Original Article

GAS EXCHANGE AND FRUIT YIELD OF YELLOW PASSIONFRUIT GENOTYPES IRRIGATED WITH DIFFERENT RATES OF ETo REPLACEMENT

TROCAS GASOSAS E PRODUÇÃO DE FRUTOS DE GENÓTIPOS DE MARACUJAZEIRO-AMARELO IRRIGADOS COM DIFERENTES TAXAS DE REPOSIÇÃO DA ETo

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ABSTRACT: Water is a limiting factor in agricultural activity and its deficiency in the soil affects the physiological processes of the plant and later interferes in the production of the culture. Aiming to evaluate the influence of different rates of reference evapotranspiration (ETo) replacement, over the leaf gas exchange and yield of hybrid yellow passionfruit plants, this experiment was carried out from August/2009 to September/2010, in an area of the semiarid region of the state of Paraiba, Brazil. The treatments consisted of the combination of four levels of irrigation (33, 66, 100 and 133% of ETo replacement) and two hybrid yellow passion fruit species ('BRS Sol do Cerrado' and 'BRS Gigante Amarelo'), in an experimental randomized block design, with five replications. The following variables were evaluated: gas exchange – stomatal conductance (*gs*), transpiration (*T*), net photosynthesis (*A*), instantaneous water use efficiency (IWUE), internal carbon concentration (*Ci*) and instantaneous carboxylation efficiency (*A*/Ci); fruit weight (distributed into three classes: 'A', 'B' and 'C', per plant) and also, the total production per plant. The gas exchange rates were higher in the 'BRS Sol do Cerrado' hybrid, in which a higher production was registered when irrigated with 133% of the ETo. The 'BRS Gigante Amarelo' genotype is most indicated to grow under low water availability.

KEYWORDS: *Passiflora edulis* f. *flavicarpa* Deg. Photosynthesis. Transpiration. Fruit production.

INTRODUCTION

Irrigated fruit crops demand good quality water, which results in a relative decrease of water availability for human and animal consumption. At the same time, there is a need to expand agricultural boundaries due to a greater demand for food for mankind, a fact that has caused pressure on the efficiency and sustainable usage of water resources (KNOX et al., 2012). These issues are notorious in regions where rainfall is deficient and irregular, as in the case of semiarid region of Brazil.

Among the environmental factors that influence the physiological and metabolic processes of plants, water stands out as one of the most important, and it is a selective factor in environments with low water availability (YOO et al., 2009; KNOX et al., 2012). According to Campbell et al. (2010), the photosynthetic capacity of vegetables is negatively affected by water stress, by a direct action of the dehydration of photosynthetic apparatus, or by an indirect effect associated to stomatal closure and by the genetics.

In the productive process of a crop, several factors are involved. Among those factors are the genetic nature of a plant because it enables the obtaining of materials with a greater production potential (CAMPBELL et al., 2010; PIRES et al., 2011a), as is the case of the hybrid plants. However, to express all of their productive potential, hybrid plants need adequate conditions, especially water availability in adequate levels, since water is the factor that most affects crop yield (CAMPBELL et al., 2010). In this context, in semiarid regions, where water is a limiting factor to the establishment of agricultural crops, the irrigation technique is essential.

Although publications on irrigation exist for passionfruit plant (*Passiflora edulis* Sims f. *flavicarpa* Deg.*)* at different stages of its development (CARVALHO et al., 2002; SOARES et al., 2002; SUASSUNA et al., 2010; PIRES et al., 2011a), there is no available information about physiological studies on the 'BRS Sol do Cerrado' and 'BRS Gigante Amarelo' yellow passionfruit hybrids in literature. Such information could aid in

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the decision making for water resource economy and in the performance of genotypes and enable the expansion of cultivated area. So, the objective of this study was to evaluate the alterations of gas exchange and the yield of two hybrids of passionfruit plants irrigated with different replacement rates of reference evapotranspiration (ETo), in the semiarid ecosystem of the state of Paraiba.

MATERIAL AND METHODS

The study was performed from Aug. 2009 to Sep. 2010, in Catolé do Rocha county, located in the semiarid region of the state of Paraiba, Brazil (latitude 6º 20` 38`` S; longitude 37º 44` 48'' W; altitude 250 m). The climate of the region is BSw'h', according to the classification of Köppen, characterized by hot semiarid, with two distinct seasons, one rainy with irregular precipitation and another one without precipitation (PEEL et al., 2007). During the period of this study, the average maximum temperature was 34.7 ^{o}C and the minimum was 21.1 ^{o}C, with 325.8 mm of rain, distributed: 67.9 mm in Aug/09; Jan/10 – 79.5 mm; Feb/10 – 30.2 mm; Mar/10 – 85.2 mm; Jun/10 – 51.0 mm and 12 mm in Jul/10.

The soil of the experimental area is Entisols Fluvents Eutrophic of sandy texture (USDA Soil Taxonomy), with the following physical, chemical and water attributes from samples collected from the layer 0 – 20 cm: pH (H_2O) = 7.1; P (Mehlich^{-1}) = 36 mg dm^{-3}; K = 0.83 cmol$_c$ dm^{-3}; Ca = 2.8 cmol$_c$ dm^{-3}; Mg = 0.7 cmol$_c$ dm^{-3}; Na = 0.16 cmol$_c$ dm^{-3}; Al = 0.0 cmol$_c$ dm^{-3}; H+Al = 0.49 cmol$_c$ dm^{-3}; CTC = 4.4 (cmolc dm3); V = 88.88%; organic matter = 9.54 g kg^{-1}; apparent density = 1.51 g cm^{-3}; total porosity = 0.47 m^3 m^{-3}; humidity: 148 g kg^{-1} at 3.0 MPa, 110 g kg^{-1} at 15.0 MPa.

The experiment was organized in randomized blocks, with 5 replications, in a 4 x 2 factorial design, with four irrigation water levels (33%, 66%, 100% and 133% of the replacement rate of ETo, corresponding to 323, 646, 978 and 1,300 mm, during the cycle, respectively) and two yellow passion fruit hybrids ('BRS Sol do Cerrado' and 'BRS Gigante Amarelo'). The experimental unit was composed of five plants, with the three plants in the center row as useful, and an extra row of plants, encircling all of the experiment, as a margin. The seeds were sowed in plastic pots (250 cm^3 of volume), in a nursery, and after germination, the seedlings were transplanted with a spacing of 4.0 m x 3.0 m, in holes of 0.40 x 0.40 x 0.50 m. Then, they were guided up a vertical support structure, with a wire at the height of 1.8 m.

Before transplanting the seedlings, fertilization was performed based on the soil analysis data and the procedures obtained from the research by Brito et al. (2005). This was done by applying 20 L of bovine manure per hole and 200 g of simple superphosphate per hole. After the passionfruit seedlings were transplanted, the following supplements were applied at the equivalent to 1.0 L ha^{-1} every 15 days, by using drip fertirrigation on a Venturi type injector, calibrated at a flow of 70 L h^{-1}: 240 g/plant/year of N (as urea) and 360 g/plant/year of K (as KCl), plus an organic-mineral fertilizer (commercial name of Vitan), with the following chemical composition: N - 6.0%, P - 8.0%, K - 8.0%, Ca - 1.0%, Mg - 0.5%, S - 2.4%, B - 0.6%, Cu - 0.2%, Mn - 0.5%, Mo - 0.2%, Zn - 1.0%, Total Organic Carbon 12.0% and density of 1.45 g L^{-1}. During the period of study, pests and diseases were controlled when necessary.

The reference evapotranspiration was calculated by the Penman-Monteith model, standardized by Allen et al. (1998) (Equation 1). Data utilized in the estimation of the ET_O were collected daily at the automated Agro-meteorological Station installed near the experimental area.

$$ETo = \frac{0.48\Delta(R_n - G) + \gamma\left(\frac{900U_2}{T+273}\right)(e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)} \qquad (1)$$

In which: ETo = reference evapotranspiration (mm day^{-1}); Rn = net radiation on the surface of the crop (MJ m^{-2} day^{-1}); G = flow of heat on the soil (MJ m^{-2} day^{-1}); □ = inclination of the vapor pressure versus air temperature curve (kPa ^{o}C^{-1}); U_2 = velocity of the wind measured at two meters of height (m s^{-1}); T = temperature (^{o}C); e_s = pressure of saturation of water vapor (kPa); e_a = real pressure of water vapor (kPa); □ = psychrometric factor (MJ kg^{-1}).

The gross water flow, the intensity of water application, and irrigation time were determined by equations 2, 3 and 4, respectively, extracted from Mantovani et al. (2006).

$$LB = \frac{ETo \cdot Kc \cdot Ks}{Ef} - Pe \qquad (2)$$

In which: LB = gross water flow (mm day^{-1}); ETo = reference evapotranspiration according to Penman-Monteith (mm day^{-1}); Kc = crop coefficient, considering 1,0, for application of the ETo; Ks = percentage of area that was wet by the emission; Pe = precipitation occurring in the period (mm); Ef = efficiency of irrigation.

$$Ia = \frac{n \cdot v}{ec} \qquad (3)$$

In which: Ia = intensity of application (mm h^{-1}); n = number of emissions per plant; v = flow of emission (L h^{-1}); ec = area occupied by the plant (m^2).

$$Ti = \frac{LB}{Ia} \quad (4)$$

In which: Ti = irrigation time (h); LB = gross water flow (mm day^{-1}); Ia = intensity of application (mm h^{-1}).

Management of the application of the different water levels was made by varying the number of drippers per plant, by utilizing 1, 2, 3, and 4 self-compensating dripper(s) with a flow of 4 L h^{-1} to obtain levels correspondent to 33%, 66%, 100% and 133% of the ETo, respectively.

In August/2010, when the plants were in full productive stage, gas exchange determination was performed, and data for the following variables were obtained: photosynthesis (*A*) (µmol m^{-2} s^{-1}), transpiration (*T*) (mmol of H_2O m^{-2} s^{-1}), stomatal conductance (*gs*) (mol m^{-2} s^{-1}) and internal concentration of CO_2 (*Ci*) (µmol mol^{-1}), by procedures contained in literature (PASSOS et al., 2005; REIS; CAMPOSTRINI, 2008; MELO et al., 2009). These evaluations were made on the third leaf when it was completely formed, identified from the apex of the tertiary branch, between 8 and 10 o'clock AM, with the use of an IRGA equipment (ACD, model LCPro, Hoddesdon, UK), with an air flow of 300 mL min^{-1} and an auxiliary light source, adjusted at 1200 µmol m^{-2} s^{-1}.

The instantaneous water use efficiency (IWUE) was estimated by calculating the net photosynthesis/transpiration ratio (*A/T*) based on procedures contained in Pires et al. (2011b), and the instantaneous carboxylation efficiency (*A*/*Ci*), by the net photosynthesis/internal concentration of carbon ratio (MAGALHÃES FILHO et al., 2008).

Fruit production was evaluated based on the number and mass of the fruit harvested per plant, distributed into three fruit classes, according to the criteria contained in Suassuna et al. (2011): Class A - fruit with mass superior to 150 g; class B - fruit with mass between 100 g and 150 g, and class C - fruit with mass inferior to 100 g.

The data were submitted to variance analysis by the F test ($p < 0.05$), and regression analysis was performed for the 'L factor - water level' due to its quantitative nature, with the adjustment of the models by the Student test ($p < 0,05$); the averages related to the 'H factor – hybrid passion fruit', due to qualitative nature, were compared by the F test. When the interaction was not significant, unfolding of the factors was performed, based on considerations contained in Perecin; Cargnelutti Filho (2008), according to whom frequently only part of the effects of the interactions contributes effectively to the Interaction Sum of Squares, thus being interesting to analyze it.

RESULTS AND DISCUSSION

Passion fruit plants transpiration was affected by water levels (*T*) (p<0.01), however without showing a significant difference between the hybrids (Table 1). Although the interaction between them was not significant, unfolding the factors was performed on transpiration, and a linear increase in water loss was confirmed by passionfruit plants from 'BRS Gigante Amarelo' hybrid, with increment in the replacement rate of the ETo. However, for the hybrid 'BRS Sol do Cerrado', the effect was quadratic (Figure 1 A).

Table 1. Summary of the analysis of variance and averages for transpiration (*T*), stomatal conductance (*gs*), photosynthesis (*A*), water usage efficiency (*A/T*), internal carbon concentration (*Ci*) and instantaneous carboxylation efficiency (*A/Ci*) of passion fruit hybrids submitted to different ETo replacement rates. Catolé do Rocha-PB, 2010 e 2011.

Sources of variation	GL	*T*	*gs*	*A*	*A/T*	*Ci*	*A/Ci*
	QM						
Block	4	0.835^{ns}	0.0016^{ns}	6.582^{ns}	1.186^{ns}	209.97^{ns}	0.0011^{ns}
Level(L)	3	1.785^{**}	0.0140^{**}	22.05^{**}	0.047^{ns}	10.739^{ns}	0.0039^{*}
Hybrid(H)	1	0.222^{ns}	0.0184^{**}	30.23^{*}	3.955^{**}	2472.7^{**}	0.0028^{*}
L * H	3	0.0417^{ns}	0.0009^{ns}	2.640^{ns}	0.164^{ns}	22.10^{ns}	0.0005^{ns}
Residue	28	0.318	0.0023	4.680	0.230	287.14	0.00012
C.V (%)		15.7	16.3	19.9	15.7	7.5	22.7

* and ** significant at 5% and 1% probability, respectively; ns not significant; QM: Mean Squared Error. F test Analyses

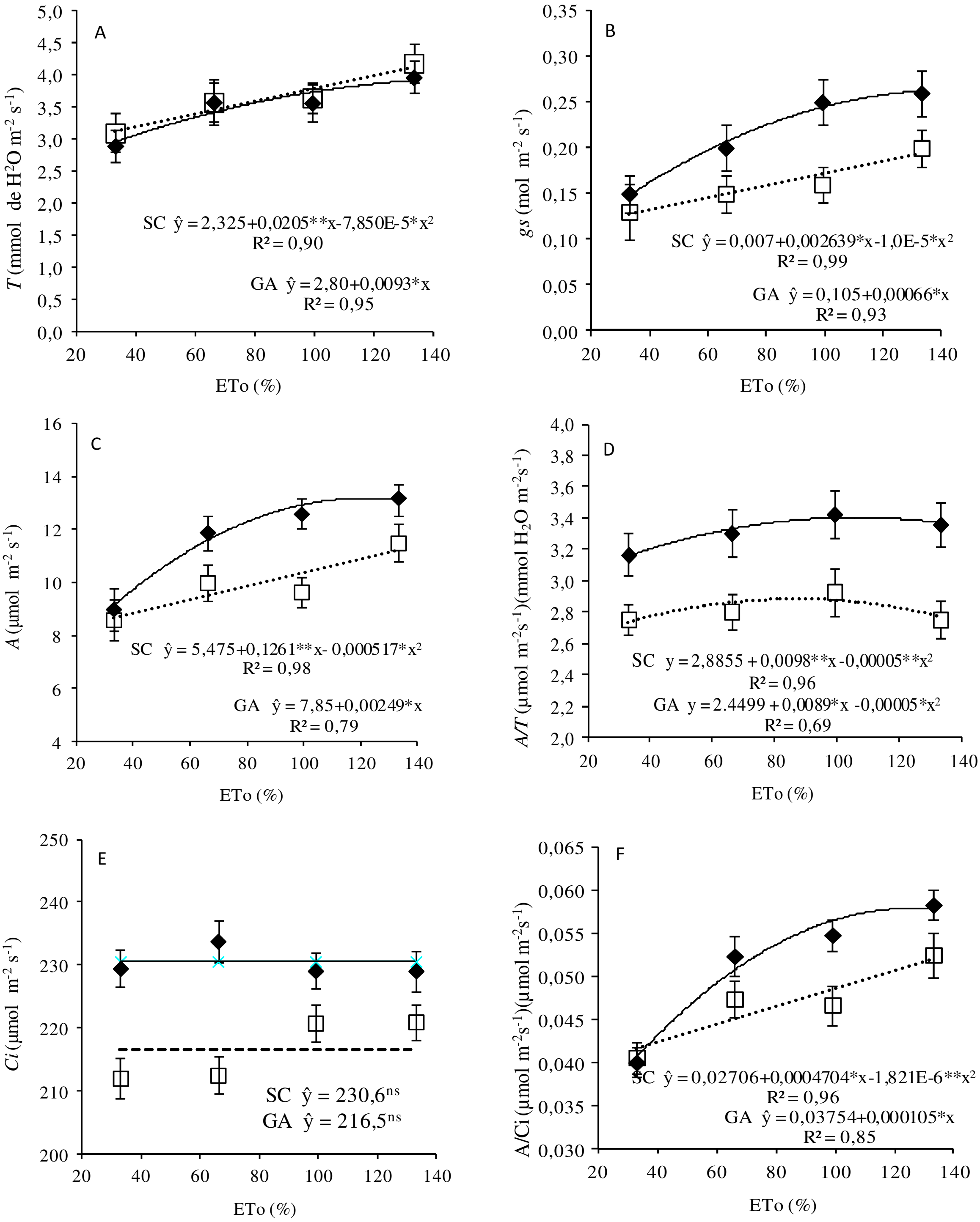

Figure 1. Transpiration (A), stomatal conductance (B), photosynthesis (C), instantaneous water use efficiency (D), internal carbon concentration (E) and instantaneous carboxylation efficiency (F) of passion fruit hybrids submitted to different water levels (ETo replacement rates). Significant at *($p<0,05$) and **($p<0,01$) by the Test F. The vertical bars are graphical representations of the standard deviation. Hybrids: 'BRS Gigante Amarelo' □ GA; 'BRS Sol do Cerrado' ♦SC. Catolé do Rocha-PB, 2010 e 2011.

As the replacement rate of the ETo was increased from 33% to 133%, the transpiration of the 'BRS Gigante Amarelo' hybrid was increased by 30%. In relation to 'BRS Sol do Cerrado', the estimated level of 130% of the ETo proportioned the highest transpiration rate (3.66 mmol of H_2O m^{-2} s^{-1}). These values are similar to those found by Pires et al. (2011a) in ornamental species of *Passiflora* under different insolation conditions; they registered transpiration, under full sun, varying between 1.59 and 3.27 mmol m^{-2} s^{-1}, depending on the *Passiflora* genotype.

This fact can be explained due to the greater stomatal conductance (*gs*) observed in the leaves of both genotypes when they were irrigated with larger quantities of water (Table 1 and Figure 1B). The low values of transpiration verified in the lowest replacement rate of water (33% of the ETo) are associated to the reduction of the stomatal opening, which increased the diffusive resistance, a defensive reaction to water deficit (YOO et al., 2009). Cavalcante et al. (2001) did not find difference in the transpiration of yellow passion fruit seedlings submitted or not to water stress, possibly because of the short period of their study, about seven days. They registered values which varied between 1.8 and 2.1 mmol of H_2O m^{-2} s^{-1}; these values are higher when compared to the ones registered in this study, possibly because the plants that were used were young, and in seedlings the gas exchange is usually high (MUTHURI et al., 2009), and also due to nursery and small-container cultivation conditions.

Reductions in the *gs* can be due to the mechanism used by the plant to maintain the water *status*, notably in stress situations, however, if this situation persists, it will result in loss of photosynthesis capacity, and overall, in accumulation of dry matter (YOO et al., 2009).

Stomatal conductance in the 'BRS Gigante Amarelo' increased linearly from 0.12 mol m^{-2} s^{-1} to 0.19 mol m^{-2} s^{-1} (increment of 58%) in the variation of irrigation water levels from 33% to 133% of the ETo (Figure 1B). For the ‘BRS Sol do Cerrado’ hybrid the stomata openings were greater, and the effect of the irrigation water levels was quadratic; maximum conductance (0.24 mol m^{-2} s^{-1}) was verified in the replacement rate of the ETo at 131.9%. Although the values of *gs* in the ‘BRS Sol do Cerrado’ were higher (Figure 1B), the transpiration data were similar in the two hybrids (Figure 1A), an evidence of this plant genotype having some mechanism of adaptation to diminish water loss despite its larger stomatal opening; in the hottest periods of the day, the leaf blades of this genotype (BRS Sol do Cerrado) bend in the longitudinal direction of the lobes, which may result in reduction of the transpiration, due to the concentration of water vapor in the curved space, and thus diminish its drag by winds.

In tomato plants, Pires et al. (2011b) verified a direct relation between transpiration and stomatal conductance of the plants, a fact which was equally observed in this study, although varying in magnitude among the hybrids.

In literature, references are found to reduction of the stomatal conductance in other fruit species of commercial interest when water availability is reduced in the soil (coconut - PASSOS et al., 2005; papaya – REIS; CAMPOSTRINI, 2008). When Melo et al. (2010) studied the physiology of irrigated watermelon plants in the semiarid ecosystem of the state of Paraíba, they detected a reduction in stomatal resistance with the increase of the water level applied, mainly in the morning, which resulted in a higher rate of stomatal conductance due to a lower thermal amplitude.

Photosynthesis was affected by the water levels ($p<0.01$) and varied between the passion fruit plants hybrids ($p<0.05$) (Table 1; Figure 1C). In the ‘BRS Gigante Amarelo’, the values of photosynthesis increased linearly in the different replacement rates of the ETo, from 8.6 µmol m^{-2} s^{-1} to 11.5 µmol m^{-2} s^{-1}, when the irrigation varied from the lower to the higher water level. In the ‘BRS Sol do Cerrado’ hybrid, with higher values of photosynthesis, the increment was of quadratic nature, and registered a maximum of 13.2 µmol m^{-2} s^{-1} in the level estimated at 123% of the ETo. When comparing these photosynthesis data in *Passiflora edulis* with those obtained by Pires et al. (2011a) in ornamental species of *Passiflora*, a similarity is found to *P. suberosa litoralis* (15.13 µmol m^{-2} s^{-1}) and to *P. palmeri* (10.49 µmol m^{-2} s^{-1}), when grown without shade, in the south of the state of Bahia.

When the data obtained from the hybrids were compared, it was noted that photosynthesis values in the ‘BRS Sol do Cerrado’ were superior to the ones found in the ‘BRS Gigante Amarelo’, with similar values only when the plants were irrigated with 33% of the ETo (Figure 1C). This difference in the net photosynthesis in the higher replacement rates of ETo can be related to the increase in CO_2 fixation which was facilitated by greater stomatal conductance of the genotype ‘BRS Sol do Cerrado’ when cultivated without water restrictions.

The greatest diffusive resistance of the stomata identified in ‘BRS Gigante Amarelo’, resulted in reduction of the photosynthesis by the restrictions to the CO_2 flow in the leaves, a fact that is usually related to climactic factors, also confirmed by Campbell et al. (2010) when they worked with *Ipomopsis* species in Colorado, USA; in coconut plants cultivated in the coastal plains of the state of Sergipe, photosynthesis varied from 7.53 µmol m^{-2} s^{-1} in the dry season to 9.87 µmol m^{-2} s^{-1} in the rainy season, which showed the negative effect of water deficit on carboxylation (PASSOS et al., 2005).

Regarding instantaneous water use efficiency (IWUE), expressed by the interdependency between the photosynthesis (A) and transpiration (T) ratio at the moment of the data evaluation, differences were obtained between the hybrids ($p<0.01$), however without effect of irrigation water levels (Table 1). By unfolding the factors, based on the report by Perecin; Cargnelutti Filho (2008), higher water use efficiency was verified in the 'BRS Sol do Cerrado' hybrid (Figure 1D), with a maximum value of 3.37 (µmol CO_2 m^{-2} s^{-1}) (mmol H_2O m^{-2} s^{-1})$^{-1}$ for IWUE, at the water level corresponding to 98% of the ETo; in the 'BRS Gigante Amarelo', the highest IWUE value was 2.89 (µmol CO_2 m^{-2} s^{-1}) (mmol H_2O m^{-2} s^{-1})$^{-1}$, which was confirmed at the level of 89% of the ETo. In tomato plants, Pires et al. (2011b) obtained higher values of IWUE with increase of irrigation levels, which may be due to the herbaceous structure of the plants of this species and their higher water demand when compared to passion fruit plants.

The higher IWUE of the ‘BRS Sol do Cerrado’ (Figure 1D) in comparison to the other hybrid reinforces what has been discussed before in relation to its greater ability to capture and reduce CO_2 in organic compounds (Fig. 1C) without increasing transpiration (Fig. 1A); this fact is reflected in greater water use efficiency, which can increase production. This will be discussed subsequently in this study. According to Muthuri et al. (2009) and Campbell et al. (2010), the identification of genetic materials with high efficiency in carboxylation processes (photosynthesis), and thus maintaining low transpiration, is very useful to genetic studies (genotype screening) of plants, aiming to select genotypes with greater water use efficiency.

The internal concentration of carbon (*Ci*) between the hybrids of yellow passion fruit plant was different ($p<0.01$), however without this variable being affected by the water levels utilized in the irrigation (Table 1). The *Ci* in both genotypes was maintained relatively constant in rising irrigation levels, with an average of 230.6 µmol of CO_2 m^{-2} s^{-1} in the ‘BRS Sol do Cerrado’ hybrid, a value statistically superior to the rate of 216.5 µmol of CO_2 m^{-2} s^{-1} registered in the ‘BRS Gigante Amarelo’ (Figure 1E).

Melo et al. (2009) point out that the internal concentration of carbon reflects the availability of substrate for the photosynthesis and can indicate if the stomatal closure is restricting this activity. The decrease in the loss of water by transpiration by means of stomatal closure diminishes the flow of carbon dioxide from the atmosphere into the substomatal cavity, reducing photosynthesis due to the limitation of stomatal conductance and internal concentration of CO_2 (LONG; BERNACCHI, 2003; KO; PICCINI, 2009), a fact that may have happened to the ‘BRS Gigante Amarelo’ plants.

For instantaneous efficiency of carboxylation (*A*/*Ci*), there was a difference among the hybrids and the effect of the water levels ($p<0.05$), although without interaction among these factors (Table 1). The increase in the rates of ETo replacement (from 33% to 133%) resulted in an increment of 25% in the *A*/*Ci* estimated for the ‘BRS Gigante Amarelo’ (Figure 1F). In ‘BRS Sol do Cerrado’ genotype, the data adjusted to the quadratic model (R^2= 0.96), confirmed by the highest value in the *A/Ci* of 0.057 µmol m^{-2} s^{-1}, at the rate estimated at 129% of the ETo. Comparing the data between both hybrids, a higher efficiency of carboxylation was found in ‘BRS Sol do Cerrado’, except under conditions of low irrigation (33% of the ETo), when the results were similar. Such results are consistent with the higher photosynthesis rates registered in ‘BRS Sol do Cerrado’ (Figure 1C), due to greater absorption of CO_2 and accumulation of internal carbon (Figure 1E), a fact that may reflect in greater plant fructification.

Thus, the parameters involving gas exchange varied according to the water availability and genotypes used in this work; this information is useful to evaluate the water status and to connect the yield reduction to the water deficit of the plants (KO; PICCINI, 2009).

The variables of production of the passion fruit genotypes were also affected by the irrigation levels and by the interaction among levels and yellow passion fruit hybrids (Table 2). The ‘BRS Sol do Cerrado’ hybrid produced more and better quality fruit (types A and B) when the quantity of irrigation water increased, compared to the other genotype (Figures 2A and 2B).

The production of class A fruit (weight > 150 g) of the ‘BRS Sol do Cerrado’ genotype was 18.20 kg per plant, registered at the level of 133% of the ETo, while in the 'BRS Gigante Amarelo' the maximum production was lower, 11.58 kg per plant, but with a lower irrigation level, only 91% of the ETo (Figure 2A). At the lower water availability level (33% of the ETo), the production of 'BRS Gigante Amarelo' fruit surpassed that of the other genotype by 41%, but at the higher irrigation level (133% of ETo), the ‘BRS Sol do Cerrado’ hybrid produced 25% more fruit.

Table 2. Summary of the analysis of variance for production of class A fruit (P-CA), class B fruit (P-CB), class C fruit (P-CC) and total fruit per plant (Pt), of passion fruit hybrids submitted to different ETo replacement rates. Catolé do Rocha-PB, 2010 e 2011.

Sources of Variation	GL	P-CA	P-CB	P-CC	Pt
		------------------ QM	--------------------		
Block	4	5.158^{ns}	1.428^{ns}	2.244^{ns}	6.413^{ns}
Level (L)	3	70.48**	30.40**	13.57**	276.5**
Hybrid (H)	1	23.43*	0.157^{ns}	10.69**	3.875^{ns}
L x H	3	45.20**	10.65**	4.03**	88.51**
Resídue	28	5.808	1.01	0.215	5.09
C.V (%)		14.53	13.8	13.6	11.01

* and ** significant at 5% and 1% probability, respectively; ^{ns} not significant; QM: Mean Squared Error. F test Analyses

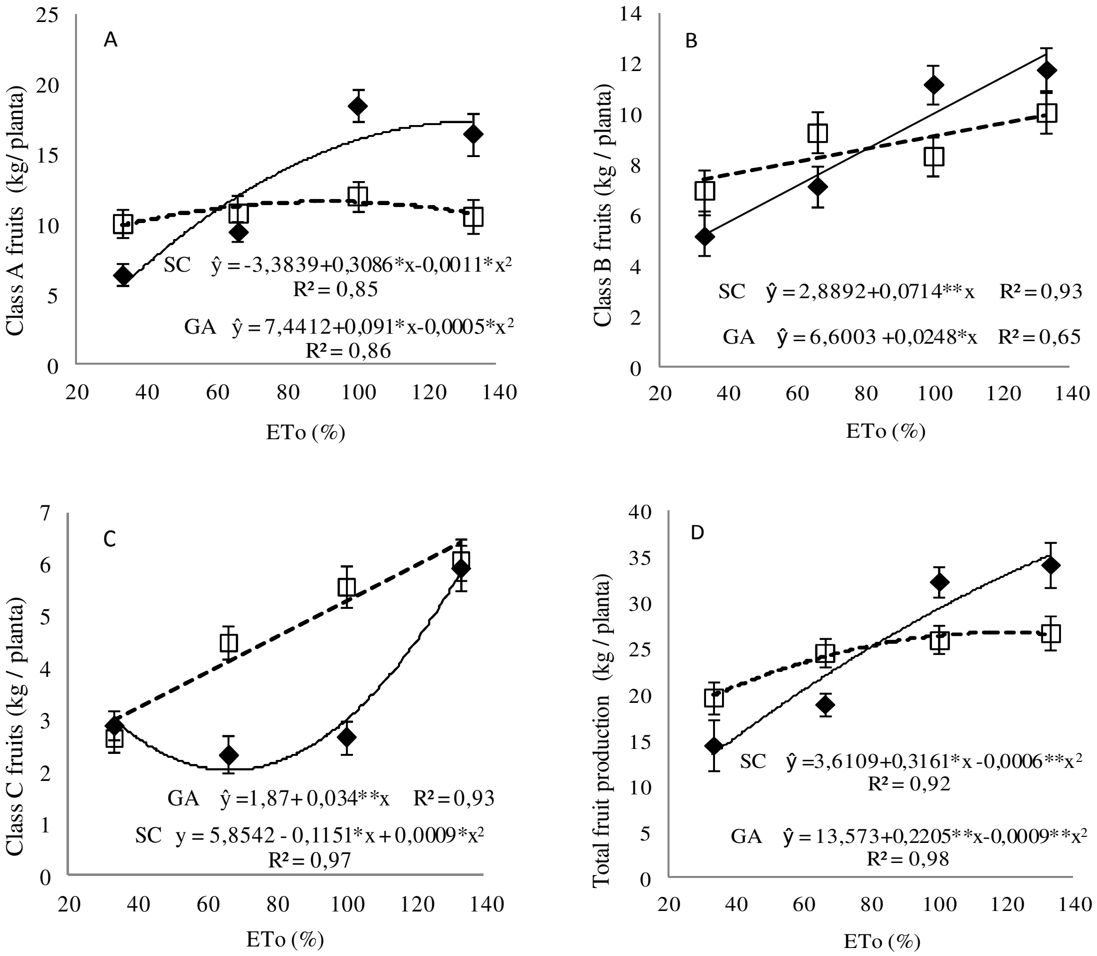

Figure 2. Production of fruit (kg per plant) for class A (A), class B (B), class C (C) and total fruit (D) of the passion fruit hybrids cultivated under crescent water levels (ETo replacement rates). Significant at *(p<0,05) and **(p<0,01) by the Test F. The vertical bars are graphical representations of the standard deviation. Hybrids: 'BRS Gigante Amarelo' □ GA; 'BRS Sol do Cerrado' ♦ SC. Catolé do Rocha-PB, 2010 e 2011.

In relation to the production of Class B fruit (100 - 150 g), the data of both hybrids adjusted to the crescent linear model (Figure 2B); when the applied water level varied from 33% to 133% of the ETo, percentage gains of 136% in the production of ‘BRS Sol do Cerrado’ (5.25 → 12.39 kg per plant) and 33% of ‘BRS Gigante Amarelo’ (7.42 → 9.90 kg per plant) occurred. However, when analyzing the values of production of the two genotypes obtained with 33% of the ETo, the production of the ‘BRS Gigante Amarelo’ was 41% higher, while in the ETo replacement at 133%, the production of the ‘BRS 'Sol do Cerrado' surpassed that of the other hybrid by 25%, evidence of greater adaptability of the 'Gigante Amarelo’ to water deficit.

The production in the Class C fruit category (<100 g) is of lower quality, and the best harvest was obtained in the ‘BRS Gigante Amarelo’ hybrid at irrigation levels of 100% of the ETo, precisely the genotype with the lowest production of better quality fruits (Figure 2C). The 'BRS Sol do Cerrado' data adjusted to a 2nd grade regression, without an biological explanation.

The total fruit production of the ‘BRS Sol do Cerrado’ (Figure 2D) reached 35.04 kg per plant (estimate of 29 t ha^{-1}) at the replacement rate of 133% of the ETo, while the maximum production of the ‘BRS Gigante Amarelo’ was 27.08 kg per plant (23 t ha^{-1}) at the water level estimated at 122.5% of the ETo; these values may be considered high, in relation to the national average for production, which is between 12 and 15 t ha^{-1}, and to the potential yield of the passion fruit plant, which is between 30 and 40 t ha^{-1} (SILVA et al., 2009).

Furthermore, when irrigating with rates were inferior to 66% of the ETo, the production of the ‘BRS Gigante Amarelo’ was higher, however, the results inverted when there was greater availability of water, with a higher production by ‘BRS Sol do Cerrado’. As an example of this, at the irrigation level of 33% of the ETo, the ‘BRS Gigante Amarelo’ hybrid (19.69 kg per plant → estimate of 16 t ha^{-1}) produced 32.4% more fruit, while at the higher level tested (133% of the ETo), the production of the ‘BRS Sol do Cerrado’ (34.17 kg per plant → 29 t ha^{-1}) was superior, at 27.8%. Under the conditions at Piracicaba, in the state of São Paulo, Sousa et al. (2005) registered productivities between 18 and 40 t ha^{-1}, varying potassium fertilization, and with a water level applied between 468 and 944 mm per year; the high yield obtained by these authors is due to the use of higher doses of K and higher rainfall occurring in that region.

The higher production potential of the ‘BRS Sol do Cerrado’ genotype is a consequence of the greater efficiency in gas exchange, as discussed in the physiologic parameter data, decisively influencing the photosynthesis process as well as better adaptability and water resource economy, reflecting in a higher yield of fruit.

CONCLUSIONS

The rates of gas exchange are higher in the ‘BRS Sol do Cerrado’ hybrid than in the ‘BRS Gigante Amarelo’.

The production of fruit with a better classification standard is higher in the ‘BRS Sol do Cerrado’ genotype when irrigated with 133% of the ETo.

The ‘BRS Gigante Amarelo’ genotype is more indicated for growing under conditions of low water availability.

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RESUMO: A água é um fator limitante à atividade agrícola e sua deficiência no solo afeta os processos fisiológicos da planta, interferindo, posteriormente, na produção da cultura. Com esse enfoque, foi conduzido este experimento em área do semiárido paraibano, no período de agosto/2009 a setembro de 2010, objetivando-se avaliar a influência de diferentes taxas de reposição da ETo, sobre trocas gasosas e rendimento de híbridos de maracujazeiro-amarelo. Os tratamentos consistiram da combinação entre quatro lâminas de irrigação (33, 66, 100 e 133% de reposição da ETo) e dois híbridos de maracujazeiro-amarelo (‘BRS Sol do Cerrado’ e ‘BRS Gigante Amarelo’), no delineamento experimental em blocos casualizados, com cinco repetições. Foram avaliados: trocas gasosas - condutância estomática (*gs*), transpiração (*T*), taxa de fotossíntese líquida (*A*), eficiência do uso da água (*A/T*), concentração de carbono interna (*Ci*) e eficiência instantânea de carboxilação (*A*/Ci); peso de frutos (distribuídos em três classes ‘A’, ‘B’ e ‘C’, por planta) e, também, a produção total por planta. As taxas de trocas gasosas foram maiores no híbrido ‘BRS Sol do Cerrado’, em que se registrou a maior produção, quando irrigado com 133% da ETo. O genótipo ‘BRS Gigante Amarelo’ é mais indicado para cultivo sob baixa disponibilidade hídrica.

PALAVRAS-CHAVE: *Passiflora edulis* f. *flavicarpa* Deg.. Fotossíntese. Transpiração. Produção de frutos

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