GAS EXCHANGE IN 'POME' BANANA PLANTS GROWN UNDER DIFFERENT IRRIGATION SYSTEMS

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KEYWORDS

Musa spp, AAB and AAAB genotypes, physiology.

ABSTRACT

This study aimed to evaluate Pome type bananas grown under different irrigation systems. Seventy-two treatments were used in a factorial 3x2x12 scheme, where factors consisted of three irrigation systems (under-tree sprinkling, micro-sprinkling, and dripping), two cultivars ('Prata-Anã' and 'BRS Platina'), and twelve evaluation periods (months). The treatments were arranged in a completely randomized design with five repetitions. During the third production cycle, plant phytotechnical and physiological traits were evaluated in different months at five different times of the day. The results showed no significant interactions between cultivars and irrigation systems. All the assessed traits varied for each irrigation system, except for plant yield. The banana plants presented higher vigor and a larger number of hands when grown under conventional sprinkling and micro-aspersion systems, regardless of the cultivar. The cultivar 'Prata-Anã' has larger leaf areas and number of hands, regardless of the irrigation system. Moreover, plants irrigated by dripping exhibited higher leaf temperatures, higher transpiration rates, and lower instant water-use efficiency. When irrigated by micro-sprinklers, the plants displayed greater water-use efficiency. As leaf temperature rose, perspiration increased linearly, while the instant water-use efficiency decreased linearly.

INTRODUCTION

Banana cultivation in areas under water scarcity requires a most rational use of this resource. An irrigation system is chosen based on the quantity and quality of available water, soil type, relief, climate, and other factors. Localized irrigation systems are more efficient; however, few studies have been carried out about its effects on plant physiological processes. The water sprayed onto the plant leaves and pseudostems may improve plant cooling and, therefore, better conditions for plant development under stressful thermal conditions. Leaf temperature variations reflect the heat transfers between plant and the environment, which directly interferes with plant physiological processes, affecting final yield (Taiz & Zeiger, 2013).

In the recent years, several studies have investigated the gas exchanges in banana plants, but generally under controlled conditions. The response of plant physiological variables have been assessed under different conditions such as salinity levels (Silva Junior et al., 2012), nutrient rates in solutions (Neves et al., 2002; Melo et al., 2010), soil water deficit (Mahouachi, 2009), natural shading (Senevirathna et al., 2008), and amount of irrigated water (Turner, 2013). Other studies have been carried out on the efficiency of irrigation systems separately, but still, there is demand for studies testing the responses of phytotechnical and physiological traits of Pome type bananas to different irrigation systems in field conditions.

Based on the above-mentioned, the present study aimed to evaluate the gas exchanges of Pome type banana trees submitted to different irrigation systems.

MATERIAL AND METHODS

The assay was installed in the experimental area of the *Instituto Federal Baiano* (Federal Institute of Bahia), in Guanambi Campus, Bahia state, Brazil. The local soil is classified as a Red-Yellow Latosol. The mean annual rainfall and temperature are 680.0 mm and 26 °C, respectively. On January 31 of 2008, micropropagated

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seedlings of 'Prata-Anã' and 'BRS Platina' banana cultivars were planted, spaced by 3.0 x 2.5 m. Crop implementation, fertilization, and management followed the recommendations provided by Rodrigues et al. (2015) for this specific plant.

Seventy-two treatments were conducted in a 2x3x12 factorial scheme. The factors consisted of two cultivars ['Prata-Anã' (AAB) and its progeny 'BRS Platina' (AAAB)], three irrigation systems (conventional under-tree sprinklers, micro-sprinklers, and dripping), and 12 evaluation months (from October 2009 to September 2010). Treatments were arranged in a fully randomized design with five repetitions. Each experimental plot was composed of one plant fully bordered.

Three irrigation systems were tested in this experiment: I) an under-tree conventional sprinkling with sectoral sprinklers (model 427 ½"; NaaDan Indústria e Comércio de Equipamentos para Irrigação Ltda., Leme - SP, Brazil), with a 1,500 L h⁻¹ water outflow and 3.2-mm nozzles spaced 12 m between side lines and 12 m between sprinklers; II) pressure compensating micro-sprinkling with Netafim emitters (Netafim Israel, Kibbutz Hatzerim, Israel), with a 70 L h⁻¹ water outflow, 6-m wetting diameter, and 1.33-mm green nozzles spaced 6 m between side lines and 5 m between emitters; III) a dripping system with one lateral drip line per plant row and over the ground emitters (model Catif; Plastro Brasil Sistemas de Irrigação, Uberlândia, MG, Brazil), with a 2.3 L h⁻¹ water outflow and spaced 3 m between side lines and 0.30 m between emitters.

Irrigation was managed based on crop evapotranspiration (ETc) from reference evapotranspiration (ETo) and crop coefficient (Kc). ETo was indirectly calculated by the Penman-Monteith method according to FAO bulletin 56 and based on data from a weather station in the *IF Baiano* (Guanambi Campus), installed near the experimental areas. The mean water depth used in each system was 5.04 mm a day; however, the amount of water varied throughout the experiment and considered each system application efficiency, which was 90, 85, and 80% for dripping, micro-sprinkling, and conventional sprinkling, respectively.

The Kc values used for crop evapotranspiration calculation during irrigation management followed Equation 1, as described by Borges et al. (2011). From implementation until banana seedling young phase, i.e. the first 120 days after transplanting (DAT), the water depth was the same for all treatments. From then on, the Kc values varied approximately between 0.60 and 1.4 from 120 to 300 DAT, respectively. These values were maintained in all subsequent cycles up to the end of the crop cycle. Yet the coefficient of location (Kl) was calculated based on the shaded area of the plant or on the emitter wetting area, depending on which one was the highest.

Equation 1: Kc = 0.704 - 6.443 x 10-3 DAP + 6.437 x 10-5 DAP² - 1.174 x 10-7 DAP³; R² = 0.978;

The vegetative characteristics were measured during the flowering stage of the third production cycle.

These traits consisted of plant height, distance from soil level to leaf rosette, pseudostem perimeter at soil level, number of functional leaves (i.e. unbroken or with at least 50% of their leaf blade intact). During the third cycle harvest, the number of functional leaves and yield characteristics (mass of the hands, number of hands per bunch and bunch mass) was measured for each useful plant, following the procedures adopted by Donato et al. (2006; 2009). Total leaf area was determined according to Zucoloto et al. (2008) and the leaf area index (LAI) was calculated by the formula: LAI = TLA/area occupied by the plant (m^2/m^2).

Gas exchange, leaf temperature, and incident radiation were assessed in the third or fourth leaf from the top to bottom by an infrared gas analyzer (IRGA), LCpro⁺® Portable Photosynthesis System model (ADC Bioscientific Limited, UK). The measures were made at ambient temperature and irradiation, and with an airflow of 200 mL min⁻¹, always with the radiation shield directed towards the sun.

Twelve assessments were conducted at monthly intervals, at five different times of day (8 am, 10 am, 12 pm, 2 pm, and 4 pm). Leaf temperature (T_{leaf}; °C), transpiration (E; mmol H_2O $m^{-2}s^{-1}$), liquid photosynthesis (A; μmol CO_2 $m^{-2}s^{-1}$), instant water-use efficiency (A/E; μmol CO_2 $m^{-2}s^{-1}$/mmol H_2O $m^{-2}s^{-1}$), and carboxylation efficiency (A/C_i).

Statistical analysis was performed as follows: 1) plant vegetative and yield characteristics were analyzed in a two-factor design (3 irrigation systems and 2 cultivars) in a fully randomized design (FRD). The data underwent variance analysis to check for interaction significance, and means were compared by Tukey's test (P<0.05); 2) plant physiological characteristics were arranged in a 3x2x12 factorial scheme in an FRD (2 irrigation systems, 2 cultivars, and 12 months). These data were also submitted to variance analysis and, when interactions were significant, factors were analyzed individually.

The averages were compared using the F and the Tukey tests (P<0.05) for both cultivar and irrigation system factors, respectively; then, they were grouped together by the Scott-Knott criteria (P<0.05) for the monthly evaluation factor. Correlation and regression studies were conducted for the variables, and the mathematical models were adjusted according to beta significance, determination coefficient, correlation coefficient, and the difference between them.

RESULTS AND DISCUSSION

During the third cycle, the plant parameters varied according to banana cultivar and irrigation system, in an independent manner, with no interaction between them (Table 1). These results were similar to those found by Marques et al. (2011), who also observed no significant interactions between cultivars and irrigation systems, except for number of fruits per hand in the first cycle and mass of hands in the second one.

TABLE 1. Vegetative and yield characteristics assessed during the third production cycle of 'Prata-Anã' and 'BRS Platina' banana cultivars, under conventional sprinkling, micro-sprinkling, and dripping irrigation systems. Guanambi, BA, 2009-2010.

Characteristics	Irrigation Systems			Cultivars		CV (%)
	Micro	Sprinkling	Dripping	'BRS Platina'	'Prata-Anã'	
Plant height (cm)	396.58a	395.46ab	371.62b	391.92a	383.86a	9.11
Perimeter of pseudostem (cm)	127.33a	127.37a	116.46b	120.55b	126.88a	7.63
Number of leaves at flowering	17.00a	16.83a	17.12a	15.47b	18.50a	13.11
Number of leaves at harvest	11.00a	11.38a	11.92a	10.11b	12.75a	19.80
Leaf area (m^2)	17.58a	17.38a	17.96a	16.28b	19.00a	23.39
Numbers of hands per bunch	11.21a	11.37a	10.42b	9.92b	12.08a	10.33
Bunch mass (kg)	23.73a	23.98a	23.45a	24.37a	22.51a	23.16
Hand mass (kg)	20.65a	21.02a	19.74a	20.13a	20.81a	23.10

[1] Averages, followed by the same letters in the lines, displayed no differences amongst themselves for irrigation systems, verified by the Tukey test, and for the cultivars, verified by the F Test, at 5% probability.

Plant height only differed among irrigation systems (P<0.05), regardless of the cultivar (Table 1). These results are in agreement with the results obtained by Marques et al. (2011), and confirm the statements made by Donato et al. (2006; 2009) that 'Prata-Anã" and 'BRS Platina' have similar sizes. Banana plants irrigated by micro-sprinklers were taller (396.58 cm) if compared to those irrigated by dripping (371.63 cm), which is probably due to the differences in root system distribution in the soil (Sant'ana et al., 2012).

The pseudostem perimeter at soil level differed for each irrigation system and cultivar in an independent manner. The results were higher for banana plants irrigated by micro-sprinkling and conventional under-tree sprinkling, being of 127.33, and 127.37 cm, respectively. However, the results were lower for banana plants treated with dripping (116.46 cm). These results are all in agreement with Marques et al. (2011).

Plant heights and pseudostem perimeters responded to environmental and management factors, showing the vigor of plants. This first was mostly affected by management and environmental factors, which can limit cultivation in regions with strong winds (Soto Ballestero, 2008), while the second represents the number of emitted leaves and can alter the number of hands (Robinson & Galán Saúco, 2010).

The number of functional leaves at flowering and at harvest and the total leaf area were influenced exclusively by the cultivars, regardless of the irrigation system (Table 1). The number of functional leaves at flowering and harvesting and the leaf area were 18.5, 12.75, 19.0 m² for the cultivar 'Prata- Anã', and 15.47, 10.11, and 16.28 m² for the cultivar 'BRS Platina', respectively (Table 1). The number of live leaves has an influence on the factors leaf area and leaf area index; this number depends on climatic and management conditions, being related to light absorption and energy.

The vegetative characteristics varied according to the cultivar, except for plant height that was higher for the cultivar 'Prata-Anã' (Table 1). These results are similar to those found by Donato et al. (2006) and Marques et al. (2011) and displayed the genetic differences between both

them. The cultivar 'Prata-Anã' showed a larger number of leaves than does the 'BRS Platina', regardless of the irrigation system. Donato et al. (2009) have already reported different results when in the presence of yellow Sigatoka. According to these authors, both cultivars have a similar number of leaves when affected by such disease. In contrast, Oliveira et al. (2008) registered a higher number of leaves for 'BRA Platina', when in the presence of black Sigatoka, which might be because of its resistance to the disease (Oliveira et al., 2008).

The number of hands per bunch differed independently among irrigation systems and cultivars (Table 1). Banana plants irrigated by micro-sprinklers and conventional sprinklers presented a larger number of bunches (11) when compared to the dripping irrigation system (10). Concerning the cultivars, the 'Prata-Anã' presented a larger number of hands per bunch (12) than did 'BRS Platina' plants (10), regardless of the irrigation system (Table 1), which is in agreement with Donato et al. (2006; 2009). Marques et al. (2011) reported larger hand sizes and bunch masses in the second production cycle for plants irrigated by micro-sprinklers when compared to those irrigated by dripping, in the same experimental conditions.

Significant interactions were observed at all five assessment times for all the assessed factors and for all the studied physiological characteristics (Tables 2, 3, 4, 5, and 6). We expected to find physiological differences between the two genotypes when irrigated with different systems, which would allow their grouping according to the seasons of the year. However, the differences between the months prevented grouping by the Scott-Knott criteria (P< 0.05).

The leaf temperature (T_{leaf}) for each banana plant cultivar differed in all irrigation systems and assessment times. By and large, 'BRS Platina' showed the lower results while 'Prata-Anã' the higher ones. At all assessments times, both cultivars presented different T_{leaf} values for the different irrigation systems most months. In most cases, if compared to the plants irrigated by micro-sprinkling, leaf temperature was higher in both cultivars when irrigated by dripping.

TABLE 2. Physiological variables measured at 8 a.m. on the third sheet of 'Prata-Anã' and 'BRS Platina' banana plants in their third cycle of production, grown in three different irrigation systems from October 2009 to September 2010 in Guanambi, BA.

Months	Cultivars	T_{Leaf}			E			A			A/C_i			A/E		
		Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri
Oct09	'BRS Platina'	30,94Bb	35,94Aa	35,54Aa	2,32Bb	1,97Ab	5,51Aa	4,33Ab	5,13Ab	12,56Aa	0,01Ab	0,023Aab	0,05Aa	1,88Aa	2,61Aa	2,21Aa
	'Prata-Anã'	31,86Ab	35,08Ba	35,72Aa	3,07Ab	2,06Ac	5,31Aa	5,96Aa	4,74Aa	6,16Ba	0,02Aa	0,019Aa	0,02Ba	1,94Aa	2,37Aa	1,16Aa
Nov09	'BRS Platina'	29,96Bb	33,20Ba	33,00Aa	2,01Bc	4,06Aa	3,46Ab	9,86Ab	14,72Aa	10,17Ab	0,04Aa	0,073Aa	0,04Aa	4,89Aa	3,63Aab	2,95Ab
	'Prata-Anã'	32,14Ab	34,54Aa	31,80Bb	3,01Ab	4,08Aa	3,38Ab	9,99Ab	13,83Aa	11,96Aab	0,03Aa	0,065Aa	0,05Aa	3,31Ba	3,52Aa	3,55Aa
Dec09	'BRS Platina'	32,68Bc	35,52Aa	34,30Bb	1,78Bc	6,01Aa	4,85Bb	7,26Bb	20,22Aa	17,52Aa	0,03Bb	0,10Aa	0,08Aa	4,06Aa	3,41Aa	3,62Aa
	'Prata-Anã'	34,76Aa	34,72Ba	34,92Aa	6,85Aa	5,92Ab	5,26Ac	24,47Aa	21,84Aab	17,40Ab	0,11Aa	0,11Aa	0,10Aa	3,58Aa	3,64Aa	3,71Aa
Jan10	'BRS Platina'	29,86Ac	30,56Bb	33,62Aa	0,82Ab	1,28Bb	3,99Aa	1,79Ab	2,86Ab	12,65Aa	0,006Ab	0,010Ab	0,05Aa	2,22Aa	2,20Aa	3,16Aa
	'Prata-Anã'	30,24Ac	31,66Ab	33,68Aa	0,76Ab	1,80Aa	1,20Bb	1,97Aa	3,61Aa	3,06Ba	0,007Aa	0,013Aa	0,01Ba	2,58Aa	2,01Aa	2,53Aa
Feb10	'BRS Platina'	29,64B	31,98B	-	1,25B	3,60A	-	4,77B	16,26A	-	0,019B	0,07A	-	3,78A	4,50A	-
	'Prata-Anã'	30,32Ac	32,70Ab	34,82Ba	4,52Ab	1,22Bc	5,20Aa	16,29Aa	3,58Bb	15,76Aa	0,06Aa	0,01Bb	0,07Ba	3,58Aa	2,84Aa	3,04Ba
Mar10	'BRS Platina'	31,22Bc	33,60Bb	36,04Aa	2,88Ab	1,97Bc	3,45Ba	12,09Aa	6,59Bb	10,79Aa	0,04Aa	0,02Aa	0,04Aa	4,21Aa	3,34Aa	3,14Aa
	'Prata-Anã'	31,94Bc	34,80Aa	35,30Ba	2,91Ab	3,34Aa	4,20Aa	10,01Aa	9,82Aa	10,66Aa	0,03Aa	0,04Aa	0,04Aa	3,43Aa	2,96Aa	2,53Aa
Apr10	'BRS Platina'	29,60Bc	31,14Bb	32,52Aa	1,16Bb	2,62Ab	2,40Aa	3,51Bc	11,36Aa	7,40Ab	0,01Ba	0,04Aa	0,02Aa	3,13Ba	3,67Aa	3,09Aa
	'Prata-Anã'	30,94Aa	33,00Aa	33,18Aa	2,82Ab	2,45Aa	2,66Aa	14,88Aa	10,19Ab	8,66Ab	0,05Aa	0,04Aa	0,03Aa	5,27Aa	4,35Aab	3,22Ab
Mai10	'BRS Platina'	30,14Bb	30,70Bb	33,74Aa	2,89Ba	3,15Aa	1,19Bb	20,83Aa	15,44Ab	4,96Bc	0,09Aa	0,07Aa	0,02Ab	7,21Aa	5,02Ab	4,13Ab
	'Prata-Anã'	31,28Ac	32,38Ab	33,72Aa	4,03Aa	2,66Bb	3,87Aa	17,01Ba	10,11Bb	11,65Aa	0,06Aa	0,04Aa	0,04Aa	4,23Aa	3,82Ba	3,05Aa
Jun10	'BRS Platina'	25,50Bc	28,62Bb	30,12Aa	0,99Bc	1,62Bb	2,35Aa	3,90Bb	9,72Ba	9,78Aa	0,01Ba	0,04Aa	0,04Aa	3,92Bb	5,99Aa	4,16Ab
	'Prata-Anã'	26,38Ab	29,76Aa	29,62Aa	1,52Ab	2,22Aa	1,81Bab	10,00Aab	12,70Aa	7,30Bb	0,04Aa	0,06Aa	0,02Aa	6,57Aa	5,70Aa	4,04Ab
Jul10	'BRS Platina'	27,06Ab	28,76Aa	28,48Aa	1,48Ba	1,69Aa	1,33Aa	4,50Ab	10,79Aa	4,29Ab	0,014Ab	0,05Aa	0,01Ab	3,05Ab	6,33Aa	3,23Ab
	'Prata-Anã'	27,48Ab	28,62Aa	28,00Ab	1,92Aa	1,81Aab	1,39Ab	3,01Ab	9,21Aa	2,36Ab	0,009Aa	0,03Aa	0,007Aa	1,59Bb	5,13Ba	1,70Bb
Aug10	'BRS Platina'	27,10Ac	28,06Bb	29,70Ba	1,89Ac	2,57Bb	3,36Aa	6,57Bc	11,82Bb	17,49Aa	0,02Ab	0,04Aab	0,08Aa	3,46Bb	4,59Aab	5,21Aa
	'Prata-Anã'	26,36Bc	29,18Ab	30,50Aa	2,22Ac	3,49Aa	2,88Bb	10,89Ab	16,10Aa	12,44Bb	0,04Aa	0,06Aa	0,05Aa	4,87Aa	4,61Aa	4,35Aa
Sep10	'BRS Platina'	27,10Bc	28,56Bb	30,32Aa	2,10Bb	3,26Aa	2,32Ab	11,28Bb	16,90Aa	12,00Ab	0,04Aa	0,07Aa	0,06Aa	5,21Aa	5,17Aa	5,22Aa
	'Prata-Anã'	28,94Ab	30,16Aa	30,62Aa	2,97Aa	2,16Ab	2,03Ab	15,60Aa	9,32Bb	10,13Ab	0,07Aa	0,04Aa	0,05Aa	5,22Aa	4,32Aa	5,08Aa
CV(%)			1,19			11,69			17,67			31,91			21,43	

T_{leaf} (ºC): Leaf temperature; E (mmol H_2O $m^{-2}s^{-1}$): Transpiration rate; A (µmol CO_2 m^{-2} s^{-1}); Photosynthesis rate; A/C_i: CO_2 Carboxylation efficiency; A/E ((µmol CO_2 m^{-2} s^{-1}/ mmol H_2O $m^{-2}s^{-1}$): Instant water use efficiency; Mic: Micro-sprinkling system; Spr: Conventional under-tree sprinkling system; Dri: Dripping irrigation system.

*Average followed by the same letter, upper case in the columns for cultivars, and lower case in the lines for irrigation systems, had no difference amongst each other, verified by the F Test and the Tukey Test at 5% probability, respectively.

TABLE 3. Physiological variables measured at 10 a.m. on the third sheet of 'Prata-Anã' and 'BRS Platina' banana plants in their third cycle of production, grown in three different irrigation systems from October 2009 to September 2010 in Guanambi, BA.

Months	Cultivars	T_{Leaf}			E			A			A/C_i			A/E		
		Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri
Oct09	'BRS Platina'	32,92Bc	36,32Bb	38,18Aa	2,87Bb	3,51Bb	6,46Ba	5,69Bb	6,32Bb	10,66Aa	0,020Bb	0,024Bb	0,043Aa	2,02Aa	1,79Aa	1,63Aa
	'Prata-Anã'	37,28Ab	38,34Aa	38,42Aa	3,95Ac	5,56Ab	7,47Aa	9,23Ab	9,74Aab	11,80Aa	0,042Aa	0,039Aa	0,045Aa	2,34Aa	1,74Aab	1,57Ab
Nov09	'BRS Platina'	31,08Bc	34,00Bb	35,34Ba	2,73Bc	4,23Bb	5,33Ba	13,2Ab	15,85Aa	16,92Aa	0,061Ab	0,073Aab	0,076Aa	5,00Aa	3,77Ab	3,19Ab
	'Prata-Anã'	32,28Ac	34,94Ab	37,04Aa	3,83Ac	5,11Ab	7,09Aa	13,53Ab	14,52Ab	18,51Aa	0,055Ab	0,061Ab	0,080Aa	3,55Ba	2,83Bab	2,61Ab
Dec09	'BRS Platina'	32,30Bc	35,82Bb	38,44Aa	3,40Ab	3,43Bb	8,66Aa	3,02Bb	4,07Bb	21,75Aa	0,009Bb	0,014Bb	0,093Aa	0,91Bb	1,19Bb	2,51Aa
	'Prata-Anã'	33,00Ac	37,06Ab	38,68Aa	3,88Ac	6,89Aa	5,95Bb	6,71Ac	20,35Aa	13,56Bb	0,023Ac	0,093Aa	0,058Bb	1,72Ab	2,97Aa	2,28Aab
Jan10	'BRS Platina'	31,88Bc	34,50Bb	37,38Ba	1,92Bb	2,32Bb	5,69Aa	5,35Ab	2,71Bc	11,73Aa	0,020Ab	0,009Bb	0,050Aa	2,78Aa	1,18Bc	2,06Ab
	'Prata-Anã'	34,62Ac	36,68Ab	38,52Aa	4,25Aa	4,13Aa	4,42Ba	5,68Ab	9,83Aa	7,85Bab	0,018Ab	0,045Aa	0,037Ba	1,34Bb	2,37Aa	1,77Aab
Feb10	'BRS Platina'	30,40Bb	31,18Aa	31,58Aa	3,24Aa	2,78Aa	3,05Aa	13,87Aa	13,18Aa	12,53Aa	0,052Aa	0,065Aa	0,056Aa	4,28Aa	4,73Aa	4,14Aa
	'Prata-Anã'	30,78Ab	31,50Aa	31,36Aa	2,85Aa	2,52Aa	2,97Aa	9,15Ba	11,22Aa	9,19Ba	0,035Ab	0,054Aa	0,035Bb	3,21Bb	4,44Aa	3,08Bb
Mar10	'BRS Platina'	33,02Bc	36,70Bb	39,36Ba	3,49Bb	5,23Ba	5,50Ba	15,23Aa	15,35Ba	11,84Ab	0,063Aab	0,072Aa	0,054Bb	4,38Aa	3,04Ab	2,19Ac
	'Prata-Anã'	35,82Ac	38,48Ab	40,06Aa	5,21Ac	7,81Aa	6,39Ab	14,99Aa	17,54Aa	13,86Ab	0,058Ab	0,073Aa	0,068Aab	2,92Ba	2,24Bab	2,18Ac
Apr10	'BRS Platina'	32,52Bc	35,18Ab	36,62Ba	2,65Bb	3,15Ab	5,24Aa	10,26Bb	11,72Ab	16,69Aa	0,037Bb	0,046Ab	0,072Aa	3,91Aa	3,86Aa	3,20Aa
	'Prata-Anã'	34,28Ac	35,02Ab	37,24Aa	3,58Aa	2,63Ab	2,93Bab	15,33Aa	3,61Bc	6,51Bb	0,060Aa	0,012Bc	0,026Bb	4,23Aa	1,40Bb	1,90Bb
Mai10	'BRS Platina'	33,74Bc	37,30Ab	40,44Aa	2,68Bb	7,18Aa	1,07Bc	8,862Bb	22,23Aa	1,98Bc	0,032Bb	0,098Aa	0,009Bc	3,27Aa	3,12Aa	1,84Bb
	'Prata-Anã'	35,86Ab	38,10Aa	38,10Ba	5,81Aa	5,94Aa	5,94Aa	18,11Aa	17,16Aa	17,16Aa	0,075Aa	0,080Ba	0,080Aa	3,14Aa	2,89Aa	2,89Aa
Jun10	'BRS Platina'	31,18Bc	32,80Bb	34,40Ba	3,37Ab	5,08Aa	2,82Bc	9,258Ba	6,26Ab	8,17Bab	0,033Ba	0,019Ab	0,037Ba	2,80Ba	1,22Bb	2,98Aa
	'Prata-Anã'	32,52Ab	32,86Ab	35,30Aa	3,80Ab	3,90Aa	6,12Aa	13,76Aa	7,95Ac	19,71Aa	0,057Ab	0,029Ac	0,091Aa	3,62Aa	2,24Ab	3,21Aa
Jul10	'BRS Platina'	29,38Bc	31,56Ab	33,22Ba	1,97Ab	3,48Aa	2,98Aa	9,21Ab	13,27Aa	10,94Aab	0,037Ab	0,055Aa	0,052Ba	4,67Ba	3,81Ab	3,67Ab
	'Prata-Anã'	30,76Ac	31,50Ab	34,64Aa	1,90Ab	2,07Bb	3,34Aa	9,35Ab	6,27Bc	12,63Aa	0,043Ab	0,024Bc	0,066Aa	4,91Aa	3,03Bc	3,81Ab
Aug10	'BRS Platina'	31,48Bc	33,28Bb	34,42Ba	1,72Bc	3,18Ab	4,46Aa	7,236Bc	10,46Ab	16,21Aa	0,033Bb	0,046Ab	0,083Aa	4,18Aa	3,29Ab	3,64Aab
	'Prata-Anã'	32,68Ac	33,82Ab	35,08Aa	4,76Aa	3,58Ab	1,98Bc	16,60Aa	10,36Ab	4,89Bc	0,068Aa	0,045Ab	0,022Bc	3,47Ba	2,88Aab	2,43Bb
Sep10	'BRS Platina'	30,08Bc	32,94Bb	34,72Aa	2,82Bb	2,91Bb	4,91Aa	14,93Ba	12,04Bb	16,31Aa	0,069Bab	0,062Bb	0,076Aa	5,27Aa	4,16Ab	3,33Ac
	'Prata-Anã'	31,70Ac	33,50Ab	34,32Ba	4,15Aa	4,11Aa	3,05Bb	18,17Aa	15,83Aa	11,22Bb	0,083Aa	0,077Aa	0,057Bb	4,41Ba	3,85Aab	3,67Ab
CV(%)			0,83			12,31			14,29			18,19			21,43	

T_{leaf} (ºC): Leaf temperature; E (mmol H_2O $m^{-2}s^{-1}$): Transpiration rate; A (µmol CO_2 m^{-2} s^{-1}); Photosynthesis rate; A/C_i: CO_2 Carboxylation efficiency; A/E ((µmol CO_2 m^{-2} s^{-1}/ mmol H_2O $m^{-2}s^{-1}$): Instant water use efficiency; Mic: Micro-sprinkling system; Spr: Conventional under-tree sprinkling system; Dri: Dripping irrigation system.

*Average followed by the same letter, upper case in the columns for cultivars, and lower case in the lines for irrigation systems, had no difference amongst each other, verified by the F Test and the Tukey Test at 5% probability, respectively.

TABLE 4. Physiological variables measured at 12 p.m. on the third sheet of 'Prata-Anã' and 'BRS Platina' banana plants in their third cycle of production, grown in three different irrigation systems from October 2009 to September 2010 in Guanambi, BA.

Months	Cultivars	T_{Leaf}			E			A			A/C_i			A/E		
		Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri
Oct 09	'BRS Platina'	32,06Bc	37,68Bb	43,04Aa	3,06Bb	3,93Ba	4,60Ba	10,03Aa	7,64Aab	5,71Bb	0,03Aa	0,032Aa	0,026Ba	3,27Aa	1,93Bb	1,23Ac
	'Prata-Anã'	36,26Ac	41,94Aa	42,02Ba	3,90Ac	5,76Ab	6,64Aa	9,95Aa	5,24Ab	9,11Aa	0,04Aa	0,019Ab	0,04Aa	2,54Ba	0,90Ab	1,36Ab
Nov09	'BRS Platina'	34,82Ac	37,58Bb	39,54Aa	3,75Bb	4,24Bb	7,97Aa	12,04Ab	7,00Ac	14,74Aa	0,05Aa	0,027Ab	0,063Aa	3,22Aa	1,61Ab	1,85Ab
	'Prata-Anã'	37,76Bc	38,36Ab	39,78Aa	4,73Ac	5,53Ab	7,41Aa	10,67Ab	7,56Ac	14,15Aa	0,04Ab	0,030Ab	0,06Aa	2,26Ba	1,40Ab	1,95Aab
Dec 09	'BRS Platina'	35,62Bc	38,78Bb	40,36Ba	3,42Ab	3,12Bb	7,32Aa	12,31Aa	6,06Ab	11,25Aa	0,05Aa	0,025Ab	0,045Aa	3,60Aa	1,92Ab	1,54Ab
	'Prata-Anã'	37,60Ac	39,56Ab	41,36Aa	3,36Ab	4,60Aa	5,27Ba	11,42Aa	7,27Ab	8,48Bb	0,05Aa	0,030Ab	0,03Ab	3,54Aa	1,58Ab	1,61Ab
Jan10	'BRS Platina'	35,92Bb	39,98Ba	40,40Ba	2,42Bc	3,49Bb	4,35Aa	7,58Aa	5,50Ba	7,16Aa	0,03Aa	0,025Ba	0,034Aa	3,11Aa	1,58Ab	1,66Ab
	'Prata-Anã'	37,52Ac	41,10Ab	42,66Aa	5,24Ab	7,23Aa	2,67Bc	7,59Ab	13,45Aa	3,51Bc	0,02Ab	0,067Aa	0,01Bb	1,45Ba	1,86Aa	1,31Aa
Feb10	'BRS Platina'	29,22Bc	31,32Bb	32,32Ba	1,92Bb	2,15Ba	3,34Ba	9,56Ab	11,29Ab	14,39Aa	0,03Ab	0,059Aa	0,064Ba	4,96Aab	5,27Aa	4,32Ab
	'Prata-Anã'	30,62Ac	32,02Ab	33,62Aa	2,50Ab	2,04Ab	4,34Aa	9,26Ab	11,13Aab	12,61Aa	0,03Ab	0,066Aa	0,05Ab	3,73Bb	5,46Aa	2,90Bc
Mar10	'BRS Platina'	34,94Bc	39,40Bb	40,44Ba	4,83Ab	5,65Ba	4,10Ac	13,82Aa	11,78Aa	8,28Ab	0,05Aa	0,050Aa	0,041Aa	2,86Aa	2,09Ab	2,00Ab
	'Prata-Anã'	39,18Ac	40,62Ab	41,36Aa	5,40Ab	6,99Aa	4,64Ac	11,65Ba	11,70Aa	8,07Ab	0,05Aa	0,048Aa	0,04Aa	2,16Ba	1,69Ba	1,79Aa
Apr10	'BRS Platina'	33,50Bc	35,58Bb	38,00Ba	2,72Bb	3,05Bb	6,32Aa	15,14Ab	11,89Ac	18,17Aa	0,06Aab	0,057Ab	0,07Aa	5,64Aa	4,05Ab	2,89Ac
	'Prata-Anã'	34,76Ac	36,88Ab	38,90Aa	3,96Aa	4,28Aa	3,71Ba	14,74Aa	13,89Aa	7,77Ab	0,05Aa	0,060Aa	0,03Bb	3,77Ba	3,28Ba	2,13Bb
Mai10	'BRS Platina'	30,50Bc	33,50Bb	38,26Ba	2,89Aa	3,52Ba	0,35Bb	11,73Aa	11,32Aa	0,38Bb	0,04Aa	0,042Aa	0,001Bb	4,04Aa	3,21Ab	1,26Ac
	'Prata-Anã'	32,22Ac	35,44Ab	38,86Aa	3,45Ac	4,17Ab	6,21Aa	11,14Aab	12,62Aa	9,42Ab	0,03Aab	0,053Aa	0,03Ab	3,20Ba	3,01Aa	1,52Ab
Jun10	'BRS Platina'	32,14Bc	34,26Bb	35,26Ba	3,69Aa	4,13Aa	3,60Aa	14,97Aa	12,34Ab	9,99Bb	0,06Aa	0,053Bab	0,045Ab	4,03Aa	2,99Ab	2,77Ab
	'Prata-Anã'	33,70Ac	34,82Ab	35,74Aa	4,16Aa	4,09Aa	4,42Aa	15,30Aa	14,30Aab	12,38Ab	0,06Aa	0,073Aa	0,05Aa	3,68Aa	3,49Aa	2,80Ab
Jul10	'BRS Platina'	34,22Ab	34,20Ab	35,96Aa	2,27Bb	2,77Ab	3,80Ba	8,27Ab	10,27Ab	12,93Aa	0,04Ab	0,059Aa	0,074Aa	3,61Aa	3,73Aa	3,39Aa
	'Prata-Anã'	34,56Ac	33,74Ab	35,82Aa	2,92Ab	2,22Ac	4,91Aa	10,29Ab	6,38Bc	14,60Aa	0,05Ab	0,030Bc	0,07Aa	3,53Aa	2,89Ba	2,96Aa
Aug 10	'BRS Platina'	33,22Bc	34,90Bb	37,30Ba	2,43Bb	1,90Bb	3,83Aa	6,62Aab	4,48Ab	8,60Aa	0,02Ab	0,019Ab	0,042Aa	2,69Aa	2,36Aa	2,25Aa
	'Prata-Anã'	35,16Ac	36,10Ab	38,98Aa	3,23Aa	2,64Ab	1,83Bb	8,35Aa	5,24Ab	3,21Bb	0,03Aa	0,022Aab	0,01Bb	2,57Aa	1,98Aab	1,77Ab
Sep10	'BRS Platina'	32,88Bc	35,82Bb	38,14Aa	3,28Bb	2,52Bc	4,76Aa	14,42Ba	7,66Bc	11,10Bb	0,07Ba	0,039Bb	0,053Bab	4,38Ba	3,04Ab	2,33Ac
	'Prata-Anã'	34,42Ac	36,70Ab	37,38Ba	5,33Aa	4,28Ab	4,99Aa	19,19Aa	12,95Ab	13,71Ab	0,09Aa	0,069Ab	0,07Ab	3,60Aa	3,04Aab	2,74Ab
	CV(%)	1,01			11,37			16,67			18,19			16,36		

T_{leaf} (ºC): Leaf temperature; E (mmol H_2O $m^{-2}s^{-1}$): Transpiration rate; A (µmol CO_2 m^{-2} s^{-1}); Photosynthesis rate; A/Ci: CO_2 Carboxylation efficiency; A/E ((µmol CO_2 m^{-2} s^{-1}/ mmol H_2O $m^{-2}s^{-1}$): Instant water use efficiency; Mic: Micro-sprinkling system; Spr: Conventional under-tree sprinkling system; Dri: Dripping irrigation system.

*Average followed by the same letter, upper case in the columns for cultivars, and lower case in the lines for irrigation systems, had no difference amongst each other, verified by the F Test and the Tukey Test at 5% probability, respectively.

TABLE 5. Physiological variables measured at 2 p.m. on the third sheet of 'Prata-Anã' and 'BRS Platina' banana plants in their third cycle of production, grown in three different irrigation systems from October 2009 to September 2010 in Guanambi, BA.

Months	Cultivars	T_{Leaf}			E			A			A/C_i			A/E		
		Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri
Oct09	'BRS Platina'	35,04Bc	39,28Bb	43,22Aa	3,75Ab	4,83Aa	5,17Ba	7,83Aa	8,30Aa	6,53Ba	0,031Aa	0,037Aa	0,03Aa	2,09Aa	1,71Aa	1,26Aa
	'Prata-Anã'	37,70Ac	42,46Ab	43,10Aa	4,41Bb	3,17Bc	8,29Aa	7,57Ab	4,12Bc	11,07Aa	0,03Aab	0,019Ab	0,04Aa	1,71Aa	1,28Aa	1,33Aa
Nov09	'BRS Platina'	36,66Bc	38,82Ab	39,62Aa	3,17Bc	7,13Aa	6,34Bb	6,29Bc	15,86Aa	8,24Bb	0,026Bb	0,074Aa	0,03Bb	2,16Aa	2,22Aa	1,31Aa
	'Prata-Anã'	38,06Ac	39,20Ab	40,04Aa	5,41Ab	4,64Bc	7,52Aa	12,89Aa	9,30Bb	14,07Aa	0,05Ab	0,047Ba	0,06Aa	2,36Aa	2,02Aa	1,86Aa
Dec 09	'BRS Platina'	34,70Bc	37,84Ab	38,60Ba	1,06Bb	1,97Aa	2,38Aa	9,47Ab	7,35Ac	13,85Aa	0,062Aa	0,030Ab	0,08Aa	9,57Aa	3,73Bb	6,18Bc
	'Prata-Anã'	35,44Ab	37,60Aa	37,73Ba	2,10Aa	1,17Bb	0,93Bb	11,07Aa	7,72Ab	8,28Bb	0,04Ab	0,039Ab	0,08Aa	5,44Bb	7,97Aa	8,98Aa
Jan10	'BRS Platina'	37,86Bc	40,02Ab	41,32Aa	2,29Bb	5,51Aa	5,90Aa	5,78Aa	6,96Aa	7,57Aa	0,029Aa	0,028Aa	0,03Aa	2,51Aa	1,26Aa	1,28Aa
	'Prata-Anã'	38,84Ac	40,36Ab	41,46Aa	3,94Aa	4,34Ba	4,03Ba	4,90Ab	5,91Aab	7,36Aa	0,01Aa	0,026Aa	0,04Aa	1,24Ba	1,36Aa	1,82Aa
Feb10	'BRS Platina'	32,58Bb	34,08Aa	34,24Aa	1,17Bc	2,13Bb	3,59Ba	4,52Bc	8,66Ab	11,83Ba	0,019Ab	0,047Aa	0,05Aa	3,85Aa	4,06Aa	3,27Aa
	'Prata-Anã'	33,36Ab	33,98Aa	34,36Aa	3,05Ab	3,02Ab	5,64Aa	9,75Ab	6,65Bc	15,04Aa	0,03Aab	0,025Bb	0,05Aa	3,20Aa	2,22Ba	2,66Aa
Mar10	'BRS Platina'	34,26Bc	38,38Bb	39,80Ba	2,36Bb	3,97Ba	3,74Aa	8,69Ab	11,18Ba	10,77Aa	0,03Ab	0,059Ab	0,10Aa	3,61Aa	2,91Aa	3,04Aa
	'Prata-Anã'	36,57Ac	39,52Ab	42,06Aa	3,67Ab	6,71Aa	2,94Bc	7,28Ab	15,23Aa	4,33Bc	0,02Ab	0,070Aa	0,02Bb	1,98Ba	2,27Aa	1,57Ba
Apr10	'BRS Platina'	30,32Bc	31,66Bb	33,86Ba	2,16Aa	1,18Ab	2,51Aa	4,53Ab	3,24Ab	11,04Aa	0,01Ab	0,011Ab	0,05Aa	2,09Ab	2,75Ab	4,60Aa
	'Prata-Anã'	31,02Ac	32,34Ab	34,74Aa	1,78Aa	1,39Ab	2,54Aa	4,02Aab	2,24Ab	4,89Ba	0,01Aa	0,007Aa	0,01Ba	2,29Aa	1,62Aa	1,96Ba
Mai10	'BRS Platina'	31,22Bc	35,06Bb	39,56Ba	2,52Bb	4,89Aa	2,41Bb	12,77Aa	10,97Aa	3,20Bb	0,05Aa	0,040Aa	0,01Bb	5,07Aa	2,22Ab	1,30Ab
	'Prata-Anã'	33,68Ac	37,86Ab	40,20Aa	3,36Ab	2,74Bc	7,33Aa	5,85Bb	6,43Bb	15,22Aa	0,01Bb	0,029Ab	0,06Aa	1,73Ba	2,35Aa	2,06Aa
Jun10	'BRS Platina'	31,70Bb	36,42Ab	36,56Ba	2,93Aa	2,46Ab	3,92Aa	12,28Aa	6,30Ab	6,70Ab	0,05Aa	0,029Aab	0,02Ab	4,19Aa	2,56Ab	1,71Ab
	'Prata-Anã'	34,42Ac	36,30Ab	37,82Aa	3,20Aa	2,41Ab	2,98Bab	11,57Aa	5,47Ab	7,12Ab	0,05Aa	0,024Ab	0,03Aab	3,62Aa	2,26Aa	2,39Aa
Jul10	'BRS Platina'	32,78Bb	33,96Aa	33,68Aa	1,16Ac	2,12Ab	3,62Aa	3,55Ac	5,90Aa	6,30Ba	0,016Aa	0,026Aa	0,02Aa	3,07Aa	2,80Aa	1,75Aa
	'Prata-Anã'	34,80Aa	34,00Ab	33,48Ab	1,10Ac	1,83Ab	3,06Ba	3,26Ac	5,31Ab	8,94Aa	0,01Aa	0,026Aa	0,04Aa	2,92Aa	2,93Aa	2,92Aa
Aug 10	'BRS Platina'	36,48Bc	38,16Ab	38,98Ba	1,91Bb	1,64Bb	3,74Aa	1,76Bb	2,25Bb	7,53Aa	0,006Bb	0,009Ab	0,03Aa	0,92Ba	1,40Aa	2,01Aa
	'Prata-Anã'	37,34Ab	37,40Bb	39,24Aa	4,29Aa	2,77Ab	2,10Bc	10,54Aa	4,90Ab	4,12Bb	0,05Aa	0,021Ab	0,02Ab	2,46Aa	1,76Aa	1,94Aa
Sep10	'BRS Platina'	34,60Bc	37,18Bb	39,02Aa	1,78Bb	2,22Bb	6,05Aa	6,99Bb	4,80Bc	14,19Aa	0,042Bb	0,022Bb	0,07Aa	3,88Aa	2,16Ab	2,36Ab
	'Prata-Anã'	36,12Ac	38,52Ab	37,88Ba	5,38Aa	3,48Ab	5,06Ba	16,67Aa	8,97Ab	6,71Bc	0,08Aa	0,052Ab	0,02Bc	3,09Aa	2,56Aab	1,32Bb
	CV(%)	1,03			11,96			16,14			43,39			35,44		

T_{leaf} (ºC): Leaf temperature; E (mmol H_2O $m^{-2}s^{-1}$): Transpiration rate; A (µmol CO_2 m^{-2} s^{-1}); Photosynthesis rate; A/Ci: CO_2 Carboxylation efficiency; A/E ((µmol CO_2 m^{-2} s^{-1}/ mmol H_2O $m^{-2}s^{-1}$): Instant water use efficiency; Mic: Micro-sprinkling system; Spr: Conventional under-tree sprinkling system; Dri: Dripping irrigation system.

*Average followed by the same letter, upper case in the columns for cultivars, and lower case in the lines for irrigation systems, had no difference amongst each other, verified by the F Test and the Tukey Test at 5% probability, respectively.

TABLE 6. Physiological variables measured at 4 p.m. on the third sheet of 'Prata-Anã' and 'BRS Platina' banana plants in their third cycle of production, grown in three different irrigation systems from October 2009 to September 2010 in Guanambi, BA.

Months	Cultivars	T_{leaf}			E			A			A/C_i			A/E		
		Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri	Mic	Spr	Dri
Oct09	'BRS Platina'	33,04Bc	35,34Bb	37,92Aa	2,33Ab	3,95Aa	1,97Ab	3,32Ab	8,32Aa	3,08Ab	0,01Aa	0,03Aa	0,01Aa	1,42Aa	2,06Aa	2,18Aa
	'Prata-Anã'	35,16Ab	37,58Aa	37,84Aa	1,84Ab	2,47Ba	1,28Bb	2,86Aab	4,76Ba	2,18Ab	0,011Aa	0,02Aa	0,01Aa	1,57Aa	1,90Aa	1,64Aa
Nov09	'BRS Platina'	32,52Bc	35,58Aa	35,18Ab	2,76Àab	2,32Bb	3,31Ba	8,08Aa	5,19Bb	5,61Bb	0,03Ba	0,02Aa	0,02Ba	2,94Aa	2,23Aa	1,67Ba
	'Prata-Anã'	32,88Ac	34,88Bb	34,44Ba	1,24Bb	4,09Aa	4,46Aa	3,87Bb	10,60Aa	11,06Aa	0,018Bb	0,04Aab	0,04Aa	3,10Aa	2,55Aa	2,48Aa
Dec09	'BRS Platina'	31,04Bc	35,66Aa	34,98Ab	0,29Aa	0,73Aa	0,59Ab	5,02Ab	6,92Aab	7,70Aa	0,06Ab	0,07Aa	0,10Aa	18,65Aa	9,70Bc	13,22Ab
	'Prata-Anã'	34,92Ac	35,02Ba	34,30Bb	0,50Aa	0,53Aa	0,13Ab	3,07Bb	6,23Aa	2,16Bb	0,011Bb	0,05Aa	0,03Bab	6,11Bc	11,87Ab	16,16Aa
Jan10	'BRS Platina'	35,44Bc	36,36Bb	37,10Aa	1,53Aa	2,08Ba	2,09Ba	3,86Aa	3,89Aa	1,44Bb	0,01Aa	0,01Aa	0,01Ba	2,51Aa	1,87Aa	0,70Aa
	'Prata-Anã'	35,98Ab	37,48Aa	37,40Aa	1,29Ac	2,64Ab	4,43Aa	1,74Bc	5,18Ab	9,94Aa	0,006Ab	0,02Aab	0,049Aa	4,27Aa	1,96Aa	2,23Aa
Feb10	'BRS Platina'	35,08Ac	37,48Bb	38,68Aa	2,07Ba	1,83Ab	1,20Bb	6,52Aa	2,31Ab	2,67Ab	0,03Aa	0,01Aa	0,01Aa	3,19Aa	1,31Aa	2,89Aa
	'Prata-Anã'	36,28Ac	38,34Aa	37,88Bb	3,12Ab	2,29Ab	1,78Ab	4,32Ba	3,83Aa	2,46Aa	0,01Aa	0,01Aa	0,01Aa	1,37Aa	1,66Aa	1,63Aa
Mar10	'BRS Platina'	-	-	-	-	-	-	-	-	-						
	'Prata-Anã'	-	-	-	-	-	-	-	-	-						
Apr10	'BRS Platina'	32,32Aa	32,00Aa	31,98Aa	2,99Aa	0,79Ab	1,89Ac	10,41Aa	2,61Ab	3,83Ab	0,04Aa	0,01Ab	0,01Ab	3,47Aa	3,29Aa	2,10Aa
	'Prata-Anã'	32,12Aa	31,92Aa	31,94Aa	1,35Ba	0,89Aab	0,65Bb	3,04Ba	1,84Aab	0,99Bb	0,01Ba	0,006Aa	0,003Aa	2,25Aa	2,06Aa	1,52Aa
Mai10	'BRS Platina'	30,70Bc	32,64Bb	34,70Aa	2,09Aa	2,52Aa	0,18Bb	7,03Aa	5,93Aa	1,06Bb	0,02Aa	0,02Ba	0,01Aa	3,37Ab	2,34Bb	5,99Aa
	'Prata-Anã'	31,72Ac	33,66Ab	34,92Aa	2,53Ab	1,46Bc	3,39Aa	5,99Aa	6,15Aa	4,29Aa	0,02Aa	0,03Aa	0,01Aa	2,38Aab	4,35Aa	1,26Bb
Jun10	'BRS Platina'	33,36Aa	33,36Ba	32,84Ab	3,37Aa	2,04Ab	1,02Bc	12,61Aa	6,51Ab	0,72Bc	0,06Aa	0,03Ab	0,01Ab	3,73Aa	3,19Aa	0,71Ab
	'Prata-Anã'	33,40Ab	33,98Aa	32,68Ac	2,40Ba	1,29Bb	1,79Ab	8,07Ba	1,82Bb	3,25Ab	0,038Aa	0,006Ab	0,01Aab	3,35Aa	1,40Aa	1,81Aa
Jul10	'BRS Platina'	33,08Aab	32,72Ab	33,10Aa	2,11Aab	2,54Aa	1,56Ab	6,62Ab	9,48Aa	4,85Ab	0,03Aab	0,05Aa	0,02Ab	3,25Aa	3,72Aa	3,09Aa
	'Prata-Anã'	32,88Aa	32,76Aa	32,80Ba	1,88Ab	2,66Aa	1,27Bc	5,69Ab	9,96Aa	2,84Bc	0,026Aab	0,05Aa	0,01Bb	2,99Aa	3,75Aa	2,19Ba
Aug10	'BRS Platina'	34,14Ac	35,86Ba	35,04Ab	0,98Bb	0,89Ab	2,37Aa	2,40Ab	1,98Ab	5,14Aa	0,01Aa	0,01Aa	0,02Aa	2,44Aa	2,21Aa	2,16Aa
	'Prata-Anã'	33,94Ac	36,54Aa	34,34Bb	2,21Aa	0,92Ab	1,40Bb	3,60Aa	1,96Ab	3,43Ba	0,01Aa	0,01Aa	0,01ABa	1,73Aa	2,18Aa	2,40Aa
Sep10	'BRS Platina'	34,96Ab	36,14Aa	36,20Aa	3,66Aa	2,12Bb	1,12Bc	10,38Aa	5,19Ab	3,29Bc	0,04Aa	0,02Ab	0,02Ab	2,83Aa	2,43Aa	2,92Aa
	'Prata-Anã'	34,92Ac	36,00Aa	35,32Bb	3,32Aab	2,76Ab	3,69Aa	10,03Aa	4,96Ab	9,21Aa	0,05Aa	0,02Ab	0,04Aab	3,01Aa	1,77Aa	2,48Aa
	CV(%)	0,73			20,18			25,45			74,76			46,20		

T_{leaf} (°C): Leaf temperature; E (mmol H_2O $m^{-2}s^{-1}$): Transpiration rate; A (μmol CO_2 m^{-2} s^{-1}); Photosynthesis rate; A/Ci: CO_2 Carboxylation efficiency; A/E ((μmol CO_2 m^{-2} s^{-1}/ mmol H_2O $m^{-2}s^{-1}$): Instant water use efficiency; Mic: Micro-sprinkling system; Spr: Conventional under-tree sprinkling system; Dri: Dripping irrigation system.

*Average followed by the same letter, upper case in the columns for cultivars, and lower case in the lines for irrigation systems, had no difference amongst each other, verified by the F Test and the Tukey Test at 5% probability, respectively.

The water sprinkled onto the pseudostem exerts an additional cooling effect (sensible heat exchange) in plants. The longer term required to apply the same water depth by micro-sprinkling when compared to a conventional sprinkling might be due to the lower water flow of emitters, and can also be associated with the lower T_{leaf} results reported.

During the hotter periods of the day, the leaves of both cultivars irrigated by dripping reached temperatures higher than 43.0 °C, which is close to the thermal damage point for banana plants (Robinson & Galán Saúco, 2010). When studying the Williams cultivar, Thomas et al. (1998) observed that the maximum T_{leaf} at which photosynthesis would be zero is between 43 and 44 °C. This might be due to the extreme thermal damage caused by membrane rupture and denaturation of proteins. Although the aforementioned author defined the gas exchanges as the main response mechanism the effect of the pressure deficit and the density of the photosynthetically active flow, at the expense of the leaf temperature (T_{leaf}).

The transpiration rates (E) measured by various authors in banana plants are similar to those observed in the present study (Thomas et al., 1998; Neves et al., 2002; Melo et al., 2009). The rates reported at the different times showed significant variation between cultivars irrigated by different watering systems, in most of the months, being the highest observed for the cultivar 'Prata-Anã'.

The variations of E of the cultivars among the irrigations systems were observed in most of the months and at all assessment times, with the highest rates being registered in the dripping system and the lowest reported for the micro-sprinkling system, with the exception of the 4 p.m. assessment. This is probably because banana plants irrigated with micro-sprinklers presented lower leaf temperature, due to the better cooling provided by sprinkling the pseudostem of the plants with water. Furthermore, the continuous supply of water favors transpiration, which is proven by the inversion of the results at the 4 p.m. assessment caused by morning irrigation, simultaneous to the best conditions for physiological activities.

The hybrid exhibited higher T_{leaf} when irrigated with the dripping system, moderate T_{leaf} in conventional under-tree sprinkling and lowest T_{leaf} in the micro-sprinkling system. This behavior is similar to that observed in most of the months and at all the assessment times for both cultivars. The highest T_{leaf} result being reported in the dripping system was probably because it had no limiting effect on A, proven by the fact that the lowest T_{leaf} average reported for 'BRS Platina' irrigated by micro-sprinklers (29.60°C) and the highest average reported for 'Prata-Anã' (33.18°C) are both within the optimum band gap for balance between growth and liquid absorption rate (27°C), therefore, lower than the temperature which characterizes the beginning of the thermal stress in banana plants (34°C) (Robinson & Galán Saúco, 2010).

For 'Prata-Anã', in April 2010 at 8 a.m., higher A was observed (14.88 μmol CO_2 $m^{-2}s^{-1}$) when irrigated by micro-sprinklers, and lower levels of A (11.36 and 8.66 μmol CO_2 $m^{-2}s^{-1}$) when irrigated by dripping or sprinkling systems, respectively. The T_{leaf} exhibited by the 'Prata-Anã' cultivar when irrigated with micro-sprinklers was lower than the others were, as well as in most of the months in all assessment times. The combination of high T_{leaf} and high levels of photosynthetically active radiation incident on the leaf (Q_{leaf}) probably limited the A of the

cultivars irrigated by the dripping system, showing better water use efficiency when irrigating with the micro-sprinkling system.

Furthermore, in the month of April 2010, at 8 a.m., E and A were highest in 'BRS Platina' irrigated with the conventional sprinkling and dripping systems, and lowest in the plants irrigated with micro-sprinklers, although the internal CO_2 (C_i) and stomatal conductance (g_s) concentrations showed no difference among systems. The lower A-level observed for this cultivar when irrigated by micro-sprinklers can be caused by the small differences in g_s of the different systems, which are undetectable by the Tukey test (P<0.05), but still represent a difference of 220% from the lowest absolute value (0.10 mol H_2O m^{-2}s^{-1}) to the highest (0.32 mol H_2O m^{-2}s^{-1}). Small variances in g_s seem to cause higher variation in E and in A.

The highest levels of A occurred at 8 a.m. in the month of December 2009 in all irrigation systems for both banana plant cultivars, with the exception of 'BRS Platina' irrigated by the micro-sprinkling system. December 2009 presented a temperature high of 35°C, as well as rainfall and higher humidity levels, which are favorable conditions for optimum physiology. T_{leaf} of both cultivars were similar only when plants were irrigated by micro-sprinklers. BRS Platina showed lower T_{leaf} when plants were irrigated by micro-sprinklers and there was no T_{leaf} variance for 'Prata-Anã' in any of the systems. E was highest in 'Prata-Anã' in all irrigation systems, except for in conventional sprinkling which showed similar results. Additionally, A was lowest (7.26 µmol CO_2 m^{-2}s^{-1}) in 'BRS Platina' when irrigated with the micro-sprinkling system and coincided with the lowest levels of E (1.78 mmol H_2O m^{-2}s^{-1}) and g_s (0.08 mol m^{-2}s^{-1}). E and g_s, in addition to the lower A/Ci proportion (0.03 µmol CO_2 m^{-2}s^{-1}/µmol CO_2 mol^{-1}), an efficiency measurement for carboxylation of the rubisco enzyme whose decrease expresses a change in the direction of oxygenase activity, justify the reduction of A.

The assessment conducted at 10 a.m. reported different A levels for each cultivar in all irrigation systems in most months (Table 3). When irrigated by micro-sprinklers and conventional sprinklers, the lowest levels of A where exhibited by the 'BRS Platina' cultivar, while 'Prata-Anã' presented higher levels of A. The opposite was reported when plants were irrigated by the dripping system. Both cultivars had different levels of A when irrigated by the different systems in most of the months. The highest A levels were reported when irrigation was conducted by the dripping system in most of the months.

The rains in May 2009 raised air humidity, and maximum temperatures remained below 35 °C. Under these conditions, alterations in gas exchange of 'BRS Platina' plants stood out, especially at 10 a.m., which had the highest results among the evaluated months. When irrigated by the conventional sprinkling system, the variables presented the following results: Q_{leaf} (1.520 µmol photons m^{-2}s^{-1}); E (7.18 mmol H_2O m^{-2}s^{-1}); g_s (0.56 mol H_2O m^{-2}s^{-1}); A (22.23 µmol CO_2 m^{-2}s^{-1}); carboxylation efficiency A/C_i (0.098 µmol CO_2 m^{-2}s^{-1}/µmol CO_2 mol^{-1}); and A/E (3.12 µmol CO_2 m^{-2}s^{-1}/mmol H_2O m^{-2}s^{-1}). Simultaneously in the same month, the lowest results were reported when plants were irrigated by the dripping system, despite the fact that they were submitted to the same Q_{leaf} (1.397 µmol photons m^{-2}s^{-1}); these results

were the following: E (1.07 mmol H_2O m^{-2}s^{-1}); g_s (0.02 mol H_2O m^{-2}s^{-1}); A (1.98 µmol CO_2 m^{-2}s^{-1}); carboxylation efficiency A/C_i (0.009 µmol CO_2 m^{-2}s^{-1}/µmol CO_2 mol^{-1}); and A/E (1.84 µmol CO_2 m^{-2}s^{-1}/ mmol H_2O m^{-2}s^{-1}). The inferior banana plant cooling caused by the dripping system, attested by the highest T_{leaf} result (40.44°C), jeopardized the enzymatic functions, as shown by the A/C_i ratio, and promoted stomatal closure, which is proven by the lower g_s results, despite the mild weather conditions of the aforementioned month.

The cultivars studied differed concerning A at the 12 p.m. assessment time only when irrigated by the dripping system (Table 4). Additionally, A varied for all irrigation systems in both cultivars in most of the months assessed. The cultivars exhibited the highest A levels when irrigated with micro-sprinklers and lowest levels when irrigated by the dripping and by conventional under-tree sprinkling systems, respectively.

The results for 'Prata-Anã' irrigated with micro-sprinklers in the months of August and September 2010, at 12 p.m., estimated the same Q_{leaf} (1,416.10 and 1,442.80 µmol photons m^{-2}s^{-1}), however, the gas exchange did differ. E (3.23 and 5.33 mmol H_2O m^{-2}s^{-1}), A (8.35 and 19.19 µmol CO_2 m^{-2}s^{-1}), and A/E (2.57 and 3.60 µmol CO_2 m^{-2}s^{-1}/mmol H_2O m^{-2}s^{-1}) were lowest in August and highest in September, respectively. This is an avid example of the response to stomatal closure, ascertained by the lower g_s result (0.12 and 0.33 mol H_2O m^{-2}s^{-1}, respectively), and by the change in the activity of the rubisco enzyme, attested by the lower A/C_i ratio (0.03 and 0.09 µmol CO_2 m^{-2}s^{-1}/µmol CO_2 mol^{-1}, respectively).

The behavior described above represents the response of the plant to the lower humidity in the month of August than in the month of September. Both months exhibited absence of rainfall but differed concerning relative humidity (lower than 40%), which was the lowest reported in the whole experimentation period. Additionally, August 2010 recorded higher ambient temperature (maximum temperature close to 35°C) and higher leaf temperature (35.16°C) in comparison to September of that same year.

The photosynthesis rates registered at 2 p.m. were the same for both cultivars in most of the months, except in cases in which the plants were irrigated with micro-sprinklers (Table 5). 'Prata-Anã' exhibited higher A in all the irrigation systems. The Banana plants presented variation in the level of A when irrigation was conducted by the different systems in most months and the highest results were obtained when the plants were irrigated with the dripping system.

The Pome type banana plants, regardless of the irrigation system, at 2 p.m., always exhibited higher T_{leaf}, as well as higher E, a cooling mechanism of the plant. However, as a sign of stomatal closure, we observed lower g_s and reduction of A, even when submitted to high levels of Q_{leaf} (Table 5). 'BRS Platina', in January 2010, irrigated by micro-sprinkling and conventional sprinkling, exposed to high and moderate radiation (1,628 µmol photons m^{-2}s^{-1} and 782.40 µmol photons m^{-2}s^{-1}, respectively), exhibited the highest T_{leaf} values reported for this experiment, 37.86°C and 40.02°C, respectively. Meanwhile, the photosynthesis rates were similarly low, 5.78 and 6.96 µmol CO_2 m^{-2}s^{-1}, respectively.

Another example of the same cultivar irrigated with the dripping system and exposed to Q_{leaf} high radiation levels (1,415.75 µmol photons $m^{-2}s^{-1}$) occurred at 2 p.m. in October 2009. In these conditions, we obtained the highest T_{leaf} of the entire experimentation period (43.22°C); high levels of E (5.17 mmol H_2O $m^{-2}s^{-1}$), serving as a compensatory cooling mechanism; and, consequently, reduced level of A (6.53 µmol CO_2 $m^{-2}s^{-1}$). This was a consequence of the jeopardized enzymatic system caused by the increase of temperature, which resulted in a low A/E ratio. Donato et al. (2013), studying genomic groups and subgroups of banana plants, found that A/E decreased as T_{leaf} increased, for all the water depths varying from 25 to 125% of the crop evapotranspiration. The same authors concluded that when cultivated in regions and/or in periods of above-optimal temperatures, even when provided with adequate amount of water, the plants had their transpiration and photosynthesis jeopardized.

Thus, under stressful conditions, cultivation practices should prioritize hydric and thermal comfort. Therefore, defoliation, sprout thinning, pseudostem cutting, straw management, and dimensioned irrigation to fit the peaks of evapotranspiration are indispensable practices in high productivity banana crops. These techniques allow better plant cooling through the exchange of latent and sensible heat, promoted by the water sprayed in the leaves or pseudostem, as well as better crop ventilation. Furthermore, in the case of more demanding consumer markets, it is possible to adopt protected cultivation techniques, such as those used in the Canary Islands, Turkey, and Israel (Galán Saúco & Damatto Junior, 2012).

The assessment conducted at 4 p.m. registered different photosynthetic rates for each cultivar in most of the months when irrigated by micro-sprinkling and dripping systems (Table 6). Results were higher for 'BRS Platina' and lower for 'Prata-Anã'.

Carboxylation efficiency of CO_2 (A/C_i) is an efficiency measurement of the rubisco enzyme and its variation exhibits the change of the activity of this enzyme from carboxylase to oxygenase.

The evaluated cultivars presented similar A/C_i at all the assessment times in most of the months and in all of the irrigation systems, with the exception of assessments at 10 a.m., when we observed different A/C_i for each cultivar in all of the irrigation systems in most of the months (Table 3); and for assessments at 12 p.m., in which we obtained significant variance of A/C_i for each cultivar in most of the months only in plants irrigated with the dripping system (Table 4). Furthermore, the values were higher in the 'Prata-Anã' cultivar in both aforementioned assessment times in most cases.

Each cultivar presented different A/C_i levels when cultivated in the different irrigation systems in most of the cases, with the exception of the 'Prata-Anã' cultivar at 8 a.m. and 'BRS Platina' at 4 p.m. However, it was impossible to establish an optimum variation standard. On the other hand, we observed that during the hottest time (2 p.m.), the highest A/C_i level was reported in banana plants irrigated by dripping, which is probably due to the continuous supply of water during a long term.

Leaf water-use efficiency or instant water-use efficiency (A/E) represents how much of carbon was fixed per a certain amount of transpired water. This variable can be expressed by the ratio between photosynthesis and transpiration. The values of A/E found in the present study for Pome type banana plants cultivated in different irrigation systems were similar to those reported by Thomas et al. (1998) and Neves et al. (2002) and inferior to those observed by Melo et al. (2009).

The 'BRS Platina' and 'Prata-Anã' cultivars exhibited similar A/E in most of the cases studied. Significant differences among cultivars regarding A/E were observed at several assessment times, especially when irrigated with the micro-sprinkling system. This system probably provided lower stress conditions for the plants since the A/E values were higher. Additionally, we could observe the superiority of the hybrid in relation to its parents.

Differences of A/E in each of the irrigation systems for both cultivars in most of the months were observed at all the assessment times, with the exception of the last two; their values always being superior in the plants irrigated with micro-sprinklers. In the last assessment time, A/E of the Pome type banana plants exhibited the highest percentage difference (2,526%), observed at all of the assessment times, when considering all of the factors. 'BRS Platina' irrigated by dripping in June 2010 and by micro-sprinkling, in December 2009, displayed the lowest (0.71 µmol CO_2 $m^{-2}s^{-1}$/mmol H_2O $m^{-2}s^{-1}$) and highest (18.65 µmol CO_2 $m^{-2}s^{-1}$/mmol H_2O $m^{-2}s^{-1}$ of H_2O) water use efficiency values, respectively.

The Pearson correlation test was applied to all the variables; however, positive, elevated, and significant correlations were found only between the transpiration rates (E) and the leaf temperature (T_{leaf}) (Figure 1). Furthermore, negative, elevated, and significant interactions were observed only between the instant use of water (A/E) and leaf temperature (T_{leaf}) (Figure 2), similar to what Donato et al. (2013) reported.
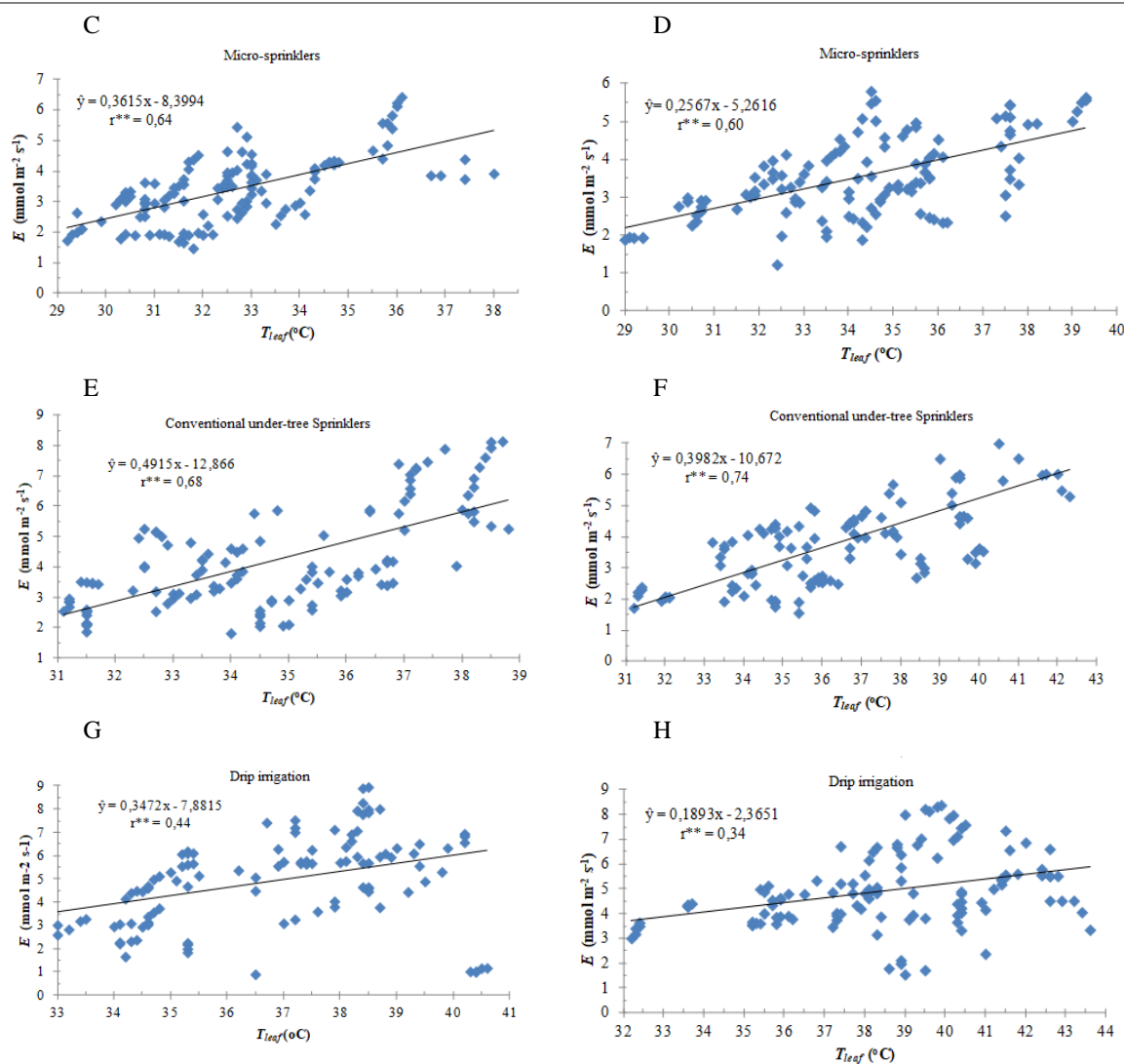
A

B
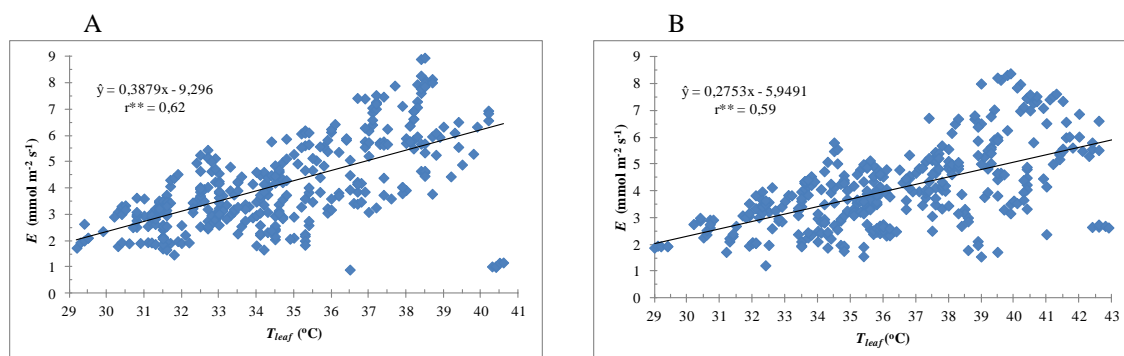
FIGURE 1. Correlation between transpiration rate (E), H_2O mmol m^{-2} s^{-1}, and the leaf temperature (T_{leaf}), $^{\circ}$C, of 'BRS Platina' and 'Prata-Anã' banana plants at 10 a.m. (A) and at 12 p.m. (B); and in the various irrigation systems at 10 a.m. (C, E and G) and 12 p.m. (D, F and H) in Guanambi BA, 2009-2010.

The correlations between E and T_{leaf}, considering all the factors, enabled the adjustment of a linear model, for the 10 a.m. assessment, which estimates an increase of 0.38 units of E for each one-unit variation of T_{leaf} (Figure 1A)

Linear models were also selected that describe the transpiration rate variation in relation to temperature for both cultivars in all irrigation systems at 10 a.m. (Figures 1C, E, and G) and at 12 p.m. (Figures 1D, F, and H). The largest variation (0.49 units) of E for each increased unit of T_{leaf} occurred when plants were irrigated by conventional

under-tree sprinkling at 10 a.m. (Figure 6E). Furthermore, in the dripping irrigation system, we observed the highest transpiration levels.

Transpiration increased as leaf temperature increased, however, the photosynthesis and the stomatal conductance rates displayed different behavior, which contradicts logic. This proves that the alterations of photosynthesis rates in regions with stressful thermal conditions are more heavily influenced by enzymatic impairment, provoked by the temperature increase, than by stomatal closure.
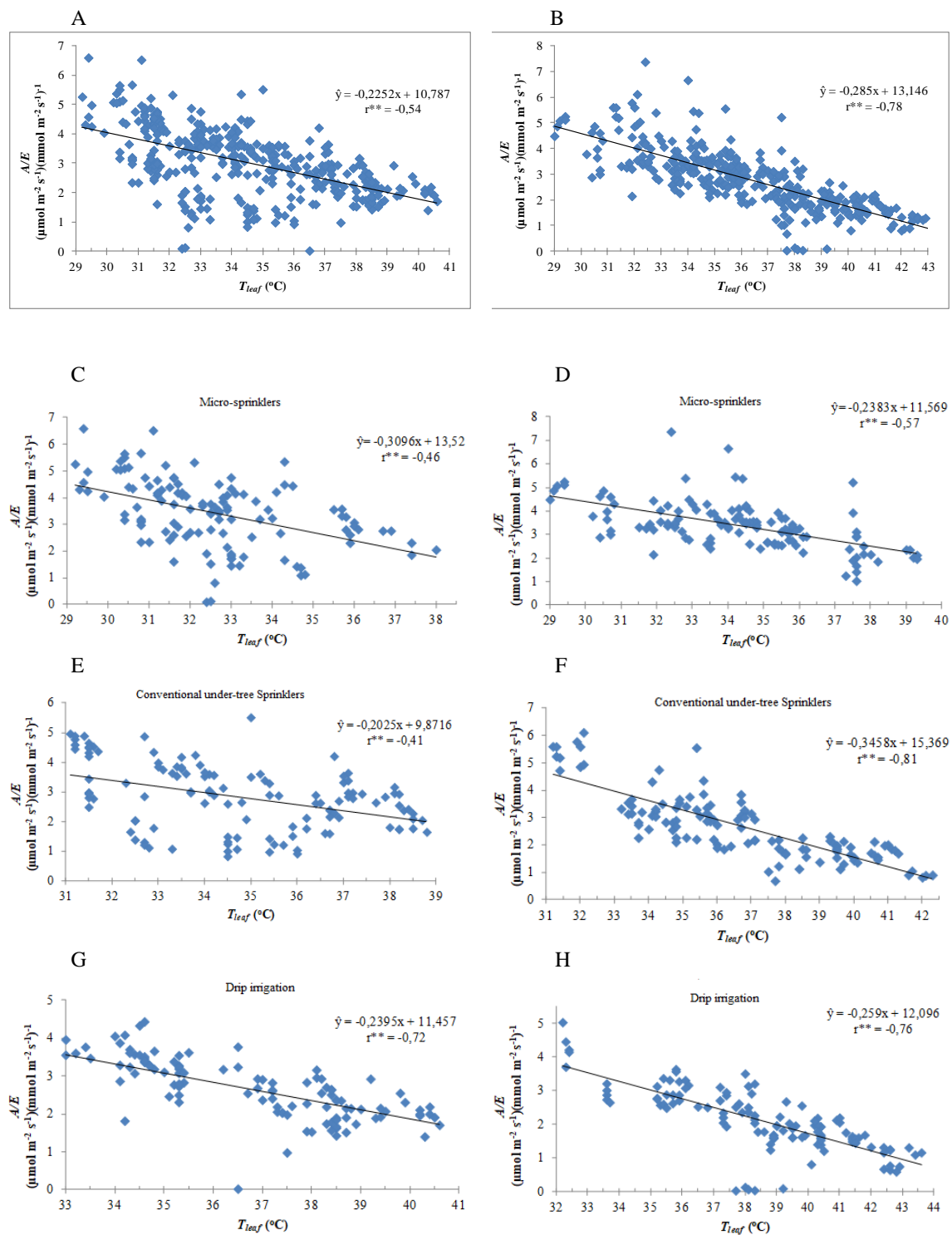
FIGURE 2. Correlation between the instant water use (A/E), μmol CO_2 m^{-2} s^{-1} / (mmol H_2O m^{-2} s^{-1}) -1, and the leaf temperature (T_{leaf}), ^{o}C, of 'BRS Platina' and 'Prata-Anã' banana plants at 10 a.m. (A) and 12 p.m. (B); and the several irrigation systems at 10 a.m. (C, E and G) and 12 p.m. (D, F and H) in Guanambi BA, 2009-2010

The adjusted models, based on the correlation between A/E and T_{leaf}, estimated a variation rate in A/E, which varies from the lowest value (0.20 units) in conventional under-the-tree sprinkling at 10 a.m. (Figure 2E) to the highest (0.34 units) in conventional under-the-tree sprinkling at 12 p.m. (Figure 2F), for the increase of each unit in T_{leaf}. The lowest A/E was observed in the dripping irrigation system and the highest efficiency in the micro-sprinkling system. Thus, water-use efficiency decreased as the T_{leaf} increased, which clearly demonstrates the effect of thermal stress.

CONCLUSIONS

Pome type banana plants display better strength and a larger number of hands when irrigated with micro-sprinklers and conventional under-tree sprinkling systems than when watered by the dripping irrigation system, regardless of the cultivar used, while yield was similar for all systems. Furthermore, when irrigated by dripping, the

plants exhibited higher leaf temperature (T_{leaf}), higher transpiration, and lower instant water use efficiency, while plants irrigated by micro-sprinkling displayed better water use efficiency.

The 'Prata-Anã' banana plant presented higher leaf area and a larger number of hands than 'BRS Platina', regardless of the irrigation system used.

The transpiration rates increased linearly as the leaf temperature increased, while the instant water use efficiency decreased linearly.

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