BAHÇE BİTKİLERİ YETİŞTİRME VE ISLAHI ÇALIŞMALARI

Editör: Prof.Dr. Levent ARIN

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İÇİNDEKİLER

CHILLING REQUIREMENT CALCULATION METHODS IN VITICULTURE

Turhan YILMAZ[1]

1. INTRODUCTION

Numerous external influences define the difficult union of disciplines that is vineyard cultivation, and they have a significant impact on vine improvement, fruit development, and ultimately wine quality (Robinson et al., 2013). The need for chilling in and of itself appeared to be an important factor influencing grapevine dormancy and the subsequent phenological stages (Zhang et al., 2021). The chilling requirement, which can be expressed up as all the chilly temperatures experienced during the fall and spring dormant season, is essential for measuring fruit budburst, blooming, and setting, all of which influence the vines' seasonal developmental process (Dokoozlian & Kliewer, 1996). Understanding how to precisely predict chilling requirements is crucial for vineyard management since it has a significant impact on vine effectiveness, output, and fruit quality (Shultz, 2000). Over many years, researchers and grape producers have developed a variety of approaches for determining the amount of chilling required. Each method offers a different perspective on the intricate relationships between temperatures inactivity, and grapevine physiology (Guo et al., 2014). A wide range of methods, from straightforward depictions of cumulative chilling hours to complex dynamic strategies incorporating temperature variations and daylight hours factors, are utilized to estimate

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chilling specifications for viticulture (Luedeling & Brown, 2011; Erez et al., 1991). For this thorough analysis, we look into every technique used to estimate the amount of chilling required for viticulture, researching beyond its theoretical foundation, real-world application configurations, and comparative productivity across multiple grape-growing regions. Using recent scientific findings and technology advancements in methodology, this review aims to provide vineyard management, academics, and consumers with a thorough understanding of the current methods to measure chilling requirements in grapevine (Naor et al., 2003). To promote more informed decisions and enhance vineyard management practices in the pursuit of excellent wines and environmentally friendly vine cultivation, we would like to draw attention to the benefits, drawbacks, and potential future directions of chilling (Duchene et al., 2010).

2. UTAH MODEL

The first of the primary methods to determine chilling requirements in the vineyard, the Utah model, functions via stacking up chilling hours throughout a specific range of temperatures as vines remain inactive. This strategy's simplicity and ease in usage resulted to its acceptance in grapevine (Richardson et al., 1974). The aggregate number of hours occurring under the desired chill range, whose temperature is frequently from 0°C to 7°C (32°F and 45°F), has been referred to be called "chilling hours" in the setting of the Utah model (Richardson et al., 1974). Grape growers can forecast the exact date of budburst and additional phenological activities on grapevines, plus the quantity of dormancy fulfillment, through making up accumulated chilling hours during the length of the fall dormancy period. Regardless due to its clarity, the Utah model is intelligible to viticulture producers as well as academicians. That required straightforward math applying specified temperature thresholds and rudimentary temperature information from recording equipment. Additionally, the concept of chilling hours is an advantageous instrument for vineyard management to use given that it aligns perfectly with the natural responses of grapevines to lower temps throughout dormancy (Erez et al., 1991). Nevertheless, the Utah strategy carries certain limitations that require being considered account of notwithstanding its broad scope. The failure to take temperature variations and changes in chilling efficiency throughout various temperature ranges into account represents one of its primary drawbacks. In this regard, not every hour within the ideal chilling spectrum contributes identically to the fulfillment of dormancy due to on average, degrees that are near the lower end of the range are more successful in breaking dormancy (Dokoozlian & Kliewer, 1996). Further, that it's conceivable that the Utah model may not adequately capture the complicated interactions among heat, the photoperiod and other outside factors that influence vineyard dormancy breaking. Given that, the accurate weather circumstances and grapevine varieties that are considered seriously might influence the reliability of the forecast. Consequently because of its fundamental straightforwardness, the Utah model has restrictions as it involves handling variations in temperature and other environmental conditions, even if it supplies an obvious approach to assess chilling requirements in vineyards. To circumvent these obstacles, growers might speculate considering expanding the Utah model by including additional dynamic simulations or introducing additional factors, like photoperiod alterations, to boost the efficiency of the assessment of chilling demands for vineyard practices (Shultz, 2000).

3. DYNAMIC MODEL

In viticulture, dynamic models offer a more comprehensive method of determining chilling requirements by providing more nuanced insights into the intricate interactions between temperature changes, dormancy, and grapevine physiology. Dynamic models provide a more accurate estimate of dormancy fulfillment and phenological development in grapevines than simple accumulation models like the Utah model (Luedeling & Brown, 2011). These models include additional parameters like chilling portions and temperature variations. The idea of chilling sections, which gives varying weights to hours spent within the ideal chilling temperature range, is the foundation of dynamic models. Since different chilling hours contribute differently to the release of dormancy, dynamic models are designed to account for the different ways that temperature exposure might disrupt dormancy. For example, lower temperatures—that is, those closer to the chilling range—are usually more successful in meeting dormancy requirements than are higher temperatures (Erez et al., 1991). Furthermore, dynamic models incorporate temperature variations during the dormant season, recognizing that grapevines could react differently to extended cold spells than to sporadic temperature swings. Dynamic models provide a more realistic picture of chilling accumulation dynamics and their effect on dormancy release by including temperature fluctuation into the calculation (Richardson et al., 1974). The incorporation of photoperiod impacts on dormancy release is another important characteristic of dynamic models. These models modify the computation of chilling requirements according to the length of daylight during the dormant season, acknowledging the impact of day length on grapevine physiology. Dormancy fulfillment and budburst timing in grapevines are more accurately estimated by dynamic models because they consider both temperature and light inputs (Zhang et al., 2021). Although dynamic models are more accurate and realistic than simple accumulation models, they also have more requirements for data and are inherently more complex. To achieve accurate estimates of chilling requirements in viticulture, dynamic model implementation may require exact meteorological data, advanced modeling approaches, and empirical validation. Further study and improvement of dynamic modeling techniques are required since the ideal weighting factors for chilling parts and photoperiod adjustments may differ across various grape-growing locations and cultivars (Guo et al., 2014). To sum up, dynamic models are a useful tool for determining the amount of chilling needed in viticulture, providing more realism and accuracy than conventional accumulation models. Dynamic models provide a more thorough knowledge of dormancy dynamics and phenological development in grapevines by taking into consideration temperature fluctuation, chilling fractions, and photoperiod effects. This assists with decision-making related to vineyard management and fruit quality optimization.

4. THE CHILL PORTIONS MODEL

Aiming to surpass conventional accumulation techniques such as the Utah model, the Chill Portions Model presents a novel approach to determining chilling requirements in viticulture by considering the varied potency of temperature exposure within the ideal chilling range. The Chill Portions Model, which demonstrates the variable efficacy of temperature exposure in achieving dormancy requirements, assigns different weights or "portions" for various hours spent within the optimal chilling temperature range, in contrast to traditional models that accumulate chilling hours indiscriminately (Luedeling & Brown, 2011). This model acknowledges that chilling hours vary in their ability to cause grapevines to come out of dormancy. Temperatures closer to the lower end of the ideal chilling range seem to be more successful in thawing dormancy than those closer to the upper end. The Chill Portions Model provides a more accurate and realistic estimate of the dynamics of chilling accumulation and its effect on dormancy fulfillment by assigning different weights to chilling hours according to their temperature (Erez et al., 1991). Finding the relative efficacy of temperature exposure within the ideal chilling range is necessary for calculating chill portions. This can be accomplished by finding the temperature levels at which dormancy release is most noticeable by empirical research or physiological experiments. These weighting factors are then determined and applied to each chilling hour within the ideal range; colder temperatures are assigned higher weights since they have a greater impact on establishing dormancy (Guo et al., 2014). To apply the Chill Portions Model in viticulture, precise temperature data collecting, and advanced analytical methods are needed to determine the proper weighting factors for chilling hours. Furthermore, it might be essential to conduct empirical validation and fine-tuning of the model parameters to guarantee its dependability and forecast precision in various grape-growing areas and cultivars (Richardson et al., 1974). Although the Chill Portions Model incorporates temperature efficacy and is an improvement over vital accumulation approaches, it poses difficulties in defining universal weighting variables that are applicable to a variety of environmental situations and genotypes of grapevines. To improve the model's use in real-world vineyard management scenarios and to adjust its parameters, more investigation and testing are required (Dokoozlian & Kliewer, 1996). In conclusion, the Chill Portions Model offers a more sophisticated and physiologically appropriate way than conventional accumulation approaches, making it a promising alternative for determining chilling requirements in viticulture. This model offers vineyard managers important insights into the dynamics of dormancy and phenological development in grapevines by considering the differential effectiveness of temperature exposure within the ideal chilling range. This ultimately leads to more informed decision-making and optimized fruit quality.

5. THE CHILL UNITS MODEL

Rather than just adding up chilling hours as is the traditional method; the Chill Units Model gives a quantitative methodology for calculating chilling requirements in viticulture by defining chilling units based on specified temperature thresholds (Luedeling & Brown, 2011). This model recognizes the varying efficiency of temperature exposure within certain ranges during the grapevine dormant phase to provide a more accurate measurement of chilling accumulation. The Chill Units Model divides the temperature spectrum into distinct segments and allocates matching chilling units to each segment, in contrast to conventional accumulation paradigms that focus on the aggregate duration within an ideal chilling temperature range (Erez et al., 1991). For example, particular chilling units may be assigned to temperatures between 0°C and 7°C (32°F and 45°F); temperatures outside of this range may not contribute to the accumulation of chilling units. The distribution of chilling units usually results from empirical studies or physiological tests that identify the temperature limits that most significantly cause dormancy release (Richardson et al., 1974). In general, lower temperatures in the lower half of the ideal chilling range draw larger chilling unit values, highlighting their stronger ability to induce dormancy in comparison to milder temperatures in the upper half of the range. To assign appropriate chilling unit values, the Chill Units Model implementation in viticulture requires careful measurement of temperature data and accurate calibration of temperature thresholds. This model provides a more objective and consistent measure of dormancy fulfillment by quantifying chilling accumulation through chilling units, making cross-regional and inter-varietal comparisons easier. However, the Chill Units Model poses difficulties in defining temperature thresholds and chilling unit values that are generally applicable in a variety of climatic conditions and grapevine genotypes. Moreover, it is possible that the model may not fully capture the complex interactions between temperature, photoperiod, and other environmental factors that affect grapevine dormancy release. To sum up, the Chill Units Model offers a different and more sophisticated method of estimating the amount of chilling needed in wineries by providing a quantitative perspective on the buildup of chilling that is based on temperature thresholds. Although this model provides a more uniform and objective measure of dormancy fulfillment, it must be carefully calibrated and validated to determine its validity and suitability for use in a variety of viticultural scenarios.

6. THE DAYNAMIC MODEL WITH PHOTOPERIOD ADJUSTMENT

A more accurate way of determining chilling requirements in viticulture is the Dynamic Model with Photoperiod Adjustment, which combines temperature dynamics with the effect of photoperiod on dormancy release (Zhang et al., 2021). This method recognizes the complex relationship between temperature and day length in controlling dormancy and subsequent phenological events in grapevines, in contrast to more straightforward accumulation models. Fundamentally, the Dynamic Model with Photoperiod Adjustment combines the modifying influence of photoperiod on dormancy release with temperature-driven chilling accumulation (Naor et al., 2003).

Although chilling accumulation is measured using techniques like dynamic models or chilling hour accumulation, the model modifies these accumulations according to how long daylight lasts during the dormant season. Studies have indicated that variations in day duration can affect when and how much grapevines shed their dormancy; generally speaking, prolonged days slow down budburst while longer days speed it up (Shultz, 2000). Through the integration of photoperiod modifications into chilling requirement calculations, the Dynamic Model seeks to offer a more thorough and precise estimation of phenological development and dormancy fulfillment. Precise meteorological data, including as temperature records and daylight length, are necessary for the Dynamic Model with Photoperiod Adjustment to be used in viticulture. Advanced modeling techniques are also needed to take into consideration the intricate connections between temperature and photoperiod (Winkler, 1974). Additionally, to guarantee the model's dependability and relevance across various grape-growing locales and cultivars, empirical validation and model parameter adjustment might be required (Gu, 2016). Even though the Dynamic Model with Photoperiod Adjustment incorporates photoperiod effects and makes substantial progress in calculating chilling requirements, precisely measuring, and modeling these interactions remains a difficulty. Furthermore, variations in grapevine genotypes and climatic conditions may have an impact on the model's prediction accuracy. To sum up, the Dynamic Model with Photoperiod Adjustment is a promising method that combines temperature and photoperiod dynamics to provide increased accuracy for determining chilling requirements in viticulture. This model gives vineyard managers important insights into dormancy dynamics and phenological development by considering the intricate interactions between these variables. It serves to improve fruit quality and decision-making.

7. CONCLUSION

To sum up, this thorough analysis has examined numerous approaches to determining the amount of chilling needed in viticulture and has emphasized the benefits, drawbacks, and uses of each (Guo et al., 2014). Each method offers a different perspective on the intricate relationship between temperature, photoperiod, and grapevine physiology. Traditional accumulation models like the Utah Model and Chill Portions Model are among the more sophisticated approaches, while Dynamic Models are more conventional. While more basic accumulation models offer easy computations based on portions or chilling hours, they could not be as accurate as necessary to take into consideration the genetic diversity of grapevine varieties and their varied environmental circumstances (Gu, 2016). On the other hand, sophisticated models include physiological processes, genetic information, and photoperiod adjustment to provide more precise and customized estimates of chilling requirements. The assessment also emphasizes how crucial it is to consider each vineyard's unique requirements and limitations when choosing a method for calculating chilling requirements. Considerations like the availability of data, processing capacity, and the required degree of precision need to be considered to make sure the approach selected will support vineyard management goals. Additionally, the development of hybrid models that incorporate the best features of several methodologies or the integration of numerous methods may present potential directions for future research (Winkler, 1974). Vineyard managers may maximize grapevine phenology, maximize fruit quality, and adjust to changing climate circumstances by utilizing the combined insights from several approaches. This analysis highlights the dynamic nature of estimating chilling requirements in viticulture and the ongoing development of strategies to address the intricate problems that grape producers confront. Viticulturists can improve their capacity to manage vineyards responsibly and yield premium grapes in a variety of growing locales by keeping up with developments in methods for calculating chilling requirements and utilizing multidisciplinary approaches.

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HEAT REQUIREMENT IN VITICULTURE

Turhan YILMAZ[1]

1. INTRODUCTION

Success in viticulture depends on knowing how much heat grapevines require, because temperature affects vine growth, development, and grape quality (Jones et al., 2005). Heat accumulation, measured in Growing Degree Days (GDD), Growing Degree Hours (GDH), or other indices, provide vineyard managers useful information about vine phenology and ripening patterns, which helps them optimize vineyard practices and maximize fruit quality. This introduction presents the groundwork for discussing the many approaches used to determine the required amount of heat in viticulture. Each technique provides a different perspective on the intricate relationship between temperature and vine development, ranging from more conventional methods like GDD to more complex indices like the Huglin and Heliothermal indices (Winkler, 2974). Viticulturists can improve vineyard management techniques and adjust to shifting climate circumstances by evaluating the benefits, drawbacks, and applications of various heat requirement estimation techniques. The ideas, procedures, and implications for vineyard management of the wide range of approaches available for determining heat requirements in viticulture will all be covered in this review of the literature (Gu, 2016). By delving into the subtleties of each technique, we hope to offer a thorough grasp of how temperature affects the growth and development of

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grapevines and how viticulturists can use this expertise to produce wines and grapes of the highest quality. The goal is to enhance the understanding of viticulture by equipping researchers and vineyard managers with the necessary tools to efficiently handle the intricate dynamics of temperature in grape production.

2. DYNAMIC MODEL GROWING DEGREE DAYS (GDD)

One commonly used technique for determining the amount of heat required in viticulture is Growing Degree Days (GDD) (Jones, 2005). By measuring heat accumulation based on temperature thresholds and duration, this technique offers important new information about vine phenology and ripening patterns. GDD is calculated by adding up the variations over a particular time frame between the base temperature threshold, usually around 10°C (50°F), and the average daily temperature (Winkler, 1974). The amount of accumulated heat units represents the temperature conditions that grapevines endure during their growth cycle. Vineyard managers will find GDD to be an easy-to-implement and understand metric of heat accumulation due to its simplicity and intuitiveness. Growers can make timely management decisions by anticipating vine phenological stages like budburst, flowering, veraison, and harvest by monitoring GDD accumulation throughout the growth season. However, it's important to understand the GDD method's limitations. Although it offers a broad indicator of heat buildup, it could oversimplify the intricate connection between temperature and vine growth. Variations in temperature, intense heat waves, and microclimates within vineyards are some of the factors that might impact and compromise the accuracy of GDD estimations. Despite these drawbacks, GDD is nevertheless a useful technique in viticulture for determining grape phenology and evaluating heat requirements (Gu, 2016). Combined with other techniques and local knowledge of vineyard conditions, GDD might help vineyard managers in maximizing fruit quality and optimizing vineyard management. In conclusion, Growing Degree Days (GDD) is a simple and popular technique for figuring out how much heat is needed in viticulture. For a thorough knowledge of temperature dynamics in grape production, it is important to consider the limitations of GDD calculations and supplement them with other techniques, even if they provide insightful information about vine phenology and ripening patterns.

3. HELIOTHERMAL INDEX

A technique for determining heat requirements in viticulture is the Heliothermal Index, which combines data on temperature and UV rays to produce an all-encompassing assessment of heat accumulation (Winkler, 1974). The combined effects of temperature and sun exposure on grape growth and development have been considered by the Heliothermal Index, in contrast to conventional techniques such as Growing Degree Days (GDD), which only take temperature thresholds into account. Data on temperature and sun radiation can be collected over a predetermined time, usually the growth season, to construct the Heliothermal Index (Gu, 2016). The direct heating impact of sunshine on vine physiology is explained by solar radiation, which is expressed in terms of solar energy received by the vineyard canopy. A more sophisticated evaluation of heat accumulation that considers both thermal and radiant energy inputs is made possible by the integration of temperature and sun radiation data. A useful tool for understanding how temperature and sunlight combine to drive grape phenology and ripening is the Heliothermal Index. It is especially appropriate for areas with high solar radiation levels or fluctuating weather patterns since it considers variations in climate and microclimate conditions by adding data on solar radiation. However, it might prove difficult to find accurate sun radiation data in some places, which is a need for computing the Heliothermal Index. Furthermore, viticulture and climate science specialists may need to possess specific knowledge and skills to properly evaluate and implement the index. Notwithstanding these difficulties, vineyard managers looking to enhance fruit quality and optimize vineyard techniques ought to find the Heliothermal Index to be a useful tool (Webb et al., 2012). Growers can improve the quality of their grapes and the sustainability of their vineyards by managing the canopy, scheduling harvests, and applying irrigation techniques with knowledge of how temperature and sun radiation interact with grapevine physiology. In conclusion, the Heliothermal Index is a technique that combines data on temperature and solar radiation to determine how much heat is needed in viticulture. Although it provides insightful information on the intricate relationship between temperature and sunshine that influences vine growth and development, its application can necessitate specific knowledge and access to trustworthy data.

4. THE HUGLING INDEX

In viticulture, the Huglin Index—created by Professor Pierre Huglin—is a technique used to calculate the amount of heat that accumulates throughout particular phenological stages, like flowering and veraison (Huglin, 1978). With the use of this index, which offers a localized measurement of heat requirements, farmers can evaluate the suitability of a location and the adaptability of a grape variety to various climatic zones. Temperature data are collected at crucial phenological periods, usually from budburst to harvest, in order to calculate the Huglin

Index (Jones et al., 2005). In order to measure heat accumulation during critical growth times, the index adds up all temperature units above a base threshold, which is typically set at roughly 10°C (50°F). The Huglin Index provides information on the temperature conditions that grapevines face throughout crucial growth and ripening phases by concentrating on particular phenological stages. Huglin Index is a useful tool for matching grape varietals and choosing vineyard sites. It helps growers to compare various regions for grape cultivation and assess a site's suitability for grape production based on its thermal characteristics. Furthermore, the indicator can help anticipate when grapes will ripen, which enables producers to schedule harvesting operations and maximize fruit quality. Even though the Huglin Index offers insightful information about heat accumulation during particular phenological periods, it's critical to recognize its limitations. Variations in temperature or periods of intense heat that can affect vine development may not be properly taken into account by the index. Consequently, in order to provide thorough vineyard management and account for temperature variations, its application should be supplemented with other techniques.

5. CONCLUSION

Comprehending vine growth, development, and grape quality in viticulture requires an awareness of heat requirements. Many techniques have been devised to estimate heat accumulation in vineyards, each having advantages and disadvantages. Several of these techniques, such as Huglin Index, Heliothermal Index, and Growing Degree Days (GDD), have been examined in this review, with an emphasis on their problems, uses, and guiding principles. A popular and straightforward method for calculating heat accumulation based on temperature thresholds is Growing Degree Days (GDD). It might, however, oversimplify the intricate connection between temperature and vine growth. For a more complete assessment of heat buildup, especially in areas with high sun radiation, the Heliothermal Index combines temperature and solar radiation data. The Huglin Index helps with site suitability assessment and grape variety selection by estimating heat accumulation during phenological periods. Although these techniques provide insightful information on the amount of heat needed in viticulture, it's important to recognize their limitations. There are still issues including the lack of trustworthy data, the unpredictability of microclimates, and the requirement for localized models. Therefore, for accurate heat demand estimation and efficient vineyard management, a variety of techniques and careful consideration of site-specific elements are required. In conclusion, vineyard managers have access to a variety of useful tools that help them enhance fruit quality and optimize vineyard activities due to the wide range of approaches available for determining heat requirements in viticulture. Growers may adapt to shifting environmental circumstances and produce premium grapes and wines by knowing the advantages and disadvantages of each technique and combining it with local knowledge and experience. To improve heat demand estimation methodologies and increase their application in viticulture, more research and developments in modeling techniques are needed. The viticultural community may better manage the intricacies of temperature dynamics and contribute to the sustainable future of grape production by embracing innovation and solving present difficulties.

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