Journal of Medicinal Plants Studies
www.PlantsJournal.com

ISSN 2320-3862
JMPS 2017; 5(1): 193-199

Received: 26-11-2016
Accepted: 27-12-2016

Patrícia Chaves de Oliveira
Institute of Biodiversity and Forest, Universidade Federal do Oeste do Pará, Campus Tapajós, CEP 68040-070, Santarém, Pará, Brazil

Helton Luís Nina Lameira
Postgraduate Program in Natural Resources of Amazonia (PPGRNA), Universidade Federal do Oeste do Pará, Campus Tapajós, CEP 68040-070, Santarém, Pará, Brazil

Correspondence
Patrícia Chaves de Oliveira
Institute of Biodiversity and Forest, Universidade Federal do Oeste do Pará, Campus Tapajós, CEP 68040-070, Santarém, Pará, Brazil

Physiological behavior of *Annona muricata*, *Dipteryx odorata* and *Copaifera langsdorffii* in response to water and light stress

Patrícia Chaves de Oliveira and Helton Luís Nina Lameira

Abstract
The Amazon is a biome where in recent decades climate change has caused the increase in physiological plasticity of certain plant species. This plasticity characterized as resilience strategy of these species to environmental stress conditions such as drought stress. In this context, understanding the physiological adaptation mechanisms of plants that has ethnobotanical interest to Amazonian traditional communities is new and of great importance for the socio-economic sustainability. Thus, the aim of this study was to analyze experimentally the physiological behavior of *Annona muricata, Dipteryx odorata* and *Copaifera langsdorffii* in response to water and light stress. The variables analyzed were photosynthesis (µmol m^{-2} s^{-1}), stomatal conductance (mol m^{-2} s^{-1}), transpiration rates (mmol m^{-2} s^{-1}) and leaf temperature (°C) in leaf tissues subjected to four treatments. The equipment used for the measurement was an Infrared gas analyzer (IRGA). The water and light stress affected more *Dipteryx odorata*, while *Copaifera langsdorffii* and *Annona muricata* were more tolerant to water stress because they have drastically reduced the stomatal conductance and transpiration rates. In function of the ethnobotany´s importance that such species have to Amazonian populations, physiological responses found here, suggest different ways of cultivation and water´s supply.

Keywords: Amazon, Annona, Copaifera, water stress

1. Introduction

Global and local climate change in the Brazilian Amazon been accentuated in recent decades as IPCC data (IPCC 2014) [15]. Thus, the physiological behavior of woody plants in the different ecosystems in the Amazon also been modified in an attempt to increase their resilience to adverse weather conditions characterized by severe droughts interspersed with periods of heavy rain. Thus, plant species have evolved and adapted physiology at constant environmental stress (Lourenço *et al* 2014) [23].

Water stress, typical of dry periods in the Amazon characterized by reduced rainfall between the months of July to November, have worsened in recent years, where in 2015 for example in the municipality of Santarém, state of Pará, were observed 150 days without rain. This scenario results in the adoption of physiological strategies by plants to tolerate very negative potential water in Amazonian soils. These strategies range from the reduction in stomatal conductance (Santos Filho 1984) [36], reducing transpiration rates and photosynthetic rates, osmotic adjustments and changes to the genetic level, as reported Noorka1.

In this context, species of high ethnobotanical value to traditional communities in the Amazon as Soursop (*Annona muricata* L.), Cumaru (*Dipteryx odorata* (Aubl.) Willd) and Copaíba (*Copaifera langsdorffii* Desf.) are of great importance for research on the physiology of drought stress.

The genus *Copaifera* (*Leguminosae – Caesalpinioideae*) occurs in Africa (4 spp.), Central America (4 spp.), South America (about 37 spp.) and probably in Asia (1 sp.). The follow species recognized within the Brazilian Amazon: *Copaifera duckei, C. glycycarpa, C. guyanensis, C. martii, C. multijuga, C. paupera, C. piresii,* and *C. pubiflora e C. reticulate and C. langsdorffii*. Their habit varies between shrubby and tree-like, with some species forming 40 m tall trees. As sour soup (*Annona muricata)* belongs to *Angiospermae, Magnoliidae,* order. When the tree is mature, it can reach up to 8 meters high, with single trunk and asymmetric branch. As *Dipteryx, odorata* has the follow taxonomy: Angiospermae, Eurosídeas I, Fabaceae, and Faboideae. This specie is part of a successional group considered climax or climax in demanding light. It is a tree with ever- green behavior.

The largest trees reach dimensions close to 40 m tall and 150 cm in diameter.

The choice of physiological characters for species selection could boost genetic improvement in order to obtain varieties tolerant to water stress conditions over the periods of low rainfall and high vapor pressure deficits (DPV) in the Amazon, with a view to sustainable agriculture and local extraction. Several parameters been studied to assess the response of plant species to water stress and / or light, water potential, photosynthetic activity, stomatal conductance, transpiration and leaf temperature (Nogueira *et al* 2001) [31].

However, little known about the physiological behavior of young plants of Cumaru (*Dipteryx odorata*) and Copaíba (*Copaifera langsdorffii*) which are species of high economic value on Amazon. They can be used in plantations for reforestation and forest production (Clay *et al* 2000, Tonini *et al* 2008 e Batista *et al* 2003) [5, 44, 3]; beyond Soursop (Gonçalves *et al* 2010) [12] is an important local fruit for economy of family agriculture, which support a short periods of drought.

As for *Annona muricata* for example, it is currently presented as an alternative to cancer treatments (Astirini *et al* 2013) [1] because it has three compounds are a potential anti-cancer, are mono-tetrahydrofuran acetogenins namely, muricin H, muricin I, and cis-annomontacin. Thus, the use of water stress in certain species of plants can make adjustments in leaf water potential and consequently the osmotic potential, where the increase of certain substances in the leaves can be very useful herbal medicine aimed at curing cancer. In this sense, *Annona muricata* cultivation in different soils with different water potentials should analyzed, considering that in flooded soils there is a reduction in photosynthetic rates according to (Peng *et al* 2012) [34], and therefore the synthesis of compounds of interest.

As to gender *Dipteryx*, it has high importance to ethnobotany for communities in remote areas in forest ecosystems and savannahs in the Amazon due to its anti-ophidic action. According to (Yoshida *et al* 2015) [45], the phenolic compounds from *Dipteryx alata* Vogel assayed against the in vitro neurotoxic effect induced by *Bothrops jararacussu* (Bjssu) venom. Therefore, knowing the physiological responses of *Dipteryx odorata* as the efficient use of water and strategies to water stress is importance for the management of the species and consequent production of anti-ophidic substances. Other works about fertilization methods for growing Cumarú, such as (Jaquetti *et al* 2014) [14], the results suggested the combination of green and chemical fertilization was more effective in improving the photosynthetic performance and growth of *Dipteryx odorata* during initial establishment in a degraded area than either treatment (alone fertilization). However, little known about the physiological behavior of Cumaru under low potential water of soil.

As for *C. langsdorffii,* studies have shown that this kind functions as phytoremediation for heavy metals. According to work (Soares *et al* 2001) [41], the group of plants only slightly affected by soil contamination such as *Acacia mangium*, *Copaifera langsdorffii* and *Cedrela fissilis* who accumulated more Zn and Cd in the roots than in the shoots, therefore indicating reduced translocation is involved in their tolerance to the excess of heavy metal in soil. Similarly, there is a lack of studies on the physiological responses of Copaíba under water stress.

The objective of this research was to analyze the physiological behavior of A. *muricata, D. odorata* and *C. langsdorffii* in response to different water and light levels.

2. Materials and Methods

The experiment was conducted in the greenhouse at Universidad Federal do Oeste do Pará - UFOPA, whose coordinates are 2º 25 ' 04.71" S and 54º 44' 26.61" W in the municipality of Santarém-Pará-Brazil. According to IBAMA (2004) [17], the climate is Ami according to Köppen. Santarém has a small annual temperature variation with average ranging from 25.4 °C to 30.1 °C. The relative humidity values of air are high throughout the year, with an average of 86.7 % and rainfall with annual averages hovering around 1920 mm (INMET 2011) [18].

The study carried with 20 individuals (six months age) of each specie (*Annona muricata* L., *Dipteryx odorata* (Aubl.) Willd. and *Copaifera langsdorffii* Desf**)**. Herbarium of EMBRAPA took taxonomic identification of the species.

The plants were on black polyethylene bag, containing about 1.5 kg of organic substrate. The chemical composition and granulometry was: coarse sand - 153 g kg^{-1}, sand - 85 g kg^{-1}, silt - 483 g kg^{-1} and clay Total - 280 g kg^{-1}; pH (H_2O) - 5.3 ; Total Nitrogen - 1.12%; phosphorus - 150 mg dm^{-3}; potassium - 108 mg dm^{-3}, calcium - 9.2 cmol dm^{-3}, calcium more magnesium - 12.6 cmol dm^{-3} and aluminum - 0.1 cmol dm^{-3} (EMBRAPA 2011) [9].

The four treatments were T1: normal light conditions (100% light) and water (240 ml dia^{-1}); T2: normal light conditions (100% light = 1 500 µmol m^{-2} s^{-1}) and water stress (without H_2O); T3: normal water conditions (240 ml dia^{-1}) and light stress (80% shading = 800 µmol m^{-2} s^{-1}) and T4: water stress (without H_2O) and light (80% shading). The shading done on Photosynthetic Active Radiation (PAR) for seven days, as well as the irrigation was suspended. The determination of the optimal amount of irrigation in the seedlings pots (240 ml dia^{-1}) was determined by calculating the capacity of field for the specific size of seedlings pots obtained from the irrigation process until the leakage limit of the water in the pots. The photoperiod in the region is 12 hours a day.

The collected data made on two consecutive days of June. The variables measured in mature leaves fully expanded, intact and asymptomatic of health or nutritional deficiencies in plants with 1 year of life were 1. Leaf temperature (° C), 2. Photosynthetic rate (µmol m^{-2} s^{-1}), 3. Stomatal conductance (mol m^{-2} s^{-1}) and 4- transpiration rate (mol m^{-2} s^{-1}). Measurements determined by a portable equipment, an IRGA (Infrared Gas Analyzer), LCPRO model + ADC and carried out between 08:30 to 10:30 hours. The conditions was under the following conditions: radiation environment around the leaf tissues 1500 µmol m^{-2} s^{-1} and radiation on leaves in the shading around 800 µmol m^{-2} s^{-1}; atmospheric pressure of 1.012 mbar, photosynthetically active radiation (PAR) 1 500 µmol m^{-2} s^{-1} (constant) and reference carbon around 406 ppm. Statistical analyzes were determined by BioEstat program. Version 5.0 through the Statistical Analysis Descriptive, Multivariate analysis using Hotelling test, ANOVA (Tukey test) and Factorial (a x b x c).

3. Results and Discussion

The results showed that for *Annona muricata* (soursop), photosynthetic rates, stomatal conductance, transpiration rates and leaf temperature, reduced in treatments (T2, T3 and T4) (Figures 1, 2, 3 and 4). These results indicate that water and light deficits are limiting the processes of gas exchange between these species (*A. muricata*, *D. odorata, C. langsdorffii*) and the atmosphere, because it reduced important physiological variables needed for growth, maintenance and plant development, mainly due to the low supply of water and light for short period.

For the specie *D. odorata*, the rates photosynthetic between treatments (T1, T2 and T3) had a tendency to be forthcoming, however, treatment with water and light stress (T4) was greatly reduced photosynthesis (Figure 1). The stomatal conductance and transpiration rates for T1 and T2 have similar values, but there was a considerable reduction to the T3 and T4 (Figures 2 and 3). Leaf temperature for the treatment T2 was reduced sharply compared with the treatments (T1, T3 and T4), which had average similar (Figure 4). These results were similar to those reported by Costa Azevedo (2014) studying the *B. excelsa* behavior and andiroba (*C. guianensis*). He found that *B. excelsa* were sensitive to moderate water stress associated with higher photosynthetic rates and faster growth of *C. guianensis* under full sun and moderate water stress make this species a promissory candidate to experiment in reforestation programs.

The results showed that the interaction of water and light stress influenced the photosynthesis, stomatal conductance and transpiration of young plants of Tonka bean and the light stress can impair the behavior of the species by influence Gs, E and Tf. Thus, the light is decisive factor in the physiology of the species that showed very sensitive when subjected to light restraint, resulting in less force for the plants during the early stages of development. According to Marenco *et al* 2003 [26], the rate of electron transport (J), A, and water-use efficiency (WUE) increased consistently at increasing internal CO_2 concentration (Ci). Conversely, increasing [CO_2] decreased Gs, E, and photorespiration (Pr) at *Ochroma pyramidal* leaf tissues. Copaíba had a tendency to similar photosynthetic and stomatal conductance rates between treatments (T1 and T3) (Figures 1 and 2). However, treatments (T2 and T4) for the variables A and Tf reduced when compared with other treatments (Figures 1 and 4). For sweating there were considerable decreases in treatment (T2 and T4) when compared to the T1 (Figure 3), while leaf temperature was reduced to the treatments (T3 and T4) (Figure 4). The results show that in general way was no relationship between A, Gs and E, observed under water stress (T2) and bright stress (T4). So, the stress from lack of water supply may have caused increase in temperature leaf due to the closure of stomata reducing the transpiration of water vapor, necessary for cooling of the leaf surface resulting in lower CO_2 assimilation.

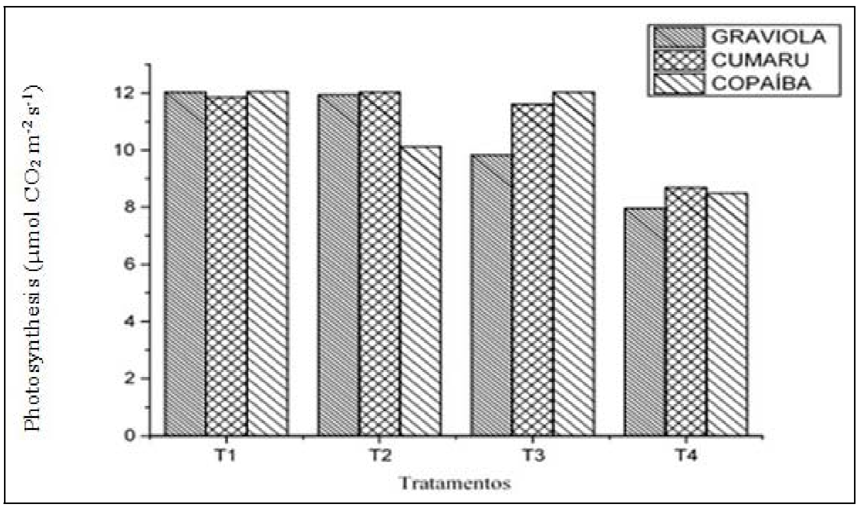

Fig 1: Photosynthetic rates (umol $CO_2 m^{-2} s^{-1}$) of young plants of soursop (graviola), tonka bean (cumaru) and copaiba subjected to four treatments (T_1: norma light conditions (100% light) and water (240 ml dia^{-1}), T_2: normal light (100% light) and water stress (without H2O), T_3: normal water conditions (240 ml dia^{-1}) and light stress (80% shading) and T_4: water stress (without H_2O), and light (80% shading).

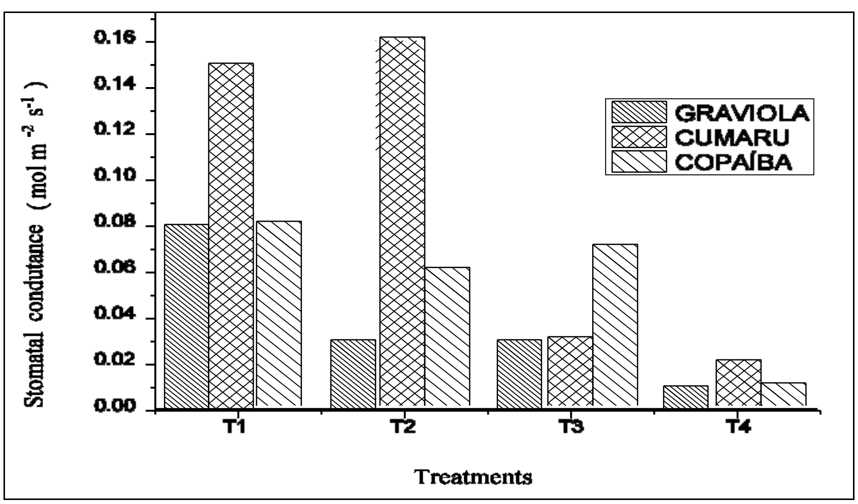

Fig 2: Stomatal conductance (mol $m^{-2}s^{-1}$) of young plants of soursop (graviola), tonka bean (cumaru) and copaiba subjected to four treatments (T_1: normal light conditions (100% light) and water (240 ml dia^{-1}), T_2: normal ligh (100% light) and water stress (without H_2O) and light (80% shading).

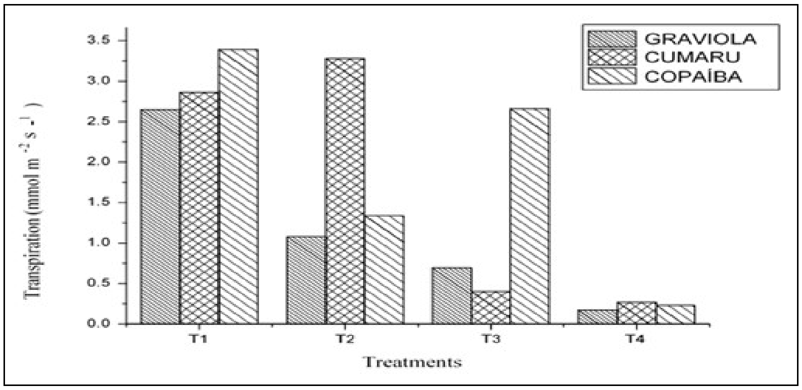

Fig 3: Transpirations rates (mmol m_{-2} s_{-1}) of young plants of soursop (graviola), tonka bean (cumaru) and copaiba subjected to four treatments (T_1: normal light conditions (100% light) and water (240 ml dia^{-1}), T_2: normal light (100% light) and water stress (without H_2O), T3: normal water conditions (240 ml dia^{-1}) and light stress (80% shading) and T4: water stress (without H_2O) and light (80% shading).

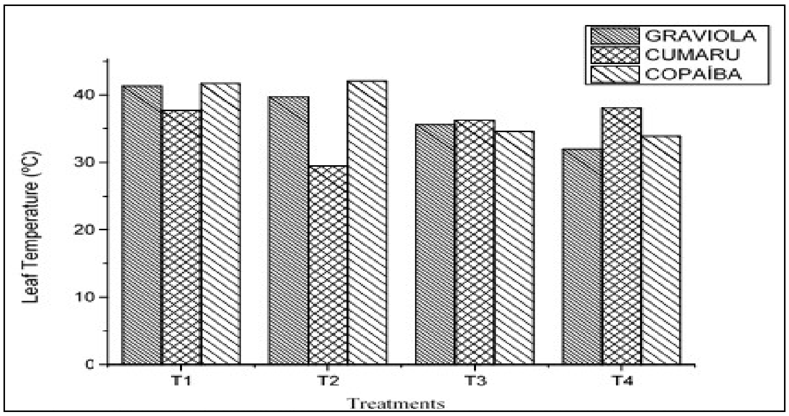

Fig 4: Leaf Temperature (ºC) of young plants of soursop (graviola), tonka bean (cumaru) and copaiba subjected to four treatments (T_1: normal light conditions (100% light) and water (240 ml dia^{-1}) T_2: normal light (100% light) and water stress (without H_2O), T_3: normal water conditions (240 ml dia^{-1}) and light stress (80% shading) and T_4: water stress (without H_2O) and light (80% shading).

The results of comparing the photosynthetic rates of young plants of Soursop, Cumaru and Copaíba over a week under four treatments showed significant difference ($p = 0.0389$) between the photosynthesis of the species under conditions of water and light stress as factorial analysis (Table 1). These results eventually differing photosynthetic responses of species over a week and thus demonstrating that under unfavorable conditions the species utilize different strategies in relation to the assimilation of CO_2, resulting in different growth in the field can determine a successful and extinction another species.

The light intensity and soil moisture are factors that affect the photosynthetic activity of plants (Marenco *et al* 2006) [25]. The process of opening and closing of stomata is mainly related to the intensity of light and the hydration status of the sheet. Thus, the functioning of stomata and leaf area influence the productivity of the plant. The first factor because it controls the absorption of CO_2 and the second because it determines the interception of light. Variations in leaf water potential can affect the assimilation of plant carbon (Hisao 1973) [14]. This is because, if the plant loses water at a higher rate than their capacity to absorb and transport, the leaf water potential decreases, leading to stomatal closure and reduction of photosynthesis (Oren 1999) [3].

According to Koslowski 1962 [21], increased shadowing decreases photosynthesis and, consequently, the production of assimilates and growth regulators, causing reduction in stem diameter. The author considers that photosynthesis apparently keeps a more direct relationship with the growth in diameter than the height of the plant.

However, the results for (Gs, E and Tf) along one week experiment (Table 1) indicated no significant difference in the physiological variables when comparing water and light treatments. These results standardizing physiological responses for the variables in question and therefore the assimilation of CO_2 and H_2O vapor transpiration into the atmosphere under different conditions. Thus, it is not surprising to find a low correlation between A and Gs in natural conditions and stresses of light and humidity. Furthermore, a poor correlation between Photosynthesis and stomatal conductance can indicate lack of uniformity in the opening of the stomata in the leaf surface (stomatal spots), as shown by Marenco 2006 [25]. The cause can be attributed also to Gs, E and Tf that were similar in treatments imposed to species. The increase or reduction in stomatal density can occur with the increase or decrease of the irradiance and a response is found in young plants of many species (Holmes & Cowling 1993) [13].

However, other authors found results where stress conditions influence on physiological variables. In accordance to Gonçalves *et al* 2005 [11] when submitting saplings of *Aniba rosaeodora* to different light intensities, observed reductions in transpiratory rate and stomatal conductance. Second Nogueira *et al* 2001, [31] studying relations between cherry plants subjected to water deficit consisted that increasing periods of water stress caused decreases in plant transpiration and total or partial closing of the stomata also occurred because of such stress extension, the leaf temperature, and the loss of latent heat by trasnpiration.

Table 1: Factor Analyses (a x b x c) to compare interactions of photosynthetic rates (A µmol CO_2 m^{-2} s^{-1}), stomatal conductance (GS mol H_2O m^{-2} s^{-1}), transpirations rates (E mmol H_2O m^{-2} s^{-1}) and leaf temperature (T ° C) of young plants of Soursop, Tonka bean and Copaíba under 4 treatments (T)*.
* T1: 100% light + 240 ml H_2O $week^{-1}$, T2: 100% light +0 ml H_2O $week^{-1}$, T3: 80% shading + 240 ml H_2O $week^{-1}$ and T4: 80% shading + 0 ml H_2O $week^{-1}$

Sources of variation	**A**	GS	E	T
	p	***p***	***p***	***p***
Factor A= species	---	---	---	---
Factor B= Light	---	---	---	---
Fator C= water	---	---	---	---
Interaction A x B	0.1102	0.1057	0.1828	0.6010
Interaction A x C	0.1585	0.5910	0.1217	0.5050
Interaction B x C	0.0389	0.5599	0.9432	0.2132

Over seven days of observation, the physiological behavior of Graviola (soursoup) specie, in different treatments was significant differences ($p<0.01$) for the variable photosynthesis between treatments (T1 and T4, T2 and T4), identified by analysis of variance (Tukey test). To the variable stomatal conductance were no differences between treatments (T1 and T2, T1 and T3, T1 and T4). Trasnpiration also showed differences between the same treatments for stomatal conductance and more between treatments (T2 and T4) and leaf temperature were no differences between all treatments.
For Cumaru specie was no differences ($p<0.01$) in photosynthesis between treatments (T1 and T4, T2 and T4, T3 and T4), in stomatal conductance and transpiration rates (T1 and T3, T4 and T1, T2 and T3; T2 and T4) and leaf temperature ($p<0.01$) for most of the treatments. And for Copaíba specie was no differences ($p<0.01$) among treatments in photosynthesis (T1 and T4, T3 and T4).
Numerous physiological processes of plants have been correlated to hydric stress, among these transpiration and leaf temperature. Under normal conditions, the transpiration rate is determined in the leaves by radiation and especially by stomatal conductance (Santos Filfo 1984) [36]. The stomatal closure, which makes the loss of water vapor slower, reduces the absorption of CO_2 and hence photosynthesis (Nogueira 1997) [30]. The leaf temperature varies according to the stomatal behavior and loss of latent heat by transpiration. The sheet is receiving light and / or what is transpiring is affected by temperature differentials caused by differential absorption of radiation (Sheriff and Muchow, 1984) [37].
According to Souza *et al* 2001 observed oscillations at nine o'clock in photosynthesis curves, stomatal conductance and transpiration in vine cuttings, and these changes accompany the changes of radiation and vapor pressure deficit. From the seventh day without irrigation were 50% reductions observed in photosynthetic rates and values close to zero.
According to Carneiro *et al* 2008 [4], determining the stomatal conductance and transpiration in irrigated eucalyptus plantations not irrigated during the early dry period, it showed that plants of both treatments reduced their variables with increased solar radiation and therefore the temperature avoiding dehydration and decreasing CO_2 assimilation.
A Multivariate Analysis by Hotelling test (Table 2) for comparison of treatments (T1 and T4) for Soursop, Cumaru and Copaíba showed significant differences (p <0.0001) in the physiological behavior. The water deficit (without H_2O $week^{-1}$) and excessive shading (80%) may limit the productivity of plants, mainly because they reduce important variables in the assimilation of carbon dioxide necessary for growth, development and maintenance of the plants in the first months of life. Periods dry short are common during the rainy season in the region and can be detrimental to the survival of young plants whose root system is not yet fully developed and the effects of shading become especially critical in forest environments [20] or agroecosystems consortium due to natural competition between species.

Table 2: Multivariate analysis using Hotelling Test for comparison of the physiological behavior of young plants of soursop, Tonka bean and Copaíba submitted to 4 treatments (T)* in greenhouse conditions. The variables studied was A (µmol CO_2 m^{-2} s^{-1}), GS (mol H_2O m^{-2} s^{-1}), E (mmol H_2O m^{-2} s^{-1}) and T (° C).
* T1: 100% light + 240 ml H_2O $week^{-1}$, T2: 100% light +0 ml H_2O $week^{-1}$, T3: 80% shading + 240 ml H_2O $week^{-1}$ and T4: 80% shading + 0 ml H_2O $week^{-1}$

	Graviola (soursop)			
Variable	**A**	**Gs**	**E**	**Tf**
Sample 1: T1	12.03	0.08	2.65	41.32
Sample 2: T4	7.96	0.01	0.17	31.97
(p) =	< 0.0001	---	---	---
	Cumaru (Tonka bean)			
Variable	A	Gs	E	Tf
Sample 1: T1	11.86	0.15	2.86	37.72
Sample 2: T4	8.69	0.02	0.27	29.49
(p) =	< 0.0001	---	---	---
	Copaíba			
Variable	A	Gs	E	Tf
Sample 1: T1	12.05	0.08	3.39	41.70
Amostra 2: T4	8.48	0.01	0.23	33.90
(p) =	< 0.0001	---	---	---

According to Lima *et al* 2008, [22] studying the growth of *Caesalpinia ferrea Mart. ex Tul*. (Leguminosae, Caesalpinoideae) found that this specie had limitations imposed on light conditions (50 and 70% shading), reducing biometric variables that affect better growth. However, Siebeneichler *et al*. (2008) [40] found that the growth of H*ymenaea* and *E. contortisiliquum* under 80% shade level as well as 30, 50% favors the formation of stronger seedlings.
According to Costa e Marenco 2007 [7], they found a low correlation between A and Gs and between Gs and Ψ, confirming that both photosynthesis and stomatal conductance are parameters of the plant simultaneously respond to a set of factors that interact in a coordinated manner, but highly complex. While the low concentration of CO_2 and high irradiance directly stimulate the opening of the stomata, low humidity and excessive sweating cause decrease in leaf water potential, which can lead to the closing of the stomata (Marenco *et al* 2006) [25].
According to Medina *et al* 1999, studying photosynthesis, stomatal conductance and transpiration in *Valencia Orange* under water stress observed that photosynthesis increased around 9:00 am, when it reached a maximum of 7-8 mmol of CO_2 m^{-2} s^{-1}, then decreasing and remaining virtually stable until 16:00. Stomatal conductance also decreased after 9:00 with averages were 0.08 mol $H_2O.m^{-2}.s^{-1}$ to values close to zero and at 8:00 am sweating were close to zero and along the day increased reaching 6 mmol H2O m^{-2} s^{-1}.
According to Ronquim *et al* 2009, [35] studying the growth and photosynthesis of young plant leaves of *C. langsdorffii* under different irradiance, found photo inhibition in the leaves during the dry season and in the shadow associated with drought in the leaves, where the largest means of photosynthesis were around 1-5 umol CO_2 m^{-2} s^{-1}.
Therefore, the carbon absorption is made by leaves while the water and mineral nutrients is made by the roots, resulting in fostering biomass allocation in leaves when light limitation

and in favor of roots where mineral nutrients become limiting for growth (Shipley 2002) [39].

The growth and primary productivity of ecosystems are dependent mainly on the process of photosynthesis. The chemical energy stored in the oxidation reaction processed through the electron transport chain in the thylakoid of chloroplasts by a series of clips to produce NADPH and high-energy molecules (ATP) to use in reduction reactions of carbon (Melis 1999) [28]. Thus, the species can accumulate carbon under stress conditions (high light intensity and low nutrient availability, for example) and carbon stocks can sustain growth when the stress is relieved (Martin & Smith 1995) [27]. Our results showed different levels of physiological plasticity among the three species studied before light and water stress, thus daytime photosynthesis regulatory processes are essential to maintain a positive internal balance for the various processes involved (physical components, photochemical and biochemical) while responding to environmental conditions (Geiger & Servaites 1994) [10]. News studies are need for understanding all physiological behavior of *A. muricata, D. odorata and C. langsdorffii,* like studies with osmotic adjustment and fluorescence.

4. Conclusions

The interaction of water and light stress can influence the development of Amazonian species such as *A. muricata, D. odorata and C. langsdorffii* during the early stages of growth, especially in photosynthetic capacity and transpiration, stomatal conductance and leaf temperature plants.

The water and light stress affected more *D. odorata*, because it is a complaining sort of light and rapid growth, while *C. langsdorffii* and *Annona muricata* were more tolerant to water stress because they have drastically reduced the stomatal conductance and transpiration rates. In function of the ethnobotany´s importance that such species have to Amazonian populations, physiological responses found here, suggest different ways of cultivation and water´s supply.

5. Acknowledgments

Our Acknowledgments for CNPQ (financial support).

6. References

1 Astirin OP, Artanti AN, Fitria MS, Perwitasari1 EA, Prayitno A. *Annona muricata* Linn Leaf Induce Apoptosis in Cancer Cause Virus, Journal of Cancer Therapy, 2013; 4:1244-1250 http://dx.doi.org/10.4236/jct.2013.47146

2 Ayres M. Bio Estat 5.0: Statistics Applications in Medical and Life Sciences, Belém, PARÁ, 2007.

3 Batista MMF. Effects of macronutrient omission on growth, symptoms of nutritional deficiency and mineral composition in *Annona muricata*. *Revista Brasileira de Fruticultura*, Jaboticabal, 2003; 25(2):315-318.

4 Carneiro RLC. Water consumption in *Eucalypt* plantation: part 1: determination of stomatal conductance in irrigated and non-irrigated treatments. *Revista Árvore,* Viçosa-MG, 2008; 32(1):1-10.

5 Clay JW, Sampaio PTB, Clement CR. Amazonian biodiversity: examples and use strategies. Business and Technological Development Program, Manaus-AM. 2000, 409.

6 Costa Azevedo GF. Photosynthetic parameters and growth in seedlings of *Bertholletia excelsa* and *Carapa guianensis* in response to pre-acclimation to full sunlight and mild water stress. *Acta Amazonica* 2014; 44(1):67-78.

7 Costa GF, Marenco RA. Photosynthesis, stomatal conductance and leaf water potential in young trees of andiroba (*Carapa guianensis*). *Acta Amazônica*, 2007; 37(2):229-234.

8 Cruz JA. Plasticity in light reactions of photosynthesis for energy production and photo protection. *Journal of Experimental Botany*. 2004; 56:395-406.

9 Empresa Brasileira de Pesquisa Agropecuária da Amazônia Oriental Soil Analysis results. Embrapa Amazônia Oriental: Laboratório de Solos, 2011.

10 Geiger DR, Servaites JC. Diurnal regulation of photosynthetic carbon metabolism in C3 plants. *Annual Review of Plant Physiology and Plant Molecular Biology*, 1994; 45:235-256.

11 Gonçalves JFC. Growth, photosynthesis and stress indicators in young rosewood plants (*Aniba rosaeodora* Ducke) under different light intensities. *Brazilian Journal Plant Physiology*, 2005; 17:325-334.

12 Gonçalves JFC. Chlorophyll fluorescence analysis of young plants of *Carapa guianensis* and *Dipteryx odorata* under two light environments. *Acta. Amazônica*, 2010; 40(1).

13 Holmes PM, Cowling RM. Effects of shade on seedlings growth, morphology and leaf photosynthesis in six subtropical thicket species from eastern Cape, South Africa. *Forest Ecology Managemen*t, 1993; 61:199-220.

14 Hsiao TC. Plant responses to water stress. Annual Review of Plant Physiology and Plant Molecular Biology, 1973; 24:519-570.

15 IPCC, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea and L.L.White (Eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2014, 1-32.

16 Ijaz Rasool Noorka1, Saba Tabasum. An Empirical Approach to Get the Vitality of a Genotype to Water Stress Tolerance in Yield and Yield Contributing Traits. American Journal of Plant Sciences 2013; 4:999-1003 http://dx.doi.org/10.4236/ajps.2013.45123

17 Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis Tapajós National Forest: Management Plan. Belterra, Pará: IBAMA. 2004, 373.

18 Instituto Nacional de Meteorologia (INMET). Climatological data from Santarém-PA City in 2011: Automatic Weather Stations. Brasília, DF: INMET, 2011.

19 Jaquetti RK, Gonçalves JFC, Ferraz JBS, Ferreira MF. Green Fertilization Enhances the Photosynthetic Performance and the Growth of Leguminous Trees for Restoration Plantation in Central Amazon. American Journal of Plant Sciences. 2014; 5:2497-2508.

20 Kanegae Mf, Braz VS, Franco AC. Effects of seasonal drought and light availability on survival and growth of *Bowdichia virgilioides* in two typical vegetation types of savannas on central Brazil. Revista Brasileira de Botânica, São Paulo, 2000; 23(4):459-468.

21 Kozlowski TT. *Tree growth*. The Ronald Press, New York, 1962, 149-170.

22 Lima JR. Light effects on the growth of seedlings of

Caesalpinia ferrea Mart. ex Tul. (Leguminosae, Caesalpinoideae). Acta Amazônica, 2008; 38(1):5-10.
23 Lourenço ACS, Baroneza JE, Ramos SP, Miguel LK, Juliani LC, Taylor AP *et al*. American Journal of Plant Sciences. 2014; 5:3464-3473.
24 Marchese JA. Water deficit effect on the accumulation of biomass and artemisinin in annual wormwood (*Artemisia annua* L., Asteraceae). Braz. J Plant Physiol., 2010; 22(1):1-9.
25 Marenco RA. hydraulically based stomatal oscillations and stomatal patchiness in Gossypium hirsutum. Functional Plant Biology, 2006; 33(12):1103-1113.
26 Marenco RA. Leaf micronutrient concentrations and potential photosynthesis in *Ochroma pyramidale* established in a degraded land Acta Amazonica. 2003; 33(1):23-31.
27 Martin Ce, Smith AM. Starch biosynthesis. The Plant cell, 1995; 7:971-985.
28 Melis A. Photosystem-II damage and repair cycle in chloroplasts: what modulates the rate of photo damage *in vivo*? Trends in Plant Science, 1999; 4(4):130-135.
29 Medina CL, Machado EC, Gomes MMA. Stomatal conductance, transpiration and photosynthesis in orange 'valence' under water deficiency. Revista Brasileira de Fisiologia Vegetal, 1999; 11(1):29-34.
30 Nogueira RJMC. Physiological expression of acerola *(Malpighia emarginata D. C.)*. Tese de Doutorado. Universidade Federal de São Carlos, São Carlos. 1997, 205.
31 Nogueira RJMC. Changes in resistance to vapor diffusion of leaves and water relations in cherry plants subjected to water déficit. Revista Brasileira de Fisiologia Vegetal, 2001; 13(1):75-87.
32 Noorka1 IR, Tabasum S. An Empirical Approach to Get the Vitality of a Genotype to Water Stress Tolerance in Yield and Yield Contributing Traits. American Journal of Plant Sciences, 2013; 4:999-1003; http://dx.doi.org/10.4236/ajps.2013.45123
33 Oren R. Survey and synthesis of intra and interspecific variation in stomatal sensitivity to vapour pressure deficit. Plant, Cell and Environment, 1999; 22(12):1515-1526.
34 Peng XY, Yang SSX, Zhang JY, Mo1 WP, Zhu JY, Ye YX *et al*. Effects of flooding on grafted Annona plants of different scion/rootstock combinations. Agricultural Sciences 2012; 3(2):249-256 http://dx.doi.org/10.4236/as.2012.32029
35 Ronquim CC, Prado CHBA, Souza JP. Growth, photosynthesis and leaf water potential in young plants of *Copaifera langsdorffii* Desf. (Caesalpiniaceae) under contrasting irradiances. Brazilian Journal Plant Physiology. 2009; 21(3):197-208.
36 Santos Filho BG. Biophysical and physiological parameters associated with water saving in sugarcane plants (Saccharum spp.) under water stress. Thesis of Doctored. Universidade de Campinas, Campinas. 1984; 158.
37 Scheriff DW, Muchow RC. The water relations of crops. In: P. R. Goldsworthy & N.M. Fisher (Eds.). The Physiology of Tropical Field Crops. John Wiley & Sons, New York, 1984, 39-83.
38 Schultz T. Ethnopharmacology and physiology of medicinal plants at quilombo Tininigú, Santarém, Pará. Thesis. (Graduate Program of Natural Resources of the Amazon) - Universidade Federal do Oeste do Pará, Conselho Nacional de Desenvolvimento Científico e Tecnológico. Advisor: Patrícia Chaves de Oliveira, 2015.
39 Shipley B, Meziane D. The balance-growth hypothesis and the allometry of leaf and root biomass allocation. *Functional Ecology,* 2002; 16(3):326-331.
40 Siebeneichler SC. Morphological and physiological characteristics in plants of *Tabebuia heptaphylla* (Vell.) Tol. in light conditions. Acta Amazônica, 2008; 38(3):467-472.
41 Soares CRF, Accioly AMA, Lanza de Sá TCL, Marques M, Siqueira JO. Accumulation and distribution of heavy metals in roots, stems and leaves of tree seedlings in soil contaminated by zinc industry wastes. *Revista Bras. Fisiol. Veg*., 2001; 13(3):302-315.
42 Souza CR, Soares AM, Regina MA. Gas exchange of vine cuttings obtained by two rootstocks, submitted to water deficit. *Pesquisa agropecuária brasileira*, Brasília, 2001; 36(10):1221-1230.
43 Souza MH. Soil water availability in *Eucalyptus* productivity in three regions of the basin of Rio Doce. *Revista Árvore*, 2006; 30(3):399-410.
44 Tonini H, Oliveira Jr, MMC, Schwengber D. Growth of Amazonian native species subjected to plant in Roraima. *Ciência Florestal*, 2008; 18:151-158.
45 Yoshida EH, Ferraz MC, Tribuiani N, Silva Tavares RV S, Cogo JC, Santos MG *et al*. Evaluation of the Safety of Three Phenolic Compounds from Dipteryx alata Vogel with Antiophidian Potential. *Chinese medicine*, 2015; 6:1-12. http://dx.doi.org/10.4236/cm.2015.61001