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The effect of irrigation on the vegetative and generative performance of grapes and the quality of the crop

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Theses of the doctoral thesis

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Doctoral school

Name: Horticultural Doctoral School

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1. INTRODUCTION AND AIMS OF THE STUDY

The extreme weather caused by climate change is causing increasing damage to agriculture and viticulture. Among the changing environmental factors, the uneven rainfall distribution is one of the most striking, which can make water extremely limited for grapes. As a result, drought stress is expected to be more frequent not only in the Mediterranean region, but also in wine-growing regions around the world (COSTA et al. 2016).

The irrigation of wine grapes can only be considered common in a few countries, while growers have to face drought seasons more and more frequently not only in the Mediterranean region, but also in Hungary. A particular problem is that although the required annual rainfall falls in most seasons, its distribution shows increasingly extreme patterns. This problem is further exacerbated by the fact that there is insufficient rainfall precisely at the time when the grapes are most in need of phenological phases, i.e. from the period from the flowering of the grapes until the ripening of the fruit. If water scarcity occurs in these phenological stages, it not only results in severe drought stress symptoms, but may even result in declining yields, deteriorating nutritional values or even capital destruction.

Irrigated wine grape plantations can be found in many places in the wine-growing countries of the world. Just look at America, New Zealand or Australia. In many places, they are watered throughout the entire growing season. In Hungary, irrigation of table grape plantations used to be an integral part of agrotechnics, while water supply of wine grapes was not common.

It should be emphasized that the irrigation of wine grape orchards was difficult to accept by the *terroir-oriented* professional society, as they believed that the effect of the given vintages was modified too much

by the replacement of the missing rainfall. Every year more and more people turn to irrigation of wine grapes in the wine-growing countries of the world, including in Hungary. The positive effects of irrigation have been experienced for many years by viticulture and research experts, domestic and foreign reports are available to us. In Hungary, this is a less researched topic nowadays.

Thus, the main goal of my doctoral thesis is not only to map the possible effects of irrigation through various indicators against unirrigated plots, but also to prove and present possible differences between drip irrigation and underground irrigation.

Our studies were carried out in 'Hárslevelű' orchards grown on plots treated with unirrigated (control), drip irrigation and underground irrigation in several vintages between 2021 and 2024. Our aim was to determine how the different irrigation methods affect the vegetative, generative indicators and physiological characteristics of the grapes in each vintage compared to the control rows. The exact objectives were:

a. The effect of irrigation on the fertility of buds
b. The effect of irrigation on the structure of canopy
c. The effect of irrigation on morphometric indicators of leaves
d. Effects of irrigation on sRGB-based color indices of leaves
e. The effect of irrigation on the chlorophyll content in the leaves
f. Determination of water potential values of capitals
g. Effects of irrigation on yield and nutritional values of musts.

2. MATERIALS AND METHODS

2.1. The effect of irrigation on the fertility of buds

In this study, based on the method of CSEPREGI (1992), the effect of different irrigation methods and vintage on bud differentiation and shoot formation of the 'Hárslevelű' grape variety was compared. The assessment of bud productivity was carried out over four years from 2021 to 2024.

2.2. The effect of irrigation on the structure of canopy

In Smart's point quadrat study (SMART 1990), we assessed how the vintage and the different treatments affect the foliar structure of vines, including leaf layer count, percentage of canopy gaps and cluster count. Unlike the traditional point quadrat test method, during our work we determined the individual structural features on three different floors on the canopy of each vine. Our studies were conducted over a period of four years.

2.3. The effect of irrigation on morphometric indicators of leaves

In the studies, leaf morphometric indicators were identified that are affected by the years or treatments studied. For analysis, GRA. LE.D. (BODOR et al. 2012) software was used to determine 52 different morphological stamps per letter sample.

2.4. Effects of irrigation on sRGB-based color indices of leaves

We examined the sRGB (Red, Green, Blue) color values of the leaves from each treatment in 3 vintages and the 31 color indices calculated from them and identified those that had statistically detectable variability.

2.5. The effect of irrigation on the chlorophyll content in the leaves

In this study, chlorophyll content in leaves was compared between treatments in three different vintages. For this, the chlorophyll meter Apogee MC100 was used. Our goal was to obtain information on whether there were differences between the formation of leaf clay samples collected from different treatments in the years studied.

2.6. Water potential values of capitals

During the water potential measurement, we determined with the help of a "pump up" pressure chamber how the water condition of the vines changed during periods of drought in the orchard where the experiment took place.

2.7. Effects of irrigation on yield and nutritional values of musts

It was established whether there was a change in the morphological properties of grape bunches in different seasons as a result of different irrigation treatments. Furthermore, whether the nutritional values of the musts obtained differ as regards acid, sugar content or pH.

Our experiments were carried out in the factory plantation of the Mikóczy Family Vineyard on the 'Hárslevelű' grape variety in Láthegy in Tata between 2021 and 2024. The capital cultivation method used is a low cordon, and three rows were left without irrigation equipment, three rows of drip irrigation systems and three rows of underground irrigation systems.

3. RESULTS AND DISCUSSION

For the indicators studied during capital withdrawal, it can be said that treatments showed a significant effect, except for the percentage of bud dormancy. In the case of the number of dormant buds, the number of twin shoots, the number of infertile shoots and the number of clusters of shoots stemming from light buds, subsurface irrigation showed particularly high significant differences between years. Drip irrigation was significant between years when the number of inflorescences per vine evolved. In addition to twin shoots, the vintages had a significant effect on the results for all indicators examined (percentage of bud dormancy, number of fruiting shoots, number of infertile shoots, clusters/light bud shoots, number of inflorescences/vines). Previous research has shown that climatic factors such as rainfall, humidity and solar radiation can greatly influence the differentiation of grape buds. For example, according to MARTÍNEZ-LÜSCHER et al. (2013), water available during bud differentiation can affect grape growth and bud fertility. Excessive rainfall or high humidity can increase the risk of infection with fungal diseases, which can also affect bud health and subsequent fruiting (GADOURY et al. 2012). Sun exposure, especially in the period following bud burst, plays a critical role in photosynthesis and carbohydrate accumulation, which are essential for bud development and fruit binding. Climate factors can significantly alter grape bud differentiation, ultimately affecting the potential yield and quality of the grape crop (KELLER 2010; TARANYI et al. 2023).

The effect of irrigation on bud fertility in domestic conditions was also investigated by FÜRI (1977). In line with our own results, he found that irrigation had a positive effect on fertility coefficients, relative in his case. In line with our results, irrigation also had the

most positive effect on the bud fertility of vines with underground irrigation. LIGETVÁRI (1984) highlights 'Hárslevelű' from among the examined varieties, the condition of which increased the most as a result of irrigation, emphasizing the sensitivity of the variety to water supply. Both Hungarian studies draw attention to the fact that it is worth evaluating the obtained indicators individually for each variety, since reactions to irrigation can also be varietal characteristics. In addition, our own data emphasize the special effect of the vintage, as the vintage can also contribute to or worsen certain values. In terms of treatments, the number of twin shoots at Hárslevelú was the only indicator for which the change of vintages did not have a significant effect, only the difference between the treatment methods. So, the number of twin shoots can vary most for this grape variety under the influence of irrigation.

When studying the structure of canopy, canopy was examined on three different floors. In the cluster zone, in the middle third of the shoots, as well as in the uppermost third of the canopy. The vintage had a significant effect on the number of leaves in the cluster zone, and the proportion of canopy gaps was significantly affected by the vintages, treatments and the interaction between the two. In the case of the number of curls, however, we found that the vintage and the treatment together have a significant effect. The average leaf layer count for the cluster zone was lowest in 2021 and highest in 2022. Overall, it can be stated that the number of leaf layers of the vines in irrigated areas was higher in the cluster zone than that of the untreated vines, so the shading of the clusters is likely to be higher on these vines. Thus, in warmer seasons, the berries on these clusters are less exposed to sunburn, and the change in their nutritional values may also develop differently than in the clusters of unirrigated vines. The

number of leaf layers on the middle third of the canopy was also significantly affected by vintages, treatments and interaction between the two. The proportion of canopy gaps at this level was also significantly influenced by vintages and treatments. In 2022, 2023 and 2024, vines with underground irrigation had the highest average leaf layer count value. Only in 2021 was it different, as this year the number of leaf layers of vines with drip irrigation was the highest. The number of leaf layers of control vines at this level was significantly lower than that of those treated. In the top third of canopy, the number of leaf layers was also significantly affected by seasons and treatments. In the case of foliar gaps, only treatments proved to be significant. It is true for all four vintages that the number of leaf layers in the irrigated vines was higher than in the case of the vines on the control plot.

The effect of irrigation on the canopy of Hárslevelű, divided into separate floors, has not been studied before. It is clear that different leaf floors may react differently to irrigation, and it is not uniform between years which irrigation method is the most effective or which vintage has a significant difference. There may be several reasons for this. One of them is that there are differences between the different seasons between the quantities of irrigation water applied, the time of application and the frequency of their application on an annual basis. Thus, it can be assumed that drought stress occurred earlier in some years in terms of phenological phases of the vine, which affected the intensity of shoot growth or the number of leaves on the shoots, so that irrigation could not improve the density of canopy on treated vines or the number of leaves compared to untreated vines. Our studies clearly show that irrigation has a positive effect on the density of canopy of Hárslevelű, especially underground irrigation, but the vintage effect still plays a major role, which in some years may even

be greater than the effect of irrigation, so it would be necessary to accurately determine the amount of irrigation water and, in particular, to predict the exact time of application. On the one hand, this promotes a more economical application of water, and on the other hand, we can ensure optimal and undisturbed shoot growth in terms of canopy.

In domestic conditions, FÜRI (1964) described that as a result of sprinkler irrigation, the growth of shoots of two table grape varieties, and thus the size of the canopy, responded positively to irrigation, as opposed to untreated vines. So much so that he put the differences in shoot size measured after the last irrigation date between 20-30 cm. Moreover, the shoots of irrigated vines continued to grow even more after the sprout growth of untreated vines stopped.

MUNITZ et al. (2020) also investigated the effect of irrigation timing on foliar structure and concluded that the first irrigation in the initial phase of the growing season greatly contributed to greater vegetative growth, resulting in a more balanced canopy density, as opposed to the effects of irrigation timing performed much later.

HAMMAN AND DAMI (2010) obtained results similar to my doctoral work, according to which irrigation increased the length and width of shoots, and the vines that were irrigated during growing seasons had the most balanced canopy density. They also highlight that in many cases, as a result of the increased number of leaves and shoots, the fruits have become much more shaded, which may result in a deterioration in the amount of the crop.

PÉREZ-ALVAREZ et al. (2021) investigated the canopy properties of the 'Bobal' grape variety. They found that irrigation resulted in higher growth of shoots and weight of canes, resulting in larger canopy of the vines being treated. Their studies to determine the

structure of canopy were supplemented by studies on the size of the surfaces of individual leaves, which also confirmed that irrigation increases the individual leaf surface area and thus the density of canopy. The results obtained during our studies also support this, that the surface of the leaves increases as a result of irrigation, and that the number of denser leaf layers can be observed on each canopy floor as a result of the treatment, which also suggests denser canopy.

Water deficiency can also affect the formation of canopy structure in grapes, as demonstrated by CASTELLARIN et al. (2007). The structure of canopy gradually deteriorated during the growing season in their study as exposure to water scarcity increased. The number of leaf layers at harvest in 2004 and in the last two weeks of ripening in 2005 was significantly lower for vines suffering from water scarcity. The difference was greater in 2005, when grapes were exposed to more intense water shortages at the end of a given vintage.

Overall, comparing our results with research found in the literature, irrigation has a positive effect on the vegetative growth of grapes, as well as on canopy density and structure. However, its degree depends on the grape variety grown, the specific vintage (especially the degree of drought), the irrigation time. In addition, our results highlight that by examining the structure of canopy on a separate floor, we can see even more detailed differences. Thus, in the future, phytotechnical operations on the "Hárslevelű" vineyard can be carried out even more efficiently and accurately, either adapted to the variety and the vintage, or by treating each leaf floor separately.

Ampelometric studies:

- Leaf surface, length of veins, linear properties:

According to the results for the leaf surface, it can be seen that the leaves from vines with subsurface irrigation had the largest surface

area. During this treatment, we observed an increasing trend over the four vintages. With the smallest leaf surface, control and drip irrigation vines showed approximately the same values. The length of the N1 main vein has shown an increasing trend over the years, which suggests that the leaf surface is also increasing. There was no change depending on the treatments. In terms of the length of the other main and secondary vessels, an increase can be seen in the case of leaves from the control and underground irrigated areas, so over the years the leaf surface has become larger. Outstanding of the two are the leaves of aboveground irrigated vines. The distance between the apex of the N2 vein and the apex of the first transient of N2 was also most increased in control and subsurface irrigation areas, especially in underground irrigation.

- Lobes and size of bays:

The distance, size and width of the shoulder bays were greatest for leaves from irrigated areas, i.e. treated leaves are more lobed and shoulder bays are more open than leaves from control plots. It should be emphasized that at the same time the angles between the apex of the leaf veins N 4 and N5 and the meeting point of the petiole-leaf plate and the apex of veins N 4, N5 were greatest in the case of leaves from the control plot each year.

- Angles between veins:

For almost all OIV properties, the angles between the veins were greatest every year during underground irrigation, thus increasing the surface area and width of the leaves picked from that area. However, the angles between the apex of the lower lateral veins on the left side of the leaves picked from drip irrigation and the apex of the veins N 3, N4, N5 and the point of origin of the petiole were the greatest each year, so that the left side of these leaves differed from those of the leaves picked from other treatments.

- Marginal teeth size:

The serration of the leaf edges was especially pronounced in the case of leaves picked from irrigated areas, especially in samples taken from areas with drip irrigation. The serration of control leaves approached that of irrigated leaves when the vintage was less droughty.

- Non-OIV defined morphological properties:

Non-OIV morphological properties were based on distances between individual points determined on the leaves. In one of the measured parameters (D01-04) no significant difference was observed between the vintages or the treatments. For the other morphological features, the effect of vintages showed significant differences on all indicators. Among the points measured on the leaves, the treatments showed the most statistically verifiable differences in distances on the right side and in the width affecting the upper part of the leaf. The results show that where there was a significant effect from each treatment, the distances between measured points were greater than for untreated leaves.

The change in the ampelometric properties of grape leaves as a function of irrigation has been partially studied on the basis of literature data on different varieties. For example, GUTIÉRREZ-GAMBOA et al. (2021) described how the water supply of grape plants can affect the size of leaves, the size of their surface area and some morphological features. Water scarcity can result in a smaller leaf surface, and even mild drought stress can trigger size differences. Furthermore, SCHULTZ and MATTHEWS (1993) have shown that irrigation significantly increased the size and thickness of vine leaves, as opposed to leaves of plants under drought stress. The asymmetric change of leaves, which we also experienced in our case, is also supported by their results published by BENITEZ et al. (2020).

However, changes in some OIV indicators of leaves under the influence of irrigation have not been studied before. Since these descriptive indicators are closely related to each grape variety, in the case of 'Hárslevelű' we found 5 indicators where there was no significant difference, either due to the vintage or the treatment. Presumably, therefore, these characteristics do not change either as a result of drought stress or irrigation, so these can be markedly characteristic marks of "Hárslevelű". 35 indicators at "Hárslevelű" can only change under the influence of vintages, 2 pieces only under the influence of irrigation, and 7 pieces can change under the influence of the vintage and treatment together. So, as a result of irrigation and vintage, in addition to changes in the size of the leaf surface, individual leaves of "Hárslevelű" can also undergo significant morphometric changes.

During colorimetric measurements in 2021, 2022 and 2024, sRGB-based color data of leaf samples collected from untreated and treated areas were analyzed, from which additional color-based vegetation indices were calculated based on SÁNCHEZ-SASTRE et al. (2020). Based on the results, in 24 of the 34 color indices examined, we found that both vintages, treatments and the interaction between the two variables had a significant effect on our results. Thus, our results highlight that the environmental effects caused by irrigation and vintages can influence the color of grape leaves from year to year and from treatment to treatment, and thus to individual vegetation indices as well. In cases where treatments have shown significant effects, it is clear that the vegetation indices of leaves from irrigated areas differ greatly from those of the vines of untreated plots. Our results are confirmed by research conducted by GUTIÉRREZ-GAMBOA et al. (2021), according to which different water conditions can also cause

differences in coloration on grape leaves. Previous studies have also shown that RGB-based vegetation indices of leaves may also be related to chlorophyll content, so these methods may be useful for monitoring water scarcity conditions in the future (SANG et al. 2021; SÁNCHEZ-SASTRE et al. 2020; CHENG et al. 2017).

When measuring chlorophyll content , we found that in 2022 and 2023, the chlorophyll content of the leaves of irrigated vines was higher than that of control vines. However, in 2024, the chlorophyll content of leaf samples collected from the control plot was the highest. Taking into account the year-to-year differences, the chlorophyll content of the leaves of underground irrigation was the most balanced, we did not experience any outliers between the vintages. Chlorophyll content has been used in the past to assess how the chlorophyll content of a plant develops when dehydrated. FLEXAS et al. (2010) demonstrated that irrigation improved the chlorophyll content of plants compared to unirrigated vines.

Measurement of water potential was carried out in 2022 and 2023. In 2022, which was also a drought year based on climatic data, severe water scarcity was measured in both control and irrigated areas during the August measurements. Water potential values improved with the use of irrigation, but water shortages were still experienced in the plantation in case of severe drought. The year 2023 was a more fortunate year in terms of precipitation, however, during the measurements in August, we experienced a water shortage condition on the control plots. Similarly to 2022, measured water potential values in irrigated areas improved in irrigated areas as a result of the amount of water applied. INTRIGLIOLO and CASTEL (2006) obtained similar results, as they showed that the water potential of the shoots of grape plants was much higher and more balanced under the

influence of irrigation, compared to the water potential of non-irrigated plants.

Monitoring the water potential of vines can be an important tool for determining the extent of drought and measuring its progression. By complementing this method, sensory measurements can help predict drought, thus determining the exact amount of irrigation water and the exact timing of application.

The effect of irrigation on the quality and quantity of the harvested crop was examined by comparing the average weight of the bunches, the average weight of 50 berries, and the acid, sugar content and pH value of the musts. The average mass of clusters was highest for underground irrigation in 2021, drip irrigation in 2022 and drip irrigation in 2023. The average weight of berries was highest for samples taken from irrigated areas in all three years, especially for drip irrigation. In terms of nutritional values of musts, acidity was highest in control samples, except in 2021. And the lowest was during drip irrigation. When measuring sugar content, samples of irrigated areas and samples of non-irrigated areas did not differ much. This is confirmed by the works of GINESTAR et al. (1998), GOODWIN and JERIE (1989) and WILLIAMS and GRIMES (1987). In terms of pH values of musts, drip irrigation had the highest pH values in 2021 and 2022.

The effect of irrigation on the sugar and acid content of grapes has been extensively studied both domestically and internationally on many different grape varieties.

FÜRI (1964) experienced an increase in sugar content as a result of irrigation in table grape orchards (Kocsis Irma, Szauter Gusztávné).

FÜRI and KOZMA (1975) also experienced an increase in sugar content, but this varied from year to year and variety to variety.

During experiments in Hungary, Ligetvári (1984) wrote that in the case of the Hárslevelú grape variety, with the exception of only one year, unirrigated vines provided the higher must degree (with minimal difference) analyzed at plot level. However, the sugar yield per vine (g/capital) was higher for irrigated Hárslevelú vines. In contrast, we did not find any outstanding differences between treatments and controls in any of our studies. When measuring the acidity, Hárslevelű experienced only the minimum excess acid in the absolute quantity per vine as a result of irrigation.

FÜRI (1977) found similar findings in his study, according to which, contrary to foreign literature data, he did not experience significant differences in sugar content either in his earlier studies (1963-1970) or between 1971 and 1975. He reported the acidity in the same way.

According to ZILAI (1994), higher must levels can be achieved by irrigation in drought years, and especially when irrigation during the period of green berry growth does not have to be feared with a significant decrease in sugar content, according to experimental reports. However, it also draws attention to the fact that a longer growing season is required to produce higher sugar, in light of which irrigated vines should be expected with a 1-2 week delay in ripening. This explains why there is no significant difference in sugar content as a result of irrigation if harvesting took place at the same time as the control vines. Regarding the development of acidity, he said that in some drought years a decrease can be observed as a result of irrigation.

Based on foreign reports, REYNOLDS et al. (2007), when examining American Cabernet Sauvignon grape varieties, found that the sugar content showed no or very little difference between irrigated and unirrigated vines. As regards acidity, it was reported that higher

titratable acidity was observed in 2 out of 4 test years for irrigated vines.

Based on the results of MIRÁS-AVALOS et al. (2019), it can be seen that as a result of irrigation, acidity increased compared to control. But they also point out in their work that the differences between the different vintages were due to climatic conditions rather than irrigation.

Thus, based on the literature and the results of our research, it can be assumed that despite irrigation, in many cases the temperature and precipitation patterns characteristic of the given vintage have a greater influence on the sugar and acid content of the crop. However, in more droughty years, this may be overwritten and the effect of irrigation will be stronger. In addition, the reaction of irrigated grape varieties to irrigation can also be a unique issue, as the nutritional values of the crops may react differently. When assessing these parameters, it is essential to evaluate the vintage effect, the effect of irrigation and the individual characteristics of the varieties together.

4. NEW SCIENTIFIC RESULTS

1. Proved that the irrigation method and the vintage have a significant effect on the bud fertility and canopy structure characteristics of the 'Hárslevelű' grape variety, as well as on the number of fruiting shoots, the number of inflorescences per vine, the number of infertile shoots and the number of clusters of shoots stemming from light buds.
2. It can be concluded that under the influence of irrigation, the ratio of leaf layer number and canopy gaps on the middle third of the canopy and the upper third of the canopy changes significantly along with the vintage effect. The number of leaf layers in the cluster zone is significantly affected by the vintage. Further, it can be noted that the indicators characterizing the foliar structure of irrigated areas showed higher values.
3. Based on the results, it can be concluded that the surface area of the leaf becomes larger as a result of subsurface irrigation, and the length of the main veins also increases as a result of this treatment. Irrigation may also change the openness, size and width of the shoulder bays, the angles between the veins and the size of the teeth at the edge of the leaf.
4. It can be concluded that irrigation and vintage also have a significant effect on the color of the leaves, as well as vegetation indices based on sRGB. Also, that the chlorophyll content in the leaves under the influence of irrigation can take on higher values.

5. PUBLICATIONS

Basic requirements

Scientific publications with impact factors

1. **Lepej Peter** ; **Taranyi Dóra** (Taranyi Dóra Ágnes Szőlészet) ; Rakun Jurij ; Nagy Balázs (Nagy Balázs Borászat) MATE/SZBI/Borászati Tanszék ; Steckl Szabina (Steckl Szabina Borászat) MATE/SZBI/Borászati Tanszék ; Lukácsy György ; Mikóczy Nárcisz ; Sárdy Diána Ágnes Nyitrainé (Nyitrainé Sárdy Diána Borászat) MATE/SZBI/Borászati Tanszék ; Bodor-Pesti Péter (Bodor-Pesti Péter Szőlőtermesztés) MATE/SZBI/Szőlészeti Tanszék
   The Effect of Irrigation on the Vineyard Canopy and Individual Leaf Morphology Evaluated with Proximal Sensing, Colorimetry, and Traditional Morphometry
   HORTICULTURAE (2311-7524): 10 7 Paper 716. (2024)
   Nyelv: Angol | DOI WoS Scopus Egyéb URL
   Folyóirat szakterülete: Scopus - Horticulture SJR indikátor: Q1
   Folyóirat szakterülete: Scopus - Plant Science SJR indikátor: Q2
2. **Bodor-Pesti Péter** (Bodor-Pesti Péter Szőlőtermesztés) MATE/SZBI/Szőlészeti Tanszék ; **Taranyi Dóra** (Taranyi Dóra Ágnes Szőlészet) MATE/MATE DI/Kertészettudományi Doktori Iskola ; Nyitrainé Sárdy Diána Ágnes (Nyitrainé Sárdy Diána Borászat) MATE/SZBI/Borászati Tanszék ; Le Phuong Nguyen Lien (Nguyen Lien Food Science) MATE/ÉTTI/ÉTK/Állatitermék és Élelmiszertartósítási Technológia Tanszék ; Baranyai László (Baranyai László Élelmiszertudomány, képfeldolgozás) MATE/ÉTTI/BFK/Élelmiszeripari Méréstechnika és Automatizálás Tanszék
   Correlation of the Grapevine (Vitis vinifera L.) Leaf Chlorophyll Concentration with RGB Color Indices
   HORTICULTURAE (2311-7524): 9 8 Paper 899. (2023)
   Nyelv: Angol | DOI WoS Scopus Egyéb URL
   Folyóirat szakterülete: Scopus - Horticulture SJR indikátor: Q1
   Folyóirat szakterülete: Scopus - Plant Science SJR indikátor: Q2

Refereed scientific publications without impact factors

Taranyi D. (Taranyi Dóra Ágnes Szőlészet) ; Mikóczy N. ; Deák T. (Deák Tamás Növénybiológia) ; Varga Zs. (Varga Zsuzsanna Szőlészet) ; Nyitrainé Sárdy D.A. ; Bodor-Pesti P.

The effect of irrigation on the bud fruitfulness of the grapevine (Vitis vinifera L.) cultivar ‘Hárslevel ű ’
ACTA HORTICULTURAE: TECHNICAL COMMUNICATIONS OF ISHS (0567-7572 2406-6168): 1 1385 pp 175-180 (2023)
Nyelv: Angol | DOI Egyéb URL
Folyóirat szakterülete: Scopus - Horticulture SJR indikátor: Q4
IV. Agrártudományok Osztálya IVAO A

Further scientific publications with impact factors (beyond the basic requirements):

1. Bodor-Pesti Péter (Bodor-Pesti Péter Szőlőtermesztés) MATE/SZBI/Szőlészeti Tanszék ; Taranyi Dóra (Taranyi Dóra Ágnes Szőlészet) MATE/SZBI/Szőlészeti Tanszék ; Vértes Gábor (Vértes Gábor Sándor Szőlőtermesztés) MATE/SZBI/Szőlészeti Tanszék ; Fazekas István (Fazekas István Szőlőtermesztés) MATE/SZBI/Szőlészeti Tanszék ; Nyitrainé Sárdy Diána Ágnes (Nyitrainé Sárdy Diána Borászat) MATE/SZBI/Borászati Tanszék ; Deák Tamás (Deák Tamás Növénybiológia) MATE/SZBI/Szőlészeti Tanszék ; Varga Zsuzsanna (Varga Zsuzsanna Szőlészet) MATE/SZBI/Szőlészeti Tanszék ; Baranyai László (Baranyai László Élelmiszertudomány, képfeldolgozás) MATE/ÉTTI/BFK/Élelmiszeripari Méréstechnika és Automatizálás Tanszék
Smartphone-Based Leaf Colorimetric Analysis of Grapevine (Vitis vinifera L.) Genotypes
HORTICULTURAE (2311-7524): 10 11 Paper 1179. 11 p. (2024)
Nyelv: Angol | DOI WoS Egyéb URL
Folyóirat szakterülete: Scopus - Horticulture SJR indikátor: Q1
Folyóirat szakterülete: Scopus - Plant Science SJR indikátor: Q2

2. Mezőfi László (Mezőfi László Növényvédelmi entomológia; Arachnológia) MATE/NVI/Rovartani Tanszék ; Markó Viktor (Markó Viktor Növényvédelmi entomológia, ökológia) MATE/NVI/Rovartani Tanszék ; Taranyi Dóra Ágnes (Taranyi Dóra Ágnes Szőlészet) ; Markó Gábor (Markó Gábor ökológia) MATE/NVI/Növénykórtani Tanszék
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3. Bodor-Pesti Péter (Bodor-Pesti Péter Szőlőtermesztés) MATE/SZBI/Szőlészeti Tanszék ; Taranyi Dóra (Taranyi Dóra Ágnes Szőlészet) MATE/MATE DI/Kertészettudományi Doktori Iskola ; Deák Tamás (Deák Tamás Növénybiológia) MATE/SZBI/Szőlészeti Tanszék ; Nyitrainé Sárdy Diána Ágnes (Nyitrainé Sárdy Diána Borászat) MATE/SZBI/Borászati Tanszék ; Varga Zsuzsanna (Varga Zsuzsanna Szőlészet) MATE/SZBI/Szőlészeti Tanszék
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István Fazekas (Fazekas István Szőlőtermesztés) ; Diána Nyitrainé Sárdy (Nyitrainé Sárdy Diána Borászat) MATE/SZBI/Borászati Tanszék ; Dóra Taranyi (Taranyi Dóra Ágnes Szőlészet) ; Varga Zsuzsanna (Varga Zsuzsanna Szőlészet) MATE/SZBI/Szőlészeti Tanszék
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