be considered in greenhouse fruit growing as follows; it is very important that the fruits growing under greenhouse are early maturing varieties, have lower chilling requirements, can yield early with higher yields and are dwarf growing. In addition, it should not be affected by stress conditions, be suitable for pruning and training, is resistant to pollination and fertilization problems, forming weak branches rather than strong branches, and having fruitful side branches. Besides, since greenhouse fruit growing is an expensive production model, marketing and releasing should be set up correctly. Moreover, greenhouse fruit production requires knowledge and equipment. For this reason, garden, disease and pest control, plant nutrition and irrigation management should be planned correctly. At the same time, it is necessary to increase production-based government support, to reduce the initial investment cost, to make production planning, and to support organized production in terms of the production of bananas, strawberries, avocados, loquats, plums, apricots, nectarines, peaches and some tropical fruits by taking into account the geographical, ecological advantages and market superiority.

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CHAPTER 5

A RESEARCH ON THE USE OF WOOD VINEGAR (PYROLYSIS ACID) AND BIOCHAR IN THE HORTICULTURAL PRODUCTION

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INTRODUCTION

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. However, in Turkey as the agriculture is not considered as an industry, synthetic production inputs are uncontrolledly used and also a very intensive agricultural production is carried out without considering the consequences of negative processing techniques and technologies, just like in the developed countries of the world (Tarhan, 2005).

Wood vinegar is a by product from the charcoal production process (Fengel and Wegener, 1984). It contains more than 200 chemicals including wood vinegar, acetic acid, methanol, phenol, ester, acetal, ketone, formic acid and many other organic chemicals (Mu et al., 2003; Kadota and Nimii, 2004). Wood vinegar consists mainly of water soluble compounds, over 200 kinds. Its main ingredients are organic. Acetic acid acids, phenolics, alkanes, alcohol and ester compounds are its main components. There are many uses for wood vinegar in the agriculture (Jothityangkoon et al., 2007). Wood vinegar when used as foliar fertilizer enhances yields in cucumber, lettuce and cole (Mu et al., 2006; Jothityangkoon et al., 2007). Mixing charcoal and wood vinegar in planting materials improves growth, branching and survival rate of Zinnia and increases yield of it (Kadota and Niimi, 2004). In recent years, wood vinegar has been used in horticultural agriculture as plant growth regulator to improve soil quality, prevent soil-borne diseases and pests, support root growth and enhances the growth of stems, leaves, and flower and fruits (Mu et al., 2003, 2004; Burnett, 2013). Especially in organic farming, producers use wood vinegar, which is an organic product rather than toxic chemicals in plant growing against diseases and pests. In addition, wood vinegar promotes seed germination, plant growth, improves fruit quality, and acts as a herbicide in weed control (Loo et al., 2007). It has been determined that wood vinegar in horticulture reduces the harmful effects of pathogenic factors such as *Fusarium* spp., *Phytium* spp. ve *Rhizoctonia* spp. that adversely affect fruit trees. It has been reported that when used at the appropriate concentration, it promotes the fertilizer consumption and reduces the damage of many diseases. It is also known that wood vinegar helps plants to meet their nutritional needs for growth by absorbing soil nutrients, improve hairy root growth and stimulate the soil microbial community (Namlı et al., 2014). In the experiment conducted to determine the effects of bamboo vinegar on lettuce, cucumber and rape seeds, Mu et al. (2003) stated that using wood vinegar diluted 500 times increases yield between 18.8-20.2%, and has an effect on plant height and weight compared to control (Jun et al., 2006) When wood vinegar is applied on plant leaves, the leaves become shiny and darker in color. This is due to the increase in chlorophyll through the effect of ester in the wood vinegar which promotes photosynthesis. This ester also helps in the formation of sugar and amino acids. This also results in a better taste of the produce. The healthier leaves naturally have a stronger resistance against pests and diseases. (Velmurugan et al., 2009). The fruit quality is closely related to health of the plant. Therefore, wood vinegar significantly improves the fruit quality and quantity. Besides, wood vinegar increases the value of the products, because excessive pesticides are not used, in both domestic and foreign markets. Since synthetic drugs used as biocides have harmful effects on human health, the advantage of the bactericidal and fungicidal properties of wood vinegar should be taken in order to reduce the negative effect. The effects of wood vinegar, which is presented to the producers as a alternative to chemical fertilizers and pesticides in the market, should be clearly explained to producers, and studies on the use of wood viegar should be regard as necessary in order to contribute to the sustainable use of soils (Namlı et al., 2014).

Figure 1: Wood vinegar application in strawberry garden (Silifke / Mersin)

Reference: Niyazi Cin/ Çelebi Company.

The Thai Ministry of Agriculture reported that wood vinegar was used towards soil quality improvement, pest elimination, plant growth stimulation, promotion of the growth of roots, stems, tubers, leaves, flowers and improvement of yield. At the same time, it enhance the root growth by increasing the beneficial microbial population.

The aim of this study is to improve the deteriorated soil structure due to excessive fertilization, pesticide and irrigation, to restore the degraded ecosystem by enabling plants to absorb nutrients more easily, and to examine the effects of wood vinegar and biochar application on horticultural agriculture as an alternative to chemical fertilizers and pesticides in order to ensure the sustainability of agricultural areas.

1.APPLICATION OF WOOD VINEGAR FOR PEST AND DISEASE MANAGEMENT

In recent years, in order to reduce the use of pesticides with the purpose of protecting food safety and natural balance, there has been a global shift towards more environmentally sustainable ways of managing pests and plant diseases. Pesticides are produced in a way that neutralizes specific target organisms or groups of organisms that harm economic agricultural products. However, pesticides distrupt the natural balance. The effects of long lasting pesticides (usually chlorinated hydrocarbons) and permanent pesticides (consisting of arsenic, lead or mercury) are quite dangerous to natural balance except for those that are moderately lasting due to their natural, organic and synthetic properties (Karaismailoğlu, 2016; El- Nahas et al., 2017; Kayhan, 2020). Scientific researches proceed intensively in order to discontinue the pesticide use and to increase the preference of environmentally friendly applications. For this purpose, in a study conducted by Ahadiyat et al, they reported that they greatly reduced the harmful effects of fungal disease of coconut shell by applying the concentration of wood vinegar of ratio 1:20, 1:20, 1:40, 1:60, 1:80, 1: 100 to coconut shell. Wood vinegar, extracts of Mexican turnip and the seed of Chinaberry tree are used within the study carried out against housefly. They reported that because wood vinegar causes disorders in the larval, pupal and adult stages, it prolongs the duration of their development period and shorten the life span of adults (Pangnakorn et al., 2012). Chalermsan et al. (2009) reported in a study they conducted that wood vinegar (pyrolysis acid) could be an effective fungicide that can be used against fungal diseases which damage plants. Moreover, the reason why wood vinegar has antifungal properties is due to the phenolic compounds it contains (Baimark & Niamsa, 2009).

Figure 2: Images after wood vinegar application in Nova Tangerine garden (Şahinağa Village/ Adana)

Reference: Niyazi Cin/ Çelebi Company.

Wood vinegar is effective against pathogenic fungi such as *Alternariamali Rhizoctonia solani, Sclerotium oryzae, Helminthosporium mayis, Pythium sp., Colletotrichum gloeosporioides* and *Choanephora cucurbitarum* in horticultural crops (Chalermsan et al., 2009; Jung, 2007). It has been detected using different application rates of wood vinegar that the growth of *Coriolus versicolorm* and *Gloeophyllum trabeum* is inhibited in order to identify the antifungal properties (Chen et al., 2012). Besiders, wood vinegar is widely used in animal products against external parasites and insects such as flies, ticks, fleas. (Chan et al., 2012; Rakmai, 2009). It has been recorded that wood vinegar is an effective repellent for the control of the vole (*Clethriono mysrufocanus bedfordiae*), slugs *(Arionlusitanicus*) and snails(*Arantaarbustorum*) damaging the plants. (Lindqvist et al., 2010). In another study, it was reported that wood vinegar has positive effect on the growth of wheat plants and contributed to the improvement of soil properties. The effect of various forms of wood vinegar on wheat development and a series of soil chemical characteristics was investigated in a greenhouse experiment by Namlı et al. (2014). In the same study, it has been determined that the application rate of 0.5 %, wood vinegar can completely inhibited *C. ceticola* development at a rate of 77,4-91,1 %. In line with the data obtained in the study it is concluded that wood vinegar can be alternatively used as a biocide agent *in vivo* conditions. In a study conducted by Saberi et al. (2013), different concentrations of wood vinegar (0.125%, 0.25% and 0.50%) reduced the pathogenicity rate of the pathogens of *Rhizoctonia solani* and *Sclerotinia sclerotiorum* in cucumber (*Cucumis sativus* L.) up to

87% compared with the control. In a study conducted in Indonesia, it was reported that wood vinegar provided a natural protection against anthracnose (*Colletotrichum* sp.) on pepper (*Capsicum annuum* L.) According to this research, different concentrations of wood vinegar (0.40; 0.42; 0.44; 0.46; 0.48; 0.50; and 0.52%) are used and it is reported that the rates of 0.50 and 0.52% have the best results. Therefore, they stated that it reduced anthracnose in hot peppers up to 87.98% (Wardoyo et al., 2020).

2.THE EFFECTS OF WOOD VINEGAR AND BIOCHAR ON YIELD AND QUALITY OF PLANTS

Fertilization is carried out with the intent to protect and improve soil productivity in order to ensure the sustainability of vegetative production and high yield from plants (Bellitürk, 2011). Productivity in agriculture depends on making up for mineral deficiencies in the soil and meeting the nutrient demand of products. Producers have recently started to use chemical fertilizers intensively to obtain more products

Figure 3: Application of biochar (Erdemli/Mersin)

Reference: Niyazi Cin/ Çelebi Company.

per unit area in order to meet the nutritional needs of the increasing world population. However, it has become a fact accepted by all scientific circles that chemical fertilizers contaminate the soil and groundwater resources. This situation endangers the sustainability concept in agricultural production. While chemical fertilizers, which have been used for years, have increased productivity in agriculture, they cause the exhaustion of the soil, sodification, desertification and degradation of soil. As a result of this, researchers today recommend the use of alternative nature-friendly fertilizers such as biofertilizer, vermicompost and biochar, which have the capacity to successfully reverse the negative effects of chemical fertilizers (Yetkin, 2010; Aydın, 2019).

In a study conducted by Zulkarami et al., (2011) in Malaysia, three fertilizer formulations namely; (M), Cooper Standard (CS) and Benoit(BEN), a local formulation commonly used by farmers containing calcium nitrate, potassium nitrate, magnesium sulfate and mono potassium were evaluated in combination with four levels of pyroligneous acid (0,10, 20 and 30%) for enhancement of growth, fruit yield and quality of rockmelon in soilless culture. The concentration of 30% was toxic as most plants died while the concentration of 20% increased the growth and yield of rockmelon plants. However, it is reported that the local M fertilizer in combination with 10% pyroligneous acid gave the best results. In different studies, it is reported that the combination of wood vinegar and charcoal increased soil fertility for rice (*Oryza sativa*), melon (*Cucumis melo*), sweet potato (*Ipomoea batatas*), sugar cane (*Saccharum officinarum*), tomato

(*Lycopersicum esculentum*) (Kadota et al., 2002; Tsuzuki et al., 1989; Du et al., 1997; Du et al., 1998; Uddin et al., 1995; Mungkunkamchaoa et al., 2013). Moreover, it is stated that it significantly increased plant growth in vegetable species such as lettuce (*Lactuca sativa*), canola (*Brassica napus*) and cucumber (*Cucumis sativa*) (Mu et al., 2003). Due to utility of wood vinegar as soil conditioner, it increases enzyme activity in the soil and reduces the toxic effect of heavy metals in the soil by minimizing ammonia volatilization (Lashari et al., 2013; Win et al., 2009; Liu et al., 2018). In a study conducted to analyze the effect of wood vinegar on seed germination and seedling growth, the seeds of corn are dipped in wood vinegar of different densities. Later, corn seeds were monitored in the germination media and it has been observed that concentrations of wood vinegar had obvious effects on up-ground length and up-ground dry weight of corn seedlings but there was no significant difference on chlorophyll value and dry weight underground (Zhou et al., 2009).

Biochar, which is a product synthesized through pyrolysis acid and carbonized carbon of different biomasses of plant or animal waste, is a material that has the property of improving the soil and the environment. Biochar also affects the soil microbial activity, facilitates the uptake of nutrients and water, thus increases yield (Ahmad et al., 2014; Zheng et al., 2013; Zheng et al., 2013; Jones et al., 2012; Razaq et al., 2017). In a comparative study on blueberry, it is observed that when wood vinegar was applied alone or combined with biochar in the nutrient medium of the blueberry, the amount of $NH4 + $-N, $NO3^{-}$-N, and Mg in the soil, plant growth, and the fruit yield was increased. In addition, it is found that vitamin C content and mineral substances increased but the titratable acidity decreased within the blueberries.

In conclusion, it has been stated that when wood vinegar is applied alone or combined with biochar, it improves soil structure and increases nutrient contents (Zhang et al., 2020). A study was carried out on the three seedlings of mango in randomized complete block design with two (2) treatments, three (3) sub-treatments, and three (3) replications with five (5) samples per replication. According to this study, control and 20 ml wood vinegar were applied and while there was no significant variation observed in the plants under control, significant differences were observed in the height of the mango seedling applied wood vinegar. It has been reported that wood vinegar applications accelerate root and leaf growth in mango seedlings (De et al., 2021).

3.THE USE OF WOOD VINEGAR FOR PRESERVING HORTICULTURAL PLANTS

In a study conducted in China in order to keep-fresh effect of harvested Jingya grapes by increasing the shelf life, harvested Jingya grapes were immersed in three different concentration of wood vinegar (5.0 g/L,3.4 g/L and 2.5 g/L) and 100.0 g/L garlic juice, 6.7 mol/L of ethanol, mixtured solutions of 3.4 g/L wood vinegar and 100.0 g/L garlic juice for 2 minutes, then stored under room temperature (20 −25 °C). The best result is obtained from 5.0 g/L wood vinegar. As a result, it has been reported that application of 5.0 g/L wood vinegar to Jingya grapes after harvest reduces the respiratory rate, water loss, rotting rate and content of malondialdehyd (MDA) of grapes, delayed the aging of grapes and extend the freshness and shelf life of grapes (Xue et al., 2009). In a study conducted in China in 2013 in order to determine the effect of wood vinegar against R. nigrican (black rot) factor formed on peach after preservation; the inhibition effect of wood vinegar concentrations of 10, 20, 25, 33.4, 50 and 100.0 g/L, and 100.0 g/L were investigated. In this study, peaches were immersed in wood vinegar concentrations of 12.5, 16.7, 25.0 and 50.0 g/L for 2 minutes and then stored at 20-23 °C. It is observed that the spore germination of *R.nigrican is* significantly reduced. It has been reported that fruits preserve their freshness and significantly extend their shelf life. In particular, it has been reported that the application of 5.0 g/L wood vinegar reduces the rotting rate and water loss, the respiratory rate and the content of malondialdehyd (MDA) in fruits, delayed the aging and extend the freshness and shelf life (Xue et al., 2013). In China, Shi et al. (2019) also investigated effects of bamboo vinegar and peach gum on grey mould (*Botrytis cinerea*) in blueberry. According to this study, blueberries were immersed in different concentration of wood vinegar (BV: 0.1, 0.5, 1 and 1.5% v/v) and peach gum (PG: 0.5, 1, 2 and 3% w/v) solutions under room tempeture for two minutes. In this study, it is reported that wood vinegar combined with peach gum preserved the quality of product and delayed aging by controlling gray mold disease development during storage and activating antioxidant enzymes such as CHI (chitinase), GLU (glucanase), PAL (phenylalanine ammonia-lyase), PPO (polyphenol oxidase) and POD (peroxidase) that have an important role in preserving fruit quality. Jun and Zhang (2010) used solutions consisting of wood vinegar + chitosan and chitosan + acetic acid mixtures to extend the shellf life of cherry-tomatoes in their study. According to the results of this study, they reported that when wood vinegar + chitosan was applied, the weight loss ratio is reduced, the appearance and quality are increased, and the shelf life is extended.

CONCLUSION

As the world population increases, the food demand increases correspondingly. Therefore, in terms of agricultural production, it has become necessary to obtain more products per unit area in agricultural lands and to use it more intensively. At the same time, using more fertilizer, more pesticides against disease and pests, and more water has been a must due to the necessity of intensive use of agricultural lands and the need to obtain high yield per unit area and this lead to the sodification and salinization of soils, degradation of soil fauna and flora, soil pollution and desertification. For this reason, agricultural researchers are in search of new environmentally friendly agricultural production methods (such as good agricultural practices, organic agriculture, ecological agriculture, biological agriculture) to restore the deteriorated agricultural soil and ecosystem. Especially, they aimed to improve the soil structure with practices such as good agriculture and organic agriculture. For this purpose, instead of using pesticides against diseases and pests, biomass including organic enviromentally-friendly ingredients, organic fertilizers of vegetables and animals, as well as applications of soil regulators as biochar and wood vinegar have become recently popular in developed and developing countries, especially in East Asian countries. The aim is to increase the use of enviromentally-friendly biochar and wood vinegar in order to recover the soil deterioration due to excessive use of pesticides, chemical fertilizers and unconscious use of water since agricultural production has been carried out with traditional methods for many years. Applications of wood vinegar and biochar both improve the soil structure and facilitate the intake of nutrients and water, allowing plants to grow faster and give higher yields. Especially in the production of horticultural plants, soilless culture and fruit production, as application of wood vinegar and biochar promotes the potassium uptake in order to the plants have a strong root system, it helps plants to grow healthier by preventing soil borne diseases and damages. There are still ongoing researches on whether wood vinegar can be used as an alternative to fungicides containing pesticides against soil borne fungal diseases such as *Fusarium spp, Sclerotinia sclerotiorum, Verticillium spp, Bortrytis cinerea, Penicillium italicum*, *C. beticola*, *R.nigrican, Alternariamali Rhizoctonia solani, Sclerotium oryzae, Helminthosporium mayis, Pythium spp., Colletotrichum gloeosporioides ve Choanephora cucurbitarum, Leveillula spp, Monilinia spp* that negatively affect yield and quality in plant cultivation. Besides, researches continues to verify that it has a repellent effect against pests such as root knot nematodes (*Meloidogyne spp*.), aphids (*Aphididae spp*.), fruit flies (*Ceratitis capitata*), fruit moths (*Cydia molesta Busck*), fruit worm (*Capnodis spp.*), vole (*Clethriono mysrufocanus bedfordiae*) slugs (*Arionlusitanicus*) and snails (*Arantaarbustorum*). For this reason, an enviromentally-friendly practice is important in terms of food safety against both fungal diseases and pests that cause damage to plants.

When wood vinegar and biochar are used in appropriate concentrations, they provide healthier leaves and higher fruit yield and flowering especially regarding the fruit trees. At the same time, it has been reported by many researchers that wood vinegar is very effective in extending the shelf life of the products after harvest and it promotes seed germination, seedling and growth of the plants when used in different concentrations and combinations. For example, it is tested and verified that the shelf life of fruits such as grapes, peaches, blueberries and mangoes increased when they were immersed in a different wood vinegar solutions after harvest.

In conclusion it is necessary to carry out more detailed studies in order to increase the use of biochar and wood vinegar in agricultural production. There is a need for more comprehensive studies on its usability as a rooting medium, especially in tissue culture applications. Moreover, it is recommended that more detailed studies on using wood vinegar in terms of preserving fruits and vegetables should be performed. In addition, this study can be considered as important for shedding light on more comprehensive studies to be carried out in the future.

ACKNOWLEDGEMENT

Çelebi Company which inspired us to write this study is one of the few companies in Turkey that invest in the use of wood vinegar and biochar and carry out R&D studies accordingly. It is also the largest company that produces fabricated wood vinegar. Therefore, due to the studies and activities they have carried out, they have led us to write this article.

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CHAPTER 6

THE PEACH: BRIEF DESCRIPTION and GROWING

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INTRODUCTION

Peach is the third most produced crop among temperate climate fruit species after apple and pear. Peach trees shed their leaves during winter dormant period. Peach that grows in the form of tree is a perennial woody plant. Peach trees can live up to 20-30 years. However, economical life span of fruit orchards established for commercial purpose varies in interval of 12-15 years. Peach is a type that yields early and while it is generally raised for its fruit, especially in China and Japan it is also used as a ornamental plant.

Peaches are very broad in color (skin color; red, purple-red, pink, orange and variegated) (Fruit color; red, yellow, white or red-yellow, red-white), texture, shape (full round, slightly flattened or fully flattened), size and flavor. Due to this reason, demand for peach can vary as per countries or even from one region to another. Peach is the most produced type among the stone fruit types. Peach fruit is among types that are consumed with pleasure by many people as being used for human nutrition. Its importance in terms of human nutrition and health comes from the content of phenolic compounds, vitamins and antioxidants. Peach has low calories and it is a good source of potassium, vitamin A and C. While peach is generally used as a table top item, it is also used as raw material for processing industry. For example, it can be preserved in syrup or processed into fruit juice concentrate and pulp. In addition, jam and marmalade are made from peaches, and some varieties are dried and processed (Serra et al., 2020).

1. CULTURAL HISTORY AND ORIGIN

All commercial peach cultivars are cultivars of *Prunus persica* (L.) Batsch. Peaches have n=8 (2n=16) number of chromosomes. Peaches form a well determined fruit group genetically and it is used as a model type for the whole *Rosaceae* family. It is known that the peach, whose botanical name is *Prunus persica* (L.) Batsch, originally came to Central Asia from Iran and was cultivated in China, where it has been cultivated for over 3000 years. Although peach is a fruit type which is raised since very ancient times it is not known when it entered our country (Bassi et al., 2016; Özçağıran et al., 2003).

Place of peach in plant systematic is defined as follows:

Family:	*Rosaceae*
Subfamily:	*Prunoideae*
Genus:	*Prunus*
Subgenus:	*Prunus* subg. *Amygdalus*
Section:	*Euamygdalus*
Species:	*Prunus persica* (L.) Batsch
Synonym:	*Amygdalus persica* L.
Cultural Forms:	*Prunus persica* var. persica (peach)
	Prunus persica var. nucipersica (nectarine)
	Prunus persica var. platycarpa (flat peach)
	Prunus persica var. nucipersica platycarpa (flat nectarine)

There is *Prunus persica* var. platycarpa, which is known as 'Flat peach', 'Domat peach', 'Tomato peach' in Turkey. *Prunus persica* var. platycarpa is a peach that has gained popularity in recent years with its interesting fruit characteristics. Although this fruit has been known for many years, due to its rich aromatic structure, very small seeds, easy consumption and interesting appearance, it has been used in the USA in recent years and its cultivation in Spain has grown rapidly. A large number of flat peach and nectarine cultivars have been developed with the breeding studies carried out in USA and Spain. The fruit, which is marketed as 'Donut peach' in the USA, was introduced to peach cultivation by giving the name UFO with the breeding studies carried out at the University of Florida. Flat peaches and nectarines are marketed at higher prices than standard varieties.

The origin of nectarines is unknown. Nectarine trees may have formed from peach seeds and peach trees may have formed from nectarine seeds. In addition, nectarines may have occurred in peach trees through spontaneous bud mutation (gene mutation) (Childers, 1954). Pubescence trait of nectarines was determined to be controlled by a recessive gene (Rivers, 1906; Blake, 1932; Blake and Connors, 1936; Bailey and French, 1949; Faust and Timon, 1995). Pomological varieties observed in peach and nectarines are given in Figure 1, Figure 2 and Figure 3 (Layne and Bassi, 2008; Gür, 2012).

Figure 1: Pomological diversity observed in peaches and nectarines

Figure 2: Variation in fruit flesh color of peaches and nectarines

Figure 3: White nectarine with code '17-BN-01' that is raised in Çanakkale

2. ECOLOGICAL REQUIREMENTS

Peach cultivation is carried out in temperate and subtropical climates at 30˚–45˚ north-south latitudes in the world. Minimum winter temperatures and spring frosts are the limiting factors for peach cultivation in high latitude regions (45° North and South or higher latitude regions). At latitudes that are lower than 20° (such as Australia, Brazil, Thailand and Taiwan, etc.), the lack of sufficient cooling is another important limiting factor. In tropical regions, peach cultivation can be made possible with applications that can affect flowering in high altitude regions. In the spread of peach cultivation to large areas in the world, its adapting easily to different ecological conditions, yielding in a short time, length of the harvest period, its being ostentatious and delicious, and different consumption patterns of fruits were effective factors (Byrne et al., 2012; Özçağıran et al., 2003).

Peach is one of the fruit crops that can adapt to different climatic conditions. Most important climatic factor that affects peach cultivation is temperature. Low winter temperatures, the chilling requirement of the variety, late spring frosts are the factors that prevent it from being grown economically. In places where the winter temperature drops to -18°C to -20°C, the buds and annual shoots freeze, and at -25°C the whole tree freezes. In addition to low winter temperatures, peach trees cannot adequately meet the need for cooling due to the hot or warm temperatures in winter. In this situation peach trees shake off the flower buds. In spring, flowering becomes irregular and flowering is delayed on strong shoots. The need for cooling is less than other temperate climate types. Although it varies according to the varieties, it usually varies between 50-1200 hours (≤ 7.2 °C). Since peach blooms early after almonds, plums and apricots, it is risky to cultivate it in places where late spring frosts are dangerous. Although flower buds last until -6.6°C without opening, opened flowers can be damaged at -3.6°C to -1.1°C, and newly formed fruits can be damaged at -2.7°C to -1.1°C. For regions where late spring frosts are common, it would be beneficial to select late flowering varieties (Eriş and Barut, 2000; Özçağıran et al., 2003; Ünal, 2011; Gür, 2012; Mayer, 2017).

Peach, being a hairy rooted fruit specimen, develops better in deep and light loamy soils. It does not develop well in the heavy and moist soils. The pH value of the soil should be between 6-7, which ideal for whole cultivation. Chlorosis is seen in high pH and calcareous soils. When peaches grow in fertile soils rich in nutrients and in orchards with adequate irrigation, they form high yield and very strong trees. Soil structure is among important factors that limit peach cultivation. Soil conditions are also effective in rootstock selection, constituting one of the basic elements of cultivation (Blattny, 2003; Johson, 2008; Ünal, 2011).

When the data of last ten years of world peach nectarine production is concerned, it is seen to be 25,737,841 tons in 2019 with an increase of approximately 26%. Throughout the world countries that raise highest amount of peach are China, Spain, Italy, Greece and Turkey by order (FAO, 2021). Production in Turkey in year 2020 was 892.048 tons. Highest amount of peach and nectarine productions in Turkey were realized in cities of Çanakkale, Mersin, Bursa, Denizli and İzmir (TÜİK, 2021).

3. FERTILIZATION BIOLOGY

Peach flowers are hermaphrodite. Peaches petals can have white, pink, dark pink, mottled or orange color. Generally, it is a self-fertile species. Although the majority of peach-nectarine varieties are self-fertile, J.H. Hale is not a self-fertile variety. But, it can be fertilized with almost all varieties that flower in the same period, except for the Elberta variety. Clones of J.H. Hale with different characteristics (Early Hale and Hale Haven) definitely need another variety as a pollinator for adequate fruit set. Bees and insects play a primary role in the pollination of peach (Eriş and Barut, 2000; Bassi and Monet, 2008; Raja et al., 2018).

4. PROPAGATION TECHNIQUES AND ROOTSTOCKS

Even though peach is a self-fertile species, seed propagation is not used. This is because when it is propagated by seed, it loses its variety by showing genetic variation. For this reason, seeds are used in breeding studies and to obtain seedling rootstocks. Peach varieties are propagated by grafting on seedling rootstocks obtained from seed or on vegetatively propagated clone rootstocks. The most commonly used grafting method for this purpose is T bud grafting (Eriş and Barut, 2000; Ünal, 2011; Mayer, 2017).

One of the fundamental elements of fruit growing is the selection of rootstock. Rootstock development studies that are suitable for soil and climatic conditions, especially for frequent planting, are carried out with big care. It is necessary to use clonal rootstocks for economically early yielding and high yield per unit area. In the use of clonal rootstock, it is effective to ensure the continuity of the genotype, to create a sample population, to have a shorter juvenile sterility period and therefore to bear fruit earlier. For these reasons, the use of clonal rootstocks in peach cultivation has been increasing in recent years (Arıcı, 2008; Mayer, 2017).

Peaches reveal their best growth performance on peach rootstock. For this aim, seeds of varieties such as Elberta, Halford, Lowell, Flordaguard, Rutgers Red Leaf are used widely. However, peach rootstocks are especially susceptible to root knot nematode in sandy soils. For this reason, Nemaguard is used as rootstock in places where this disease is seen intensely. This rootstock is not resistant to winter cold. In Canada, the cold-resistant Siberian C rootstock has been developed. There are many rootstocks obtained as a result of hybridization of different species in the genus *Prunus*. These hybrids are selected to have superior characteristics by combining different superior characteristics of both parents. In this way, rootstock types with different strengths can be obtained. Peach x Almond hybrid clone rootstocks are used especially in calcareous soils (GF-677, GF557, Adarcias, Castore, Polluce, Sirio). Although GF-677 is the most well-known clone, the number of clone rootstocks developed in recent years with different superior characteristics has been increasing rapidly. For peaches, rootstocks of plum and peach x plum hybrids are used in areas with heavy ground water. In rapidly advancing technology, clonal rootstocks can be propagated by in vivo or in vitro methods. With tissue culture, disease-free, virus-free, quality, healthy and required number of plant materials are obtained in a short time. It is used extensively in the production of peach clonal rootstocks. (Eriş and Barut, 2000; Özçağıran et al., 2003; Ünal, 2011; Bryne et al. 2012).

Generally, peach orchards are established with one-year-old grafted seedlings. Deep soil tillage and preparation is recommended just like it is the case with other fruits. As a planting interval in the orchard site, a distance of 5x5 m, 6x6 m or 7x7 m must be allocated depending on rootstock and soil conditions. But spring planting is recommended in places where excess cold winters exist.

5. VARIETIES OF PEACH – NECTARINE

Variety development studies in peach and nectarine are realized quite fast. About 100 new varieties of this type are introduced to the market in each year in the world. Due to the constant changes in market demands, production systems, terrain and climatic conditions, many new varieties are being developed by different breeding techniques (Eroğlu, 2012).

Some important peach- nectarine varieties raised throughout the world are:

- Varieties with splitted fruit flesh and yellow
- Clingstone or freestone peach varieties;
- Nectarine varieties with yellow-fleshed (nectarines – yellow); New interspecific hybrids are also developed within the genus *Prunus*, obtained by cross-breeding. Those are as follows:

Peacotum: They are interspecies hybrids between peaches, apricots and plums.
Aprium: Interspecies hybrids between apricot and plum.
Cherry-plum: Cherry is a triple hybrid between European and Japanese plums.
Plumcot: They are interspecies hybrids between plum and apricot.
Nectaplum: They are interspecies hybrids between nectarine and plum.
Pluerry: interspecies hybrids between Japanese plums and cherries.
By interbreeding, our people should be offered fruits with new tastes and appearance beyond the standard varieties.

Some important peach and nectarine varieties grown in Turkey are as follows:

- **Early varieties:** Francoise, May Crest, Spring Crest, Super Rich, Rich May, Early Red, Armking (Nectarine), Silver King (Nectarine), Extreme June (Nectarine), Fresh Red
- **Mid-season varieties:** Redhaven, Royal Glory, Royal Gem, Glohaven, Big Top (Nectarine), Caldesi 2000 (Nectarine), Extreme July, Extreme Red (Nectarine), Extrem Big
- **Late Varieties:** Elegant Lady, Monroe, Rio Oso Gem, Suncrest, O'Henry, Fantasia (Nectarine), Stark Redgold (Nectarine), Venus (Nectarine), Morsiani-51 (Nectarine), Sweet Lady (Nectarine), Fairlane (Nectarine), Fresh Lady, Fresh Big, Fresh Late, Extreme 460, Extreme Sunny (Nectarine) (Toprak, 2014).

White nectarine has the characteristics of a population consisting of different types and commercially grown only in Bayramiç and Lapseki districts of Çanakkale province in Turkey. Fruits ripen between the end of July and the beginning of September. Due to the high prices of white nectarines, known in the region as 'Pubescence White Peach', 'Bayramiç Pubescence', 'Bayramiç Nectarine', in recent years, producers in Çanakkale have turned to these nectarines. White nectarine is a nectarine unique to Çanakkale region, attracting attention especially due to the differences in fruit color and aromatic structure, and introduced to the international literature by Çanakkale Onsekiz Mart University Faculty of Agriculture. Although white nectarine trees are very similar to peach and other nectarines in terms of morphological features, they show great differences in fruit characteristics. This difference is thought to occur as a result of cross-hybridization between stone fruit species.

Market value of the varieties introduced to the market in June in the Marmara Region and in April–May in the Mediterranean and Aegean Regions in Turkey is high, and due to this reason, the cultivation of early peach–nectarine varieties gains importance. (Eroğlu, 2012).

6. CROP LOAD MANAGEMENT

Fruit size constitutes a very important commercial feature in peaches. Peach trees bloom and give fruit in large quantities. Product load management on the tree should be planned by thinning during flowering or early fruit development and at different times. In this way, optimum fruit size and quality must be ensured by preventing competition. The dilution process is carried out by three main methods. Manual dilution is the safest method for most peach varieties, but is more costly than others. In manual dilution, it is done in such a way that every 15 -20 cm fruit or 40-60 leaves fall on each fruit. Another method is the use of some growth regulators in general for dilution. However, the type, application time and dose of the growth regulators to be used for this purpose may vary according to the type and variety of the plant. Mechanical shakers are used in mechanical thinning and can be an alternative to manual and chemical thinning in fruit trees. Studies have shown that manual thinning should be followed by mechanical thinning in order to achieve optimum product load and fruit color distribution (Eriş and Barut, 2000; El-Boray et al., 2013; Assirelli et al., 2018).

7. PRUNING AND TRAINING

Training and pruning of peach trees have critical importance for quality fruit production. The outcome of proper cultivation and pruning is ease of harvesting high quality and productive fruits. Early finishing and pruning will help the tree form the desired shape, and future pruning and maintenance will become more comfortable (Hansen, 2018). Most common forms of cultivation applied to peach and nectarine trees in the world are goble, modified leader, open vase, palmette, central leader, meadow orchards, Y-shaped tree, perpendicular-V systems (Corelli-Grappedelli and Marini, 2008).

8. ORCHARD MANAGEMENT

Tillage is done for the purpose of destroying weeds in peach orchards, preventing water loss from the soil, increasing the aeration of the soil and thus to increase the root activity of the tree, to facilitate the work of microorganisms and thus to enable the tree roots to benefit from nutrients better.

Following the first planting year, tillage should be done 1 m from the bottom of the seedlings and from all sides of the sapling. Plowed strip can be widened as the crowns of the trees grow. In gardens where open soil cultivation is made, this process is done in the form of ploughing, deep in the autumn. In spring and summer, a disc harrow or hoe is used.

Amount and time of irrigation in peach orchards changes according to the air temperature, the physical structure of the soil, the precipitation situation of that region and the ground water of the soil in the region.

"Drip irrigation" is the most suitable irrigation method in peach orchards. Besides, sprinkler irrigation and ground irrigation techniques can also be used.

Over irrigation should be prevented during dry and hot seasons. Otherwise, this situation will increase vegetative growth, prevent the shoots from becoming hardened and reduce the winter resistance of those shoots. In addition, the fruits become very large and juicy, their quality, transportation and storage capabilities decrease.

As flower buds form on the trees after harvesting, irrigation should be done if there is not enough rainfall and instead of frequent irrigation with little amount of water, irrigation should be done so as to reach depths of 150-200 cm in soil.

Adequate nutrition is required for rapid development and high yield in peach trees. Hence, the soil must be fertilized well. A good fertilization is achieved in peach orchards by adding commercial fertilizers to the soil in addition to barnyard manure and green manure. Amount of barn manure varying between 1.5 and 2.5 tons per decare applied in every 3 years or green manure applied in every year increases the organic matter content of the soil. Farm manure must be well-rotted, and green manure crops should be obtained from legumes planted in the fall and buried in the spring. Soil and leaf analyzes should be considered in commercial fertilization to be applied for peach orchards.

Diseases observed in peach and nectarine cultivation are root rot (*Armillaria mellea*), root cancer (*Agrobacterium tumefaciens*), iron chlorosis, *Monilia* sp. disease, peach black spot (*Cladosporium carpophilum*), peach powdery mildew (*Sphaerotheca pannosa*), peach leaf curl (*Taphrina deformans*). Pests observed in peach orchards are red mite (*Tetranychus urticae*), peach aphids (*Myzus persicae*), eastern fruit moth (*Cydia molesta*).

There is wide variation in fruit maturity on trees of peaches and nectarines. Due to this reason, it is sometimes necessary to harvest according to the advancing maturity in a selective way. Each variety is usually harvested for ten to fourteen days, and growers may harvest five to eight times during this period. Maturity parameters used to determine the harvest are generally the fruit size and fruit skin color. Besides, firmness of the fruit flesh and the amount of water-soluble dry matter can also be added. In peaches that have attained their skin maturity, green base color of the fruit peel turns into white and the red parts become even brighter. Fruit has size, taste and flavor that is specific to the variety (Crisosto and Valero, 2008; Lurie et al., 2013).

Different post-harvest applications are realized to preserve the quality of the harvested fruits and prolong their preservation and shelf life. Many studies have been conducted in recent years to extend storage life with modified atmosphere packaging (MAP) and 1-methylcyclopropene (1-MCP) applications.

CONCLUSION

While there are many types in the peach variety, there is not much genetic variation in terms of the characteristics of the varieties. But there are differences with regards to the tree volume, growth type, flower size and color, chilling requirement, canopy volume, fruit size, ripening time, flesh texture, fruit flesh shape, acidity, splitting condition. As a result of these characteristics, peach is successfully grown in regions ranging from Southern Canada to the highlands of Thailand. Peach has a very small genome volume. It is used as a model plant in genomic studies. Successes have been achieved in the production of genetic maps. Again, marker-assisted selection studies have found a place in peach breeding. Especially many varieties resistant to diseases have been obtained in this way (Layne and Bassi, 2008).

There is a need for productive and high quality peach-nectarines which mature in very early, early, mid, late and very late periods in Turkey. To meet these requirements, varieties developed abroad are being used. The need for domestic varieties will increase due to the particular that the competitive environment is getting tougher due to breeder's rights, patents and high license fees, which are now established on legal grounds that are increasingly influential in the world, and because of the decrease in profitability. Hence, there is an urgent need for National Variety Development programs with regards to the peaches and nectarines. Turkey has sufficient potential and knowledge to be able to develop these varieties and to present improved varieties having different characteristics to the global markets.

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CHAPTER 7

WEED MANAGEMENT IN YOUNG ALMONDS ORCHARDS

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INTRODUCTION

New almond orchards should be established in areas that do not have weed problems. If weeds are present or contaminated during the initial setup phase, these weeds compete with the almond seedlings for sunlight, water and nutrients, creating water stress especially in young saplings (Connell et al., 2001). This competition can delay the growth and yield of seedlings (Rice and Dyer, 2001). Weeds also attack pathogens (virüs, bacteria, fungi etc.), insects (stink bugs, caterpillars etc.) and rodents (voles, gophers etc.), which can then damage the tree. In addition, it complicates the maintenance processes of the garden such as fertilization and irrigation (Brodt et al., 2005; Simon et al., 2011).

Since weeds in newly established and young almond gardens have a large empty space, they can quickly access water and sunlight, can easily take mineral substances from the soil, and even benefit from fertilization, so it is difficult to cope with weeds (Doll, 2019). In this period, since the roots of the almond seedlings are in the development period, their stems are still green due to mechanical struggle, and these control methods should be carried out sensitively in order not to damage the fruit plants (Foote, 2019).

Almond orchards should not be established in places with weed problems and preventive measures should be taken to prevent contamination. Because the weed problem is one of the most important problems that we may encounter in a new garden setting period (California Almonds, 2021).

Weeds are more or less in everywhere. It is possible to find weeds in the orchard to be established. However, attention should be paid to the weed species and their infestation (Elmore, 1989; Mia et al., 2020). Determining weed species and densities is the first step in developing a weed control strategy (UC IPM, 2021).

Weeds can be one-year, two-year and perennial, and they germinate in different periods as winter and summer and can be a problem. According to the life cycle and phonological periods of weeds, garden visits should be made several times a year in different periods and it should be recorded which type of weeds are seen in which period (Cornell et al., 2001; Wolter, 2020). Accordingly, based on the economic damage threshold and critical periods of weeds, appropriate preventive measures, cultural measures, physico-mechanical methods, biological / biotechnical tactics and, as a last resort, chemical control methods should be selected (Doll, 2010; Herrick, 2012).

Consequently, care should be taken that the herbicides to be used in chemical control are licensed and used according to their label information. Herbicides used in chemical control are grouped as before planting, before emergence and after emergence. Preplant and preemergence, the use of herbicides should be started after the age of about three years of the tree. Postemergences should apply from early emergence when grass weeds are actively growing until the end of tillering period, and broad-leaf weeds should be used in the 2-6-leaf period. Before using herbicide, consult the nearest Provincial Directorate of Agriculture and Forestry.

1. SOIL, WATER AND HERBICIDE INTERACTION

Weeds are an important problem in orchards. For this reason, weeding is inevitable in most gardens. First of all, when deciding on the garden facility, a foreign grassless or less grassy place should be established. If any, weeds should be cleaned before the garden is set up. The growth of trees is better in a new weed-free garden (Schonbeck, 2020).

The weeds found in the garden compete with the young saplings and cause more severe stress, especially in the first 3 years. Weeds also interfere with agricultural activity such as irrigation, fertilization and harvesting. Therefore, weeds should be controlled. Especially around the favorite part of the trees, a weedless area with a radius of 60 cm should be left (Abouziena and Haggag, 2016).

Weeds also cause indirect damage by harboring other pests (Capinera, 2005).

The tools and machines used for the control of weeds in the stone projection of trees should be avoided from damaging the roots and trunks of the trees. In addition, fruit seedlings that are fresh in the first 3 years are sensitive to herbicides. Considering such situations, weed struggle should be carried out meticulously (Sellmer et al., 2017). Weed control methods in orchards can be diversified mechanically and chemically to the developmental stages (Mia et al., 2020).

There are weeds specialized in various soil structures. Puncturevine, crabgrass, horseweed, panicgrass, and some perennial species such as johnsongrass and bermudagrass are seen to be more common in light structured soils. Perennial weeds such as curly dock, field bindweed, and dallisgrass are commonly found in heavily soils (UC IPM, 2021).

It is also effective on the half-life of prepant and preemergence herbicides. When the label information of herbicides is examined, it recommends the use of lower doses of herbicides in sandy and organic soils. Rainfall, irrigation conditions and soil moisture are other important factors affecting herbicide application. Spraying while the soil is annealed increases the effectiveness of the herbicide (UC IPM, 2021).

Emitting, sprinkling and drip irrigation methods affect the number and density of weed species. Note that weed seeds or other propagation material may be further contaminated by flooding or wild irrigation. Rain irrigation is recommended for the use of preemergence herbicides. This method is preferred in terms of the ability of herbicides to form a creamy layer and to have a long-term effect. Since more water is applied around the fountains in sprinkler irrigation, these weeds should be controlled separately as there may be excessive weeding in these areas. If possible, a drip irrigation system should be installed to prevent weed contamination. Since the intensity of the initial irrigation is more determinant in the transport and settlement of herbicides, it should not be excessive and controlled. Whichever irrigation system is used, frequent irrigation should be avoided. Excessive irrigation increases herbicide degradation (UC IPM, 2021). On the other hand, an effective weed control in dry years enables fruit trees to benefit from water more easily and to cope with water stress more easily (UC IPM, 2021).

It affects some weeds, non-germinated weeds, some germinated weeds, and some even both. If we want to interfere with the weed reserve in the seed bank, we should opt for prepant or preemergence herbicides, if we want to control germinating and actively growing weeds, we should apply postemergence herbicides. The ACCase inhibitor (-fop, -dim, -den) can be used to control grass weeds germinated in almond orchards. However, more care should be taken if a herbicide will be used for post-emergence control of broadleaf weeds. It can be applied more easily during November-February when the almond trees are dormant. However, care should be taken that the herbicide to be applied between March and October, when the trees are active, does not come into contact with green and fresh non-lignified parts such as leaves. Spraying can be done by wrapping the eyes of young trees with preservatives (UC IPM, 2021).

2. MONITORING

Regular observations should be made to determine the weeding situation in orchards. Economic loss thresholds are determined especially in critical periods. Records of garden visits should be kept and records should be reviewed before each visit. As general weed control can be done, sometimes local weed problems should be given special attention (EPA, 2021). Important weeds seen in the almond orchards are given in the table below.

Table 1: Common weeds in almond orchards (UC IPM, 2021)

Scientific Names	**Common Names**
Allium canadense	Onion, wild
Amaranthus spp.	Pigweeds
Amsinckia spp.	Fiddlenecks
Asparagus officinalis	Asparagus
Avena fatua	Oat, wild
Brassica spp.	Mustards
Bromus spp.	Bromegrasses
Calandrinia ciliata	Redmaids (desert rockpurslane)
Capsella bursa-pastoris	Shepherd's-purse
Cenchrus spp.	Sandburs
Chamomilla suaveolens	Pineappleweed
Chenopodium album	Lambsquarters, common
Chenopodium murale	Goosefoot, nettleleaf
Claytonia perfoliata	Lettuce, miner's
Convolvulus arvensis	Bindweed, field
Conyza bonariensis	Fleabane, hairy
Conyza canadensis	Horseweed
Cynodon dactylon	Bermudagrass
Cyperus esculentus	Nutsedge, yellow
Digitaria spp.	Crabgrasses
Echinochloa colona	Junglerice
Echinochloa crus-galli	Barnyardgrass
Epilobium brachycarpum	Willowherb, panicle-leaf
Eragrostis spp.	Lovegrasses
Erodium spp.	Filarees
Euphorbia (=Chamaesyce) spp.	Spurges
Hordeum leporinum	Barley, hare
Hypochaeris radicata	Catsear, common
Lactuca serriola	Lettuce, prickly
Lamium amplexicaule	Henbit
Leptochloa spp.	Sprangletops

Lolium spp.	Ryegrasses
Malva parviflora	Mallow, little (cheeseweed)
Medicago polymorpha	Burclover, California
Ornithogalum umbellatum	Star of Bethlehem
Panicum capillare	Witchgrass
Paspalum dilatatum	Dallisgrass
Phalaris canariensis	Canarygrass
Physalis spp.	Groundcherries
Poa annua	Bluegrass, annual
Polygonum arenastrum	Knotweed, common
Polygonum aviculare	Knotweed, prostate
Polypogon monspeliensis	Polypogon, rabbitfoot
Portulaca oleracea	Purslane, common
Raphanus raphanistrum	Radish, wild
Rubus spp.	Blackberries
Rumex acetosella	Sorrel, red
Rumex crispus	Dock, curly
Salsola tragus	Thistle, Russian
Senecio vulgaris	Groundsel, common
Setaria spp.	Foxtails
Sisymbrium irio	Rocket, London
Solanum spp.	Nightshades
Sonchus spp.	Sowthistles
Sorghum halepense	Johnsongrass
Stellaria media	Chickweed, common
Taraxacum officinale	Dandelion
Toxicodendron diversilobum	Poison-oak, Pacific
Tribulus terrestris	Puncturevine
Trifolium spp.	Clovers
Urtica urens	Nettle, burning
Urtica spp.	Nettles
Veronica spp.	Speedwells
Xanthium spp.	Cockleburs

When examined according to the classes of weeds found in almonds, there are both grass and broadleaf, generative and vegetative reproduction, also annual, biennial and perennial weeds.

Surveys should be organized in the winter and spring months for winter weeds and in summer and autumn for summer weeds. Weed observations, the areas where rhizome weeds are found to be intense should not only be approached with mechanical tactics, but also chemical methods should be applied. In total herbicide applications, contact of the herbicide with trees should be avoided. It should be kept in mind that selective herbicides affect certain weeds. Therefore, different herbicides related to uncontrollable weeds should be directed (Abouziena and Haggag 2016). Provincial / District Directorates of Agriculture and Forestry should be contacted for the diagnosis of problematic weeds and their control.

3. WEED MANAGEMENT BEFORE PLANTING

The almond orchards should be leveled and drained well. It should be remembered that weed propagation material and herbicides can drift or accumulate in pit areas (Wolter, 2020). Almond orchards should not be established on fields that are known to be infested with perennial weeds such as field bindweed, bermudagrass and nutsedge, and the contamination of these grasses to the garden should be prevented (UC IPM, 2021). If there are perennial weeds in the areas where orchards will be planted, the garden should be established after these weeds are taken under control.

Chemical control should be used as a last resort. The herbicide to be used must be registered in PPP (PPP, 2021). Table 1 shows a list of herbicides that, at last check, can be used on tree crop orchards.

Table 2: Herbicides for orchards (Jarvis-Shean and Hanson, 2018)

	Herbicide	Trade Name	MOA*	Notes
Pre-emergence	EPTC	Eptam	N/8	For well-established
	Flumioxazin	Chateau	E/14	1 year needs carton
	Indaziflam	Alion	L/29	1 year
	Isoxaben	Trellis	L/21	
	Norflurazon	Solicam	F1/12	18 months
	Oxyfluorfen	Goal	E/14	
	Pendimethalin	Prowl	Kl/3	
	Oryzalin	Surflan	Kl/3	
	Penoxsulam	PindaarGT	B/2	9 or 15 months
	Rimsulfuron	Matrix	B/2	Established 1 season
Post-emergence	Carfentrazone	Shark	E/14	Not OK on green bark
	Clethodim	Select	A/1	Non-bearing only
	2, 4-D	Dri-Clean	O/4	1 year
	Diquat	Diquat	D/22	Non-bearing only
	Fluazifop-p-butyl	Fusilade	A/1	Non-bearing label
	Glyphosate	RoundUp	G/9	
	Glufosinate	Rely 280	H/10	Not OK on green bark
	Paraquat	E/14	D/22	Not OK on green bark
	Pyraflufen	Venue	E/14	Not OK on green bark
	Saflufenacil	Treevix	E/14	Not OK on green bark
	Sethoxydim	Poast	A/1	

*MOA= Mode of Action (or Site of Action)

Chemical control is the last method to be used. Beforehand, the incident should be approached as follows. Care should be taken to control annual weeds reproducing by seed before seeding. Efforts should be made to prevent weed contamination by means such as almond gardens, wind, water and agricultural equipment. Weeds should be tried to be controlled by hoeing first. Among the mulching, cover crops, and thermal methods, those available should be tried.

Care should be taken that the total herbicide does not touch the green part of the trees. After applying the herbicide preemergence, care should be taken not to enter the garden as much as possible. Selective herbicides should be used according to the label information. Although it is not a licensed herbicide against broad-leaved weeds, it is seen that herbicides such as fluazifop are licensed against grass weeds for some orchards (PPP, 2021). Grass herbicides can be used safely in all periods, but they are recommended to be used when the weeds are growing actively.

4. WEED MANAGEMENT IN ROW AND MIDDLES

When almond orchards are newly established, weed appears as a problem. During this period, as the saplings are very young, weed competition is the weakest. If weeds are not controlled, they can cause economic losses (UC IPM, 2021). Tillage and the use of herbicides are the most common methods to control weeds. Necessary precautions should be taken to prevent almond seedlings from being damaged by the soil cultivation tools used in this sensitive period and to be negatively affected by herbicides. With this match, the cultivation should be done at the appropriate depth and distance in order not to injure the root areas while the soil is being cultivated. Tree trunks can be wrapped with protective tubes (cartons, sleeves, or wraps) to prevent herbicide phytotoxicity (Barberi, 2003; Crassweller, 2018; Parsons, 2021).

More care should be taken in weed control that grows in the root areas of trees. Mulching can be done or delicate handpieces recommended. If herbicide is to be used, care should be taken that the trees are over 3 years old (Zeleznik and Zollinger, 2004). Considering that field mice can shelter in mulches and the risk of phytotoxicity in herbicide application, it is prominent to pick or mow the weeds manually in the root areas of young trees for the first 3 years (OMAFRA, 2021).

Weed management in orchards is often separated tree row and tree middles (Parsons, 2021; UC IPM, 2021). Treating between rows with tillage tools is important for the control of germinated weeds. However, disc-harrow may spread rhizomes, stolons or tubers in orchards (Sharma et al., 2013).

One of the most effective ways to weed management in almond orchards is the use of cover crops (rye with a high allelopathic effect, like clover that binds nitrogen to the soil).

5. WEED MANAGEMENT FOR A HEALTHY ORCHARD

It is desirable that almond groves be set up in an area without weeds, but this is impossible. For this reason, weed control is inevitable before the garden is established or in the first years. In the place where the garden will be established, germinated weeds or herbicides should be cleaned. If necessary, the weeds that will germinate in the future are suppressed by applying the preemergence herbicide. As it can be understood, weed control starts before tree planting and will continue as long as that garden exists (California Almonds, 2021; Parsons, 2021).

Weed control in gardens is a routine job that should be done every year (OMAFRA, 2021). For effective foreign management in almond orchards, Provincial / District Directorates of Agriculture and Forestry, Institutes, Universities and Producer Unions, Chambers and Cooperatives should be in cooperation.

After learning what you are dealing with in almond orchards, it should be decided which herbicides or other control methods to choose according to the weed species that are problematic in the garden and their infestation (UC IPM, 2021).

In recent years, the Ministry of Agriculture and Forestry has established a Nut Fruits Research Institute in Adıyaman and this institute has focused on almond production especially in the Southeastern Anatolia Region. The development of a weed center within the phytosanitary unit in the institute in question is important in terms of recognizing and effectively tackling weeds in almond orchards.

CONCLUSION

As in other newly established gardens, weeds in almonds compete with saplings, delaying growth and yield. Since young trees are in a sensitive period, it is important to remove weeds in newly established gardens. Weeds in newly established gardens are a problem and there are difficulties in their struggle. As it is known, the most preferred method in weed control is herbicide chemical control because of its practicality. However, since young seedlings are sensitive to herbicides, such applications should be considered. Therefore, seedlings that are tolerant to herbicides can be developed.

The identification of weeds and the detection of their infestation plays a key role in determining the method to be applied in weed control. Weed control options in a newly established almond garden may be as follows. Weeds are a big problem in newly established almond orchards. Although this problem varies from region to region, then more caution should be exercised if the problem of perennial weeds such as leeches and field wine. It is inevitable that herbicides come into play to control such weeds. However, there are risks of using herbicides in almond orchards that are only a few years old. Licensed current herbicides should be checked from PPP. Herbicide applications should be made according to the label information. While the problem of soil moisture and root contact is prominent in herbicide applications before emergence, post emergence herbicides (using for broadleaf weeds) may be phytotoxic if they come into contact with green leaves and young stalk.

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CHAPTER 8

CHARACTERIZATION of ALMONDS (*Prunus amygdalus* L.) IN NORTHERN IRAQ'S SULAIMANIA CHAMCHEMAL PROVINCE

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INTRODUCTION

The almond (*Prunus dulcis* Miller syn *Prunus amygdalus* Batsch) is one of the oldest tree nut crops, and in present times represents the major production among all commercial tree nuts. Almond trees grow in areas of the world that have a Mediterranean climate, with warm, dry summers and mild wet winters (Kester and Gradziel, 1996). These species originated in Asia and represent divergent evolution with xerophytic environments (Watkins, 1976). *Prunus* species were found grown wild from Eastern China to mountainous areas and deserts in Western China, Turkistan, Afghanistan and Iran (Grasselly, 1976; Browicz and Zohary, 1996; Kester and Gradziel, 1996).

Almond is both a fruit and a very valuable plant in terms of its use in making firewood and chipboard. In addition, some biochemical (amygdalin and prunasin) substances, which contain fruit and leaf, are used for pharmacy and tıp. Besides, the almond oil obtained from bitter almonds is used as raw material in the chemical and paint industry. Especially in recent years, it has been reported that because of unsaturated fatty acids (linoleic and oleic) content, increases the level of good cholesterol in the blood, decreases the level of bad cholesterol and thus reduces the risk of cardiovascular diseases and heart attack (Kafkas et al., 1995).

The almond production in the world has been estimated to be about 3.497.148 tons in 2019. The main producing country is the United States of America which accounts for 55% of the world production by 1.936.840 tons. The other producing countries are Spain by 340.420

tons 9.7 %, Australia 146.410 tons 4.1 %, Iran 177.015 tons 5.1 %, morocco 102.185 tons % 2.9, Italy 77.300 tons 2.2 %, Turkey 150.000 tones 4.2 %, Tunisia 80.000 tons 2.2 %, Algeria 72.412 tones 2.1 %, china 45.000 tons 1.2 %, followed by Syria, Libya, Lebanon, and Iraq is ranked 36th in world by 456 tons with ratio 0.02 % and others countries with a lower production (Anonim, 2021).

Table 1: Countries which poduce almond (2019) (www.fao.com)

No.	Country	Production in tons
1	United States of America	1.936.840
2	Spain	340.420
3	Iran	177.015
4	Turkey	150.000
5	Australia	146.410
6	Morocco	102.185
7	Tunisia	80.000
8	Italy	77.300
9	Algeria	72.412
10	China	45.000
36	*Iraq*	*454*
	Total world	**3.497.148**

The Parts of Almond

Almond fruit consists of correctly four parts: outer green shell cover or almond hull, middle shell, a thin leathery layer known as brown skin of the meat, and kernel or meat. The most important of the almond fruit is related to its kernel used as a healthy human nutritional source. Other parts of almond fruit like hulls and shells were used as livestock feed; different phenolic components were characterized in almond kernel extract and its skin, shell and hull as almond by-products.

Figure 1. Parts of the almond fruit

On the other hand, polyphenols are rich in the human diet and have a great role in the prevention of degenerative diseases like cardiovascular diseases and cancer. The health effects of polyphenols depend on their bioavailability and the amount used. (Esfahlani et al., 2010).

Almond Nutrition Components

Almond is a very useful food, and researches during the last 2 decades on the health benefits of almonds have linked consumption of almonds with reduced risk of chronic diseases like coronary heart disease and type 2 diabetes, as well as to weight control. Almonds have been part of mankind's food system since the pre-agricultural centuries and their consumption continued to grow in modern times, either as snacks or as part of a meal. Almonds ate a whole (fresh or roasted) or its components like almond oil, almonds can be used in a wide range of food industry productions. Almonds have complex food forms consist of diverse nutrients and other phytoprotective materials that have act on the physiology of the human body. Almonds are energy-dense, fats have in almond in high levels, but much of fats are unsaturated (Richardson et al., 2009).

Health Benefits of Almond

Almonds are wealthy in fiber, monounsaturated fat, α-tocopherol, minerals such as copper and magnesium, and phytonutrients, yet being energy-dense. The favorable fat composition and fiber contribute to the hypocholesterolemic benefit of almond utilization. By ideals of their interesting supplement composition, almonds are likely to advantage of other modifiable cardiovascular and diabetes dangers, such as body weight, glucose regulation, aggravation, and oxidative push. Almond has hypocholesterolemic benefits for controlling body weight, glucose control, oxidative stretch, and irritation, almond utilization usefully impacts incessant degenerative infection cholesterol reduction, especially in populaces with metabolic disorder and sort 2 diabetes mellitus.

Origin of Almond

The almond (*Prunus dulcis* (Miller) has been grown in cultivation for consumption of its eaten kernels since ancient times. From its source of origin in Central Asia Mountains, it was spread to all ancient civilizations in Asia (2000 BC) and North Africa (600 - 700 AD) Europe (350 BC), (Kester et al., 1991). Almond production and cultivation are concentrated in the city of Tabriz in Northwest Iran and grow in other countries in Central Asia. Commercial cultivation and production occur in Syria, Turkey, Afghanistan, Israel, Iraq, Pakistan, and Northwest of India and Union of Soviet Socialist Republics. Almond growing has not changed for centuries; many almond orchards consist of seedling plants, oftentimes grown in mixed fields with other crops in bad situations resulting in low production (Kester et al., 1991).

The attentive selection studies of wild plant forms have been done for many years and these studies have been used since the beginning of breeding experiences (Özbek, 1978). Until today, one of the most grown standard varieties in the world most of the accordance have been selected as grains. In America, Nonpareil, Texas, Ne Plus Ultra, IXL; Lauranne in France; Tuono, Genco Cristomorto in Italy; In Portugal, Verdeal, Gama, Boa Casta; Glorieta Masbovera in Spain is an example of these (Dokuzoğuz et al., 1968). There are a few studies about almond in Iraq because of the war situation but From 1968 to the present day in Turkey almond selection studies were carried out by different researchers (Dokuzoğuz et al., 1968; Dokuzoğuz and Gülcan, 1973; Kalyoncu, 1990; Cangı and Şen, 1991; Aslantaş, 1993; Bostan et al., 1995; Şimşek, 1996; Gerçekçioğlu and Güneş, 1999; Black Sea et al., 1996; Ax, 2002; Yıldırım, 2007). However, over the past 40-50 years, there were more studies about (almonds) in many countries like (Italy, Spain, France, the USA, Turkey, Iran, Australia and Israel) have begun to produce high-quality almonds, and studies are still concentrated.

1. MATERIALS AND METHODS

1.1. Materials

Geographical location of the study area: This work was carried out in 2017-2018 in the Gawrade region of Chamchamal Sulaymaniyah Province of Northern Iraq there are thousands of almond trees on the ground, For this study, a government orchard was selected, which consisted of thowthands almond trees was planted by Iraq government in 1972.

Geographical Features of the Research Area

Gawrade Latitude : 35.74872123,

Gawrade Longitude : 45.0312673

Latitude DMS : 35°31'45.16"N,

Longitude DMS : 44°49'18.22"E

Elevation of Gawrade : 1400 m

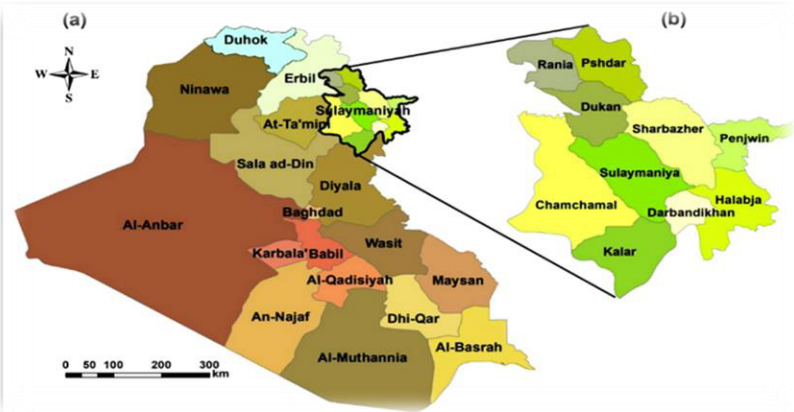

Figure 1: Study area. (The U.S. Agency for International Development (USAID)

Chamchamal Sulaymaniyah climate properties

The climate of this locale has been recognized concurring to Koppen classification as bone-dry and semi-arid climate (steppe -BSh and Mediterranean – Csa). It is cold and damp in winter and hot and dry in summer, with short autumn and spring seasons compared to winter and summer. In winter, this locale falls beneath the impact of Mediterranean cyclones that moves east to the northeast over the locale. The Arabian Sea winds move northward passing over the Arabian Gulf carrying extraordinary sums of dampness causing huge sums of precipitation over the locale. In summer, the locale falls beneath the impact of subtropical tall weight belts and Mediterranean anticyclones. The sub-tropical tall weight centers that move from west to northeast and north it passing over the Middle Eastern Landmass carrying sand to the region. The highest everyday temperature may reach as tall as 50°C in hot summer periods, while the low everyday temperature can drop to -10°C in cold winters. (Anonymous, 2016)

1.2. Methods

Selection of samples for study: In this study, the research area was covered in detail with the help of local governments, village headmen and regional farmers. Selection of trees has taken into account the criterion of high fruitiness and high kernel rate, low double rate, which is late-blooming, good fruit characteristics, a good period of reaping, good gripping properties, resistance to diseases and harmful, abundant and regular products as well as good fruit characteristics. During the harvest period, in the direction of the opinions of the growers, 100 almond trees will be identified and fruit specimens will be taken to represent the tree. Trees will be numbered with oil paint. Fresh fruit samples are brought immediately and after weighting with green shells, separated from the green shells, they will be left to dry for 4 months in a shady environment at room temperature. Selected almond genotypes were determined according to the weighted ranked method.

Almond varieties and genotypes location tree characteristics and location:

1. Owner of the tree,
2. Location of the trees,
3. Wind conditions,
4. The state of irrigation,

5. The case of drugs, information from the owner of the tree,

6. Pruning condition, 7. Soil condition,

8. Fertility status, 9. Coordinates and Altitude.

Tree characteristics: These include all properties of trees like tree height (cm), Crown Width (cm), tree stems circumstance (cm), and tree stems number, several branches and almond tree shapes, shown in Table 4.

Total tree height: All trees selected for this study are measured by (m) from the ground to the top of the tree crown by the tape meter like Figure 3.

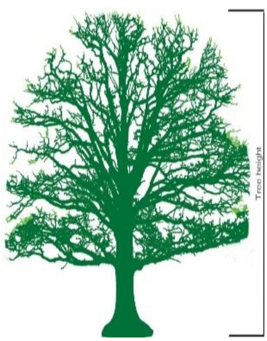

Figure 3: Total tree height.

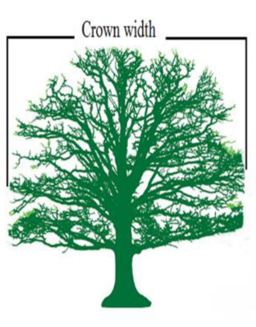

Figure 4: Tree crown width

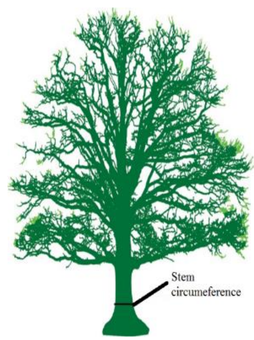

Figure 5: Tree stems circumference.

Crown width: All trees were selected for this study their crown width measured by the tape meter like Figure 4 (Şimşek, 1996).

Tree stems circumference: All trees measured over 60 cm above the ground by the tape meter as showed in Figure 6 (Şimşek, 1996).

Tree stems a number: In this study, the stem numbers of all trees were determined by counting the main tree branches.

Figure 6: Tree stems number.

Figure 7: Number of branches.

Number of branches: In this study, the branch numbers of all trees were determined by counting all branches of all trees as shown in Figure 7.

Pomological analyzes

Green fruit weight: Almond green fruit weight was determined by weighting 100 fruit of trees that selected to study with a digital sensitive scale to 0.01 g all weights showed in Table 3.

Shelled fruit weight: Shelled Almond fruit weight was determined by weighting 100 fruit trees that were selected to study with a digital sensitive scale to 0.01 g all weights explained in the Table 1&4 (Şimşek et al., 2011).

Kernel almond weight: The weight of almond kernels will be determined by weighing 100 almond trees that were selected to study, on a sensitive scale sensitive to 0.01 g explained in Table 3. (Şimşek et al., 2010).

Almond kernel ratio: The kernel rate determined for 100 almond trees that selected for study, the samples calculated according to the following formula:

Kernels ratio = (Average kernel weight / Average fruit weight) x 100 (Şimşek et al., 2010).

Shell thickness: The shell thickness will be determined in mm with the help of a digital caliper for 100 samples of almond fruits selected for study (Şimşek et al., 2010).

Shell hardness: Shell hardness was determined for all 100 almond tree fruits that were selected for study which divided for 4 groups.

1. Hand almonds
2. Dental almonds
3. Hard almonds
4. Stone almonds. (Şimşek et al., 2010)

Fruit almond with shell and kernel almond sizes : Fruit sizes were accounted for 100 trees that selected for study with calipers include shelled fruit length, depth and thickness (mm), kernel almond length, depth and thickness (mm) as shown in Figure 8 all measurements showed in the Table 3. (Şimşek et al., 2010)

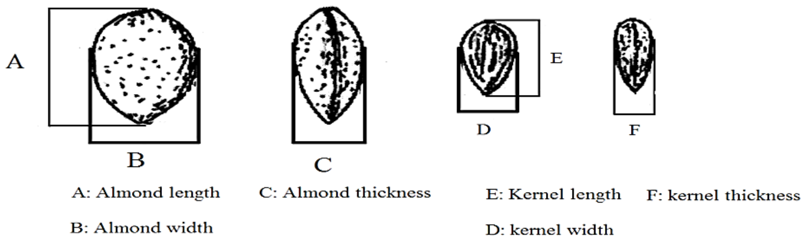

Figure 8: Fruit sizes in almond genotypes.

Table 2: Average value fruit characteristics and importance

Fruit characteristics	The variation ranges to this study	Value given	Importance level
Fruit weight (g)	5.55-8.79 4.52-5.48 3.18-4.49 2.14-2.79	10 8 5 2	25
Fruit length (mm)	43.40-37.00 36.80-34.00 33.80-32.00 31.90-21.10	8 6 4 3	5
Kernel length (mm)	31.40-27.10 27.00-25.00 24.90-23.00 22.90-11.60	8 6 4 3	5
Fruit thickness(mm)	18.55-14.00 13.66-12.50 12.46-12.00 11.93-10.20	8 6 4 3	5
Shell thickness(mm)	2.10-2.69 2.70-2.98 3.00-3.37 3.40-4.45	8 6 4 3	5
Shell suture opening	close open very open	8 5 2	5
Kernel weight	2.02-1.20 1.19-1.00 0.99-0.80 0.79-0.54	10 8 5 2	20
Kernel ratio (%)	31.89-25.44 24.53-21.05 20.85-17.09 16.94-10.09	10 8 5 2	20
Kernel color	light medium dark	8 6 3	10

Shell suture opening: Shell suture clearance was determined for all 100 almond fruits that were selected for this study which are considered as closed, open and very open.

Double kernels ratio: The double kernel rate counted for all 100 sample almond fruits selected for this study.

The taste of the almond kernels: The taste of the almond kernels for all samples selected for study grouped as bitter and sweet.

2. RESULTS

In the Gawrade region of Chamchamal District of Sulaimaniyah Province of Northern Iraq, there is intensive almond tree cultivation, Gawrede village has a suitable climate and suitable topography so this area was chosen by the Iraqi government to plant almond trees which began in 1972.

This study was carried out from 2017 to 2018 and the research area was fully visited and examined according to the "point selection method".

Firstly 100 almond trees were selected and marked by oil paint after that Phenology and morphological observations were recorded during the spring and summer of the first year (2017) of the study. All characteristics of trees that were selected were recorded like tree height, stem circumference, crown width, flower color, tree shape, first flowering date, full flowering date, shell hardness, almond taste, number of stems and number of main branches as shown in table (4.2). Then the total of 100 almond fruit samples was taken from marked trees, the fruit samples were collected in the numbered paper bags respectively during the harvest time of the first year (2017) of the study. A total of 10 genotypes were selected according to many criteria like fruit weight, length, depth, shell thickness. and kernel weight, length, depth, thickness, kernel ratio of the fruit, kernel color and shell opening suture as shown in Table 4, because all of these characteristics have their importance to determine the best types of genotypes, finally 10 types were selected which considered as promising according to the grading method. Thus, the mixing of fruits taken in the same area has been avoided. Genotypes are coded according to the selected number to facilitate their registration. In addition, the location coordinates and morphological characteristics of the trees are recorded. The fruit samples were immediately removed from the green shells and placed in the perforated paper bags and all samples were transferred to the laboratory for research works.

2.1. Pomological Analyzes

Pomological analysis carried out for all 100 trees were selected for the study

Green fruit weight: Almond green fruit weight was determined by weighing 100 fruit trees that were selected to study with a digital sensitive scale to 0.01 g all weights showed in 4.1 tables as a result there was a range from maximum 15.96 g to minimum range 5.15 g with average 9.18 g.

Shelled almond weight: Shelled Almond weight was determined by weighing 100 fruits of trees that selected to study with a digital sensitive scale to 0.01 g all weights as explained in table 3 as a result there were a weight from 8.79 g as a maximum to 2.14 g as a minimum weight with average weight 4.51 g.

Kernel almond weight: The weight of almond kernels determined by weighing 100 fruit kernels of almond trees that selected to study, on a digital sensitive scale sensitive to 0.01 g the result showed that there were weights from 2.02 g as a maximum weight to 0.52 g as a minimum weight and 0.93 g as average weight.

Fruit kernel ratio: The kernel ratio was determined for 100 fruit samples of almond trees selected for this study. The results showed that there were kernel ratios from 31.89 g as a maximum ratio and 10.09 as a minimum ratio with 21.10 as an average ratio.

Shell thickness: The shell thickness determined for all 100 sample fruits of trees that selected to study in mm after fracturing hard fruit shells with the help of a digital caliper as showed in Table 4, the result showed that there were a 4.45 mm as a maximum shell thickness and 2.1 mm as a minimum shell thickness with 3.11 mm an average.

Shell hardness: Shell hardness is divided into 4 groups in the world (Hand almonds, Dental almonds, hard almonds and stone almonds), after investigation for all 100 samples the result showed that all fruits were stone almonds types as showed in Table 3.

Shell almond and kernel almond sizes: Fruit sizes were accounted for 100 trees that selected for study with digital caliper include shelled fruit length, fruit depth and fruit thickness (mm), kernel length, depth and thickness (mm) as shown in Figure 8 all measurements showed in table (3), the result showed that there was a measurement for fruit length 43.4 mm as a maximum length, 21.1 mm as a minimum length with 34.54 mm as an average length. The results showed that there were 37.1 mm maximum fruit width and 11.8 mm as a minimum fruit width with 21.43 mm as an average fruit width, 18.55 mm as a maximum fruit thickness 10.2 mm as a minimum fruit thickness.

The maximum kernels length 31.4 mm and 11.6 mm as a minimum kernels length with 11.6 mm as an average kernel length, 22.3 mm as a maximum kernel width 9 mm as a minimum kernel width with 13.34 mm as an average kernel width, 8.5 mm as a maximum kernel thickness 3.66 mm as a minimum kernel thickness with 5.69 mm as an average kernel thickness.

Shell suture opening: Shell suture opening determined for all 100 almond fruits that selected for study which considered as closed, open and very open, results determined that all of the samples were close as shown in Table 4.

Double kernels rate: The double kernel rate counted for all 100 almond fruits that selected for study and chose by chance from 100 fruit selected and broken 12 % of them are double kernel.

The taste of the almond kernels: The taste of the almond kernels for all samples that were selected for study, grouped as bitter and sweet 5 % of them were bitter.

2.2. Tree characteristics

Tree characteristics include all properties of trees like tree height (cm), Crown Width (m), tree stems circumference (cm) and tree stem number, number of branches and almond tree shapes, showed in Table 4.

Total tree height: All trees selected to study were measured from the ground to the top of the tree crown by the tape meter the result determined that there was 780.00 cm as a maximum tree height and 380.00 cm as a minimum tree height with 521.90 cm as an average tree height.

Crown width: All trees were selected to study their crown width measured by the tape meter like the result determined that there were 31.00 m as a maximum tree crown width and 7.50 m as a minimum tree crown tree with 18.27 m as an average tree crown width.

Trees stem circumference: All trees measured over 60.00 cm above the ground by the tape meter results determined that there were 198.00 cm as a maximum stem diameter and 39.00 cm as a minimum stems diameter with 109.27 cm as an average stem diameter.

Tree stems number: The stem number is determined by counting main tree branches results determined that, there were four stems as a maximum and one stems as a minimum.

Number of branches: Number of branches selected by counting all branches of all trees that selected for study results determined that there were 8 branches as a maximum number and 1branches as a minimum number with 3.50 as an average branch number.

Almond tree shapes: Tree shapes were determined according to the angle of tree crown width and divided in to 4 groups which were (very steep, steep, wide and very wide), the result explained (Table 4).

Date of flowering: Date of flowering is the most important thing for almond tree because date of flowering determines the harvest rate the result showed that there were different dates for flowering for trees according to the place and types of trees, 25 FE to 10 MA, 22 FE to 8 MA, 27 FE to12 MA and 23 FE to 7 MA.

2.3. Characteristics of Selected Almond Genotypes (Pomological Analyzes)

All characteristics of 10 genotypes that selected were explained in Table 3; consist of green fruit weight, shelled fruit weight, fruit length, fruit width, fruit thickness, shell thickness, fruit taste, kernel weight, kernel length, kernel ratio, kernel color, shell opening suture and shell hardness. in other hands all characteristics for trees are also explained in Table 4 such as tree length, tree crown width, stems circumference, tree shape, number of stems, number of branches date of flowering and flower color.

Green fruit weight: Results explained in Table 4 as a result there were ranges from maximum 13.9 g to minimum range 7.53 g with average 10.84 g.

Shelled fruit weight: Results explained in Table 4 there was weight from 6.74 g as a maximum to 3.46 g as a minimum weight with an average weight 5.41 g.

Kernel weight: Results explained in Table 3 there were weights from 2.02 g as a maximum weight to 1 g as a minimum weight and 1.40 g as average weight.

Fruit kernel ratio: The result explained in Table 3, there were ratios from 30.51 % as a maximum ratio and 21.25 % as a minimum ratio with 25.71 % as an average ratio.

Shell thickness: Results explained in Table 3, there were a 3.43 mm as a maximum shell thickness and 2.45 mm as a minimum shell thickness with 2.96 mm as an average.

Shell hardness: Result explained that all fruits were stone almond types as showed in the Table 3.

Shell almond and kernel fruit sizes: Results explained in Table 3, there was the measurement for fruit length 43.40 mm as a maximum length, 33.00 mm as a minimum length with 37.66 mm as an average length, 25.60 mm maximum fruit width and 12.4 mm as a minimum fruit width with 21.95 mm as an average fruit width, 16.40 mm as a maximum fruit thickness 11.07 mm as a minimum fruit thickness 13.28 mm as an average.

The maximum kernels length consist of 31.00 mm and 22.90 mm as a minimum kernels length with 26.98 mm as an average kernel length, 22.30 mm as a maximum kernel width 12.00 mm as a minimum kernel width with 15.43 mm as an average kernel width, 8.5 mm as a maximum kernel thickness 3.66 mm as a minimum kernel thickness with 5.97 mm as an average kernel thickness.

Shell suture opening: Result explained in Table 3 as a result determined there were only one type all of samples were close.

Double kernels rate: Results explained one of these 10 hopeful almond genotypes was the double kernel.

The taste of the almond kernels: Results explained all hopeful almond genotypes were sweet.

Tree characteristics: Results explained tree characteristics maximum total tree height 700 cm, minimum tree height 380cm, maximum crown width 31 m, minimum crown width 14 m, maximum tree stems circumference 174 cm minimum stems circumference 64 cm, trees have 1 stem, maximum number of branches 5, minimum number of branches 2, almond tree shapes 4 of them were very wide, 3 of them were wide, 3 of them were steep and date of flowering were from 22 February to 12 March explained in the Table 4.

Table 3: Selected fruit characteristics of selected almond genotypes

Sample number	Almond weight with green shell (g)	Almond weight with shell (g)	Kernel weight (g)	Kernel rate (%)	Shell thickness (mm)	Fruit length (mm)	Fruit width (mm)	Fruit thickness (mm)	Kernel Length (mm)	Kernel width (mm)	Kernel thickness (mm)
SU-24	10.81	5.16	1.19	21.25	3.43	43.40	22.20	11.07	31.00	13.00	4.90
SU-40	12.40	6.74	1.59	23.59	2.68	36.70	25.60	12.34	26.50	16.50	3.66
SU-67	9.83	6.53	1.88	28.79	2.45	41.30	25.40	12.92	28.40	17.30	6.00
SU-65	10.73	5.84	1.63	27.91	3.00	36.70	20.40	16.40	27.10	12.00	8.50
SU-69	12.85	5.63	1.59	28.24	2.90	39.20	22.40	13.10	28.60	13.20	6.05
SU-76	10.33	4.82	1.05	21.78	2.86	40.50	19.60	13.22	22.90	22.30	6.10
SU-82	10.89	4.84	1.11	23.02	2.97	36.10	23.30	13.20	25.80	13.40	6.45
SU-26	9.19	4.49	1.00	22.04	2.95	36.10	23.40	13.58	25.80	15.70	5.47
SU-79	13.90	6.62	2.02	30.51	3.30	33.60	24.80	15.20	28.00	16.90	7.00
SU-70	7.53	4.00	1.22	30.05	3.13	33.00	12.40	11.86	25.70	14.00	5.59
Max	13.90	6.74	2.02	30.51	3.43	43.40	25.60	16.40	31.00	22.30	8.50
Min	7.53	4.00	1.00	21.25	2.45	33.00	12.40	11.07	22.90	12.00	3.66
Average	10.85	5.47	1.43	25.72	2.97	37.66	21.95	13.29	26.98	15.72	5.99

Table 4: Selected tree characteristics of selected almond genotypes

Sample number	Tree height (cm)	Stems diameter (cm)	Crown width (m)	Flower color	Tree shape	First flowering	Full flowering	Stem number	Branch number
SU-24	400	129	20	white	wide	22 FE	8 MA	1	4
SU-40	550	87	15	white	steep	23 FE	9 MA	1	3
SU-67	500	64	16	pink	steep	25 FE	10 MA	1	2
SU-65	380	87	14	white	wide	25 FE	10 MA	1	4
SU-69	700	186	31	white	very wide	25 FE	10 MA	1	4
SU-76	450	83	17	white	wide	25 FE	10 MA	1	4
SU-82	550	159	23	white	wide	23 FE	7 MA	1	4
SU-26	400	98	15	white	steep	22 FE	8 MA	1	3
SU-79	550	163	26	pink	very wide	25 FE	10 MA	1	4
SU-70	550	174	20	pink	very wide	25 FE	10 MA	1	5
Average	503.00	123.00	19.70						
Maximum	700.00	186.00	31.00						
Minimum	380.00	64.00	14.00						

Total points of selected almond genotypes to weighted ranked method: There were many criteria were taken into account in the calculation of weighted ranked method of genotypes such as fruit weight (g), fruit length (g), kernel length (g), fruit thickness (mm), shell thickness, shell opening suture, kernel weight, kernel color, kernel ratio, each of this criteria have its weight according to its importance as explained in Table 5.

Table 5: Total points of selected almond genotypes to weighted ranked method

Genotype No.	Point
SU-69	910
SU-65	900
SU-67	900
SU-79	890
SU-40	850
SU-24	840
SU-82	780
SU-76	765
SU-26	760
SU-70	730
Maximum	910
Minimum	730

Identification of selected almond genotypes: In this study identification of selected almond genotypes were given explained below which contain all characteristics of almond fruits and almond kernel (Figure 9).

Figure 9: Fruit characteristics of selected genotypes

4. DISCUSSION AND CONCLUSION

The aim of the study in the Gewrede region of Chemcemal Suleymaniye province in Northern Iraq is to determine the tree and fruit characteristics of the almond genotypes cultivated in this region.

In the Northern Iraq chamchamal region, where vegetative propagation techniques are known to be used almost exclusively, there is a very important almond gene source grown entirely from the seed. This genetic wealth that the region possesses is of great importance for breeding studies.

There is no known work on almond selection to evaluate this genetic trait in the region. The work carried out in this context is the first known work in the sense of selection.

The most important step of almond breeding studies is selection studies. In selection studies, the most important pomological criteria to consider are fruit weight, kernel weight, kernel ratio and shell thickness. In almond cultivation, it is desired that the weight of shelled almond fruit is 4.00-7.00 g and its kernel weight is 1.00-2.50 g, the kernel ratio is over 20-60 % and the fruit is light yellow color.

As a result of the research, 10 genotypes of almond which had the highest scores in terms of quality characteristics according to the Weighted ranked method were selected as hopeful for breeding studies. The findings of these characteristics are compared with the kinds and genotypes of almonds grown in other regions.

In this study, these 10 almond genotypes scored the highest point (SU-69, SU-65, SU-67, SU-79, SU-40, SU-24, SU-82, SU-76, SU-26 SU-70) they were selected as a hopeful type.

In the selected hopeful genotypes, the shelled fruit weight was between 6.74 g to 3,46 g, the kernel weight was between 2,02 g to 1,00 g, the shell thickness was between 3,43 mm to 2,45 mm, the kernel ratio was between 30.51 % to 21.25 % and, the double kernel was 10 %, in terms of the kernel color for 10 hopeful genotypes five of them were light and five of them were medium light, all of them were very hard in shell hardness Beyhan and Şimşek (2007).

In this study, the recorded data for fruit characteristics of the selected genotypes is possible to establish similarities between the numerical data of the types that hopeful almond selection of Turkey's various regions by several researchers. (Dokuzoğuz et al., 1968; Cangı and Şen, 199; Karadeniz and Erman, 1996; Şimşek, 1996; Gerçekçioğlu and Güneş, 1999; Beyhan and Şimşek, 2007; Şimşek and Osmanoğlu, 2010)

It is also desirable that the commercial almond varieties have a kernel weight of over 1g (Kester and Asay, 1979, Kester et al., 1991, Balta, 2002). As a result of this research, genotypes determined between 1.00-2.02 g in terms of kernel weights were found important.

In some other studies, fruit weight with shell changed from 5.86 to 3.45 g (Bostan et al., 1995), 7.58 to 2.18 g (Gerçekçioğlu and Güneş, 1999), 7.58 to 3.39 g (Beyhan and Şimşek, 2007), 4.93 to 1.42 g and 3.80 to 2.37 g (Gülsün et al., 2014). The values of fruit weight with shell in this study were partly similar to those of (Bostan et al., 1995), (Gerçekçioğlu and Güneş, 1999), (Beyhan and Şimşek, 2007), but were mostly higher than those of the other researchers.

Karadeniz and Erman (1996), Şimşek and Küden (2007), Şimşek (2008) and (Gülsün et al., 2014) determined that the kernel weight of the selected types changed from 1.80 to 1.01 g, 1.52 to 0.51 g, 1.14 to 0.66 g and 1,0 to 0,71 g respectively. The values of kernel weight in this study were mostly similar to those of Karadeniz and Erman (1996), Şimşek and Küden (2007) and but partly higher than those of Gülsün et al. (2014).

Şimşek and Küden (2007) determined that the kernel ratio changed from 62.41 to 25.39 % and 60.16 to 13.91 %, respectively. The values of the kernel ratio in this study were mostly lower than those of Şimşek and Küden (2007).

Şimşek and Küden (2007) determined that the shell hardness was shown to be very hard in four types, medium in three types and soft in two types. In addition, Şimşek (2008) determined that the Shell hardness was shown to be very hard in three types, medium in one type and soft in two types. Balta (2015) determined that particularly in the genotypes, hard-shell structures have been noted. All of our selected almonds were identified as very hard-shelled. The shell hardness can change according to genetic characteristics. Aslantaş (1993) and Şimşek (2008).

Şimşek (2008) observed that the kernel color intensity was found to be light in one type, medium in three types, and dark in two types. The values concerning kernel taste in this study were similar to those of Şimşek and Küden (2007) and Şimşek (2008). The values of kernel color in this study were five of them were light and five of them were medium light. Kernel taste of almond types and cultivars can change according to the purpose of researches. All of our selected almonds were identified as sweet.

During two years (2017-2018) of working in Chamchamal region of the type selected in this study results, when considered collectively in terms of the important fruit and tree characteristics, according to Turkey and other countries show that they have a very important value in terms of many features compared to the results obtained as a result of studies conducted in other countries. This is important because it shows that Northern Iraq has a rich genetic resource in terms of almonds. These genetic resources should be protected, care should be given to the study of selection in almonds and studies should be planned to protect this genetic potential, which has been achieved for centuries. This study is a first for almond selection in the region and will serve as a basis for the preservation, reproduction and standardization of these highly qualified genotypes determined by more detailed studies to be carried out in the region.

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CHAPTER 9

PROJECTION OF THE WORLD AND TURKEY NUT PRODUCTION

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INTRODUCTION

Turkey has a favorable climate and topographic structure fruits except for tropical fruit species because Turkey has been home to many tribes and civilizations, been on migration and trade routes, and had geographical location. For this reason, Turkey is the center of fruit culture and the homeland of many fruit species that are grown commercially. Nearly 75 of 138 fruit species grown in the world are grown economically in this geography. However, a significant part of the fruit species grown in Turkey are sub-tropic climate fruits. Among these, nut varieties such as hazelnut, walnut, chestnut, almond, pistachio are widely grown. Nuts are grown between 30-45 south-north latitudes and intensively in the northern hemisphere. These areas can be expressed as microclimate, starting from China, Mediterranean countries including Turkey, the United States, and mild regions of Chile and Australia in the southern hemisphere (Gezginç and Duman 2004; Tilkat, 2006). Nuts are rich in nutritional content and various minerals such as calories, protein, carbohydrates, Vitamins ($B_{1,3,5,6}$, C, E, K), calcium, iron, magnesium, phosphorus, and potassium, zinc, and antioxidants. These are foods with a high oil acid ($Omega_{3,6}$) value, which has been recommended to be consumed in recent years (Şen et al., 2006). After the Second World War, technological developments and the increase in the welfare level affected eating habits. As the importance of fruits in human health and nutrition is understood, rapid improvements have been experienced in fruit production and consumption. Nuts are functional foods and are preferred because they can be processed into many products.

1. MATERIAL AND METHOD

1.1. Material and Method

In this study, we used FAO data (United Nations Agriculture and Food Organization) and TUIK (Turkish Statistical Institute) of nut species such as pistachio, almond, walnut, hazelnut, and chestnut. In addition, it was benefited from national and international data. This study tried to reveal the perspective of nut production in Turkey and the world. This analysis study was carried out on five nut varieties that have economic importance for the world and Turkey. Among the five selected nuts, this study evaluates each fruit, both in general and specific based on comments and analyses of production amount, areas, and yield for 2000-2019 (Anonim 2021a, b).

2. RESULTS

2.1. Developments in World Nut Fruit Production

According to the data of 2000, which we took as the beginning of the production period, world nuts production with 4.890.221 tons, reached 12.439.500 tons at the end of 2019 with an increase of approximately 2.54 times. The primary source of the production increase in the world nut production is the increase in planting areas and yield. The reason for the rise in demand can be associated with the increase in population and economic welfare.

According to the 2000-2019 period values, walnut ranks first in world hazelnut production with 4.498.442 tons and a share of 36.16%. Almonds follow this with a 3.497.148 tons production and a share of

28,11%, chestnut with 2.406.903 tons production and a share of 19.35%, hazelnuts 1.125.178 tons production and a share of 9.05%, and pistachios with 911.829 tons production and a share of 7.33%, respectively. During this period, the highest rise in production was in walnut with an improvement of approximately 26%, followed by; Chestnut with an increase of 156%, almond with an increase of 140%, hazelnut with an increase of 67% and pistachio with an increase of 66% (Table 1). Although it is seen that the least increase in yield is in pistachio, this may be a misleading result for us. Due to the intense periodicity of pistachios, the possibility that this year will coincide with the year of periodicity should not be ignored. Since when we consider the increase in area, it is seen that the pistachio production areas increased approximately 148% in this period. Since pistachios are late in fruiting and show a more intense periodicity than other nut varieties, the increase in the production area and the developments in production techniques are not reflected in the rise in yield. It is essential to evaluate the production statistics of fruit varieties with such intense periodicity, taking into account two consecutive years, as an average, to obtain healthier results. The countries that have an important role in world nut production are China, the USA, Turkey, Iran, Spain, and Italy. It is observed that significant production increases were recorded in these countries. In addition to the advantage of being the gene center of many fruit varieties, China's vast geography and climate differences allow many fruit varieties to cultivate. With this advantage, China is the leader in the world's nut production, producing 4.551.114 tons today. The USA follows it with a production of 2.904.810 tons, Turkey with a production of 1.308.701 tons, Iran with a production of 852.025 tons, Spain with 559.260 tons, and Italy with a production of 226.610 tons (Table 1). Fruit production has increased tremendously with the liberalizations in the fruit sector since 1984 (Gül and Göksel, 2006). Nuts also contributed significantly to these increases. The most important reasons for these increases in fruit production are the expansion of planting areas, the development of productive and high-quality new varieties, the planting of more seedlings per unit area with dwarf cultivation in many fruit varieties, and the more conscious cultural processes such as irrigation, pruning, and fertilization. During this period, the economic reforms that took place in China, giving the producers freedom in making production decisions, have led to severe increases in fruit production in recent years. Especially in mountainous regions, fruit production has been the most popular production branch (Shi and Wahl, 1996). Between 2000 and 2019, the amount of world nut production increased by 154%. The country with the highest increase in nut production was China with 372%, followed by the USA with an increase of 230%, Spain with an increase of 106%, Turkey with a rise of 73%, and Iran increase of 70%. On the other hand, in these twenty years, the production of nuts in Italy decreased by 16% (Table 1).

Table 1: World production of nut (Tons)*

Countries	Species	Years 2000	2015	2016	2017	2018	2019	% Change	% Share in Country production	% Share in World production
CHINA	Pistachios	22.000	83.553	90.310	95.591	100.873	106.155	382.52	2.33	11.64
	Hazelnut	9.000	25.101	26.312	27.314	28.316	29.318	225.76	0.64	2.61
	Walnut	309.875	1.941.886	2.114.495	2.250.164	2.385.834	2.521.504	713.72	55.40	56.05
	Almond	17.000	43.080	43.212	43.000	43.000	45.000	164.71	0.99	1.29
	Chestnut	598.185	1.633.071	1.798.589	1.797.735	1.822.155	1.849.137	209.12	40.63	76.83
	Total	**956.060**	**3.726.691**	**4.072.918**	**4.213.804**	**4.380.178**	**4.551.114**	**376.03**	**100.00**	**36.59**
USA	Pistachios	110.220	122.470	406.646	272.290	447.700	335.660	204.54	11.56	36.81
	Hazelnut	20.410	28.123	39.916	29.030	46.270	39.920	95.59	1.37	3.55
	Walnut	216.820	549.754	625.050	571.530	615.980	592.390	173.22	20.39	13.17
	Almond	553.000	1.436.383	1.617.816	1.716.850	1.721.380	1.936.840	250.24	66.68	55.38
	Total	**900.450**	**2.136.730**	**2.689.428**	**2.589.700**	**2.831.330**	**2.904.810**	**222.60**	**100.00**	**23.35**
TURKEY	Pistachios	75.000	144.000	170.000	78.000	240.000	85.000	13.33	Haz.49	9.32
	Hazelnut	470.000	646.000	420.000	675.000	515.000	776.046	65	59.30	68.97
	Walnut	116.000	190.000	195.000	210.000	215.000	225.000	93.97	17.19	5.00
	Almond	47.000	80.000	85.000	90.000	100.000	150.000	219.15	11.46	4.29
	Chestnut	50.000	63.750	64.750	62.904	63.580	72.655	45.31	5.55	3.02
	Total	**758.000**	**1.123.750**	**934.750**	**1.115.904**	**1.133.580**	**1.308.701**	**72.65**	**100.00**	**10.52**
IRAN	Pistachios	284.454	430.000	574.987	648.934	143.695	337.815	18.76	39.65	37.05
	Hazelnut	10.290	13.516	16.465	15.835	15.978	16.121	56.67	1.89	1.43
	Walnut	129.276	420.000	349.000	393.598	304.040	321.074	148.36	37.68	7.14
	Almond	78.582	146.000	111.845	129.566	200.882	177.015	125.26	20.78	5.06
	Total	**502.602**	**1.009.516**	**1.052.297**	**1.187.933**	**664.595**	**852.025**	**69.52**	**100.00**	**6.85**
SPAIN	Pistachios	598	2599	5618	7545	-	-.	-	-	-
	Hazelnut	25.188	11.423	9.510	10.487	8.030	12.370	-50.89	2.21	1.1
	Walnut	11.418	14319	14923	15744	15180	17540	53.62	3.14	0.39
	Almond	92.844	211.084	199.167	255.503	339.030	340.420	266.66	60.87	9.73
	Chestnut	9.230	16.413	16.178	15.623	184.770	188.930	1946.91	33.78	7.85
	Total	**139278**	**255838**	**245396**	**304902**	**547.010**	**559.260**	**301.54**	**100.00**	**4.5**
ITALY	pistachios	2.768	3868	3649	3873	-	-	-	-	-
	Hazelnut	98.540	101.643	120.572	131.281	132.700	98.530	-0.01	43.48	8.76
	Walnut	16.000	12055	12205	12189	12450	10800	-32.50	4.77	0.24
	Almond	104.755	70.399	74.587	79.599	79.800	77.300	-25.67	34.11	2.21
	Chestnut	50.000	50.913	53.145	53.422	32.790	39.980	-20.04	17.64	1.66
	Total	**272.063**	**238878**	**264158**	**280364**	**257.740**	**226.610**	**-16.71**	**100.00**	**1.82**
OUTHER COUTRIES	Pistachios	54.758	51.398	54.927	77.369	76.193	47.199	-13.80	2.32	5.18
	Hazelnut	42.347	110.304	116.016	119.549	134.767	152.873	261.00	7.5	13.59
	Walnut	472.426	750.352	752.079	747.770	798.404	810.134	71.48	39.77	18.01
	Almond	559.780	681.398	674.625	683.940	740.808	770.573	37.66	37.83	22.03
	Chestnut	233.172	248.574	247.277	249.808	260.101	256.201	9.876	12.58	10.64
	Total	**1362523**	**1842053**	**1844924**	**1878436**	**2.010.295**	**2036980**	**49.50**	**100.00**	**16.38**
WORLD	Pistachios	549.798	837.888	1.306.137	1.183.602	1.008.479	911.829	65.85	7.33	**100.00**
	Hazelnut	675.815	936.110	748.791	1.008.496	881.061	1.125.178	66	9.05	**100.00**
	Walnut	1.271.815	3.878.393	4.062.752	4.200.995	4.346.892	4.498.442	253.7	36.16	**100.00**
	Almond	1.452.206	2.668.344	2.806.252	2.998.458	3.224.900	3.497.148	140.82	28.11	**100.00**
	Chestnut	940.587	2.012.721	2.179.939	2.179.492	2.363.396	2.406.903	155.89	19.35	**100.00**
	Total	**4.890.221**	**10.333.456**	**11.103.871**	**11.571.043**	**11.824.728**	**12.439.500**	**154**	**100.00**	**100.00**

* TUİK (2021); FAO (2021)

2.2. Production Areas

One of the main factors determining the amount of production is the width of the areas allocated for the product and production activity in question. In this context, the developments in the world's nut production areas were examined in the same period of evaluation. The change and development in the world nut production areas during the period of 2000-2019, which is considered within the scope of this study, are given in Table 2. Between 2000 and 2019, significant increases were recorded in the world's nut production areas. World nut production areas, which were 3.707.852 hectares as of 2000, reached 6.062.383 hectares, increasing 63% in twenty years. During this period, the nut species with the highest increase in the production area was pistachio with 616.755 ha and 148%. It was followed by walnut with 482.087 ha production area and 122% increase, almond with 4.765950 ha production area and 29% increase, chestnut with 277.443 ha production area with 87% increase, and hazelnut with 265.822 ha production area and 36% increase respectively. When the current situation of the countries in the production areas of nut is examined, the highest increase in the production areas was realized in China with a cumulative 716.542 ha and 235% rate. Turkey follows it with 595.625 ha production area and 86% increase rate, USA with 440.310 ha production area and 136% increase rate, other countries with 587.064 ha production area and 67% increase rate, 127,321 ha production area and 30% growth rate respectively. Iran followed with an increase of 43.455 hectares and Spain with 43.455 hectares and an increased rate of 6%. The only country whose production areas decreased in this period was Italy, with

13,842 ha and -7%. While the source of the increase in the area based on the country is walnut with 463.330 ha and almond with 220.370 ha in China, pistachio with 329.867 ha, and hazelnut with 193.409 ha in Turkey. In the USA, there was an increase in almonds with 225.179 ha and pistachios with 86.750 ha. In Iran, although pistachio is grown with 136.979 ha, there has been a slight decrease in almond and walnut production areas While producing pistachio with almond and walnut production areas, slight decreases were recorded. Although there was an increase of 30.866 ha in chestnut production areas and 16.696 ha in almond production areas in Spain, there was a decrease in hazelnut and pistachio fields. Although there was an increase of 15.068 ha in chestnut production areas and 10.482 ha in hazelnut production areas in Italy, decreases were detected in almond and pistachio production areas. When the share of fruit varieties in nut production areas is examined, almonds take first place with 35%. This is followed by walnut with 21%, pistachio with 17%, hazelnut with 16%, and chestnut with 10%. The increase in almond production areas is low because the orchards established from low-yielding and low-quality varieties in which almonds are produced are removed and renewed with productive and quality varieties.

Table 2: World production areas of nut (ha)*

COUNTRIES	Species	Years						% Change	% Share in Country Production areas	% Share in World production areas
		2000	2015	2016	2017	2018	2019			
CIHNA	Pistachios	12.000	28.064	29.444	30.410	31.330	32.207	168.39	3.156	3.11
	Hazelnut	6.000	12.410	12.892	13.211	13.521	13.824	130.40	1.35	1.38
	Walnut	168.000	530.286	563.606	587.132	609.687	631.330	275.79	61.86	48.36
	Almond	8.000	13.493	13.159	12.797	12.513	12.811	60.14	1.25	0.60
	Chestnut	110.000	289.237	322.699	322.091	326.007	330.370	200.34	32.37	55.46
	TOTAL	**304.000**	**873.490**	**941.800**	**965.641**	**993.058**	**1.020.542**	**235.70**	**100.000**	16.83
USA	Pistachios	30.200	94.292	96.720	101.170	106.840	116.950	287.25	15.34	11.30
	Hazelnut	11.470	13.759	14.973	16.190	17.810	20.230	76.37	2.65	2.02
	Walnut	78.100	121.406	127.480	135.570	141.640	147.710	89.13	19.37	11.32
	Almond	202.340	372.311	392.550	416.830	411.110	477.530	136.00	62.63	22.46
	TOTAL	**322.110**	**601.768**	**631.723**	**669.760**	**677.400**	**762.420**	136.70	**100.00**	**12.58**
TURKEY	Pistachios	36.349	57.996	60.814	68.237	354.500	366.210	907.48	28.50	35.39
	Hazelnut	541.000	702.628	705.455	706.667	728.381	734.409	35.75	57.15	73.42
	Walnut	59.000	71.820	86.853	92.013	111.775	124.553	111.11	9.69	9.54
	Almond	18.000	29.671	33.322	35.202	42.191	47.088	161.60	3.66	2.21
	Chestnut	35.000	40.160	39.000	39.580	39.080	12.714	-63.67	0.99	2.13
	TOTAL	**689.349**	**902.275**	**925.444**	**941.699**	**1.275.927**	**1.284.974**	**86.40**	**100.00**	21.20
IRAN	Pistachios	274.503	334.000	547.487	429.535	135.404	411.482	49.90	74.24	39.76
	Hazelnut	10.452	31.041	18.419	17.822	18.144	18.472	76.73	3.33	1.85
	Walnut	51.971	142.000	78.285	53.952	50.902	44.780	-13.84	8.08	3.43
	Almond	89.996	93.000	59.025	50.856	90.704	79.509	-11.65	14.35	3.74
	TOTAL	**426.922**	**600.041**	**703.216**	**552.165**	**295.154**	**554.243**	29.82	**100.00**	**9.14**
SPAIN	Pistachios	932	6487	14974	20415	-	-	-	-	-
	Hazelnut	23.570	13.301	13.137	12.806	13.510	13.020	-44.76	1.74	1.30
	Walnut	4065	8.926	9634	10367	11000	11440	181.43	1.53	0.88
	Almond	670.534	548.604	583.673	633.562	657.770	687.230	2.49	91.78	32.32
	Chestnut	6.254	35.898	36.174	36.451	36.680	37.120	493.54	4.96	6.231
	TOTAL	**705355**	**613216**	**657592**	**713601**	**718.960**	**748.810**	6.16	**100.00**	**12.35**
ITALY	Pistachios	3.602	3.838	3.813	3.873	-	-	-	-	-
	Hazelnut	68.868	72.214	69.285	73.772	78.590	79.350	15.22	46.04	7.93
	Walnut	4.000	3.895	3.979	39.71	4.500	4.670	16.75	2.71	0.36
	Almond	88.500	58.112	57.421	57.593	57.990	52.040	-41.20	30.20	2.45
	Chestnut	21.212	21.487	22.132	22.076	36.330	36.280	71.04	21.05	6.09
	TOTAL	**186.182**	**159.546**	**156.630**	**157.314**	**177.410**	**172.340**	-7.43	**100.00**	**2.84**
OUTHER COUNTRIES	Pistachios	36.106	104.014	107.733	112.076	107.245	107.947	198.97	7.35	10.79
	Hazelnut	73.049	85.326	93.826	95.534	100.050	120.926	65.54	8.23	9.26
	Walnut	54.300	225.360	243.459	282.336	286.530	290.464	434.92	19.78	13.66
	Almond	572.339	662.337	648.445	713.118	753.677	770.096	34.55	52.44	12.93
	Chestnut	145.794	174.445	175.010	175.293	179.149	179.219	22.93	12.20	2.96
	TOTAL	**881.588**	**1.251.482**	**1.268.473**	**1.378.357**	**1.426.651**	**1.468.652**	66.59	**100.00**	**24.23**
WORLD	Pistachios	418.041	628.691	860.985	765.716	735.319	1.034.796	147.53	17.07	17.07
	Hazelnut	734.409	930.679	927.987	936.002	970.006	1.000.231	36.20	16.50	16.50
	Walnut	587.436	1.183.259	1.189.984	1.183.830	1.252.683	1.305.349	122.21	21.53	21.53
	Almond	1.649.709	1.777.528	1.823 598	1.919.958	2.025.955	2.126.304	28.89	35.07	35.07
	Chestnut	318.260	561.227	595.015	595.491	617.246	595.703	87.17	9.83	9.83
	TOTAL	**3.707.852**	**5.081.384**	**5.397.569**	**5.400.997**	**5.601.249**	**6.062.383**	**63.50**	**100.00**	**100.00**

* TUİK (2021); FAO (2021)

2.3. Yield

According to the varieties, when the developments in the world nut yield are evaluated, there are significant fluctuations among varieties of nut. When the fruit production values of 2000 are accepted as 100%, it is seen that there is a considerable decrease in pistachio yield in kg/da. The low yield was seen in pistachios as kg/da is because the areas planted in recent years have not reached the yield age yet, as well as the intense periodicity this year. On the other hand, there is an increase in the yield of almonds, walnuts, chestnuts, and hazelnuts.

As of the examined period (2000-2019), the nut with the highest annual average yield increase is almond with 87%, followed by walnut with 59%, chestnut with 37%, hazelnut with 22%, and pistachio with a yield of-33% decrease was recorded (Table 3). When the yield (kg/da) of nut species is analyzed based on species, the highest yields were obtained in Pistachio with 330 kg/da in China, followed by the USA with 287 kg/da. The lowest yield was realized in Turkey with 23 kg/da. The highest yield in hazelnut was in China with 212 kg/da, followed by the USA with 197 kg/da, Georgia with 179 kg/da, Azerbaijan with 124 kg/da and Turkey with 106 kg/da. The highest yield of walnuts was in Iran with 717 kg/da, followed by the USA with 401 kg/da, China with 399 kg/da, Chile with 301 kg/da, Italy with 231 kg/da and Turkey with 180 kg/da. The highest yield per decare of almonds was realized in the USA with 406 kg. This was followed by China with 351 kg/da, Turkey with 319, Iran with 223 kg/da, Italy with 148.54 kg/da, Spain with 49.54 kg/da. In chestnut, the highest yield was in China with 560 kg/da, followed by Turkey with 571 kg/da, Spain with 509 kg/da, Bolivia with

144 kg/da and Italy with 110 kg/da. When the world nuts fruit yield developments are evaluated based on important producer countries, the increase in productivity becomes evident. The USA and China achieved a significant advantage over other producing countries in terms of yield per decare and production amount. However, Iran's 717 kg/da yield in walnut was quite remarkable.

Table 3: World yield of nut (kg/da)*

Countries	Species	YEARS						% Change
		2000	2015	2016	2017	2018	2019	
CHİNA	Pistachios	183.33	297.75	306.72	314.34	321.97	329.60	79
	Hazelnut	150.00	202.26	204.09	206.75	209.42	212.04	41
	Walnut	184.45	366.20	375.17	383.25	191.32	399.40	116.53
	Almond	212.50	319.27	328.38	336.02	343.64	351.26	65.30
	Chestnut	543.80	564.61	577.36	558.15	558.93	559.72	2.93
USA	Pistachios	364.97	129.88	420.44	269.14	419.04	287.01	-21.36
	Hazelnut	177.94	204.40	266.59	179.31	259.80	197.33	10.90
	Walnut	277.62	452.82	490.31	421.58	434.89	401.05	44.46
	Almond	273.30	385.80	412.13	411.88	418.72	405.60	48.41
TURKEY	Pistachios	206.33	248.29	279.54	114.31	677.01	23.21	-88
	Hazelnut	86.88	91.94	59.54	95.82	70.70	105.67	20.85
	Walnut	196.61	264.55	224.52	228.23	19.235	180.65	8.12
	Almond	261.11	269.62	255.09	255.67	237.02	318.55	21.99
	Chestnut	142.86	158.74	166.03	158.93	163.38	571.46	300.01
IRAN	Pistachios	103.63	128.74	105.02	151.14	106.12	82.10	-20.78
	Hazelnut	98.45	43.54	89.39	88.85	86.50	87.27	-11.36
	Walnut	248.75	350.00	444.35	729.53	597.30	717.00	188.24
	Almond	87.32	156.99	189.49	254.77	221.47	222.64	154.59
SPAIN	Pistachios	64.16	40.06	37.52	18.67	-	-	
	Hazelnut	106.86	85.88	72.39	81.89	59.44	95.01	11.09
	Walnut	280.88	160.42	154.90	151.87	138.00	153.32	-45.41
	Almond	33.59	38.48	34.12	40.33	51.54	49.54	47.48
	Chestnut	147.59	45.72	44.72	42.86	504.03	508.97	244.85
ITALY	Pistachios	76.85	100.78	95.70	100.01	-	-	-
	Hazelnut	143.09	140.75	174.02	177.96	168.85	124.17	-12.61
	Walnut	400.00	302.51	306.74	306.95	276.67	231.26	-42.18
	Almond	117.51	121.14	129.89	138.21	137.61	148.54	26.41
	Chestnut	235.72	236.95	240.13	241.99	90.26	110.20	-53.25
OTHER COUTRIES	Pistachios	151.66	49.41	50.98	69.03	71.05	43.72	-71.34
	Hazelnut	57.97	129.28	123.65	125.14	134.70	126.42	118.08
	Walnut	212.52	332.96	308.91	264.85	278.65	278.91	31.24
	Almond	97.81	102.88	104.04	95.91	98.29	100.01	2.25
	Chestnut	159.93	142.49	141.30	142.51	145.19	143.01	10.58
WORLD	Pistachios	131.52	133.27	151.7	154.57	137.15	88.12	-33.00
	Hazelnut	92.02	100.58	80.69	107.75	90.83	112.49	22.25
	Walnut	216.5	327.77	341.41	354.86	347	344.62	59.18
	Almond	88.02	150.12	153.88	156.17	159.18	164.47	86.86
	Chestnut	295.54	358.63	366.37	365.99	382.89	404.04	36.71

* TUİK (2021); FAO (2021)

2.4. Developments in Nut Production in Turkey

2.4.1. Production

In parallel with the increase in world fruit production in the 2000-2019 period, Turkey's nut production also showed an increasing trend. Especially in the early 2000s, seedlings and plant support are given to the producers to support agricultural production. So, this situation has effectively expanded the nut production areas since the income from the unit area and product prices are higher than the other agricultural production areas. Turkey's nut production amount, which was 758.000 tons in 2000, increased by 72.65% and reached 1,308,701 tons at the end of 2019. However, the increase in the production of nuts in Turkey lagged behind the world production of 154.38%. Productivity increases had a significant impact on this increase in nut production. During this period, the highest growth in yield occurred in chestnut with 571.46 kg/da, followed by almond with 318 kg/da. Considering the fluctuations in the yield of fruit varieties during this period, there was no significant increase in hazelnut yield. The yield seems to be low in walnuts and pistachios due to the new production areas and periodicity that have not reached the yield age. According to the 2000-2019 period data, Turkey's nut production was highest in hazelnuts, with 776.046 tons. Walnuts followed this with 225.000 tons, almonds with 150.000 tons, pistachios with 85.000 tons, and chestnuts with 72.625 tons, respectively. The fruit that has the largest share in our nut production is hazelnut, with a share of 59.30%. This is followed by walnuts with a share of 17.19%, almonds with a share of 11.46%, pistachios with a share of 6.49%, and chestnuts with a share of 5.55%. In the examined period, the biggest increase in the production of the nut was realized in almond production at 219.15%. Walnuts followed this with 93.97%, hazelnuts with 65.00%, chestnuts with 45.31%, and pistachios with 13.33%. Various projects have been carried out within the body of the Ministry of Agriculture and Forestry to improve fruit growing in our country. With the cooperation of the Ministry of Agriculture and Forestry, Research Institutes, and Universities, working groups have been formed as in cherry, walnut, pistachio, and almond. Fruit growing has been improved with activities that bring together the producers, Ministry experts, and faculty members. In addition, successful results have been obtained from various projects and studies carried out by research institutes and universities for cultivar development.

Table 4: Turkey production of nut (Tons)*

Country	Species	YEARS						% Change	% Share in Country Production	% Share in World Production
		2000	2015	2016	2017	2018	2019			
TURKEY	Pistachios	75.000	144.000	170.000	78.000	240.000	85.000	13.33	6.49	9.32
	Hazelnut	470.000	646.000	420.000	675.000	515.000	776.046	65.12	59.30	68.97
	Walnut	116.000	190.000	195.000	210.000	215.000	225.000	93.97	17.19	5.00
	Almond	47.000	80.000	85.000	90.000	100.000	150.000	219.15	11.46	4.29
	Chestnut	50.000	63.750	64.750	62.904	63.580	72.655	45.31	5.55	3.02
	TOTAL	**758.000**	**1.123.750**	**934.750**	**1.115.904**	**1.133.580**	**1.308.701**	**72.65**	**100.00**	**10.52**

* TUİK (2021)

Turkey is a net exporter only in hazelnuts in the production of nuts. Turkey is self-sufficient in pistachios and chestnuts, and it is tried to balance the market with imports in the year of absence and small-scale exports in the year of the year. To meet the domestic demand, 90.525 tons of walnuts and 58.528 tons of almonds were imported in 2019. Even in the years when the pistachio product is plentiful, the domestic market price is high. There are essential producer countries such as Iran and Syria in our immediate vicinity, which can sell cheaper, and the inability of the producers to organize in marketing limits the export opportunity. Despite the positive developments in fruit production in Turkey, it is a fact that the desired level of efficiency cannot be achieved in the marketing system of these products. One of the important gaps in our country's foreign marketing channels is the lack of direct connection between exporters and wholesalers, and retailers in the export market (Aksoy and Sargent, 1994). However, it is seen that producers are organized in various unions in countries that have a significant position in world fruit production and trade. Producer unions and cooperatives established for many products in the first years of the republic in our country lost their functions over time and became dysfunctional.

2.4.2. Production area

Turkey's nut production areas have increased from 689.349 ha to 1.284.974 ha, with a share of 86% as of 2000-2019. The development and current status of the nuts production areas in Turkey can be observed in Table 5. When the nuts production areas were examined, the largest share was 734,409 ha, and hazelnut with a share of 57%. It is followed by pistachio with a production area of 366.210 ha and a share of 28%, walnut with a production area of 124.553 ha and a share of 10%, almonds with a production area of 47.088 ha and a share of 4%, and a production area of 12.714 ha and a share of 1%. followed by chestnut. Hazelnut and pistachio are the most important fruit varieties that draw attention to the increase in the production areas of nut in

Turkey. Despite the 2844 numbered decree on the restriction of hazelnut areas, which was issued in 1984, the number of hazelnuts increased about two times. As marketing and stock problems cannot be solved in the product, this problem is getting bigger day by day.

Table 5: Turkey production areas of nut (ha)*

Countries	Species	Years						% Change	% Share in Country Production Areas	% Share in World Production Areas
		2000	2015	2016	2017	2018	2019			
TURKEY	Pistachios	36.349	57.996	60.814	68.237	354.500	366.210	907.48	28.50	35.39
	Hazelnut	541.000	702.628	705.455	706.667	728.381	734.409	35.75	57.15	73.42
	Walnut	59.000	71.820	86.853	92.013	111.775	124.553	111.11	9.69	9.54
	Almond	18.000	29.671	33.322	35.202	42.191	47.088	161.60	3.66	2.21
	Chestnut	35.000	40.160	39.000	39.580	39.080	12.714	-63.67	0.99	2.13
	TOTAL	**689.349**	**902.275**	**925.444**	**941.699**	**1.275.927**	**1.284.974**	**86.40**	**100.00**	21.20

* TUİK (2021)

From 2000 to 2019, pistachio production areas increased by 907.48% from 36.349 ha to 366.210 ha. Since these gardens have not yet reached the yield age, the increase in the area has not been fully reflected in the product. With the yield of these orchards, there is a high probability of a large stock of excess consumption in pistachios. In the production area increase, pistachio was followed by almond with an increase of 161%, walnut with an increase of 111%, and hazelnut with an increase in production area by 36%. In this period, chestnut production areas decreased by -64%.

2.4.3. Yield

Developments in fruit yields in Turkey are reflected in Table 6. As seen from this chart, as of 2000-2019, chestnut in nut varieties has increased above the world average with a yield of 571.46 kg/ha and a yield increase of 300%. On the other hand, Almond was above the world average with a yield of 319 kg/da but remained below the world average with a yield increase of 22%. Hazelnut with 106 kg/da yield and 21% yield increase, walnut with 181 kg/ha yield and 8% yield increase remained below the world averages. Pistachio showed a serious fluctuation and experienced a significant product loss with a production of 23 kg/da and a yield reduction of -88%. The yield of pistachios in the previous year was 677 kg/da.

Table 6: Turkey yield of nut (kg/da)*

Country	Species	Years						%
		2000	2015	2016	2017	2018	2019	Change
Turkey	Pistachios	206.33	248.29	279.54	114.31	677.01	23.21	-88.00
	Hazelnut	86.88	91.94	59.54	95.82	70.70	105.67	20.85
	Walnut	196.61	264.55	224.52	228.23	19.235	180.65	8.12
	Almond	261.11	269.62	255.09	255.67	237.02	318.55	21.99
	Chestnut	142.86	158.74	166.03	158.93	163.38	571.46	300,01

* TUİK (2021)

2.4.4. Place of Turkey in World Nut Growing

Our country is a country with self-sufficiency in fruit production and export potential in terms of its production area and ecological structure. In the 2000-2019 period, which was examined within the scope of the study, Turkey's share in the world's nut production varied between 8-15%. The fruit that Turkey has the largest share in world fruit production is hazelnut, with 776.046 tons of production. Turkey alone meets 69% of the world's hazelnut production. When analyzed by periods, it is seen that Turkey's share in world hazelnut production has decreased between 56-70%. Although Turkey has an essential share in the world's nut production, our production in other nut varieties, excluding pistachios, is below 10%. With a general evaluation, although there is an increase in the production of nut varieties, it is seen that Turkey's share in the production of nut varieties, excluding pistachio, tends to decrease.

Considering the 2000-2019 period in Turkey and world nut production, the fruits with the highest annual increase in production for Turkey are almonds, walnuts, hazelnuts, and chestnuts, respectively. The last increase was observed in the pistachio. However, considering the rise in pistachio production areas in our nut production and this increase has not yet been reflected in the yield, it is seen that it has great potential. The highest production increase was recorded in walnut, with 4.498.442 tons and an increase of 254%. Almonds follow this with 3.497.148 tons of production and 141% increase, chestnuts with 2.363.396 tons of production and 156% increase, hazelnuts with 1.125.178 tons of production and 66% increase, and pistachio 911.829 tons of production with an increase of 65%, respectively. During this period, the growth rates of nuts production in Turkey were below the world average. Only hazelnut production is very close to the world average (Table 6). Considering Turkey's position in the general profile of world fruit growing, Turkey is by far the world leader in hazelnut production among the five nut varieties known as Royal fruits, which have the highest production potential and economic importance. In pistachio, we rank second after Iran with a production area of 366.210 ha. Because of the long period of youth sterility in pistachios, the rapid increase in area in recent years has not yet been reflected in production.

CONCLUSION

In this study, the developments in the world and Turkey's nut cultivation covering the period of 2000-2019 were evaluated. Significant increases in area and productivity have been recorded in world fruit production. The source of the 154% increase recorded in the world nut varieties production in the last 20 years is the increase in both the production area and the yield. However, the main source of the increase in the production of nuts in this period is the increase in yield. As in these 20 years, while the production areas increased by only 63%, the production increased by 154%. Because of the dependence of agricultural production on natural conditions, there were fluctuations in yield and production from year to year. However, the general trend was an increase in world fruit production. Although the cumulative increase in fruit production continues, there was a relative decrease in the annual growth rate. Today, when the border of agricultural areas is reached, it can be stated that future production increases will be primarily due to productivity. The source of the observed increases in productivity is the increase in the level of consciousness in parallel with the developments in information and technologies. This situation raises the level of knowledge of the producers, and it is thought that the increase has occurred due to the conscious, appropriate, and timely implementation of cultural practices in agricultural production. In direct proportion to the rise in world fruit production, there have been significant changes in fruit production in Turkey. However, it should not be ignored that the increase in the production of nuts in Turkey is below the world average. In the 2000-2019 period, it is seen that the rapid rise in the production areas of hazelnut, pistachio, walnut, and almond, as well as the yield, affects the improvement in the production of nut in Turkey. Although there was a 64% decrease in the chestnut production areas in this period in the production of nut in Turkey, an increase of 45% was recorded in the production. The reason for this can be shown as obtaining more product per unit area.

Turkey provides the most significant contribution to the world's nut production with hazelnut production, of which it is the leader. A point to be noted here is that Turkey's share in the world's nut production tends to decrease in this period. This can be attributed to the fact that the production rise recorded in nut varieties such as hazelnut, pistachio, walnut, almond, etc., is below the world average. The production areas are approaching the end of the expansion limit. However, in this period, recovery can be achieved by reflecting the 907% increase in the pistachio production areas in a short time. The source of this increase in pistachio production areas is the support given by the Ministry of Agriculture and Forestry to the producers for seedlings, facilities, and good agricultural practices, and various projects implemented by local administrations and non-governmental organizations. Turkey is one of the countries with a high export potential besides being self-sufficient in fruit production due to its ecology, geographical location, and production area. However, it cannot be said that this potential has been adequately evaluated. Regarding the sustainability of Turkey's position in world nut production, developments in world production and trade should be closely monitored. In addition, the establishment of similar producer associations on a product basis, as in developed countries, is important in terms of branding, implementation of integrated struggle methods, and sustainability.

Especially in recent years, production has increased due to the demand for organic products in the world. It is also very important to evaluate Turkey's production potential in this direction. Since Turkey is among the homeland of nuts, it is a great advantage to have a rooted fruit-growing culture and a dynamic domestic market demand. Namely, it is seen that Turkey is the country where the most per capita consumption of these fruits, known as royal fruits (king, noble fruits, or kings' food), is made. One hundred fifty thousand tons of hazelnuts per year in Turkey, 315.000. It ranks first globally with 875.000 tons of nuts per year, approximately 10.5 kg per capita, including tons of walnuts, 130.000 tons of pistachios, 210.000 tons of almonds 70.000 tons of chestnuts. There is a need to develop productive and high-quality varieties suitable for confectionery and industry resistance to global warming, drought, and abiotic stress conditions, closely related to our country.

Most of our Orchards, especially in the first Production Zone, have completed their economic life and their yields are very low. These gardens urgently need to be renewed with quality varieties and modern planting systems for increased yield and sustainable production. Hazelnut producers' economic power and education level are low, and their businesses are small and very fragmented. This situation causes them to be insensitive in adopting new technologies, increasing input costs, decreasing profitability, and making production activity uneconomic. Despite the law numbered 2844 on the planning of hazelnut production and the limitation of planting areas, the overflow of hazelnut production areas beyond their natural borders increases the production more than necessary, causes decreases in quality, and brings along marketing problems. Pistachio yield is low because most old orchards are established in barren areas that cannot be irrigated. In recent years, especially in Şanlıurfa, Gaziantep, Siirt, and Kahramanmaraş, the establishment of gardens in fertile areas where irrigation systems are drip irrigation is positive developments increase in the future. It will also increase fencing in fruits, which is an essential criterion in marketing due to the rise in internal fullness with irrigation. The increase in the use of modern technology in harvesting, drying, preservation, and processing will reduce production costs and increase hygiene in the product, thus providing an advantage in marketing. The yield, late spring frosts, and early autumn frosts of our local varieties with high taste and aroma suitable for our regions have not been solved yet. The main variety with high side branch yield, late leafing, short vegetation period, and suitable pollinators should be developed from our local varieties by applying for breeding programs.

Since chestnut has been accepted as a forest tree until recent years in our country, the garden plant has not been encouraged. Although quality varieties have been developed, it has not received the necessary attention. Chestnut forests in the Black Sea region have been transformed into hazelnut orchards because their economic value has not been adequately understood. High-quality and highly productive domestic varieties that can compete with foreign varieties in nuts, except hazelnut, have not been developed yet. Because mechanization is not used in Nuts, our production costs are quite high compared to competing countries. As the role of Nuts in human nutrition and health is better understood, demand will increase rapidly as the level of economic welfare increases. By activating product promotion groups, the role of nuts in human health and nutrition can be processed. The Near East countries can turn into new markets with intensive promotional activities and promotions, which can effectively solve our marketing problems. Cooperatives established for essential products in Turkey are deactivated. As the market is under the control of monopolistic companies in product control, marketing is an obstacle for manufacturers to sell their products at fair prices. The expansion of licensed warehousing should be encouraged by establishing a Specialty Exchange for Nuts. Thus, the speculative pressures of monopolistic companies on the market will be eliminated, products will be recorded, and stock control will be made from a single source. Increasing irrigation opportunities in the Southeast Anatolia Region provide an essential opportunity, especially for pistachio and almond (Ertürk et al., 2015). With the R&D contributions and guiding supports provided by the Ministry of Agriculture and Forestry, we can meet the domestic consumption of walnuts and almonds in a short time and become an exporter. With the ongoing breeding studies, the development of new varieties with low periodicity tendency, early and high hatching rate in pistachio will provide significant advantages in export.

Although Iran, our close neighbor, and competitor in the export of nuts, has come to the end of its irrigated areas, Turkey has excellent potential for irrigable pistachio and almond cultivation areas that it has not yet used. The efforts of Georgia, Iran, and Azerbaijan in our nearby geography to become serious competitors in hazelnut production should not be ignored. In addition, the self-sufficiency policies of the European Union, which is our most important foreign market, should be closely followed, and strategies should be developed.

Because hazelnut farming is mostly carried out on non-agricultural lands with high slopes, the inability to modernize will cause more important problems in the future in terms of cost increase in production, low productivity, and competition with rival countries. The dissemination of good agriculture, organic farming techniques in nuts, and early varieties will increase fresh consumption and processing in the food industry. With these developed varieties, domestic consumption can be increased. It is important to transfer the R&D results to the economy and related sectors as quickly as possible. Effective innovation studies should be carried out by ensuring the active participation of all stakeholders in R&D studies. Branding is mandatory for the developments to be healthy and permanent (Anonim, 2014).

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CHAPTER 10

A SMALL FRUIT: CURRANT

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INTRODUCTION

As a cradle of many civilizations since the first ages of history and as a country located on a significant migration route, Turkey has a significant potential for growing horticultural crops with its diverse ecological conditions. In this context, Turkey is a gene origin of grapes and many other fruit species (Ağaoğlu, 1986; Ağaoğlu et al., 2019). According to TURKSTAT (2018) data, share of Turkey in world grape fruit production is 8 %, of which 24.9 % is strawberry and 25.2 % is other berries (Engin and Boz, 2019). Plant species in our country constitute approximately 3.6 % of the plant species in the world (Esin, 2007; Adak, 2019).

Berry cultivation, including Ribes (also known as currants or gooseberries), has become increasingly important especially in recent years. Cultivation of berry fruits-except strawberries-are not currently widespread in Turkey but many wild forms can be encountered in different regions of the country. They constitute a naturally rich genetic resource. Although its large scale cultivation is widespread in Europe and in the USA today, this fruit is mostly found in home gardens and landscapes or cultivated for hobby or intercropped in gardens. However, modern, single-variety currant orchards can be encountered in recent years (Işık et al., 2001; Anonymous, 2011; Akbulut et al., 2015; Ağaoğlu, 2019; Beyli and Yeşil, 2019).

Introduction and adaptation of currants have been studied and new, suitable varieties well adopted to different regions have been determined by many institutions, especially by Yalova Atatürk Horticultural Central Research Institute (Onur, 1977, Onur et al., 1999; Ağaoğlu, 2006; Erenoğlu et al., 2003, 2006; Göktaş et al., 2006; Kaplan and Akbulut, 2006). Its gene origin is North Asia, Central and Northern Europe 75 % of the world currant production is in the Russian Federation and Poland. These countries are followed by Ukraine, France, England, Germany and Denmark (Anonymous, 2021a). Currant, which is not a demanding plant, can also be used as an erosion combat plant on slopes. Since they are short, their maintenance is easier compared to other fruit trees. Currant cultivation has a complementary position in small and medium scaled agricultural enterprises. But in such enterprises, it plays an important role in utilizing family workforce, to increase income, to settle a certain population in rural areas and to reduce migration to cities.

In Turkey, agricultural statistics of the currant production is not available since production is very low. Jostaberries are a hybrid of currant and gooseberry, their fruits are larger and blacker than currants, and their ecological aspirations are almost the same (Gerçekçioğlu and Ağaoğlu, 2013).

1. HEALTH EFFECTS OF CURRANT

Currants, whose nutritional content is given in Table 1, improves heart health, slows aging and plays an important role in preventing diseases such as Alzheimer's. It softens the skin and can be effective against psoriasis.

It protects body from cancer, improves eye health, strengthens the immune system, relieves constipation, regulates blood sugar levels, prevents anemia, strengthens bones, helps to slimming, prevents asthma and can prevent viral outbreaks.

Despite all these benefits, excessive consumption of currant oil can result with diarrhea or intestinal gas. Since it reduces blood coagulation, its consumption is not recommended for individuals who will undergo surgery (Pecko et al., 1993; Anonymous, 2009; Çelik, 2012; Gerçekçioğlu and Ağaoğlu, 2013; Okatan et al., 2015; Sezgin, 2015; Berk and Tuna, 2017; Ekşi, 2017).

Table 1: Nutritional Content of 100 g Currant Fruit (Sezgin, 2015)

	Water (g)	**Calory (kcal)**	**Protein (g)**	**Lipid (g)**	**Carbohydrate (g)**	**Diet fiber (g)**	**Vitamin C (mg)**	**Other Vitamins (mg)**	**Minerals (mg)**	**Antioxidant level (micromol TEAC)**
Red	70	56	1.3	0.2	7.9	3.5	80	0.324	368.13	2.10-2.24
Black	72	63	1.4	0.4	14.0	4.3	181	0.864	463.77	-

2. PLACE IN SYSTEMATICS

Currant has diploid chromosomes (2n = 16); placesin the *Ribes* genus of the Saxifragaceae family of the Rosales order, and polyploid forms have not yet been found in *Ribes* species. A tetraploid form has been identified only in Jostaberry (Ağaoğlu, 1986).

Today, although members of the *Ribes* genus are examined under 4 subgenus (*Berisia*, *Ribesia*, *Coreosma* and *Grossularia*), the red and white currant species are examined under the *Ribesia* subgenus, and the black currant species are placed under the *Coreosma* subgenus (Bauer et al., 1962; Okatan et al., 2015; Sezgin, 2015).

There are five types of currant in Turkey; these are black fruited currant (*Ribes nigrum* L.), Eastern black currant (*Ribes orientalis* L.), Alpine black currant (*Ribes alpinum* L.), Caucasian currant (*Ribes biebersteinii* berl. ex. Dc.) and ornamental species *Ribes rubrum* (Davis, 1972; Kayacık, 1975; Çelik, 2012).

3. PLANT CHARACTERISTICS

Although currants usually shed their leaves in winter, ever green varieties also exist. They can easily be affected by unfavorable conditions since they have fringed, thin and delicate roots (Figure 1).
The plant is generally 1-1.5 m tall with upright growing branched bushform. They regenerate from shoots emerging from the root collars. The bark of the thornless shoots can be peeled off and generally 2-3 years old shoots bear fruit. Black currant plants have a shorter life span

than red currants, while they are taller and stronger in structure. The edges of the leaves are saw tooth shaped, 3-5 lobed, sometimes sharp and bright green. Both deep sliced and non-sliced leaves can be seen and leaves are very similar to grape leaves (Figure 1).

Cluster type flower buds start blooming about one year after differentiation, blooming starts at base flowers towards the terminal of the clusters, tip of clusters produce low quality fruits and flowering ends in 3-4 weeks depending on the climatic conditions.

Figure 1: Roots (Left), Habitus (Middle) and Leaves (Right) Of Currant Plant

The down-facing, closed, small, hermaphrodite flowers may be white, yellow, orange or red in color and the clusters emerge at the terminal end of one-year-old branches. Filaments are shorter than the surrounding and wrapping sepals.

Its round and/or oval, multi-seeded, shiny and sourish fruits are botanically true fruits. The ripening fruit is semi-transparent, depending on the variety the flesh is red, white or black. Since those other than black currants are self-fertile, they can be grown as single variety, but instead it is beneficial to have different pollinators in the garden. Self-incompatible black currants can often bear fruit under controlled pollination, and sometimes stimulative parthenocarpic fruits may occur. Insects, especially honey bees, are effective in pollination. In studies on currants of foreign origin, it is stated that there is no requirement for a pollinator variety, as all varieties are self-fertile (Shoemaker, 1978; Pırlak and Güleryüz, 1977; Ağaoğlu, 1986; Koltowski et al., 1999; Densow, 2003; Erdoğan and Erdoğan, 2006). Red and white currants were first cultivated in the 15th century and found place in the gardens in the 16th century (Özbek, 1971). Fertilization is generally necessary for fruit formation in currants, and with a good fertilization, the number of seeds and therefore the fruit size increases. In black currants, pre-harvest fruit shedding may be observed due to insufficient pollination. In Ağaoğlu (1986), It is reported that unbalanced lengths of stigma and anther in a variety increase silking. In addition, late frosts and excessive rainfall during the flowering period may result with silking. Although the grain shape may vary depending on the variety, common forms are "Flat", "Round" and "Egg" (Ağaoğlu, 1986).

4. ECOLOGICAL REQUIREMENTS OF CURRANT

Karaer and Adak (2006) reported that natural currants (*R. orientale* Desf. and *R. Multiflorrum* Kit.) species of the *Ribes* genus can grow in different regions of Turkey up to 2500 m altitude, and even along the river edges at 3000 m altitude in Eastern/Central Anatolia regions

(Onur, 2006; Sezgin, 2015).

Ribes species stand out with their resistance to cold, with long chilling period requirements (800-1600 hours), early ripening and sensitivity to summer temperatures, which adapt the species well to northern regions. They can get protected from extreme winter colds by snows covering their bushes, which help plant to tolerate up to -35 °C temperatures during winters. Plants need 80-140 days to ripen their fruits depending on the variety and region, and are sensitive to high temperatures rather than cold; especially to hot summer winds. Although its resistance to cold is higher than other berries, black currants are slightly sensitive to harsh winters (Ağaoğlu, 1986; Göktaş et al., 2006; Kaplan and Akbulut, 2006; Gerçekçioğlu and Ağaoğlu, 2013). In terms of temperature, almost all berries fit well to winter wheat and grape cultivation zones. However, currant cultivation is very risky in regions with high probablity of late spring frost. This is particularly evident in black currants. Extreme weather conditions during the flowering period may result with silking. Red currants require less growing degree days for fruit ripening than blacks. Since currants flower early, at locations with late frost risk, establishing plantations on north-facing slopes or in intermediate directions can reduce frost damage by delaying flowering. Currant orchards should be protected from wind and need to receive plenty of sunlight. Especially in large scale gardens to be established for commercial purposes, the phenological periods should definitely be taken into consideration (Figure 2).

Although an annual rainfall of 800 mm is required for optimum development and good fruit quality, the distribution of this precipitation to months is more important. Since the roots are shallow, weekly mild irrigation will be helpful (Ağaoğlu, 1986). Although currants are not very selective in terms of soil, they grow well in permeable clayey-sandy rich soils containing >1% organic matter. They require organic fertilizer addition in heavy or light soils. At least 45-60 cm soil depth is adequate. Currant, prefer medium acidic soils (pH 5.5-6.5), and can not be grown economically in very salty and acidic soils (Ağaoğlu, 1986; Onur,1996; Okatan et al., 2015; Sezgin, 2015).

Figure 2: Phenological Periods in Currant

5. PROPAGATION METHODS FOR CURRANTS

Reproduction by seed: This method does not have any value for fruit production but used in breeding studies.

Propagation by plant cuttings: Many factors such as the plant growth stage, position of the cuttings on the plant, ecology, use of hormones and the variety are effective on rooting ratio of the cuttings (Kaşka and Onur, 1977; Polat et al., 2017). The most suitable method for red, white and black currants is propagation from stem cuttings. Cuttings should be taken from strong, well-developed, healthy branches during the dormant period, should be about 20 cm long, contain one or two buds at the tip of the cuttings and should be slightly coated to protect from drying. These cuttings get planted in the 5-8 cm x 20-25 cm distanced ditches and then the soil is needed to be compressed. Ideal planting time of cuttings is the end of September-early October. These cuttings normally produce roots until autumn, are ready to prune before planting and then growing in the nursery at a distance of 70 cm x 20 cm in the nursery garden in the second year before removing from soil at the end of second year (Figure 3). Although it depends on the rooting environment, currant cuttings do not require any hormone applications due to easiness of rooting. It is possible to propagate currants with root and wood-bud cuttings other than wood cuttings. However, fogging is necessary for good rooting of wood-bud cuttings. Fulfilling chilling requirement affects the rooting of currant cuttings positively.

Many researchers report that currants are also successfully propagated with green cuttings (Keipert, 1981; Ağaoğlu, 1986). For this purpose, green cuttings are cut from the mother plant in June and cleared of leaves except two leaves on terminal end. Cuttings are rooted in rooting medium by fogging during about two months.

Propagation by Layering: Tip layering usage is more common in currants. Tip layering (Figure 4) involves the cut of the top of a plant at dormant stage and then newly developing shoots coming from the bottom of the tree at the soil level get buried with soil. (Kaşka and Yılmaz, 1974; Anonymous, 2011).

Figure 3: Sapling Production Parcel (Left) and Planting of Cutting (Right)

Figure 4: Saplings Produced by Mound Layering

Plants targeted to be tip layered should be planted previous year and the stem should be cut over 2-3 cm above the ground level just before re-growth in the early spring in the second year. When new shoots reach a length of 2-12 cm, their stems should be burried with soil up to half the height of the shoot and repeated until the soil height is 15-20 cm. Rooted shoots need to be cut at dormant period and planted in the nursery. The parent plant can be utilised with this method for 15-20 years (Anonymous, 2011).

Propagation by Grafting: The purpose of this method is to reduce the infection risk, to reduce frost damage by obtaining a tall plant, to prevent fruit contaminations, to obtain machine harvestable forms and to facilitate regular maintenance activities. For grafting, the rootstock of *R. Aureum* preference is common which is substantially an ornamental species suitable to different grafting techniques (Ağaoğlu, 1986; Gerçekçioğlu and Ağaoğlu, 2013).

Propagation by tissue culture: Meristem culture, as one of the tissue culture methods, is currently the most used method. It is necessary to determine the appropriate culture medium by testing at targeted species and varieties to study (Ağaoğlu, 1986).

6. ESTABLISHMENT OF CURRANT ORCHARD

Currants, which produce fruits within 2-3 years after planting, reach full yield production within 4-5 years, and their economic life can reach up to 30 years depending on the maintenance and environmental conditions (Anonymous, 2011).

Ecological requirements and economic factors should be considered for the land selection for currant orchards and soil should be well prepared prior planting. Residues of previous crop should be cleared if exist and organic fertilizers should be applied if possible. Land should deeply plowed before planting, base fertilization is needed and if necessary, the soil should be leveled with 2nd class soil cultivation tools before planting.

Plantings: Although *Ribes* spp. can be grown in the bunch, fence or tree forms, it is common to grow in the form of a fence or in a tree form. Saplings to be planted should be one year old if possible, healthy and containing well developed roots and shoots (Figure 5). Although one year old are most preferred, two years old saplings can also be used. Although it is best to plant the saplings as soon as they enter the dormant period, they can also be planted in early spring before the beginning of development in very cold regions. Plant to plant distances can be between 1.0-1.5 m x 2.5-3.5 m depending on the growth form and targeted final shape of the species and varieties, the working width of the agricultural machinery to be used and the orchard layout types (Figure 6).

Figure 5: Saplings Ready for Planting

Rectangular planting, square planting and especially triangular planting can be chosen as the layout type. Waist or hand auger should be used for planting saplings in small orchards, but machine power may save time and cost for establishing large scale orchards. Sap should be given immediately after planting after planting pruned saplings.

Figure 6: A Newly Established (Left) and Fruitful Currant Orchard (Right)

7. MAINTENANCE ACTIVITIES

Systems of Pruning and Tree Forms: If bunch or fence forms were targeted, suitable 5-6 shoots emerging from the root collar are needed to be kept to form the shape, while dead and very weak shoots should be pulled out from the bottom. These selected 5-6 branches are needed to be pruned from the terminal end by keeping 6-10 eyes on each stem, depending on the plant's strength and variety/species feature. Pruning processes vary by species (Figure 7). Usually the fruits of black currants are formed on a vigorously growing one year old branch. In red currants, fruits mostly bear on 2-3 years old fruit branches, but 1 year old branches also bear fruit. Four years old branches are mostly unproductive and needed to be removed by pruning. In order to obtain the desired quantity and quality of fruit product, amount of 1-3 aged branches are protected or pruned. Thus, improved aeration and light penetration provided in the crown helps better disease and pest control (Ağaoğlu, 1986; Gerçekçioğlu and Ağaoğlu, 2013).

For single stem culture: Starting from the planting year, pruning is directed depending on the stem height and target shape. In all three systems, the aim is to increase the amount of quality fruits and scion by providing optimal air circulation and lighting between the crown and shoots. It is more appropirate to prune at the stage of post-defoliation in regions with mild winter, and at the stage of regrowth in colder regions.

Figure 7. Pruning in Bunch Form (Left), Fence Cultivation (Medium) and Single Stem Culture (Right)

Soil cultivation: The conventional tillage method is common in Turkey which cultivates soil deeply and intense but increases the production costs, rupture the soil structure and increases erosion especially in sloped lands. Total 34.4 % of Turkey's land is in this group (Korucu et al., 1998/2005). In the protective soil cultivation, which is getting more popular in recent years, bases on usage of secondary tillage equipments such as cultivator, disc harrow, chisel, etc., to add benefits of less time consumption and incorporating crop residues to soils. By this way, the above mentioned disadvantages of conventional tillage reduces significantly. Nitrogen and herbicide leaching was also found to be less in the protective tillage system (Önal, 1995).

Irrigation: Especially in arid and hot regions, irrigation should be done at regular intervals, considering ecological conditions of the region for an ideal development, yield and product quality. However, drip irrigation system should be preferred especially in big scaled orchards and areas if irrigation water is scarce. Since the quality of the irrigation water is important, it is required to be analysed. To estimate the irrigation time, soil samples taken from the depth at which moisture is to be measured are need to be squeezed in hand, observe the wetness and mud ball shape formed in hand, observe stripes formed between the fingers, and the color of mud. However, this method requires experience (Güngör et al., 2018).

Fertilization: Especially if the structure of the soil is too light or heavy, organic fertilization must be included with a certain plan and program. If commercial fertilizers are planned to be used, care should be taken to apply according to the soil or leaf analysis results. Fertilizer applications should target to approximate soil pH to 5.5-6.5.

Half of the nitrogenous fertilizers should be applied in early spring (about 3 weeks before re-growth), where the remainder should be applied just after the fruit set, before the rains if possible. Then mixing the applied fertilizer into the soil and irrigation is required. Since the movement of other fertilizers in the soil is much slower, they should be applied at the end of winter or at early spring when the weather conditions are available, with single application to the rhizosphere. If micronutrient deficiency is not excessive, it should be applied viafoliage (Ağaoğlu, 1986; Gerçekçioğlu and Ağaoğlu, 2013; Güneş et al., 2013). If drip irrigation system exist, water-soluble fertilizers may be prefered (Akgül and Uçgun, 2004).

Pest and Weed Control: Since currant cultivation is not widespread, its diseases and pests are not expected to be common, but environmental conditions and maintenance operations (such as pruning and irrigation) are increasing the spread of diseases, pests and weeds. The first step for timely and effective plant protection is the correct diagnosis of diseases, pests and weeds. It would be better to adopt an "Integrated Pest Management" including all functioning methods in a sequence at correct place and time, with special care to environment and human health, basicly aiming to keep the pest intensity below the economic damage threshold rather than a simple pesticide spraying.

8. HARVESTING, PACKAGING, STORAGE AND UTILISATION OF CURRANTS

Harvest period of currant is very long and harvest timing varies according to the targeted utilisation of the fruits. Harvest time is the pre-ripening stage for those to be used in the production of jelly, the full maturation stage for the fresh consumption, and post-full maturation stage for the jams. The harvest should be done by cutting the cluster stem with a knife. Timely harvest is important because, at delayed maturity stage, increased berries damage reduce vitamin C amount. The yield can be 1-4 kg/plant or up to 20 tons/ha depending on the variety, planting density, maintenance conditions and the region.

Although currant harvest can be done by hand or by machine, hand harvesting is common in Turkey since gardens are small scaled. In hand harvest, a worker can collect 60-70 kg/day product, depending on the condition of the garden, worker, yield, variety and layout type.

Among the berries, the most successful results in mechanical harvesting were obtained from currants. However, it should be taken into account that not all varieties are suitable for machine harvesting, and if the green tissues and shoots of the plant are damaged during machine harvesting, next year's yield loss may be up to 50 %.

Harvested currant fruits are packed in 0.5 kg packs for retail sale and in 5-10 kg in crates for the delivery to process in food industry. Packaged currants to be consumed fresh should be delivered to the market in small batches immediately.

Currants, have a short storage period due to high water content, but can be stored in cold storages for up to 5 weeks at -l / 0 °C and 90 % humidity after pre-cooling at 4 °C, and approximately weight loss during this periodis 3 %. Currants are beneficial for human health with their fine taste and fragrance, vitamin and other biochemical contents. They are mostly used for fruit juice, concentrate, jelly, jam, marmalade, composte, sugar, cake, ice cream, wine and fruit yoghurt production. Their fresh consumption is not common (Ağaoğlu, 1986; Göktaş et al., 2006; Kaplan and Akbulut, 2006; Gerçekçioğlu and Ağaoğlu, 2013).

9. SOME CURRANT CULTIVARS AND THEIR PROPERTIES

There are red, white and black varieties of cultivated culture forms. The main cultivars are given in the subsequent page (Anonymous, 2021b).

Rovada: The fruit of the variety with short clusters is red, medium-sized, sweet, aromatic, highly resistant to transportation and very productive. It is used in fruit juice and pastry industry.

Tokat 3: Its habitus is spreading, its bunches are large, black, its fruits are sweet, aromatic, its strength is high and it is very productive. It is used in fruit juice and pastry industry.

Red Lake: The bushes are completely upright and the habitus is wide-round. It is mid season, has long clusters, fruits are red, medium small, sweet, aromatic, resistant to transportation and very productive. It is used in fruit juice and pastry industry. It is mostly grown for fresh consumption.

Golyat: Small, short cluster, black, medium large, sweet, aromatic, resistant to transportation and very productive. It is used in fruit juice and pastry industry.

Jostaberry: "Blackcurrant x Gooseberry" hybrid (Keipert, 1981). Fruit size is between blackcurrant and gooseberry and rather resembles black currant. It has a shiny skin, no bubbles and no odor. Its plant develops very strongly. The leaves are medium-sized, wavy and shiny, resistant to diseases.

White Grape: Although it is the most well-known variety among the white varieties grown, it is not very important commercially. It is originated in Europe and has spread more in the USA.

Rosenthals: It is a variety with long, round and black berries with a cluster stalk and a thin skin. It has a sweet and strong aroma. It is a type sought after in the fruit juice industry. Habitus develops strongly and grows sideways. Since its shoots and flowers are sensitive to cold, it is not recommended for cold areas. High yield, early flowering and ripening. The shoots are bluish red, the leaf slices are deep, separated and pointed.

Wellington XXX: The variety has a versatile use. The bunches are long, but the fruit stalks are short. Berries; black, large, but the fruit skin is thick. Pruning should be done every year due to its strong development and high branching. It grows spreading. Its flowers are sensitive to cold. Fruit maturity is mid-season, yield is high.

Boskoop Giant: This variety, which was imported into our country and taken to trials, fluctuates in yield due to insufficient fertilization. Early ripening fruits are large and of high quality. It has spread from England to Europe and the USA.

Silvergieter: Since its bunches are a bit shorter than Rosenthals, the berries are more dense and have a short stem. Its development is strong, its shoots grow upright and its shoots have better frost resistance than Rosenthals. The leaves are darker, deeper and pointed than Rosenthal. Its flowers are sensitive to cold. Despite its high yield, it is not highly sought after in the industry because it is low in vitamin C and acid. It is early, its berries are large, thin-skinned and moderately aromatic. It is suitable for table consumption because it is sweet.

Çeliks: It is a variety of Sivas origin, obtained by selection by Yalova Atatürk Horticultural Central Research Institute in 2018. The plant is in bush form, grows upright and strong. It is an early variety. It is self-efficient. It begins to produce in the second year after planting. It is a very productive variety. It forms long and abundant fruit clusters. The cluster stem is long. The fruit is spherical, fleshy, juicy and very large, dark red. It is a variety suitable for fresh consumption and processing. It is sensitive to red spider. Regions that are humid, rainy and whose daytime temperature does not exceed 35 ° C in summer (Marmara, Black Sea, Central Anatolia, Eastern Anatolia and Aegean Region) (Anonymous, 2021b).

CONCLUSION

Cultivation of berry fruits-except strawberries-are not currently widespread in Turkey but many wildforms can be encountered in different regions of the country. There are five types of currant in Turkey; these are black fruited currant (*Ribes nigrum* L.), Eastern black currant (*Ribes orientalis* L.), Alpine black currant (*Ribes alpinum* L.), Caucasian currant (*Ribes biebersteinii* Berl.Ex.Dc.) and ornamental species (*Ribes rubrum*). Natural currants (*R. orientale* Desf. and *R. Multiflorrum* Kit.) species of the *Ribes* genus can grow in different regions of Turkey up to 2500 m altitude, and even along the river edges at 3000 m altitude in Eastern/Central Anatolia regions. Introduction and adaptation of currants have been studied and new, suitable varieties well adopted to different regions have been determined by many institutions, especially by Yalova Atatürk Horticultural Central Research Institute. Currant cultivation has a complementary position in small and medium scaled agricultural enterprises. But in such enterprises, it plays an important role in utilizing family workforce, to increase income, to settle a certain population in rural areas and to reduce migration to cities. *Ribes* species stand out with their resistance to cold, with long chilling period requirements (800-1600 hours), early ripening and sensitivity to summer temperatures, which adapt the species well to northern regions. They can get protected from extreme winter colds by snows covering their bushes, which help plant to tolerate up to -35°C temperatures during winters. Plants need 80-140 days to ripen their fruits depending on the variety and region, and are sensitive to high temperatures rather than cold; especially to hot summer winds. Extreme weather conditions during the flowering period may result with silking. Red currants require less growing degree days for fruit ripening than blacks. Since currants flower early, at locations with late frost risk, establishing plantations on north-facing slopesor in intermediate directions can reduce frost damage by delaying flowering. Although an annual rainfall of 800 mm is required for optimum development and good fruit quality, the distribution of this precipitation to months is more important. Since the roots are shallow, weekly mild irrigation will be helpful. Ecological requirements and economic factors should be considered for the land selection for currant orchards.

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CHAPTER 11

STORAGE OF KIWIFRUITS (*ACTINIDIA DELICIOSA* VAR. HAYWARD) IN CONTROLLED AND MODIFIED ATMOSPHERE CONDITIONS

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INTRODUCTION

Harvest maturity, storage conditions, and ethylene concentration are important factors in the storage of kiwifruits. Thus fruit softening and weight loss can reduce the amount of marketable fruits significantly. Arpaia et al. (1994) reported that kiwifruit firmness was rapidly reduced after harvest. However, this reduction was slowed down by low temperatures but did not stop completely due to ethylene concentration at storage conditions. They further stated that the reduction in kiwifruit firmness was closely correlated with degradation of fruit starch and 40% reduction in fruit firmness occurred during the first 3 months of storage. Furthermore fruit softening is an important factor for the storage of kiwifruit and the limit of weight loss is 3-4% during storage, otherwise shriveling will occur (McDonald, 1990). In addition, there is a close correlation between postharvest quality of Hayward variety and the total soluble solids (TSS) contents of fruits at harvest (Asami et al., 1988). According to Arpaia et al. (1984), softening of Hayward kiwifruit was excessive when stored at normal atmosphere (NA) (0ºC) condition and if movement of fruits to CA condition was delayed, the softening of fruits together with the increase of the total soluble solids (TSS) increased and reduction of titratable acidity occurred. On the other hand, storage in CA even after 180 days did not cause the same level of the reduction on the fruit firmness. Xu and Gao (1993) reported that fruit softening, ascorbic acid degradation, and total and invert sugars increased during the climacteric rise of Hayward variety kiwifruit in

CA condition whereas no significant change was observed in acidity. Many researchers have suggested the use of the CA storage system for kiwifruits and the suggested gas mixtures for kiwifruit storage were 3-5% CO_2 with 2-3% O_2 (McDonald and Harman, 1989), 5% CO_2 + 2% O_2 and 3% CO_2 + 3% O_2 , 3% O_2 + 3% CO_2 and 3% O_2 + 5% CO_2 (Sale, 1990). The usage of LDPE film during 7 months storage at 0°C and using polypropylene film during 5 to 7 days storage at room temperature were found as the most suitable storage conditions (Tanaka, 1987). Moreover, the use of low and medium density PE with different thickness and permeability property is recommended for the storage of Hayward variety. This reduced decay, softening, and weight lost and fruits could be stored successfully for six months with high quality (Manolopoulou et al., 1997).

1. MATERIAL AND METHODS

1.1. Plant Material

In this study, fruits of seven years old kiwifruit plantation of Hayward variety from an orchard in Çanakkale were used as plant material.

1.2. Storage systems and storage conditions

Storage trials were carried out in mechanically cooled rooms at 0°C- 1 °C with 90%- 95% RH conditions and three different storage systems such as NA, MA, and CA were used. Storage at normal atmosphere (NA) as control. Storage at modified atmosphere (MA): MA1: 12 µ PVC shrink film, MA2: 15 µ PVC shrink film MA3: 16 µ PVC shrink film. Storage at controlled atmosphere (CA): CA1: 3% O_2 + 3% CO_2, CA2: 3% O_2 + 5% CO_2, CA3: 5% O_2 + 5% CO_2.

For CA facilities, fruits were stored in 25 kg capacity plastic containers. For MA storage studies, PVC polymers with standard permeability to water, O_2 and CO_2 (15 µ PVC: 5753 ml O_2, 15880 ml CO_2/m^2.day.atm./100C, 200 g. water vapor/m^2.day.atm./100°C) were used in passive system. For CA storage studies, modified gas mixtures were obtained using a fluent system which can adjust gas mixture with micro valves by using flow board.

1.3. Quality assessments

After harvest and each two month storage period, some quality properties as fruit firmness, total soluble solids (TSS), titratable acidity (TA) and weight loss were evaluated. In this context, for flesh firmness determination, 1cm^2 of the skin was removed and penetration force measurements were individually recorded using a 5/16 (8 mm) diameter probe on a penetrometer (Bishop, Italy). Total soluble solids (TSS) concentration was determined in each fruit with a digital refractometer Atago PAL-1 (Atago Co. Ltd., Japan) at 20°C. For titratable acidity (citric acid) content determination, each replicate was measured electrometrically with WTW pH meter (WTW, Germany) as the neutralization the pH value of fruit juice to 8.10 with NaOH with 0.1normality. Moreover TA values were expressed as ($g.100g^{-1}$) of citric acid. Weight loss was measured as percentage of cumulative weight loss.

1.4. Statistical analyses

Data from 3 replicates with 25 fruits for each replicate were subjected to ANOVA analysis. Sources of variation were treatment and storage period. Mean comparisons were performed using LSD test at $p<0.05$ level using "Minitab 15" software.

2. RESULTS

2.1. Titratable acidity

Titratable acidity values of storage systems were found significantly different ($p < 0.05$) for first year (Table 1). Kiwi fruits stored at normal atmosphere (NA) had the highest titratable acidity and it was followed by MA and NA storage systems, respectively. However, the titratable acidity which was 1.55 g/100 g at harvest reduced during the storage and average storage period differences were found significant ($p < 0.05$).

The rate of decline in titratable acidity increased storage time. Changes in titratable acidity during storage showed variation depending on the storage systems and interaction between storage period and storage system was found significant ($p < 0.05$) (Table 1).

Table 1: Changes in titratable acidity (g.100g^{-1} citric acid) of kiwifruits stored at different systems.

Storage system (SS)	Storage Time (ST) (days)				SS average
	0	60	120	180	
NA	1.55 BC	1.67 A	1.60 AB	1.42 FGH	1.56 a
MA1	1.55 BC	1.52 CDE	1.50 CDE	1.42 FGH	1.50 cd
MA2	1.55 BC	1.52 CDE	1.50 CDE	1.56 BC	1.53 ab
MA3	1.55 BC	1.53 BCD	1.49 CDEF	1.46 DEFG	1.51 bc
CA1	1.55 BC	1.50 CDE	1.45 EFG	1.41 GH	1.48 cd
CA2	1.55 BC	1.47 DEFG	1.45 EFG	1.40 GH	1.47 d
CA3	1.55 BC	1.47 DEFG	1.45 EFG	1.37 H	1.46 d
ST average	1.55a	1.5257b	1.4914c	1.4343d	
LSD (0.05)		0.03			0.04

Storage System × Storage Time LSD (0.05): 0.08. Numbers within a column followed by the same letter are not significantly different (P<0.05).

2.2. Fruit firmness

The storage systems significantly affected fruit firmness ($p < 0.05$) (Table 2). The highest firmness was obtained in kiwifruits stored at CA3 and CA2 treatments, which were followed by CA1 treatment. In all MA treatments, fruit firmness ranged from 2.60 to 2.66 kg. In addition, NA (control) fruits had the lowest average fruit firmness (Table 3). Decline in fruit firmness, however where of different magnitudes depending on the storage systems and fruits stored in NA condition were softened in a shorter time than other treatments.

Table 2: Changes in fruit firmness (kg) of kiwifruits stored at different systems.

Storage Systems (ST)	Storage Time (ST) (days)				SS Average
	0	60	120	180	
NA	7.97 A	0.98 E	0.44 JK	0.34 KL	2.43 d
MA1	7.97 A	1.29 D	0.50 IJ	0.63 H	2.60 c
MA2	7.97 A	1.29 D	0.77 FG	0.613 HI	2.66 b
MA3	7.97 A	1.36 D	0.62 H	0.63 H	2.65 bc
CA1	7.97 A	1.74 C	0.65 H	0.28 L	2.66 b
CA2	7.97 A	2.13 B	0.85 F	0.64 H	2.90 a
CA3	7.97 A	2.12 B	0.88 EF	0.67 GH	2.91 a
ST Average	7.97 a	1.56 b	0.67 c	0.54 d	
LSD (0.05)	0.044				0.058

Storage System × Storage Time LSD (0.05): 0.12. Numbers within a column followed by the same letter are not significantly different (P<0.05).

2.3. Total soluble solids

Changes in TSS of the kiwifruits stored at different systems are given at Table 3. Differences among the storage systems in terms of TSS were found significant ($p < 0.05$) (Table 3).

The highest average TSS value with 13.95% was determined in fruits stored in NA condition, followed by MA (13.29-13.34%) and CA (12.52-13.15%) conditions. Differences among the storage periods in terms of TSS increase were significant ($p < 0.05$). Changes in TSS during storage for different storage periods depending on the storage systems and the interaction between storage period × storage system were also found significant ($p < 0.05$). This increase was higher in fruits stored in NA and MA than in fruits stored in CA (Table 3).

Table 3: Changes in TSS value (%) of kiwifruits stored at different systems.

Storage Systems (ST)	Storage Time (days)				SS Average
	0	60	120	180	
NA	7.8 I	15.0 C	16.4 A	16.6 A	13.98 a
MA1	7.8 I	14.1 G	15.5 B	15.7 B	13.28 bc
MA2	7.8 I	14.5 DEF	15.5 B	15.5 B	13.33 b
MA3	7.8 I	14.3 EFG	15.6 B	15.6 B	13.33 b
CA1	7.8 I	14.6 DE	15.1 C	15.1 C	13.15 c
CA2	7.8 I	14.2 FG	15.1 C	14.8 CD	12.98 d
CA3	7.8 I	13.7 H	14.3 EFG	14.2 FG	12.5 e
ST Average	7.8 c	14.34 b	15.37 a	15.36 a	
LSD (0.05)	0.12				0.16

Storage System × Storage Time LSD (0.05): 0.32. Numbers within a column followed by the same letter are not significantly different (*P*<0.05).

2.4. Weight Loss

Weight loss in different conditions observed at different magnitude depending on storage systems. Weight loss of fruits stored in NA was 4.88% after 60 days of storage, 10.15% after 120 days of storage, and 14.94% after 180 days of storage (Fig.1). In MA condition, weight loss was 2.06 - 2.52% after 60 days of storage, 4.12 - 5.21% after 120 days of storage, and 5.68 - 7.44% after 180 days of storage. On the other hand, weight loss was about 1% in CA conditions even after 180 days of storage. Weight loss in the kiwifruits stored in NA exceeded the 5% acceptable for marketing after 2 months storage and it reached to 10.15% after 4 months storage, which was unacceptable. About 5% weight loss was reached after 4 months of storage in MA whereas even after 6 months of storage in CA, weight loss did not reach to the 5%.

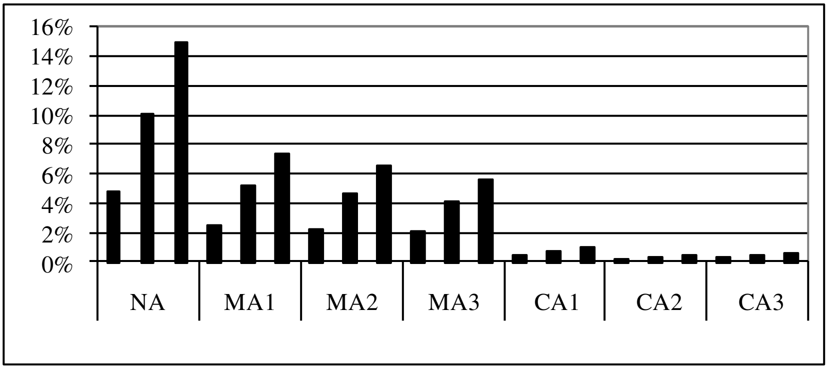

Figure 1: Average fruit weight loss values of Hayward kiwi variety during storage periods at different systems.

3. DISCUSSION AND CONCLUSION

The results of citric acid suggested that high CO_2 and low O_2 concentrations in CA treatments reduced the usage of organic acid and limit the activities of enzymes which play important roles in the transformation of malic acid to pyruvate and oxalic acid (Wang, 1990). Furthermore our results about the changes in titratable acidity during storage depending on storage systems agreed with the results of Park and Kim (1995). Our results of fruit firmness share similarities with the findings of (Crisosto et al., 1997). Softening can be explained as structural deformation of cell wall carbohydrates due to changes in enzyme activity. According to Agar (1993), CA prevents the decline in the fruit firmness by blocking the ethylene production since ethylene promotes activities of pectinesterase and polygalacturonase.

(Nicolas et al., 1989) reported that softening in kiwifruit during the prolonged storage periods could be reduced by high CO_2 treatment. (Brigati et al., 1989) also stated that high CO_2 treatment before storage did not affect the softening of kiwifruits and fruits stored in ULO conditions had the highest fruit firmness. (Arpai et al., 1994) proposed CA and low temperatures for the storage of kiwifruits and pointed out that the changes in the fruit firmness during storage were due to ethylene in storage atmosphere. These results generally agreed with our results related to fruit firmness, especially with our findings that fruit softening started at first period of storage and it was greatly prevented by storage in CA. As for total soluble solids, the results demonstrated that degradation of starch to sugars reduced significantly in MA and CA conditions. This effect could be explained by suppression of enzyme activities due to high CO_2 and low O_2 concentration in storage atmosphere (Hansen and Weichmann, 1987). The increase in TSS was higher in fruits stored in NA and MA than in fruits stored in CA that was similar to the results of Antunes & Sfakiotakis (2002).

Controlled atmosphere conditions with 5% O_2 + 5% CO_2 and 3% O_2 + 5% CO_2 gas combinations besides modified atmosphere based on 16 µ and 15 µ PVC shrink film affected fruit firmness, total soluble solids and titratable acidity positively. Thus these treatments reduced fruit softening, prevented rapid increase of TSS and decreased weight loss during storage during 6 months storage.

Kiwifruit is an important product for Turkey, especially for Black sea and Marmara region due to their climatic conditions. Prolonging the storage period with keeping the quality of this is very important because of its climacteric behavior. Storage in suitable modified atmosphere packaging or in controlled atmosphere with appropriate gas combinations can help in keeping its commercial quality for longer period.

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CHAPTER 12

HARVEST, STORAGE AND POST-HARVEST TECHNOLOGIES OF QUINCE

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INTRODUCTION

World quince (*Cydonia oblonga*) acreages increased by 14% in the last five seasons and reached 94 thousand ha in 2019/20 season. China ranks first with a 55% share of the quince acreages, Iran ranks second with 7.7% and Turkey ranks third with 7.6%. World quince production was 670 thousand tons with an average yield of 7.1 t/ha. Although China has seven times more quince acreages than Turkey, Turkey is leader in world quince production. Also Turkey is the world's largest quince exporter and 41.4% of the world's quince exports were made by Turkey (SGB, 2021).

Quince is in the pome fruits group and its fruit has fresh consumption in Turkey. Quince fruit has an important place in the Turkish economy. Acreages, production amount, yield data for quince for year 2019 for Turkey are given in Table 1.

Table 1: Acreages, production amount and yield data for quince for year 2019 for Turkey (TUIK, 2021)

Data	Unit	Value
Number of fruit bearing trees	tree	3,4 millions
Number of non fruit bearing trees	tree	0,8 millions
Total acreages of ordered orchards	ha	7.100
Yield for fruit bearing trees	kg/tree	53
Fruit production amount	tons	180.500

Quince production is concentrated in some zones in Turkey. Sakarya, Denizli, Bursa, Isparta, Kahramanmaraş and Çanakkale provinces covers 67% of the quince acreages in Turkey (SGB, 2021). The common quince variety in the Marmara Region, where quince cultivation is intense, is "Eşme quince". Unsold quince fruits are stored until the year end to market fruits for extended period of time (Türk, 1985). In general, for harvest timing, bark ground color changes are monitored and harvest starts when the color turns from dark green to light green. Quince fruit is very sensitive to crushing and bruising; therefore, as a result of careless harvesting and loading, brown spots may occur in the fruit peel and tissues under the peel (Özelkök et al., 1997).

Quince is an underutilized Mediterranean fruit. Therefore, there is very little knowledge on its storage and quality (Nanos et al., 2014). Quince can be stored successfully under 0-4°C temperature and 85-90% relative humidity conditions. Improper fruit harvest, transport and storage conditions increase physiological deterioration and result with market loss in export (Ryall and Pentzer, 1982; Türk, 1992). Within the scope of darkening, which is the most important physiological disorder seen in this fruit, it has been determined that different environmental conditions and harvest times affect the darkening of the fruit flesh of the "Eşme" quince. Delays in harvest time increases the fresh consumption quality at the beginning stage of storage, but results with an increase in the darkening of the fruit flesh. (Türk and Memiçoğlu, 1993).

1.QUALITY CRITERIA and OPTIMUM STORAGE CONDITIONS

Quince harvest time lasts from mid-September to the mid-October. The fruit can be stored at 0-2°C for 2-6 months but storage can be extended to seven months under controlled atmosphere conditions (2% O_2+ 3% CO_2 at 2°C). Flesh browning is the main storage limiting factor for quince fruit (Gunes, 2007).

Moradi et al. (2018) harvested fruits of 15 different quince genotypes at optimum maturity to store for 0, 30, 60, 90 and 120 days in cold storage and to observe changes in some quality parameters. At harvest time, the soluble solid content was between 13.0-18.8%, titratable acidity was between 0.38-0.95%, pH was between 2.55-3.75 and density was between 0.89-0.98 g/cm3. Also, carbohydrate content was between 255-349 mg/100 g DM, pectin content was between 7.3-23.0% and fiber content was between 11.7-33.3% across genotypes. Negative correlations were determined between weight loss and density.

Quince fruit is a rich source of bioactive compounds. The fruit of 15 quince genotypes were analysed by Moradi et al. (2016) and determined that fruit ascorbic acid (26.8 to 44.4 mg/100 g FW), total phenol (157.7 to 380.7 mg GAE 100−1 g FW), and total flavonoid (5.3 to 10.7 mg/100 g FW) concentrations, total antioxidant activity (86.7% to 98.2%) across genotypes at harvest time. The overall ascorbic acid, total antioxidant activity, total phenol and total flavonoid decreased during storage.

For the “Eşme” quince variety, the optimum harvest period for long-term storage is the stage when the ground color turns from green to yellow. At this stage the fruit flesh hardness is in the range of 12.5 kg-13.5 kg and the water-soluble dry matter ratio is around 13.4%-14.5%. While early harvest result with water loss and lack of taste improvement during storage, late harvest causes physiological and pathological deterioration (Kaynaş et al., 2011).

2.POST-HARVEST PHYSIOLOGICAL AND PATHOLOGICAL DISORDERS

2.1. Physiological Disorders

Flesh browning is the main storage disorder for quince fruit. It is triggered especially by the time of harvest and precipitation during the harvest period (Figure 1). The harvest stage and the location of the garden are very effective on the storage quality of “Eşme” quince (Türk and Memiçoğlu, 1993; Kaynaş et al., 2011). Especially late harvest and harvesting just after precipitation triggers internal browning at significant levels. It has been determined in previous studies that another factor affecting the physiological deterioration is calcium deficiency.

Another important physiological deterioration is scald. This is generally the case in cold storage below 0°C in early harvested quinces.

On the other hand, this fruit type is sensitive to water loss during cold storage. Harvesting by completely removing the fruit stalk, which is especially common in Turkey, greatly increases the water loss.

Figure 1: Internal browning (flesh browning) at quince.

2.2. Pathological Disorders

The most intense pathological deteriorations during cold storage process in quince are Brown rot caused by *Monilinia fructicola* (Figure 2), penicillium rot caused by *Penicillium expansum* (Figure 3) and black spots by *Fabraea maculata* (Figure 4). These pathological deteriorations cause significant losses at the post-harvest stage.

Figure 2: Brown rot

Figure 3: Pencillium rot

Figure 4: Black spots

3. POST-HARVEST TECHNOLOGIES

3.1. 1-Methylcyclopropene

1-Methylcyclopropene (1- MCP) is a chemical that inhibits ethylene in climacteric fruit and vegetable species in general (Sisler and Serek, 1997). 1-MCP, with its trade name Smartfresh^{TM}, is considered to be the most easy and effective application to control ripening at post-harvest stages. Various studies on this subject also support this view. Functionally, 1-MCP chemically binds to ethylene receptors and is not activated by inhibiting ethylene binding. The effective application concentration of 1-MCP varies according to the product, time, temperature and application method (Watkins, 2002).

1-MCP applications in quince, which is a climacteric fruit type, have significant effects on storage quality of fruits when harvest was performed at the optimum time (Sakaldaş et al., 2010). It significantly reduce the inner browning (Figure 5). Today, Smartfresh brand product licensed by Agrofresh company is generally applied by commercial quince warehouses.

Figure 5: General internal view of fruits after 6 months of cold storage in quince with 1-MCP application

In a study of Nanos et al. (2014), quince fruits harvested at commercial maturity, were treated with 600 nl L-1 1-MCP for five days and stored at 2°C with no cover or at 10°C in loosely closed polyethylen bags for up to 151 days. Also a part of fruits were stored in a storage room with gradual decrease of temperature from 20 to 2°C within a month at 80-90% RH. Control fruit were kept at ambient conditions at 4-17°C at 35-95% RH. Fruit stored at 2°C or treated with 1-MCP were greener (lower a*, b* and chroma values and higher hue angle values) compared to fruits stored at higher temperatures. 1-MCP treatment or storage at 2°C were not effective to improve flesh firmness of fruits. Fruits developed flesh browning at ambient conditions. As a result of the study, storing quince at 10°C in polyethylen bags without 1-MCP treatment was recommended for acceptable quince fruit quality for up to 106 d.

3.2. Controlled Atmosphere

Tuna et al. (2008) was determined that under controlled atmosphere storage conditions of 2% O_2 + 3% CO_2, quality of "Eşme" quince was protected during seven months of storage. However, it is absolutely necessary to determine the storage performance of quince under ULO and dynamically controlled atmosphere storage conditions.

An experiment was conducted by Rahemi & Akbari (2003) to evaluate the effects of the type of packing under heat treatment on storage quality of quince fruits. Fruits were kept at 38°C for 0 hr, 36 hr and 72 hr, then packed in polyethylene bags (with or without holes) and stored at 0°C for periods of 2,5 and 5 months. As a results, 36 hr heat treatment significantly increased fruit firmness, reduced astringency and weight loss of fruits after 2,5 months or five months storage at 0°C.

3.3. Antifungal treatments

The use of vegetable oils based fungicides against the pathological deterioration in quince at post-harvest stage has started in recent years. Since the surface structure of the quince is not suitable for water immersion applications, these fungicides are applied by fogging method.

3.4. Gamma irradiation treatment

Gamma irradiation is an effective alternative methods for preserving foods as an alternative to chemicals. Matured green quince fruits were harvested at commercial maturity, irradiated with 0.3–2.1 kGy gamma irradiation and storaged under ambient (temperature 15 ± 2°C, RH 85%) conditions to evaluate feasibility of gamma irradiation to extend fruit shelf-life in the study of Hussain et al. (2019). Physico-chemical parameters of the fruits were evaluated at five days intervals. Irradiation treatment significantly maintained the storage quality of fruits. Positive correlations observed for the irradiation and firmness retention. Inverse correlation was determined between radiation and water soluble pectin. Decrease in L value for color scores of the fruits was 13.1% for control fruits 3.4% for 1.8 kGy irradiated fruits and and 2.8% for 2.1 kGy irradiated fruits after storage for 30 days. Dose at 1.8–2.1 kGy range were significantly inhibited decaying in quince and extended storage about 40 days under ambient storage.

CONCLUSION

Quince is one of the most important export products of Turkey and protecting its quality and shelf life during harvest, cold storage and transportation is an important aspect to prevent value losses during domestic and foreign trade. In this context, the practices of precision in harvesting and quality preservation in cold storage will minimize post-harvest losses. Post-harvest losses in quince and fluctuations in export markets force producers especially in the most important production region, Marmara. Besides, it will be possible to supply quality products in a long period of time to the domestic market as well as in exports. This situation will provide an advantage to the country's economy, producers and consumers. On the other hand, increasing the numbers of single variety orchards especially in the Marmara and Aegean regions may increase export quantities of this low input fruit type.

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CHAPTER 13

CITRUS GROWING

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INTRODUCTION

Citrus is a plant community that includes species that are widely cultivated and have economic value, such as grapefruit, lemon, mandarin and orange, as well as other species such as shadok, laym, citron and bergamot. The origin of citrus fruits is in Southeast Asia, including the region that spreads from East Arabia to the Philippines and from the south of the Himalayas to Indonesia-Australia. In this area, it is believed that Northeast India and North Burma are the centres of origin. However, according to the latest findings, it is seen that China is important as a homeland due to the presence of many different citrus species in the Yunnan region (Davies and Albrigo, 1994; İncesu, 2011). Citrus cultivation globally is mostly carried out between 400 north and south latitude, but this may narrow according to regional changes in altitude and climate (Spiegel-Roy and Goldschmidt, 1996). Citrus fruits are economically grown in three main regions: tropical, semitropic and subtropical. Although its homeland is tropical and semitropic regions, citrus cultivation is widespread in subtropical regions. In subtropical regions, production is carried out for home consumption; in other regions, it is generally oriented to industry. In the tropical and semitropic regions, the inner and outer colouration and the quality of the fruit are not good, and the aroma is insufficient (İncesu, 2011). Citrus production of Turkey can be classified into three regions as Mediterranean, Aegean and Eastern Black Sea. The ecological conditions of our country allow for extremely successful citrus cultivation in terms of quality in the Mediterranean and Aegean Regions. World citrus production has increased significantly in recent years and reached 157,979,260 tons in 2019. With this production value, citrus fruits have the largest trade capacity and are the most produced fruits in the world (FAO, 2019). While orange (49.81%) has the largest portion in world citrus production, it is followed by mandarin (22.44%), lemon (12.69%), grapefruit (5.89%) and other citrus species (9.17%), respectively. Considering the areas where citrus fruits are grown in the world, the largest citrus producer countries in the northern hemisphere are the USA and Mexico in North America; the Dominican Republic, Cuba and Venezuela in Central America; Turkey, Italy, Spain, Greece, Morocco, Egypt, Tunisia, Syria, Algeria, Israel, TRNC, Southern Cyprus in the Mediterranean countries; China, Japan, India, Pakistan from Asian countries. Major producer countries in the southern hemisphere are Brazil, Argentina, the Republic of South Africa and Australia. The amount of citrus fruits produced in the northern hemisphere constitutes 74% of the world production (Yeşiloğlu et al., 2007; İncesu, 2011). The largest citrus producer country in the world is China, followed by Brazil, India, Mexico, the USA and Spain (FAO, 2019). According to 2019 data, our total citrus production is 4.301.415 tons. 1,700,000 tons of orange (39.50%), 1,400,000 tons of mandarin (32.54%), 950,000 tons of lemon (22.08%), 249,185 tons of grapefruit (5.79%) and 2230 tons of sour orange (0.09%) constitute this amount. Turkey's proportion in the world's total citrus fruit production is approximately 2.7% (FAO, 2019). When Turkey citrus production values are examined between 1980 and 2019, there was an increase of approximately 26.92% in our total citrus production (Table 1).

Table1: Citrus Production of Turkey on the bases of Species (Tonne) (FAO, 2019).

Tonne/Year	1980	1990	2000	2010	2019
Orange	679.000	735.000	1.070.000	1.710.500	1.700.000
Mandarin	167.000	345.000	560.000	858.699	1.400.000
Lemon	283.000	357.000	460.000	787.063	950.000
Grapefruit	17.000	33.000	130.000	213.768	249.185
Sou Orange etc.	12.000	4000	2200	2.346	2.230
Total	**1.158.000**	**1.474.000**	**2.222.200**	**3.572.376**	**4.301.415**

Turkey makes up to 94% of its citrus exports to countries such as Eastern European countries (especially Russia, Ukraine, Romania, Poland and Bulgaria) and Middle Eastern countries (Iran, Iraq and Saudi Arabia), where the consumer reflex has not yet fully developed (Yeşiloğlu, 2012). Citrus fruits, which have significant benefits to human health, are used as jam, marmalade, fruit juice, as well as fresh consumption and used as a raw material in the cosmetics and pastry industry. Citrus fruits have high nutritional components such as carotenoids, phenolic compounds and vitamin C. These herbal chemicals with high antioxidant content protect cells against oxidative damage caused by free radicals. Phenolic acids are very important in terms of health due to their antioxidant content and protective properties against various diseases. Citrus fruits containing ascorbic acid are an important fruit in human nutrition, and ascorbic acid is an additive in many foods due to its antioxidant capacity (Burdurlu et al., 2006; Dhuique-Mayer, 2007; Xu et al., 2007).

1. IMPORTANT CITRUS TYPES AND VARIETIES

1.1. ORANGE (*Citrus sinensis* (L.) Osb.)

Oranges are pomologically examined in 4 groups as navel, normal, blood and sugar oranges. The most important feature of blood oranges is its pulp and its fruit skin, which contains red colour pigments originating from anthocyanin in some cases. Colour pigments increase at low night temperature (Rapisarda et al., 2001). The reason why blood orange cultivation is intense in Mediterranean countries is that the night temperature is low and the daytime temperature is high in these regions. Some important orange varieties grown are:

Washington Navel: This variety, which forms the basis of the navel oranges group, was formed due to the natural eye mutation from the Celesta orange variety in the Bahia region of Brazil before 1822. Washington Navel has very common cultivation areas due to its early season and seedless, medium-large, dark orange coloured, easily peeled sweet, specially flavoured fruits. Compared to other orange varieties, it was determined that the tree growth force was little, the productivity was more moderate than the others, and the variety was very selective in terms of climate. This is one of the most important factors limiting its cultivation. It is an early medium variety suitable for storage and transportation. Due to the parthenocarpy, severe cold, hot or dry winds create important fruit dumps. The best quality Washington Navel orange can only be obtained in the mild subtropical Mediterranean climate. Despite this, Washington Navel is one of the most important fresh consumption varieties in the regions where there is extensive citrus growing in the world and constitutes a large part of the citrus production areas of China, Spain, Morocco, Turkey, South Africa, California, Australia, Uruguay and Argentina (Saunt, 2000). The fruits are round, with a navel at the style end. The peel is orange-dark orange and slightly rough; the peel is normally attached to the pulp. The pulp is orange-coloured, crispy, aromatic, superior quality, very tasty and an important fresh consumption (Özsan and Bahçecioğlu, 1970; Tuzcu, 1990).

Navelate: It was obtained as a result of a natural mutation from Washington Navel in Spain. Although its fruits are similar to the Washington Navel, they are smaller, lighter in colour, and the trees have a larger habitus than the Washington Navel. The fruit ripening period is February, but it can remain on the tree until the middle of April. It is one of Spain's important orange varieties (Saunt, 2000).

Lane Late: It is obtained from Washington Navel as a result of a bud mutation. It is a variety originating from Australia. Its trees have the same features as the Washington Navel. Fruits are smaller and brighter than Washington Navel. It is about two months later than Washington Navel orange variety. The tree size is the same as Washington Navel. (Saunt, 2000).

Valencia: It was formed in Spain in 1860 as a result of natural mutation. It is a late variety with high total temperature demand, resistant to high temperatures. It is seedless in commercial terms. Fruits are small, juicy, slice membrane thick and self-fertile. In subtropical climate conditions, the flowering period and the fruit maturity period coincide simultaneously (Saunt, 2000).

Cara Cara: It was obtained by natural mutation from Washington Navel in Venezuela in 1976. Tree characteristics are similar to the Washington Navel orange variety. The pulp is red, the skin colour is normal orange, and light pink spots can be seen towards the end of the harvest. The fruit navel is closed and small.

Tarocco: It is a blood orange originating in Italy. It is a medium-sized, round-oval-shaped, highly juicy, fruitful, quality and seedless variety. The pulp is coloured in medium darkness, and the colouration is in the form of a line. It is a mid-season orange variety that ripens between December and January. Fruit dumps occur when the harvest is delayed. It is suitable for storage.

Moro: It is a blood orange variety originating from Sicily. It is a very fruitful, medium-sized, easy-to-peel, low-seeded variety with a slightly rough skin harvested the earliest among blood oranges. The fruit quality is high, the fruit shape is round and slightly oval, and the pulp varies from pink to dark red. It ripens in December and cannot stand on the tree after ripening. Its fruits are in the form of clusters on the tree. It is a variety that can adapt to different ecologies (Tuzcu, 1990; Saunt, 2000)

Sanguinello: It is a variety of Sicily origin and is highly grown in Catania and Syrakus regions. Its fruits are long oval-shaped, pitted, delicious, forming round habitus and have partly red fruit pulp.

Sanguinello blood orange is a late variety that matures in February (Hodgson, 1967).

1.2. MANDARIN (*Citrus reticulata* Blanco)

Mandarins are examined in four groups as Satsuma mandarins, Mediterranean mandarins, King mandarins and Normal mandarins. Some important cultivated mandarin varieties are:

Satsuma: Originated from Japan. It is produced intensively in Japan and Spain and very resistant to cold. It is seedless, slightly rough, and the fruit peel is yellow-orange. Fruits are yield, medium-sized, ellipse-shaped, and they are suitable for transport and storage. Satsuma mandarin variety is divided into two groups as Owari and Wase.

Miho Wase: It was obtained by controlled hybridization from Miyagawa variety in Japan in 1940. Miho Wase trees have a better growth tendency than Okitsu variety. It is an abundant, easily peeled, very early variety with small and flat fruits. It is harvested between September and October.

Dobeshi Beni: Californian, satsuma hybrid variety. Its resistance to cold is very good, and its trees show strong development. It is a highly efficient variety suitable for storage and transportation. Fruits are flat and seedless, with rough and thin skin darker in colour than the satsuma mandarin variety. Its harvest starts in October.

W.Murcott: It is one of the most preferred varieties in the mandarin garden plant, the importance of which has increased in our country in recent years. It is of Moroccan origin. Its fruits are medium-sized and ellipse-shaped. The fruit peel is thin and slightly rough, orange in colour and easy to peel. It is fruitful, and it yields early. It is harvested in February. It is named Nadarcott in Morocco and W.Murcott in California.

Ortanique: It was obtained as a chance seedling in Jamaica in 1920. The peel is thick, hard to peel, rough and yellow-orange, and the fruits are large, ellipse-shaped and seeded. It is a mid-late mandarin variety (Reuther et al., 1967).

Klemantin: It is a medium-early variety with medium-sized trees. The peel and pulp of the fruit are dark orange. It is a yield variety with high fruit juice content. The number of seeds varies depending on the type of pollinator. It matures in early November.

Nova: It was formed by the hybridization of Clemantine mandarine and Orlando tangelo. The harvest time is between November and December. The peel is slightly rough, orange in colour and tightly attached to the fruit pulp. It is a juicy, seedly type of mandarin with very good fruit quality.

1.3. LEMON (*Citrus lemon* Burm. F.)

Almost all of the lemon production in Turkey comes from Mersin (53%), Adana (30%), Muğla (7.23%), Antalya (5.37%) and Hatay (4.53%). Small amounts of lemon are produced in Aydın, İzmir and Osmaniye provinces (TUİK, 2019). 50% of the lemon varieties grown in Turkey are Kütdiken, 20% Interdonato, 20% Meyer and 10% Aydın, Italyan Memeli, Lamas, Molla Mehmet, Cyprus and Eureka varieties (Yeşiloğlu et al. 2017). Some important lemon varieties grown are:

Interdonato lemon: It is of Sicilian origin. It is the earliest lemon variety that grows most in our country throughout the world. The tree grows at medium strength and tends to periodicity, so its productivity is uneven. It is medium yielding, and fruits are wide and long cylindrical. Fruits are scattered on the tree. The peel is light green during the harvest period, which is from September to October. Since its fruits are marketed in the early period, they are not stored. Interdonato variety is an early variety, proportionally resistant to phoma tracheiphila disease. Since Interdonato is heavily affected by ecological problems, there is a decrease in its production.

Kütdiken: Its origin is thought to be Italy. It is the oldest lemon variety in Turkey. It is in the Eureka group, Feminello sub-group and, with its very superior fruit quality, the most produced and stored variety in Turkey. Fruit skin colour is light green-yellow or lemon yellow, and the style end is not well developed. Its fruit is elliptical. It is highly efficient and gives regular fruit. Its trees grow at medium strength, the distribution of fruits on the tree is regular. It is a mid-season variety. Superior fruit quality increases its export availability. This variety is widespread in the Mediterranean region, especially in Hatay and Mersin provinces; however, it is necessary to be careful in selecting the garden places, and maintenance works to be applied because it is sensiti phoma tracheiphila and pytophthora (Tuzcu, 1990).

Meyer lemon: A variety of Chinese origin obtained in 1908. It is thought that it is not a true lemon but a hybrid of lemon with orange or lemon with mandarin. Its harvest starts in September. The shape of the fruit is round, and the style end is very small. The peel is smooth and yellowish-orange in colour. It is not resistant to storage due to its thin peel thickness. Meyer lemon has become an increasingly important lemon variety in recent years due to its early yield, being earlier and fruitful, high water content, and more resistance to low temperature and phoma tracheiphila disease than other lemon varieties. When they are budded on Volkameriana rootstocks, they begin to yield earlier.

Italian lemon: It is grown especially in the Mersin region in Turkey. A seeded, juicy, regularly yielded lemon variety with a spinning top shape and a lemon yellow peel colour. It is resistant to phoma tracheiphila disease. Harvest time is between November and January (Tuzcu, 1990).

Molla Mehmet lemon: It is a widely grown lemon variety in Mersin and its surroundings in Turkey. The fruit has a neck, rough and blant tip shaped. It is resistant to phoma tracheiphila disease. It is a high yielding fruit, and it gives fruit regularly.

Cyprus lemon variety: It is believed that it entered our country in 1920 from the island of Cyprus to Anamur and Alanya province. It is a native variety common in the Western Mediterranean region. It is productive and yields early. The fruit quality is high, and it is not suitable for storage. Its fruits ripen in mid-November.

Eureka lemon variety: It is the main lemon variety of many lemon-producing countries globally, especially Italy and Spain. It constitutes an important part of lemon production in California, South Africa, Australia, Israel and Argentina (Barry et al., 2020). Eureka is fruitful, yield fruit early, and the trees grow flat and less thorny. Fruits are round-shaped, and style end formation is less apparent. It is less tolerant to low temperatures and very susceptible to phoma tracheiphila disease.

1.4. GRAPEFRUIT (*Citrus paradisi* Macf.)

It originated on the island of Barbados as a chance seedling. It is thought to be a natural orange-chadok (pummelo) hybrid. Some important grapefruit varieties that are cultivated are:

Rio Red: It is one of the coloured grapefruit varieties found due to eye mutation from Ruby Red. It is less seeded and forms homogeneous fruit with quite high fruit juice. Trees are strong and grow flat. The fruit pulp is dark red, and the fruits are round shaped. The fruit shell is tightly attached to the fruit pulp, which can remain on the tree for a long time after ripening. It is a late grapefruit variety harvested in January-February (Saunt, 2000).

Star Ruby: It was obtained by artificial mutation from the seed of the Hudson variety in the USA. The fruit shape is round. The peel is red, smooth and tightly attached to the fruit pulp. It is medium-yielding, commercial seedless and the least bitterness grapefruit variety whose fruits, with a dark colour of fruit pulp harvested in November-

December (Saunt, 2000). It is the most sensitive to ecology among the grapefruits and quite sensitive to herbicides.

Henderson: It is a more fertile and seeded variety formed due to an eye mutation in the USA, producing more homogeneous fruit than Star Ruby. The flesh is dark red, and the fruit juice is red due to the red colour of the fruit flesh. It is suitable for fresh consumption.

Marsh Seedless: It is obtained as a chance seedling from the Duncan grapefruit variety. It is seedless, fruitful, and gives regular fruit in clusters that can stay on the tree for a long time. It is a mid-season variety suitable for preservation and can be harvested in January-February. The pulp is very juicy and light yellow. It is the most cultivated variety among the white fleshy grapefruit varieties.

2. ROOTSTOCKS

Approximately 95% of the sour orange varieties in Turkey are grafted on the sour orange rootstock due to its suitable rootstock characteristics and is followed by three-leafed rootstocks such as Carrizo and Troyer citrange. Sour orange rootstock is widely used in the Mediterranean region, which constitutes a large part of our country's total sour orange production. Due to various diseases, obtaining an alternative rootstock that can replace sour orange rootstock with superior characteristics has gained importance (Uysal, 2009). Tristeza disease poses a huge risk in sour orange production in the world sour orange industry. Sour orange rootstock is very susceptible to Tristeza disease. This disease factor has no intensity in our country due to the fewer numbers of the insect race that carries the disease. As a result of the drying of sour orange trees in many countries worldwide due to Tristeza, other rootstocks instead of sour orange are converged. The lime ratio is high in almost all of the soils in Turkey, where citrus fruits production are held, so the selection of rootstocks with good tolerance to iron chlorosis emerging in this alkaline soil is a very important issue. It is of great importance to choose a highly tolerant or durable rootstock for *Phytopthora* spp. disease, which is common in our heavily textured soils. For this reason, different rootstocks are used in citrus fruits except for sour orange.

Common Sour Orange: It is widely used as rootstock for orange, grapefruit, mandarin and lemon in citrus-producing countries, especially in Mediterranean countries. Although it continues to be used as the most common rootstock in sour orange growing areas in the world, especially because mandarin, grapefruit and oranges grafted on sour orange are susceptible to Tristeza (CTV) virus disease, its usage has been restricted in newly established gardens in Australia, Argentina, Brazil, California, Spain, South Africa and a large part of Florida. However, sour orange is a very good rootstock for fresh citrus production in medium-heavy soils where CTV is not a problem (Davies and Albrigo, 1994). The varieties grafted on the sour orange form are medium strength and large trees. It grows more slowly than the rough lemon rootstock. The drought resistance of the varieties grafted on this rootstock is moderate. Since sour orange is resistant to high soil pH, it is widely used in heavy soils with poor drainage (Davies and Albrigo, 1994). Resistant to calcareous soils, this rootstock generally shows a good match in other commercial varieties except for satsuma mandarins, kumquats and some lemons. When sour orange is used as rootstock, it is not a significant problem for Exocortis, Xyloporosisvirus disease. It is generally defined as resistant to *Phytopthora* spp. disease. It can show sensitivity to *Phoma tracheiphile* disease and nematodes. As they form approximately 85% nucellar embryos, they give uniform seedlings. It has a moderate effect on growth, productivity, harvest, fruit quality and economic life (Sakovich, 1986; Davies and Albrigo, 1994; Tuzcu, 1994; Saunt, 2000).

Gou Tou Orange: It is s a Chinese rootstock, tolerant to Tristeza. Gou Tou rootstock has been reported to be tolerant to *Phytophthora citrophthora* and *Phytophthora parasitica* diseases (Matheron et al., 1998). Saunt (2000), in his study in Florida, reported that citrus fruits grafted on Gou Tou rootstock form a larger shape than those grafted on sour orange rootstock.

Volkameriana: It is an Italian rootstock. It is a hybrid of lemon x sour orange. It can adapt to different soil conditions and creates fertile trees in warm regions. It starts the yield early, creates strong trees and increases the fruit size in the varieties that it is grafted on. It is a rootstock that adapts to calcareous soils and has poor salt resistance (Davies and Albrigo, 1994). It is (Exocortis), Tristeza (CTV) and Xyloporosis diseases tolerant and is resistant to *Phoma tracheiphila*. It is a rootstock compatible with citrus species and varieties (Sakovich, 1986; Saunt, 2000).

Carrizo citrange: It is a rootstock obtained by Swingle in 1897 by hybridization of Washington Navel orange x trifoliate poncirus. It develops poorly in calcareous soils. However, it is more successful than three-leaf rootstock in adaptation to calcareous soils (Davies and Albrigo, 1994). It is an early fruit with a high yield and resistance to drought and *Phoma tracheiphila* disease (Özcan and Ulubelde, 1984; Castle, 1984; Jackson, 1985). It withstands to Tristeza and Xyloporosis virus disease. *Pytophthora* is tolerant to *Citrophthora*. Because of these features, it is widely used as a rootstock (Saunt, 2000). Campbell (1991), in his study, reported that Carrizo citrange showed a weak development in calcareous soils with high pH and microelement deficiency was observed in such soils.

Troyer citrange: It is a Washington Navel orange x Trifoliate hybrid (Özcan and Ulubelde, 1984). It suits calcareous soils better than Trifoliate. It develops poorly in salty soils and tolerant to Psorosis, Tristeza and Xyloporosis. Moderately resistant to cold, it is a rootstock sensitive to exocortis disease.

C-35 Citrange: It was obtained by hybridization of Ruby Blood orange and Trifoliate rootstock. It produces 25% smaller trees than the Troyer citrange rootstock. Its resistance to cold is at least as much as Carrizo citrant, and its resistance to calcareous soils is more sensitive than Carrizo citrant. It has good adaptability with clayey, sandy-clayey, sandy soils (Saunt, 2000; Forner-Giner et al., 2003). It is tolerant of Tristeza and Pytophthora diseases.

Poncirus Trifoliate: It is a rootstock used for the satsuma mandarin variety in Japan and an ornamental plant in China (Castle, 1987). It is a type that shed its leaves, which are in three parts, among citrus types. Flower bud formation occurs one year earlier. It has a high tendency to polyembryonia. It is very sensitive to exocortis disease and tolerant to Tristeza and Pytopthora (Castle, 1987; Saunt, 2000). It is a rootstock that is very sensitive to calcareous soils and has good tolerance to cold.

3. CLIMATE

The most important factor limiting citrus cultivation is low temperatures. Therefore, it is a subtropical climate zone fruit species. Citrus fruits are grown in three different climate zones, mainly tropical, semitropic and subtropic regions.

Tropical Region: It is the zone where the temperatures are quite stable, and the temperature degrees are close to each other; that is, there are no significant differences between temperatures. There is not much difference between day and night temperatures. The temperature is 30-32 degrees, but the precipitation is quite high, and the precipitation is distributed throughout the year. The Tropical Region is located between 22 and 23 latitude degrees of the Equator. Getting higher from here, semitropical, subtropical, and even terrestrial climate can be encountered. Since there are short day and night differences in this region, colouration is not good; oranges take on yellow-green. However, dry substance and acid formation are also not good in hot regions. The fruits grown here are of poor quality, juicy, colourless and flavourless. In this region, production is carried out for industrial farming, not for daily consumption. The cultivation of the fruits is distributed throughout the year.

Semitropic Zone: It is located in the zone between 22-23 latitude and 28-29 latitude in the world. The climate of this region is hot and rainy in summers, with dry and warm winters. Here, citrus fruits bloom depending on the dry and rainy period. Flowering can occur in both periods (in dry and rainy periods). Citrus fruits grown in this region are not as poor quality as in the tropics. Citrus growing is suitable for industry. Although it is consumed fresh, fruit production is mostly for the industry. The higher the altitude, the higher the quality is. Fresh consumption is carried out in higher places as the colouring is better.

Subtropical Region: It is located in the zone between 30 and 40 degrees latitude in the world. Summers here are hot and dry; winters are rainy and cold. The most prominent subtropical regions of the world are the Mediterranean, California, Southern Hemisphere, the south of Australia, and the middle regions of Chile in South America. Production for fresh consumption is important in these regions. Subtropical regions are mandarin and orange regions in terms of quality. As we approach north to 40 degrees latitude, orange leaves its place to mandarin.

4. TEMPERATURE

The temperatures that limit citrus cultivation are low. If we list the species from heat-sensitive to heat resistance as a plant, the most sensitive species is citron, followed by Mexican Lime and limes. Next comes lemon, grapefruit, orange, sour orange, mandarin and kumquat. Trifoliate are the most durable among citrus fruits. Some trifoliate varieties can withstand temperatures of -22 ^{o}C. Hamlin orange is the most resistant orange to low temperatures. The Duncan variety is the most durable of the grapefruits. The most durable mandarin variety is Satsuma mandarin. Apart from the low temperature, the growth temperature is also important. Webber accepts growth temperature as a physiological zero temperature of 12.8 ^{o}C in citrus fruits. Citrus fruits do not grow below this temperature; vegetative growth begins on it. Studies have shown that 12.8 ^{o}C cannot be generalized for all citrus fruits. 12.8 ^{o}C is the physiological zero temperature for sour orange, orange and some mandarin varieties. We can say that acidic fruits and grapefruits start to grow after 6 to 8 ^{o}C. On the other hand, growth starts at 15-16 ^{o}C in trifoliate. In order to obtain good fruit in terms of quality in citrus fruits, we must know the total temperature demand of the species. The sum of temperatures in citrus fruits is generally the sum of temperatures above 12.8 ^{o}C. Among the commercially grown citrus varieties, the species with the highest temperature total requirement is grapefruit. Grapefruits need a total temperature of 2400-3770 degrees. Turkey's average total temperature is between 2200-2500 degrees. This situation affects the fruit quality in grapefruits. The total temperature demand in mandarins varies between 2500 and 2800 degrees. It drops to 1200 degrees on satsumas. Real growth in citrus fruits starts at 18-20 °C, and the fastest growth occurs between 26-28 °C. The optimum temperature is at 26-28 °C, growth slows down and gets close to stop at 38-39 °C, the rate of photosynthesis decreases to a minimum at 38-39 °C, growth stops at 42-43 °C, and deaths begin at these temperatures.

Another factor affecting citrus cultivation is high temperatures. The most resistant to high-temperature species is grapefruit. Mandarin, lime, orange, lemon follow it respectively. Lemon likes cool and humid summers and warm and slightly dry winters. For this reason, it is widespread in Mersin and Erdemli. The best germination temperature in citrus fruits occurs at 20-35 °C in subtropical climates. The optimum germination temperature is 27-32 °C.

When the soil temperature is four o C, growth begins in the roots. Growth is accelerated at 15-20 °C in the roots. When the soil temperature reaches 37-38 °C, root growth stops. If we consider low temperature and frost risk, the best planting time is fall planting. During the winter, the roots will grow continuously for four months, albeit slowly, and the saplings will develop better in the spring. If we do not consider this risk, we can plant our seedlings in the spring.

5. HUMIDITY

In order to obtain quality fruit, the optimum moisture content in citrus cultivation should be around 75-80%, and the proportional humidity should be above 50%. Citrus cultivation has become widespread in the

Çukurova Region as the relative humidity increases with the widespread use of irrigation. For citrus fruits, the relative humidity must be above 50% to obtain quality fruit. Fruit colouring is not good in very humid places because the reason for poor colouration in the tropics is humidity and temperature. Colouration is not good in low humidity areas, as well. Quality Washington Navel cultivation cannot be done in extremely hot places with low relative humidity. Middle hot regions are suitable for it. Washington Navel ecology is in line with lemon ecology. The best quality Washington Navel is grown in Mersin.

6. SOIL

The main factor of the soil requirements of citrus fruits is the aerated soils. Citrus roots need oxygen, and roots cannot develop well in non-aerated soil. Citrus fruits are plants of light textured soils. It is not a plant of heavy soils; it needs more oxygen. Active capillary root depth is between 30-90 cm in normal well aired soils. When the aeration in the soil's pores decreases, the roots rise to the soil surface to take oxygen, and capillary roots can be seen on the soil. In this case, roots can be damaged by tillage. Citrus soil is well aired soils with at least 9-10% of the total volume of air space. Soil pH slightly acid, i.e. 5.5-6 or even 6, is ideal for us. In citrus fruits, the pH range is between 4-9. Citrus soil should have a clay ratio between 8 and 10% in terms of the physical structure and should not exceed 20%. We need to consider whether to cultivate in soils with a clay ratio exceeding 10%. In addition, the soil should be 50% sand, 20% sandy loam and the amount of lime between 5 and 10%. The active lime amount should not exceed 10%.

7. IRRIGATION

In citrus cultivation, it is necessary to irrigate at the right time and in sufficient amount to increase the yield and quality. The tree's age, the rootstock used, the area where the cultivation is made, the irrigation method used and the soil structure effectively determine the prepared irrigation program. Irrigation applications in fruit trees should be made without the amount of moisture in the soil falling to the minimum level determined for the trees. In citrus cultivation in the Mediterranean and Aegean regions, irrigation is generally carried out from mid-April to early November, although it varies according to years. The annual water need of citrus fruits varies between 800-1.200 mm. When the soil moisture drops below the critical moisture level and approaches the wilting point, the plants begin to close their stomata and transpiration decreases. Irregular irrigation causes flower and fruit dumps and fruit cracking. Soil moisture can be estimated by the hand control method.

Soil is taken from the soil surface from a depth of 0-30 cm and compacted by hand; if there is enough water in the soil, the soil we compacted will stick and not disperse. In the opposite case, when the soil is compacted, it will disperse, and this situation informs us that it is time for irrigation. The most accurate method is provided by using a moisture measuring instrument such as a tensiometer. The holding power of the water in the soil is measured in centibars with the manometer in the tensiometer. Tensiometer can be placed to the southwest part of the trees and the 0-30; 30-60;60-90 cm depth of the habitus projection. In citrus trees, tensiometers are generally used in those with a depth of 0-30 cm, and irrigation is started when the manometer exceeds 30 centibars. In the past, irrigation was used in citrus gardens using bowl and surface methods. With these methods, much water is used. Excessive use of water also has negative effects on plants. Diseases such as root rot are seen in trees; salinity problems occur in soils. Citrus producers have started to use drip irrigation systems from pressurized irrigation systems to increase efficiency and quality, reduce production inputs, save water and energy, protect the environment and apply fertilizer with irrigation water (fertigation) in recent years. Utilizing water and fertilizers at the highest efficiency level has given the drip irrigation system and fertigation with this method prominence. The fact that water application efficiencies reach 90-95% in drip irrigation systems and increase water use efficiency have revealed the necessity to be considered one of the basic conditions for sustainable agriculture (Bozkurt-Çolak et al., 2014).

8. PRUNING

Pruning in citrus fruits is generally applied to control tree size, reduce pest and disease effects, and increase fruit yield and quality (Sauls, 2002; Yıldırım et al., 2010). The tree should be left in its natural shape as much as possible, and sunlight should enter the habitus. In citrus trees, the fruit yield will decrease in the trees that do not receive sufficient light in the habitus and these trees are considered unproductive trees. If the light exposure is good, the shoot forth and the flower and fruit formation will be high; the fruits will be distributed evenly on the tree. Pruning is done in the form of shape pruning, yield pruning and rejuvenation pruning in citrus fruits.

In shape pruning: the application is on young saplings and trees, and the saplings are shaped at the height of 60-65 cm, leaving 3 or 4 main branches. The aim is to create a solid and balanced habitus. Saplings are shaped from 60-65 cm and the main branches left are cut from 25-30 cm. Thus, secondary branches are created this way and pruning is done from 25-30 cm on the shoots emerging from them.

Yield pruning: is a pruning method applied regularly every year after citrus trees lay on the fruit. Dried, diseased, water sprouts and overlapping brances should be cut and removed while pruning the citrus fruits. Pruning other than these branches damages the tree and causes the balance of the tree to deteriorate. Lemons, on the other hand; require a different pruning than other species with their top bud dominance. Lemon shoots tend not to give side branches and grow upright. Top bud dominance should be removed for flower bud formation. For a good lemon growing, branches must be pruned every year. For this purpose, lemons are pruned every year on shoots. With fertility pruning, it should be ensured that dry, diseased, inefficient branches and water sprouts that exploit the tree should be removed. One of the biggest mistakes made in yield pruning is cutting the skirt branches to provide aeration. In a citrus tree, the skirt branches should not be cut; if they are to be cut, the cutting height should not exceed 30 cm from the ground.

Rejuvenation pruning: As the citrus trees do not create enough new shoots after a certain age, the yield decreases. This situation is related to the nitrogen/carbon balance. This problem is tried to be solved by rejuvenation pruning. Citrus fruits are not suitable for large, thick branches cutting. Within this situation, the closing of large wounds will be late and difficult. When rejuvenation pruning is done, trees should be painted with whitewash or white water-based paint to protect the trees from the sun. In the time following pruning, with the formation of the shoot, the habitus of the tree is filled.

Pruning times are the winter months for all citrus fruits except lemon. *Phoma tracheiphila* disease, which threatens lemon production, is transmitted from wounds in the tree. For this reason, top pruning should be done when the risk of transmission of the *phoma tracheiphila* disease is lowest. The cause of this disease is not effective when the air temperature is 30 degrees and above. It is best to do the top pruning in mid-October, and early November, when the risk of transmitting the disease is the lowest and the shoot will not come up after cutting. Mechanical pruning applications have been made in citrus fruits in recent years. The most commonly used pruning for tree size control is mechanical top and side branch pruning (Davies and Albrigo, 1994). Top and side branch pruning applications are important in controlling the tree size and increasing the yield in old gardens (Sauls, 2002; Yıldırım, 2010). Machine cutting has become mandatory, especially in dense planting gardens, and is widely used in many developed countries. Especially in large enterprises, due to the abundance of land, mechanical applications have been adopted rather than the workforce. Mechanical pruning is applied not to improve manual pruning, but especially in medium or large gardens for producers to make easy pruning (Sansavini, 1978; Yıldırım et al., 2010). Pruning is very important in citrus orchards to get high efficiency. Pruning should be done on time, deep pruning should be avoided unless necessary, dry, damaged, intertwined branches should be cut, and light should enter the tree habitus.

9. FERTILIZATION

Soil and leaf analysis must be done to determine the nutritional elements needed by citrus species and varieties. Nutritional problems occur as a result of unbalanced fertilizer applications. The fertilizer program should be prepared according to the results of soil and leaf analysis. The nutrition program in citrus fruits is determined by the soil structure, age and yield of the tree and the type and variety. The nutrient application should be made in the right amount and at the appropriate time to produce a quality and high-efficiency production. Jackson (1962) and Güneş et al. (2010) specified limit values in evaluating soil analysis results (Table 2).

Macro and micronutrient elements are significant in citrus nutrition. Nitrogen (N), Phosphorus (P) and Potassium (K) from the macronutrients and Iron (Fe), Zinc (Zn) and Manganese (Mn) among the micronutrients are needed the most. Embleton et al. (1973) reported the nutrient limit values used to evaluate leaf samples taken from fruitless shoots in September in citrus fruits.

Table2: Limit Values Used in the Evaluation of Soil Analysis Results (Jackson, 1962 and Güneş et al. 2010)

Nutrition and Method	Very Low	Low	Medium	High	Very High
P (ppm)($NaHCO_3$)	<2.5	2.5-8.0	8.0-25	25-80	>80
K (ppm) (CH_3COONH_4)	<50	50-140	140-370	370-1000	>1000
Ca (ppm) (CH_3COONH_4)	0-380	380-1150	1150-3500	3500-10000	>10000
Mg (ppm) (CH_3COONH_4)	0-50	50-160	160-480	480-1500	>1500
Mn (ppm) (DTPA)	<4	4-14	14-50	50-170	>170
Zn (ppm) (DTPA)	0.2	0.2-0.7	0.7-2.4	2.4-8.0	>8.0
	Low	Medium	High		
Fe (ppm) (DTPA)	<0.2	0.2-4.5	>4.5		
	Deficient	Sufficient			
Cu (ppm) (DTPA)	<0.2	>0.2			
	Low	Sufficient	Medium	High	Very High
Calcium (%) (Scheibler)	0-1	1-5	5-15	15-25	>25
	Sufficient	Salinity	High Salinity		
Salanity (EC mmhos)	0.0-2.0	2.0-4.0	>4.0		
	Very Low	Low	Medium	Sufficient	High
Organik Matter (%)	0-1	1-2	2-3	3-4	>4
	Medium Acidity	Light Acidity	Notr	Light Alcalinity	Very High Alcalinity
pH (1:2.5 water)	4.5-5.5	5.5-6.5	6.5-7.5	7.5-8.5	>8.5
	Sandy	Loamy	Clay Loamy	Clay	Very High Clay
Teksture (%) (saturasyon)	0-30	30-50	50-70	70-110	>110

In recent years, most of the citrus orchards have been irrigated with the drip irrigation method. The fertilizers used in drip irrigation have a low salinity effect, high solubility in water, does not form sediment and has an acid character. Foliar fertilizer application in citrus is made to support the application of fertilizer from the soil. Foliar fertilization can never be as effective as soil fertilization; it effectively provides the missing nutrients during flowering and fruit growth periods.

Table3: Nutrient Element Limit Values in Leaves of Fruitless Shoots (Embleton et al., 1973)

Nutrient	Deficiency	Low	Optimum	High	Very High
N (%)	<2.2	2.2-2.3	2.4-2.6	2.7-2.8	>2.8
P(%)	<0.09	0.09-0.11	0.12-0.16	0.17-0.29	>0.30
K (%)	<0.40	0.40-0.69	0.70-1.09	1.10-2.00	>2.30
Ca (%)	<1.60	1.60-2.90	3.00-5.50	5.60-6.90	>7.00
Mg (%)	<0.16	0.16-0.25	0.26-0.60	0.70-1.10	>1.20
Na (%)	-	-	<0.16	0.17-0.24	>0.25
Fe (ppm)	<36	36-59	60-120	130-200	>250
Mn (ppm)	<16	16-24	25-200	300-500	>1000
Zn (ppm)	<16	16-24	25-100	110-200	>300
Cu (ppm)	<3.60	3.60-4.90	5-16	17-22	>22
B (ppm)	<21	21-30	31-100	101-260	>260

10. CITRUS PESTS

Panonychus citri, Phyllocoptruta oleivora, Planococcus citri, Dialeurodes citri, Aonidiella aurantii and *Aonidiella citrina, Phyllocnistis citrella,, Aceria sheldoni, Ectomyelois ceratoniae, Prays citri, Ceratitis capitata* cause damage to citrus fruits.

1-Citrus Red Mite (*Panonychus citri*): Adult females have colours ranging from red to purple. Adults and their larvae suck on citrus leaves and fruits and cause pale spots on the sucking areas. Over time, these spots increase, and the leaves take a silvery colour, then dry and fall off. They can lay their eggs on leaves, fruits and shoots. A female can lay 20-50 eggs, 2-3 times a day. Chemical Challenge; In citrus orchards at the end of February and the beginning of March in the spring, active individuals on the lower and upper surfaces of the leaves are counted. If there are an average of 4-9 individuals per 10 leaves, it should be struggled with summer oils, if more, with acaricides. In its struggle, summer oils and acaricides with active ingredients Pyridaben, Abamectin, Spirodiclofen, Etoxazole are used.

2-Citrus Rust Mite (*Phyllocoptruta oleivora*): It is brown to yellow, and its shape resembles a carrot. They spend the winter in the cracks in the branches and trunks of citrus trees or under the bark. From the end of April to the beginning of May, they pass to fresh shoots and leaves. They can give up to 30 offspring in a year. They suck on harmful fresh shoots, leaves and fruits and form rust-coloured spots on the fruits. Summer oils and acaricides with active ingredients Pyridaben, Abamectin, Spirodiclofen are used in Chemical Control.

3-Citrus Mealybug (*Planococcus citri*): More than 60 *Planococcus citri* species are seen in citrus fields worldwide (Ben-Dov, 1994). Adult females are elongated oval in shape and covered all over the body with a veil of white thin waxy strands. In citrus fruits, they cause damage in the sepals where the fruits meet with the stem and in the places where the fruits come into contact with each other, and in the navel of the navel oranges. *Planococcus citri* reduce fruit quality and cause the fruits with weakened stem bottoms to fall in the early period and form fumagin by sucking on leaves and fruit stems. (Lodos, 1986). Chemical Challenge; Summer oils and medicines with Spirotetramat 100g / l active ingredient are used to fight against *Planococcus citri*. Biological Control: *Cryptolaemus motrouzieri* Muls. (Col.:Coccinellidae) predator insects and *Leptomastix doctiilopii* How (Hym .: Encyrtidae) parasitoid are their most important natural enemies (Soylu et al., 1977; Kansu et al., 1980; Yiğit et al., 1994).

4-Citrus Whitefly (*Dialeurodes citri*): Adults are white due to the waxy substance in white powder covering them. Its eggs are oval and attached to the underside of the leaf with a short stem. Eggs hatch within 8-24 days, and they can give 2-3 offspring a year. They damage the plant by sucking the sap. Yellowish spots occur due to chlorophyll breakdown in the suction areas on the lower surfaces of the leaves. The growth of trees is adversely affected by fumagin, which is formed due to the development of saprophytic fungi on the sweet substances secreted by whitefly larvae and pupae. Summer oils are used in chemical control. In its biological control, emphasis should be placed on placing the predatory insects, *Serangium parcecetosum*, in gardens.

5-Red and Yellow Scale (*Aonidiella aurantii*) and (*Aonidiella citrina*): The rind of the mature female is in the form of a circle; the shell colour is dirty yellow in *A. citrina* and red in *A.aurantii*. The eggs hatch in the female's abdomen, and the female gives birth to motile larvae. Both species are seen at the beginning of May in the Mediterranean Region. Both pests give 4-5 offspring in the Mediterranean Region. In Chemical Control, pest control can be done against this pest in two separate periods, winter and summer. Summer oils and drugs with active ingredients Buprofezin, Pyriproxifen, Spirotetramat are used in the fight.

6-Citrus Leaf Miner (*Phyllocnistis citrella*): Adults are usually active in the evening and at night and lay their transparent eggs one by one, usually under the newly developing fresh leaves. When the density is high, eggs are laid on the leaves, shoots and fruits. The development of seedlings is prevented due to the damage done to young seedlings. Especially in nurseries and new plant gardens, pest control should be done when the larvae are in the majority. In Chemical Control, drugs with active ingredients Abamectin, Acetamiprid are used.

7-Citrus Bud Mite (*Aceria sheldoni*): The adult's body is in the form of a cylinder, and its colour is yellowish or slightly pink. It distorts the shape of the flowers, leaves and shoots. The places where it sucks turn brown, and the leaves and shoots become rosettes. The flowers are shorter than normal, thick and bifurcated, and most such flowers do not fructify, and typical deformities are seen in the fructified ones.

8-Carob Moth (*Ectomyelois ceratoniae*): *Ectomyelois ceratoniae*, which spends the winter as a larva inside the fruits under natural conditions, is harmful to navel oranges and partially to grapefruits. The larvae are fed by entering the navel of oranges. It is also harmful in grapefruits contaminated with *Planococcus citri*. Drugs with Bacillus thuringiensis are used in Chemical Struggle.

<u>9-Citrus Flower Moth (*Prays citri*):</u> Adult females lay their eggs on fresh, dark coloured lemon flower buds and rarely on purple coloured fresh lemon shoots when they cannot find flowers. The flower buds on which *Prays citri* feeds do not grow. Since it eats male and female organs in flowers, it prevents fructification. Drugs with *Bacillus thuringiensis* are used in Chemical Struggle.

<u>10-Mediterranean Fruit Fly (*Ceratitis capitata*):</u> The pest spends the winter in the soil or in the fruits left on the tree. Depending on the climatic conditions, the adults lay their eggs under the bark of the ripe fruit in the place where they open with their ovipositors after feeding in late spring and early summer. Fruits laid eggs by the pest turn yellow early and fall before harvest time. In order to lay eggs, the temperature must be above 16 °C. In chemical control, exit *Ceratitis capitata* control should be done by hanging tempting traps in citrus orchards in late August and early September, before the oranges and especially the early variety Satsuma mandarins mature. In the chemical control of the pest, 25% Technical malathion + Enzymatic hydrolyzed protein or drugs with the active ingredient Spinosad are used.

11. CITRUS DISEASES

Important diseases seen in citrus cultivation are:

1-Brown Rot and Stem Gum in Citrus Fruits (*Phytophthora citrophthora*): It is a soil-based fungus. It lives in plant residues in the soil in humid conditions, root and stem contamination occurs mostly in winter and spring, fruit contamination occurs in autumn. The disease spreads easily from the wounds opened on the trunk and branches during the rainy seasons. Fruit infections occur close to the soil when the wound or fruit peel tissue contaminates the spores transmitted from the soil by raindrops. The optimum development of fungus in fruits is at 26-28 ºC; fungus can be contaminated at 7-32 ºC. The most damage is seen in lemon, mandarin, orange, grapefruit and sour orange. Cultural Measures: surface irrigation and surface type irrigation that will leave the root neck of the tree in water should not be done. Irrigation should be done with a drip irrigation method; root neck and stem should not get wet. When establishing a garden, seedlings should not be planted deep, and a garden should not be established on lands with high groundwater. Dense planting should be avoided to ensure good aeration. The grafting point should be high (at least 35 cm), especially for sensitive species and varieties such as lemon and Washington Navel orange. Fruits should not be injured during collection and packaging, and wet fruit should not be collected. Before planting, the roots and stems of the seedlings should be dipped in 1.5% claret red slurry.

2-Mal Secco (*Phoma tracheiphila*): Spores spreading in the spring enter the plant through the openings and wounds in the branches. The optimum temperature for the development of the disease is 18-20 ^{0}C. The disease is most common in the spring and autumn months. Leaf-blades fall off on diseased branches, and the petioles usually remain on the branch. A dark brown or orange colour in the wood texture is seen when the branches that have dried from the end are cut. The disease is mostly seen in lemons among citrus species. For this reason, care should be taken to the pruning of lemons during periods when the disease is inactive. Above 30 ^{0}C and below three ^{0}C, the fungus is inactive.

Cultural Precautions: A garden should be established with healthy and certified seedlings, production material should not be taken from diseased trees, diseased shoots should be cut a little below the diseased place and pruning tools should be disinfected.

Chemical Control: Spraying should be done three times, between October and March.

3-Citrus Brown Spot Disease (*Alternaria alternata* f.sp. Citri): The disease spends the winter on the untimely formed fruits, leaves and shoots on the tree. Due to rain, dew formation and excessive irrigation during the shoot development period, the disease occurs on the young shoots and leaves and the green fruit peel. The disease is particularly common in mandarin and mandarin hybrids. Cultural measures: Excessive nitrogen fertilization and irrigation, deep pruning, frequent planting should be avoided. Chemical control: It is carried out when the first signs of the disease are seen and after the shoots reach a length of approximately 5-10 cm. Spraying is continued until the temperature rises and until the fruit diameter reaches 4 cm.

<u>4-Citrus Dwarf Viroid (Citrus Exocortis pospiviroid, CEVd):</u> The disease is spread by graft eye and pruning tools. The disease shows symptoms in the form of stunting and a general yellowing of the trees. Cracking, splitting, peeling and drying of the bark are seen on the rootstock. Tree death occurs in severe contamination. In its control: disease-free, certified seedlings should be used, pruning tools and equipment should be disinfected (with 10% sodium hypochlorite) before pruning each tree. Trees showing signs of disease should be removed with their roots. Disease-resistant rootstocks should be used, and carrier vectors should be fought.

<u>5-Citrus Tristeza Virus (Citrus Tristeza closterovirus, CTV):</u> Aphids are the important vector of the disease. The virus is transmitted by pruning tools, graft buds, and aphids. When the bark part is removed from the wood tissue from the grafting point of the infected tree, pitting can be seen on the inner surface of the bark. Stunting, backward deaths and small fruit formation occur in sick trees. In the rapidly developing sign of sudden death of the disease, the leaves suddenly wither, dry and eventually fall. Sour orange rootstock is a very sensitive rootstock to tristeza. <u>In its struggle:</u> disease-free, certified seedlings should be used, pruning tools and equipment should be disinfected (with 10% sodium hypochlorite) before pruning each tree. Trees showing signs of disease

should be removed with their roots. Disease-resistant rootstocks should be used, and carrier vectors should be fought.

CONCLUSION

Citrus fruits are the most produced fruit group in the world. They have the largest trade volume due to their positive effects on human health and their fresh consumption, as well as their use in different branches such as fruit juice, pastry, jam, cosmetics industry and their ability to be kept on the tree for a long time. However, there are some problems in the cultivation and marketing of citrus fruits. Most citrus fruit-producing plants in Turkey do not have sufficient knowledge in terms of citrus production technique. Therefore there are inaccurate practices in the cultural care processes. Orchard plants with new varieties and modern fruit growing practices are not at sufficient levels, and agricultural organization among citrus producers is not sufficient. Establishing an orchard with new varieties demand in the foreign market and prolonging the production season, applying dense planting, modern irrigation and fertilization techniques, applying fertilizers as a result of soil and leaf analysis, using nature-friendly pesticides and modern spraying tools and equipment in the fight against diseases and pests will increase fruit yield and quality and economic income level. Approximately 95% of citrus varieties in Turkey are grafted on sour orange rootstocks due to their suitable rootstocks, followed by trifoliate and trifoliate hybrids such as Carrizo and Troyer citrange. Sour orange rootstock is a rootstock with superior qualities. However, due to various diseases, studies to obtain an alternative rootstock that can replace sour orange have gained importance in our country, like other Mediterranean countries (Uysal, 2009). In addition, breeding studies should be accelerated to obtain new rootstocks and varieties in citrus cultivation, and the efforts to obtain drought-resistant rootstock should be increased due to global warming, which has been of great importance in recent years.

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CHAPTER 14

HARVEST TIME ALTERS FRUIT QUALITY TRAITS OF BARBERRIES (*Berberis vulgaris*)

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INTRODUCTION

The Barberry is a thorny plant in the form of a bush that can grow up to 1- 4 m from the Berberidaceae family. It grows between stony slopes and bushes at altitudes of 500-1500 m. Its fruits are elliptical, in the form of a bunch of fruits, and vary according to the species, but are red, fire red, dark purple, or black in color (Anonymous, 2020; Karadeniz, 2004). Its leaves, on the other hand, are short-stalked and finely toothed on the edges (Karadeniz, 2004). Its flowers are formed in April-May with the combination of 10-15 flowers in the form of clusters (Yücel et al., 1995).

The homeland of *Berberis* is North Africa, and it grows in a wide area from the Caucasus to Europe. In our country, it grows naturally in Istanbul and Thrace, and different species naturally grow in the provinces of Kastamonu, Artvin, Samsun and Tokat (TÜBİVES, 2021; Karadeniz, 2004). Barberry is known in different regions of our country with names such as Karamuk, Sour Cream, Yellow Bush, Zibike, Thorn Grape and Barberry (Karadeniz, 2004). There are approximately 190 species of barberry in the world (Meliani et al., 2011), and there are 4 species in our country: *B. vulgaris*, *B. integerrima*, *B. crataegiana*, *B. cretica* (Davis, 1965).

B. vulgaris fruit is a good source of Vitamin C for daily consumption (Hanachi and SH, 2009). The fruits, flowers, leaves, stems, and roots of the barberry contain important anthocyanins, alkaloids, flavonoids, phenolic compounds, vitamins, and minerals (Mozhdeh Sarraf et al., 2019; Ulusoy Deniz, 2016). *B. vulgaris* is generally used as an appetite stimulant (Özdemir and Alpınar, 2015), stimulating the immune system and reducing fever, in the treatment and prevention of stone formation in the gastrointestinal tract (Rahimi-Madiseh et. al, 2017). *B. vulgaris* is used as an ornamental plant in urban design areas due to its attractive flowers and fruits (Surat, 2020). Its fruits are consumed fresh, used in making jams and marmalades, in Iran, the fruits are used in soups and decorate the pilaf (Rahimi and Arslan, 2012).

Many factors such as ecology and genetic structure, market demands are effective in determining the harvest time. Early and late harvest adversely affect the quality. For this reason, harvesting at the right time is important for high yield and quality. Although it varies according to the species and variety, many criteria such as TSS, acidity, firmness of fruit flesh, color, shape, and size are used to determine the harvest time in fruits (Özcan, 2018). Since these criteria are easily affected by environmental factors and cultural practices, they may not give reliable results on their own. For this reason, several of these criteria should be used together to determine the harvest time. Therefore, the harvest should be done at the optimum time in accordance with its purpose (Özcan, 2018).

The harvest date, drying, and harvesting methods affect the fruit quality in the barberry, the fruit yield increases when the harvest is delayed (Javadzadeh, 2013; Rezvani Moghaddam et al., 2013; Moradinezhad et al., 2018) and the time of harvest during the day affect the harvest (Rezvani Moghaddam et al., 2013) Mountainous regions are recommended for early harvest and quality barberry cultivation

(Moradinezhad et al., 2018). The goal of this study was to determine the appropriate harvest time for barberry grown in Bolu ecology.

MATERIAL AND METHOD

Material

The material of this study consisted of three different genotypes of barberry located in the Bolu Abant İzzet Baysal University Campus area (Figure 1).

Figure 1: The fruit, seed, leaf, bunch, and shoot of barberry that in the form of a bush.

Method

Sampling

Fruits were gathered from the genotypes in four different periods as 20 September (Harvest. 1, H1) , 25 October (Harvest. 2, H2), 15 November (Harvest. 3, H3), and 14 December (Harvest. 4, H4). Since the harvest of Genotype 3 was completed on 14 December, fruit samples could not be taken. Harvested fruits were brought to the laboratory without losing any time and pomological analyzes were made.

Pomological Analysis

Cluster length, cluster width, fruit stalk length and fruit stalk width were measured with a digital hand caliper with 0.001 mm precision. Fruit, seed and cluster weights were weighed with a digital scale with 0.001 g precision. TSS was detected with a hand refractometer. pH was determined with a table-type pH meter and titratable acidity titration method. Fruit color was determined with a handheld colorimeter in the CIE color space in terms of L*, a*, b*, Chroma and Hue.

Statistical analysis

The student's LSD test was used to statistically compare the changes in fruit characteristics at different harvest times. The relationships of cluster weight with other fruit characteristics at different harvest times were determined by correlation analysis and these relationships were revealed for each genotype.

RESULTS AND DISCUSSION

In clustered-fruit forming plants, cluster weight is the main factor determining yield (Branislava et al., 2011). Knowing the cluster characteristics is important in terms of yield and quality in determining the appropriate harvest time since the barberry produces clusters of fruit. In all three genotypes studied, cluster weights and the number of fruits per cluster differed statistically at different harvest times ($p<0.05$, Table 1). The cluster weights ranged from 0.95 (G1H4) to 2.55 (G2H3) g. The largest clusters were obtained from Genotype 1 and Genotype 3 in October with 2.05 g and with 2.54 g, respectively. Genotype 2 had the highest cluster weight in November with 2.55 g (Table 1). After these dates, a decrease in cluster weight was observed. Therefore, it was evaluated that these dates were the optimum maturity periods of the genotypes, and the following periods were the over-ripening periods. The cluster weights in the study were found to be higher than Safari-Khuzani et al. (2020) and similar to Goodarzi et al. (2018). It is thought that the differences between cluster weights are due to the genotype and differences in shoot development. It is known that there is a positive correlation between the growth of the cluster and the growth of the shoot in which the cluster is located, therefore the cluster and grain weights on strong and productive shoots are higher (Todorov, 1970).

The number of fruits in the cluster varied between 8.40 (G3H3) and 18.00 (G2H1), while the number of fruits in the cluster decreased starting from November for Genotypes 1 and 2 and from October for Genotype 3 (Table 1). The decrease in the number of grains in the cluster in the following months, seen in all genotypes, indicates that the ripening barberry fruits tend to fall. The reasons for the shedding may be the inability of the shoot to feed the increased fruit biomass or the increase of bioactive substances that reduce the holding force of the fruit stalk in the fruits that are in the over-ripe stages. Fruit shedding is associated with ethylene, auxin conjugation, abscisic acid response, brassinosteroids biosynthesis and signaling, and cell-wall disassembly processes (Travisany et al., 2019). Therefore, it is predicted that the accumulation and activities of these bioactive substances increase in barberry fruits from October in the Bolu ecological conditions. In the study of Safari-Khuzani et al., (2020), the number of fruits in a cluster is higher than our study, and this may be due to genotypic, climatic differences, and nutritional status. In this study, bunch length was 26.89 (G1H3)-50.91 (G2H1) cm, bunch width was 0.16 (G3H1)-0.29 (G2H1) cm, fruit stalk length was 4.98 (G1H2)-10.09 (G2H1) mm, and fruit stalk width was 0.06 (G2H3)-0.17 (G1H2, G3H2) mm (Table 1).

Table 1: Cluster properties of barberries in different harvest dates.

Genotypes	Harvest Times	Cluster Weights (g)	Number of Fruits Per Cluster (pieces)	Bunch Length (cm)	Bunch Width (cm)	Stalk Length (mm)	Stalk Width (mm)
1	September	1.75a	16.80a	42.21a	0.22 ns	6.91 ns	0.11 ns
	October	2.05a	14.60a	41.89a	0.18	4.98	0.17
	November	1.31b	14.20a	26.89b	0.25	7.39	0.15
	December	0.95c	11.80b	33.84a	0.21	6.19	0.12
2	September	2.20a	18.00a	50.91ns	0.29 ns	10.09a	0.14a
	October	1.76b	10.00b	41.26	0.24	6.85b	0.14a
	November	2.55a	11.60b	48.77	0.25	8.88a	0.06b
	December	2.07a	11.20b	41.31	0.24	9.16a	0.14a
3	September	1.85b	14.80a	42.33 ns	0.16b	7.93 ns	0.06b
	October	2.54a	16.60a	45.22	0.26a	8.35	0.17a
	November	1.16c	8.40b	44.85	0.19ab	7.56	0.13a

Different letters in the same row indicate significant differences. ns: Not significant.

Fruit weight and dimensions are some of the crucial harvest criteria. The fruit weights of the genotypes varied between 0.08 g (G1H3) and 0.22 g (G2H3) (Table 2). The effect of harvest date on fruit weight was significant ($p<0.05$). October stood out as the highest period in terms of fruit weight for all genotypes. After this period, serious decreases were observed in the fruit weights of genotypes 1 and 3, which indicates that the genotypes reached harvest maturity in October and passed into the over-maturity period in the following months. 100 fruit weight of barberry was reported as 10.78 g in September, 12.00 g at the beginning of October, 12.56 g at the end of October, and 13.11 g in November (Rezvani Moghaddam et al., 2013). The reason for the lack of decrease in fruit weight values reported by the researchers is estimated to be the fact that the studied genotypes have not yet reached the over-maturity stage in mentioned periods. It is basic physiology that has been reported for many plant species in which fruit weight losses occur during the over-ripe stage (Osuna-García et al., 2010; Wanitchang et al., 2011). The fruit weight values in our study are higher than the values reported by some previous researchers (Çakır and Karabulut, 2020; Yıldız et al., 2014; Ersoy et al., 2018). Compared to the study of Rezvani Moghaddam et al., (2013), although the fruits in our study are larger, the fruit weights differ as the harvest date progresses, and the fruits harvested in October for Genotype 1 and 3 and in November for Genotype 2 reach their full size. This situation is thought to be caused by genetic and ecological factors such as genotype, light, and temperature.

In terms of fruit lengths, Genotype-1 reached the highest values with 10.22 mm in September, while Genotype 2 and Genotype 3 reached the highest values in December and in October with 10.84 mm and 10.73 mm, respectively. In this study, fruit length 9.11 (G1H4)-10.84 (G2H4) mm, fruit width 3.91 (G3H3)-6.63 (G2H3) mm, seed weight 0.02 (G1H1, G2H2, G3H1)-0.04 (G3H3) g, seed length 4.38 (G1H2)- 5.97 (G3H3) mm and core width varied between 1.76 (G1H2)-2.27 (G2H4) mm (Table 2). In a similar study, fruit length was reported as 9.28 mm in September, 9.53 mm at the beginning of October, 9.75 mm at the end of October, and 9.91 mm in November (Rezvani Moghaddam et al., 2013). In some other studies on barberry, the fruit length values were

10.08 mm (Çakır and Karabulut, 2020), 7.40-10.84 (Goodarzi et al., 2018), 6.94-14.89 mm (Safari-Khuzani et al., 2020). Fruit width was reported as 5.11 mm (Çakır and Karabulut, 2020), 4.39-8.05 mm (Goodarzi et al., 2018), 5.11-9.00 mm (Safari-Khuzani et al., 2020). While the seed weight values obtained in this study are higher than the study of Safari-Khuzani et al., (2020), there is a similarity with the literature in terms of seed length and width. The fact that the kernel weight and size values obtained in this study and previous studies are relatively close to each other proves that the heritability of the kernel traits of barberry is high and shows less variation among genetic sources than other traits.

Table 2: Fruit and seed characteristics of barberry genotypes at different harvest dates

Genotypes	Harvest Times	Fruit Length (mm)	Fruit Width (mm)	Fruit Weight (g)	Seed Weight (g)	Seed Widht (mm)	Seed Length (mm)
1	September	10.22 ns	4.79 ab	0.15ab	0.02 ns	2.19 ns	5.37a
	October	9.48	5.33a	0.16a	0.03	1.76	4.38b
	November	9.60	4.76 ab	0.08c	0.03	2.04	5.18ab
	December	9.11	4.31b	0.11bc	0.03	2.25	5.29a
2	September	9.99b*	5.33c	0.15b	0.03 ns	2.12 ns	4.43 ns
	October	10.61ab	6.11 ab	0.21a	0.02	2.18	4.82
	November	10.80a	6.63a	0.22a	0.03	2.10	5.10
	December	10.84a	5.71 bc	0.21a	0.03	2.27	4.82
3	September	9.35b	4.53ab	0.12b	0.02 ns	1.85 ns	5.67 ns
	October	10.73a	5.48a	0.18a	0.03	1.87	5.81
	November	10.27ab	3.91b	0.11b	0.04	2.03	5.97

*Different letters in the same row indicate significant differences. ns: Not significant.

TSS and total titratable acidity are important chemical criteria to define the optimum harvest time (Fallahi et al., 2010). In our study, TSS was between 11% (G1H1)-24% (G1H2), pH was 2.55 (G2H4)-3.01 (G1H3) and titratable acidity was 0.13% (G1H4)-1.33% (G2H1). The highest TSS content of Genotype 1 was determined in October, while Genotype

2 and Genotype 3 had the highest amounts in November. pH values showed the highest values in Genotype 1 and 2 in November, and in Genotype 3 in September. The lowest titratable acidity values were obtained from the fruits in December for Genotype 1, November for Genotype 3, and October for Genotype 2 (Table 3). Rezvani Moghaddam et al., (2013) found the TSS to be 11.9% in September, 14.4% at the beginning of October, 13.7% at the end of October, and 15.9% in November. In our study, TSS was higher compared to similar studies (Okatan and Çolak, 2019; Çakır and Karabulut, 2020; Yıldız et al., 2014; Akbulut et al., 2009; Ersoy et al., 2018; Moradinezhad et al., 2018) and acidity was lower then Rezvani Moghaddam et al., (2013) stated. As the maturity progresses in fruits, the amount of TSS increases significantly, while the amount of acids decreases. However, this situation can be affected by various factors such as climate, yield, and nutrition. So our dissimilar findings from the researchers are due to genotypes and climatic factors. Fallahi et al. (2010) concluded that by delaying the harvest date, TSS, pH and titratable acidity decreased in barberry. Our TSS values decreased in Genotype 1 after October, in Genotype 2 after November, while pH decreased in Genotypes 1 and 2 after November, and in Genotype 3 after September.

Table 3: TSS, pH and Acidity features of barberry genotypes at different harvest dates

Genotypes	Harvest Times	TSS (%)	pH	Asitlik
1	September	11.00 ns	2.96 ns	0.44 ns
	October	24.00	2.89	0.94
	November	21.00	3.01	0.33
	December	22.50	3.00	0.13
2	September	16.00 ns	2.63 ns	1.33 ns
	October	16.00	2.69	0.28
	November	18.20	2.79	0.74
	December	16.00	2.55	0.72
3	September	17.00 ns	2.92 ns	0.70 ns
	October	15.50	2.59	1.05
	November	21.00	2.78	0.29

Different letters in the same row indicate significant differences. ns: Not significant.

Fruit color is one of the important features when deciding the harvest date and it is a kind of feature that influenced by genetics and some environmental factors. The only statistical difference among harvest dates in terms of color properties was observed in the b* value. The fruits of the studied genotypes were detected at the highest brightness in different periods. Luminosity (L) values were highest in Genotype 1 in December, in Genotype 2 in September, and in Genotype 3 in October. The highest a*, b* and chroma values for all three genotypes were measured from the fruits harvested in September. Hue angle reached the highest values in December for Genotype 1, September for Genotype 2, and October for Genotype 3. The luminosity declines with increasing ripening due to alteration of the presence of chlorophyll, carotenoids, and pigments (Lancester and Lister, 1997). This phenomenon is known as very sharp in some species (Vendamiri and Trugo, 2000) and is mostly associated with the flesh structure and climacteric characteristics. The a* and b* values are scales of the red and blue color. Results of this study clear that fruits of barberry have a stable fruit color during a wide period of harvest. Moreover, the substantial difference among genotypes in terms of the b* values indicates the occurrence of waxy layers depends on genetics. Color properties of fruits studied in this research differed from the L*, a*, b* values in the studies of Çakır and Karabulut, (2020), Yıldız et al., (2014), and Ersoy et al., (2018). These differences may be due to differences in different genotypes, low temperatures and growing seasons.

Table 4: Fruit color properties of barberry genotypes at different harvest dates

Genotypes	Harvest Times	L*	a*	b*	Chroma	Hue
1	September	26.40 ns	29.69 ns	9.64 ns	31.34 ns	17.41 ns
	October	26.98	23.18	7.58	24.40	17.85
	November	26.59	22.30	6.47	23.27	15.87
	December	28.39	23.43	7.74	24.74	19.17
2	September	31.71 ns	39.47 ns	23.04a	45.74 ns	30.08a
	October	29.89	34.97	15.95ab	38.45	24.50b
	November	28.65	32.74	12.74b	35.14	21.17b
	December	29.93	35.81	15.42ab	39.00	23.10b
3	September	31.15 ns	40.47 ns	29.31 ns	46.39 ns	29.29 ns
	October	34.73	39.74	23.37	46.13	30.62
	November	33.06	33.78	19.73	39.15	30.42

Different letters in the same row indicate significant differences. ns: Not significant.

Linear relationship of cluster weight with the number of fruits in the cluster, shoot length and shoot width, stem length and width, seed length and seed width, fruit length, fruit width, and fruit weight, L*, a*, b*, Chroma, and Hue values according to harvest times and genotypes determined by correlation analysis (Table 5).

At the 1st harvest date (September), the a* value (0.83**) showed the greatest effect on the cluster weight in G1, and the seed width (0.82**) showed the negative very important effect on the cluster weight. In G2, the b* value is very significant (1.00**), seed width negatively (0.82**); In G3, Chroma value showed negative very important (1.00) and Hue value (0.99) showed positive very important linear relationship.

The most linear relationship on cluster weights at the second harvest date was positive in G1 (0.94**), positive very important, and fruit weight (0.98**) negative very important; In G2, cluster weight (0.87**) was positive very important and Hue value negative very important (0.82**); In G3, it was determined that the Hue value was positive very important (0.97) and the a* value was negative very important (0.99).

With cluster weights, in G1H3, b* value is positive and important (0.97**), L* value is negative very important (0.79**), in G2H3, positive is very important in fruit number (1.00**), negative in fruit width is very important (0.68**); In G3H3, positive very important (0.98**) relationships were found in Hue values and negative very important (0.79**) relationships between a* value.

In December, which is the last harvest date, cluster weights indicate that fruit width is positively very important (0.86**), a* value is negative very important (0.68); In G2H4, on the other hand, it is seen that it has fruit number positive very important (0.77**) effect on fruit number and negative very important (0.85**) effect on seed length.

Hue value showed a positive effect on cluster weight in all genotypes in H1. 2. At harvest, it was observed that there was a* positive correlation between cluster length and seed length on cluster weight in all three genotypes. Our results are similar to the positive correlation between cluster weight and cluster length of Goodarzi et al. (2018) and Akbulut et al. (2009). 3. At harvest, it was determined that there was a negative correlation between cluster weight and fruit length, width, and L* value, and positive correlation between hue value and fruit number in all three genotypes. Goodarzi et al. (2018) and Akbulut et al. (2009) found a positive correlation between cluster weight and fruit length and width, and the findings of our study are similar. 4. It was determined that there was positive correlation between fruit number, fruit weight, fruit width, bunch Length, L* and hue values in both genotypes at harvest, and negative correlation between stalk width, seed length and seed widht. Safari-Khuzani et al. (2020) showed similar results with the finding of a* positive correlation between fruit weight and cluster weight.

Table 5: The linear relationship of cluster weight with other characteristics according to harvest times and genotypes.

Traits	G1H1	G2H1	G3H1	G1H2	G2H2	G3H2	G1H3	G2H3	G3H3	G1H4	G2H4
Number of Fruits Per Cluster (pieces)	-0.22*	0.00	0.76**	0.79**	0.74**	0.02	0.13	1.00**	0.74**	0.71*	0.77**
Bunch Length (cm)	-0.38*	0.40*	-0.20	0.54*	0.83**	0.82**	0.52*	0.70**	-0.16	0.15	0.61*
Bunch Width (cm)	-0.39*	0.79**	-0.01	-0.37*	0.87**	0.01	0.13	-0.36*	0.78**	0.32	-0.50*
Stalk Length (mm)	0.48*	-0.59*	0.23*	-0.12	-0.48*	0.38*	0.08	-0.34*	-0.64**	0.70**	-0.08
Stalk Width (mm)	0.42*	-0.81**	-0.05	0.38*	-0.06	0.31*	0.58**	-0.25*	0.59**	-0.12	-0.34*
Fruit Length (mm)	0.41*	-0.64*	-0.78**	-0.81**	0.84**	-0.04	-0.56*	-0.38*	-0.56*	0.39*	-0.60**
Fruit Width (mm)	0.50*	-0.33*	-0.43*	-0.14	-0.09	0.17	-0.42*	-0.68**	-0.48*	0.86**	0.11
Fruit Weight (g)	-0.73**	-0.73**	-0.45*	-0.98**	0.06	0.20	-0.19*	0.33*	-0.43*	0.72**	0.39*
Seed Length (mm)	-0.42*	0.48*	0.47*	0.44*	0.41*	0.69**	0.66**	-0.17	0.18	-0.43*	-0.85**
Seed Widht (mm)	-0.82**	-0.82**	0.86**	0.94**	-0.25*	0.55*	0.17	-0.48*	0.24	-0.11	-0.19*
L*	0.44*	0.89**	-0.82**	0.72**	-0.75**	-0.93*	-0.79**	-0.58*	-0.41*	0.56*	0.27*
a*	0.83**	0.97**	-1.00**	0.34*	0.46*	-0.99**	0.63**	0.38*	-0.79**	-0.69**	-0.11
b*	0.72**	1.00**	-0.87**	0.22	-0.16	-0.60*	0.97**	0.67**	-0.01	-0.37*	0.07
Chroma	0.79**	0.99**	-1.00**	0.32*	0.33*	-0.97**	0.69**	0.43*	-0.72**	-0.68**	-0.08
Hue°	0.73**	0.99**	0.99**	0.03	-0.82**	0.97**	0.92**	0.99**	0.98**	0.77	0.63**

G:genotype, H:harvest time
*,** indicates statistical significance at $p<0.05$ and $p<0.01$, respectively

CONCLUSION

In this study, the changes in fruit characteristics of Barberry in different harvest periods were examined and the most suitable harvest time was determined in terms of these characteristics. The properties directly related to yield such as cluster weight, fruit weight, and fruit size reached the highest values in October and then decreased. In addition, since the physicochemical properties in this period are not statistically lower than in other periods, it is obvious that the fruits have reached harvest maturity. Therefore, the most suitable harvest time for barberry fruits in Bolu ecology stands out as October. In the study, it was also determined that barberry fruits could preserve their color in a very long harvest period, so determining the harvest date by looking at the color characteristics could be misleading. Furthermore, it has been revealed that color values are a genetic distinguishing feature and show great changes according to genotypes.

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CHAPTER 15

THE IMPORTANCE OF IRRIGATION IN PISTACHIO AND ITS HISTORICAL DEVELOPMENT IN TURKEY

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INTRODUCTION

Middle East and Central Asia are the gene origins of the pistachio, aka "Green Gold" or "Golden Tree" due to the green fruit inner color and high economic value. It is known that it was first cultivated in Southern Anatolia by Hittites (Anonymous, 2013). Archaeological evidences show that the pistachio was a product consumed around 6750 BC. The currently grown form of pistachio is of Bronze Age origin and its lineage is based on the geography including Uzbekistan (Anonymous, 2021a) (Figure 1). The plant is grown in regions with a suitable microclimate in the world between 30-45^{o} latitude. Anatolia, especially the Southeastern Anatolia region, has the biggest share in the production of this fruit due to its very suitable ecology for pistachio cultivation in Turkey.

Figure 1: View of Pistachio Fruit (Cluster)

Although it varies according to the type of plant, the fresh biomass of plants contain 60-95% water. A large part of this content get used in transpiration, photosynthesis, nutrient transport, structural support and growth processes (James, 1993). Approximately 40% of the world food supply is produced on irrigated agricultural areas. Global warming, industrialization and the rapidly increasing world population are forcing food supply & demand balance. When the increasing demand for food is evaluated with the reality of high consumption ratio (75%) of the fresh water resources in agricultural production, it is clear that protection of water resources and reduction pressures on food production has critical importance. For this reason, increasing productivity in irrigated agriculture is better formulated as "more crop per drop" (Ayars et al., 2015).

1. PISTACHIO PRODUCTION IN THE WORLD

Top pistachio producing countries are Iran, USA, Turkey and Syria, respectively. Production quantities of the leading pistachio producing countries for last 10 years are given and compared in Table 1. Total 80.3% of the world's production is supplied by four countries, where the remaining 18 countries share 19.7% of total production. Turkey's share in total production is 13.1%. In Iran, 57% of the total 457.000 ha pistachio production acreages (total area is 411.432 ha according to FAO) is in the Kerman region. Irrigation water is the major limiting factor for pistachio production in Iran, especially in the Kerman region. Surface irrigation methods are widely used in irrigated pistachio cultivation in this region. However, irrigation efficiency for this method was determined as 47.7% for 1990-2000 period. With the use of porous pipes for irrigation, subsurface irrigation system was adopted as a new and widely accepted method. However, the rate of irrigation in pistachio orchards decreased in parallel to the decreases in groundwater levels (Mohammadi & Panahi, 2006, Mohammadabadi et al., 2020).

Table 1: Pistachio Production in the World

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average (tones)	% of World Productior
Iran	216.000	157.000	183.001	225.001	44. 814	430.000	574.987	648.934	143.695	337.815	335.725	34.4
USA	236.775	201.395	275.500	213.188	233.146	122.470	406.646	272.290	447.700	335.660	274.477	28.2
Turkey	128.000	112.000	150.000	88.600	80.000	144.000	170.000	78.000	240.000	85.000	127.560	13.1
Syria	57.471	55.610	571.95	54.516	28.786	28.800	28.800	51.048	61.631	31.813	45.567	4.7
Subtotal	**638.246**	**526.005**	**665.696**	**581.305**	**782.746**	**725.270**	**1.180.433**	**1.050.272**	**893.026**	**790.288**	783.329	80.3
Others	**137.904**	**172.143**	**165.754**	**171.926**	**182.975**	**196.151**	**216.014**	**228.921**	**216.326**	**227.696**	191.581	19.7
TOTAL	**776.150**	**698.148**	**831.450**	**753.231**	**965.721**	**921.421**	**1.396.447**	**1.279.193**	**1.109.352**	**1.017.984**	974.910	100.0

Source: http://www.fao.org/faostat/en/#data/QC

The history of pistachio production in America dates back to 1854. It was started to be produced in Sonoma in 1854 for the first time in California, where it is still widely cultivated. As a result of the studies conducted during a long period, it was been determined that the most suitable climate for the pistachio plant is California climate as was started to be grown. The history of pistachio in California is started with the journey of American botanist William E. Whitehouse to Iran in 1929 who collected 20 kilos of pistachio. After long years of research, large-scale pistachios plantations were established during 1960s firstly in California and then in Arizona and New Mexico. The first commercial crop, "Kerman" pistachio, was harvested in California in

1976 (Geisseler & Horwath, 2016). According to FAO statistical data, acreages of pistachio in America was 117 thousand hectares in 2019. Although in America, acreages are approximately 3.5 times less and production history is new compared to Iran (Table 2), yield and production amount is higher by the help of adoption of advanced irrigation techniques and programs, drip irrigation and fertigation (Ayars et al., 2015; Anonymous, 2017). In this context, irrigation studies were conducted on adult pistachio trees using drip irrigation in 1985 in California (Phene et al., 1985).

Table 2: Pistachio Harvested Acreages (2019)

Country	Acreages (ha)
Iran	411 432
USA	116 950
Turkey	366 210
Syria	59 989

Source: Faostat (2021)

2. PISTACHIO PRODUCTION IN TURKEY

Although the wild pistachio species used as rootstock can be encountered in 56 provinces in Turkey (Arpacı & Atlı, 1996), cultivation is carried out in 44 provinces (Anonymous, 2017; Şimşek, 2018). Southeastern Anatolia region is the main production area with a 92% share in Turkey's pistachio production. Data on pistachio acreages, production amounts, number of trees and ratios of provinces in Turkey are given in Table 3.

Table 3: Acreages and production estimates for the major pistachio producing provinces (Aslan, 2017)

Provinces	Acreages (da)	Production (ton)	% Ratio		Total number of trees
			Acreages (%)	Production (%)	
Gaziantep	1.335.385	75.298	42.61	44.29	21.982.745
Şanlıurfa	1.129.895	48.106	36.05	28.30	21.122.116
Adıyaman	261.298	18.758	8.34	11.03	6.550.592
Siirt	198.950	6.713	6.35	3.95	3.972.500
Kilis	64.677	2.183	2.06	1.28	1.034.832
Batman	27.755	1.518	0.89	0.89	826.050
Mardin	10.029	1.921	0.32	1.13	316.100
Diyarbakır	4.603	2.224	0.15	1.31	226.576
Sum of GAP* Region	**3.032.592**	**156.721**	**96.75**	**92.19**	**56.031.511**
Other Provinces	101.724	13.279	3.25	7.81	3.731.305
Sum of Turkey	**3.134.316**	**170.000**	**100**	**100**	**59.762.816**

*GAP: Project of South East Anatolia Region in Turkey

Turkey's pistachio production of 170 thousand tons in 2016 was increased to 296 thousand tons in 2020 according to the data of the Turkish Statistical Institute. This increase in production quantity was associated with the increases in the irrigated production, the acreages and the number of trees.

3. HISTORY OF IRRIGATED PISTACHIO PRODUCTION IN TURKEY

Pistachio is one of the main agricultural product for the Southeastern Anatolia region which has a significant impact on the economy of the region. Summers in the region are hot and dry, and winters are quite cold due to typical continental climate. In addition, irrigation emerges as an important requirement in the region due to low and irregular annual rainfalls, high amount of evaporation and transpiration due to dry air. With promotion of the appropriate genetic structure of the plant, this species was mostly grown in arid and economically unsuitable lands in the past, but the development of water resources, irrigation technologies and farmer consciousness in recent years increased cultivations under irrigated conditions. Since pistachio orchards in the past were established in arid and unfavorable areas remote to water sources, the producers could not have the opportunity to irrigate the trees. The tolerance of pistachio to drought was misinterpreted by unscientific approaches and the opinion of "tree may die under irrigated conditions" became widespread in past. On the contrary, when pistachio is irrigated during critical physiological development periods, it can produce higher yields with higher quality.

The availability of irrigation at establishment stage of pistachio orchards plays a decisive role on the facilities. Sharp reduction in water and nutrient competition between trees under irrigated conditions enable narrow plantings (4-6 m) compared to wide plantings (6-8 m) under unirrigated arid conditions. The use of a disease-resistant rootstock and an appropriate irrigation system are prerequisites for the orchards under irrigated conditions. In unirrigated arid conditions, where water and nutrient competition exist for trees, wider interplant distances (6x10 or 8x8) are needed (Anonymous, 2013). For this reason, the full and complete implementation of other cultural applications together with the irrigation applications significantly increase pistachio yields. Irrigation method is also an important factor as well as irrigating to improve yield and quality. Advances in irrigation technologies have led farmers to adopt to water conserving and efficient surface-drip or underground-drip irrigation systems.

In the Southeastern Anatolia region, where pistachio cultivation was intensively carried out, cultivation was under dry conditions until 1980 due to absence of irrigation facilities. After this date, irrigation infrastructures of the “Southeastern Anatolia Project” became operational and pistachio irrigations was started (Ak et al., 2018). Irrigation studies on pistachio in Turkey were also started after this date. The first scientific study was carried out by Bilgen (1982) in the Ceylanpınar State Production Farm between 1976-1979 at the Pistachio Research Institute. In this study, the amount of irrigation water was determined according to the water content of 90-180 cm soil depth by applying the method of pan irrigation in pistachio trees at productive age. In the study, instead of soil observations, "Class A Pan" evaporation values were evaluated. This study was very important because it was a measurement-based irrigation study and revealed the agronomic effects of water, but the approach was not fully fit to requirements of irrigation engineering techniques. In the study, no detailed information was given on issues such as evapotranspiration, amount of irrigation water and number of irrigations, and was just stated the irrigation interval as between 18-50 days.

In another study, which was conducted between 1975-1983 by Kanber et al. (1990), in a 35-40 years old orchard, information was detailed with fundamental subjects such as plant water consumption, irrigation time and amount, which are important aspects for irrigation engineering, as well as plant growth and yield relations. As a result of the proliferation of irrigation practices in pistachio, studies aiming to develop irrigation programs, including information on water amount and timing, were started in this period. In a study conducted for this purpose in Sanliurfa-Harran Plain between 1991-2000 by Bilgel et al. (1999), the amount of irrigation, time and irrigation-yield relationship were determined by observing the water content at a depth of 120 cm of soil with the pan method. More detailed irrigation-efficiency, evapotranspiration, fertilization and advanced fertigation studies were carried out over time.

Aydın (2004) conducted a research in the fields of Pistachio Research Institute and studied drip fertigation applications with different nitrogen doses in a 25-year-old pistachio orchard during 1998-2004. In the study, detailed investigations were made on the amount of irrigation water, plant water consumption, irrigation intervals and water-yield-periodicity relationship. The effect of irrigation on yield increase was determined as 32% when other cultural applications were optimum. With this study, the positive effects of irrigation on basic agronomic parameters such as plant growth, pistachio fruit quality characteristics and periodicity were determined.

In the study of Arpacı et al. (1995) conducted in Şanlıurfa Tektek mountains, it was determined that irrigation was provided significant increases in yield, fruit size and cracking rate, and reduction in empty fruit rate and periodicity. In this study, 60-80 kg/da yield in dry conditions and 262 kg/da yield in irrigated conditions were obtained. 3-4 times increase in yield with irrigation were obtained by researchers. Following these studies, water and nitrogen doses were investigated in pistachio by Kanber et al. (2004) in a TUBITAK supported study between 1999-2002. Different studies for the determination of water consumption of fruit bearing trees and pistachio seedlings and studies comparing sapling irrigation methods were conducted until today (Aydın, 1998; Demir & Atılgan, 2016).

It is not possible to track all pistachio irrigation studies in chronological order. It is not also possible to follow the increase and historical development of irrigated areas with high precision. Statistics on pistachio irrigation acreages can not be found in any of the sources, including the Turkish Statistical Institute (TUIK), the World Food and Agriculture Organization (FAO) and the Ministry of Agriculture and Forestry. Statistical data released by different sources on the subject are completely relativistic and each institutions were calculated estimations according to own approaches. Banks keep records of farmers who used irrigation loans, and Agricultural Credit Cooperatives own records of agri-input customer farmers. Farmer Registration System (FRS) of Ministry of Agriculture and Forestry keep data of the farmers who benefited from agri-support payments who registered their land or pistachio plantations. Since the notifications made to the FRS system are completely based on declaration, they may not reflect the actual figures. As an example, the areas registered in the FRS of Gaziantep

Provincial Directorate of Agriculture and Forestry are given in Table 4 (Anonymous, 2021b).

Table 4: Report of irrigated and rainfed pistachio acreages for Districts of Gaziantep (2021)

Districts	Irrigated (da)	Non-irrigated (da)	Total (da)
Araban	4.951	76.508	81.459
İslahiye	309	444	753
Karkamış	16.630	168.641	185.271
Nizip	11.680	397.479	409.159
Nurdağı	554	0.0	554
Oğuzeli	10.684	134.372	145.057
Şahinbey	2.356	47.448	49.804
Şehitkamil	1.344	135.697	137.041
Yavuzeli	20.410	107.821	128.231
TOTAL	**68.917**	**1.068.410**	**1.137.327**

While the number of pistachio fields under irrigation given in the chart and the number of farmers engaged in irrigation was low at the end of the 1990s and represent leading large scale landowners in certain regions, today irrigation is carried out also on small lands by many farmers. As an addition to these data, "Belkıs-Nizip Irrigation Union" provides irrigation services to Nizip farmers. The irrigation union consists of two irrigation regions. The first one is Belkıs Irrigation Zone which consists of an area of 101.640 da. Since the water source of this zone is the Euphrates River, the site does not have any water supply problem. Since Belkıs Irrigation Union draws irrigation water from the Euphrates River through a pump, the cost of water use is high due to the reflected cost of electricity. Pistachio acreages cover 85%

(approximately 86.400 da) of this area. In 2020, total 20.577 da pistachio fields were irrigated in this region. The second zone is the Hancağız irrigation site with an area of 61.400 da. The water source of this area is the Hancağız Dam. The water sources of the dam are rains and wastewaters. Pistachio is produced in approximately 65% (approximately 40,000 da) of the Hancağız irrigation area (Anonymous, 2021c). Since the water of the Hancağız dam is contaminated due to the domestic and industrial wastes of Nizip district, it is not used by farmers for irrigation, in relation to the opinion that it kills the pistachio trees.

Within the service area of Nizip-Belkıs Irrigation Union, only 20.577 da of 126.000 da pistachio fields are irrigated through this Irrigation Union. Pistachio irrigation by underground water pump outside the Union irrigation area is estimated to increase the total irrigated acreage amount. Interviews with the farmers and the service providing private sector officials showed that irrigated pistachio acreages are around 37.000 da in this region. As can be seen in the example presented, although there is not enough statistical data, it is observed that there is a very rapid spread in pistachio irrigation in Nizip region and that the application is accepted by many farmers.

Aydın et al. (2016) conducted a study in order to determine the irrigation trends of Siirt region pistachio growers. According to the findings of the study, to a great extent (68.9%), the farmers stated that irrigation was beneficial. Also farmers stated that "Siirt Pistachio" should be irrigated and it has a priority, at a rate of 52%. However, the irrigation rate is not high enough due to insufficient water resources, high irrigation cost and inavailable land structure. Producers stated that irrigation applications do increase yields (71%) and does not result with any harm (65.6%).

A similar study was conducted to determine the production habits of pistachio producers in the Siirt region. In the survey study, Siirt province pistachio producers were asked to inform their irrigation system preference and researchers determined the ratios of 21.4%, 3.1%, 13.3%, 16.3%, 63.3% drip irrigation, sprinkler irrigation, flood irrigation, furrow irrigation and no irrigation, respectively. Since Siirt pistachio is produced for consumption as snack, producers are concerned that the taste, aroma and quality of the product will deteriorate with irrigation. Due to this concern, rainfed farming is mostly prefered in the region. The condition or insufficiency of irrigation water resources in the region also prevent irrigations. In the related study, the method of producers for irrigation was by groundwater wells (12.2%), water delivered by canals from dams and ponds (14.3%), and by nearby water resources such as rivers and streams (29.6%). Total 59.2% of the producers marked the “other option” (I do not irrigate, I do not have irrigation water or I irrigate with my own means) as a reply of this question (Akboğa & Pakyürek, 2020).

Different irrigation methods are used in the pistachio growing orchards in the Southeastern Anatolia Region due to reasons such as the state of water resources, accessibility to water, irrigation cost and topographic structure of the land. Applied irrigation methods were improved in parallel to the chronological development since the second half of the

1970s, when irrigation applications started. In recent years, usage of buried drip irrigation systems is increasing in many regions (Figure 2). Although irrigation becomes widespread, it is predicted that problems related to irrigation may arise in the future due to the implementation problems (such as the simultaneous use of the sprinkler system in addition to the drip or buried drip irrigation system) and the use of improper irrigation programs.

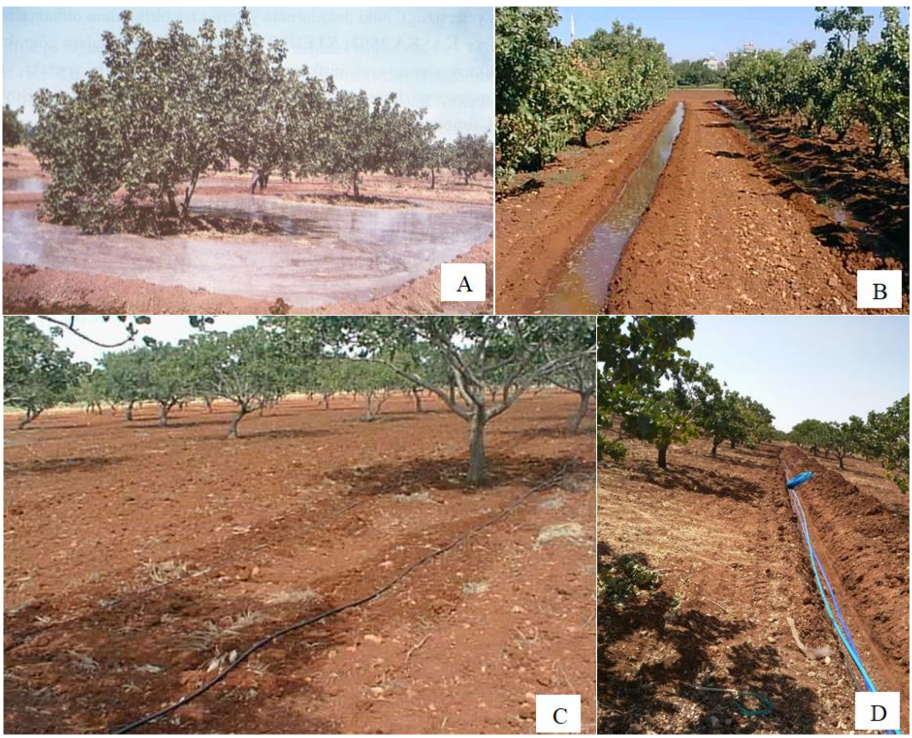

Figure 2: Application examples of different irrigation methods in pistachio irrigation
(A. Ponded irrigation, B. Furrow irrigation, C. Drip irrigation, D. Burried drip irrigation).

CONCLUSION

The production of pistachio, which is an important economic value in the economy of the Southeastern Anatolia region, especially for the Gaziantep, Urfa and Siirt provinces, rapid development in parallel with the adoption of irrigation technologies and the increase in the farmer consciousness levels is obtained. The shift in the general attitude towards irrigation in the last 20 years, adoption of irrigation, the increase in fruit quality and yield in irrigated areas over the years can be considered the main reasons for the rapid development in this area. Shift of position of Turkey in pistachio production to the second or first place in the world rank may only be possible with the widespread usage of modern irrigation and cultivation techniques in production. On the other hand, some preliminary measures should be planned and implemented in order to prevent possible damages sourced from basic issues such as plant health and disease & pest control related to the wrong and unconscious irrigation practices. In addition, it is necessary to determine the pollution level of irrigation water resources and take necessary precautions to increase water quality for pistachio irrigation and to improve access to irrigation water at an affordable cost.

However, in some regions where pistachio cultivation is still carried out, the biased approach of producers to irrigation should be taken into account. In order to replace these prejudices with correct information, conducting studies revealing the current situation is an important point to start. When the availability of statistical data is insufficient, questionnaire studies should be included in the exact determination of the production behavior of the producers. Training activities should be organized in cooperation with Universities and the Ministry of Agriculture and Forestry to improve producers adoption and knowledge on modern irrigation techniques. In pistachio cultivation zones, the importance of irrigation in production should be emphasized by opinion leaders and leading producers. The number of guiding pistachio orchards established with a modern irrigation system should be increased. New dams such as the Ilısu Dam, should also be delivered into service for pistachio producers, as was in the Gaziantep region.

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ISBN: 978-625-7562-09-6