RESEARCH REGARDING THE DIURNAL DYNAMICS OF SOME PHYSIOLOGICAL PROCESSES IN *MALUS DOMESTICA* BORKH.

NICOLAE Ion

Abstract. The research regarding the diurnal dynamics of physiological processes was performed on apple variety Idared cultivated in the climatic conditions of Oltenia region. Physiological analyses were performed on mature leaves, in 2 phases of vegetation: the fruit growth phase (June 10, 2009) and the fruit maturation phase (July 10, 2009). At the analyzed plants, there was noticed that the photosynthesis dynamics and the transpiration varies depending on weather conditions, showing a minimum in the morning, a maximum after lunch and a minimum toward the evening, but the recorded values are lower in fruits maturation phase. At the plant leaves, analyzed in the stage of fruit growth, which had a higher intensity of photosynthesis and transpiration there was recorded a lower water content. The pigment chlorophyll content positively correlated with the photosynthesis intensity, recording higher values at the leaves of the analyzed plants, in the phase of fruit growth.

Keywords: leaves, photosynthesis, transpiration.

Rezumat. Cercetări privind dinamica diurnă a unor procese fiziologice la *Malus domestica* BORKH. Cercetările privind dinamica diurnă a proceselor fiziologice s-au efectuat la soiul de măr Idared cultivat în condiţiile climatice din regiunea Olteniei. Analizele fiziologice s-au efectuat, la frunzele mature, în două faze de vegetaţie: faza de creştere a fructelor (10 iunie 2009) şi faza de maturare a fructelor (10 iulie 2009). La plantele analizate s-a constatat că dinamica diurnă a fotosintezei şi transpiraţiei variază în funcţie de condiţiile climatice, prezentând un minim dimineaţa, un maxim după prânz şi un minim spre seară, dar valorile înregistrate sunt mai mici în faza de maturare a fructelor. La frunzele plantelor, analizate în faza de creştere a fructelor, care au avut o intensitatate a fotosintezei şi transpiraţiei mai mare s-a înregistrat un conţinut mai mic de apă. Conţinutul în pigmenţi clorofilieni se corelează pozitiv cu intensitatea fotosintezei, înregistrându-se valori mai mari la frunzele plantelor analizate, în faza de creştere a fructelor.

Cuvinte cheie: frunze, fotosinteză, transpiraţie.

INTRODUCTION

The apple originated from Central Asia and is represented by over 300 species, with edible fruit or leaves, ornamental flowers and fruit.

Malus domestica BORKH. grows in all countries with temperate, warm climates. The plant has a thick trunk with smooth gray bark in the beginning, which then exfoliates in irregular plates. The apple crown consists of both extended branches and of shorter ones with fruit.

The leaves have oval or elliptical tongue, serate edge and they are petiolated. The flowers are hermaphrodite, arranged in corymb inflorescence, present five triangular sepals, five large pale pinkish petals. Stamens are arranged in three circles and the gyneceum consists of five carpels united only at the basis and which, after fertilization, merge into receptacle.

The fruit itself is a polyfollicles represented by five membranous lodges where seeds are found. The fleshy, edible part forms the false fruit, called grapes.

An easily grown plant, it succeeds in most fertile soils, preferring a moisture retentive well-drained loamy soil. It prefers a sunny position but succeeds in partial shade, though it fruits less well in such a situation.

The research conducted on the diurnal dynamics of the process of photosynthesis suggests that it has a maximum in the early hours of illumination of leaves, remains constant through the period of leaf illumination, and decreases when darkness sets in (CREWS et al., 1975).

Other research conducted on apple leaves emphasized that there was a slight decrease in the intensity of photosynthesis at midday (LANDSBERG et al., 1975).

The intensity of the photosynthesis process is higher in the case of the apple leaves located at a height of 1.8 m compared with those located at 1.0 m above the ground (CORELLI & SANSAVINI, 1989).

The young leaves have the highest intensity of the transpiration process and as they get older, the transpiration intensity decreases, the lower values being recorded at senescent leaves (BURZO et al., 1999).

The intensity of transpiration process at apple has higher values in the full flowering stage and gradually decreases 100 days after petal fall (ROM & FERREE, 1986).

It was discovered that the shaded leaves have lower transpiration intensity, compared to the sunny ones (CHALMERS et al., 1983).

The intensity of photosynthetically active radiations is higher near the edge of the crown and close to the stem axis and decreases from higher to lower levels (MARINI & MARINI, 1983).

The intensity of transpiration process commensurately increases with that of photosynthesis, both processes being dependent on solar radiation intensity (BIGNAMI & NATALI, 1992).

MATERIAL AND METHODS

The research regarding the diurnal dynamics of physiological processes was determined in the apple variety Idared cultivated in the climatic conditions of Oltenia region (Banu Mărăcine, Dolj).

The diurnal dynamics of photosynthesis and transpiration was established with the analyzer LCi portable photosynthesis system. The analyzer LCi automatic performs recording and measurements of other parameters with the importance in process of photosynthesis and transpiration: photosynthetic active radiations, leaf temperature, stomatal conductance etc. The obtained results were graphically represented and statistically interpreted.

The total water contents and of dry substance were determined by the help of the drying stove - gravimetric method. The content of the chlorophyll pigments was estimates by Minolta SPAD 502 chlorophyll meter.

RESULTS AND DISCUSSIONS

Fruit growth represents a process of quantitative accumulation, which takes place in 2 stages: the first stage with the cell division and the second stage with the cell extension, which is manifested by the increase of the fruit size. Fruit maturation is a process of qualitative accumulations that determines the achievement of the traits characteristic to this variety.

The apple Idared variety, introduced in America in 1942 as a cross between Wagner and Jonathan, is characterized by plants with medium vigour and spherical crown. The fruits are medium to large in size (170-200 g), are shaped as flat sphere with intensely red surface. It is harvest in late September and reaches optimal maturity for consumption after 3-4 months of storage.

Physiological investigations were performed on mature leaves in the phase of fruit growth on June 10, 2009 and the phase of fruit maturation on July 10, 2009 (Figs. 1; 2).

Figure 1. Fruits growth phase at *Malus domestica*.
Figura 1. Faza de creştere a fructelor la *Malus domestica* (original).

Figure 2. Fruits maturation phase at *Malus domestica*.
Figura 2. Faza de maturare a fructelor la *Malus domestica* (original).

The diurnal dynamics of the physiological processes at the plants was established according to the climatic conditions. Among the factors with importance upon photosynthesis and transpiration, there were analysed: the photosynthetic active radiation incident on the surface of the leaf, the leaf temperature, and stomatal conductance.

The diurnal dynamics of photosynthesis and transpiration presents a minimum in the morning, a maximum after lunch, and a minimum toward the evening with specific variations depending on the climatic conditions.

In the analyzed plants, one can notice an intensification of the photosynthesis rate morning (9 a.m.), when one can record values of 9.18 μmol $CO_2/m^2/s$ in the fruits growth phase and of 8.26 μmol $CO_2/m^2/s$ in the fruits maturation phase, their growth up until after lunch (1 p.m.), when one record values of 14.89 μmol $CO_2/m^2/s$ in the fruits growth phase and 13.76 μmol $CO_2/m^2/s$ in the fruits maturation phase and towards evening (5 p.m.), one can notice a gradual

decrease recording values of 12.65 μmol $CO_2/m^2/s$ in the fruits growth phase and of 11.7 μmol $CO_2/m^2/s$ in the fruits maturation phase (Fig. 3).

The maximum photosynthesis intensity was recorded at the analyzed leaves, in the phase of fruit growth, which corresponds to the highest efficiency of water usage.

In the apple plants, one can notice an intensification of the transpiration starting morning (9 a.m.), when one can record values of 3.15 mmol $H_2O/m^2/s$ in the fruits growth phase and of 2.78 mmol $H_2O/m^2/s$ in the fruits maturation phase, their growth up until after lunch (1 p.m.), when one record values of 5.76 mmol $H_2O/m^2/s$ in the fruits growth phase and 5.24 mmol $H_2O/m^2/s$ in the fruits maturation phase and towards evening (5 p.m.), one can notice a gradual decrease recording values of 4.65 mmol $H_2O/m^2/s$ in the fruits growth phase and of 4.23 mmol $H_2O/m^2/s$ in the fruits maturation phase (Fig. 4).

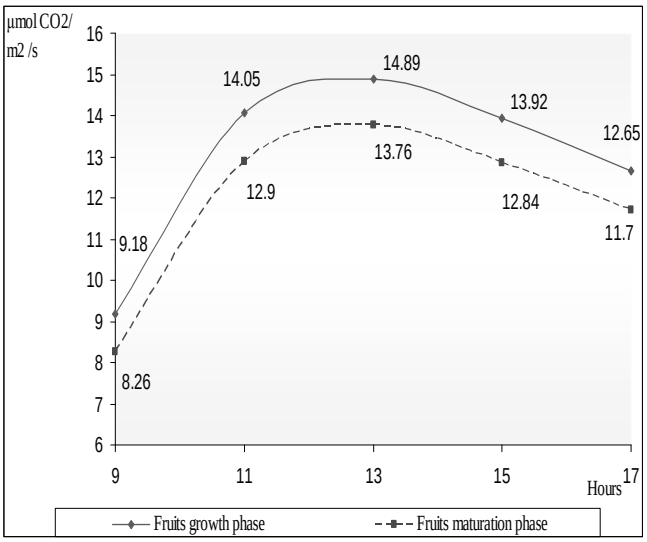

Figure 3. The diurnal dynamics of photosynthesis at the leaves of *Malus domestica* - Idared variety. / Figura 3. Dinamica diurnă a fotosintezei la frunzele de *Malus domestica* - soiul Idared.

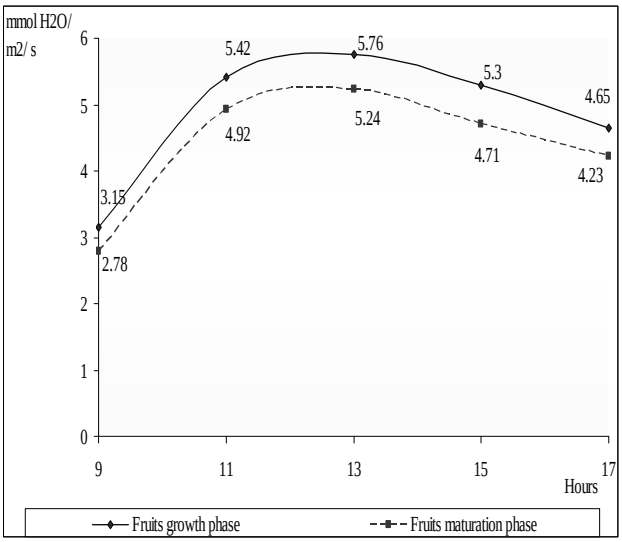

Figure 4. The diurnal dynamics of transpiration at the leaves of *Malus domestica* - Idared variety. / Figura 4. Dinamica diurnă a transpirației la frunzele de *Malus domestica* - soiul Idared.

The intensity of photosynthesis and transpiration varies depending on the light radiation received by leaves, which are dependent on the position of leaves on plants. At the apple plants, one can observe an intensification of the photosynthetic active radiations present on the surface of the leaves starting with the early hours of the morning (9 a.m.), when one can record values of 1,160 μmol/m^2/s in the fruits growth phase and of 1,245 μmol/m^2/s in the fruits maturation phase, their growth up until after lunch (1 p.m.), when one record values of 1,486 μmol/m^2/s in the fruits growth phase and 1,640 μmol/m^2/s in the fruits maturation phase and towards evening (5 p.m.) one can notice a gradual decrease recording values of 1,325 μmol/m^2/s in the fruits growth phase and of 1,520 μmol/m^2/s in the fruits maturation phase.

The intensity of photosynthesis and transpiration correlates with the photosynthetic active radiations, but present different values at the analyzed plants in the fruits growth phase, in comparison with the analyzed plants in the fruits maturation phase.

Linear regression made between the photosynthesis rate and photosynthetic active radiations shows a good correlation between the 2 analyzed factors; the coefficient of determination (R^2) was 0.98 in the fruits growth phase and 0.96 in the fruits maturation phase (Fig. 5).

Linear regression made between the transpiration rate and photosynthetic active radiations shows a good correlation; the coefficient of determination (R^2) was 0.98 in the fruits growth phase and 0.97 in the fruits maturation phase (Fig. 6).

The intensity of photosynthesis and the intensity of transpiration depending on the temperature air do correlate positively with the relative humidity. Thus, increasing air temperature causes relative air humidity decrease, which causes intensification of transpiration.

The leaf temperature increases starting with the early hours of the morning (9 a.m.), when one can record values of 24.5°C in the fruits growth phase and of 26.4°C in the fruits maturation phase, their growth up until after lunch (1 p.m.), when one record values of 31.6°C in the fruits growth phase and 32.6°C in the fruits maturation phase and towards evening (5 p.m.), one can notice a gradual decrease recording values of 30.2°C in the fruits growth phase and of 32.4°C in the fruits maturation phase.

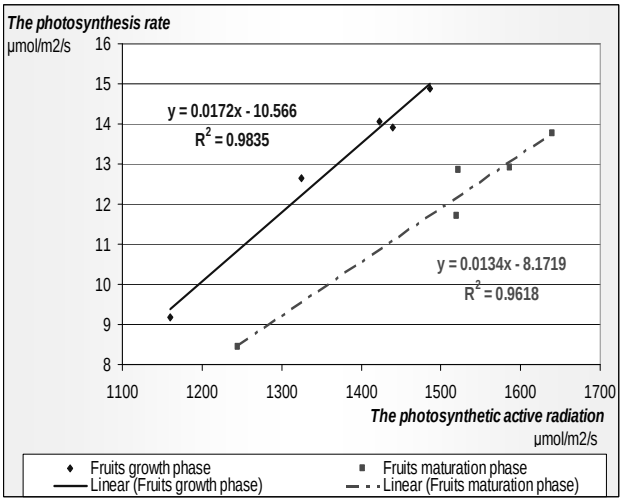

Figure 5. The correlation between the intensity of photosynthesis and the photosynthetic active radiation at the leaves of *Malus domestica* - Idared variety. / Figura 5. Corelații între intensitatea fotosintezei și radiația fotosintetic activă la frunze de *Malus domestica* - soiul Idared.

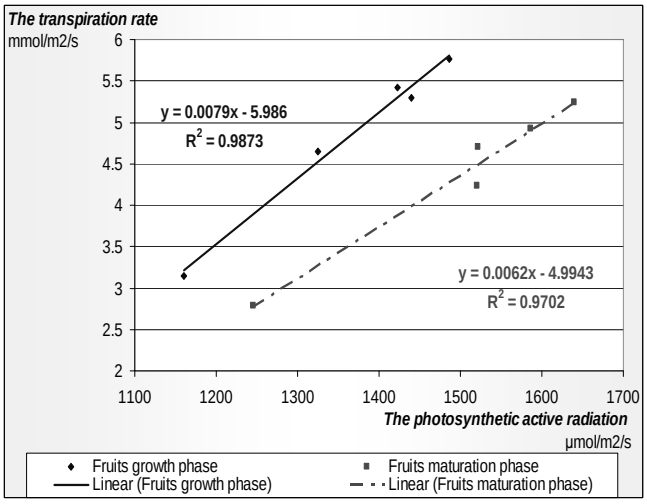

Figure 6. The correlation between the intensity of transpiration and the photosynthetic active radiation at the leaves of *Malus domestica* - Idared variety. / Figura 6. Corelații între intensitatea transpirației și radiația fotosintetic activă la frunze de *Malus domestica* - soiul Idared.

Linear regression made between the photosynthesis rate and leaf temperature shows a positive correlation between the 2 analyzed factors; the coefficient of determination (R^2) was 0.84 in the fruits growth phase and 0.79 in the fruits maturation phase (Fig. 7).

Linear regression made between the transpiration rate and leaf temperature shows a good correlation; the coefficient of determination (R^2) was 0.81 in the fruits growth phase and 0.74 in the fruits maturation phase (Fig. 8).

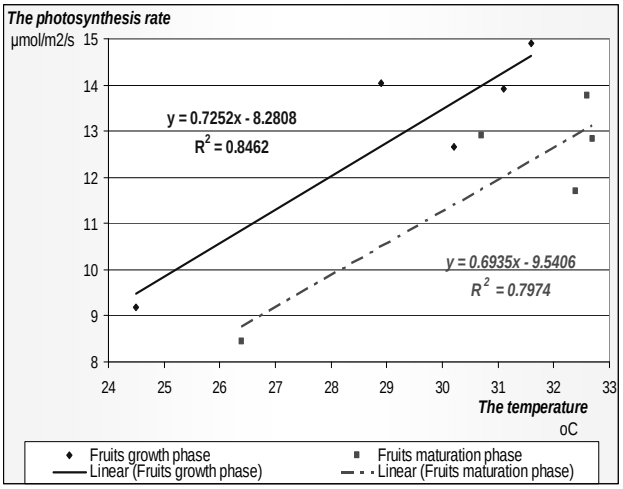

Figure 7. The correlation between the intensity of the photosynthesis and the leaf temperature at the *Malus domestica* - Idared variety. / Figura 7. Corelații între intensitatea fotosintezei și temperatura frunzei la *Malus domestica* - soiul Idared.

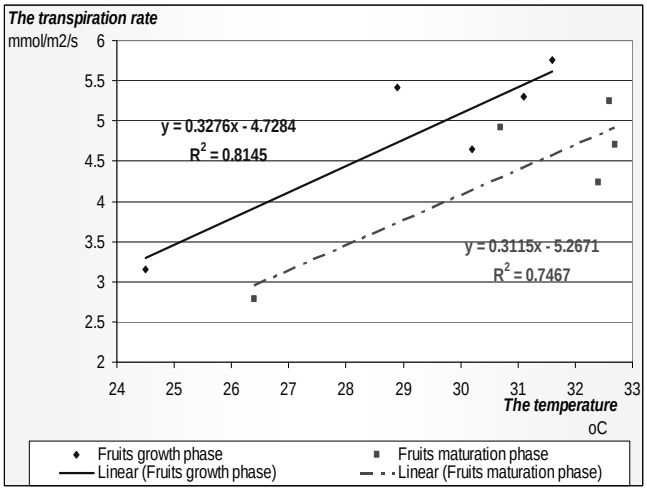

Figure 8. The correlation between the intensity of the transpiration and the leaf temperature at the *Malus domestica* - Idared variety. / Figura 8. Corelații între intensitatea transpirației și temperatura frunzei la *Malus domestica* - soiul Idared.

Stomatal conductance for CO_2 increases until lunch and decreases from then on, as the result of the reduction of the stomata level of opening under the influence of high temperature and relatively low air humidity. Under the hydric stress, the closing of stomata determines the increase of resistance, the decrease of stomatal conductance and the reduction of photosynthesis intensity.

Starting with the early hours of the morning (9 a.m.), one can observe an intensification of the stomatal conductance of CO_2 when they record values of 0.1 mol/m^2/s in the fruits growth phase and of 0.07 mol/m^2/s in the fruits maturation phase, their growth up until after lunch (1 p.m.), when they record values of 0.34 mol/m^2/s in the fruits growth phase and 0.26 mol/m^2/s in the fruits maturation phase and towards evening (5 p.m.) one can notice a gradual decrease recording values of 0.28 mol/m^2/s in the fruits growth phase and of 0.17 mol/m^2/s in the fruits maturation phase.

Linear regression made between the photosynthesis rate and stomatal conductance shows a positive correlation between the 2 analyzed factors; the coefficient of determination (R^2) was 0.94 in the fruits growth phase and 0.96 in the fruits maturation phase (Fig. 9).

Linear regression made between the transpiration rate and stomatal conductance shows a good correlation; the coefficient of determination (R^2) was 0.92 in the fruits growth phase and 0.94 in the fruits maturation phase (Fig. 10).

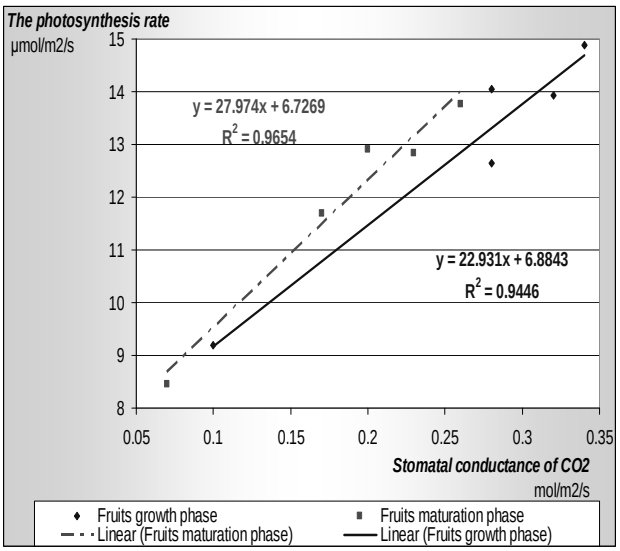

Figure 9. The correlation between the intensity of photosynthesis and the stomatal conductance at the leaves of *Malus domestica* - Idared variety. / Figura 9. Corelaţii între intensitatea fotosintezei şi conductanţa stomatală la frunze de *Malus domestica* - soiul Idared.

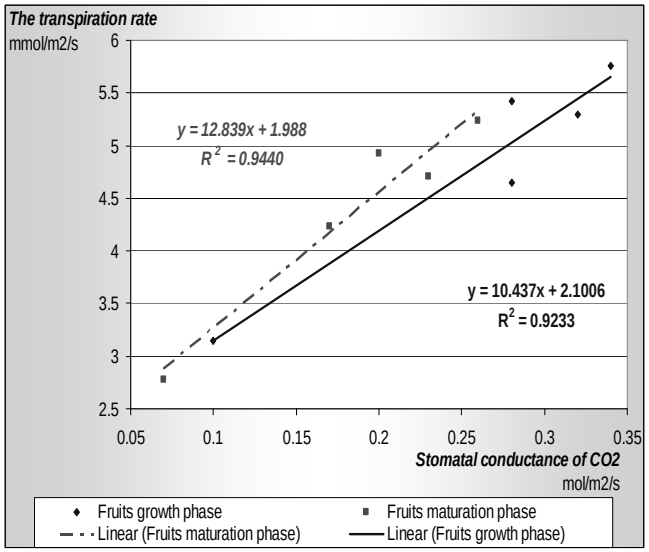

Figure 10. The correlation between the intensity of transpiration and the stomatal conductance at the leaves of *Malus domestica* - Idared variety. / Figura 10. Corelaţii între intensitatea transpiraţiei şi conductanţa stomatală la frunze de *Malus domestica* - soiul Idared.

At the analyzed apple plants, in the fruits maturation phase, there can be seen an increase of the water contents by 2.67% and a decrease of the dry substance contents by 5.31% (Fig. 11).

The pigments chlorophyll content was higher at the plants analyzed in the phase of fruit growth, compared to the leaves of the plants analyzed in the fruit maturation phase. In the fruits maturation phase, it was recorded a decrease of the chlorophyll content by 3.67% a result of the gradual deterioration of the chlorophyllian pigments (Fig. 12).

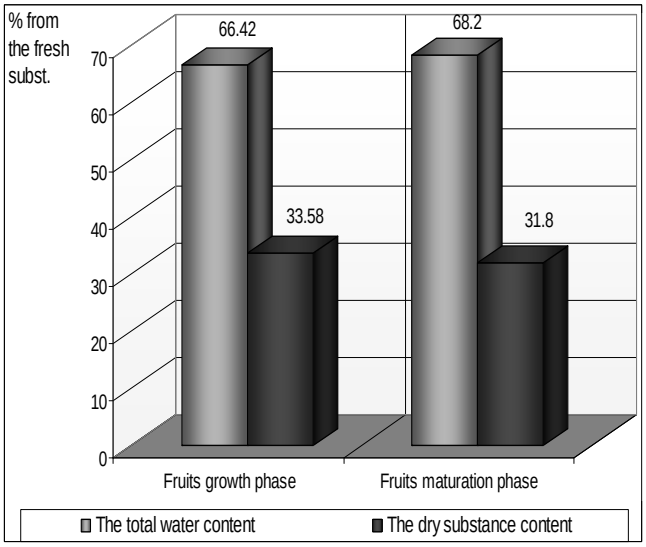

Figure 11. The water content and the dry substance content at the leaves of *Malus domestica* - Idared variety.
Figura 11. Conţinutul de apă şi conţinutul de substanţă uscată la frunze de *Malus domestica* - soiul Idared.

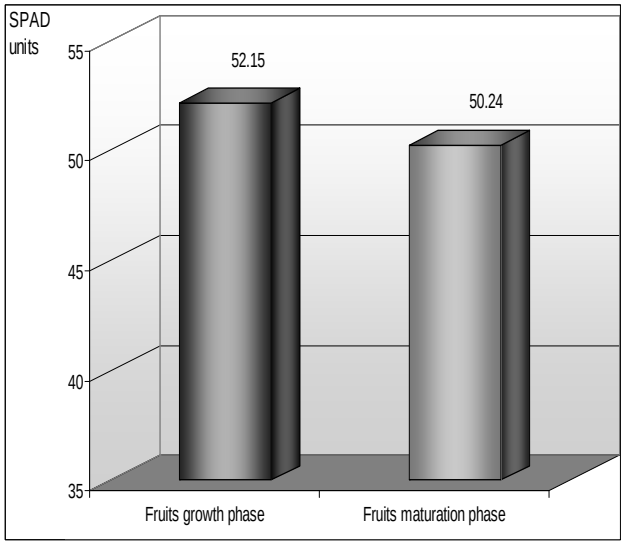

Figure 12. The chlorophyll content at the leaves of *Malus domestica* - Idared variety.
Figura 12. Conţinutul de clorofilă la frunze de *Malus domestica* - soiul Idared.

CONCLUSIONS

In the analyzed plants of *Malus domestica* BORKH., it was observed that the diurnal dynamics of the photosynthesis and transpiration presents a minimum in the morning, a maximum after lunch, and a minimum toward the evening, with specific variations depending on climatic factors. Positive correlations were established between the intensity of the physiological processes and the photosynthetic active radiation, the leaf temperature and stomatal conductance.

At the leaves of the plants analyzed in the phase of fruit growth, which had higher transpiration intensity, lower water content was recorded. The pigment chlorophyll content was higher at the plant leaves, analyzed in the phase of fruit growth, being a positive correlation between the pigment chlorophyll content and the photosynthesis intensity.

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