EFFECTS OF METEOROLOGICAL VARIABLES ON *Pinus caribaea* GROWTH IN DIFFERENT AGES AT THE AMAZON REGION.

Gabriel Miranda Lima de Lima[1]*, Nei Sebastião Braga Gomes[2], Thiago Augusto da Cunha[3], Afonso Figueiredo[4]

[1]*Universidade Federal do Acre, Programa de Pós-Graduação em Ciências Florestais, Rio Branco, Acre, Brasil – gabrielmirandalima33@gmail.com
[2]Universidade Federal do Acre, Centro de Ciências Biológicas e da Natureza. Rio Branco, Acre, Brasil – nei.gomes@ufac.br
[3]Universidade Federal do Acre, Centro de Ciências Biológicas e da Natureza. Rio Branco, Acre, Brasil – Thiago.cunha@ufac.br
[4]Universidade Estadual do Centro-Oeste, Departamento de Engenharia Florestal, Paraná, Brasil – afigfilho@gmail.com

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Resumo

Efeito das variáveis meteorológicas no crescimento de Pinus caribaea var. hondurensis Barrett & Golfari em diferentes idades, na região amazônica. O objetivo desta pesquisa foi comparar o efeito de cinco variáveis meteorológicas no crescimento diamétrico da espécie *Pinus caribaea* var. *hondurensis* Barrett & Golfari, no município de Vilhena, Rondônia. Foram avaliadas 1968 árvores, sendo classificadas em diferentes idades: 600 árvores com um ano de idade; 600 árvores com dois anos; e 768 árvores com 13 anos. Nos povoamentos jovens de um e dois anos de idade, realizou-se a medição do diâmetro ao nível do solo (DS), enquanto no povoamento de 13 anos, mensurou-se o seu diâmetro a 1,3 m (DAP) e, utilizando-se o trado de Pressler, foram retirados 50 rolos de incremento do DAP para medição dos anéis de crescimento no LINTAB™ 6. O crescimento diamétrico foi avaliado por meio do Incremento Periódico (IP) para os povoamentos jovens; e o Incremento Corrente Anual (ICA) para os povoamentos adultos. Levando em consideração as variáveis: temperatura média (°C), precipitação (mm), radiação solar (Kj m^{-2}), evapotranspiração real (mm) e umidade relativa máxima (%). Para estabelecer a relação entre o crescimento e as variáveis meteorológicas, utilizou-se o coeficiente de correlação de Pearson (r) proposta por Callegari-Jacques e o coeficiente de variação (CV%). Para os povoamentos jovens, as variáveis com maior correlação positiva foi evapotranspiração real e umidade relativa máxima, já nos povoamentos adultos a variável com maior correlação positiva foi a temperatura média, demonstrando uma correlação muito forte até o 6° ano de vida da espécie.

Palavras-chave: Correlação de Pearson, diâmetro ao nível do solo, incremento periódico

Abstract

This study compares the impact of five meteorological variables on the diametric growth of *Pinus caribaea* var. hondurensis Barrett & Golfari in Vilhena, Rondônia. One thousand nine hundred sixty-eight trees were evaluated and classified at different ages: 600 trees were one year old; 600 trees were two years old; 768 trees were 13 years. The diameter measurement at the soil level (SL) was conducted in young stands between one and two years old. In the stand with 13 years old, the diameter was measured at 1.3 m (DCH). Using a Pressler borer, 50 increment cores were removed at DCH to measure the tree rings in LINTAB™ 6. The diametric growth was evaluated through the Periodic Increment (PI) for young stands and Current Annual Increment (CAI) for adult stands. The following variables were considered: average temperature (°C), precipitation (mm), solar radiation (Kj m^{-2}), real evapotranspiration (mm), and maximum relative humidity (%). The Pearson Correlation Coefficient (r) proposed by Callegari-Jacques and the coefficient of variation (CV%) were used to establish the relationship between growth and meteorological variables. For young stands, the variables with higher positive correlation were real evapotranspiration and maximum relative humidity. However, the variable with a higher positive correlation in adult stands was average temperature, demonstrating a strong correlation until the sixth year of the species.

Keywords: Pearson Correlation, diameter at soil level, periodic increment.

INTRODUCTION

From its beginnings until nowadays, the development of the Amazon region was not concerned with the balance between economic development and environment conservation. From the 1960s onwards, the Federal Government fomented the unrestrained substitution of native forests by agricultural and livestock production areas. Such statement is exemplified by the Federal Law n. 5174, from October 1966, which deals with the tax exemption for legal entities related to agricultural and livestock production. In Brazil, the decrease of productive areas in the South and Southeast regions and the tax exemption for new lands in the North were the main responsible for reducing forests in these areas. Currently, the Amazon biome still suffers from its original area's decrease. In January 2020, the Deforestation Alert System of the *Instituto do Homem e Meio Ambiente da Amazônia* – IMAZON detected 188 km² of deforestation in the Legal Amazon, an increase of 74% compared with January 2019, when the deforested area was 108 km².

Agricultural expansion and timber requirement as a raw material generates more degraded areas with low or no productive capacity and the absence of any forest structure. The concept of planted forest emerges as a viable alternative to repopulate such regions. There is a harmonious encounter with economic production, providing raw material for various products, environmental conservation, carbon dioxide fixation, and nutrient reallocation in the area.

Among the most common species in Brazilian planted forests, the species of the genus *Pinus* are highlighted, which were introduced in Brazil in the 19th century by European immigrants. In 2018, forests of this genus occupied 1.6 million hectares, concentrated in Paraná (42%) and Santa Catarina (34%). Such stands are primarily for the pulp and paper industry, lumber, and resin gum extraction (IBÁ, 2018).

Some states of the North region, such as Amapá, Roraima, Tocantins, and Pará, have considerable extensions of planted forests due to the metallurgy and pulp industries in the region. However, in the northern states of Amazonas, Acre, and Rondônia, the areas are small but with expressive growth (MOREIRA et al., 2017). Among the species of the genus *Pinus* used in the states of Acre and Rondônia, *Pinus caribaea* var. *hondurensis* Barrett & Golfari is highlighted due to its favorable adaptation to the climatic conditions, especially in Rondônia.

There is a variety of studies about the climatic influence on the growth of *Pinus* individuals. Nevertheless, observing the studies related to the Amazon region, there is a limitation to recommend species with better adaptation to the different climates and with better yields in the various states of the region (VERÍSSIMO; PEREIRA, 2015). Pelissari et al. (2011), while determining volumetric models for *Pinus caribaea* var. *hondurensis* and *Pinus tecunumanii* in stands 12 years old, reported that many volume models of the literature have the performance affected by the species and the regional climate.

In this context, this study compares the effects of five meteorological variables on the diametric growth of *Pinus caribaea* var. *hondurensis* Barrett & Golfari in Vilhena, Rondônia. We hypothesize that this species' correlation of diametric growth varies during the seasons and under different spacings. Such information permits managers to know the periods of higher growth for the species and the best period for applying forestry practices.

MATERIALS AND METHODS

Study area

This study was conducted in Vilhena, Rondônia. Vilhena is situated at the south of Rondônia, latitude 12º44’26” S, and longitude 60º08’45” W. The average altitude is 615 meters, and the territorial extension is 11,699.146 km², with an estimated population of 97,448 inhabitants. The predominant climate is the Aw-type according to the Köppen classification (tropical with a dry season during the winter). The municipality has a warm and wet climate, considered mild for the climatic standards of the Amazon region, with cold averages between April and September, an average annual temperature of 25.8 °C, and average annual precipitation of 2,043.60 mm. It presents a soil classified as Latossolo Vermelho-Amarelo distrófico, sandy texture, which is associated with areas of flat, slightly undulated, or undulated reliefs (SCHLINDWEIN et al., 2012).

For the research development, stands of the species *Pinus caribaea* var. *hondurensis* Barrett & Golfari were evaluated in two areas of Vilhena-RO: the farm OCB Forestry (12°29'31" S and 60°03'17" W), with a total planted area of 2,585 ha; and the farm Nova Londrina (12°39'13" S and 60°18'47" W), with a total planted area of 241.24 ha.

Data collection

To evaluate the growth of the species *Pinus caribaea* var. *hondurensis* Barrett & Golfari, it was established that the trees of the farm OCB Forestry represented the young stand of the study. In this area, 600 trees planted in 2016 were selected, and 600 trees planted in 2017, resulting in 1,200 trees, with a spacing of 3.50 x 2.70 m. In each measurement of these trees, the diameter at the soil level (SL) was evaluated using a digital caliper. These stands were measured every four months, during one year and four months between August 2018 and December 2019.

The trees of the farm Nova Londrina represented the adult stand of the study, with 13 years old trees. Seven hundred sixty-eight trees were selected, with a spacing of 2.50 x 2.50 m. For this stand, two data collections were conducted, in December 2018 and December 2019, to compare the manual diametric measurement with the analysis of the rings and determine which trees would provide the core samples. With this aim, the circumference of these trees was measured at 1.3 m height (DCH) with a tape measure. Besides, 50 trees were sampled with a Pressler borer, extracting increment cores at DCH. 10 trees were collected for the following diametric classes: Class I (10-15 cm), Class II (15-20 cm), Class III (20-25 cm), Class IV (25-30 cm), Class V (larger than 30 cm).

Afterward, the increment cores had their surfaces thinned out with sandpapers of different grit sizes, 120, 150, and 180, used in this order. This procedure was necessary for clear visualization and measurement of the growth rings with the tool RINNTECH LINTAB™ 6 in the Forestry Science Laboratory of the UFAC.

Increment correlation with the meteorological variables

To analyze diameter growth at soil level (SL) in young stands, the Periodic Increment (PI) was determined every four months, corresponding to the interval between measurements. After these increments were determined, graphics were made, relating them with the months to compare the species' growth in the two seasons of the region: the rainy and the dry season. A comparison of the periodical increments with the meteorological data was made to corroborate this relationship between growth and the different seasons. It took into account the meteorological variables provided by the *Instituto Nacional de Meteorologia* (INMET - National Institute of Meteorology), which has in its database information for the years between 2010 and 2020, such as average temperature (°C), precipitation (mm), solar radiation (Kj.m-²), real evapotranspiration (mm), and maximum relative humidity (%). All meteorological data were obtained from the INMET database from two meteorological stations at Vilhena – RO. The first was at the *Instituto Federal de Rondônia* (Federal Institute of Rondônia) and the second at the margins of the road BR-364. The distance between the first station and the farms, Nova Londrina and OCB Forestry, is 20 and 29 km, respectively. The distance of the second station from the farms, Nova Londrina and OC Forestry, is 14 and 27 km, respectively.

To substantiate this correlation between the growth of *Pinus caribaea* var. *hondurensis* Barrett & Golfari and the meteorological variables, we compared it with stands of different ages, as aforementioned. Thus, we made a historical analysis of this relation in adult stands by comparing the Current Annual Increment (CAI) for diameter at chest height without bark, based on the data obtained by the increment cores' measurement, and the meteorological variables: average temperature (°C) and precipitation (mm).

Data representativeness

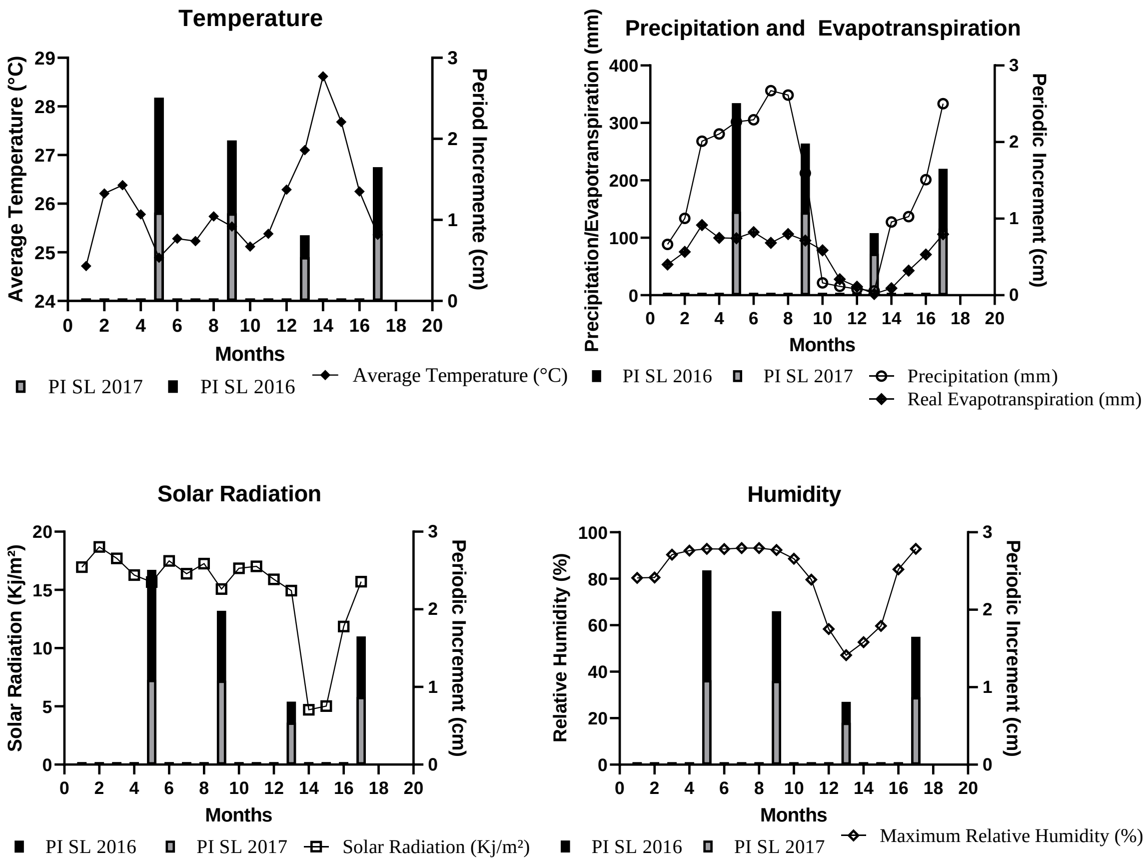
Pearson (r) correlation analysis for the evaluation period and the two seasons was conducted to establish the existence or absence of relation between the meteorological variables aforementioned and the species growth. The data obtained were submitted to the statistical analysis in the Statistical Analysis Software (SAS) on-demand version for academics, determining the variance values, correlation coefficient in percentage (CV%), standard deviation, and Pearson correlation.

This correlation coefficient is highly susceptible to outliers. Therefore, it was necessary to establish a maximal acceptable value for data distribution. Thus, we used the coefficient of variation (CV%) below 35% for each variable studied. The classification proposed by Pimentel-Gomes & Garcia (2002) was adapted for this coefficient. According to the authors, this coefficient is low when below 10%; mid, between 10 and 20%; and high between 20 and 30%. This adaptation was essential due to the difference in the stands' age and the striking differences between the growth of the diameter at chest height and diameter at soil level. This fact means that these growth variables present different growth rates, perceived in a previous diagnostic inventory of the area.

The qualitative evaluation of the Pearson correlation (r) was made based on the criteria established by Callegari-Jacques (2007). According to the author, if the correlation is between $0,00 < r < 0,30$, there is a weak linear correlation; if $0,30 \leq r < 0,60$, there is moderate linear correlation; if $0,60 \leq r < 0,90$, there is strong linear correlation; if $0,90 \leq r < 1,00$, there is a very strong linear correlation.

RESULTS

The diameter at the soil level is a variable widely used to describe the initial growth behavior of a tree species in response to the climatic variations of a given region (SCHNEIDER et al., 2014). While evaluating this variable's increment, a behavioral difference was perceived between the stands of 2016 and 2017. The stands planted in 2016 presented higher growth. Nevertheless, such growth oscillated according to the season, with higher growth in the rainy period between September and May (represented in the graphic by the months from 2 to 10) (Figure 1). This dendrometric variable presented positive and negative responses regarding the meteorological variables for both young stands. This fact graphically demonstrates a directly proportional increase in the diameter increment at the soil level regarding the variables precipitation, solar radiation, real evapotranspiration, and maximum relative humidity. Nevertheless, the average temperature presented an inversely proportional behavior to the increment.



Legend: Months 1 to 17 – the period between August 2018 and December 2019; The evaluations of the meteorological variables were made monthly from August 2018 and December 2019.

Figure 1. Relation between the periodic increments of the diameter at soil level and the monthly meteorological variables with more correlation with *Pinus caribaea.*

Figura 1. Relação entre incrementos periódicos em diâmetro ao nível do solo com as variáveis meteorológicas mensais mais correlacionadas com *Pinus caribaea*

The accumulated diameters at the soil level and their respective periodic increments for both stands presented coefficients of variation below 35% (Table 1). This number indicates a variation of the data obtained according to the limits stipulated in this study. Thus, higher efficiency is guaranteed to determine a positive or negative relationship between this variable and the meteorological alterations of the region studied. However, the data related to the periodic increment of the diameter at the soil level of the 2017 stands presented a coefficient of variation of 39.23%, which is higher than stipulated by the study due to these stands' juvenility (Table 1). Nevertheless, such data were inserted in the evaluation, considering that their respective diameter at the soil level presented a coefficient of variation of 34.36%, which is within limits established in this study (Table 1).

Table 1. Descriptive statistics for the dendrometric variable diameter at soil level of young stands of *Pinus caribaea* var. *hondurensis* Barrett & Golfari.1

Tabela 2. Estatísticas descritivas para a variável dendrométrica diâmetro a altura do solo de povoamentos jovens de *Pinus caribaea* var. *hondurensis* Barrett & Golfari.

Variables	$\bar{X}$	s	CV%
SL 2016	7.7627	2.6807	34.53
SL 2017	4.0674	1.3975	34.36
PI SL 2016	1.7375	0.2593	28.98
PI SL 2017	0.8950	0.5110	39.23

Average Temperature	25.7200	0.9589	3.73
Precipitation	213.835	146.8823	68.70
Solar radiation	15.34825	0.3949	2.57
Real Evapotranspiration	75.6275	49.1760	65.02
Maximum Relative Humidity	81.3300	22.7880	28.02

Legend: $\overline{X}$ – arithmetic mean; s – standard deviation; SL – diameter at soil level; PI SL –periodic increment of the diameter at soil level; average temperature (°C); Precipitation (mm); Real evapotranspiration (mm); solar radiation (Kj.m-²); Maximum Relative Humidity (%).

The periodic increment of the diameter at the soil level (PI SL) was an efficient variable to determine the growth correlation with the climatic characteristics of the region. The Pearson correlation and its classification presented a strong or very strong linear correlation with the five meteorological variables evaluated in the study (Table 2). Besides, the individuals of young stands of different ages presented a similar behavior. Nevertheless, the solar radiation indicated a difference between them. For the young stands implemented in 2016, this variable demonstrated a strong linear correlation with PI SL. However, 2017 stands' individuals had an average linear correlation with their respective PI SL.

Table 2. Pearson correlation matrix between the periodic increment of the diameter at soil level and the meteorological variables in young stands of *Pinus caribaea*

Tabela 2. Matriz de correlação de Pearson entre o incremento periódico do diâmetro ao nível do solo e as variáveis meteorológicas em povoamentos jovens de *Pinus caribaea*

Meteorological variables	**PI SL**	**2016 stands r-PI SL 2016**	**p-value**	**PI SL**	**2017 stands r-PI SL 2017**	**p-value**
Average Temperature	-0.9442	Very strong	p<0.01	-0.9183	Very strong	p<0.01
Preccipitation	0.7915	Strong	0.0388	0.7727	Strong	0.0390
Solar radiation	0.6269	Strong	p<0.01	0.4976	Moderate	p<0.01
Real Evapotranspiration	0.8398	Strong	0.0451	0.8830	Strong	0.0656
Maximum Relative Humidity	0.8686	Strong	p<0.01	0.9185	Very strong	p<0.01

Legend: PI SL – periodic increment of the diameter at soil level; Average temperature (° C); Precipitation (mm); Real evapotranspiration (mm); solar radiation (Kj.m-²); Maximum Relative Humidity (%).

The meteorological variable with a higher positive correlation with the diametric increment was the maximum relative humidity with values of 0.87 and 0.92 for the 2016 and 2017 stands. On the other hand, the meteorological variable with a higher negative correlation with this increment was the average temperature with values of -0.94 and -0.92 for the 2016 and 2017 stands. This strong relationship is evidenced in the period of average temperature increase, especially between the 12th (July 2019) and 17th (December 2019) months measured – drought period in the region. In this period, the relationship was inversely proportional between the diametric increment and the average temperature in these stands (Figure 1).

The correlations obtained by the analysis of young stands are not sufficient to demonstrate the entire behavior of a species in a given region. Therefore, we evaluated if the behavior in the initial stages of the species *Pinus caribaea* var. *hondurensis* Barrett & Golfari was similarly manifested in older individuals.

The data obtained from the evaluation of the growth ring's samples of adult individuals made it possible to graphically relate these individuals' growth with the meteorological variables precipitation and average temperature. This growth was determined by the Current Annual Increment of the DCH (without bark) – CAI DCHwb – of this species. When related to the meteorological variables precipitation and average temperature, an atypical behavior was observed during these individuals' lives, directly or inversely proportional only in the first years. However, with more years, this behavior did not present a direct relation between these variables (Figure 2).

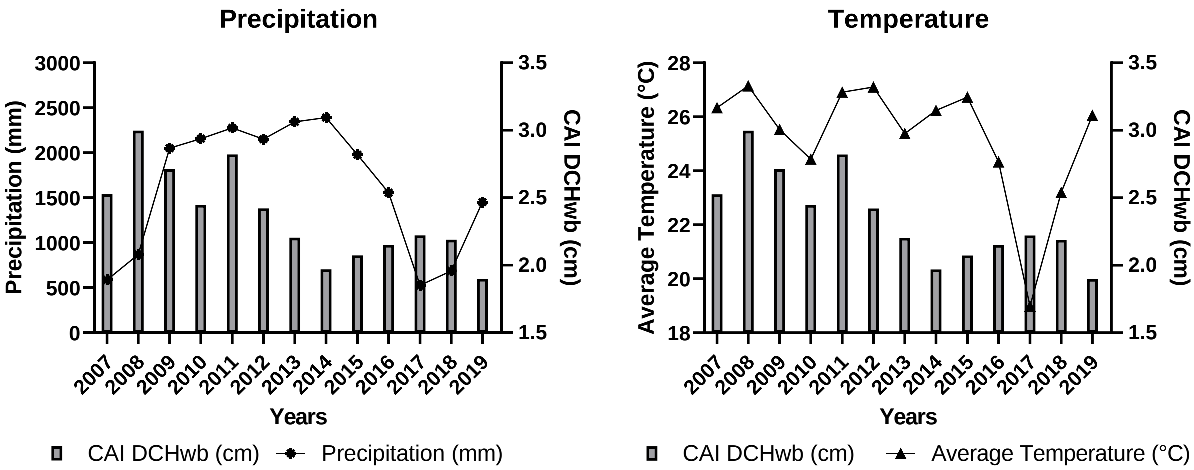


Figure 2. Relation between the current annual increment in the diameter at chest height without bark (DCHwb) and the meteorological variables with more correlation with *Pinus caribaea* var. *hondurensis* Barrett & Golfari.

Figura 2. Relação entre o incremento corrente anual em diâmetro altura do peito sem casca (DAPsc) com as variáveis meteorológicas mais correlacionadas com *Pinus caribaea* var. *hondurensis* Barrett & Golfari.

While evaluating the Pearson correlation in adult stands of *Pinus caribaea* var. *hondurensis* Barrett & Golfari, the behavior graphically presented was considered atypical. The correlation between the Current Annual Increment in DCHwb and the meteorological variables demonstrated a strong correlation until the sixth year of the trees for both variables. The meteorological variables presented a moderate correlation with the increment until nine years old. After this period, a difference in this correlation occurred regarding the variable average temperature, which showed a weak correlation with growth for 12 years old trees (Table 3). Due to this difference in the correlation of both variables after nine years, we represent the data in 3-year intervals.

Table 3. Pearson correlation matrix between the meteorological variables and the current annual increment in the diameter at chest height without bark (DCHwb) in adult stands of *Pinus caribaea* var. *hondurensis* Barrett & Golfari.

Tabela 3. Matriz de correlação de Pearson entre variáveis meteorológicas e o incremento corrente anual em diâmetro altura do peito sem casca (DAPsc) em povoamentos adultos de *Pinus caribaea* var. *hondurensis* Barrett & Golfari.

Years	Precipitation	r-Precipitation	p-value	Average Temperature	r-Temperature	p-value
3	-0.9094	Strong	0.0146	0.9958	Strong	0.0007
6	-0.7044	Strong	0.0499	0.5347	Strong	0.0001
9	-0.4676	Moderate	0.0547	0.3365	Moderate	0.0009
12	-0.3870	Moderate	0.0897	0.2624	Weak	0.0096

Legend: r-Precipitation – qualitative evaluation of the Pearson correlation (r) for precipitation; r-Temperature – qualitative evaluation of the Pearson correlation (r) for average temperature.

The qualitative evaluation of the Pearson correlation indicated that, during the 12 years lifespan, the meteorological variables presented an interaction from moderate to weak with the diametric growth. It is worth mentioning that, differently from young individuals, the adult trees showed a different behavior regarding the meteorological variables precipitation and average temperature. This fact indicates that different forestry treatments, managements, or soil preparation types can significantly interfere in evaluating the behavior observed for the species *Pinus caribaea* var. *hondurensis* Barrett & Golfari.

DISCUSSION

Diameter is a dendrometric variable with high oscillation during the life cycle of a tree. Besides, the position in which this variable is measured makes it easily influenced by other internal factors of the plants, such as the species conicity, the root type, bark morphology, among others (MACHADO et al. 2014). Thus, distinct values between individuals of the same stand are often found while measuring diameter at the soil level, resulting in more data variation. Silva et al. (2019a), while evaluating the productivity of *Pinus caribaea* var. *hondurensis* Barrett & Golfari in the Brazilian Cerrado region, found average coefficients of variation for the variable diameter at chest height (DCH), according to the classification established by Pimentel-Gomes & Garcia (2002). Advanced stages of physiological maturity or chronological age of these trees promote homogenization of the height parameters and an uneven standard for the variables DCH and volume (SILVA et al., 2019).

The meteorological variables evaluated presented different correlations regarding the increment of diameter at the soil level. For both young stands – 2016 and 2017 stands – this dendrometric variable showed positive and negative responses regarding the meteorological variables. They graphically demonstrate a directly proportional increase in the variables of precipitation (mm), solar radiation (Kj/m²), real evapotranspiration (mm), and maximum relative humidity (%). The maximum relative humidity stood out, expressing a higher positive correlation with the increment. The maximum relative humidity indicates the amount of water vapor in the air. A high amount of water in the gaseous form directly influences the metabolic processes of plants, resulting in a lower transpiration loss by the plants, which permits an increase of their photosynthetic rate (LANDSBERG; SANDS, 2011). Thus, observing in figure 1 the rainy season of the region, between September 2018 and May 2019, we found a higher accumulation of diametric increment in 2016 stands. In the same perspective, the correlation between the meteorological variables precipitation and real evapotranspiration and the growth of the species *Pinus caribaea* var. *hondurensis* Barrett & Golfari can be understood, as they are attributes that directly influence the amount of water available in the system soil-plant and, then, the transpiration to the atmosphere (TESKEY et al., 2015).

Nevertheless, considering the 2017 stand, the meteorological variables did not affect the diametric increment in the rainy season. A possible explanation is that juvenile individuals, such as in this stand, prioritize height growth instead of diametric growth. Machado et al. (2014), who evaluated the monthly growth of *Pinus taeda*, found that the current annual increment in diameter at 10 cm from the soil presented low variation in the three years studied. However, while evaluating the monthly increment in the third year, they observed alterations related to the meteorological variables temperature, photoperiod, and lower temperature.

During the drought season, between July and December 2019, the meteorological variables directly affected the diameter increment at soil level in both young stands. Therefore, observing in figure 1 the relation between the diametric increment and the average temperature, it is possible to observe an inversely proportional correlation where the increase in average temperature corresponds to the decrease in the plant's increment. Furthermore, this fact can be found by the Pearson correlation of the average temperature regarding the periodic increment of diameter at soil level with values of -0.94 and -0.92 in the 2016 and 2017 stands, indicating a very strong negative correlation. This fact might be explained by the ideal average temperature for the species studied. *Pinus caribaea* var. *hondurensis* Barrett & Golfari presents an ideal temperature range for its growth between 20 and 27°C (SILVA et al., 2011). In temperatures over the ideal range, the plant is stressed, reducing its sunlight absorption and photosynthetic capacity (PEREIRA et al., 2018; BILA et al., 2012). Higher temperatures can reduce plant growth due to their negative effect of inactivating or accelerating enzyme systems that promote the coagulation and denaturation of proteins, resulting in plant tissue damage (PIROVANI et al., 2018). In this case, the region's average temperature varied between 25 and 29°C, reflecting directly in the periodic increment reduction in the hottest months between July and October. In September 2019, the average temperature was 29°C.

Solar radiation presented the lowest positive correlation with the increment in diameter at the soil level among all meteorological variables, with values of 0.63 and 0.50 for the young stands of 2016 and 2017. A possible explanation is the photosynthetic capacity of these plants. Young individuals present a limited ability to absorb solar radiation. Then, the increase in this meteorological variable is not followed at the same speed by the diametric growth of individuals.

Evapotranspiration in this study presented a strong correlation with diameter increment at the soil level. In this sense, this meteorological variable is essential for many mechanisms and metabolic processes of plants. It highlights the photosynthesis process, as the water vapor concentration in the atmosphere is indispensable for cellular respiration and CO_2 absorption, essential resources for plants. Moreover, this variable presents a relation with the others, as the high concentration of water vapor emission to the atmosphere, for instance, provokes a reduction in local temperature.

Observing the adult stands shows an inversely proportional relationship between the species growth and the precipitation until its 6th year (table 3). This relation might be explained by soil type in the region studied, classified as red-yellow latosol, with dystrophic sand, which presents low nutrient retention capacity in its layers, making it susceptible to leaching during rains. According to Viera & Schumacher (2010), the availability of essential micronutrients for photosynthesis – potassium (K) and magnesium (Mg) – is related to the leaching action caused by rain excess. Nevertheless, according to Silva et al. (2016), *pinus caribaea* varieties present higher values for organic matter content, which is an indicator of these species' capacity for better soil covering and the chemical attributes in red latosol soils. Similarly, according to Braga et al. (2016), *pinus caribaea* var. *hondurensis* presents a system with low efficiency to maintain fertility and life-emerging conditions in the soil.

Furthermore, the Pearson correlation in table 3 between the increment in diameter at chest height without bark (DCHwb) regarding precipitation shows a moderate relation between this variable from the 9th to the 12th year of trees. For instance, with the plant and its structure development, the deeper root system reduces the exclusive dependency on the rainfall rate. Besides, through the emergence of interactions with other organisms that aid nutrient absorption, such as the association between roots and fungi, called mycorrhiza, the plant can reduce the negative effect promoted by the excess leaching.

However, the relation between average temperature and diametric increment presented opposite behaviors between young and adult stands, being an inversely proportional relation in young stands and a directly proportional in adult stands. Temperature is directly related to the amount of solar radiation in the soil, i.e., a higher temperature directly indicates a higher incidence of solar radiation (GÓMEZ et al., 2018). Thus, as the temperature increase is related to the amount of solar radiation, we can state that, with a higher temperature, there is a higher photosynthesis rate by plants, which indicates a higher production of photoassimilates and living tissues. Therefore, by presenting a more developed root structure and sap and water flow system, adult trees have higher photoassimilate production gains with temperature increases than young stands (SCHONS et al., 2019).

Another determining factor for this variation is the difference between the dendrometric variables evaluated for young and adult stands, respectively, diameter at soil level (SL) and diameter at chest height without bark (DCHwb), variables with different measurement points in the trees. In addition, distinct spacings between stands can negatively affect plant growth, especially competition between individuals. In this context, adult individuals were planted in an arrangement of 2.50 x 2.50 m between plants, which, by its turn, favor competition between individuals, limiting nutrient availability and permitting the formation of dominant and suppressed trees. This relation directly affects the tree's ability to absorb nutrients and resist drastic climate alterations.

CONCLUSIONS

- The initial growth of *Pinus caribaea* is positively influenced by the increase of the variables precipitation, solar radiation, real evapotranspiration, and relative humidity.
- The meteorological variables precipitation and average temperature presented divergent responses regarding diametric growth due to differences in soil, spacing, and age of trees.
- Finally, further studies are required to explain how this species' root development and the interaction soil-plant can alter the influence of meteorological variables on its growth.

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