SOME ASPECTS OF GROWTH AND DEVELOPMENT OF SELF-SEEDING *Dipterocarpus turbinatus* C. F. GAERTN (1805) (SOUTHEAST VIETNAM)

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1. INTRODUCTION

Trees *Dipterocarpus turbinatus* C. F. Gaertn (1805) is a common forest-forming species of tropical forest ecosystems. These trees are widely used both in reforestation activities and in forest parks.

D. turbinatus is a valuable source of wood widely used for furniture production. As a result of this, these trees were intensively cut down. For this reason, *D. turbinatus* has been assessed for The IUCN Red List of Threatened Species in 2017 and is listed as Vulnerable [1]. Thus, natural forests with grown and growing trees of *D. turbinatus* were under strong stress from anthropogenic influence. According to our observations, such impacts have not bypassed the tropical forests of Southeast Vietnam. However, in these forests, the mother trees of *D. turbinatus* can be found. These trees are characterized by good fruiting. As a result of this, abundant self-seeding can be observed in forest areas. In this case, the issue related to the possibility of natural regeneration of forests with the participation of Dipterocarpaceae becomes relevant. This issue is of particular relevance in protected areas.

The germination of seeds, and later on the growth of self-sowing, is influenced by many factors. The primary of these is the water supply of plants and their illumination [2, 3]. At the same time, the lack of illumination plays a much more pronounced role in humid forests compared to dry forests [4]. Secondary factors, in our case, include various kinds of damage to seedlings by leaf-gnawing and leaf beetles, as well as fungi.

Conducting studies covering the above factors will answer some questions related to the growth and development of self-seeding *D. turbinatus*, in particular, with the prospect of its exit from under the forest canopy.

2. MATERIALS AND METHODS

2.1. Growing conditions

The studies were conducted in 2020-2022 at the Southern Branch of the Joint Vietnam-Russia Tropical Science and Technology Research Centre in the territory of the Cat Tien National Park (Southeast Vietnam) [5]. The Park is located in the zone of subequatorial tropical monsoon climate, characterized by two pronounced seasons: dry, lasting from November to April, and wet - from May to October. The amount of precipitation in the dry season is about 15 mm/month, and in the wet season - up to 440 mm/month. The average monthly temperature varies from 24°C in January to 28°C in April [6]. The soils of most of the territory of the park are red-yellow ferrallite, loamy granulometric composition [7]. The soil layer in many places is not deep and is supported by basalt slabs.

Weather data were obtained from the weather station for long-term climatic observations, located in the research area.

2.2. Plant material

The main object of the study was seedlings *D. turbinatus* grown from the fruit nuts of the mother tree in mid-April 2020. The height of the mother tree is 34 m, and the average diameter at a height of 1.3 m is 110 cm (11.41530º N, 107.42460º E). For observations, in the area of the mother tree (experimental site SA1), 10 seedlings were randomly selected. Each of these seedlings was regularly measured in height, the number of leaves was counted, and a visual assessment of their damage was carried out.

2.3. Spread fruit

The spread of fruit *D. turbinatus* is primarily determined by the presence of a paired impeller on them (Fig. 1), which determines their aerodynamic properties. To study their aerodynamic properties, we dropped the fruits from a height of 20 m and recorded the time of their flight. According to the data obtained, the speed of their fall was calculated. Then the fruits were weighed, then dried to completely dry weight (CDW) and weighed again.

2.4. Experience with artificial planting of fruits

For the purpose of mobile observation of seedlings, on April 15, 2020, we prepared a garden bed measuring 1.5x2 m, which was located in an open area. On this bed, 16 hatched fruits of *D. turbinatus*, collected under the mother tree, were planted [8]. Planting of fruits was carried out at a depth of 2-5 cm, at a distance of 35-40 cm from each other. As the soil dried up in the garden bed, the planting nests were watered.

As an alternative to the growth of seedlings on SA1, 4 seedlings of *D. turbinatus* grown from the same seed material were planted at the site of the fall of a mature tree. In continuation of the experiment, 2 seedlings were removed.

2.5. Study of self-seeding mortality dynamics

In order to study the dynamics of self-seeding mortality, in 2021 we set up an experimental site SA5. The site is located next to the mother tree, on its southern side, and has the shape of a square with an area of $S = 34.8\ m^2$. For the convenience of accounting for self-seeding, the site was divided into 4 lanes. On this site, a complete recalculation of self-sowing was carried out, and the average seedling height and the average number of leaves on it were determined by random sampling. Based on the data obtained, the self-seeding density was calculated.

2.6. Measurement of soil moisture content and linear dimensions

Soil moisture content was measured using a HydroSense II soil moisture meter (Campbell Scientific, Inc. USA). The moisture meter allows you to determine the percentage of volumetric water content in mineral soils (VWC) with an accuracy of ±3%. The moisture content was determined in 12 cm of the surface soil layer. Measurements of moisture content on the experimental site SA1 were carried out near each observed seedling, and on SA5 - at 6 equally spaced points.

The height of the seedlings was measured with a tape measure with an accuracy of ±2.5 mm.

2.7. Photosynthesis, transpiration and light regime

In this work, we have considered the photosynthesis processes from the standpoint of CO_2 gas exchange. To plot and analyze photosynthesis response curves to photosynthetically active radiation (PAR), we used data obtained on 10.07.2020, from 9:00 to 10:30, from two average seedlings with antagonistically different physiological parameters.

The values of photosynthesis and transpiration were measured using a portable gas analyzing system Portable Photosynthesis System LI-6800 (LI-COR, USA). For the study, intact leaves were used, growing above the first two oppositely formed leaves of the seedling. The part of the sheet limited by the frame of the measuring chamber of the system with an aperture of 3x3 cm was subjected to measurements. For the artificial illumination of the studied sheet, a 3x3 cm light source supplied by the manufacturer LI-6800 as an additional device to device was used. The emission spectrum of the light source consisted of red (λ = 660 nm) and blue (λ = 453 nm) colours in a ratio of 9:1.

During the measurements, the necessary parameters of the microclimate were set in the measuring chamber LI-6800 - the illumination of the object, the temperature and humidity of the air, and the concentration of CO_2.

When obtaining data for constructing dependences of photosynthesis on PAR, the following microclimate parameters were set in the LI-6800 measuring chamber: air temperature 30ºC, relative air humidity 60%, CO_2 concentration in the air 400 $\mu mol \cdot mol^{-1}$.

When conducting research on the dependence of photosynthesis on temperature: illumination 200 $\mu mol \cdot m^{-2} \cdot s^{-1}$, CO_2 concentration 400 $\mu mol \cdot mol^{-1}$, humidity ~60%. The measurements were carried out in automatic mode in the temperature range from 21 to 36°C.

When conducting research on the dependence of photosynthesis on CO_2 concentration: illumination 150 $\mu mol \cdot m^{-2} \cdot s^{-1}$, temperature 30°C, humidity ~60%. The measurements were carried out in automatic mode in the range of CO_2 concentrations from 0 to 1000 $\mu mol \cdot mol^{-1}$.

The Michaelis-Munten equation [9,10] was taken as the basis for the mathematical description of photosynthesis response curves to PAR (light curves). We used this equation in a modified form [11,12]:

$$A = A_m \cdot Q/(Q + K_M) + A_d \tag{1}$$

where A is the intensity of photosynthesis, $\mu mol \cdot m^{-2} \cdot s^{-1}$; A_m is the maximum intensity of photosynthesis, $\mu mol \cdot m^{-2} \cdot s^{-1}$; A_d is the intensity of dark respiration, $\mu mol \cdot m^{-2} \cdot s^{-1}$; Q - PAR, $\mu mol \cdot m^{-2} \cdot s^{-1}$; K_M is the Michaelis constant. The values of the

K_M constant are used by researchers when comparing the physiological characteristics of plants [11,13]. According to equation (1), the light compensation point (LCP) was determined, which shows at what intensity of PAR photosynthesis becomes equal to zero [14].

To estimate the efficiency of photosynthesis, we used the slope of the tangent a to the curve of function (1) at the point corresponding to K_M. From a physical point of view, this coefficient reflects the rate of change in the intensity of photosynthesis when the PAR changes by one unit.

The light regime of seedlings was determined using the LI-160 instrument (LI-COR, USA), which measures PAR. Measurements on SA1 were carried out near each of the studied seedlings, and on SA5, at 6 equally spaced points. The obtained data were averaged. PAR values measured in open space were used as a control point.

2.8. Statistical analysis

The analysis of the data obtained, and the construction of graphs was carried out using mathematical methods of statistics, using the MS Excel environment.

The obtained data were processed using the MS Excel package "Descriptive statistics" ($p < 0.05$). The degrees of association of the studied data sets were determined using Pearson's correlation coefficients, k. The values of K_M, the coefficient b of the equation $ax+b$ of the tangent, were selected using the MS Excel package "Solution search parameters" (limit number of iterations 100, relative error 0.00001, tolerance 5%, convergence 0.0001). The coefficient a, as well as the extremum points of the graphical dependences, were determined using differentiation methods. Calculation of the parameters of the equation in the description of the obtained dependences was carried out using the least squares methods.

3. RESULTS AND DISCUSSION

3.1. Spreading fruits

As the fruits (nuts) of *D. turbinatus* ripened, the peaks of their abundant fall were associated with fairly powerful gusts of wind. For example, in 2020 the wind speed reached 17 m/s.

An experiment related to the study of the free fall of the fruits of *D. turbinatus* showed the following. For the first 1 - 1.5 m the fruit falls with acceleration. Further, the movement of the fruit, in some approximation, can be considered as obeying the Stokes law. The average fruit fall speed was 2.5 cm/s (SD = 0.6). In some cases, we observed some slowdown in the speed of the fall of the fruit above the crowns of the lower trees. We presumably associate this circumstance with ascending water vapor released by plants during transpiration. The average weight of the fetus was 6.70 g, CDW - 4.14 g.

Our reconnaissance studies in the area of the experimental plots allowed us to identify several young *D. turbinatus* trees located at distances up to 500 m from them.

The fact that the peaks of abundant fruit fall of *D. turbinatus* are associated with strong gusts of wind is an obvious fact and is largely determined by the presence of an impeller on them. Thanks to the wind, the fruits are also spread, and over considerable distances.

Assume that the fruits on the parent tree were located at a height of ~ 30 m. Then, the average time of their fall will be ~ 12 s. During this time, under the influence of wind, the trajectory of the fall of the fruits can deviate by a significant amount. Taking into account the fact that earlier the territory of the park belonged to the forestry and the forest was largely sparse, it is possible to explain the distribution of *D. turbinatus* at significant distances from the mother trees.

3.2. Growth and development of seedlings

A distinctive feature of the formation of the *D. turbinatus* seedling is that it remains connected with the fetus through two outgrowths for a relatively long period (these two outgrowths are clearly visible in Fig. 1). The outgrowths appear to be transformed cotyledons that do not leave the fetal membrane. Due to this, the seedling can use the nutrients stored in the endosperm for a long time. Then these outgrowths die off.

Here it should be noted that the question connected with the study of the supply of nutrients in the fruits of plants, as well as in the seedlings themselves, is not studied. In the perspective indicated above, an assessment of the efficiency of nutrients stored in plant seeds would make it possible to answer some of the main questions related, in particular, to the prospects for self-sowing to emerge from under the forest canopy in natural conditions.

3.2.1. Formation of the root system

D. turbinatus fruits ripen and fall at the beginning of the wet season [6]. Fallen fruits, in the case of favorable environmental conditions, first places, such as precipitation, the associated increased soil moisture and, accordingly, increased air humidity, throw out the embryonic root, which begins to grow intensively.

Precipitation in the form of rain contributes to both the germination of fruits and they are rooting, and the increased humidity of the air associated with precipitation prevents the tip of the root from drying out. We noted that even short-term breaks in precipitation caused the germinating roots to dry out, which ultimately led to a significant limitation in the germination of fruits and their death. Such fruits were later subjected to eating by insects and rodents, as well as rotting.

Germinating fruits first begin to form a taproot. Approximately 7 - 8 days after the beginning of root growth, the developing root slightly raises the fruit above the soil surface. From the point of view of eurythelism [15], raising the fruit above the soil surface is explained by the problem of expediency - *D. turbinatus* grows in the tropics and raising the fruit contributes to its longer preservation - the fruit will be less susceptible to moisture, and, accordingly, rotting. At the same time, a sprout begins to form. The root length during this period reached more than 10 - 12 cm. We failed to obtain more accurate results of the root length, due to the impossibility of a complete analysis of the root systems, due to their mechanical damage during digging - the root tip, which has a thickness of less than 0.5 mm, under mechanical influences broke off, not to mention the root hairs. The root growth rate during this period was ~ 1.5 cm/day.

Due to the fact that the soils in the study area are propped up by basalt slabs, the root cannot grow in depth and its growth continues in any possible direction. In this case, depending on the shape of the obstacle, the formation of a panicle at the end of the root, the twisting of its tip into a spiral, a complete change in the direction of growth, etc. were observed (Fig. 1). In this case, due to the impossibility of reaching the deeper layers of the soil by the root, and in the future reaching the groundwater level, the water supply of plants becomes limited. In particular, we associate one of the reasons for the drying out of seedlings with a lack of moisture.

Figure 1. Development of the root system of *D. turbinatus* seedlings

Here we may also note the occasional case in which we found a fruit with a root that was growing in its own fruit. This can be imagined as a kind of "cannibalism" that gives plants growing some time.

3.2.2. Stem formation

The stem of the plant begins to form on the 7 - 8th day after the germination of the fruit. The development of the stem is characterized by a kind of "shooting" of the shoot up to a height of 14.7 cm (SD = 2.6), occurring within 3 - 4 days (Fig. 2), with the formation of two opposite leaves. The shoot growth rate at this time is 4 - 5 cm/day.

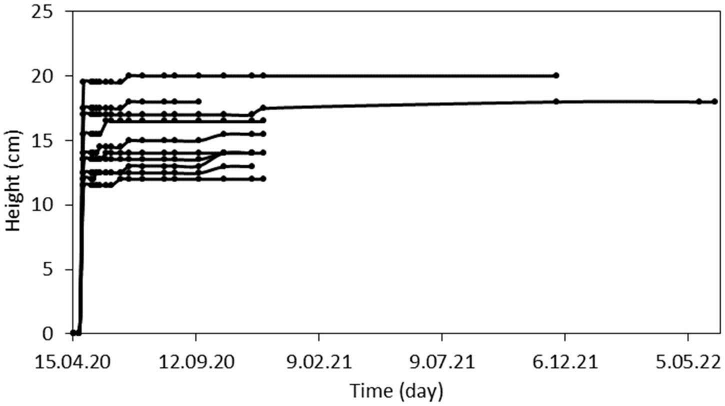

Figure 2. Self-seeding growth of *D. turbinatus* in height (SA1)

In the future, the growth of self-seeding is practically not observed - self-seeding turns into the so-called "sticking out sticks ". At the end of June and in the middle of October 2020, self-seeding increments of ~ 5 mm were noted (Fig. 2). Soil moisture (VWC) at this time reached 25-39% due to precipitation. Thus, the observed stem growth is associated with an increase in soil moisture. This confirms our argument that one of the reasons limiting the growth of seedlings is their water supply. Starting from mid-May, the stems showed the appearance of the third leaf, and on some - the fourth. By the end of 2020, 8 out of 10 seedlings have dropped out. By the end of July 2022, the last seedling fell out.

3.2.3. Experience with artificial planting of fruits

Artificial planting of germinated fruits, carried out by us in a bed at a depth of 2-5 cm, did not allow the plants to form a stem. In this case, despite the formation of the root, the stem could not break through the soil layer - the direction of its growth was chaotic and continued, apparently, during the stage of seedling formation (Fig. 3). Of the fruits planted, only two sprouted, which had an unsatisfactory condition and soon fell out.

The impossibility of germination of the stem through a relatively small layer of soil and its chaotic growth under it allows us to assume that in this case, we are dealing with insufficiently developed negative geotropism in these plants. We can also conclude that the fruits of *D. turbinatus* belong to the above-ground type of seed germination.

An analysis of the sizes of the root and stem formed under the soil layer (Fig. 3) and their comparison with those of seedlings growing under natural conditions allow us to come to the following conclusion: during the period of root and stem formation until the formation of two opposite leaves, the nutrition of the plant occurs due to the nutrients stored in the endosperm of the fetus. Thus, this experience provides an opportunity to make a potential assessment use of stored nutrients in the fetus in the process of seedling formation. The nutrition of the sprout due to the endosperm occurs within 10-12 days.

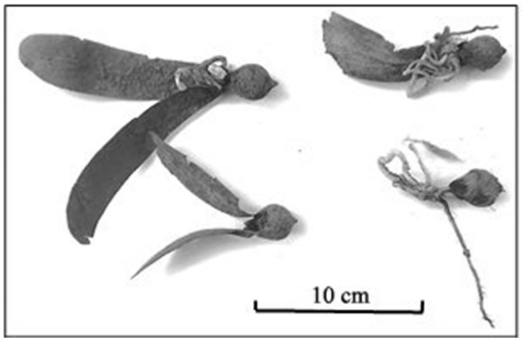

Figure 3. Sprouted fruits in the garden bed experiment

The experience with artificial seedlings showed that at the end of July 2022, the average height of seedlings planted at the site of a fall of a mature tree was 37.0 cm. The seedlings had 8 formed leaves, and the most developed seedling had a height 40.5 cm and began to form a side branch. The first two leaf plants formed in the initial stage of growth are absent.

3.3. Self-seeding mortality dynamics

Observations of the development of self-seeding on SA5 showed the following.

Initially, abundant growth of self-seeding was observed, but in the future, there was a process of its death. The leaves were damaged by leaf beetles and fungi. Seedlings were observed both partially and with completely dead leaves. The dynamics of self-seeding density are shown in the graph (Fig. 4a).

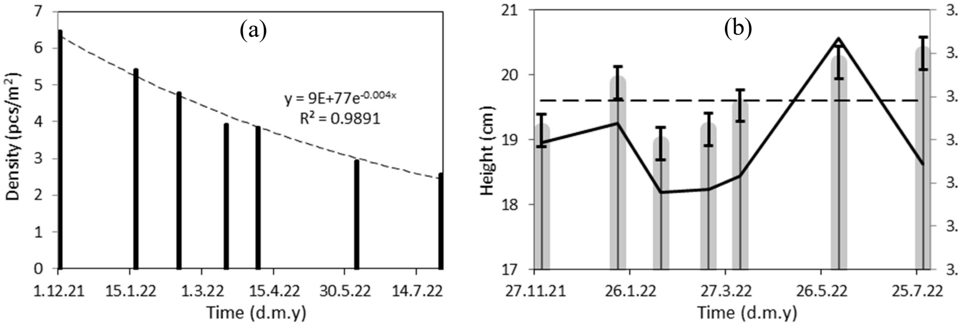

Figure 4. (a) - dynamics of the self-seeding density of *D. turbinatus* (the dotted line shows the graph of the exponential function); (b) - dynamics of the average height of self-seeding (histogram) and average values of the number of leaves (solid line) (the dotted line shows the average height of seedlings over the observation period. The bars show the absolute measurement error)

As the SA1 experiment showed, all the plants eventually fell out. The experiment on SA5 allowed us to reveal the falling out of a self-seeding, which is described by an exponential function with a high degree of association (Fig. 4a). Extrapolation of the function allows us to make a prediction that by the end of 2024 all seedlings of 2022 will fall out.

The dynamics of the average height of seedlings, as well as the dynamics of the average values of the number of leaves, are shown in the graphs (Fig. 4b). The correlation coefficient between these values until 06.06.2022 was $R^2 = 0.87$. The dotted line corresponds to the average height of seedlings over the observation period.

As can be seen from the graph (Fig. 4b), during the course of the experiment, the average height of the seedlings varied - no tendency for regular growth was observed. A similar situation was observed with respect to the average number of leaves per seedling. At the same, until 06.06.2022, there was a close association between the height and the number of leaves ($R^2 = 0.87$) - that is, the growth of seedlings in height was accompanied by an increase in leaf mass, which is natural. However, these plants need more water. Let's look at this side of the issue.

With a low moisture content in the soil, more developed plants begin to experience a greater degree of lack of moisture. The consequence of this is their weakening, which is the cause of their damage by various pests. As a result of lack of moisture and damage, such plants die. For example, a decrease in the average height of seedlings, as well as in the number of leaves, after 20.01.2022 (Fig. 4b) can be associated with a decrease in average soil moisture to 14% (SD = 4). Later, due to precipitation, soil moisture reached 26% (SD = 0) on 14.02.2022, and further increased to 30% (SD = 3). Accordingly, the height of the seedlings also increased (Fig. 4b). Based on this, we can conclude that in our case, one of the factors affecting the growth and development of seedlings is their water supply. The decrease in the number of leaves by 29.07.2022 (Fig. 4b) is associated with an increase in the damage by leaf pests due to the weakening of plants.

3.4. Photosynthesis response curve to PAR and light regime

The response curve of photosynthesis to PAR is shown in Fig. 5. Mathematically, this curve is described by equation (1) with the following parameters: $A_m = 6$ μmol·m^{-2}·s^{-1}, $A_d = -0.3$ μmol·m^{-2}·s^{-1}, $K_M = 66$ ($R^2 = 0.90$).

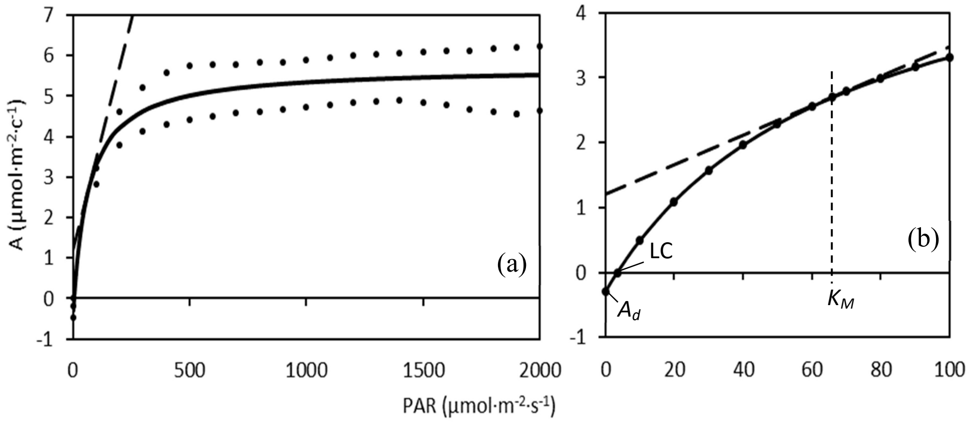

Figure 5. The photosynthesis response curve of self-seeding *D. turbinatus* to PAR (solid line); photosynthesis values (markers); tangent line to K_M point (dotted line). Plots (a) and (b) are shown at different scales

PAR measurements carried out near the seedlings under study showed that the seedlings received only ~ 1% of the PAR supplied to the plantation. Similar results have been obtained by other researchers working in tropical forests [16].

A distinctive feature of photosynthesis in the studied seedlings is a rather low value of the light compensation point LCP = 3.5 $\mu mol\cdot m^{-2}\cdot s^{-1}$ and a high value of the tangent slope a = 0.082 (Fig. 5). Thus, the studied leaves are characterized by a rather high growth rate of photosynthesis at low illumination values. Such characteristics of photosynthesis, as a rule, are characteristic of shade leaves. For comparison, for example, in the shadow leaves of *Rhizophora apiculata* Blume, 1827, a = 0.020, and TCR was 20 $\mu mol\cdot m^{-2}\cdot s^{-1}$ [17].

In conditions of insufficient illumination, such properties of the leaf make it possible to use the PAR coming to it with the greatest efficiency. For example, on average, seedlings receive only ~1% of the PAR supplied to the plantation. This means that at best, at noon, when the maximum possible PAR is 2200 $\mu mol\cdot m^{-2}\cdot s^{-1}$, only 22 $\mu mol\cdot m^{-2}\cdot s^{-1}$ will reach the leaf. However, even with this amount of PAR, photosynthesis becomes equal to A=1 $\mu mol\cdot m^{-2}\cdot s^{-1}$ (Fig. 5b). It is also necessary to take into account possible, albeit very short-term periods when the seedling is in the zone of a sunspot - the maximum value of one of these spots recorded by us was 100 $\mu mol\cdot m^{-2}\cdot s^{-1}$. These moments allow the seedlings to grow for some time.

To put an end to this discussion, we will carry out simple calculations that allow us to estimate the net productivity of the leaf. In the first case, consider the net productivity of a leaf on a cloudless day that could be observed in the dry season, for example, 21.03.2020, with a maximum PAR value of 2056 $\mu mol\cdot m^{-2}\cdot s^{-1}$. In this case, the daily respiration of the leaf was 14 070 $\mu mol\cdot m^{-2}\cdot s^{-1}$, while the net photosynthesis productivity was 27 670 $\mu mol\cdot m^{-2}\cdot s^{-1}$. That is, under this illumination, we observe a positive balance of the net photosynthesis productivity, which is 13 600 $\mu mol\cdot m^{-2}\cdot s^{-1}$.

Now, for example, let's take a more typical day for the study area, with partly cloudy and, for example, with a maximum PAR value of 1200 $\mu mol\cdot m^{-2}\cdot s^{-1}$. In this case, we already observe a negative net photosynthesis productivity balance of -680 $\mu mol\cdot m^{-2}\cdot s^{-1}$. Further, during the wet season, the negative net photosynthesis productivity balance can be up to - 25 000 $\mu mol\cdot m^{-2}\cdot s^{-1}$. To this, it should be added that, in addition to leaf respiration, in this work, we did not take into account the respiration of the stem and root system of the seedling.

This state of affairs fully explains the most significant fall out of self-seeding in the wet season - over the period under review, the density of self-seeding decreased by 2.5 times (Fig. 4a). Thus, we can conclude that the main limiting factor in the life of seedlings in our case is their illumination. This is also shown by the experience with the artificial planting of seedlings in the "window" of a forest plantation, formed as a result of the fall of an adult tree - in this case, the plants grow in conditions of sufficient lighting and here we observe well-developing plants.

It should also be taken into account here that even during the wet season, some of the seedlings grew in conditions close to water deficit. This is evidenced by the apparent depression of photosynthesis, which began to be traced in some seedlings at maximum PAR values of 1500-2000 µmol·m^{-2}·s^{-1} (Fig. 5a). In the case of even short breaks in precipitation, the soil desiccates - in our case, at such a time, we recorded soil moisture up to ~ 11%. In the case of seedlings surviving until the dry season, they were under the influence of an acute moisture deficit. For example, the minimum soil moisture values we recorded in January 2022 were 7.0% - that is, some plants grew in conditions of soil moisture corresponding to the wilting point. Under the influence of these two negative factors - insufficient illumination and lack of moisture, the seedlings weaken, their growth and development stop, and they become more susceptible to damage by leaf pests, which ultimately leads to their disappearance.

3.5. Dependences of photosynthesis and transpiration on temperature and CO_2 concentration

The dependences of photosynthesis and transpiration on air temperature are shown in Fig. 6a. These dependencies with a high degree of association ($R^2 = 0.96$ and $R^2 = 0.98$) are described by quadratic equations (the corresponding equations are shown in the graph).

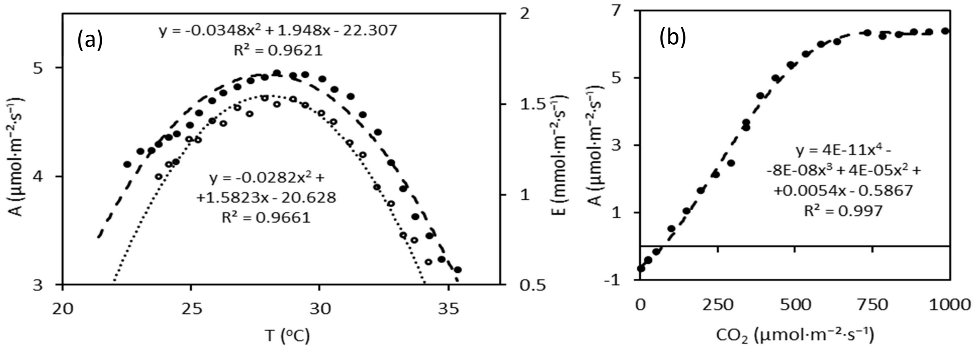

Figure 6. (a) **-** dependence of photosynthesis A and transpiration E on air temperature T; (b) - dependence of photosynthesis on CO_2 concentration. Markers in the form of circles reflect the values of *A*; markers in the form of circles - values of *E*; dotted line - mathematical dependence of photosynthesis; the points line is the dependence of transpiration (the corresponding equations of these dependencies and R^2 are presented in the graphs)

As follows from Fig. 6a, the optimal air temperature for photosynthesis and, accordingly, for the growth of seedlings, is T_{opt} = 28±1 ºC. Deviation of air temperature from T_{opt}, causes a decrease in photosynthesis. The same temperature is the extremum point for transpiration. The dependences of photosynthesis and transpiration are highly associated with each other (k = 0.98). This suggests that, at least in this temperature range, the leaf does not experience overheating and water deficiency - a natural increase in photosynthesis is accompanied by a natural increase in transpiration and vice versa. Otherwise, when measuring transpiration, we naturally observed a decrease in transpiration with an increase in photosynthesis.

The dependence of the of photosynthesis of seedlings on the concentration of CO_2 in the air, with a high degree of association, is described by a polynomial equation of the fourth degree (Fig. 6b). As can be seen from the figure, in the studied range of CO_2 concentrations, with an increase in CO_2 concentration, the photosynthesis of seedlings naturally increases to a CO_2 concentration of ~ 600 $\mu mol \cdot mol^{-1}$. Further, no increase in photosynthesis is observed - with a further increase in the concentration of CO_2, the processes of photosynthesis enter saturation mode. An increase in photosynthesis in seedlings at an increased concentration of CO_2 in the air is noted in many works, for example [18, 19].

In our case, for example, if we consider the most optimistic forecasts associated with an increase in the concentration of CO_2 in the air in the next decade from 412 ppm to 460 ppm (and such a concentration is already observed over cities), then the intensity of photosynthesis in the seedlings under study will increase by ~ 6%. This trend will be one of the stimulating tools for the growth of seedlings.

4. CONCLUSION

This paper presents the results related to the study of the growth and development of self-seeding *D. turbinatus* growing in natural conditions. As a result of the research, the following was revealed.

- Peaks of mass fruit fall of *D. turbinatus* are associated with strong gusts of wind. Due to the wind, the fruit is also distributed.

- The formation of a seedling before the formation of two oppositely arranged leaves occurs due to the nutrients of the endosperm. This time period is 10 - 12 days.

- The emerging roots of *D. turbinatus* are sensitive to the air humidity around them - even short-term breaks in precipitation lead to a significant limitation of fruit germination.

- In the initial period of development, *D. turbinatus* forms a tap root with growth of ~ 1.5 cm/day. On the 7 - 8th day, the developing root lifts the fruit above the soil surface. Supporting soils with basalt slabs prevents the roots from reaching deeper layers of soil, and in the long run from reaching the groundwater level, which negatively affects their water supply.

- The stem of the plant is formed on the 7 - 8 th day after the germination of the fetus. Stem growth is characterized by rapid growth, 4 - 5 cm/day, lasting for 3 - 4 days, with the formation of two opposite leaves. In the future, the growth of seedlings practically stops.

- *D. turbinatus* belongs to the above-ground species of seed germination and does not have a developed negative geotropism.

- The mortality of self-seeding is characterized by an exponential dependence - the largest mortality is observed in the first six months. There is also a trend toward the dropped out of more developed plants. Single specimens of seedlings can survive up to two years.

- The studied leaves are characterized by high sensitivity of photosynthesis to PAR at its low values.

- The main limiting factor in the life of seedlings in our case is their illumination. Another factor affecting the life of seedlings is their water supply.

- The optimum air temperature for the processes of photosynthesis and transpiration of seedlings is 28 ± 1°C. With an increase in the concentration of CO_2 in the air, photosynthesis accordingly increases.

- The conducted research raises the question related to the study of the supply of nutrients both in the fruits and the plants themselves. At this point in time, in the tropical forests of southern Vietnam, this issue is not studied.

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SUMMARY

The paper presents studies related to the growth and development of self-seeding *Dipterocarpus turbinatus* C. F. Gaertn (1805), which grows in the Cat Tien National Park (Southeast Vietnam) under natural conditions. It is shown that the main limiting factors influencing the vital activity of self-seeding are air humidity, illumination and water supply. Some features of seedling development are revealed. The root growth rate was determined to be ~ 1.5 cm/day, and the stem growth rate was 4 - 5 cm/day. It is shown that the formation of the seedling occurs due to the nutrients of the endosperm and lasts for 10 - 12 days. In conditions of insufficient illumination, the seedlings reach a certain height and turn into "sticking out sticks". Approximately in the second year, self-seeding falls out. It was revealed that self-seeding is characterized by a high growth rate of photosynthesis at low PAR values. The optimum air temperature for the processes of photosynthesis and transpiration of seedlings is 28 ± 1°C. With an increase in the concentration of CO_2 in the air, of photosynthesis naturally increases.

Keywords: *Endosperm, fruit, photosynthesis, photosynthetically active radiation, transpiration, water supply, nội nhũ, quả, quang hợp, bức xạ hoạt động quang hợp, thoát hơi nước, cấp nước.*

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