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Gas exchange in bacurizeiro (*Platonia insignis* Mart.) genotypes in the dry and rainy seasons in the Middle North region of Brazil

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Abstract

The bacurizeiro (*Platonia insignis* Mart.) is a species of great economic and social importance in the North and Middle North regions of Brazil. However, little is known about the environmental effects on its physiological characteristics. The objective of this work was to determine the gas exchange of genotypes of bacurizeiro in the dry and rainy seasons in the Middle North region of Brazil. The experiment was conducted in the Embrapa Meio Norte experimental field, located in Teresina-Piauí. A completely randomized design in a 7x2 factorial scheme was used, with seven genotypes and two seasons (dry and rainy), with three replications. The genotypes were M1MP14p12f1, M1MP14p13f1, M2PP2p18f5, M3MP6p14f1, M3MP6p15f1, M4MP6p7f4 and M7PP5p18f3 from the improvement program of Embrapa Meio Norte. Liquid photosynthesis, stomatal conductance, transpiration and internal CO_2 concentration, ratio between internal CO_2 concentration and ambient CO_2 concentration, intrinsic water use efficiency and instant water use efficiency were evaluated. The environmental variation affects the plasticity of the bacurizeiro genotypes. There is less efficiency in the use of water in the dry period in all genotypes of bacurizeiro, with values between 1.20 and 1.55 µmol CO_2 m^{-2} s^{-1} / µmol H_2O m^{-2} s^{-1}, respectively. The genotypes M1MP14p13f1, M2PP2p18f5 and M7PP5p18f3 are the most stable in the face of environmental variations, since in both seasons they are in the same formed groups.

Keywords: Climatic variation; *Platonia insignis*; Native fruit trees; Phenotypic plasticity; Photosynthetic rate.

Introduction

Brazil has one of the largest biodiversities in the world in native fruit trees, among which stands out the bacuri tree, a tall tree that probably has its center of origin in the western Amazon, more precisely in the state of Pará (Oyama-Homma et al., 2018). In addition to this, the occurrence in the whole North region of Brazil and part of the Northeast Region, mainly in the states of Maranhão and Piauí, where it is a source of income for thousands of families at the time of production, is highlighted (Paraense et al., 2020).

Native fruit trees, especially bacuri, have gained space in the market outside the regions of occurrence due to their chemical and therapeutic properties, in addition to their high commercial value. These factors have aroused great interest in the area of fruit agribusiness, so universities and research centers have been looking for agronomic methods and techniques that enable a commercial and rational exploitation of the bacurizeiro (Amorim et al., 2020). The knowledge of the physiological mechanisms of the species may be a starting point for the selection of genotypes more adapted to climatic adversities, which may result in more productive plants (Paraense et al., 2020). Plants in general have different physiological patterns, which according to Castro et al. (2005) may be attributed to intrinsic characteristics, such as: leaf size and shape, color, waxy, orientation in relation to the light beam and the amount of palisade and lacunous parenchyma. These are strongly influenced by environmental conditions, light, temperature, wind, availability of carbon dioxide and water (Leal et al., 2020). In addition to this, photosynthesis is the main mechanism of energy entry in living beings, being a complex process by which green parts of plants produces organic compounds and oxygen from carbon dioxide and water in the presence of light (Marrenco 2009). The photosynthetic rate is higher as the light intensity increases to a certain point, which varies from species to species (Melo-Filho et al., 2020). Furthermore, other environmental factors such as elevated temperature may result in changes in stomata aperture responses, promoting their complete closure, resulting in loss of CO_2 supply, for assimilation of photosynthesis due to loss of stomatal cell turgor caused by excessive plant transpiration (Figueiredo et al., 2019; Leal et al., 2020; Melo-Filho et al., 2020).

There is daily variation in the patterns of environmental factors, according to the time of year for each region. Thus, stomatal conductance decreases during the day as the difference in vapor pressure between the leaf and the atmosphere increases (Marrenco 2009). Conductance is influenced by the degree of opening, size, arrangement and density of stomata per leaf (Leal et al., 2020). These physiological variables influence each other and each plant species has its own pattern.

Phenomena such as photosynthesis, respiration and transpiration are indispensable for survival on the planet, since energy is obtained, CO_2 is absorbed and O_2 is released into the atmosphere, which varies according to each region. The effect of seasonal variation on gas exchange of species of the genus *Platonia* is still scarce in the literature, especially in bacurizeiro.

According to Bertazzoni and Damasceno-Júnior (2011), the morphological characterization and the physiological behavior of plants allow us to understand functional responses with environmental variations, especially to water seasonality. Changes in environmental conditions influence the development of living beings, which in turn increases or reduces an individual's physiological fitness through their plastic behavior (Portes et al., 2010).

Several studies have been carried out with several plant species to understand the capacity that individuals have to adapt to changes in the environment, especially in relation to the availability of light, since it is a major factor in plant growth and development (Rozendaal et al., 2006; Lima et al., 2010; Bertazzoni & Damasceno-Júnior 2011).

The objective of this work was to determine the gas exchange in leaves of different genotypes of bacurizeiro in the dry and rainy seasons, in the Middle North region of Brazil.

Results and Discussion

Seasons influence on genotypes

The analysis of variance revealed a significant effect for the interaction between the genotype and two seasons (dry and rainy) for the variables, except for internal CO_2 concentration and intrinsic efficiency of water use (Table 2). Thus, the results obtained from the gas exchange characteristics evaluated demonstrated that the genotypes combined with the environment may have a direct influence on the physiological behavior of bacurizeiro plants.

In addition to this, the seven bacurizeiro genotypes exhibited differently for the liquid photosynthesis variable (*A*), in which the M4MP6p7f4 genotype showed a higher value, showing to be more efficient in both seasons, resulting in a genotype that responds well to environmental variations, and that even in the face of climatic variation the photosynthetic capacity showed similar behavior (Table 3).

The genotypes M7PP5p18f3, M4MP6p7f4, M3MP6p14f1, M2PP2p18f5, M1MP14p13f1, were the ones that presented the highest values of stomatal conductance (*gs*) and transpiration (*E*) in the dry season, therefore they are more susceptible to water deficit due to high temperatures and low relative humidity of the air. In the rainy season, there were no differences between genotypes (Table 3).

For internal CO_2 concentration and the relationship between internal CO_2 concentration with ambient CO_2 concentration, intrinsic efficiency of water use and instantaneous efficiency of water use, all genotypes showed the same behavior in the dry season, as did stomatal conductance in the rainy season (Table 3). In the rainy season, the genotypes that showed the highest values for C_i were M7PP5p18f3 and M3MP6p15fl, and for C_i/C_a it was M7PP5p18f3 (Table 3).

Regarding liquid photosynthesis, the greatest correlation presented was between *E* and g_s (0.81 and 0.77, respectively) (Table 4), since they are in the same quadrant and positively indicating that one depends on the other (Figure 3).

Liquid photosynthesis showed a greater negative correlation with A/g_s, A/E and C_i, and as the concentration of CO_2 inside the leaf increases, the plant loses water through transpiration and, consequently, the photosynthetic rate decreases (Table 4). For Bond (2000), changes in photosynthesis and conductance patterns are influenced by the age of the plants, where in young plants the process is increasing and tending to stabilize in the maturity period and decreasing with the older plant.

Stomatal conductance (*gs*) showed a higher correlation with transpiration (*E*) (0.98) (Table 4), and these characteristics are strictly linked to the control of stoma opening, regulating the entry and exit of water and carbon dioxide in the plant. According to Leal et al. (2020), stomata may close completely when the water supply is restricted. Thus, the supply of CO_2 ceases and allows the O_2 resulting from photosynthesis to accumulate (Hasanuzzaman et al., 2018). For characteristic intrinsic efficiency of water use (A/g_s), stomatal conductance has the greatest negative correlation (– 0.89) (Table 4).

Lima et al. (2007), working with mahogany (*Swietenia macrophylla* King R.A) seedlings, observed that the effect of water deficiency caused a reduction in stomatal conductance and transpiration rate, of 75.38% and 89.34%, respectively. This occurred due to the reduction of the water potential in the leaf, causing the stomata to close, decreasing stomatal conductance and, consequently, the decrease in transpiration.

The internal concentration of carbon dioxide (C_i) refers to the amount of carbon dioxide inside the cell, in stomatal chambers. This characteristic is quite variable, since it depends on weather conditions, wind speed, shading and time of day. The greatest negative correlation was found with liquid photosynthesis (-0.41) (Table 4). Ribeiro et al. (2020), point out that the reduction in the availability of CO_2 inside the leaf and the resistance to gas diffusion, due to the loss of water through transpiration, may affect the photosynthetic rate.

The degree of dependence between the variables is in the formation of the projections of the axes according to the angle formed between them. The greater the angle, the smaller the degree of correlation between variables. It is observed that *A*, g_s and *E* correlated negatively with C_i, A/g_s

and A/E, reflecting that as A, g_s and E increase, consequently decrease C_i, A/g_s and A/E (Figure 3).
This result shows that the effect of water deficiency, was probably due to the dry season, where high temperatures and low relative humidity occur, favor the reduction of stomatal conductance and transpiration, and consequently, reduce the photosynthetic rate. Bond (2000) points out that the rate of photosynthesis is greatly influenced by environmental conditions, probably due to the reduced water potential in the leaf. The reduction of this potential causes the closure of stomata, decreasing stomatal conductance and causing a decrease in transpiration (Figueiredo et al., 2019; Leal et al., 2020)

Relations between climate and genotypes
Except for the internal concentration of CO_2 (C_i), the other variables are related to the first main component (Figure 3). On the other hand, the second main component is related to C_i. Thus, the first main component presents a contrast between the rate of liquid photosynthesis (A), stomatal conductance (gs), transpiration (E) and C_i/C_a, A/g_s and A/E.
The values of the means of the groups may help in the discussion of which genotypes of bacurizeiro are more adapted to the environmental divergences in relation to the physiological characters. According to Husson et al. (2011), the analysis of main components allows the formation of groups in which the individuals studied have the same characteristics, making it impossible to study individuals separately within each group. The cluster analysis allowed the formation of four groups (Figure 4).
Group 1, formed by genotypes 2, 3, 4, 6, 7 in the dry season, presents the highest scores in PC1 (Figure 4), due to the higher values of A and lower values of C_i (Table 5). Group 2, formed by genotypes 1 and 5, present positive score values at PC1 and negative values at PC2 (Figure 3), since the highest values are for C_i and the lowest values were found for g_s (Table 5).
When evaluated the same genotypes in season 2 (rainy), there is the formation of group 3, formed by genotypes 2, 3, 5, and 7, where they have the lowest scores in PC2 and PC1, according to the values of C_i and A (Table 5). Group 4 is made up of genotypes 1, 4 and 6 which have the highest scores on PC2 and the lowest score on PC1, due to a high C_i value and a low A value.
In bacurizeiro it is observed average values of liquid photosynthesis (A) that varied from 7.97 to 8.47 μmol m^{-2} s^{-1} for groups 4 and 1, respectively (Table 5). Lima Filho & Santos (2009) observed, in *Spondias* species, a photosynthetic rate between 12.43 μmol m^{-2} s^{-1}, in the rainy season and 3.17 μmol m^{-2} s^{-1}, in the dry season. This divergence of values may be due to the very mechanism that the species presents with rapid recovery in the water balance, due to the root system being of the tuberous type, accumulating water, which in high temperature environmental conditions are favorable to a great evapotranspiratory demand.
For Larcher (2004), tree species have distinct photosynthetic bands that may vary from 1.5 to 16 μmol m^{-2} s^{-1} depending on the size conditions, and the shading of the plant. These parameters are strongly influenced by environmental characteristics, such as radiation, temperature, air humidity and CO_2 concentration (Marrenco 2009; Raven et al., 2010).
The highest transpiratory rate may be seen in group 4 with 5.19 mmol m^{-2} s^{-1} (Table 5). However, the lowest conductance is present in group 2, with a value of 0.25 mol m^{-2} s^{-1}. This result was possibly due to the fact that this group is very atypical, since the genotypes are found in different quadrants (Figure 4). The photosynthesis process uses CO_2 from absorption by diffusion through the leaf, through this same path there is the loss of water, controlled by the opening and closing of the stomata. Leal et al. (2020) point out that the greater the loss of water, the lower the conductance inside the cell, due to the reduction in the cell's turgor causing the stomata to close.
The instantaneous efficiency of water use (A/E) expresses quantitatively the instantaneous efficiency of water use, momentarily in gas exchange, which results from the absorption of CO_2 and the loss of water to an atmosphere controlled by the stomata, where this CO_2 is converted into phytomass through the photosynthetic process. According to Condon & Hall (1997), it is possible to improve the adaptation of species to different environments in which they are grown, due to genotypic variations in the assimilation of carbon dioxide and water. This efficiency changes according to the conditions for the diffusion of CO_2 and H_2O (Figueiredo et al., 2019; Leal et al., 2020). In this sense, as the genotypes in group 4 have the lowest A/E value (1.67 μmol CO_2 m^{-2} s^{-1} / μmol H_2O m^{-2} s^{-1}) considering two different seasons, they are possibly less adapted (Table 5). Portes et al. (2010) mention that the potential of a species to adapt to environmental extremes is probably related to the pattern of environmental variability present in its habitat.
Lima et al. (2010), working with growth and phenotypic plasticity of young *Caesalpinia echinata* Lam. (Pau-Brasil) - Fabaceae, *Cariniana legalis* (Martius) Kuntze (Jequitibá) - *Lecythidaceae* and *Genipa americana* L. (Jenipapo) - Rubiaceae plants at different levels of light radiation under natural conditions, that is, full sunlight and the 'Cabruca' environment (Atlantic Forest thinning for the cultivation of cocoa), and at four levels of artificial shading in greenhouse conditions, they observed that the differences in phenotypic plasticity between environments and species were more accentuated in the natural shade experiment.
Rozendaal et al. (2006) highlighted that phenotypic plasticity in relation to the sun and the shade is of fundamental importance for the survival and growth of plants in heterogeneous and dynamic environments. The ability of a given species to adapt to environmental variations, especially to conditions of sun or shade, may be evidenced by the evaluation of the initial growth of plants under different conditions of light availability (Lima et al., 2010; Smiderle et al., 2020).
The temperature has different actions on the plant's metabolism (Menegatti & Bianchi 2019). Responses to high temperatures are linked to water stress. The increase in perspiration is due to high temperatures, which promote greater dehydration of the tissues, resulting in a reduction in the accumulation of phytomass (Lambers et al., 2008). In group 4, the highest transpiration values (E) (5.19 mmol m^{-2} s^{-1}) were observed, consequently, the lowest A value (7.97 μmol m^{-2} s^{-1}) (Table 5).
Group 2 presented the highest rates of internal CO_2 concentration (262.67 μmol CO_2 m^{-2} s^{-1}) and in the C_i/C_a ratio (0.78) (Table 5). According to Leal et al. (2020), high Ci rates help in the carboxylation rate and in reducing stomatal conductance. The C_i/C_a ratio shows that the closer to 1 the greater the CO_2 balance between intracellular spaces and

Table 1. Identification and origin of the bacurizeiro genotypes available in the germplasm bank of Embrapa Meio Norte, evaluated in the dry and rainy periods in Teresina – PI, 2011/2012.

Genotype	Identification	Geographic region
1	M1MP14p12f1	Passagem Franca-MA
2	M1MP14p13f1	Passagem Franca-MA
3	M2PP2p18f5	Palmeirais-PI
4	M3MP6p14f1	Aldeias Altas-MA
5	M3MP6p15f1	Aldeias Altas-MA
6	M4MP6p7f4	Aldeias Altas-MA
7	M7PP5p18f3	Barras-PI

Source: Embrapa Meio Norte, Teresina, PI, 2012.

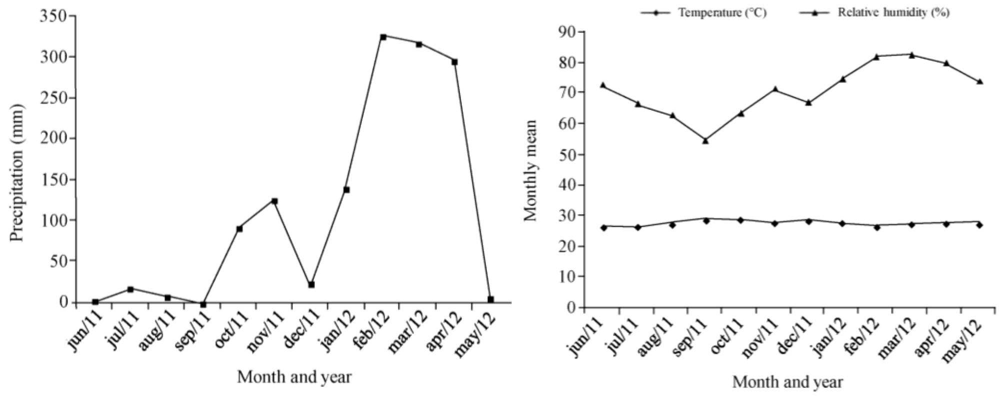

Fig 1. Characterization of the two seasons, dry period (June to December 2011) and rainy period (January to May 2012). Source: Embrapa Meio Norte, Teresina, PI. 2012.

Table 2. Analysis of variance for liquid photosynthesis (*A*), stomatal conductance (g_s), transpiration (*E*), internal CO_2 concentration (C_i), relation between internal CO_2 concentration and ambient CO_2 concentration (C_i/Ca), intrinsic water use efficiency (A/g_s) and instant water use efficiency (*A/E*), in seven bacurizeiro genotypes in two seasons. Teresina, PI, 2012.

Variation source	DF	Mean square						
		A	g_s	C_i	E	C_i/C_a	A/g_s	A/E
Genotype (G)	6	4.84*	0.01*	1110.96*	2.58*	0.01*	409.67*	0.38*
Seasons (S)	1	42.76*	0.52*	2979.64**	122.25**	0.10*	8360.72*	9.10*
G x S	6	5.35*	0.01*	432.57^{ns}	1.93*	0.00*	168.40^{ns}	0.23*
Residual	28	0.91	0.00	171.38	0.28	0.00	60.63	0.06
Total	41							
Mean		8.16	0.26	250.65	4.86	0.77	39.60	1.87
CV(%)		11.68	16.46	5.22	10.84	4.93	19.66	13.41

^{ns}, not significant; *, ** significant at 5% and 1% probability, respectively, by the F test.

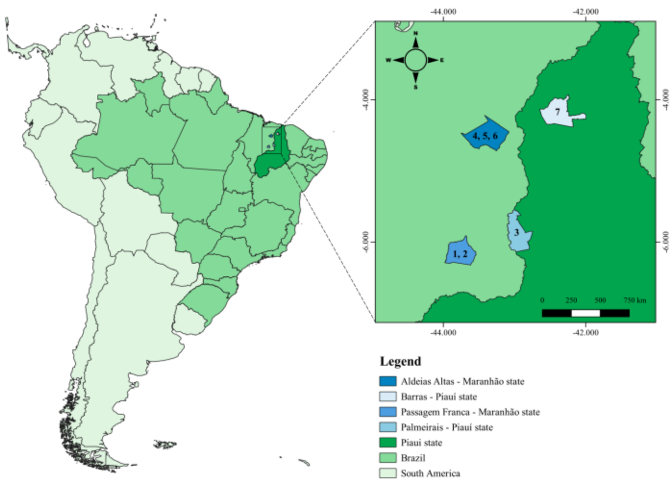

Fig 2. Geographic location of the seed collection municipalities of the bacurizeiro genotypes. Genotypes: 1: M1MP14p12f1; 2: M1MP14p13f1; 3: M2PP2p18f5; 4: M3MP6p14f1;: M3MP6p15f1; 6: M4MP6p7f4; 7: M7PP5p18f3.

Table 3. Mean of liquid photosynthesis (*A*), stomatal conductance (g_s), transpiration (*E*), internal CO_2 concentration (C_i), relation between internal CO_2 concentration and ambient CO_2 concentration (C_i/Ca), intrinsic water use efficiency (A/g_s) and instant water use efficiency (*A/E*), in two seasons in seven bacurizeiro genotypes. Teresina, PI, 2012.

Gas exchanges*	Seasons	Genotypes						
		M1MP14 p12f1	M1MP14 p13f1	M2PP2 p18f5	M3MP6 p14f1	M3MP6 p15f1	M4MP6 p7f4	M7PP5 p18f3
A	Dry	8.22bc	9.11abc	10.15ab	10.98a	7.03c	9.44 ab	9.27abc
	Rainy	5.93b	6.82b	7.15b	6.21b	7.48ab	9.91a	6.57b
g_s	Dry	0.25c	0.36abc	0.38ab	0.41ab	0.31bc	0.38ab	0.48a
	Rainy	0.08a	0.16a	0.16a	0.10a	0.17a	0.17a	0.18a
C_i	Dry	232.94a	237.58a	238.65a	238.44a	257.76a	242.35a	247.86a
	Rainy	232.75d	269.12abc	270.29ab	236.17cd	278.15a	243.12bcd	283.91a
E	Dry	5.33b	6.88a	7.05a	7.19a	4.79b	6.99a	7.73a
	Rainy	2.21b	3.50ab	3.22ab	3.65a	2.41ab	3.42ab	3.65a
C_i/C_a	Dry	0.84a	0.81a	0.78a	0.79a	0.84a	0.82a	0.85a
	Rainy	0.63c	0.75ab	0.75ab	0.67bc	0.76ab	0.68bc	0.78a
A/g_s	Dry	31.67a	25.82a	26.56a	26.66a	22.62a	24.91a	20.21a
	Rainy	75.53a	46.53bc	46.17bc	64.22ab	44.07bc	61.12ab	38.35c
A/E	Dry	1.55a	1.33a	1.44a	1.53a	1.47a	1.35a	1.20a
	Rainy	2.70ab	2.00cd	2.22bcd	2.61abc	2.05bcd	3.00a	1.81d

Means followed by the same letter on the line do not differ by Tukey's test at 5% probability. **A* (μmol m^{-2} s^{-1}), g_s (mol m^{-2} s^{-1}), *E* (mmol m^{-2} s^{-1}), C_i (μmol mol^{-1}), C_i/Ca (μmol mol^{-1}/ μmol mol^{-1}), A/g_s (μmol $m^{-2}s^{-1}$ / mol m^{-2} s^{-1}), *A/E* (μmol $m^{-2}.s^{-1}$ / mmol m^{-2} s^{-1}).

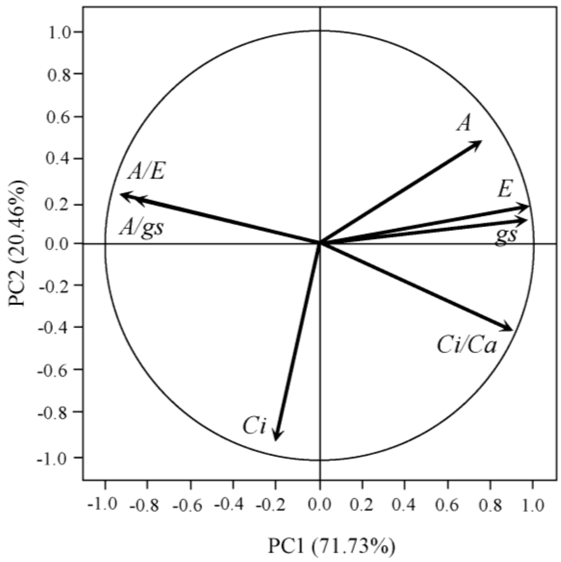

Fig 3. Principal Component Analysis (PC1 and PC2) of the liquid photosynthesis (*A*), stomatal conductance (g_s), transpiration (*E*), internal CO_2 concentration (C_i), relation between internal CO_2 concentration and ambient CO_2 concentration (C_i/Ca), intrinsic water use efficiency (A/g_s) and instant water use efficiency (*A/E*) in bacurizeiro genotýpes.

Table 4. Pearson's correlation matrix between liquid photosynthesis (*A*), stomatal conductance (g_s), transpiration (*E*), internal CO_2 concentration (C_i), relation between internal CO_2 concentration and ambient CO_2 concentration (C_i/Ca), intrinsic water use efficiency (A/g_s) and instant water use efficiency (*A/E*), in two seasons in seven bacurizeiro genotypes. Teresina, PI, 2012.

Gas exchanges*	Gas exchanges*						
	A	g_s	C_i	C_i/C_a	*E*	A/g_s	*A/E*
A	1						
g_s	0.77	1					
C_i	-0.41	-0.30	1				
C_i/C_a	0.41	0.79	0.18	1			
E	0.81	0.98	-0.34	0.77	1		
A/g_s	-0.55	-0.89	-0.03	-0.97	-0.87	1	
A/E	-0.43	-0.85	0.03	-0.93	-0.86	0.95	1

**A* (μmol m^{-2} s^{-1}), g_s (mol m^{-2} s^{-1}), *E* (mmol m^{-2} s^{-1}), C_i (μmol mol^{-1}), C_i/Ca (μmol mol^{-1}/ μmol mol^{-1}), A/g_s (μmol $m^{-2}s^{-1}$ / mol m^{-2} s^{-1}), *A/E* (μmol $m^{-2}.s^{-1}$ / mmol m^{-2} s^{-1}).

Table 5. Average values of gas exchange variables obtained in groups of bacurizeiro genotypes in two periods.

Groups	*A*	g_s	C_i	*E*	C_i/C_a	A/g_s	*A/E*
1	8.47	0.26	235.85	4.98	0.76	40.85	1.89
2	8.16	0.25	262.67	4.91	0.78	36.01	1.77
3	8.04	0.26	245.37	4.54	0.75	44.87	2.09
4	7.97	0.26	253.35	5.19	0.78	36.18	1.67

A (µmol m^{-2} s^{-1}), g_s (mol m^{-2} s^{-1}), *E* (mmol m^{-2} s^{-1}), C_i (µmol mol^{-1}), C_i/Ca (µmol mol^{-1}/ µmol mol^{-1}), A/g_s (µmol $m^{-2}s^{-1}$ / mol m^{-2} s^{-1}), *A/E* (µmol $m^{-2}.s^{-1}$ / mmol m^{-2} s^{-1}).

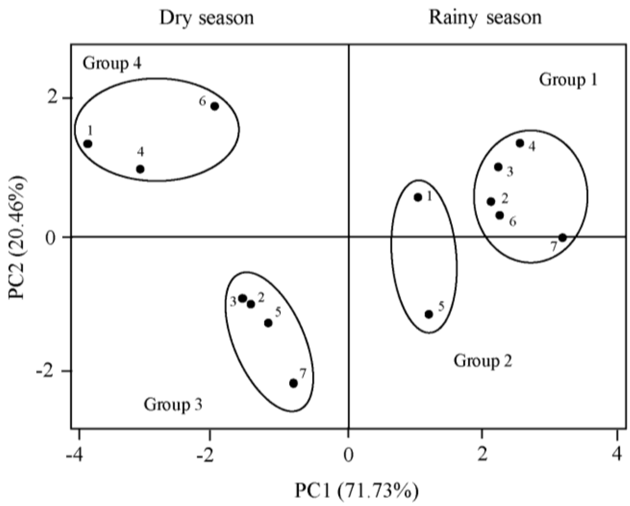

Fig 4. Groups of bacurizeiro genotypes (group 1: genotypes 2, 3, 4, 6 and 7; group 2: 1 and 5; group 3: 2, 3, 5 and 7;and group 4: 1, 4 and 6) in the dry and rainy season based on the scores of the first two main components, Teresina – PI, 2011-2012.

the environment, which favors a better use of CO_2. Raven et al. (2010) emphasize that if the concentration gradient between the internal and external environment of the leaf is low, low diffusion may occur, thus O_2 accumulates, favoring photorespiration, which is an energy-consuming process, which may considerably reduce the photosynthetic rate.

Group 3, on the other hand, showed greater efficiency of photosynthesis assimilation when related to gas exchange, since the intrinsic efficiency of water use (A/g_s) had a higher mean value of 44.87 µmol m^{-2} s^{-1} / mol m^{-2} s^{-1} (Table 5).

Materials and Methods

Experimental area

The present work was carried out in the experimental field of Embrapa Meio Norte (5° 05' S and 42° 29' W, at 72 m altitude), located in Teresina, Piauí, Brazil, from October 2011 to April 2012. The region's climate, according to Thornthwaite & Mather (1955) climatic classification, is C1sA'a', characterized as a dry, megathermic sub-humid, with moderate water surplus in the summer and a concentration of 32.2% of potential evapotranspiration in the September to November quarter. The soil in the area was classified as Red Yellow Argisol.

During the experimental period, the daily average temperature and relative humidity of the air were recorded in the cultivation area with a digital thermohygrometer model TH-500 (Figure 1).

Plant material

The evaluations were carried out in seven accesses (Table 1, Figure 2) of bacurizeiro of the plant breeding program of Embrapa Meio Norte, from seeds, from different georeferenced regions of Piauí and Maranhão. The evaluated bacurizeiro plants are approximately 10 years old, planted in the 8.0 x 8.0 m spacing grown under irrigation.

The measurements of leaf gas exchange in different bacurizeiro genotypes were carried out in a fully expanded and damage-free three-leaf limbus, located in the middle third of the canopy between 8 AM and 10 AM, both in the dry season and in the rainy season (Figure 1). The standardization of the individuals evaluated was carried out based on color and texture, selecting plants of the same age.

Experimental design and conduction of study

A completely randomized design in a 7 x 2 factorial scheme was used, with seven genotypes and two seasons (dry and rainy), with three replications.

For gas exchange analysis, liquid photosynthesis (*A*, µmol m^{-2} s^{-1}), stomatal conductance (g_s, mol m^{-2} s^{-1}), transpiration (*E*, mmol m^{-2} s^{-1}) and internal CO_2 concentration (C_i, µmol mol^{-1}) were measured using a portable infrared gas analyzer (Licor, model LI-6400XT). From these variables, the relation between internal CO_2 concentration and ambient CO_2 concentration (C_i */Ca,* µmol mol^{-1} / µmol mol^{-1}), intrinsic water use efficiency (A / g_s µmol m^{-2} s^{-1} / mol m^{-2} s^{-1}) and instant water use efficiency (*A / E,* µmol m^{-2} s^{-1} / mmol m^{-2} s^{-1}) were calculated.

Statistical analysis

The data were subjected to analysis of variance and the means compared with the Tukey test at 5% probability. Subsequently, principal component analysis and cluster analysis were performed using the Ward method. Statistical analyzes were performed with the aid of the SAS® 9.3 software.

Conclusion

The environmental variation between the two seasons affects the plasticity of the bacurizeiro genotypes. There is less efficiency in the use of water in the dry period in all genotypes of bacurizeiro. The genotypes M1MP14p13f1, M2PP2p18f5 and M7PP5p18f3 are the most stable in both seasons, being in the same groups formed.

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