Scientific Papers. Series B, Horticulture. Vol. LX, 2016
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

DYNAMICS OF PHYSIOLOGICAL PROCESSES IN TOMATOES DURING THE PHENOLOGICAL STAGES

Aurelia DOBRESCU[1], Gheorghița HOZA[1], Daniela BĂLAN[1]

[1]University of Agronomic Sciences and Veterinary Medicine Bucharest
59 Marasti Blvd., 11464 Bucharest, Romania

Corresponding author email: balan.dana@gmail.com

Abstract

Tomato (Solanum lycopersicum L.), known to belong to the Solanaceae family, is considered one of the most important vegetable in the world since the fruits are widely consumed either fresh or processed. The ripe fruits are a valuable source of vitamin C, carotenoids and minerals such as iron and phosphorous that is daily required for a healthy diet. Fruit growth and ripening are the result of multiple physiological and metabolical processes that occur during the plant development. A thorough knowledge of the physiological characteristics of tomato plants is necessary to improve the technology of cultivation under greenhouse conditions. Research regarding the intensity of physiological processes as photosynthesis, respiration, transpiration have been made on some tomato hybrids cultivated in protected spaces in different phenological stages of plant development: in the vegetative growth period, at the flowering time and at the fruiting time. The measurements were performed with electronic analyzer LCA-4. It has been noticed that dynamics of the physiological processes varies depending on the hibrid type and on the development phenophase.

Key words*: tomato, phenology, photosynthesis, respiration, transpiration*.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.), known to belong to the *Solanaceae* family, is considered one of the most important vegetable in the world since the fruits are widely consumed either fresh or processed. Beside the high nutritional value, the ripe tomato fruits are a valuable source of vitamin C, carotenoids and minerals such as iron and phosphorous that are daily required for a healthy diet (Nour et al., 2013).

Fruit growth and ripening are the result of multiple physiological and metabolical processes that occur during the plant development. Leaves are considered to be the main providers of carbon for fruit growth (Hetherington et al., 1998). Therefore, the major functions of the leaves was studied in order to relate the influence of different cultivation technologies or varying environmental conditions on fruit growth and development. A thorough knowledge of the physiological characteristics of tomato plants is necessary to improve the technology of cultivation. 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).

Recently new tomato hybrids with improved nutritional content and potential health benefits are being developed. Consequently, it has become increasingly important to assess their physiological parameters in order to recommend the use of certain cultivation technologies. For this purpose study of the intensity of physiological processes as photosynthesis, respiration, transpiration was performed on some tomato hybrids cultivated in protected spaces (greenhouse). The determinations were made in different phenological stages of plant development (growth, flowering and fruiting phenophase) so that some peculiarities of selected tomato hybrids to be emphasized.

MATERIALS AND METHODS

Four tomato hybrids from collection of Faculty of Horticulture (USAMV Bucharest) were investigated: Principe Borghese, Maressa, Izmir and Ruxandra.

Principe Borghese hybrid is a cherry tomato with determined growth, small pear-shaped

fruits, ideal for consumption in fresh and preserved condition.
Maressa hybrid is characterised by undetermined growth, uniform round fruits of middle size (150-170 g), suitable for consumption in a fresh state.
Izmir and Ruxandra are tomato hybrids with undetermined growth, which produce big round fruits (180-200 g).
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 μmols/m^2/s light intensity and a temperature of 22-24°C.
Photosynthesis, respiration and transpiration rates were determined with LCA-4 analyzing portable system (ADC Bioscientif, UK) on the fifth leaf from the top of plant. The measurements were made on 10 tomato plants randomly chosed in the greenhouse and average of these 10 measurements was calculated. The obtained results were expressed in μmols $CO_2/m^2/s$ for photosynthesis and respiration rate and μmols $H_2O/m^2/s$ for transpiration rate.

RESULTS AND DISCUSSIONS

The performed research approached the variations of some physiological parameters of certain tomato hybrids during the development stage, in different phenological phases: vegetative growth, flowering and fruiting phases.

The photosynthesis process

Tomatoes are included in C_3 photosynthetic type. The intensity of photosynthesis determines growth and development of plants, so directly influences the yield quantity and quality (Burzo and Dobrescu, 2005).
The obtained results (Figure 1) pointed out that in *the vegetative growth stage* it can be noticed that the most reduced photosynthetic rate was determined at Principe Borghese hybrid (3.21 μmols $CO_2/m^2/s$), while Izmir hybrid registered a 1.5 times higher value (4.88 μmols $CO_2/m^2/s$).
Also Maressa and Ruxandra hybrids reached similar values, no significant differences were reported by comparison with Izmir hybrid.

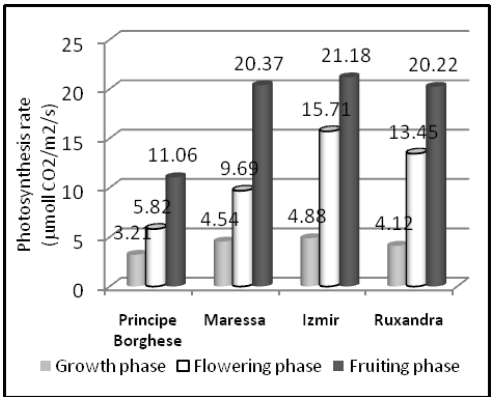

Figure 1. Dynamics of photosynthesis in the leaves of selected hybrids

The photosynthesis of tomato hybrids has been monitored also in *the flowering phenophase*, which debuted in May. In this period Izmir hybrid was noted with an increased value of photosynthesis rate (15.71 μmols $CO_2/m^2/s$), which was 1.17 times higher compared to Ruxandra hybrid and 2,7 times higher than the one registered by the Principe Borghese hybrid.
Comparing the data obtained in the two analyzed phenophases, it can be appreciated that in the flowering stage the process of photosynthesis increased in all selected hybrids, but with a different rhythm: it was 3.21 times more intense at Izmir hybrid, 2.44 times higher at Maressa and only 1.8 times higher at Principe Borghese. This dynamics of photosynthesis can be correlated with the achievement of the growth of leaves, which reached 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.
Also in *the fruiting phase* were made determinations of the photosynthetic rate, which reached higher values compared to flowering phase in all the selected hybrids because the formation and growth of the fruits stimulate the photosynthesis process. Thus, the photosynthesis increased by 2.1 times at Maressa hybrid, by 1.9 times at Principe Borghese hybrid and by 1.5 times at Ruxandra hybrid.
Izmir hybrid recorded the highest photosynthetic rate in this phenophase (21.18

μmols $CO_2/m^2/s$) compared to the other analyzed hybrids. However, in this hybrid the photosynthesis process was stimulated only 1.3 times by fructification, while the flowering determined a 3.3 times more intense rate of photosynthesis in comparison with the growth stage.

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

The transpiration process

Transpiration process consists in removal of the water excess by the plants, thus avoiding supersaturation of the cells with watter and overheating (thermoregulator role). Most importantly, transpiration generates the suction force of the leaf, which is involved in roots activity of water and minerals absorption. Thus it can be appreciated that transpiration and photosynthesis are related processes, as the suction force of leaf provides the raw materials needed to develop leaf photosynthesis (Burzo et al., 2004).

The obtained data (Figure 2) indicated that in *the growth phenophase* the transpiration rate varied between 2.33 μmols $H_2O/m^2/s$ in Principe Borghese hybrid and 3.31 μmols $H_2O/m^2/s$ in Izmir hybrid. Comparing the values determined for the selected hybrids, it was noticed that Izmir hybrid performed a transpiration rate by 1.42 times more intense than Principe Borghese, by 1.38 times higher than Maressa and by 1.4 times higher than Ruxandra hybrids.

In *the flowering phenophase* an increasing of transpiration rate can be observed compared to the growth phase in all the selected tomato hybrids: by 1.36 times at Ruxandra, by 1.11 times at Maressa, but insignificantly at Principe Borghese and Izmir. It appears that Principe Borghese hybrid registered similar values of transpiration rate both in growth and in flowering phenophase. In contrast, Ruxandra hybrid showed an increased rate of transpiration in the flowering phase, which is corelated with an increased rate of photosynthesis in the same phenophase.

The determinations performed in *the fruiting phenophase* indicated an increase of the transpiration rate in all the studied tomato hybrids as result of fruit formation and growth. The transpiration increase during this development stage may be corelated to an increased water demand provided as result of the roots absorbtion stimulated by an intense transpiration.

It is notable that Izmir and Ruxandra hybrids registered the highest transpiration rate in flowering and fruiting phases, so a positive correlation with photosynthesis rate was observed.

On the contrary, Principe Borghese hybrid registered the lowest rate of transpiration, an almost constant value (2.33-2.45 μmols $H_2O/m^2/s$) during the monitored phenophases. Also the photosynthesis process was the least intense throughout the research in this hybrid.

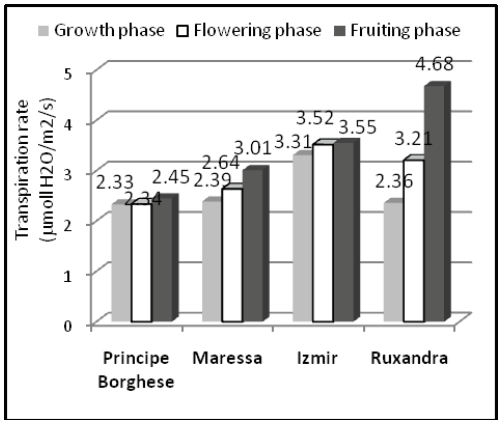

Figure 2. Dynamics of transpiration in the leaves of selected hybrids

The respiration process

The respiration is the only process that provides biochemical energy to achieve the plant growth and development. Tomatoes are climacteric plants, so the respiration process follows a characteristic dynamics: it achieves a maximum in the growth phase, then decreases, but reaches a second maximum (the climacteric maximum) during the maturity phase (Gherghi et al., 2001; Burzo et al., 2005).

Regarding the intensity of respiration process (Figure 3) in the selected tomato hybrids it was noticed high values (2.3-2.22 μmols $CO_2/m^2/s$) at Izmir and Maressa hybrids in *the growth phase*, which are positively correlated to photosynthetic process. The lowest value of respiration rate in this phenophase was registered by the Principe Borghese hybrid (1.49 μmols $CO_2/m^2/s$).

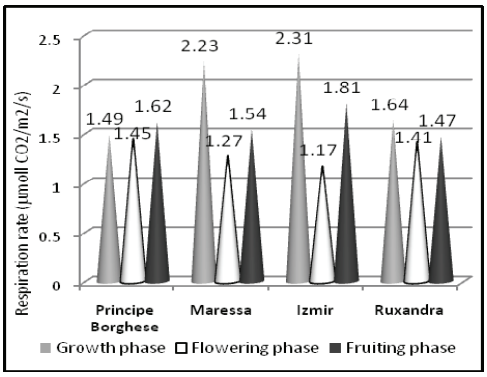

Figure 3. Dynamics of respiration in the leaves of selected hybrids

A decrease of respiration rate was noticed in *the flowering phase* in all the studied tomato hybrids, in according to speciality literature. The reduction rate of respiration was different: by 1.96 times lower in Izmir hybrid, 1.74 times at Maressa, 1.17 times at Ruxandra and insignificant decrease at Principe Borghese hybrid.

In *the fruiting phenophase* a second maximum of respiration process was determined in all the selected hybrids, the highest value (1.81 µmols $CO_2/m^2/s$) being registered at Izmir hybrid, which was characterized by an intense metabolism during the entire research period. A reduced respiration rate was measured at Maressa hybrid (1.54 µmols $CO_2/m^2/s$) and Ruxandra hybrid (1.47 µmols $CO_2/m^2/s$).

CONCLUSIONS

It has been noticed that dynamics of the physiological processes varies depending on the hibrid type and on the development phenophase.

The photosynthesis process follows an ascending evolution during the research period: both the flowering and the fruiting stage stimulate the photosynthesis, which registered increased values compared to the one determined in growth phenophase in all the studied hybrids.

The transpiration process is positively correlated to the photosynthesis, so it increased constantly, but in different rhythm during the development phenophases in all the studied hybrids.

The respiration process follows the dynamics characteristic for climacteric plants: it achieved a maximum in the growth phase, decreased in the flowering phase, but reached a second maximum (the climacteric maximum) in the fruiting phase.

Among studied hybrids, Izmir hybrid was noted with a high biological potential, given the increased values of physiological parameters during the monitored research period, which indicate an intense metabolism.

REFERENCES

Burzo I., Delian E., Dobrescu A., Voican V., Bădulescu L., 2004. Fiziologia plantelor de cultură, Vol. I. Procesele fiziologice din plantele de cultură, Editura Ceres

Burzo I., Dobrescu A., 2005. Fiziologia plantelor, 2005, Ed. Elisavaros, Bucuresti

Gherghi A., Burzo I., Mărgineanu L., Bădulescu L., 2001. Biochimia şi Fiziologia Legumelor şi Fructelor, Editura Academiei Române

Hetherington S.E., Smillie R.M., Davies W.J., 1998. Photosynthetic activities of vegetative and fruiting tissues of tomato. J. of Exp. Botany, 49(324): 1173–1181

Islam M.T., 2011. Effect of temperature on photosynthesis, yield attributes and yield of tomato genotypes. Int. J. Expt. Agric. 2(1):8-11

Ludwig L.J., Withers A.C., 1984. Photosynthetic response to CO_2 in relation to leaf development in tomato. Adv. in Photosynthetic Res. 4, 217-220

Nour V., Trandafir I., Ionica M.E., 2013. Antioxidant Compounds, Mineral Content and Antioxidant Activity of Several Tomato Cultivars Grown in Southwestern Romania. Not. Bot. Horti. Agrobo., 41(1):136-142

Radzevičius A., Karklelienė R., Viškelis P., Bobinas Č., Bobinaitė R., Sakalauskienė S., 2009. Tomato (*Lycopersicon esculentum Mill.*) fruit quality and physiological parameters at different ripening stages of Lithuanian cultivars. Agr. Res. 7, 712–718

Schwarz D., Kläring H.P., 2002. Growth and Photosynthetic Response of Tomato to Nutrient Solution Concentration at Two Light Levels. J. Amer. Soc. Hort. Sci. 127(6):984–990

Zhu J., Liang Y., Zhu Y., Hao W., Lin X., Wu X., Luo A., 2012. The interactive effects of water and fertilizer on photosynthetic capacity and yield in tomato plants. Austr. J. of Crop Science 6(2):200-20