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Determination of late spring frost effects on Monroe peach cultivars in different training systems, planting intervals and height of flower

‘Monroe’ şeftali çeşidinde farklı terbiye sistemleri, dikim sıklıkları ve ağaç yüksekliklerinde ilkbahar geç donlarının etkilerinin belirlenmesi

Melike ÇETİNBAŞ[1*]

Hasan Cumhur SARISU[1]

Sinan BUTAR[1]

[1] Republic of Turkey, Ministry of Agriculture and Forestry, Fruit Research Institute, Eğirdir-Isparta/Turkey

* Corresponding author:
melikecetinbas@gmail.com

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ABSTRACT

Objective: Main purpose of this study is to determine whether the rates of frost damages on pistils caused by the lower temperature varies between different planting distances and the different training systems with the heights of the peach trees.

Material and Methods: The flowers of Monroe/GF 677 peach trees grown in different training systems and planting distances, in the pink bud period, on the 1nd day after the frost that occurred in the period, morning of April 1, hours 5:00 AM-7:00 AM, temperatures -0.33 to -1.23° C, 3 replicates with 100 flowers in each replicate were collected from 4 sides of Slender Spindle, Y-Trellis, Central Leader and Open Vase trees planted with different planting distances from both 1m and 2m height.

Results: The frost damage rates have been obtained as 5.05% for Slender Spindle training system and 2.05% for Y-Trellis training system in the support systems. In unsupported systems, peach cultivation with the Central Leader training system caused less frost damage.

Conclusion: Y-Trellis cultivation system in supported systems and Central Leader in unsupported systems for peach cultivation resulted less frost damage and therefore it was suggested that they were a better systems in terms of productivity.

Keywords: Frost damage, Low temperature, Pistils hardness, Plant management, Y-Trellis

ÖZ

Amaç: Çalışmanın başlıca amacı, düşük sıcaklık ile oluşan dişi organ zararlanma oranının farklı dikim mesafeleri, değişik terbiye sistemleri ile ağaçların yükseklikleri arasında değişip değişmediğini tespit etmektir.

Materyal ve Yöntem: Farklı terbiye sistemlerinde ve dikim mesafelerinde yetiştirilen Monroe/GF 677 şeftali ağaçlarının çiçekleri, pembe tomurcuk döneminde, sıcaklıkları -0.33 ile -1.23 °C, saat 05:00-7:00 arasında meydana gelen dondan sonraki 1. günde (1 Nisan sabahı), farklı dikim mesafeleriyle dikilmiş, İnce İğ, Y-Trellis, Merkezi Lider ve Goble terbiye sistemlerindeki ağaçlarının 4 tarafından ve hem 1m hem de 2m yüksekliklerinde 100’er adet toplanmıştır.

Araştırma Bulguları: Dişi organların zararlanma oranları destekli sistemlerde yetiştirilen İnce İğ sisteminde % 5.05 Y-Trellis sisteminde ise % 2.05 olarak elde edilmiştir. Desteksiz sistemlerde ise, Merkezi Lider sistemi ile yetiştirilen ağaçlarda Goble sistemine göre daha az don zararı gerçekleşmiştir.

Sonuç: Şeftali yetiştiriciliği için destekli sistemlerde Y-Trellis, desteksiz sistemlerde ise Merkezi Lider terbiye sistemi, daha az don zararı ile sonuçlanmıştır ve bu nedenle şeftali yetiştiriciliğinde verimlilik açısından daha iyi bir sistem oldukları belirlenmiştir.

Anahtar Sözcükler: Don zararı, Düşük sıcaklık, Dişi organ zararlanması, Bitki yönetimi, Y-Trellis

INTRODUCTION

In fruit growing, suitability of climatic conditions according to species is one of the most important factors that direct effects the economic and sustainable production. Choosing the right species or varieties of these species and rootstocks are more important in fruit trees due to their perennial structure. Rootstock-scion combination has a direct impact on the yield and quality characteristics of the orchards in the following years. Although the trunks, roots and branches of fruit trees can withstand very low temperatures in dormant period, some parts of plants such as leaf, flower and little fruits are damaged from late spring frosts at the beginning of the active growing season (Ertürk & Güleryüz, 2007).

In recent years, it has become important to select the appropriate species and varieties in order to minimize the lower temperature damages by the increasing global climate change, to clarify the physiological facts which occur at the plants, to know the mechanisms of resistance to lower temperatures and to develop different cultivation systems and different cultural practices.

Through the climate warming in recent decades (Hansen et al., 2006), extreme cold ambient conditions are expected in less frequency (IPCC, 2012) and the expected time of the last spring frost (LSF) has advanced to further (Schwartz et al., 2006). Therefore, decreasing frequency of the extreme cold ambient conditions and severity of frost damage to the plants are expected. Under the enormous impact by climate change, plant species have been facing a trade-off between early growth to maximize the period of the growing season (carbon gain) and late growing to avoid frost damage (Augspurger 2013; Bennie et al., 2010; Ma et al., 2019).

Hence, many studies have been conducted to determine the resistance to both dormant period and spring lower temperatures for many species and varieties (Szabo et al., 1995; Özkarataş & Gülcan, 2000; Öztürk et al., 2001; Özkarataş, 2002; Gunes, 2006; Beyhan et al., 2007; Imani et al., 2012; Köse et al., 2014; Szalay et al., 2018; Ma et al., 2019; Mertoğlu et al., 2019; Pfleiderer et al., 2019; Liu & Sheirf, 2019).

Peach is a fruit which is rich in organic and mineral substances with its unique color, flavor and excellent taste. And it is very valuable in terms of fruit quality among all fruit types. In addition, the ripening time of peach varieties spreads over a long period of 5-6 months during the year which makes this fruit more valuable. Main peach producer of the world is China with 24,665,205 tons (FAO, 2019).According to TUIK (2019); Turkey ranks 6th position in the world with 789,457 tons of peach production. Peach is grown in many parts of the world and it is important to analyse the climatic conditions of the region in order to be able to grow economically.

The Peach is a species, which has early flowering so that, is affected negatively and quickly by late spring frosts. Therefore, one of the most important factors in the restriction of peach cultivation is the risk of frost in late spring. Particularly, late spring frosts cause significant yield losses. Although the peach flower buds are very resistant to cold temperatures in cold seasons, the sensitivity to frost increases with during development of the buds, the blooming of flowers and the formation of small fruits. It is reported to be petal tip for closed buds appearing (first pink) -9.44° to -3.89°C, for first flowers open (first bloom) -6.11° to -3.33°C, full flowering -4.44° and -2.78°C and for end of flowering (all petals fallen) -3.89° with -2.22°C.

These losses occasionally occur in Egirdir (Isparta, Turkey) where orcharding is executed intensively. In this study, the frost damage rates have been determined on pistils which were exposed to lower temperatures between -0.33 °C and -1.23 °C at early morning hours between 05:00-07:00 on 01st of April 2019 for ‘Monroe’ peach orchard at Egirdir (Isparta, Turkey) ecology as in period of flower petals perceptible (first bloom) [according to the BBCH scale (Biologische Bundesantalt, Bundessortenamt and Chemische Industrie), code 57]. Main purpose of this study is to determine whether the rates of frost damages on pistils caused by the lower temperature varies between different training systems (Slender Spindle, Y-Trellis, Open vase, Central leader), different planting distances (for Slender Spindle and Y-Trellis 0.5, 1, 1.5, 2m - for Open vase and Central leader 1, 2, 3, 4, 5m) and the with the heights of the trees (1 and 2m).

MATERIAL and METHODS

The study was performed in 2019 at the location on the northern side of Egirdir Fruit Research Institute (Isparta, Turkey) on Boğazova Valley where has peach tree yards and is extended between Egirdir Lake and Kovada Lake (coordinates: 37° 4930' North, 30° 5238' East, Altitude: 926 m). The experiment area has interior and passage zone ecology. The study performed on the flowers of Monroe/GF 677 peach orchard which was established in 2012 with different training systems and planting distances. The experimented rootstock, GF 677, is a peach x almond hybrid clone rootstock. It is convenient for strong and calcareous soils. Fruits of the Monroe a late season peach variety is weighing an average of 250-300 g, the fruit shape is flattened round. It has a good aroma and is a high-quality variety.

Experimental design

The experimented peach yard was established with 4 different training systems and different planting intervals. Open vase, Central Leader, Y-Trellis and Slender Spindle systems were used. Planting distances are 5x5m, 5x4m, 5x3m, 5x2m, 5x1m, for Open Vase and Central Leader systems and 5x2m, 5x1.5m, 5x1m, 5x0.5m for Y-Trellis and Slender Spindle systems. Therefore, in the experiments, Open Vase and Central Leader systems were compared between as per their planting distances and Y-Trellis and Slender Spindle systems were compared between as per their planting distances. So that, the study was established as two separate trials.

Open Vase (Goble) Training System: Standard Goble training system was applied to the trees. Plants were grown in a form with 4-5 side branches without a leading scaffold and enabled to form of bowl.

Central Leader Training System: Central Leader system (a single leader scaffold and 3 side branches on the leading scaffold) was applied to the trees.

Y-Trellis Training System: During the vegetation period of planting year, a healthy and properly grown minor branch was chosen per each. These side branches which were standing symmetrically to each other have been tied to Y-shaped bamboos. These bamboos are fixed on 3 rows wire system. By having that method, spreading of branch was applied at an angle of 70 degrees for growing. The side branches were pruned in fish bone form in the direction of the row above to enable their growing on each main supportive branch with an interval of 10-15 cm. In this way, the trees have a Y-shaped appearance as 3 meters length.

Slender Spindle Training System: The trees were supported by connecting 3-row wire system and vertical bamboos fixed on a 3 m length support system. The main trunk has reduced the growth of leader scaffold as rotated exactly one turn spirally and was kept it at 2.5-3.5 m. The trees have a narrow and conical form.

The flowers of Monroe/GF 677 peach trees grown in different training systems and planting distances, according to the BBCH scale (Biologische Bundesantalt, Bundessortenamt and Chemische Industrie-code 57) in the pink bud period. On the 1st day after the frost that occurred in the period, morning of April 1, hours 5: 00 AM-7: 00 AM, temperatures -0.33 to -1.23° C, 3 replicates with 100 flowers in each replicate were collected from 4 sides of Slender Spindle, Y-Trellis, Central Leader and Open Vase trees planted with different planting distances from both 1m and 2m height. The collected flowers were brought directly to the laboratory and pistils damaged by low temperature were counted and the number of pistils damaged in 100 flowers was determined (Figure 1). In addition, the flowering phenology of Monroe peach cultivar and some climatic data at this time were examined.

Statistical analyses

The study was conducted according to randomized block design with 3 replications and 5 replicates per tree. Statistical analysis was carried out between the averages of the damage rates on all flowers of the trees in determining the differences between the training systems and planting distances. The differences between tree heights (1 and 2 m.) were also evaluated separately. Resultant data were subjected to variance analysis with SAS-JUMP statistical software. Effects of the training systems, planting distances and tree lengths were assessed and significant differences were tested with the aid of LSD multiple comparison test at $P<0.05$ level.

Figure 1. 57 BBCH scale coded in balloon stage and pistils affected by low temperature.

Şekil 1. *BBCH skalasına göre 57 numara ile kodlanmış çiçekledeki balon dönemi ve düşük sıcaklıktan etkilenmiş dişi organlar.*

RESULTS

Phenology

The flower phenology dates of 'Monroe' was shown in Figure 2, and no differences were found between the training systems and planting distances.

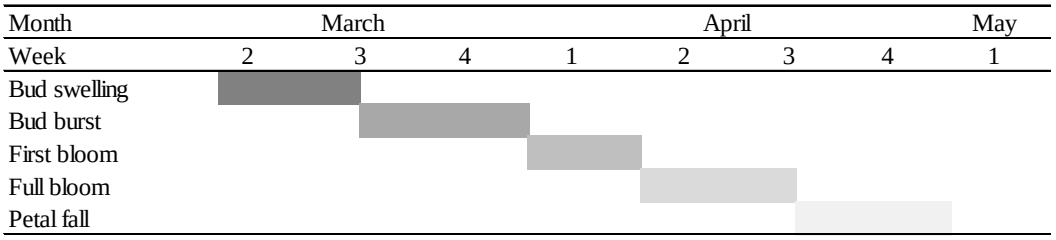

Figure 2. Dates of flower phenology of Monroe peach trees.

Şekil 2. *Monroe şeftali ağaçlarının çiçeklenme dönemi fenoloji tarihleri.*

Climate data in flowering

Some climatic data of the Egirdir (Isparta, Turkey) region between March 25 and April 9 as the most critical flowering period for late spring frosts was examined in trial orchard (Figure 3). The minimum temperature was -1.23 °C, the average temperature was 7.07 °C and the maximum temperature was 14.78 °C. On April 1, the average Dew point was 1.74 °C, the average solar radiation was 253.58 W.m-2 and the average relative humidity was 73.09%.

Low temperature damages in pistils

Damage rates on pistils caused by lower temperature were evaluated separately for training systems with supported wire (Slender Spindle and Y-Trellis) and systems with unsupported trees.

Slender Spindle and Y-Trellis training systems and planting distances compared with each other; the difference in damage rates between the systems was statistically significant ($p < 0.05$) (Table 1). There was no statistical difference in the interaction between systems and densities. Similarly, there was no statistical difference between the densities. The slender spindle (5.05%) showed more pistil damage than Y-Trellis (2.50%) due to low temperatures (Figure 4) between 6:00 and 8:00 in April 1 (Table 1). Although it is seen that the frost damage is not statistically significant in the tree heights of these two systems, the damage of the flowers at 1m was higher in both systems (Figure 5).

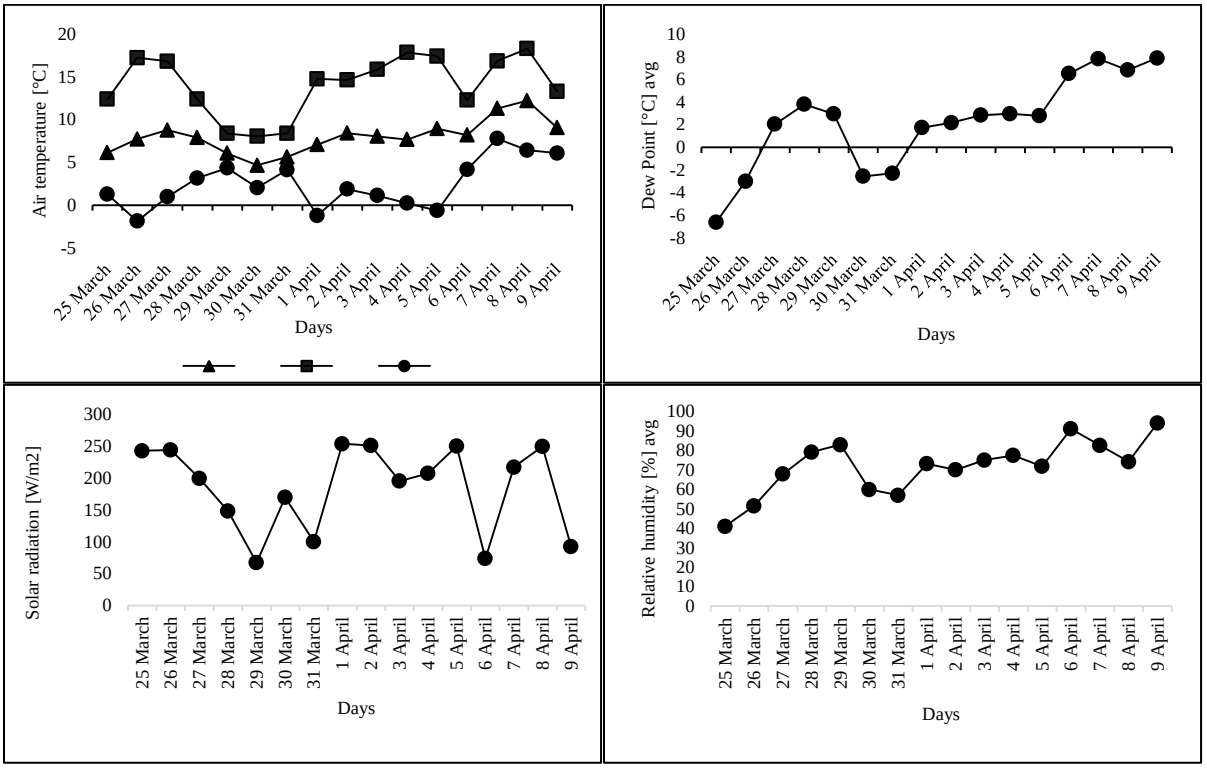

Figure 3. Climate data of peach orchard from 25 March to 9 April.

Şekil 3. *Şeftali bahçesinde 25 Mart-9 Nisan arasında gerçekleşen iklim verileri.*

Table 1. Flower frost damage ratios in slender spindle and Y-trellis (%)

Çizelge 1. *İnce iğ ve Y-trellis sistemlerindeki çiçekte oluşan don zararı oranı (%)*

Training System	Tree distance (m)	Frost damage (%)
Slender spindle	0.5	4.35
	1	6.92
	1.5	3.66
	2	5.30
Y-Trellis	0.5	2.73
	1	2.28
	1.5	2.32
	2	2.67
Training System Mean		
Slender spindle		5.05a*
Y-Trellis		2.50b
	Tree distance mean	
	0.5	3.54
	1	4.60
	1.5	2.99
	2	3.98
P value		
Training System		0.048
Tree distance		0.826
Training System x Tree distance		0.785

a-d*: It is important difference between the averages shown in different letters ($p<0.05$).

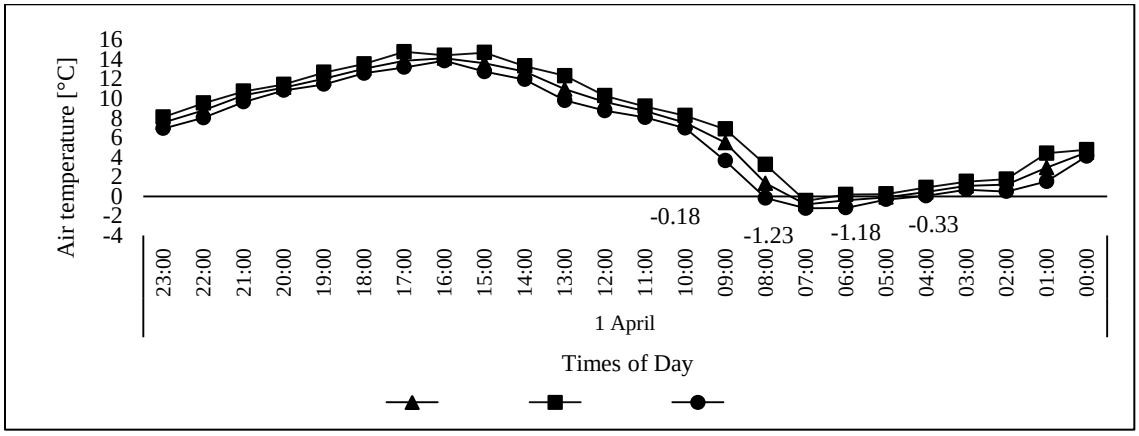

Figure 4. Hourly minimum, maximum and average air temperatures in 1 April 2019.

Şekil 4. 1 Nisan 2019 saatlik minimum, maksimum ve ortalama hava sıcaklıkları.

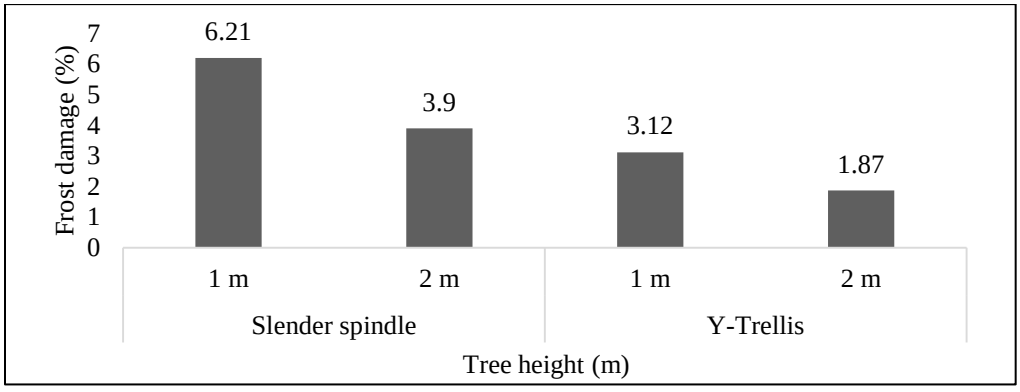

Figure 5. Damage rates of flowers in Y-Trellis and Slender Spindle systems in different tree heights (1 m and 2 m) (%).

Şekil 5. *Y-Trellis ve İnce iğ sistemlerindeki farklı ağaç yüksekliklerinde (1 m ve 2 m) çiçeklerin zararlanma oranları (%).*

According to the results of the analysis of variance on frost damage between free standing systems (Open Vase, Central Leader) and densities; the interaction between both systems and densities was found to be statistically significant ($P < 0.05$) (Table 2).

The highest frost damage was determined in the Open Vase X 2 m trees with 6.73%, while the least damage was detected in trees grown with a planting distance of 4 m in the Open Vase system with 0.43%. When we look at the planting distances; it was found that both dense planting (1 and 2 m) and wide spaced planting (5 m) showed more damage in both systems (Table 2).

It was determined that frost damage in different tree heights changed by systems. In the Open Vase, the damage of the flowers in 2 m was higher than 1 m. In the central leader system, the flowers in 1 m were more damaged (Figure 6).

Table 2. Flower frost damage ratios in Goble and Central leader (%)

Çizelge 2. *Goble ve Merkezi lider sistemlerindeki çiçekte oluşan don zararı oranı (%)*

Training System	Tree distance (m)	Frost damage (%)
Goble	1	6.07a*
	2	6.73a
	3	4.25a-c
	4	0.43d
	5	5.95a
Central leader	1	4.93ab
	2	2.23b-d
	3	0.85cd
	4	3.59a-d
	5	3.52a-d
Training System Mean		
Goble		4.69a*
Central leader		3.02b
	Tree distance mean	
	1	5.50a*
	2	4.48a-c
	3	2.55bc
	4	2.01c
	5	4.73ab
P value		
Training System		0.047
Tree distance		0.041
Training System x Tree distance		0.044

a-d*: It is important difference between the averages shown in different letters (p<0.05).

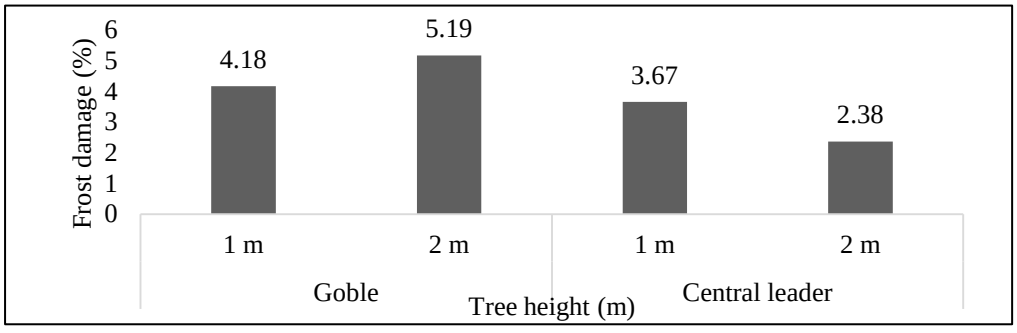

Figure 6. Damage rates of flowers in Goble and Central leader systems in different tree heights (1 m and 2 m) (%).

Şekil 6. *Goble ve Merkezi lider sistemlerindeki farklı ağaç yüksekliklerinde (1 m ve 2 m) çiçeklerin zararlanma oranları (%)*

DISCUSSION

There was no difference in the phenology of Monroe/GF 677 which was grown under the different systems and densities in the trial area which has interior and passage zone ecology. There was a 50-day period between bud swelling and petal fall. It was seen that the damaged pistils at low temperatures (0.33 / -1.23 °C) between 5:00 AM and 7:00 AM in the morning of April 1, 2019. Murray (2011) reported that it could be seen damaged flowers rated 90% at -9.44 °C and rated 10% at -3.89 °C in the petal tip of the closed buds appearing (first pink) period. In our study, although the temperature drop was not so much, the

duration of the lower temperature, dew point of the air, solar radiation, humidity etc. were thought to increase the effect of this low temperature. On April 1, 2019, at duration of lower temperatures, the average solar radiation was 253.58 W/m^2. This value shows that the weather was quite clear on that day and this situation was thought to increase the effect of lower temperature and thus damage to peach blossom. Indeed, Childers (1973) states that if the weather is clear and calm, strong radiation and even severe frost may occur and stated that these frosts are the main damaging frost in the nursery and fruit growing.

It is important to investigate how the different growing techniques, which constitute the purpose of our study, are affected by frost in this time when the temperature fluctuations become more common with the effect of global climate change. In our study, the effects of systems and densities were different not only supported but also free standing trees. It was found that the flowers in Slender Spindle were affected by the low temperature 2 times more than Y-Trellis. The Y-Trellis was considered to have better air circulation, since the two arms were open at the 70-75° angle on both sides and the tree centre was open. Frost damages in these two systems were higher at 1 m tree height. It was thought that this was due to the fact that the fruit branches with a height of 1 m were denser. In free standing trees systems, planting density of 2 m in the Open Vase with 6.73%, which suffered the most frost damage, was followed by Open Vase x 1 m (6.07%). Although the Open Vase suffered more frost damage than the Central Leader system, it is since the cold air was concentrated in the lower parts of the trees. The Open Vase was more affected by frost damage as it had shorter trees than the central leader. Decrease in scaffold height indirectly contributed to increased frost damage. In planting distances; increasing the planting density and decreasing too much caused indirect positive effect in frost damage. It can be said that the air trapped due to frequent planting cannot be distributed quickly. The damage of frost was higher in Open Vase x 2 m and in Central leader x 1 m. This was thought to be due to the fact that the fruit branches of 2 m in Open Vase and of 1 m in the Central Leader were more intense.

In general, supported systems (Slender Spindle and Y-Trellis) were found to undergo less low temperature damages than free standing tree systems. It was concluded that the trees in the supported systems were higher scaffold than the unsupported trees. Blanke et al. (1963), reported that garden management could reduce the damage of low temperature, trees (more than 30 cm) had high scaffold and tall trees the temperature rise of 1-2 °C would cause.

CONCLUSION

As a resistance to lower temperatures, training systems and planting intervals have been determined as effective in peach cultivation. As a matter of fact, the uniformity in flower bud and flower bud density vary with training systems and planting intervals. In this study, Y-Trellis cultivation system in supported systems and Central Leader in unsupported systems for peach cultivation resulted less frost damage and therefore it was suggested that they were a better systems in terms of productivity.

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