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STUDY REGARDING THE PHYSIOLOGICAL CHARACTERISTICS OF SOME VARIETIES OF BASIL CULTIVATED IN THE NUTRIENT FILM TECHNIQUE SYSTEM

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Abstract

The study presents aspects regarding the main physiological processes in the species of Ocimum basilicum, the varieties: 'Aromatic de Buzău', 'Crispum', 'Macedon' and 'Bulatum' cultivated in hydroponic system. Physiological indicators were analysed such as: photosynthesis, transpiration, respiration, dry matter content and water in the basal, middle, and apical leaves of the plants. The LCPro+ automatic analyzer was used to measure the intensity of the photosynthesis, transpiration, and respiration processes. The results obtained varied depending on the variety and the position of the leaves on the plant. The 'Macedon' variety stood out in terms of photosynthesis intensity, dry matter content, water and chlorophyll. The apical leaves showed a higher intensity of physiological processes, compared to the basal and middle leaves.

Key words*: photosynthesis, transpiration, respiration, dry matter.*

INTRODUCTION

Ocimum basilicum belongs to the genus Ocimum, the Lamiaceae family and is a herbaceous plant, native to Africa, Asia, Central and South America (Snežana, 2017). Basil plants have been used since ancient times with a wide use in various industries, such as: food industry as an aromatic plant (Ion et al., 2020) being often used in gastronomy, pharmaceutical industry, as a medicinal plant used in various diseases like: headaches, intestinal parasites, cough and diarrhea (Labra et al., 2004). It has also been widely used in perfumery as well as in dental and oral products (Simon et al., 1990).

The therapeutic action of the plants of the Lamiaceae family is due to the varied composition of the chemical compounds present in the volatile oil (Jailawi et al., 2019). The properties of basil are provided by the content of active substances it contains, having an effect in preventing and treating digestive disorders, cardiovascular disorders, menstrual cramps, diabetes and cancer (Purushothaman et al., 2018). The anti-inflammatory (Raina et al., 2016), antioxidant (Pandey et al., 2016; Flanigan & Niemeyer, 2014) and antithrombotic (Tohti et al., 2006) activity are also highlighted. Over time, it has been shown that some species of *Ocimum* have insecticidal properties, and other species have ornamental qualities varying depending on the variety (Kintzios et al., 2004).

Some phytochemical components such as phenolic compounds, carotenes and essential oils are of particular interest due to their antioxidant and anti-inflammatory properties (Zlotek et al., 2016). It is also a plant used in organic farming to control pathogens (Galea-Deleanu, 2015; Hamburdă, 2016; Teliban, 2016).

Basil, also called the king of herbs, is one of the species that behaves very well in the nutrient film technique system. It can be grown all year round on a vertical farm where much higher yields can be obtained compared to the standard from greenhouse culture (Jailawi et al., 2021).

The main physiological processes involved in plant growth and development are photosynthesis, transpiration and respiration. Photosynthesis is an important indicator in the accumulation of organic substances.

Assimilating pigments (chlorophyll a, b, xanthophyll and carotene) have an essential role in achieving this process. They also have beneficial effects on the human body such as: stimulating respiratory function and combating anemia (chlorophyll), anticancer, antimicrobial, epithelializing and antioxidant effects attributed to carotenes (Dumbravă et al., 2012).
The objective of this study was to highlight the main physiological parameters with an impact on plant growth and development using the hydroponic system.

MATERIALS AND METHODS

The research were carried out within the Hortinvest greenhouses, which belong to the Research Center for Studies of Food Quality and Agricultural Products from USAMV of Bucharest, in the nutrient film technique (NFT) system.
The biological material used was represented by the basil varieties: 'Macedon' (Figure 1), 'Aromat de Buzău' (Figure 2), 'Crispum' (Figure 3) and 'Bulatum' (Figure 4) created in the Vegetable Research and Development Station, Buzău, Romania.
Different parameters (such as photosynthesis, transpiration and respiration rate, water, chlorophyll and dry substance content), have been determined during the flowering phenophase, in May 2021, on the basal, middle and apical leaves.
The physiological parameters were analysed according to the variety and the position of the leaves on the plant. The intensity of the photosynthesis, respiration and transpiration process was determined with the LCPro$^+$ automatic analyzer, directly in the field of experience (700-800 µmol $m^{-2}s^{-1}$ light intensity and 31-32^{0}C). The results were expressed in µmol of CO_2 $m^{-2}s^{-1}$ for photosynthesis and respiration, and the results for transpiration intensity were expressed in µmol H_2O $m^{-2}s^{-1}$.
The amount of water and dry matter were determined by gravimetric analysis and expressed as a percentage. 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. The obtained results were expressed as mg 100 g^{-1} FW using the formula of Lichtenthaler & Wellburn (1983).

RESULTS AND DISCUSSIONS

The intensity of the photosynthesis process in the leaves of the basil varieties

From Table 1, the data analysis showed that the value of photosynthesis intensity in the basal leaves ranged from 2.92 µmol CO_2 $m^{-2}s^{-1}$ for 'Aromat de Buzau' to 4.52 µmol CO_2 $m^{-2}s^{-1}$for 'Macedon', in the middle leaves ranged from 4.06 µmol CO_2 $m^{-2}s^{-1}$ for 'Aromat de Buzău' to 6.68 CO_2 $m^{-2}s^{-1}$ for 'Macedon' variety while for apical leaves ranged from 13.1 µmol CO_2 $m^{-2}s^{-1}$ for 'Aromat from Buzău' to 7.18 µmol CO_2 $m^{-2}s^{-1}$ for 'Crispum' variety. The results obtained by Burzo & Mihăiescu (2005) for different varieties of basil showed that the value of the photosynthesis process varied from 4.34 µmol CO_2 $m^{-2}s^{-1}$ ('Citrodorum' variety) and 6.20 µmol CO_2 $m^{-2}s^{-1}$ ('Greek' variety).
It should be noted that the value of photosynthesis intensity is higher in the apically located leaves compared to the basal and middle leaves, this being due to a higher exposure to light radiation.
The intensity with which the photosynthesis process takes place in order to biosynthesis the organic substances, ensures the growth and development of the plants, directly influencing the production.
The leaves of plants perform the process of photosynthesis according to the photosynthetic type C3 being influenced by environmental factors, especially light, temperature, but also by variety characteristics.

The intensity of the transpiration process in the leaves of the basil varieties

The value of the transpiration intensity in the basal leaves varied between 0.91 µmoles H_2O $m^{-2}s^{-1}$ for the 'Aromat de Buzau' variety and 1.84 µmoles H_2O $m^{-2}s^{-1}$ for the 'Crispum' variety. In the case of middle leaves, the value varied from 1.07 µmoles H_2O $m^{-2}s^{-1}$ for the 'Aromat de Buzău' variety to 1.65 µmoles H_2O $m^{-2}s^{-1}$ for the 'Crispum' variety. In apical leaves, the highest value was in the 'Crispum' variety (3.80 µmol H_2O $m^{-2}s^{-1}$) followed by the 'Aromat de Buzău' variety (3.08 µmol H_2O $m^{-2}s^{-1}$).

Approximately 45% of the light absorbed by plants is converted into caloric energy which is consumed in the process of transforming liquid water into steam (Burzo et al., 2004), thus ensuring thermoregulation. It also has a role in avoiding the supersaturation of the cells with water and the generation of the suction force of the leaf through which the ascending transport of the raw sap takes place.

Table 1. Results regarding some physiological parameters in basal, middle and apical leaves of basil

Variety	Photosynthesis intensity (µmol CO_2 $m^{-2}s^{-1}$) Leaves-flowering phenophase		
	basal	middle	apical
Aromat de Buzău	2.92	4.06	13.1
Macedon	4.52	6.83	8.94
Crispum	3.72	5.44	7.18
Bulatum	3.88	6.68	9.14
Transpiration intensity (µmol H_2O $m^{-2}s^{-1}$)			
Aromat de Buzău	0.91	1.07	3.08
Macedon	1.50	1.55	1.99
Crispum	1.84	1.65	3.80
Bulatum	1.27	1.54	1.62
Respiration intensity (µmol CO_2 $m^{-2}s^{-1}$)			
Aromat de Buzău	2.03	5.24	7.34
Macedon	1.83	2.95	3.28
Crispum	2.92	3.01	4.36
Bulatum	1.63	1.58	4.50

The intensity of the respiration process in the leaves of the basil varieties

The intensity of the respiration process in the basal leaves varied between 1.63 µmol of CO_2 $m^{-2}s^{-1}$ in the 'Bulatum' variety and 2.92 µmol of CO_2 $m^{-2}s^{-1}$ in the 'Crispum' variety. In the middle leaves, the intensity of respiration was higher in the 'Aromat de Buzău' variety (5.24 µmol CO_2 $m^{-2}s^{-1}$) and the lowest value was for the 'Bulatum' variety (1.58 µmol CO_2 $m^{-2}s^{-1}$). In the apical leaves, an increase in the intensity of respiration was observed in the 'Aromat de Buzău' variety (7.34 µmol CO_2 $m^{-2}s^{-1}$) compared to the other varieties studied (Table 1).

The analysed data show that the intensity of the respiration process was lower in the basal leaves, compared to the leaves located apically.

According to Brezeanu (2009), research on tomatoes has shown that the intensity of the respiration process is dependent on the degree of maturation of the leaves. Leaves with a more advanced degree of maturation had lower respiratory intensity compared to young leaves. This process provides the biochemical energy needed for plant growth and development.

Water and total dry matter content of the basil varieties

The total dry matter contains organic substances as well as soluble or insoluble inorganic substances from plant cells, their accumulation in plant organs being largely due to the process of photosynthesis.

According to the data in Table 2, it is observed that the value of the dry matter content was higher for the apical leaves (16.17%) and the lowest value was for the middle leaves (8.44%, 'Crispum' variety).

The highest water content was in the leaves of the 'Macedon' variety. The other varieties had approximately the same values (Table 2).

The analysis of the obtained data showed that the maximum value for the dry matter was obtained for the apical leaves (16.17% for 'Macedon' variety), while the minimum value was recorded at the level of the middle leaves (8.44% for 'Crispum' variety).

Table 2. Dry matter and water content of basal, middle and apical leaves of basil

Variety	Dry matter (%)		
	basal	middle	apical
Aromat de Buzău	9.75	11.31	12.89
Macedon	12.05	11.64	16.17
Crispum	8.65	8.44	10.16
Bulatum	9.51	9.35	11.41
Water (%)			
Aromat de Buzău	90.25	88.69	87.11
Macedon	99.87	99.88	99.83
Crispum	91.35	91.56	89.84
Bulatum	90.49	90.65	88.89

Chlorophyll and carotenoids content of the studied varieties

The minimum value of the total chlorophyll content was obtained for the basal leaves (56.92 mg/100 g FW, 'Crispum' variety) while the maximum value was recorded for the apical leaves (159.89 mg/100 g FW, 'Macedon' variety, Table 3).

The total chlorophyll content was higher for the 'Crispum' variety (176.01 mg/100 g FW) analyzed by Burzo & Mihăiescu (2005).

The data in Tables 4-5 showed that the minimum value of the chlorophyll a and b content was obtained for the 'Crispum' variety (42.59 mg/100 g FW, chlorophyll a, respectively 14.33 mg/100 g FW, chlorophyll b in the basal leaves) and the highest value was recorded for the 'Macedon' variety (100.59 mg/100 g FW, chlorophyll a, respectively 59.31 mg/100 g FW, chlorophyll b in the apical leaves).

The content of chlorophyll pigments varies depending on the species, the age of the leaf (Burzo et al., 2005) and the position of the leaf on the plant (Ionescu, 2011).

From the studies performed by Dumbravă et al., 2012, it appears that basil contains a higher amount of chlorophyll pigments and carotenoids compared to rosemary.

The chlorophyll a/b ratio varied between 1.70 mg/100 g FW in the apical leaves for the 'Macedon' variety and 3.06 mg/100 g FW in the middle leaves for the 'Crispum' variety (Table 6).

In terms of carotenoids pigments content, there was an increase in the 'Macedon' variety in the basal leaves 6.16 mg/100 g FW, 8.27 mg/100 g FW in the middle leaves and apical leaves 9.63 mg/100 g FW (Table 7).

The amount of carotenoids in the apical leaves of the 'Aromat de Buzău' variety had the same value as that obtained in the basal leaves of the 'Macedon' variety (6.16 mg/100 g FW, Table 7).

The chlorophyll/carotenoids ratio of the 'Macedon' variety ranged from 18.42 mg/100 g FW in the middle leaves to 22.97 mg/100 g FW in the basal leaves (Table 8).

The content of chlorophyll pigments is correlated in the case of many plants with the intensity of the photosynthesis process and the accumulation of nutrients in plants, respectively (Aelenei et al., 2020).

Table 3. Total chlorophyll content (mg/100 g FW) of basil leaves in the varieties studied

Variety	Leaf position		
	basal	middle	apical
Aromat de Buzău	77.14	99.99	130.28
Macedon	125.17	152.36	159.89
Crispum	56.92	71.90	99.36
Bulatum	78.64	90.31	112.03

Table 4.The chlorophyll a content (mg/100 g FW) of the basil varieties studied

Variety	Leaf position		
	basis	middle	apical
Aromat de Buzău	56.50	73.25	92.01
Macedon	89.77	99.07	100.59
Crispum	42.59	54.67	74.43
Bulatum	59.20	68.07	83.88

Table 5. Chlorophyll b content (mg/100 g FW) of the basil varieties studied

Variety	Leaf position		
	basal	middle	apical
Aromat de Buzău	20.65	26.74	38.27
Macedon	35.40	53.29	59.31
Crispum	14.33	17.22	24.93
Bulatum	19.44	22.23	28.15

Table 6. Clorophyll a/b content (mg/100 g FW) of the varieties studied

Variety	Leaf position		
	basal	middle	apical
Aromat de Buzău	2.74	2.74	2.40
Macedon	2.54	1.86	1.70
Crispum	2.97	3.17	2.99
Bulatum	3.05	3.06	2.98

Table 7. Carotenoids content (mg/100 g FW) of the varieties studied

Variety	Leaf position		
	basal	middle	apical
Aromat de Buzău	3.64	4.80	6.16
Macedon	6.16	8.27	9.63
Crispum	2.81	3.42	4.46
Bulatum	3.75	4.25	5.57de

Table 8. The ratio of total chlorophyll to carotenoids (mg/100 g FW) in the varieties studied

Variety	Leaf position		
	basal	middle	apical
Aromat de Buzău	21.19	20.82	21.15
Macedon	22.97	18.42	16.61
Crispum	20.25	21.05	22.27
Bulatum	20.96	21.27	20.13

Figure 1. Morphological aspects of *Ocimum basilicum* 'Macedon' variety

Figure 2. Morphological aspects of *Ocimum basilicum.* 'Aromat de Buzău' variety

Figure 3. Morphological aspects of *Ocimum basilicum* 'Crispum' variety

Figure 4. Morphological aspects of *Ocimum basilicum* 'Bulatum' variety

CONCLUSIONS

The plants under study are an essential resource for future research on the use of these varieties of basil in various industries. The results obtained in terms of the studied parameters (photosynthesis, transpiration, respiration, dry substance, and water content) varied depending on the variety and position of the leaves on the plant. The 'Macedon' variety was noted for the intensity of its physiological processes, the content of assimilating pigments, dry matter, and water. The apical leaves showed a higher intensity of physiological processes, in comparison to the basal and middle leaves.

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