SOME ASPECTS OF THE LIGHT REACTION OF PHOTOSYNTHESIS IN *Dipterocarpus turbinatus* C. F. GAERTN SEEDLINGS IN CAT TIEN PARK, VIETNAM

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1. INTRODUCTION

The study of the physiology of woody plants occupies a predominant place in understanding the processes of their growth and development. One of the directions of such research is the study of photosynthesis. There is a large amount of work in this direction. Nevertheless, there are significantly fewer works related to the study of the reaction of photosynthesis of plants concerning the daily variations of natural illumination - circadian rhythms [1], or depending on the spectral composition of light [2]. The author did not reveal any works about plants that grow in a subequatorial tropical monsoon climate. Dipterocarpus turbinatus is a large tree with a height of 25-35 m, with a trunk up to 80 cm, belonging to the Dipterocarpaceae family, located in the ecologically dominant stratum and relatively common in forests in Cat Tien National Park.

2. METHODS AND MATERIALS

2.1. Plant material and growing conditions

The research was carried out by the South Branch of the Russian-Vietnamese Tropical Research and Technological Center at a scientific base located in the Cat Tien National Park [3].

Seedlings of *Dipterocarpus turbinatus* grown in pots were chosen as the object of the study. For planting, germinated fruits were used, Fig. 1, collected in a natural plantation under the mother tree. Plastic bottles cut from the top with holes in the bottom were used as vegetation vessels. Broken baked bricks and sand were used as drainage. For cultivation, a red-yellow ferralite soil was used, which was sieved and mixed with a small amount of sand. The fruits were planted on April 16, 2020.

Figure 1. Fruits of *D. turbinatus* used for planting

2.2. Measurements of the intensity of photosynthesis and experimental conditions

The photosynthesis rate was determined using a Portable Photosynthesis System LI-6800 (LI-COR, Inc. Lincoln, NE). To illuminate the object under study, a 3 × 3 cm light source was used, supplied by the LI-6800 manufacturer as an additional device to the device. The emission spectrum of the light source consists of red (λ = 660 nm) and blue (λ = 453 nm) colors. For the study, formed intact leaves were used. The measurements were carried out on the part of the sheet bounded by the frame of the measuring chamber of the device with an aperture of 3x3 cm.

During the research, the studied part of the leaf was illuminated with a light intensity of 1000 μmol·m-2·s-1. The measurements were carried out at a carbon dioxide concentration in the LI-6800 measuring chamber equal to 400 μmol·mol-1 and relative air humidity of ~ 60%. During the experiment, the seedlings were placed under artificial shading from direct sunlight.

A study related to the daily dynamics of photosynthesis at the same illumination of the leaf was carried out on October 17, 2020. During this test, the following parameters were maintained in the LI-6800 measuring chamber: the studied part of the leaf at each measurement was illuminated with light consisting of red and blue colors in a ratio of 0.9 to 0.1; the temperature of the air surrounding the sheet was 28°C. The measurements were carried out on different leaves of different seedlings during the twenty-four hours with an interval of about 2 hours.

A study related to the dependence of the intensity of photosynthesis on the spectral composition of light was carried out on July 12, 2020, at noon. In this process of the experiment, the ratio of red in the spectrum of radiation was varied from 0 to 100%, with a step of 10%. A temperature of 30°C was maintained in the LI-6800 measuring chamber. Measurements were carried out on different leaves of two seedlings with various combinations of increasing or decreasing the proportion of color in the light spectrum.

3. RESULTS AND DISCUSSION

3.1. Diurnal dynamics of the intensity of photosynthesis under conditions of the same illumination of the leaf

The results showed that the daily dynamics of the intensity of photosynthesis were obtained by us at the same illumination of the studied part of the leaf (the bars on the graph represent the absolute measurement error) (Fig. 2). The straight horizontal bold line on the graph denotes the light intensity with which the studied part of the leaf was illuminated. The dotted line represents the natural PPFD obtained on October 17, 2020, from a weather station located 6 km from the study site.

Statistical processing of the measurement results showed that the daily dynamics of the intensity of photosynthesis was rather closely associated with the dynamics of PPFD, k = 0.8. In particular cases, the following association of the values under consideration was traced: from 1am to 8am, k = 0.8; from 9am to 4pm, k = 0.5; from 4pm to 6pm, k = 1.

At night, under artificial illumination of the studied part of the leaf, photosynthesis was absent in *D. turbinatus* [4]. The beginning of photosynthesis was observed only towards the end of the night, from about 3 am. At the same time, the onset of photosynthesis was ahead of the beginning of dawn, at ~ 6 am (Fig.2).

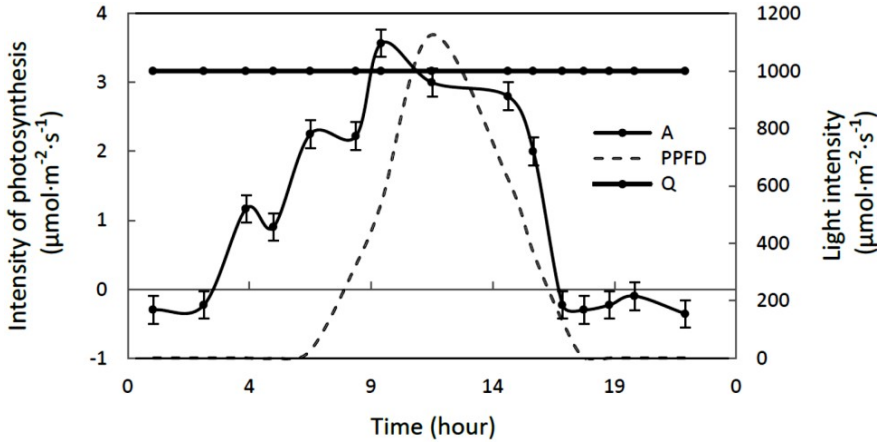

Figure 2. Diurnal dynamics of the intensity of photosynthesis, A, at the same illumination of the studied part of the leaf, Q, as well as diurnal dynamics of natural PPFD. The bars on the graph represent the absolute measurement error

By about 8 am, the intensity of photosynthesis increased in proportion to the increase in solar radiation (in the period from 1 am to 8 am, the correlation coefficient is k = 0.8). During daylight hours, from about 9 am to 4 pm, the dependence of photosynthesis on solar radiation noticeably decreased (k = 0.5). This observation suggests that in this time of day, the intensity of photosynthesis was more heavily influenced by leaf lighting conditions. Further, with sunset, from 4 pm to 6 pm, despite the illumination of the leaf, photosynthesis decreased in proportion to the decrease in natural illumination (k = 1), down to negative values.

Summarizing the results obtained, we can make an unjustified assumption that, in our case, the processes of photosynthesis were controlled by such an environmental factor as natural illumination (the diurnal dynamics of the intensity of photosynthesis under artificial illumination of the leaf was quite closely associated with the diurnal dynamics of natural PPFD, k = 0.8).

Thus, in our case, we are dealing with circadian rhythms, i.e. with cyclical fluctuations in the intensity of various biological processes associated with the change of day and night. Circadian rhythms are of endogenous origin, thus representing the body's biological clock [1].

Consequently, concerning the studies relating to plant photosynthesis, in addition to generally accepted environmental factors (illumination, water supply, carbon dioxide concentration, air humidity, temperatures of air, plant organs, and soil), which are traditionally taken into account when conducting relevant studies, circadian rhythms should also be considered.

Here, we can conclude that photosynthesis was not observed during night measurements under artificial illumination as for leaves of mangrove trees.

3.2. Dependence of the intensity of photosynthesis on the spectral composition of light

Fig. 3 shows that the values of the intensity of photosynthesis depending on the proportion of red in the total radiation spectrum expressed as a percentage. For example, the proportion of red, which is 40%, means that in the total radiation spectrum, 40% of the radiation falls on the share of red, and 60% of the blue, respectively. The curve approximating the experimental points and the quadratic equation describing the obtained regularity with the approximation confidence coefficient R^2. The bars on the graph represent the absolute measurement error (Fig. 3).

Moreover, with an increase in the proportion of red in the radiation spectrum, the intensity of photosynthesis increases. In this case, with an increase in the proportion of red from 0 to 100%, an increase in the intensity of photosynthesis by 13% was recorded. The steady increment of the photosynthetic intensity can be described through a quadratic equation (Fig.3).

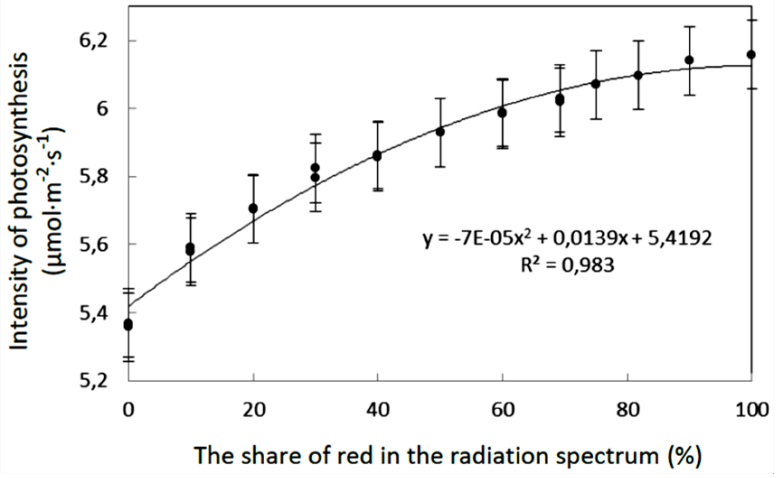

Figure 3. Values of the photosynthetic intensity depending on the red proportion in the total radiation spectrum, a curve describing the experimental points, and a quadratic equation describing the obtained regularity with R^2. The bars represent the absolute measurement error

In general, in research on the dependence of photosynthetic intensity on the spectral composition of light in D. turbinatus, it was found that the red part of the light spectrum was more conducive to the photosynthetic processes than the blue. Similar results have been obtained by other researchers. For example, when studying the effect of light spectral composition on the eco-physiological properties of spinach [6], it was suggested that plants grown in the red light spectrum showed a higher photosynthetic ability compared to plants were grown in other illumination conditions.

From a physical point of view, the explanation of these regularities types was based on a widespread assessment of the effect of light quality on photosynthesis, obtained based on the photon flux curve was absorbed by plants [5]. According to this curve, photons with a wavelength of 600-630 nm, corresponding to orange and red colors, have about 20-30% higher photosynthetic efficiency than photons with a wavelength of 400-540 nm, corresponding to the blue color gamut.

The dependence was described by a quadratic equation with a high degree of accuracy of approximation (R^2~1.0) (Fig. 3). At this stage, we carried out this study with the same parameters of the external environment, changing only the spectral composition of the light. Obviously, with other parameters of the external environment and conditions of the experiment, we will get different results [6]. However, in this case, the main question appears to be: Will the coefficients of the quadratic equation change, and if so, how much? In other words, to what extent a given spectral composition of light will affect photosynthesis under various environmental conditions and experiments.

4. CONCLUSION

In this work, we presented the results of studies related to the reaction of photosynthesis in *D. turbinatus* seedlings to light with different parameters. According to the results obtained, the following was revealed.

- Photosynthesis of *D. turbinatus* was probably controlled bycircadian cycles.

- In our case, the red part of light spectrum with a wavelength of 660 nm had the greatest influence on the photosynthesis of *D. turbinatus*. The dependence of the photosynthetic intensity on the red proportion of the total radiation spectrum was described by a quadratic equation with a high degree of accuracy of approximation (R^2 ~ 1.0).

- In the studies related to plant photosynthesis, in addition to the generally environmental factors were accounted when conducted the relevant studies, their circadian rhythms should be taken into account.

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SUMMARY

SOME ASPECTS OF THE LIGHT REACTION OF PHOTOSYNTHESIS IN *Dipterocarpus turbinatus* C. F. GAERTN SEEDLINGS IN CAT TIEN PARK, VIETNAM

The studies were carried out on 3 and 6 month old seedlings of *Dipterocarpus turbinatus* (C.F. Gaertn) were grown in the pots. Research on the diurnal dynamics of the leaf photosynthetic intensity under the same illumination conditions have shown that the photosynthesis of the seedlings was controlled by circadian cycles. The studies related to the dependence of the photosynthesis intensity on the light spectral composition showed that the red part of light spectrum with a wavelength of 660 nm had the greatest effect on photosynthesis in *D. turbinatus*. The results of dependence was described by a quadratic equation with a high degree of accuracy of the approximation ($R^2 \sim 1.0$). The main conclusion that, in the studies related to plant photosynthesis, in addition to generally environmental factors that have been traditionally considered for in previous similar studies, their circadian rhythms should be taken into account.

Keywords: *Photosynthetic intensity, light intensity, spectral composition of light, circadian rhythm.*

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