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DIURNAL AND SEASONAL COURSE OF THE RATE OF THE PHOTOSYNTHESIS IN THE APPLE TREE CASE IN THE CONDITIONS FROM THE FRUIT-GROWING REGION PITESTI-MARACINENI

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Key words: diurnal and seasonal course, rate of photosynthesis, apple tree.

Abstract.A great importance in developing the photosynthesis with the trees, bushes and herbal fruit plants is represented by the presence or absence of the inflorescences on the branches, the number of leaves, the foliar surface, the number of fruit.
In this article we have studied the diurnal and seasonal course of the rate of photosynthesis with the apple tree. The photosynthesis process presents variations during day, characterized by high values in the morning, followed by a decrease in the rate of photosynthesis. During springtime the values of the photosynthesis intensity are low, with a rise in intensity during summer months, after which one can notice a decrease of the photosynthesis intensity.
It has been established that the rate of photosynthesis is dependent on the position of the leaf on the twig (at the base, middle or at the top), as well as on the presence or absence of fruit in the bouquet. Maximum values of the rate of photosynthesis were obtained with the leaves positioned at the middle of the twig and with the fruit-bearing bouquet.

INTRODUCTION

Several researchers have determined the rate of photosynthesis with different types of apple trees, obtaining the following results: 11,0 μmol/m^2/s [10], among 7 and 15 mg CO_2/dm^2/h [22].

The rate of photosynthesis during day is conditioned by numerous environmental and internal factors. Within the temperate regions, in the conditions when the light is not very strong during March-April and September-October, the rate of photosynthesis with the shaded leaves generally follows the rate of light [21]. It starts early in the morning and increases until eight o'clock, then it follows a direction parallel with the abscise until one o'clock, and then decreases, stopping in the evening. Compared to the rate of light, which has symmetric values within the two halves of the day, the rate of photosynthesis follows an asymmetric curve, which is higher during the first half of the day. A similar diurnal rate was registered with the apricot tree [3] [4], apple tree [8] [17]. In the case of apple trees there was registered a slight decrease of the rate of photosynthesis in the middle of the day [14]. The rate of photosynthesis determined on the leaves of fruit-bearing trees presents a seasonal dynamic [1] [3] [23] [16] [25] [12] [20] [13]. The presence of fruit represents a factor that stimulates the rate of the photosynthetic process [26] [10] [4] [7] [23]. The maximum photosynthetic productivity can be obtained only when there is an adequate proportion of a leaf for a fruit. Thus, in the case of apple trees it is estimated a 200 cm^2 foliar surface for 100 g of fruit, and the increase of fruit weight by 25 g requires an increase of 75 cm^2 of the foliar surface [2].

In fruit trees such as apple, crop load is known to have a large effect on dry matter production and partitioning [11] [18]. Significant differences in leaf photosynthetic rate between fruiting and non-fruiting trees were restricted to the period of maximum fruit dry weight increase [18]. There was no clear relationship between photosynthetic rate and crop load over most of the growing season. Leaf assimilation rate showed a large response to crop load at the time when accumulation of carbohydrates in the fruit was high [19].

The rate of photosynthesis varies according to the type of leaf [22] [12].

MATERIAL AND METHODS

The researches were carried out at I.C.D.P. Pitesti-Maracineni between 2001-2005, with the following types of apple trees Idared, Golden Delicious and Jonathan. The density of the trees on the experimental area was 2341 trees / ha (planting spacing 3,60 x 1,20 m).

The determination of the rate of photosynthesis was performed by measuring the gas exchange by means of Warburg device. The results were in cm^2 O_2/ dm^2 /h. The determinations were performed at a lighting rate of 8000 lux and a temperature of 20^0C, on leaves taken from twigs from the southern or southwestern part of the canopy.

As for the determinations that were carried out on the field, the researchers used the method of determining the rate of photosynthetic process elaborated by Victor Catanescu. The method is based on well-known procedures of dosing the quantities of carbon dioxide assimilated in the photosynthesis (Ivanov procedure).

The statistic interpretation of the results was performed by means of the SPSS 13,0 programme for Windows. The processing of the experimental data was performed through adequate statistic methods. The researchers applied the model ONE-WAY ANOVA (tests for multiple comparisons, for example Duncan test) when it was the case of comparisons between more than two variants.

RESULTS AND DISCUSSION

In figure 1 there are represented graphically the results that were obtained following the determination of the rate of photosynthesis in the diurnal course. The records were effectuated on mature leaves from sun-lit twigs, orientated to southeast, from the outskirts of the canopy, in sunny days during June. The determination performed at 13.00 o'clock showed that the slight decrease of the recorded values, the average results ranging between 22,28 cm^3 $CO_2/dm^2/h$ (Idared) and 20,33 cm^3 $CO_2/dm^2/h$ (Jonathan). The statistics interpretation shows a significant difference between the of photosynthesis for the Jonathan and the other two types, for a significance threshold limit of $p<0,05$. It has been established that the highest values of the rate of photosynthesis were registered at the beginning of the day, for all three types of trees that were studied. Thus, at 9 o'clock, the recorded values were the following: 23,7 cm^3 $CO_2/dm^2/h$ for Idared, 25,19 cm^3 $CO_2/dm^2/h$ for Golden Delicious and 21,49 for Jonathan. There were pointed out significant differences for a significance threshold of $p<0,05$ among the three types of trees. At 5 o'clock, the rate of photosynthesis records lower values. Thus, for type Idared, the average was of 17,99 cm^3 $CO_2/dm^2/h$, for Golden Delicious – de 18,61 cm^3 $CO_2/dm^2/h$, and for Jonathan – 15,72 cm^3 $CO_2/dm^2/h$. There are significant differences for a significance threshold of $p<0,05$ among the three trees types.

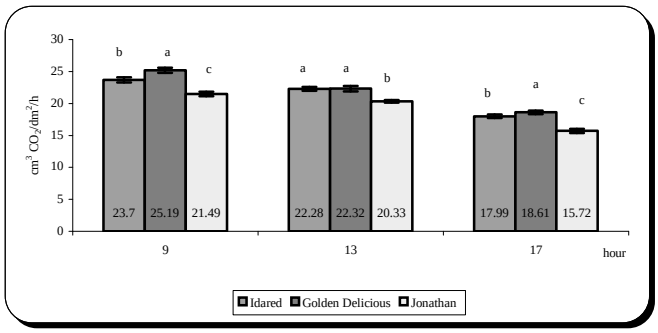

Figure 1. The diurnal course of the rate of photosynthesis with the Idared, Golden Delicious and Jonathan
(the bars represent the standard deviation; a, b, c: the interpretation of the significance of the difference by means of Duncan test, $p<0,05$)

The lower values of the rate of photosynthesis within the afternoon hours cannot be attributed to the 'fatigue' of the chloroplasts because there was not recorded a decrease of its rate when there is a constant moderate light. Within afternoon hours, the organic substances gathered from chloroplasts hinder this phenomenon. As a proof in this way, there are the experiments with branches that suffered circular decortications and prevented the flow of organic substances, leading to the inhibition of photosynthesis [21].

The diminution of the rate of photosynthesis during day can be explained through the decrease of the hydro potential, the high temperature and the heating of the stomas [6]. The plants assimilate intensely only during the first hours of the morning, and in the rest of the day, the rate of photosynthesis decreases gradually, the plants cannot restore the low balance of water during the afternoon hours, because of the intense light and high temperature. This direction of the photosynthesis takes place in long, sunny and hot days at the beginning of the summer [5]. Photosynthetic rate increased until midday and reached a maximum value coincident with the highest value of canopy conductance (nearly 5,5 mm s^{-1}) [8].

In figure 2 there are represented graphically the results that were obtained following the determination of the rate of photosynthesis with the types of apple trees that were studied, during May-October.

It has been recorded that during May, the values of the rate of photosynthesis are between 14,45 cm^3 $O_2/dm^2/h$ (for Jonathan) and 17,41 cm^3 $O_2/dm^2/h$ (for Golden Delicious). By applying the Duncan test for multiple analyses, it has been established that there are significant differences for a significance threshold of $p<0,05$ among the three types trees.

The maximum values of the rate of photosynthesis were registered during June-July, even during August the average values maintained high rates. Thus, during June, the average rate of photosynthesis recorded 21,39 cm^3 $O_2/dm^2/h$ for Idared, 23,13 cm^3 $O_2/dm^2/h$ for Golden Delicious and 20,72 cm^3 $O_2/dm^2/h$ for Jonathan. The statistic interpretation proved the existence of significant differences among the three types of apple trees, for a significance threshold of $p<0,05$. During July the values recorded for Idared and Jonathan do not vary significantly, but those recorded for Golden Delicious are increased compared to the other two types. Compared to June, the values registered in July fall down slightly. The rate of photosynthesis continues to fall down during August, too, when the following average values are recorded: 20,05 cm^3 $O_2/dm^2/h$ for Idared; 20,45 cm^3 $O_2/dm^2/h$ for Golden Delicious; 19,75 cm^3 $O_2/dm^2/h$ for Jonathan. The values recorded for Idared do not differ significantly from those recorded with the other two types. During September it can be noticed a prominent decrease of the values. There are significant differences for $p<0,05$ among the three apple trees types. In the case of Golden Delicious, where the photosynthesis was the highest, it was registered an average value of 15,00 cm^3 $O_2/dm^2/h$. During October the diminution of the

values of photosynthesis continues, reaching a value of 11,98 cm^3 $O_2/dm^2/h$ for Idared, 12,06 cm^3 $O_2/dm^2/h$ for Golden Delicious and 10,78 for Jonathan. The value recorded for Jonathan is significantly lower compared to the other two studied apple trees types

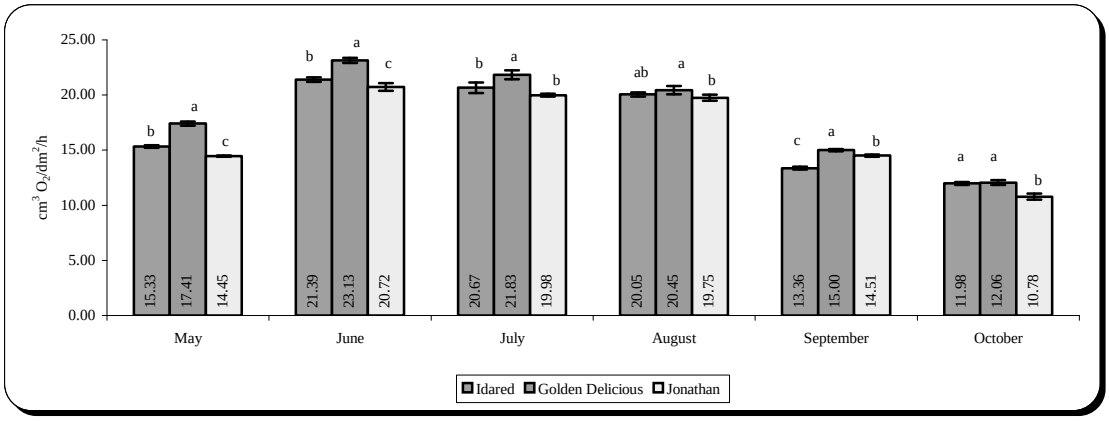

Figure 2. The seasonal course of the rate of photosynthesis (the average of 2002-2004) with the Idared, Golden Delicious and Jonathan (the bars represent the standard deviation; a, b, c: the interpretation of the significance of the difference by means of Duncan test, $p<0,05$)

During vegetation, the photosynthesis begins in spring together with the forming of the leaves and increases simultaneously with the increase of their surface and the intensity of light. In autumn, the photosynthesis decreases because of the reduction of the foliar surface and the decrease of the light and temperature rate [21] [1]. Marini R.P. and Barden J.A. also show the decrease of the rate of photosynthesis beginning with the second half of August in 1981 [16]. They prove that, up to this period, the photosynthesis correlates with the weight of the leaf, and during September, the relation between these two parameters is given as a second degree equation. Kennedy and Johnson (1981) [13] state that the biggest modifications of the photosynthesis with the apple tree took place during the first stages of the leaves' growth, in their period of great expansion and synthesis of chlorophyll. Within the growth period, photosynthesis increases for 5 times, reaching a maximum value of 40 mg $CO_2/dm^2/h$, and the value of plastochron index is 10. Within values of 10-12 for the plastochron index, different changes in the characteristic of photosynthesis take place and an apparent decrease of photorespiration is registered.

In figure 3 there are represented graphically the results that were obtained following the determination of the rate of photosynthesis for the leaves on a twig. It has been found that, for all the analyzed types, the highest rate of photosynthesis was recorded for the leaves from the middle of the twig. For Idared, the average value was 22,4 $cm^3O_2/dm^2/h$, for Golden Delicious – 23,465 $cm^3O_2/dm^2/h$, and for Jonathan – 19,642 $cm^3O_2/dm^2/h$. For Idared and Golden Delicious, the next average value was determined in the leaves positioned at the base of the twig. The leaves at the top of the twig recorded the lowest value of the rate of photosynthesis. For Jonathan, the lowest value of the rate of photosynthesis was recorded in the leaves at the base of the twig.

In figure 4 there are represented graphically the results that were obtained following the determination of the rate of photosynthesis for the leaves on twigs (at the middle of the twig), compared to the leaves from the fruiting bouquet and the leaves from the non-fruiting bouquet.

For the three types, the highest value was obtained in the leaves from the fruiting bouquet (25,134 $cm^3O_2/dm^2/h$ – Idared; 25,925 $cm^3O_2/dm^2/h$ – Golden Delicious; 24,789 $cm^3O_2/dm^2/h$ – Jonathan). For Idared type, the lowest value was recorded for the leaves at the middle of the twig (22,4 $cm^3O_2/dm^2/h$), and for the leaves on the non-fruiting bouquet -

23,467 $cm^3O_2/dm^2/h$. A similar variation was noticed for Jonathan type: 19,642 $cm^3O_2/dm^2/h$ for the leaves on the twigs and 20,846 $cm^3O_2/dm^2/h$ for the leaves on the non-fruiting bouquet. The effect of leaf-to-fruit ratio on photosynthetic assimilation may result from changes in leaf diffusive conductance and the associated changes in intercellular CO_2concentration; modifications in photosynthetic capacity caused by a shift in leaf nitrogen concentration; an increase or decrease in one or more of key components of photosynthetic capacity; or from the decrease in the electron transport rate resulting from the accumulation of photo assimilates [24]. For Golden Delicious type, the lowest value was recorded in the leaves from the non-fruiting bouquet - 20,357 $cm^3O_2/dm^2/h$.

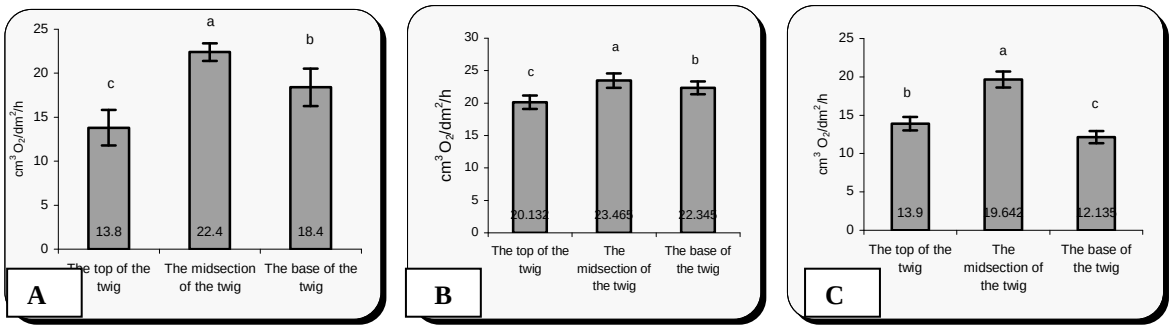

Figure 3. Determining the rate of photosynthesis on different types of leaves for Idared (A), Golden Delicious (B) and Jonathan (C) (the bars represent the standard deviation; a, b, c: the interpretation of the significance of the difference by means of Duncan test, p<0,05)

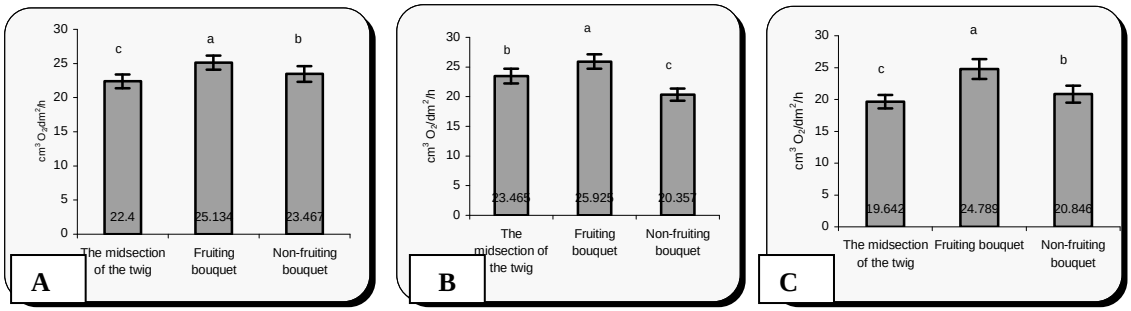

Figure 4. Determining the rate of photosynthesis on different types of leaves for Idared (A), Golden Delicious (B) and Jonathan (C) (the bars represent the standard deviation; a, b, c: the interpretation of the significance of the difference by means of Duncan test, p<0,05)

CONCLUSIONS

1. The process of photosynthesis presents variations during day, characterized by high values in the morning, followed by a decrease of the photosynthesis due to reduction of the hydro potential, increase of temperature and gathering of assimilated substances.
2. During vegetation period, a variation of the rate of photosynthesis can be noticed: in spring the recorded values are low; as the leaves grow, the number of chloroplasts and the quantity of chlorophyll increases. The intensification of the rate of photosynthesis is registered, reaching maximum values during June and July; the values maintain high rates even in August, and then this is followed by a decrease of the rate of photosynthesis.
3. Comparing the rate of photosynthesis in leaves positioned on the same twig, it was found that the highest values were recorded in leaves at the middle of the twigs, for all three types of apple trees.
4. Comparing the rate of photosynthesis in different leaves, it was found that the highest value was determined in leaves from the fruiting bouquet.

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