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Phenological Evaluation of Autumn Coloration in *Parthenocissus quinquefolia* L. using Visual Assessment and Brix Measurement

Parthenocissus quinquefolia L.'nin Fenolojik Sonbahar Renklenmesinin Görsel ve Brix Ölçümü Kullanılarak Değerlendirmesi

Candan KUŞ ŞAHİN[1], **Büşra ONAY**[2]

Abstract

Direct ground-based visual assessment, those that use repeating photography by a camera, has been conducted. We have found that the changes in phenology are easily visualized using repeat photographs, which were visually examined, and key phenology events, including autumn coloration, were recorded for *Parthenocissus quinquefolia* L. The sugar content of *P. quinquefolia*'s parts were found to be in range of 18.95 °Bx to 9.72 °Bx for leaves, in range of 10.99 °Bx to 16.78 °Bx for berries and 5.74 °Bx to 11.70°Bx for stems. However, leaf Brix values showed a correlation with visual color ratings, with higher Brix values corresponding to green colors and lower values corresponding to strong reddish colors. It is clear that autumn phenology has an impact on the sugar content of *P. quinquefolia*'s parts to some extent. It is important to note that the 0Bx properties of leaves and berries were found to be sensitive to sampling parts of *P. quinquefolia*. It was suggested that the autumn coloration of *P. quinquefolia* could be effectively monitored through five distinct color stages. Different parts of *P. quinquefolia* showed various levels of coloration from mid-May to mid-December. However, green and red hues are visible on *P. quinquefolia*'s leaves in all directions until mid-November, while only leaves in the north-east direction (V) at the end of November show rather early, intense red coloration and maturation compared to others. The light level (lux) also appears to be an important factor in the autumn coloration of *P. quinquefolia*.

Keywords: *P. quinquefolia* L. Autumn colorations, Landscape, Phenological observation

Özet

Bu çalışmada bir kamera tarafından tekrarlanan fotoğrafların kullanıldığı doğrudan zemin tabanlı görsel değerlendirme yapılmıştır. Fenolojideki değişikliklerin, tekrarlanan fotoğraflar kullanılarak kolayca görselleştirilebildiğini ve *Parthenocissus quinquefolia* L. için sonbahar renklenmesi de dahil olmak üzere önemli fenoloji olaylarının kaydedildiği görülmüştür. *P. quinquefolia*'nın parçalarının şeker içeriği yapraklar için 18.95 °Bx ila 9.72 °Bx aralığında, meyveler için 10.99 °Bx ila 16.78 °Bx aralığında ve gövdeler için 5.74 °Bx ila 11.70 °Bx aralığında bulunmuştur. Bununla birlikte, yaprakların Brix değerleri görsel renk derecelendirmeleriyle bir miktar ilişki gösterirken, izlenen örneklerde koyu yeşil renklerden güçlü kırmızımsı renklere kadar değişen renkler mevcuttur. Sonbahar fenolojisinin *P. quinquefolia*'nn parçalarının şeker içeriği üzerinde belli bir düzeyde etkisi olduğu açıktır. Sonbahar renklenmesinin izlenmesi sırasında *P. quinquefolia* 'nın beş renklenme dönemi boyunca izlenebileceği önerilmiştir. *P. quinquefolia*'nın farklı kısımları Mayıs ortasından Aralık ortasına kadar çeşitli seviyelerde renklenme göstermiştir. Bununla birlikte, Kasım ortasına kadar *P. quinquefolia*'nın tüm yönlerdeki yapraklarında yeşil ve kırmızı tonlar görülebilirken, Kasım sonunda sadece kuzeydoğu yönündeki (V) yapraklar diğerlerine kıyasla oldukça erken, yoğun kırmızı renklenme ve olgunlaşma göstermektedir. Işık seviyesi (lux) de *P. quinquefolia*'nın sonbahar renklenmesinde önemli bir faktör olarak görülmektedir.

Anahtar Kelimeler: *P. quinquefolia* L. Sonbahar renklenmesi, Peyzaj, Fenolojik gözlem

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Address: [1]Süleyman Demirel University Faculty of Architecture, Department of Landscape Architecture
Email: candansahin@sdu.edu.tr
[2]Afyon Kocatepe University Faculty of Fine Arts Department of Interior Architecture and Environmental Design "Email: bonay@aku.edu.tr

1. Introduction

Phenology is the study of periodically recurring patterns of plant growth during the year, typically deals with recurring life-cycle events (Morisette et al., 2009; Walton et al., 2016; Mu et al., 2022). One example for phenological studies is the autumn coloration of plants (Field et al., 2001). In this regard, phenological evaluation of certain plants has been of great interest, which is considered to be one of the most important values for plant-based design practices (Archetti et al., 2009; Morisette et al., 2009; Walton et al., 2009; Field et al., 2001; Bozdoğan, 2016; Tarakci Eren and Duzenli, 2017). Environmental factors such as temperature, light intensity and geographical locations have been reported to be complex mechanisms and are often characterized by a high degree of temporal and spatial variability (Kami et al., 2010; Piao et al., 2019). However, forecasting or characterization of the seasonal vegetation periods (i.e., autumn colorations) has wide social, cultural, and economic significance which may offer insights into plant physiological activities. Moreover, these may also be important parameters for landscape design approaches that reflect interactions between plant phenology and people (Zhang et al., 2012). Therefore, autumn coloration might be particularly important not only for landscapers to predict the optimum aesthetic timing, but also for tourists to see fall foliage colors.

The vegetation habits and phenological properties of plants have been widely investigated throughout the centuries, and considerable effort has also been devoted to real-time monitoring (Sahin et al., 2023; Sahin and Onay, 2023). However, the complexity of natural ecosystems presents inherent challenges to plant science (Sahin and Onay, 2023; Sahin et al., 2024). Over the past decades, various methods have been developed to detect the timing of phenological events of vegetation (Crimmins and Crimmins, 2008; Zhang et al., 2012; Peltoniemi et al., 2018; Mu et al., 2022). These efforts mainly focused on the satellite imaginary assessments, while the phenology captured by those methods often represents the mixture of wide-area coverage (e.g., forests, waters, structures and elements), especially in heterogeneous landscapes. Therefore, uncertainties in satellite data make the monitoring of vegetation phenology in real time extremely challenging (Walton et al., 2016). It has been well predicted by number a of researchers that ground-based observations may provide direct evidence of spatial variations in plant phenology while being valuable for climate change studies (Piao et al., 2019).

Many plants, which have climbing properties, are utilized in urban areas for color-effect purposes. However, *Parthenocissus quinquefolia* L. is intensely used for its climbing characteristics in urban open spaces, which is particularly preferred for its leaf color in the fall. Various studies have been conducted to determine the phenological properties of *P. quinquefolia* (Bozdoğan, 2016; Mahr, 2024). Bozdoğan (2016), evaluated effective use of color principle in planting design that to determine the autumn colors formed by *Ampelopsis quinquefolia* L. She concluded that the color change of *A. quinquefolia'* leaves were related to directions of plant and had very intensive in the period of September through November (Bozdoğan, 2016). More recent studies were also used similar color evaluation techniques for other landscape plant such as; *Torminalis glaberrima* Gand. (Sahin et al., 2023), *Viburnum opulus* L. (Sahin et al., 2024).

In this study, we used a ground-based approach for the real-time monitoring of the foliage status of *P. quinquefolia* using digital repeat photography. We assume that the autumn coloration of the selected plant can be assessed with the time series of the selected methodology through monitoring temporal variation over the course of the predetermined time. These experimental approaches may provide unique opportunities to monitor the leaf senescence process without expensive satellite imagery and offer insights into estimating the characteristic phenology. We limit our study to the start (green foliage) and end (leaf coloring), which are sensitive to change of season.

2. Material and Method

In the study, *Parthenocissus quinquefolia*, which is a member of the *Vitaceae* family, was selected as plant material for evaluating autumn leaf colorations, represents ornamental value in landscaping areas. We found a mature *P. quinquefolia* plant, on the maincampus of Suleyman Demirel University which is located in Isparta. Figure 1 shows the locational map of the study area and general appearance of *P. quinquefolia* in natural growing conditions.

Figure 1. General map of study area and appearance of *P. quinquefolia* L. at spring.

We assumed that Mid-May 2022 through late-December 2022 would be an appropriate observation period for our study. The selected plant was carefully monitored at different stages, which included the visual evaluation of discolorations via repeat photographing. Due to the oversize and growing properties at different locations, the monitoring and measurements were made at five different points on the same plant. The leaves of *P. quinquefolia* were found to be initially dark green at spring, then senescence to orange-red in color in fall. Thus, we need to adequately track the color change process over time to ensure a relatively consistent record. We used a combination of methods, including on-site visual monitoring in situ, and took photos and samples to measure the sugar content of leaves (Brix level) ex-situ. The ground-based monitoring (repeat photography) was conducted in the afternoon (5.0 pm) at least once every 15 days. Approximately 10 representative samples (leaves, stems of leaves and berries) were collected from five selected points. The collected samples were placed in bags, and collection data (collection time and point) were marked on the label.

We used the same digital camera (Nikon Corp., Tokyo, Japan) with identical settings, consistently repeating the same position, direction, angle, distance, and shooting mode. Due to weather conditions (e.g., rainy, cloudy, dusty, etc.) during digital repeat photography, only well-visible digital images were used to represent coloration occurrences at different points of the same plant. The following procedures were applied during photography:

• The photographed points must have good viewing conditions to ensure the photographs of the overall plant.

• The distance between the photograph-taken point and the plant was not too far or too close. In our study, 2 to 5 meters was found to be an ideal distance.

• We used approximately 1.0-meter distance for laboratory photographing of collected leaves. The collected leaf samples were carefully monitored at different stages of discoloration by photographing to conduct a visual evaluation for the aesthetic quality of the colorations. The study obtained numerous photos that effectively reflect the leaf coloration of the *P. quinquefolia* species, some of which are presented in Figure 2.

The light intensity (as reported Lux level) was measured by an Environment Meter (CEM DT8820- Taiwan).

In the Brix (°Bx) measurement procedure, approximately 10 samples (leaves, berries and stems) were put in a container and crushed until juice was present.

Then one drop of juice is put in a digital refractometer (Palm Abbe-PA2021, Solon, OH), while the device supports automatic temperature compensation and then brix value automatically.

3. Results and Discussion

The plant phenology is one of the important elements for landscapers which these seasonal changes may impact on plant design practices and their functions. The *P. quinquefolia's* leaves are a five-fingered, green through the summer, and in the autumn turn green to orange-red or red in the fall before falling. We were visually rated *P. quinquefolia's* leaves (foliage) during ground-based observations, numerous photos were obtained, effectively reflected the discoloration which some of those are presented in Figure 2. In this regard, we were assigned a color rating, ranged from 1 to 5;

1. = entirely green (Fig. 2A),
2. = some light red color present (Fig. 2B-D),
3. = about equal green and red color (Fig. 2E-F),
4. = almost all red color (Fig. 2G),
5. = entirely dark red color (Fig. 2 H-I)

When Figure 2 is carefully evaluated, it could be seen wide range of colors on same plant which provide visual interest particularly during autumn, may serve very aesthetic appearance to people. With having those autumn coloration properties, *P. quinquefolia* have been widely utilized to attached to vertical or horizontal surfaces, may provide visual interest while may be affect very aesthetic appearance at cost effective way.

Figure 2. Visual appearance of *P. quinquefolia'* leaves during phenological observation (A: entirely green foliage from May to July, B-D: partial leaf senescence from August to September, E-G: Full-leaf senescence from late September to Middle of November, H-I: late leaf senescence from End of November to December).

Brix is a scale measuring the sugar content of plants. It is commonly used in plant science studies, especially to rate plant or fruit maturity (Kaytanlioglu et al., 2023). In this regard, there have been many valuable results reported regarding the Brix value and sugar content of foods (Kappes et al., 2007; Bolade et al., 2009; Chauhan et al., 2014). We assumed the Brix (°Bx) value may be used to evaluate *P. quinquefolia's* parts (leaf, stems, and berries) for assessment of autumn coloration. Table 1 shows the Brix values of leaves, berries and stems presented in Figure 2, comparatively. It was observed that leaves show Brix value in range of 18.95 °Bx (sample A) to 9.72 °Bx (sample I). The berries show Brix value in range of 10.99 °Bx (sample A) to 16.78 °Bx (sample H) and stems in range of 5.74 °Bx (sample I) to 11.70°Bx (sample B). The leaves' Brix values appear to reveal some relationship with visual colour ratings (Fig.2) while dark green colors existed in Sample A, but strong reddish colors existed in Samples H and I. It is also revealed that the autumn phenology impact on sugar content of *P. quinquefolia's* parts some level. It has been presented that environmental factors could contribute to the regulation of plant phenological processes including autumn phenology (Piao et al., 2019). A number of researchers have already reported that high Brix levels are an indicator for plants growing in high stress periods, such as cold or drought conditions, and vice versa. Typically, sucrose, which is a sugar, is formed in the leaves and fruits during the growing period. The results found for *P. quinquefolia's* leaves and Brix values in this study partially consisted of literature information. One may conclude that the sugar content of leaves and berries is sensitive to sampling parts of *P. quinquefolia*.

Table 1. The Brix values of *P. quinquefolia's* parts.

Samples	Leaf	Berry	Stem
A	18.95 (1.65)	10.99 (1.58)	7.52 (0.13)
B	18.05 (1.87)	14.99 (1.09)	11.70 (2.18)
C	16.68 (1.14)	15.12 (1.37)	8.98 (0.23)
D	16.33 (0.12)	15.88 (0.63)	7.38 (0.37)
E	15.73 (1.10)	16.09 (0.39)	8.18 (0.62)
F	14.2 (1.73)	16.10 (0.41)	9.24 (0.30)
G	13.77 (1.36)	16.32 (0.18)	8.98 (0.26)
H	11.26 (2.20)	16.78 (0.16)	8.02 (1.10)
I	9.72 (0.49)	16.43 (0.23)	5.74 (1.0)

**The number in parenthesis are standard deviations of five measurements of the same sample.*

In order to find inter correlations among *P. quinquefolia's* parts (leaves, berries and stems), in terms of sugar contents, the obtained Brix values were plotted against, shown in Figure 3. It is apparent that the Brix levels were inversely correlated with leaves and fruits. It is high at initially and continuously lowered for leaves but vice versa for berries. The less similar trend was also visible for stems. The plot shape in Figure 3 and data presented in Table 1. clearly suggest that autumn coloration bring an effect of change the sugar content. This could be expected considering vast literature information have been reported, which various type of conditions including weather impact on senescence of leaves and plants (Gatti et al., 2016; Tóth, 2025; Bouillon et al., 2025; Mafrica et al., 2025).

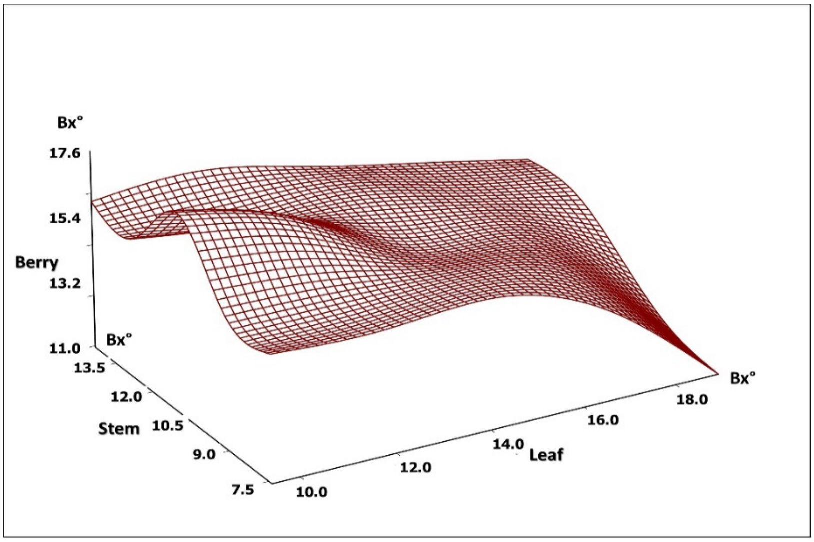

Figure 3. The Brix relationship of *P. quinquefolia's* parts.

A primary focus of this study is the autumn coloration of *P. quinquefolia*. However, a distinct seasonal response in vegetation phenology is noted during the study, which is a dark green color from May to beginning of September and intensive senescence in the late September through November, fall in December (Figure 4). When Figure 4 is carefully evaluated, to assess autumn coloration of *P. quinquefolia*, the five-discoloration period could be suggested.

• Entirely green period (from May to early September)

• Early period (mid-September),

• Middle period (late September to mid-November),

• Late period (late November to early December),

• End period (mid-December).

The leaves of the whole plant (all directions and sides) stay green until September. In September, only the leaves in the South-direction (I) are in light reddish hues. The red color of the leaves in plants on all sides has increased; green-red colors maintained their dominance until early October. In mid-October, it appears to turn from a greenish to a light reddish hue together for South- (I), South east- (II) and North-direction (III), while the dark reddish hue is dominant in the east (IV) and North-east (V) at the same time. In November, dark reddish hues are intensive in South- (I) and South east-direction (II), light reddish greenish hues to the north-east direction (III), and leaves fall in the north-east direction (V) at that time period. In mid-December, almost all leaves fall throughout the plant in all directions and sides. When the whole *P. quinquefolia* plant is considered, the earliest red coloration and leaf senescence were found in East- (IV) and North-east directions (V). In this respect, the differences in autumn colorations or leaf senescense, which observed the existence of reddish colorations, in terms of directional measurements were found to be important. It is important to note that green and red hues are visible on P. quinquefolia's leaves in all directions until mid-November. Only leaves in the north-east direction (V) at the end of November show rather early, intense red coloration and maturation compared to others.

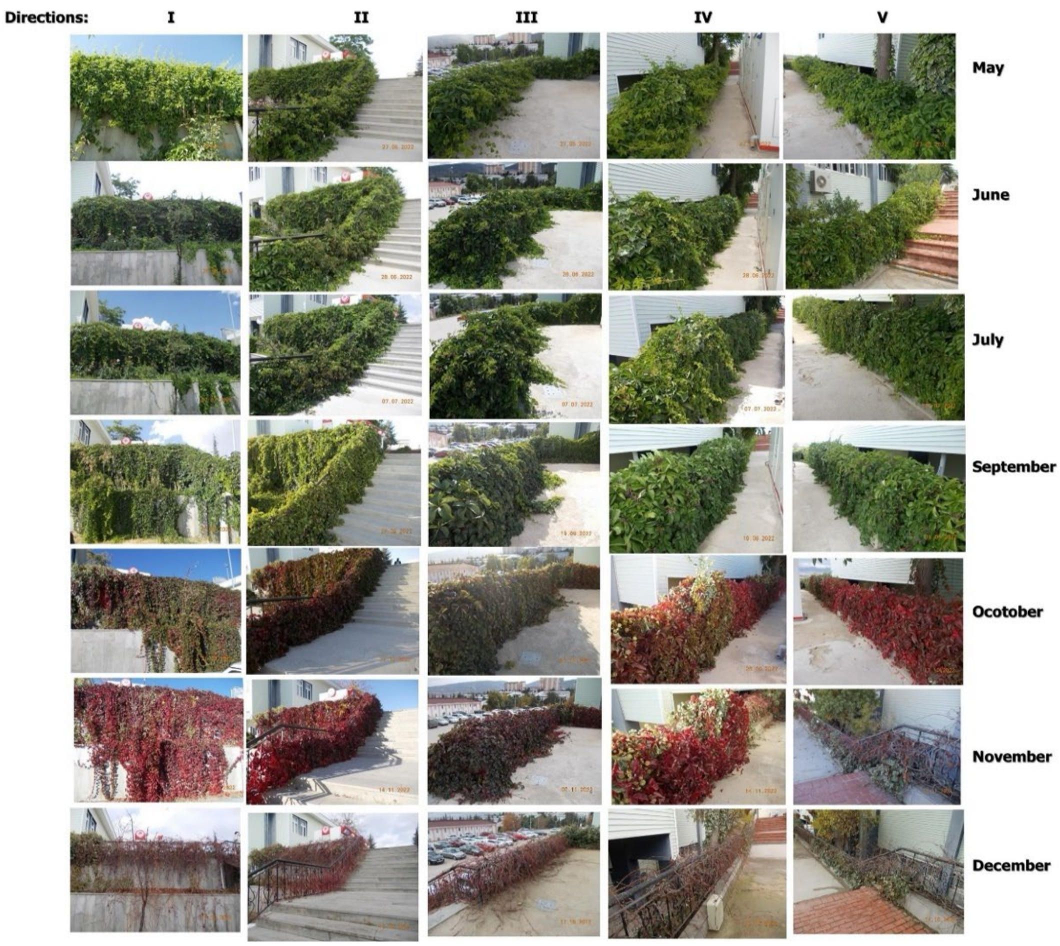

Figure 4. Visual appearance of *P. quinquefolia* from different directions (I: South, II: South-east, III: North, IV East V: North east).

The measured light levels of the selected points are; I: 609.8 lux, II: 1517.3 lux, III: 1232.3 lux, IV: 210 lux, V: 29291.7 lux. Although the evaluation of differences in signaling of the phytochromes is a phenomenon, the locational variations, and light level appear to be more important factors for autumn coloration rather than temperature at the same time period for *P. quinquefolia*.

Aesthetic appearance of plants is a very important issue for landscape design practices. However, it is very important to predict both seasonal and inter-annual color variation in ecosystems, which has important management for intended design purposes. In this regard, phenological changes of plants could be carefully considered by plant experts (Sahin and Onay 2023). Understanding the properties of plant foliage with ornamental appeal may allow plant designers to develop aesthetic design practices using easily planted species like *P.quinquefolia*. This is also a cost-effective way to accomplish aesthetic plant design for successful landscape work.

4. Conclusion

Although landscape-scale phenology estimates are based on instrument-based approaches for field measurements, ground-based observation is a traditional, but still highly useful method in phenology studies and provides first-hand direct evidence of phenological changes. Thanks to those, the timing of phenological events for specific sites and species has improved.

In general, people identify and associate certain landscapes with colors. The choice of colors to design a landscape works in exactly the same way that it decorates a house, seeking to generate a certain effect and atmosphere and giving it its own identity. In plant design practices, creating a focal point could serve to draw attention to a certain place with a plant with an unusual color. While traditional plant phonologic observations have involved recording the date of occurrence for key events (i.e., first leaf opening, first flowering, full bloom, and end of bloom), we have a simple and cost-effective way to monitor the leaf senescence of *P. quinquefolia* plant by repeated visual observations, which is important for landscape discipline. The *P. quinquefolia* selected in this study, which has excellent climbing and surface covering properties, could be an important element for design where surface covering with seasonal color changes is important. Therefore, the autumn coloration of *P. quinquefolia* may be an object that creates focal points and may attract the attention of human beings, which affects them physiologically and sociologically.

Further research is necessary to investigate to better understand the variation in the influence of plant color on visual aesthetic perception. However, the experimental approach and selected methods in this study could be useful to other plant materials that have aesthetic phenological properties throughout the year all around.

References

Archetti, M., Döring, T. F., Hagen, S. B., Hughes, N. M., Leather, S. R., Lee, D. W., ... & Thomas, H. (2009). Unravelling the Evolution of Autumn Colours: an Interdisciplinary Approach. *Trends in Ecology & Evolution, 24*(3), 166-173.

Bolade, M. K., Oluwalana, I. B., & Ojo, O. (2009). Commercial Practice of Roselle (Hibiscus sabdariffa L.) Beverage Production: Optimization of Hot Water Extraction and Sweetness Level. *World Journal of Agricultural Sciences, 5*(1), 126-131.

Bouillon, P., Belin, E., Fanciullino, A. L., Hanteville, S., Letekoma, Y., Bernard, F., & Celton, J. M. (2025). Internal browning detection in red-flesh apple (Malus domestica) using image analysis and acoustic signal-based detection. *Fruit Research*, *5*(1).

Bozdoğan, E. (2016). Monitoring the Autumn Color Change in Leaves of Amphelopsis Quinquefolia. *Asian Journal of Science and Technology, 7*(1), 2198-2202.

Chauhan, O. P., Archana, B. S., Singh, A., Raju, P. S., & Bawa, A. S. (2014). A refreshing Beverage From Mature Coconut Water Blended with Lemon Juice. *Journal Of Food Science And Technology, 51*(11), 3355-3361.

Crimmins, M. A., & Crimmins, T. M. (2008). Monitoring Plant Phenology Using Digital Repeat Photography. *Environmental Management, 41*, 949-958.

Feild, T. S., Lee, D. W., & Holbrook, N. M. (2001). Why Leaves Turn Red in Autumn. The Role of Anthocyanins in Senescing Leaves of Red-Osier Dogwood. Plant physiology, *127*(2), 566-574.

Gray, R. E., & Ewers, R. M. (2021). Monitoring Forest Phenology in a Changing World. *Forests, 12*(3), 297.

Gatti, M., Pirez, F. J., Chiari, G., Tombesi, S., Palliotti, A., Merli, M. C., & Poni, S. (2016). Phenology, canopy aging and seasonal carbon balance as related to delayed winter pruning of Vitis vinifera L. cv. Sangiovese grapevines. *Frontiers in plant science*, *7*, 659.

Kami, C., Lorrain, S., Hornitschek, P., & Fankhauser, C. (2010). Light-Regulated Plant Growth and Development. *Current Topics In Developmental Biology, 91*, 29-66.

Kappes, S. M., Schmidt, S. J., & Lee, S. Y. (2007). Relationship Between Physical Properties and Sensory Attributes Of Carbonated Beverages. *Journal of Food Science, 72*(1), S001-S011.

Kaytanlioglu, E. H. T., Fakir, H., Ozkan, U., & Sahin, C. K. (2023). A Study on Syrup of Juniperus Excelsa Cones Grown in Türkiye. *Asian J. Res. Agric. Forestry, 9*(4), 203-212

Mafrica, R., De Bruno, A., Mafrica, D. L., Merlo, C., Gattuso, A., & Poiana, M. (2025). Ripening Dynamics and Optimal Harvest Timing of 'Fantastico'and 'Femminello'Bergamot Fruit. *Agriculture*, *15*(7), 737.

Mahr, S. (2024). Virginia Creeper, Parthenocissus quinquefolia, Wisconsin Horticulture, Division of Extension, University of Wisconsin – Madison. URL: https://hort.extension.wisc.edu/articles/virginia-creeper-parthenocissus-quinquefolia/ (Reach date: 21.04.2024)

Morisette, J. T., Richardson, A. D., Knapp, A. K., Fisher, J. I., Graham, E. A., Abatzoglou, J., ... & Liang, L. (2009). Tracking the Rhythm of the Seasons in the Face of Global Change: Phenological Research in the 21st Century. *Frontiers in Ecology and the Environment, 7*(5), 253-260.

Mu, Y., Lin, W., Diao, X., Zhang, Z., Wang, J., Lu, Z., ... & Zhao, C. (2022). Implementation of the Visual Aesthetic Quality of Slope Forest Autumn Color Change into the Configuration of Tree Species. *Scientific reports, 12*(1), 1-19.

Peltoniemi, M., Aurela, M., Böttcher, K., Kolari, P., Loehr, J., Hokkanen, T., ... & Arslan, A. N. (2018). Networked Web-Cameras Monitor Congruent Seasonal Development of Birches with Phenological Field Observations. *Agricultural and forest meteorology, 249*, 335-347.

Piao, S., Liu, Q., Chen, A., Janssens, I. A., Fu, Y., Dai, J., ... & Zhu, X. (2019). Plant Phenology and Global Climate Change: Current Progresses and Challenges. *Global change biology, 25*(6), 1922-1940

Şahin, C., Kaytanlıoğlu, E. H. T., Fakir, H., & Özkan, U. (2023). Evolution of Autumn Leaf Coloration of Torminalis glaberrima Grown in Isparta, Türkiye. *Coğrafya Dergisi*, (47), 101-108.

Şahin, C.K. & Onay, B. (2023). Changing Colors of Leaves: Autumn Coloration of Broadleaf Trees and Shrubs, In: Landscape Research III, Ö. Demirel & E. Düzgüneş (editors), pp.21-30, Livre de Lyon, Lyon France (ISBN: 978-2-38236-585-4)

Şahin, C. K., Onay, B., & Rahimbayli, S. (2024). Autumn Color Determination of European Cranberrybush (Viburnum opulus L.). *European Journal of Science and Technology*, (53), 78-83.Tóth, V. R. (2025). Photosynthetic traits of Phragmites australis along an ecological gradient and developmental stages. *Frontiers in Plant Science*, *15*, 1476142.

Walton, A., Stes, E., Cybulski, N., Van Bel, M., Iñigo, S., Durand, A. N., ... & Gevaert, K. (2016). It's Time for Some "Site"-Seeing: Novel Tools to Monitor the Ubiquitin Landscape in Arabidopsis Thaliana. *The Plant Cell*, *28*(1), 6-16.

Tarakci-Eren, E., & Duzenli, T. (2017). Determination of the Visual Preference Levels and Perceptual Differences in the Appearance of Certain Taxa in Different Seasons. *Fresenius Environmental Bulletin, 26*(12A), 8304-8315.

Zhang, X., Goldberg, M. D., & Yu, Y. (2012). Prototype for Monitoring and Forecasting Fall Foliage Coloration in Real Time From Satellite Data. *Agricultural and Forest Meteorology*, *158*, 21-29.