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Photosynthesis and transpiration in **Cedrela fissilis** Vell seedlings in relation to light intensity and temperature[1/]

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COMPENDIO

Se sometieron a un fitotrón plantas de Cedrela fissilis *Vell. producidas en vivero, bajo condiciones naturales de luminosidad. La capacidad fotosintética y la transpiración fueron determinadas bajo las temperaturas de 15º C, 25º C y 30º C y bajo las intensidades luminosas de 5, 15, 25 y 40 klux. Se detectaron interacciones entre los factores ambientales y la actividad fisiológica del cedro y se demostró la existencia de una cierta umbrofilia del cedro en estado juvenil basándose en su mayor productividad en los niveles inferiores de temperatura e intensidad luminosa.*

Introduction

THE Genus *Cedrela* has a large geographical distribution in all countries of Tropical America except Chile (18) Practical observations on the physiological and silvicultural behavior of the cedar have been carried out since the beginning of this century (2, 14) Intensive experiments envolving studies of soils and site conditions (2, 3, 6, 12, 19) and light conditions (1, 4, 5, 9, 17, 19) show the complexity of the relationship between cedar species and the enviromental factors.

It has been shown (10) that fundamental studies on the ecophysiological behavior of young plants of cedar can clarify some important features of its silviculture.

This experiment was carried out to study the response on photosynthesis and transpiration of young plants of *Cedrela fissilis* Vell., to different levels of light intensity and air temperature.

Materials and methods

The two year old seedling of *Cedrela fissilis* Vell., used in the study, were produced under full daylight conditions in the nursery of the Experimental Station of the University of Paraná, Curitiba, Brazil (25º25'-S; 49º14-'W; 900 m).

Photosynthesis and transpiration rates were measured with an IRGA (infrared gas analyser) manufactured by WALZ, Western Germany. The air flow to the gas exchange chamber was 60 $l\,h^{-1}$ and relative humidity of the air was 60 per cent. The physiological parameters were measured at three temperatures: 15º C, 25º C and 30º C and at four levels of light intensity: 5, 15, 25 and 40 klux (HG-lamps GE-H250w-37-5) The final physiological parameters were calculated in relation to the dry weight of leaves of the plants. The experiment was conducted with six replications. Factorial analysis of variance at 0.05 level of significance was used for the interpretation of the results.

Results

The curves of photosynthesis as related to the intensity of light at different temperatures are shown in Fig 1.

Under a temperature of 15º C. the photosynthesis rate increases rapidly between the levels 5 and 15 klux of light intensity. After this point the increment of the curve dicreases until 25 klux and more emphasized until 40 klux. At 5 klux the photosynthesis rate was greater at 15º C. than at 25º C and at 30º C.

The greatest values of photosynthesis were measured at the temperature of 25º C. between 25 klux and 40 klux.

The photosynthesis rate curve at 30º C. always runs parallel to the 25º C curve, but with smaller values. The development tendency of these curves indicates an optimum level of light to the photosynthesis rate that probably exists above the tested levels.

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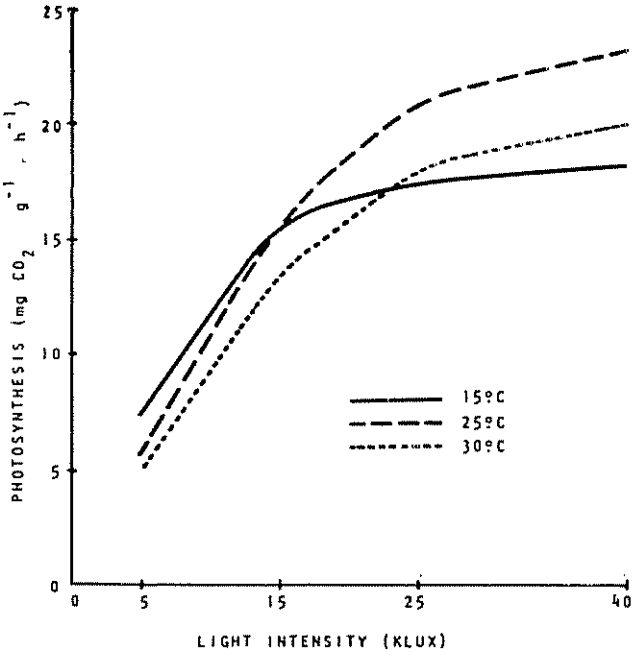

Fig. 1.—*Curves of net photosynthesis associated to light intensity and temperature in* Cedrela fissilis *Vell*

The photosynthesis rate depends on the light intensity according to the following regression equation.

$$y = 0.8185 + 1.1725x - 0.0170x^2$$

The development of this curve is similar to the caracteristic curve of the light demanding species: the curve slowly increases from low to high levels of light intensity with a culmination point at a very high level of intensity.

The photosynthetic light saturation point of the tested material is situated at nearly 35 klux.

The transpiration rates of the cedar leaflets were measured in relationship to air temperature and light intensity. The results are shown in Fig. 2.

The transpiration rates at 15º C were very small at all levels of light intensity. Therefore they are not represented in Fig. 2. There was a positive correlation between transpiration and light intensity, at 25º C and 30º C. Between 15 and 40 klux of light intensity, transpiration was always higher at 30º C than 25º C. At klux transpiration for both temperature levels was the same.

The respiration rate was linearly correlated to photosynthesis, demonstrated by the following regression equation:

$$Y = 0.2764 + 3.9006x$$

This means that an increase in the net photosynthesis rate caused by an increase in the light intensity corresponds to an increase in the transpiration rate.

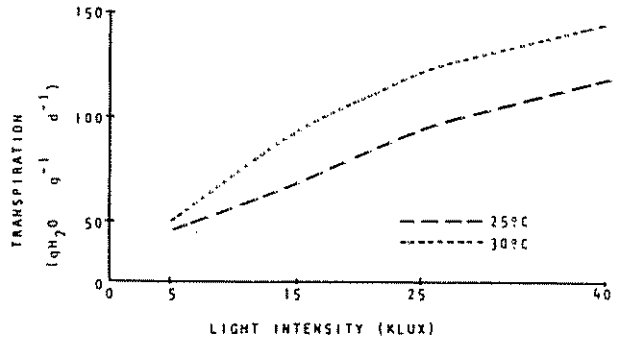

Fig. 2.—*Curves of the transpiration rate associated to light intensity and temperature in* Cedrela fissilis *Vell*

The transpiration efficiency - the ratio between photosynthesis and transpiration - was determined at 25º C and 30º C temperature. The result found at 25º C is shown in Fig. 3.

Transpiration efficiency at 30º C was strongly correlated to the light intensity. At 25º C the transpiration efficiency increases with an increase in light intensity until a point near 20 klux. From this point untill 40 klux the transpiration efficiency decreases due to two factors:

i) the increment of transpiration has a linear relationship for the whole range of light intensity.

ii) another factor is that the increment of photosynthesis tends to decrease strongly after 20 klux. Therefore there exists no linearity in the regression curve between the ratio photosynthesis/transpiration and the light intensity at a higher level of light intensity.

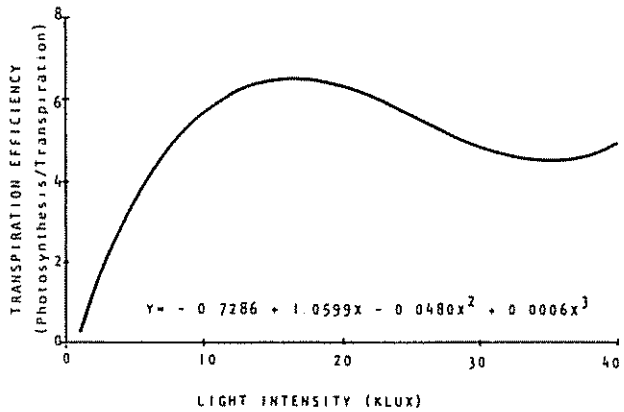

Fig. 3.—*Regression curve of transpiration efficiency in relation to light intensity at a temperature of 25ºC in* Cedrela fissilis *Vell*

Discussion

The relationship between light conditions in the forest and the adaptability of each plant is very important in the dynamics of forest ecosystems. The demand for light and the compensation point of the heliophilous pioneer species is located higher than the umbrophilous species of the later sucession

The cedars used in the experiment were grown under daylight conditions and their performance in the photosynthetic capacity showed their adaptability to the environmental light conditions. The photosynthetic curve demonstrates the high capacity of the primary production of these plants. It seems that the light saturation of the plants can be found above the level of 40 klux of light intensity. On the other hand Inoue (10) found that cedar plants growing in the shade had a higher photosynthesis rate at lower level of light intensity. In his experiment the adaptability of the cedar to the environmental light was confirmed by the analysis of the apparent economic coefficient (net apparent photosynthesis/dark respiration): at a low level of light intensity the plants growing in the shade presented a higher coefficent than those growing in the light. In the same way the plants growing under light conditions were more "economic" at a high level of illumination

In the present experiment there has been detected an interaction between light and temperature. At a low intensity of light (5 klux) greater values of photossynthesis were measured at 15º C. While at the same temperature with a greater level of light, 40 klux, the photosynthesis rate was lower at the other higher temperatures. This fact confirms the observation made by Matthaei (cited by Heath (8). Katruschenko (11) arrived at similar results with *Picea* sp and Hari *et al.* (7) with *Alnus incana* (L) Moench. On the other hand Wood et al. (20) demonstrated that *Pinus radiata* Don can assimilate more at 35º C and at very high light intensity. These examples support the supposition that the dependence of the photosynthesis on the temperature can reflect the tolerance of a species. The optimum point of temperature depends on the light intensity (16). For the species of the temperate zones this point is situated at approximately 25º C, while for the tropical evergreens it is between 28º C and 30º C (13)

Based on these observations it is possible to conclude that although *Cedrela fissilis* is able to adapt to the light conditions, it shows an umbrophilous character when the photosynthesis is measured at temperatures higher than 25º C.

It is well known that foliar transpiration depends, beyond the internal factors, on climatic factors such as vapour pressure, air humidity and temperature. Within the limits that cause no disturbance, the transpiration rate increases with the temperature. In the present case the cedar seedlings also demonstrated a higher rate of transpiration at 30º C than at 25º C or at 15º C.

The ratio assimilation/transpiration can be ten or more times greater in the morning than in the average time of a vegetative period (13). The best index of transpiration efficiency is found at 25º C by 15 klux. This performance was influenced more by the photosynthetic capacity than by the transpiration rate because this parameter was linearly correlated to the light intensity

Conclusions

Studying the dependence of the photosynthesis and transpiration rates on temperature and light intensity in *Cedrela fissilis* seedlings it is possible to conclude that:

- photosynthesis and transpiration rates increase with an increase in light intensity at the same temperature;
- at low temperatures the gain of photosynthesis is greater at lower levels of light intensity, decreasing notably with an increase of light intensity;
- the efficiency of transpiration confirms a certain umbrophilly of the cedar, that even when grown under full daylight they demonstrated greater productivity at lower levels of light intensity;
- the cedar is physiologically able to adapt to the environmental ligth condition;
- at higher temperatures a higher luminosity will be necessary for maximum productivity

Summary

Two years old seedlings of *Cedrela fissilis* Vell. growing under full daylight conditions were analysed in a Phytotron. The photosynthetic capacity and the transpiration were determined at 15º C, 25º C and 30º C of temperature and 5, 15, 25 and 40 klux of light intensity. An interaction was detected between the environmental conditions and the physiological behavior of the cedar. The higher productivity at lower levels of temperature and light intensity shows a certain umbrophilly of the cedar in the juvenil stage

Resumo

Mudas de *Cedrela fissilis* Vell. produzidas em viveiro sob condições naturais de luminosidade foram analisadas num fitotron. A capacidade fotossintética e a transpiração foram determinadas sob as temperaturas de 15º C, 25º C e 30º C e sob as intensidades luminosas de 5, 15, 25 e 40 klux. Foram detectadas interaçãoes entre os factores ambientais na atividade fisiológica do cedro. Demonstrou-se a existência de uma certa umbrofilia do cedro no estágio juvenil, baseando-se em sua maior produtividade nos níveis inferiores de temperatura e intensidade luminosa

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