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MORPHOLOGICAL AND PHYSIOLOGICAL PARTICULARITIES OF FIVE DAHLIA CULTIVARS

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Abstract

The paper presents the results of the morphological characteristics of Dahlia leaves (leaves area, the perimeter, the length of the leaves, width of leaf), physiological processes (photosynthesis, respiration and transpiration) and chlorophyll content determined at 5 Dahlia cultivars 'Topmix Red', 'Hy Pimento', 'Babylon Red', 'Marble Ball' and 'Thomas Edison'. The average leaf area has varied from 5.35 cm^2 ('Topmix Red') to 68.41 cm^2 ('Babylon Red'). As for the perimeter, 'Babylon Red' had the highest value (67.49 cm) and 'Topmix Red' had the lowest value (9.72 cm). The length of the leaves was between 14.19 cm for 'Babylon Red' and 4.43 cm for 'Topmix Red'. The width of the leaves was between 10,18 cm for 'Babylon Red' variant and 2.26 cm for 'Topmix Red'.The intensity of photosynthesis varied between 12.85 µmol CO_2 $m^{-2}s^{-1}$ for 'Babylon Red' and 15.24 µmol CO_2 $m^{-2}s^{-1}$ for 'Topmix Red', intensity of transpiration 4.69 mmol H_2O $m^{-2}s^{-1}$ for 'Hy Pimento' and 6.17 mmol H_2O $m^{-2}s^{-1}$ for 'Thomas Edison', intensity respiration 7.46 µmol CO_2 $m^{-2}s^{-1}$ for 'Hy Pimento' and 13.43 µmol CO_2 $m^{-2}s^{-1}$ to 'Marble Ball'. The total chlorophyll content was higher in the case of 'Marble Ball', at a value of 163.90 mg/100g, and the smallest quantity was recorded for the 'Babylon Red' at the value of 102.15 mg/100g.

Key words*: chlorophyll, leaf morphology, photosynthesis, respiration, transpiration.*

INTRODUCTION

The special floricultural qualities of the species of the genus Dahlia make these plants not lacking in gardens and green spaces. The genus Dahlia is distinguished by 42 species and multitude of varieties as different as possible (http://www.theplantlist.org/1.1/browse/A/Compositae/Dahlia/). They are easy to grow, the decoration period is quite long, and the flowers are numerous and with an impressive colour. The nutritional and medicinal properties (Mejía et al., 1992; Laguna, 1992) of these plants have been known since Aztec times, and all these uses have led to the study of Dahlia species and varieties by researchers around the world (Ovando et al., 2006). Thus, numerous morpho-anatomical, physiological, nutritional and medicinal research with a great scientific value have been carried out, which confirms that these plants bring benefits to humans (Ciobanu (Țurlea) et al., 2021; Mejía et al., 1992; Laguna, 1992, https://www.sarahraven.com/articles/history-of-the-dahlia.htm).

In recent decades, the food industry has focused on the search for potential sources of anthocyanins that are able to provide color to replace synthetic dyes and at the same time provide health benefits through food products. The ancestral use of the flower in several dishes, its abundance, and the intense color of the flowers known as black make the *Dahlia pinnata* flower a suitable candidate to be considered as a potential source of anthocyanins (Granados-Balbuena, 2022). Dahlia belongs to Compositae (Asteraceae family), which is the largest family, comprising over 32913 species worldwide (http://www.theplantlist.org/1.1/browse/A/Compositae/). Dalia has worldwide fans because it is a plant that easily adapts to environmental conditions and because of the great variety of species, thus providing satisfaction to anyone who wants to cultivate it (Cantor & Pop, 2008).

Dahlias grew and still grow like weeds in the mountainous regions of Mexico and Central America and the Aztecs used them for food (Santana et al., 2016).

Eid et al. (2011) mention that there are over 2000 named cultivars of *Dahlia variabilis* in the USA. The natural geographic range for the genus Dahlia includes the natural Sierra Madre Occidental region of Mexico (Figure 1). Exceptions are *Dahlia australis*, which occurs at least as far south as southwestern Guatemala, and *Dahlia coccinea* and *Dahlia imperialis*, which have been reported throughout Central America into northern South America. Plant size varies from the small *Dahlia tenuis* and *Dahlia scapigera*, which only average 30-60 cm in height on slender stems, to tall arborescent species such as *Dahlia tenuicaulis*, to *Dahlia macdougallii*, which grows from under the mosses and ferns covering tree trunks and produces long shoots that sprawl across the canopy branches of tropical hardwoods.

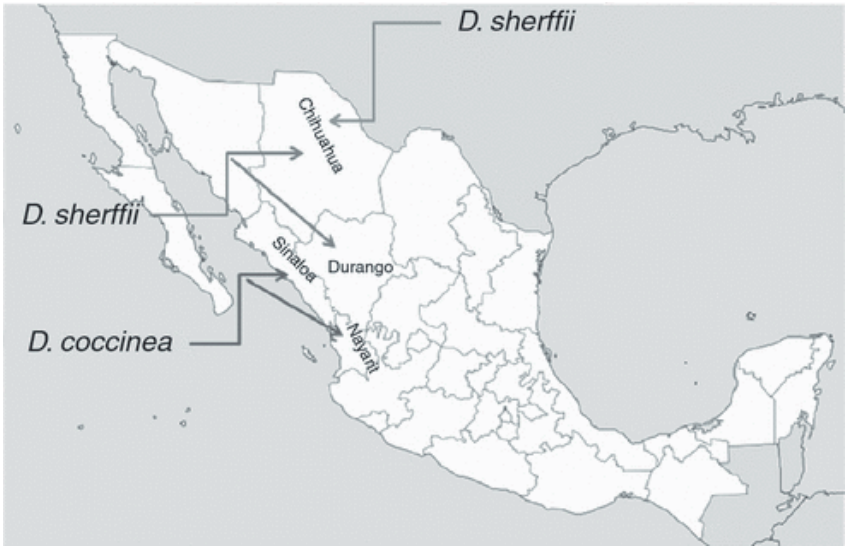


Figure 1. Map of Mexico showing the occurrence of the four wild *Dahlia* spp. Samples were collected from Nayarit, Sinaloa, Chihuahua and Durango states.
Source: https://bsppjournals.onlinelibrary.wiley.com/doi/10.1111/j.1365-3059.2010.02367.x

Selected wild Dahlia species in their natural habitats from west-central Mexico were tested for the presence of three caulimoviruses known to be associated with cultivated dahlia (*Dahlia variabilis*), viz. Dahlia mosaic virus (DMV), DMV-D10 and Dahlia common mosaic virus. The discovery of plant pararetroviruses in wild dahlia species in their natural habitats suggests a possible emergence, co-existence and co-evolution of pararetroviruses and their host plants (Eid et al., 2011).

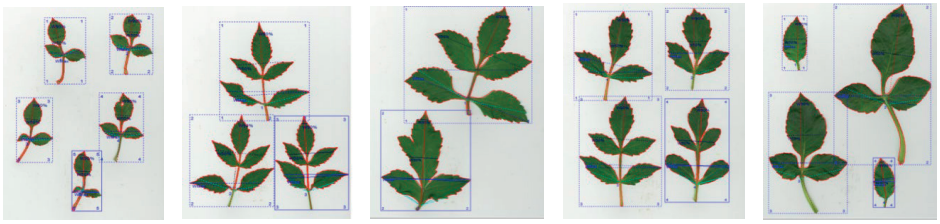
The dahlia crop is easy to maintain; dahlias are recognized for their ornamental, nutritional, pharmaceutical and antibacterial properties, and researchers want to identify their morpho-physiological traits according to the action of environmental factors in order to obtain the best possible production.

MATERIALS AND METHODS

The plants taken into study were cultivated in the "I. Todor" Botanical Garden of the University of Agronomic Sciences and Veterinary Medicine of Bucharest. The morphological and physiological characteristics were analysed in 5 cultivars of *Dahlia variabilis*: 'Topmix Red', 'Hy Pimento', 'Babylon Red', 'Marble Ball' and 'Thomas Edison'. To determine leaf morphological characteristics, all leaves of one plant were harvested from each of the 5 Dahlia cultivars in July 2022, in the seventh decade from planting. The leaves were washed with water, dried and scanned using an Epson Expression 11000XL scanner and then analyzed with software the WinFolia. The determinations done are the leaf

area (cm^2), the perimeter (cm), the length (cm) and the width (cm) of the leaves (Figure 2). The determination of the intensity of photosynthesis, transpiration and respiration was performed directly on the green part of leaves, in the field of experience, using the LCPro+ equipment, according to Aelenei et al. (2020). The determinations for the leaves of Dahlia plants were made with the LCPro+ equipment (according to Lascu et al. (2019)) in a relatively small range of variation of the intensity of photosynthetic active radiation of 1458-1484 µmol $m^{-2}s^{-1}$, at temperature 39.1-42°C (Table 2). Triplicates of independent determination were reported.

The quantitative analysis of the assimilating pigments was performed through the Arnon spectrophotometric method, which is based on the extraction of pigments in an organic solvent (80% acetone) and measuring the absorbance of the extract, by reading the sample extinction at a spectrophotometer at three different wavelengths: 470 nm, 646 nm and 663 nm, according to Asănică et al. (2017).



‘Topmix Red’ ‘Hy Pimento’ ‘Babylon Red’ ‘Marble Ball’ ‘Thomas Edison’

Figure 2. Morphological traits of the plant leaves for Dahlia ‘Topmix Red’, ‘Hy Pimento’, ‘Babylon Red’, ‘Marble Ball’și ‘Thomas Edison’
Source: original

Independent extract solutions were analyzed in triplicate. Statistical data processing was done by Microsoft Office Excel for Mac, version 16.69.1 (23011600).

RESULTS AND DISCUSSIONS

From the data regarding the biometric measurements presented in Table 1 and Figure 3 it can be observed that the average leaf area has varied from 5.35 cm (V_1 - 'Topmix Red') to 68.41 cm (V_3 - 'Babylon Red').

As for the perimeter, the variant V3 had the highest value (67.49 cm) and V1 had the lowest value (9.72 cm), mainly correlated with leaf width. The length of the leaves was between 14.19 cm for V3 and 4.43 cm for V1.

Table 1. Biometrical measurements of the leaves

Var.	Cultivar	Leaf Area (cm^2)	Perimeter (cm)	Lenght (cm)	Width (cm)
V_1	'Topmix Red'	5.35 ± 0.41	9.72 ± 0.68	4.43 ± 0.21	2.26 ± 0.11
V_2	'Hi Pimento'	40.66 ± 5.54	63.84 ± 6.98	12.04 ± 0.9	8.61 ± 0.8
V_3	'Babylon Red'	68.41 ± 7.5	67.49 ± 7.54	14.19 ± 0.99	10.18 ± 0.9
V_4	'Marble Ball'	26.75 ± 2.02	39.9 ± 2.6	9.26 ± 0.36	6.76 ± 0.4
V_5	'Thomas Edison'	44.28 ± 3.44	29.58 ± 2.06	12.4 ± 0.66	6.27 ± 0.35

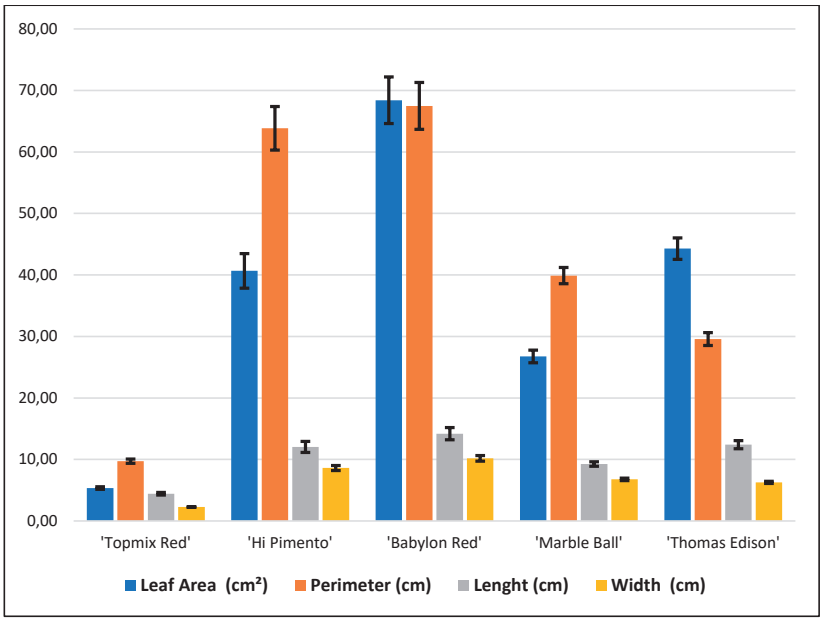


Figure 3. Biometrical measurements of the leaves (cm^2/cm)
Source: original

The width of the leaves was between 10.18 cm for V3 variant and 2.26 cm for V_1. The perimeter and the width showed the highest values in the V3 variant and the smallest in the V_1 variant.

In these conditions, it was registered different degrees of stomatal opening (between 0.18 - V_2 and 0.25 - V_5) that influenced physiological parameters.

Table 2. Intensity of photosynthesis, transpiration and respiration of Dahlia leaves, Q leaf - intensity of light incident on leaf, T°C - leaf temperature

Var.	Cultivar	Light intensity on leaf ($\mu mol^{-2}s^{-1}$)	Degree of stomatal opening (mol H_2O $m^{-2}s^{-1}$)	Leaf temp. (°C)	Photosynthesis (μmol CO_2 $m^{-2}s^{-1}$)	Transpiration (mmol H_2O $m^{-2}s^{-1}$)	Respiration (μmol CO_2 $m^{-2}s^{-1}$)
V_1	'Topmix Red'	1483	0.23	39.16	15.24	4.81	7.84
V_2	'Hy Pimento'	1484	0.18	39.50	12.88	4.69	7.46
V_3	'Babylon Red'	1473	0.19	40.71	12.85	5.19	11.52
V_4	'Marble Ball'	1475	0.24	41.05	13.95	6.07	13.43
V_5	'Thomas Edison'	1458	0.25	42.00	12.92	6.17	12.91

The intensity of the photosynthesis process ranged from 12.85 µmol CO_2 $m^{-2}s^{-1}$ for 'Babylon Red' to 15.24 µmol CO_2 $m^{-2}s^{-1}$ for 'Topmix Red'. The leaf surface and the position of the leaves against the solar radiation are important factors that condition the intensity of the photosynthesis process (Burzo et al., 2004). Regarding the intensity of the transpiration process according to the data presented in Table 2, the variation limits were between 4.69 mmol H_2O $m^{-2}s^{-1}$ for 'Hy Pimento' and 6.17 mmol H_2O $m^{-2}s^{-1}$ for 'Thomas Edison'. The intensity of transpiration varies with the species, the age of the plant and the environmental conditions (Toma & Jităreanu, 2007). The intensity of physiological processes varies according to the characteristics of the species and due to the climatic conditions. At the flowering plants, the intensity of photosynthesis is particularly influenced by light intensity and temperature. Determinations made at Dahlia show that the light intensity of 1.778 µmol $m^{-2}s^{-1}$ has a photosynthesis intensity of 11.67 µmol CO_2 $m^{-2}s^{-1}$. With regard to the process of transpiration,

research conducted at a temperature of 34.4°C indicates the intensity of transpiration of 5.75 µmol H_2O $m^{-2}s^{-1}$ (Burzo et al., 2000).

From the measured data, a weak negative correlation was recorded between the intensity of photosynthesis and the intensity of transpiration - Figure 4 - (R^2 = 0.0499, y = -0.2446x + 15.136, where y = intensity of photosynthesis and x = intensity of transpiration) probably according to the degree of stomatal opening and the temperature at the level of the leaf; it is inverse correlation, the two correlated variables vary in the opposite direction (when one increases, the other decreases).

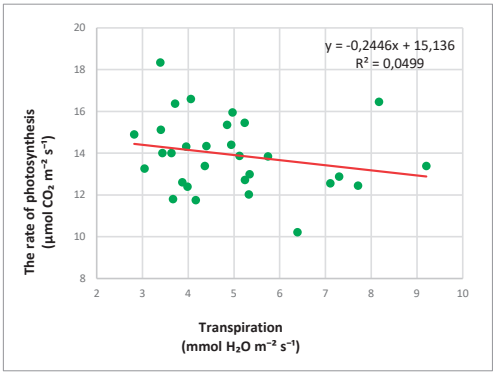


Figure 4. The correlation between the rate of photosynthesis and the transpiration at the leaves of Dahlia cultivars
Source: original

The intensity of physiological processes depends on the temperature (Nicolae, 2010). Light intensity and temperature are primary environmental factors affecting the growth and development of plants. Plants have evolved several efficient protective mechanisms that make it possible for them to survive under unfavorable light and temperature conditions. These mechanisms are linked predominantly to the photosynthetic electron transport chain, xanthophyll cycle and the photorespiratory pathway. Under stress conditions, elevated levels of reactive oxygen species (ROS) are produced, which in addition to deleterious effects also show signaling functions. Under severe, short light/temperature stress, the contents of low-molecular weight antioxidants, such as ascorbate, glutathione and prenyllipids, tend to decrease, which is correlated with an extra need for ROS scavenging. Under longer exposure of plants to unfavorable light and temperature conditions, the contents of antioxidants gradually increase as a result of acclimation during long-term responses (Szymańska et al., 2017). In their natural environment, plants are exposed to various stressors that act together, and intense irradiations combined with increased temperatures are the most frequently experienced stresses under field conditions. When changes in environmental conditions exceed plant capacity for acclimation, photoinhibition occurs (Nishiyama et al., 2011).

Linear regression made between the rate of photosynthesis and the leaf temperature shows a perfect inverse (negative) correlation between the two analyzed factors; the coefficient of determination (R^2) was 0.3382, y = - 0,52x + 34,977, where y = intensity of photosynthesis and x = temperature (Figure 5).

Nicolae (2010) mentions that the linear regression between photosynthesis rate and leaf temperature shows a good correlation; the coefficient of determination (R^2) was 0.83 in *Dahlia variabilis* for the following temperature values: at 28.4°C, the rate of photosynthesis was 1.105 µmol/m^2/s, at 33.8°C, the rate of photosynthesis was 1.410 µmol /m^2/s, and at 29.8°C, the rate of photosynthesis recorded the value of 1.280 µmol/m^2/s.

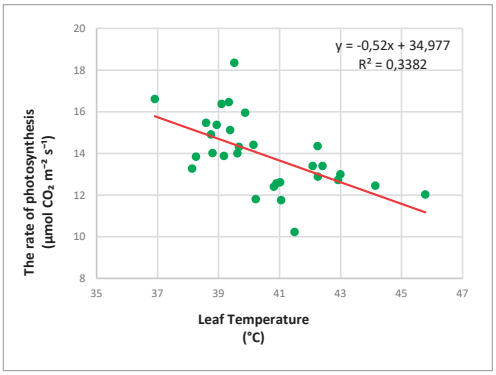


Figure 5. The correlation between the rate of photosynthesis and the temperature at the leaves of *Dahlia* cultivars
Source: original

Environmental temperature not only influences physiological processes, but also the growth of

dahlia plants. Schneck et al. (2021), notes that the supraoptimal root-zone temperatures (RZTs) to *Dahlia* x *hybrida* during production may decrease dahlia root quality, especially above 40°C and could initiate dahlia decline. Overall plant height was significantly impacted, resulting in shorter heights to plants under the influence of treatments - the supraoptimal root-zone temperatures between 40°-50°C.

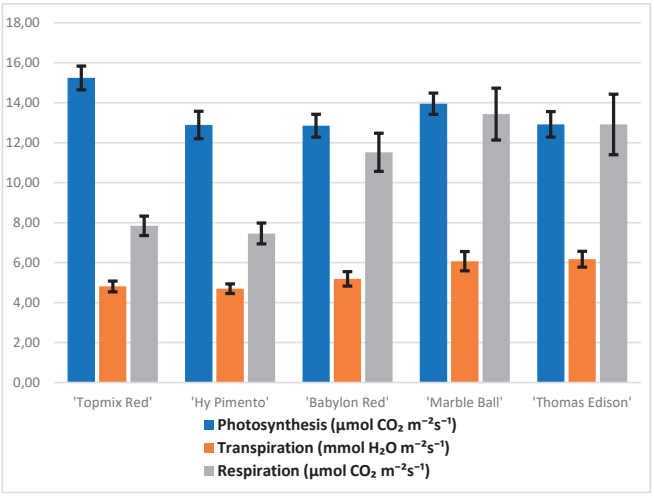


Figure 6. Intensity of the physiological processes
Source: original

Regarding the intensity of the respiration process (Figure 6) it can be appreciate that the lowest value of the intensity of the respiration was recorded for V_2 ('Hy Pimento'), 7.46 µmol CO_2 $m^{-2}s^{-1}$, and the highest value was recorded for V_4 ('Marble Ball'), 13.43 µmol CO_2 $m^{-2}s^{-1}$.

The high values of the respiration process are due to the high temperatures at which the determinations were made. For 'Babylon Red', 'Marble Ball', 'Thomas Edison' the temperature exceeded the critical value of 40°C, which led to a decrease in the intensity of photosynthesis and an increase in respiration and transpiration. Also, at these high temperatures, the stomata are wide open to allow the exit of water vapor through the ostioles and at the same time the elimination of excess heat along with the vaporization of water and the achievement of transpiration.

Considering the high temperature at which the determinations were made, the increase in respiration can also be attributed to the increase in photorespiration, knowing that the high temperature favors the oxidizing function of the RUBISCO enzyme and implicitly the biodegradation of photoassimilates in the photorespiration process. In the five Dahlia cultivars studied, the temperatures above 40°C negatively affect the photosynthesis process, positively stimulate transpiration (due to the thermoregulatory role), photorespiration and respiration.

Determinations regarding the content of chlorophyll and carotenoid pigments in the species of the Dahlia genus led to the results presented in Table 3. They highlighted the modification of the content of assimilating pigments according to the species, as follows: the chlorophyll a content was higher in the case of 'Marble Ball', at a value of 97.66 mg/100 g, and the smallest quantity was recorded for the V_3 - 'Babylon Red' at the value of 77.07 mg/100g, according to Figure 7. The quantity of chlorophyll b ranged from 25.07 mg/100g in V_3 ('Babylon Red') to 66.23 mg/100g in V_4 ('Marble Ball').

It should be noted the increased content of chlorophyll and carotenoid pigments in V_1 ('Topmix Red') in positive correlation with the photosynthesis rate.

Table 3. Assimilatory pigments content

Var.	Cultivar	Chl. a (mg/100 g)	Chl. b (mg/100 g)	Total Chlorophyll (mg/100 g)	Carotenoids (mg/100 g fw)	Chl. a/Chl. b ratio
V_1	'Topmix Red'	88.76	41.79	130.55	15.60	2.13
V_2	'Hi Pimento'	77.47	29.40	106.87	10.95	3.00
V_3	'Babylon Red'	77.07	25.07	102.15	10.16	3.55
V_4	'Marble Ball'	97.66	66.23	163.90	13.63	1.54
V_5	'Thomas Edison'	75.87	28.89	104.76	10.09	3.49

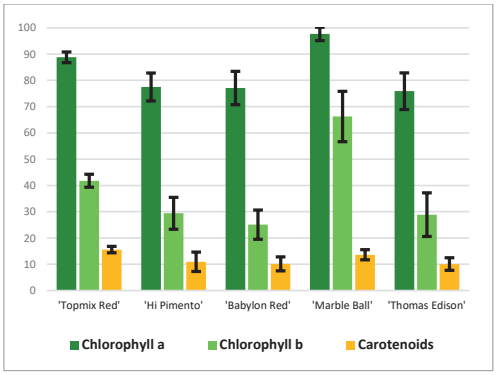


Figure 7. Content of chlorophyll and carotenoid pigments (mg/100 g)

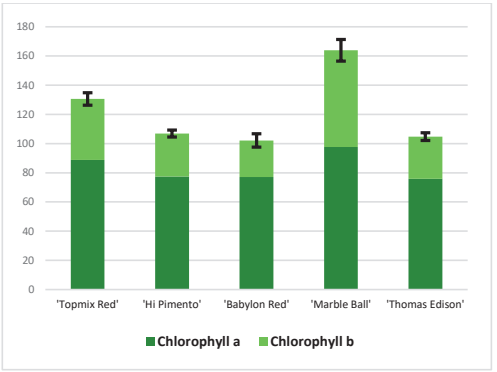


Figure 8. Content of total chlorophyll (mg/100 g)

The total chlorophyll content was higher in the case of V_4 - 'Marble Ball', at a value of 163.90 mg/100 g, and the smallest quantity was recorded for the V_3 - 'Babylon Red' at the value of 102.15 mg/100 g, according to Table 3, Figure 7 and 8.

The plants of *Dahlia variabilis* watered in the controlled way had a higher content of chlorophyll and carotenoids than the plants watered in the standard way (Jedrzejuk et al., 2022).

It seems that in the present research, the high total chlorophyll content is influenced by the culture conditions considering that the dahlia culture was irrigated daily (morning) for 2 hours (drip system).

Linear regression made between the rate of photosynthesis and of the total chlorophyll shows a weak correlation between the two analyzed factors; the coefficient of determination (R^2) was 0.0536, y = 0,0166x + 11,914, where y = intensity of photosynthesis and x = total chlorophyll (Figure 9).

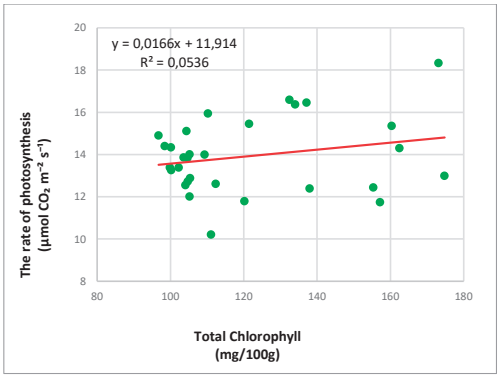


Figure 9. The correlation between the rate of photosynthesis and the total chlorophyll at the leaves of Dahlia cultivars
Source: original

A weak negative correlation was recorded between the intensity of photosynthesis and the leaf area - Figure 10 - (R^2 = 0.0816, y = -0.0235x + 14.797, where y = intensity of photosynthesis and x = intensity of transpiration).

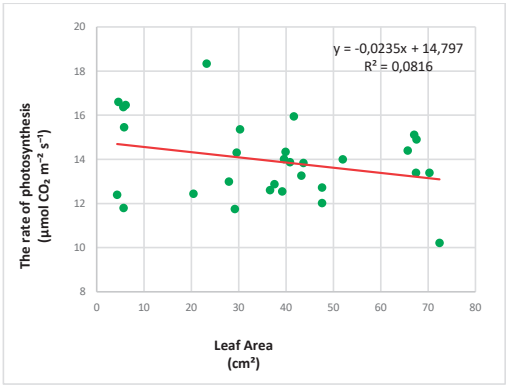


Figure 10. The correlation between the rate of photosynthesis and the leaf area at the leaves of Dahlia cultivars

CONCLUSIONS

The results obtained varied according to the cultivars and the assimilatory pigments distribution in leaf, which positively influenced the photosynthesis in leaves. The ornamental plants taken into study are useful resources for further research regarding the morphological aspects correlated with physiological processes that are carried out at the leaf level. The average leaf area has varied from 5.35 cm (V1 - 'Topmix Red') to 68.41 cm (V3 - 'Babylon Red'). The intensity of the photosynthesis process ranged from 12.85 µmol CO_2 $m^{-2}s^{-1}$for 'Babylon Red' to 15.24 µmol CO_2 $m^{-2}s^{-1}$for 'Topmix Red'. The intensity of physiological processes varies according to the climatic conditions. The total chlorophyll content was higher in the case of V4 - 'Marble Ball', at a value of 163.90 mg/100g, and the smallest quantity was recorded for the V3 - 'Babylon Red' at the value of 102.15 mg/100 g. A positive correlation was recorded between the intensity of photosynthesis and the total chlorophyll.

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