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PHYSIOLOGICAL AND BIOCHEMICAL CHANGES IN TOMATO HYBRIDS IN THE GROWING PERIOD

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ABSTRACT

The tomato is known as a major source of important nutrients including lycopene, β-carotene, flavonoids and vitamin C. Since the discovery that lycopene has anti-oxidative and anti-cancer properties, tomato is considered a protective food, therefore it acquired great popularity among consumers.
Fruit growth and ripening are the result of multiple physiological and metabolical processes that occur during the plant development. Researches regarding the intensity of photosynthesis, as well as the content in assimilatory pigments, dry matter and water in leaves have been made on some tomato hybrids cultivated in protected spaces in different stages of growth: leaf stage, flowering stage and fruiting stage. It was noted that the evolution of physiological and biochemical parameters vary depending on type of tomato hybrid and on the phenological phase.

INTRODUCTION

Tomato is one of the most important vegetable crops, which is grown widely throughout the world. The tomato is included in the *Solanaceae* family, together with other plants species of economic importance such as potatoes, eggplants, tobacco, peppers. The tomato is known as a major source of important nutrients including lycopene, β-carotene, flavonoids and vitamin C (Nour et al., 2013). Since the discovery that lycopene has anti-oxidative and anti-cancer properties properties (Gajowik A, 2014; Raiola et al. 2014), tomato is considered a protective food, therefore it acquired great popularity among consumers. At present, it is an important crop plant, so the tomatoes production and consumption continue to increase.
Fruit growth and ripening are the result of multiple physiological and metabolical processes that occur during the plant development. Since leaves are considered to be the main providers of nutrients for fruit growth (Hetherington et al., 1998), the objective of this work was to evaluate the variation of some physiological and biochemical parameters that occur in the tomato leaves. The physiological parameters depends on genetics, environmental factors (temperature, light, water and nutrient availability, air composition), agricultural techniques (Schwarz et al., 2002; Islam, 2011; Zhu et al., 2012), so a detailed research of the physiological characteristics in relationship with the biochemical indicators is necessary to improve the technology of tomato cultivation.
Considering that lately new tomato hybrids with improved nutritional content and potential health benefits are being developed, it has become increasingly important to assess their physiological and biochemical parameters in order to recommend the use of certain cultivation technologies. This paper presents the variation of photosynthetic activity in relation with assimilatory pigments, water and dry matter content in the leaves during the growing process of some tomato hybrids. The determinations were made in different

phenological stages of plant development (growth, flowering and fruiting phenophase) so that some particularities of selected tomato hybrids to be highlighted.

MATERIALS AND METHODS

Two tomato hybrids with indeterminate growth from collection of Faculty of Horticulture (USAMV Bucharest) were investigated: Mahitos and Abellus.

Mahitos hybrid is an early variety, very productive, recommended for cultivation in protected crops or open fields. The plant is vigorous, strong against extreme weather conditions. It produces high quality beef fruits (250 -300 g average fruit size), firm, uniform bright red, resistant to storage and transportation, ideal for consumption especially in fresh condition.

Abellus hybrid is an extra-early hybrid of the generativ type with indeterminate growth, tolerant of difficult climatic conditions, recommended for cultivation in protected crops or open fields. The plant is vigorous, highly productive and produces uniform small pear-shaped fruits (140-150 g average fruit size), bright red without a green lid, resistant to storage and transportation, ideal for consumption in fresh and preserved condition.

The selected tomato hybrids were cultivated in protected systems (greenhouse), that provided controlled conditions for plant growth, so that the determinations were made at 720-880 μmoll/m^2/s light intensity and a temperature of 22-24 ^oC.

All investigations were performed during the growth and development process: in the growth, flowering and fruiting phenophase. The measurements were made on 10 tomato plants randomly chosed in the greenhouse and average of these 10 measurements was calculated.

Photosynthesis rate was determined with LCA-4 analyzing portable system (ADC Bioscientif, UK) on the fifth leaf from the top of plant. The obtained results were expressed in μmoll CO_2/m^2/s.

The biochemical parameters were determined using proper methods:

- determinations of the assimilatory pigments content in the active leaves**:** c*hlorophyll* and *carotenoid pigments* were extracted in 80% acetone and determined spectrophotometrically (wavelenghts 663 nm, 647 nm and 480 nm) using the extinction coefficients and equations described by Schopfer (1989). The results were expressed in mg/100 g fresh weight;
- determination of the *water* and *dry matter* content was made by gravimetric method *:* samples has been dried to constant mass in an oven at (105 ± 5) ^oC and the loss of weight is used to calculate the moisture content of the sample (%).

RESULTS AND DISCUSSIONS

Between the physiological processes that occur in the leaves, the photosynthesis plays the most important role in determining growth and development of plants, so directly influences the yield quantity and quality (Burzo and Dobrescu, 2005). The performed research emphasized the variations of photosynthetic rate in relation with some biochemical parameters of two tomato hybrids during the development period, in different phenological phases: vegetative growth, flowering and fruiting phases.

The photosynthesis rate

During the growth phenophase the Mahitos hybrid was noted with a high value of photosynthetic rate (14.58 μmoll CO_2/m^2/s) compare to Abellus hybrid (9.57 μmoll CO_2/m^2/s) (figure 1). The photosynthesis of tomato hybrids has been monitored also in the flowering phenophase, when the Mahitos hybrid reached also a 1,10 times higher photosynthetic value than Abellus hybrid. Comparing the data obtained in these phenophases, it can be appreciated that in the flowering stage the process of

photosynthesis increased in both selected hybrids, but with a different rhythm: it was 1.49 times more intense at Abellus, but only with 1.08 times higher at Mahitos hybrid.

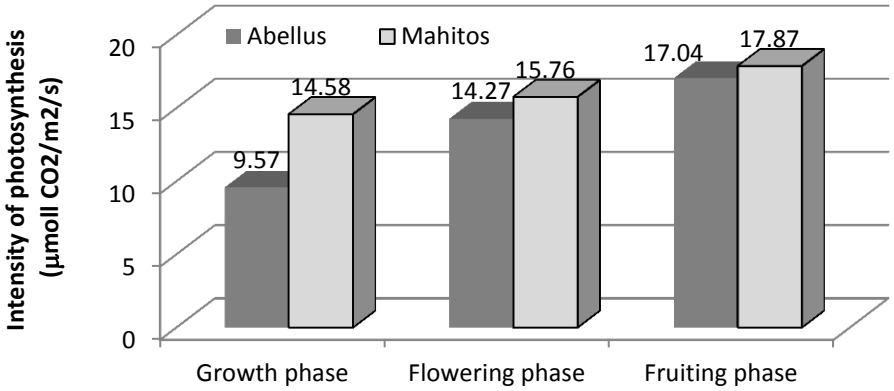

Figure 1. Intensity of photosynthesis

This evolution of photosynthesis process can be correlated with the progress of leaves growth, which achieved the characteristic dimensions. These results are in according with Ludwig and Withers (1984), which determined the highest value of photosynthesis intensity when the tomato leaves reached 30-50% of their maximum area and with previous researches that pointed out the same dynamics of the photosynthesis in other tomato hybrids (Dobrescu et al., 2016).

Also in *the fruiting phase* the determinations of the photosynthetic rate emphasized higher values compared to flowering phase in both the selected hybrids, which may be explained through the stimulating of the photosynthesis process by fruits formation and growth. Thus, the photosynthesis increased in a similar manner in at both hybrids: by 1.13 times at Mahitos and by 1.19 times at Abellus hybrid.

It is notable Mahitos hybrid as having an elevated biological potential, given the high value of the photosynthetic intensity performed during monitored phenophases.

Content in assimilatory pigments

Chlorophylls *a* and *b* represent the photosynthetic pigments in plants, which mainly capture light in the antenna complex via photosystem II with consequent electron transport (Taiz and Zeiger 2009), while carotenoids are considered as accessory components in the photosynthetic complex by providing photoprotection and stability of proteins present in the photosystem (Torres-Netto et al., 2005; Simkin et al. 2008).

The content in assimilatory pigments in the leaves changes depending on the maturity stage begining with vegetative growth phenophase to the fruiting phenophase.

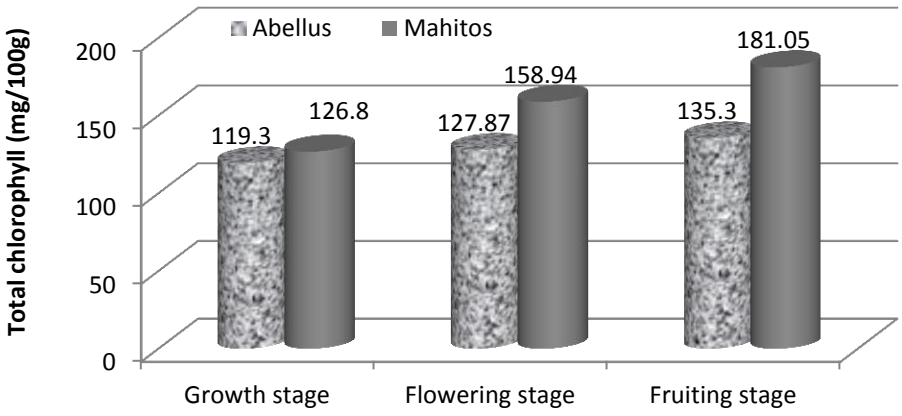

Figure 2. Content in total chlorophyll

The measurement of assimilatory pigments content (figure 2) completes picture of the results achieved under physiological aspect. Comparison between the selected hibrids emphasized the Mahitos hybrid with the highest content of assimilatory pigments in the leaves (from 126.8 mg/100 g in the growth phase to 181.05 mg/100 g total chlorophyll in the fruiting phase).

The assimilatory pigments content followed an ascendent dynamics during the studied growth period in both hybrids: the highest amount was registered in the fruiting phenophase, in correlation with the photosynthesis dynamics.

The carotenoids content registered similar values in the leaves of the selected hybrids (12.08 mg/100 g at Abellus and 11.87 mg/100 g at Mahitos in the growth phase) and also a slightly increase in the flowering and the fruiting phase, indicating a high photoprotective condition (figure 3).

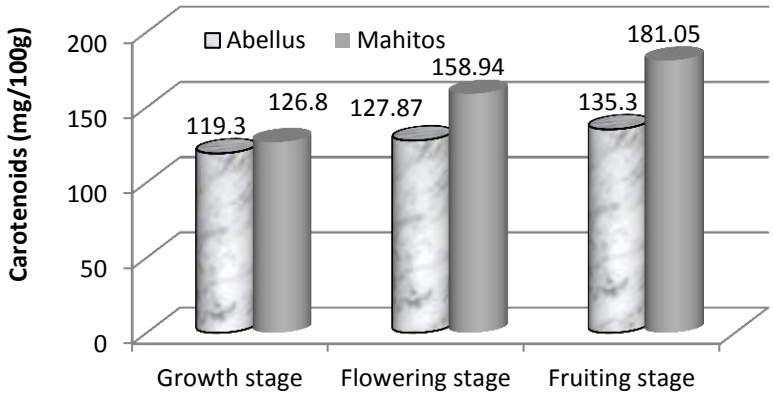

Figure 3. Content in carotenoids

Content in water and dry matter

Water is an important factor in the evolution of physiological processes that determine the growth and development of plants. The water content of a leaf is one of the important factors on which the photosynthetic activity of leaves depends (Burzo and Dobrescu, 2005).

Water requirements of tomato plants are moderate, being higher in periods of flowering and fruiting. Besides the water content, dry matter also varies depending phenophase, leaf age and mineral nutrition.

Water content (table 1) registered similar values in the studied tomato hybrids in the growth phenophases (86.97% in Mahitos hybrid comparing to 85.08% in hybrid Abellus).

Table 1

Content in water and dry matter in the leaves of tomato hybrids

	Water content		Dry matter content	
	Abellus	Mahitos	Abellus	Mahitos
Growth phase	85.68	86.97	14.32	12.03
Flowering phase	86.93	87.68	13.07	12.32
Fruiting phase	88.76	89.98	11.24	10.02

In flowering phenophase an increase in the water content was noted in the leaves of both hybrids (87.68% in Mahitos, respectivelly 86.93% in Abellus hybrid). The water content in the leaves is correlated with the intensity of photosynthesis, knowing that the water effectively participate and are consumed in the metabolic reactions during the photosynthetic process. Therefore, the higher water content measured in the leaves of

Mahitos probably favored the higher rate of photosynthesis registered in the flowering phase by this tomato hybrid.

In the fruiting phenophase the water content in the leaves of both tomato hybrids changed in a similar manner, respectivelly the highest water amount was registered by Mahitos (89.98%) compared to Abellus hybrid (88.76%).

The chemical compounds (glucids) generated by photosynthesis provides the substrate for the plant growth and energy for the production and maintenance of biomass (Osorio et al., 2014). Photosynthetically active tissues, such as mature leaves, export fixed C (primarily as sucrose) to non-photosynthetic tissues such as fruits or reproductive organs, tubers, meristems, roots (Koch, 2004).

The leaves dry matter content registered the highest value in the vegetative growth period, then followed a slightly downward trend in the flowering and fruiting phases (table 1). Analysis of data obtained to selected tomato hybrids indicated a higher biomass accumulation in the Abellus hybrid leaves compared to Mahitos hybrid in all the monitored phenophases.

Decreasing in the dry matter content of the leaves during the flowering and fruiting phases may be explained by the translocation of the photosynthesis products from leaves to the new growing organs, such as flowers and fruits. According to the scientific literature, during its lifetime, any normal plant undergoes considerable changes in the dynamics of carbon transport and metabolism in both source (leaves) and sink organs (flowers, fruits, roots etc.) which are known to induce cyclic patterns of growth (Gautier et al., 2001; Bertin et al., 2003).

CONCLUSIONS

It was noted that the evolution of physiological and biochemical parameters vary depending on type of tomato hybrid and on the phenological phase.

Generally, in all the studied hybrids the photosynthetic activity was lower in the phase of vegetative growth but it increased in the flowering and the fruiting phenophases, which stimulated the development of photosynthesis process. Mahitos hybrid was noted as having an elevated biological potential, given the high value of the photosynthetic intensity performed during monitored phenophases.

The content in assimilatory pigments was positively correlated to the photosynthesis, so it increased constantly, but in different rhythm during the development phenophases in both the studied hybrids.

The water content of the leaves follows an ascending dynamics during the monitored phenophases in accordance with the evolution of the photosynthetic process.

A decrease in the dry matter content of the leaves was registered during the flowering and fruiting phases in both the tomato hybrids, which may be explained by the translocation of the photosynthesis products from leaves to the new growing organs, such as flowers and fruits.

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