U. Ü. ZİRAAT FAKÜLTESİ DERGİSİ, 2014, Cilt 28, Sayı 1, 19-27
(Journal of Agricultural Faculty of Uludag University)

An Experience of Peach Orchard Frost Protection with Upward-Blowing Wind Machines in the East of Bursa, Turkey

Ali VARDAR[1], Onur TAŞKIN[1]

[1]*Uludağ Üniversitesi, Ziraat Fakültesi, Biyosistem Mühendisliği Bölümü, Bursa, Türkiye*
**e-mail: dravardar@uludag.edu.tr*

Geliş Tarihi: 21.05.2014; Kabul Tarihi: 09.07.2014

Abstract: Temperatures below Oº C during spring is a restrictive factor for the production in temperate zone for fruit species with early budbreak. Particularly in hilly terrains, cold air flows downhill towards the valleys, due to gravity force. The upward-blowing wind machines have been used to drain cold air from orchard expelling it upwards out of the plantation area, without disturbing existing atmospheric layers. This research investigates about the efficiency of upward-blowing wind machine in enhancing air temperature in the peach orchard. The experiment was conducted in the spring of 2013 in 10 da commercial peach orchard (40.26◦N; 29.60◦W; 240 m a.m.s.l.) on the east of Bursa, Turkey. Another key to protecting an orchard successfully from frost freeze damage is a good understanding of the meteorology. Therefore, the agricultural weather forecast maps of Turkey showing frost risk that are prepared by Turkish state meteorological service on a daily basis gave a heads-up for a light frost risk on research area. Temperature measurements were performed in the orchard and the system was run on the 17-18 April 2013 night. The minimum air temperature increased from 1.9 to 2.3^{o}C with the highest increase closest to the upward-blowing wind machine. The temperature during this night in low peach orchard shows the influence of upward-blowing wind machine operation. Research has shown that upward-blowing wind machine is so effective under conditions of thermal inversions. Thus, a producer could provide temperature increment in peach orchard against frost damage.

Key Words: Upward-Blowing Wind Machine, Frost Protection, Peach Orchard.

Bursa İli Doğusundaki Şeftali Bahçesinin Dondan Korunmasında Dikey Eksenli Rüzgar Makinesinin Kullanımı

Özet: İlkbahar mevsiminde yaşanan 0ºC'nin altındaki sıcaklıklar, erken tomurcuklanan meyve türlerinin ılıman bölgelerde üretimi için kısıtlayıcı bir faktördür. Özellikle de engebeli arazilerde, soğuk hava yerçekimi kuvvetinin etkisiyle vadilerde birikir. Dikey eksenli rüzgar makineleri ile bahçelerde biriken bu soğuk hava mevcut atmosfer katmanlarını bozmadan tahliye edilir. Bu araştırma kapsamında, Dikey eksenli rüzgar makinesinin şeftali bahçesindeki hava sıcaklığını artırmadaki etkinliği incelenmiştir. Denemeler Bursa ilinin doğusunda bulunan 10 dekarlık ticari şeftali bahçesinde (40.26°K; 29.60°B; 240 m amsl) yapılmıştır. Meyve bahçesini don zararına karşı başarıyla bir şekilde korumak için meteorolojinin de iyi anlaşılması gerekmektedir. Bu nedenle, meteoroloji genel müdürlüğü tarafından hazırlanan zirai don risk tahmin haritaları dikkate alınmıştır. Araştırma alanı için hafif don riski uyarısı haberi verilen 17-18 Nisan 2013 gecesi, meyve bahçesinde sıcaklık ölçümleri gerçekleştirilmiş ve sistem çalıştırılmıştır. Dikey eksenli rüzgar makinesine en yakın noktada 2.3°C olmak üzere, bahçedeki minimum hava sıcaklığı artışı 1.9 °C olmuştur. Dikey eksenli rüzgar makinesinin şeftali bahçesindeki etkisi sıcaklığın düştüğü gece boyunca görülmüştür. Araştırma ile dikey eksenli rüzgar makinesinin termal inversiyon koşullarında etkili olduğu ve böylece üreticilerin don zararına karşı şeftali bahçesinde sıcaklık artışı sağlayabileceği belirlenmiştir.

Anahtar Kelimeler: Dikey Eksenli Rüzgar Makinesi, Dondan Koruma, Şeftali Bahçesi.

Introduction

Cold damages are responsible of significant annual losses in the fruit growing production worldwide (Guarga et al., 2000). Frost damages are especially common during spring time, in the temperate climate world regions (Arias et al., 2010). However, two main types (advective freeze and radiation frost) of frost occur due to different weather conditions. (Turrel, 1973; Kalma et al., 1993). Within the scope of the common radiation frost; as the sun heats the earth during the day, soil and trees become warmer than the air contacting to them. When night falls; air, which is heated by sudden warming from soil and trees, rises and cool air approaches to the earth. Therefore, there happens a difference on the temperature. Cool air damages the trees by accumulating in the hollowest point of the orchard (Anonymous, 2011).

A wide range of passive (indirect) and active (direct) methods exist for avoiding or reducing frost damage. Passive methods, such as plant selection, site selection, appropriate use of cultural and management practices, and modification of the physical environment of the crop are important to avert or minimize frost damage. Active methods are implemented just before or during a frost night to prevent ice formation within sensitive plant tissue. Wind machines, sprinkling irrigation, and open air heating are the most common active protection methods (Ribeiro et al., 2006).

One of the active methods, wind machines have gained popularity as they provide energy conservation and can be used during four seasons when compared with other frost protection methods (Evans, 1999). Especially, upward-blowing wind machine was found simpler and more convenient in small gardens for the air draining. The fans used here can blow the air straight from floor to the 90 meters height different from the horizontal axis wind machines (Figure 1). Because of just accumulated cold air remove at the pit points, this process called “selective extraction” (Pregler, 2010).

The selective cold air drainage system is increasingly being used in some areas of North America, South America, Oceania, Europe and Africa. The machine was applied in Hammond’s Buena Vista, Simpkins Family, Tablas Creek, Three Amigos vineyards, the temperature increment were approximately 1.5°C, 1°C, 2.5°C, 3°C, respectively (Anonymous, 2014a). The same way increased the temperature 2°C in zones with high frost risk in vineyards of the Napa Valley, California, USA and Alto Valle, Río Negro, Argentina (Arias et al., 2010). Another experimental evaluation was made in a 432 ha citrus orchard located in Rio Negro, Uruguay. Results showed that the average frost damage observed at the lowest areas of the protected valley was 14 %, against the 42 % observed at the lowest areas of the unprotected valley. The average frost damage observed at the hilltop of the orchard was 10 % (Guarga et al., 2000). The study in Iran was validated in frost protection of a 20 ha almond orchard. The minimum air temperature increased from 0.5 to 2.8°C, with the highest increase the closest to the machine (Yazdanpanah and Stigter, 2010).

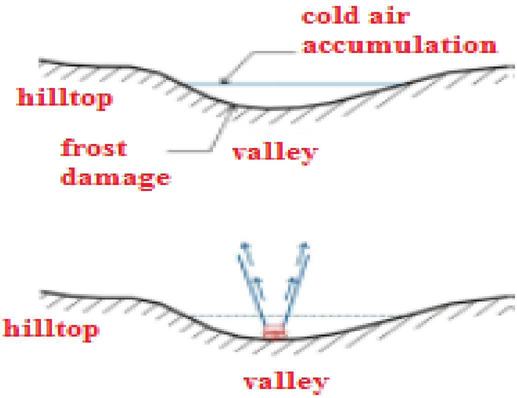

Figure 1. Selective Cold Air Drainage

The purpose of this study was to reveal the effects of upward-blowing wind machines used to provide solution against the danger of frost which is one of the significant climatic problems of peach producers. Thus, temperature measurements had been performed at different distances on a straight line from the center of upward-blowing wind machine. The prospectively positive results are being intended to enlighten the producers regarding the benefits of machine and to prevent product losses.

Materials and Methods

Experimental Site

The experiment was conducted in the spring of 2013 in a commercial peach orchard on the east of Bursa (40.26◦N; 29.60◦W; 240 m a.m.s.l.). Topographic image of orchard and Yenişehir weather station are shown in figure 2. The over the row and between the row distances of *Prunus persica* were 5m. Flowering stage of peach trees starts in April for Bursa region (Figure 3). Frost damage can affect the production negatively during this month.

Upward-Blowing Wind Machines

On 20 March 2013 one upward-blowing wind machines (Model 2500, Profan, Istanbul) were placed in the middle of two separate rows, at the bottom of the depression in the center of the trial block. This kind of wind machine thrusts the cold air upward, allowing the warmer air from above to settle downward. As the cold air is sent upward, it mixes with the above warmer, less dense air layer until it is dispersed into the upper inversion layer.

An overview of upward-blowing wind machine is shown in Figure 4. Additionally, parts of the upward-blowing wind machine are displayed in Figure 5.

Part of the upward-blowing wind machine which performs cold air suction is surrounded with wires formed as cage with square sections. Air suction is performed by the help of three-winged fan which is located horizontally inside the body. Below part of the machine when centered to the fan, performs cold air suction and transferring process of the intaken air to higher levels occurs at the upper part of the machine. Image of the fan can be seen in Figure 6.

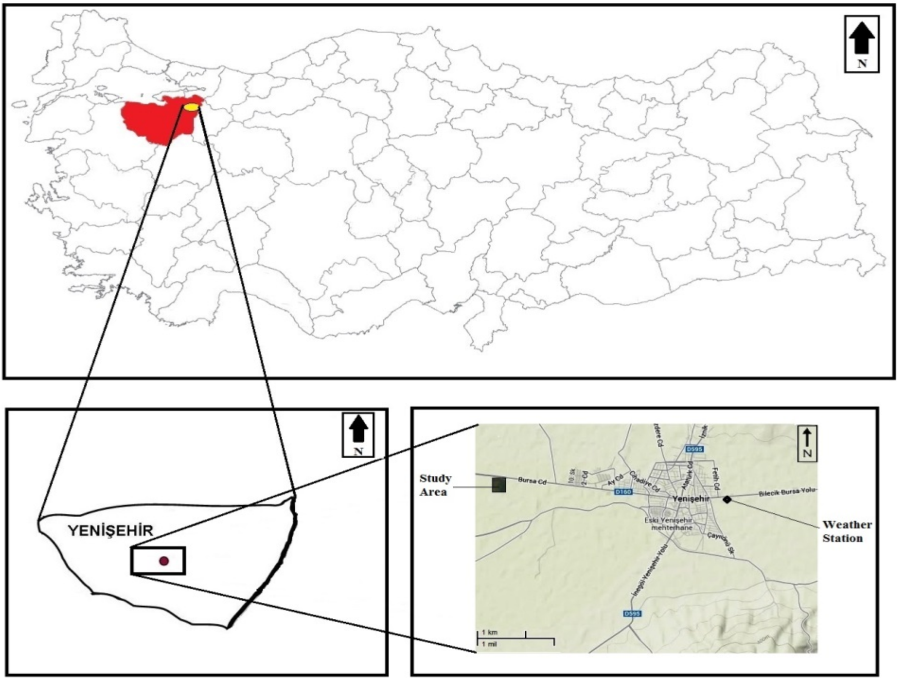

Figure 2. Location of the Orchard

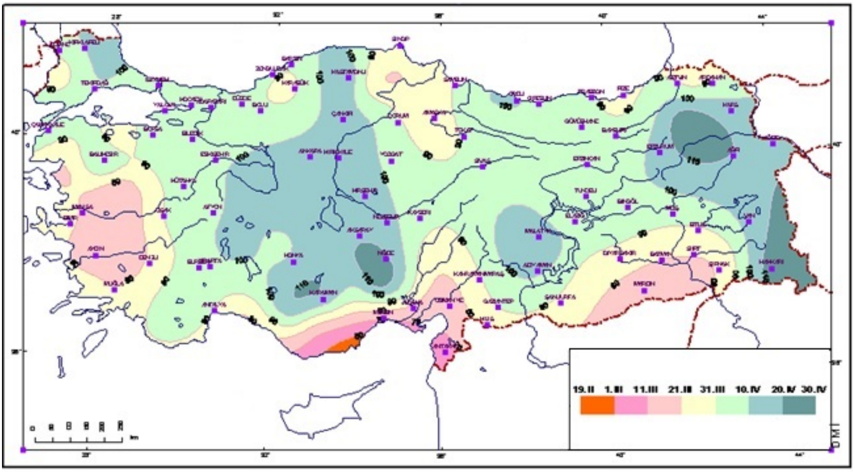

Figure 3. Average Flowering Dates of Peach Orchards in Turkey

Figure 4. Overview of Upward-Blowing Wind Machine

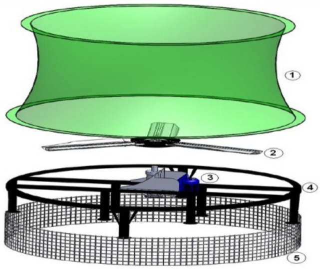

Figure 5. Parts of upward-blowing wind machine are; 1. Fan Chimney, 2. Fan Kit, 3. Engine, 4. Construction 5. Protection cage.

Figure 6. Fan

Movement of the upward-blowing wind machine is provided by an electric motor with power of 15 kW. Electric motor is located underside of the rotor. 1450 rpm rotation of the electric motor is transferred to the fan in two-stages as 450 rpm and 250 rpm values. The transmission ratio is provided with reduction unit.

Weather Station Measurements and Wind Machine Operation

As is known, one of the most important duties of agricultural meteorology is helping for protection of the cultivated plants from harmful climatic conditions at their different stages. The damage of each plant sustained due to frost depends on the type and development stage that of. The most damaged plants from frost are the early blooming fruit trees, banana and citrus gardens, vegetable seedlings and decoration plants and early grown vegetables cultivated in greenhouses.

Decrease of the temperature generally begins at afternoon and it drops below the critical level as of midnight. The speed of dropping can be fast or slow according to the conditions such as clear or overcast sky, force of the wind, relative humidity ratio, precipitation, position of the topography towards the Sun. However, the lowest temperatures appear during small hours and it peaks right before the sunrise (Anonymous 2014b).

General Directorate of Meteorology has been forming daily agricultural frost risk forecast maps of Turkey by using minimum temperature data gathered from total 227 stations. According to this source; measurements have been performed in the peach orchard with thermometer. When temperature dropped to 0^{o}C, machine was operated manually. Agricultural frost risk forecast map of 17-18 April 2013 can be seen in Figure 7.

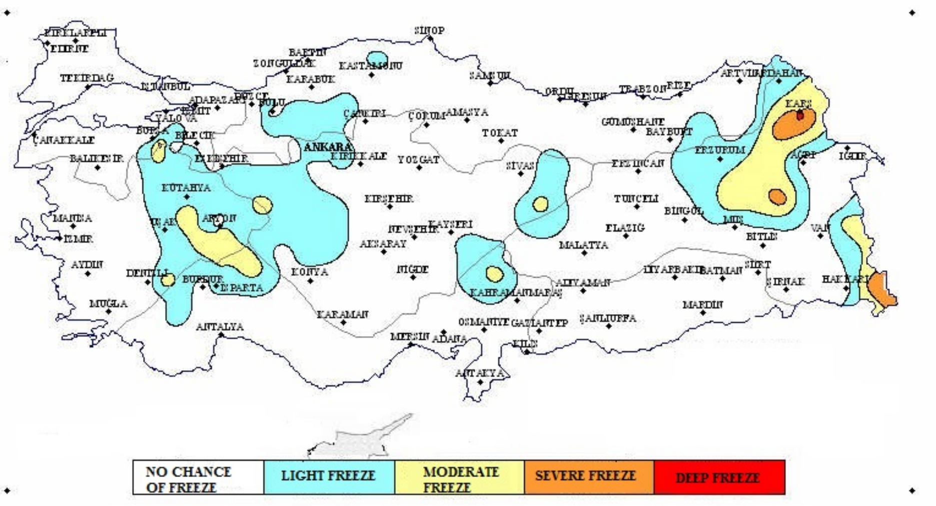

Figure 7. Agricultural Frost Risk Forecast Maps of Turkey (17-18 April 2013 Night)

Evaluation Theory

Lots of methods have been determined in the literature for mapping of the sensitive areas against frost danger. Some of them are desk works based on topographic and climatologic maps. The others are studies which are based on detailed tool measurements and supported with different field measurements. The one which is based on tool measurements is the most common method and different approaches are applied at a wide scale in this method as well. Types and practicability of the tools, density and length of observation are important factors in order the method to be beneficial (Anonymous, 2013).

In order to achieve in the fight against frost with wind machines; first, intensity of the inversion should be determined at nights with frost expectation and then wind machines should be used. At weak inversion conditions, usage of the wind machines is limited. In the areas where severe inversions happen; cost of fight against frost should be determined by considering the economic value of the protected product. Also, as the machine need to be operated by an operator, the success that of depends on the operator. Decision of the operator regarding operation of the wind machines depends on minimum temperature forecast and information on critical damage temperature threshold of the product (Gerber, 1979). These information will be helpful for protection of the orchards by using wind machines (Riberio et al., 2006).

Research was put into practice in 50 x 200 m private experimental plots (Figure. 8). Air temperature measurements were made in 20m and 40m away from wind machine. In order to monitor the regular course of weather conditions, measurements have also been recorded out of the impact zone.

Figure 8. Experimental Peach Orchard

Results and Discussion

Trials were performed in a peach orchard which is located at the lowest area of its geographical region. Temperature changes according to the time at different locations have been examined (Figure 9). From dates with frost probability; temperature dropped to the critical level, which the machine should be operated, (below $0^{o}C$) only on 17-18 April 2013. The temperature difference between the lower and higher elevation areas was reduced during radiation frost nights when the wind machine was operating. When compared with the areas outer the influence area; at 20m 1.9°C rise and at 40m 2.3°C rise were provided.

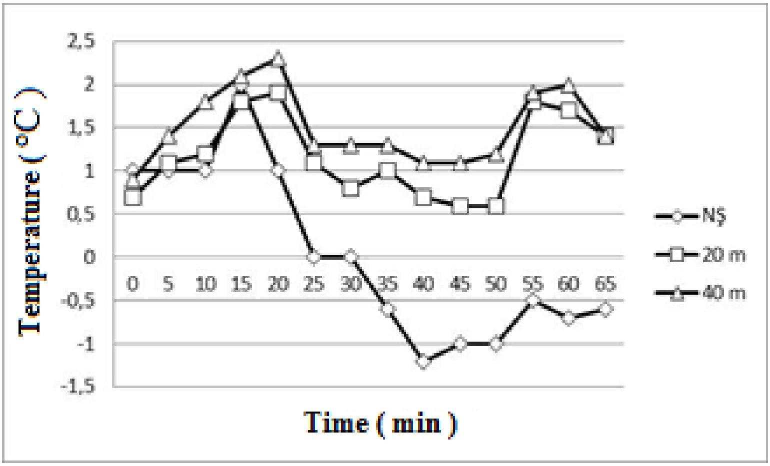

Figure 9. Results

Conclusions

The night that radiation frost was happened has been analyzed within the scope of the study. With the effect of the upward-blowing wind machine; there happened a microclimatic change between the frost prone lower area and non-frost prone upper area. By the removal of the cold air layer; rise in the temperature was provided and blooms on the peach trees were protected against freezing. With usage of the wind machine, one of the effective methods against frost damages, peach producers can be able to expect equal efficiency from their whole orchard.

Reference

Anonymous 2011. Web Address: http://www.duvardabahce.com/ruzgar-makinesi-orchard-rite (04.02.2014)

Anonymous 2013. Web Address: http://mgm.gov.tr/site/yardim2.aspx?=ZIRAIDON (01.03.2014)

Anonymous 2014a. Web Address: http://www.shurfarms.com/research&education2010.html (03.04.2014)

Anonymous 2014b. Web Address: http://www.mgm.gov.tr/tarim/zirai-don-uyari-sistemi-takvim.aspx#amac (22.04.2014)

Ribeiro, A C. Melo-Abreu J P D. Snyder, R L. 2006. Apple orchard frost protection with wind machine operation. Agricultural and Forest Meteorology, 141: 71–81

Gerber, J F. 1979. Mixing the bottom of the atmosphere to modify temperatures on cold nights. In: Barfield, B.J., Gerber, J.F. (Eds.), Modification of the aerial environment of crops, Am. Soc. Agric. Eng. Monogr. 2. St. Joseph, MI, pp. 315–324

Pregler B. 2010. Product Review: Frost Protection--Managing the Air. Wine Business Mountly.

Evans R G. 1999. Frost Protection in Orchards and Vineyards, USDA- Agricultural Research Service.

Yazdanpanah, H. Stigter, C J . 2010. Selective inverted sink efficiency for spring frost protection in almond orchards northwest of Isfahan, Iran. Theor Appl Climatol, 105: 27–35.

Guarga, R. Mastrángelo, P. Scaglione, G. Supino, E. 2000. Evaluation of the SIS, a new Frost Protection Method Applied in a Citrus Orchard. Proceedings of the International Society of Citriculture.

Arias, M. Mendina, M. Arbiza, H. 2010. Two Experiences of Frost Damage Control in Vineyards With Selectively Extraction of Coldest Air: Alto Valle, Argentina and Napa Valley, California USA. Proc. 8th IS on Temperate Zone Fruits in the Tropics and Subtropics. 407-414

Kalma, J D. Laughlin, G P. Caprio, J M. Hamer, P J C. 1993. The Bioclimatology of Frost: Its Occurrence, Impact and Protection. Springer Verlag.

Turrel, F M. 1973. The Science and Technology of Frost Protection. In: The Citrus Industry, Chapter 10. pp. 338-446.