Scientific Papers. Series B, Horticulture. Vol. LXVII, No. 2, 2023
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

CHILLING AND HEAT REQUIREMENTS OF TEMPERATE STONE FRUIT TREES (PEACH, NECTARINE, AND APRICOT)

Imad Jabbar Wadi AL SUWAID[1], Alexandru BUCUR[1], Ana Cornelia BUTCARU[2], Cosmin Alexandru MIHAI[1], Adrian ASĂNICĂ[1], Florin STĂNICĂ[1, 2]

[1]Faculty of Horticulture, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania
[2]Research Centre for Study of Food and Agricultural Products Quality, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author emails: anabutcaru@gmail.com, mcosminalexandru@yahoo.com

Abstract

Like other temperate woody species, stone fruit trees (peach, nectarine, and apricot) must accumulate a specific amount of chilling during endodormancy and heat during eco dormancy for proper growth and development. Each cultivar has particular requirements, and special attention is needed to know them for an optimal decision support system. This paper aims to present the available information on the chilling- and heat requirements of peaches, nectarines, and apricots, focusing on the methods used for their determination. The results also reflected the necessity to standardize the methodology with the possibility of extending to new cultivars tested in different areas.

Key words*: chilling hours; chilling units; chilling portions; growing degree hours.*

INTRODUCTION

Like other temperate woody species, peach, nectarine, and apricots must accumulate a specific number of chilling units during endodormancy and heat during eco dormancy for proper growth and development. Each cultivar has specific requirements, and special attention is needed to know them for an optimal decision support system.

This paper aims to present some available information on the chilling and heat requirements of peaches, nectarines, and apricots, focusing on the methods used for their determination. The reviewed data were organized into five sections: (1) General data; (2) Endo dormancy: chilling hours accumulation. Models and adjusted models; (3) Comparison between models justified by local climatic conditions; (4) When endo dormancy ends and starts heat accumulation (eco dormancy); (5) Heat accumulation models and patterns studied for different cultivars.

RESULTS AND DISCUSSIONS

(1) General data

Winter dormancy, the annual life stage of the tree between leaf drops and bud break, is the deciduous fruit tree mechanism to avoid damage from cold or freezing weather and has two stages that cannot be visually separated in the field.

In the first part, called endodormancy, tree growth is limited in the plant. A certain amount of cool temperature is required to end this first stage. This is referred to as the Chilling Requirement. Temperatures between -1°C-15.5°C contribute towards ending this first stage of winter dormancy, with temperatures between 1.6°C-10°C contributing the most chilling (Niederholzer, Scalabrelli & Couvillon, 1986).

In the second part of winter dormancy (eco dormancy), growth is controlled by an external factor - temperature. Each deciduous plant species requires a certain amount of heat to begin growing after the first stage of winter dormancy has been completed.

In conclusion, deciduous fruit trees need some cool weather and warm temperatures to start growing. Different tree species need different amounts of chilling and warm temperatures to bloom and grow (Niederholzer).

When the specific amounts of chill or heat are not completed, trees are affected by different disorders (Parker et al., 2019).

Chilling and heat requirement is critical in selecting cultivars for a given geographical region. Chilling requirements are generally largely satisfied in the temperate zone before the end of the cold season. Flowering happens too early, and low temperatures can induce an essential yield loss by frost.

Late blooming in stone fruit has been the objective of most breeding programs.

In subtropical areas, insufficient chilling is an economic problem. Symptoms of insufficient chilling are delay in flower and vegetative bud break, bud breaks spread over an extended period, or, in severe cases, a total lack of bud break.

Cross-pollination is needed in the field, so cross-compatible and simultaneously flowering cultivars must be selected as cultivars with similar chilling and heat requirements (Razavi, 2011).

Since the accumulation of temperature in the first 30 days after bloom plays a decisive role in fruit phenology, it has been found that increasing its temperature more than the specified temperature during spring after flowering in peach trees causes problems in the formation of fruit in these trees. Growing degree hours accumulate during the first 30 days after bloom reduces the number of days between the full bloom date and the reference date (Lopez & Dejong, 2007).

Investigating the growth pattern and phenological stages of early-maturing peach trees in the Mediterranean region showed that after 225 cold units to break dormancy, 6,244 growing degree hours (GDH) are required to reach full bloom, and 27,106 GDH are required before harvesting the fruit. About growing degree days (GDD), the heat requirement for full bloom was 329, and for fruit, harvesting was 1246 (Mounzer et al., 2008). It has been explained that by increasing the duration of the plant's exposure to chilling, the time and heat accumulation of breaking flower buds in peaches decreases exponentially (Okie & Blackburn, 2011). The study of peaches and nectarines cultivars found that the intensity of rest was lower in the flower buds. The resting intensity in the flower bud accompanied by chilling is reduced with a lower ratio than the leaf bud. In addition, it was found that the flower and leaf buds had different endo-dormancy depths but almost similar chilling requirements (Gariglio et al., 2006). It has been explained that terminal vegetative buds have a lower chilling requirement in the peach plant than lateral vegetative buds and flower buds. Meanwhile, the cold requirement in lateral vegetative buds and flower buds of the Redhaven cultivar was almost similar. In addition, it has been found that a temperature of 7.2°C is effective in meeting the cold requirement compared to 2°C or 3°C. Increasing the duration of chilling (2,040 hours) decreased the hours of growing degree required for the opening of vegetative buds regardless of temperature. However, the growing degree hours required for the flower buds were reduced by increasing the chilling duration to 7.2°C (Scalabrelli & Couvillon, 1986). The investigation has shown that the number of days to full bloom and the heat requirement for blooming peach trees negatively correlated with the accumulated chilling hours. In addition, it was found that the accumulated chilling hours had a significant negative correlation with the fruit shape index and fruit tip lengths. This issue confirms the effect of the number of chilling hours on the appearance of the fruit in dimensions and size. Hence, reducing the number of chilling hours during winter delays the bloom date in the tree and leads to the production of deformed fruits in peach. This issue can also be applied to other fruit trees in temperate regions (Yong et al., 2016).

Today, there are concerns about climate change and the lack of chilling requirements in trees with high chilling requirements (Parker & Abatzoglou, 2019). The study of 69 Japanese apricots found that the chill requirement in these cultivars ranged from 24 to 82 chill portions based on the dynamic model. The heat requirement in these cultivars was also observed between 691.9 and 2634.7 growing degree hours. The difference in the cold requirement of the studied cultivars makes it possible to select suitable cultivars for each region with specific climatic conditions (Zhuang et al., 2016).

(2) Endo dormancy: chilling hours accumulation. Models and adjusted models

The primary parameter in all the algorithms is the temperature. It can be measured by data loggers or specific sensors attached to meteo stations. Nowadays, there are many meteo data available worldwide on different platforms. https://www.ecad.eu/ presents an international meteo station with free daily data for 50-100 years in the past. ECA & D receives data from

85 participants from 65 countries, with 13 elements at 23,335 meteorological stations.

Other local meteo stations (on site) with free data or not are https://fruitsandnuts.ucdavis. edu/ chill-calculator, https://www.meteoblue.com, input companies (Syngenta, Bayer, etc.) and more.

Temperature can be recorded daily (Tmin., Tmax., Tavg.), hourly, 30 minutes, 15 minutes, etc. In the phenology algorithms, hourly temperature is used. If this is not available, there are more algorithms to transform daily data into hourly temperature (Chow & Levermore, 2007; Chițu, 2010).

The most used models to quantify the chilling hours are:

The chilling hours model (known before the 1950s) has been widely used for its simplicity and ease of use.

- Establishes that a cold hour (CH) corresponds to an hour with a temperature value between 0 and 7.2°C (this range of temperatures is considered to affect dormancy completion).
- Temperatures below 0°C do not affect slowed biological processes, and those above 7.2°C (45 F) were considered not low enough to affect dormancy completion.

Hutchins (1932), cited by Weinberger (1950); Richardson et al. (1975); Anderson et al. (1986).

The Utah model

- is based on the quantification of cold units (CU);
- establishes different temperature ranges with different contributions to dormancy completion;
- One cold unit corresponds to one hour for temperatures between 2.5-9.1°C, considered most effective in completing dormancy;
- Other temperature ranges have:
- 0.5 unity (1.5-2.4°C and 9.2-12.4°C),
- zero contribution (<1.4°C and 12.5-15.9°C) or
- negative (>16°C) at rest.

Richardson et al. (1974). There are more variations of the model, like the North Carolina model (Shaltout & Unrath, 1983; Anderson & Seeley, 1992), the Positive Utah model (Linsley-Noakes & Allan, 1994), Modified Utah Model (Linvill, 1990), in the effort to simulate the local conditions better.

The dynamic model (initiated in the 1980s):

- proposes accumulating an intermediate value according to low temperatures that can be reversed by higher temperatures (first stage).
- Once the value has reached a certain level, cold portions are added permanently, unaffected by higher temperatures.

Fishman et al. (1987), Luedeling (2012), https://ucanr.edu/sites/fruittree/How-to_Guides/Dynamic_Model_-_Chill_Accumulation/ (University of California), Fadón et al. (2020), Pantelidis & Drogoudi (2023).

The importance is given to the sequence of temperatures during the cold season**.** Similar temperatures at different times of the season can affect chill accumulation differently.

(3) Comparison between models justified by local climatic conditions

Researchers applied the existing chilling accumulation models in different cultivation areas and compared the results with the field reality (Luedeling, 2012; https://fruitsandnuts.ucdavis.edu/chill-calculator).

Miranda et al. (2021) published "fruclimadapt: An R package for climate adaptation assessment of temperate fruit species", describing the functions defined for chill hours(), chill_units(), chill_portions(), GDD_linear(), GDH_linear(), and GDH_asymcur().

Luedeling (2012) and most researchers compared at least two to three methods on specific cultivars for calibration. In the Lueding (2012) study, the Dynamic model was considered the best model for the species applied.

Zhu et al. (2022), in the study of flowering phenology in peaches and comparing different models with the purpose of monitoring flowering, found that the investigation of phenology based on BBCH comparison and the use of the random effect model in comparison with other models provides researchers with more accurate information. The highest score (98.82) correlated with the harmonic average of model accuracy and recall was obtained in this model. It is worth noting that real-time images recognize the specific color range and area, and the information related to the heat requirement improves the model's performance. This information facilitates the management of plant breeding, such as heat stress management, water requirements, and breeding programs.

The comparison of two critical data models and critical chilling models by Miranda et al. (2013) in Peach in Spain determined that the critical chilling models were at least 40% more efficient than the critical data model. Because in the critical chilling model, the chilling temperature was also calculated during the dormancy period. The results showed that the evolution of different phenological stages in the studied peach cultivars can be predicted with high efficiency by simple sequential statistical fitted models. In these models, chilling was evaluated by dynamic methods and forcing heat accumulation by growing degree sums. This model is applied to a wide range of climatic conditions of peach cultivation (Miranda et al., 2013).
In the study of the chilling and heat requirement of 63 nectarine genotypes and 118 peach genotypes over seven years, it was determined that the Luedeling model, compared to the Alonso model, was more successful in estimating the chilling and heat requirement in Argentina's climate conditions. In addition, chilling accumulation could be calculated using Chilling hours or positive Utah models (Maulion et al., 2014).
The study of peaches and nectarines in different climatic conditions showed that the chill accumulation in Murcia-Torre Pacheco (Spain) was 45 chill portions, in Coneo (Italy) and Bucharest (Romania), 97-98 chill portions. After earlier blooming in relatively cold areas and with a delay of 7-11 days in warmer areas, it can be explained that the bloom time is significantly affected by the delay of rest completion in those areas. The dynamic model performed better than others in predicting the bloom date (Drogoudi et al., 2023).
Another method for estimating chilling requirements in temperate trees, such as peach, can be using a portable E-nose. In the peach tree, the use of the E-nose method and the Partial Least-Squares Regression (PLSR) quantitative analysis model successfully estimated the chilling requirement. This method can also be used in other fruit trees (Yan et al., 2021).

(4) When endo dormancy ends and starts heat accumulation (eco dormancy)

There are more methods to estimate the point where to stop counting the chilling accumulation and when to start counting the heat amount:
- Take the shots in the laboratory and make observations in a controlled environment.
In the research of Milech et al. (2022), it was found that the Tabuenca test, which is based on the difference in the dry weight of the bud, has shown excellent and acceptable performance in estimating the end of dormancy in peaches. It has been explained that the d+ 7.2ºC and d+ 11ºC models are helpful and efficient in calculating chilling accumulation. According to the d+ 11ºC model, the number of hours required to complete dormancy for the BRS Bonão, Esmeralda, Granada, and Eragil cultivars was 180, 250, between 300 and 400 and more than 500 hours, respectively (Milech et al., 2022).
- Recurrent algorithms (Gaylen et al., 1977).
Where temperature and complete bloom data are available, but the end of rest data are not known, the constants can be accurately estimated with several steps through a recurrent algorithm. It starts with an estimation of the CU requirement, followed by an estimated date for the end of the rest. Calculate GDH accumulation until the observed date of full bloom for at least six years of data. Calculate the standard deviation for the GDH accumulations and repeat the steps.

(5) Heat accumulation models and patterns studied for different cultivars

Since 1730, when Reamur introduced the concept of the heating unit (McMaster & Wilhelm, 1997), many methods have been developed. GDD (growing degree days) and GDH (growing degree hours) are the most known.
GDD (growing degree days) collects the days when the average temperature exceeds a certain threshold specific to each species.
$GDD = T_{avg} – T_{base}$, if $T_{avg} \geq T_{base}$
$GDD = 0$, if $T_{avg} < T_{base}$
McMaster & Wilhelm (1997) highlight the basic formula for GDD (Tmin./Tmax.).

GDH (growing degree hours) is defined by Richardson et al. (1974) as:
(1) $GDH = F*A/2 (1+\cos (\pi + \pi (TH-TB)/ (TU-TB)))$, where:
TH = hourly temperature,
TB = base temperature (4°C for trees),
TU = optimal temperature (25°C for trees)
TC = critical temperature (36°C in trees),
A = TU-TB,

F = a stress factor (due to biotic/abiotic factors). In most of the research until now, F was considered = 1

(for ex. Nutrition status, system planting - where the Vertical axis can lead to one-week harvesting airlines than Trident, etc.)

(2) GDH = F*A (1+cos (π/2 + π/2 (TH-TU)/(TC-TU)))

If TH < TU equation (1) is used, if TH>=TU, (2) (Gu, 2016).

How many GDH are needed to bloom (BBCH 67) or to be ready for harvesting (BBCH 87) for peach/ nectarine/ apricot for a specific cultivar?

In the literature are at least two methods: (1) take the shoots in the laboratory and make observations in a controlled environment (Valentini et al., 2004; Pantelidis et al., 2022); (2) make observations in the field and summaries with multiannual data (Richardson et al. (1975), Scalabrelli & Couvillon (1986), Roman et al. (1998), Citadin et al. (2001), Marra et al. (2002), Ruiz et al. (2006), Ruiz et al. (2007), Mounzer et al. (2008), Litschmann et al. (2008), Razavi (2011), Miranda et al. (2013), Guo et al. (2015), Kwon et al. (2020), Fadón et al. (2020), Rodriguez et al. (2021), Atagul et al. (2022), Drogoudi et al. (2023).

More details in research found were on the prediction of the harvest day correlated to GDH in the first 30 or 60 days after blooming:

- ❖ Peach and nectarine: correlation between GDH30 (Mimoun & DeJong, 1999) or GDH60 () with the harvest day.
- ❖ Determine the GDH30 and GDH60, and pruning can be applied to avoid smaller fruits if there is an earliness in the harvest time.

UC DAVIS – extension services for farmers: (https://fruitsandnuts.ucanr.edu/Weather_Services/Harvest_Prediction__About_Growing_Degree_Hours/)

The researchers suggested that the blooming time is more affected by heat. As more heat accumulates, blooming in peach trees in Spain and Greece has also occurred earlier (Pantelidis et al., 2022). It has also been reported that heat accumulation after bloom is one of the critical factors in the harvest date and fruit development (Day et al., 2008).

Different cultivars of *Prunus persica* (L.) Batsch have different heat requirements for blooming and leafing. DellaNona and BR-1 cultivars had high heat requirements. However, a moderate heat requirement was observed in Planalto, Sunlite, and Eldorado cultivars. The heat requirement of Precoconho and Riograndense cultivars was also low compared to the other cultivars. During eco dormancy, the thermal requirements of vegetative and flower buds differed. Therefore, the results showed that prolonging chilling increased leafing compared to blooming (Citadin et al., 2001).

The study of different cultivars of apricot and peach showed that the cultivars' time to remove dormancy differed. This time in apricots was from late December to early February and in peaches from late December to mid-January. Furthermore, the results showed that the growing degree hour accumulations and growing degree day accumulations are reliable and effective methods for estimating the heat requirement in trees (Valentini et al., 2004).

The study of heat requirement in 136 peach cultivars for eight growing seasons showed that its range differed between the studied years from 1362 to 10,348 growing degree hours. This study observed a positive correlation between the bloom date and chilling requirement and a negative correlation between the chilling requirement and the heat requirement. In addition, it was found that the base temperature in each genotype must be determined accurately to determine the heat requirement accurately. The type of different genotypes of peach in the heat requirement provides the possibility of using them in breeding programs and introducing the cultivars capable of cultivation in regions with different climatic conditions (Atagul et al., 2022).

The study of 100-year data in Korea related to the chilling and heat requirement of peach cultivars showed that the chilling requirement of 15 investigated cultivars was between 263 and 2,123 chill hours, 377 and 1,134 chill units, 21.3 and 74.8 portions chilling. In the comparison between the models (Chill Hours, Utah, Dynamic, North Carolina, and Low Chilling models), it was also found that the dynamic model had the highest accuracy and the lowest changes between the years. In the next place was the Utah model. The range of heat requirement varied between 4,825 and 5,506 growing degree hours and was positively correlated with flowering time. During the 100 years studied, in the Utah and chill hours models, the start of chilling accumulation was delayed by 10 to 12 days (Kwon et al., 2020).

CONCLUSIONS

Fruit growing stages is an old research field with many steps made in the research network. Modeling the processes and transferring them in the deep learning machines were followed in more regions of the world.

Stone fruits were highly researched, and nowadays, accurate algorithms can be applied in different support decision systems with reasonable accuracy.

ACKNOWLEDGEMENTS

This work was supported by a grant from the University of Agronomic Sciences and Veterinary Medicine of Bucharest, project number 2022-007/16.05.2022 acronym RealTimeFruit, within IPC 2022.

REFERENCES

Anderson, J.L. & Seeley S.D. (1992). Modeling strategy in pomology: Development of the Utah models. *Acta Horticulturae 313*, 297-306.

Anderson, J.L., Richardson, E.A. & Kesner, C.D. (1986). Validation of chill unit and flower bud phenology models for 'Montmorency' sour cherry. *Acta Hortic. 184*, 71-78, DOI: 10.17660/ActaHortic.1986.184.7

Atagul, O., Calle, A., Demirel, G., Lawton, J.M., Bridges, W.C., Gasic, K. (2022). Estimating Heat Requirement for Flowering in Peach Germplasm. *Agronomy*, *12*(5), 1002. https://doi.org/10.3390/agronomy12051002

Chițu, E. (2010). Metodă de avertizare a efectelor înghețurilor târzii în plantațiile pomicole prin simulare feno-climatică, brevet, OSIM.

Chow, D. & Levermore, G.J. (2007). New algorithm for generating hourly temperature values using daily maximum, minimum, and average values from climate models. Building Services Engineering Research & Technology, 28, 237–248.

Citadin, I., Raseira, M., Herter, F.G., & da Silva, J. B. (2001). Heat Requirement for Blooming and Leafing in Peach, *HortScience HortSci, 36*(2), 305-307, https://journals.ashs.org/hortsci/view/journals/hortsci/36/2/article-p305.xml

Drogoudi, P.; Cantín, C.M.; Brandi, F.; Butcaru, A.; Cos-Terrer, J.; Cutuli, M.; Foschi, S.; Galindo, A.; García-Brunton, J.; Luedeling, E.; et al. (2023). Impact of Chill and Heat Exposures under Diverse Climatic Conditions on Peach and Nectarine Flowering Phenology. *Plants 2023, 12*, 584. https://doi.org/10.3390/plants12030584

Fadón, E.; Herrera, S.; Guerrero, B.I.; Guerra, M.E. & Rodrigo, J. (2020). Chilling and Heat Requirements of Temperate Stone Fruit Trees (*Prunus sp.*). *Agronomy*, *10*, 409. https://doi.org/10.3390/agronomy10030409

Fishman, S., Erez, A., Couvillon, G.A. (1987). The temperature dependence of dormancy breaking in plants: Two-step model involving a cooperative transition. *J. Theor. Biol., 124*, 473 – 483.

Gariglio, N., Gonzalez Rossia, D.E., Mendow, M., Reig, C. & Agusti, M. (2006). Effect of artificial chilling on the depth of endodormancy and vegetative and flower budbreak of peach and nectarine cultivars using excised shoots. *Scientia Horticulturae, 108*, 371–377.

Gaylen, A., Richardson, E. & Seeley, S. (1977). A statistical method of determining chill unit and growing degree hour requirements for deciduous fruit trees. *HortScience, 12*, 347–348.

Gu, S. (2016). Growing degree hours - a simple, accurate, and precise protocol to approximate growing heat summation for grapevines. *Int J Biometeorol*, *60*(8), 1123-34. doi: 10.1007/s00484-015-1105-8.

Guo, L., Dai, J., Wang, M., Xu, J. & Luedeling, E. (2015). Responses of spring phenology in temperate zone trees to climate warming: A case study of apricot flowering in China. *Agricultural and Forest Meteorology*, *201*, 1–7, https://doi.org/10.1016/j.agrformet.2014.10.016.

Kwon, J.H., Nam, E.Y., Yun, S.K., Kim, S.J., Song S.Y., Ju-Hyun Lee & Hwang, K. (2020). Chilling and heat requirement of peach cultivars and changes in chilling accumulation spectrums based on 100-year records in the Republic of Korea. *Agricultural and Forest Meteorology*, *288*, 108009, https://doi.org/10.1016/j.agrformet.2020.108009.

Linsley-Noakes, G. & Allan, P. (1994). Comparison of two models for the prediction of rest completion in peaches. *Scientia Horticulturae, 59*, 107–113. https://doi.org/10.1016/0304-4238(94)90077-9

Linvill, D. E. (1990). Calculating chilling hours and chill units from daily maximum and minimum temperature observations. *HortScience HortSci, 25*(1), 14-16. https://doi.org/10.21273/HORTSCI.25.1.14

Litschmann, T., Oukropec, I., & Kirzan, B. (2008). Predicting individual phenological phases in peaches using meteorological data. *Horticultural Science, 35*(2), 65-71.

Lopez, G. & Dejong, T.M. (2007). Spring temperatures have a major effect on early stages of peach fruit growth. *Journal of Horticultural Science & Biotechnology. 82*(4): 507-512.

Luedeling, E. (2012). Climate change impacts on winter chill for temperate fruit and nut production: A review. *Scientia Horticulturae, 144*, 218-229, https://doi.org/10.1016/j.scienta.2012.07.011.

Marra, F, Inglese, P., Dejong, T. & Johnson, R.S. (2002). Thermal time requirement and harvest time forecast for peach cultivars with different fruit development periods. *Acta horticulturae. 592*. 523-529. 10.17660/ActaHortic.2002.592.70.

Maulión, E., Hugo, G.V., Kovalevski, L., Prunello, M., Monti, L.L., Daorden, M.E., Quaglino, M., Cervigni, G. D. L. (2014). Comparison of methods for estimation of chilling and heat requirements of nectarine and peach genotypes for flowering, *Scientia Horticulturae*, *177*, 112-117, https://doi.org/10.1016/j.scienta.2014.07.042.

McMaster, G.S. & Wilhelm, W.W. (1997). Growing degree-days: one equation, two interpretations. *Agricultural and Forest Meteorology*, *87*, 4, 291-300,

Milech, C.G., Dini, M., Franzon, R.C., Bassols Raseira, M.C. (2022) Chilling requirement of four peach cultivars estimated by changes in flower bud weights. *Rev. Ceres, Viçosa, 69*(1), 022-030.

Mimoun, M. B. & De Jong, T.M. (1999). Using the relation between growing degree hours and harvest date to simulate run-times for peach: a tree growth and yield simulation model. *Acta Hort., 499*, 107-110.

Miranda, C., Santesteban, L.G., Royo, J.B. (2013). Evaluation and fitting of models for determining peach phenological stages at a regional scale. *Agricultural and Forest Meteorology*, *178*, 129-139, https://doi.org/10.1016/j.agrformet.2013.04.016.

Miranda, C., Urrestarazu, J. & Santesteban, L.G. (2021). fruclimadapt: An R package for climate adaptation assessment of temperate fruit species. *Computers and Electronics in Agriculture*, *180*, 105879, https://doi.org/10.1016/j.compag.2020.105879.

Mounzer, O. H., Conejero, W., Nicolás, E., Abrisqueta, I., García-Orellana, Y. V., Tapia, L. M., Vera, J., Abrisqueta, J. M., & Ruiz-Sánchez, M. d. C. (2008). Growth pattern and phenological stages of early-maturing peach trees under a mediterranean climate. *HortScience horts, 43*(6), 1813-1818.

Niederholzer F., University of California, https://fruitsandnuts.ucdavis.edu/weather-models

Okie, W.R. & Blackburn, B. (2011). Increasing chilling reduces heat requirement for floral budbreak in peach. *HortScience. 46*(2), 245–252.

Pantelidis, G. & Drogoudi, P. (2023). Exploitation of genotypic variation in chilling and heat requirements for flowering in *Prunus armeniaca* and *Prunus persica* (L.) Batsch cultivars. *Scientia Horticulturae*, *321*, 112287.

Pantelidis, G., Reig, G., Cantín, C.M., Giovannini, D., Drogoudi, P. (2022). Estimation of chilling and heat requirements of peach and nectarine cultivars grown in the EUFRIN trials located in different pedoclimatic conditions. *Acta Hortic.*, *1352* (2022), pp. 463-470

Parker, L.E. & Abatzoglou, J.T. (2019). Warming winters reduce chill accumulation for peach production in the Southeastern United States. *Climate*, *7*(8), 94. https://doi.org/10.3390/cli7080094.

Razavi, F. (2011). Comparison of chilling and heat requirement in some peach and apricot cultivars. *Research in Plant Biology, 1*(2), 40-47.

Richardson, E. A., Seeley, S. D., Walker, D. R., Anderson, J. L., & Ashcroft, G. L. (1975). Pheno-climatography of Spring Peach Bud Development1, *HortScience, 10*(3), 236-237.

Richardson, E.A., Seeley, S.D., Walker, D.W. (1974). A model for estimating the completion of rest for 'Redhaven' and 'Elberta' peach trees. *HortScience, 9*(4), 331-332.

Rodríguez, A., Pérez-López, D., Centeno, A., Ruiz-Ramos, M. (2021). Viability of temperate fruit tree varieties in Spain under climate change according to chilling accumulation. *Agricultural Systems*, *186*, 102961, https://doi.org/10.1016/j.agsy.2020.102961.

Roman, A. M., Cuculeanu, V., Cusursuz, B., Dumitru, L., Topor, E., & Alexe, G. (1998). Testing the dynamic model of chilling portions in the extreme south-east part of Romania. *AFITA*, 161-165.

Ruiz, D., Campoy, J. & Egea, J. (2006). Chilling requirements of apricot varieties. *Acta Hort. 717*, 67-69.

Ruiz, D., Campoy, J. & Egea, J. (2007). Chilling and heat requirements of apricot cultivars for flowering. *Environmental and Experimental Botany. 61*. 254-263. 10.1016/j.envexpbot.2007.06.008.

Scalabrelli, G. & Couvillon, G.A. (1986). The Effect of Temperature and Bud Type on Rest Completion and the GDH°C Requirement for Budbreak in 'Redhaven' Peach, *Journal of the American Society for Horticultural Science, 111*(4), 537-540.

Shaltout, A.D. & Unrath, C.R. (1983). Rest completion prediction model for Starkrimson Delicious apples. *Journal of the American Society for Horticultural Science, 108*, 957-961.

Sharma, H., Rai, A.K., Dahiya, D., Chettri, R. & Nigam, P. S. (2021). Exploring endophytes for in vitro synthesis of bioactive compounds similar to metabolites produced in vivo by host plants. *AIMS Microbiology, 7*(2), 175-199.

Stefan, G., Baraitareanu, S. & Gurau, M.R. (2021). The effect of antimicrobial substances to inhibit the growth of *Listeria monocytogenes* into the ready-to-eat products. *AgroLife Scientific Journal, 10* (1), 236-241.

Suciu, L., Tarau, A., Urda, C., Chetan, F., Muresanu, F., Sopterean, L., Boiu-Sicuia, O.A. & Barbu, L.D.N. (2021). The influence of bacterial inoculats on pathogens, yield and quality in soybean crop. *AgroLife Scientific Journal, 10* (1), 221-226.

Sun, X. & Guo, L.D. (2012). Endophytic fungal diversity: Review of traditional and molecular techniques. *Mycology, 3*, 65–76.

Valentini, N., Me, G., Spanna, F. & Lovisetto, M. (2004). Chilling and heat requirement in apricot and peach varieties. *Acta Horticulturae*. 199-203. 10.17660/ActaHortic.2004.636.24.

Weinberger, J.H. (1950). Chilling requirements of peach varieties. *Proceedings of American Society for Horticultural Science, 56*, 122-128.

Yan, J., Zhang, M., Peng, B., Su, Z., Xu, Z., Yang, J., Ma, R., Yu, M., Shen Z. (2021). Predicting chilling requirement of peach floral buds using electronic nose. *Scientia Horticulturae. 290*.110517.

Yong, L., Wei-chao, F., Geng-rui, Z., Ke, C., Chang-wen, C., Xin-wei, W. & Li-rong, W. (2016). Accumulated chilling hours during endodormancy impact blooming and fruit shape development in peach (*Prunus persica* L.). *Journal of Integrative Agriculture*, *15*(6): 1267–1274.

Zhu, Y., Chen, M., Gu, Q., Zhao, Y., Zhang, X., Sun, Q., Gu, X. & Zheng, K. (2022). Machine learning methods for efficient and automated in situ monitoring of peach flowering phenology. *Computers and Electronics in Agriculture. 202*. 107370.

Zhuang, W., Cai, B., Gao, Z. & Zhang, Z. (2016). Determination of chilling and heat requirements of 69 Japanese apricot cultivars. *European Journal of Agronomy, 74*(2016), 68-74.