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PRODUÇÃO E EFICIÊNCIA DE USO DA ÁGUA EM CULTIVARES DE BANANEIRA SOB IRRIGAÇÃO COM DÉFICIT CONTROLADO

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1 RESUMO

Objetivou-se com este trabalho avaliar a produtividade, a eficiência de uso da água e o tamanho dos frutos de diferentes cultivares de bananeira sob irrigação com déficit controlado no norte de Minas Gerais. O experimento foi conduzido no quarto ciclo de produção de bananeiras ‘Grande Naine’, ‘Galil-18’ (FHIA-18), ‘BRS Platina’, ‘Prata-Anã’ e ‘BRS Princesa’. A irrigação com déficit controlado (RDI) de 70 e 50% da evapotranspiração da cultura (ETc) foi realizada em um, dois ou três períodos de julho de 2016 a julho de 2017. Independentemente das cultivares, a altura da planta foi reduzida quando aplicado dois déficits de 50% da ETc, já a área foliar aumentou quando aplicados RDI em um período, RDI com 70% da ETc em dois períodos e RDI com 50% da ETc em três períodos. A RDI de até 50% da ETc em três períodos durante o ciclo da cultura não causa redução na produtividade em nenhuma cultivar avaliada, comparada à irrigação plena. A RDI com 70% da ETc em apenas um período, entre novembro e fevereiro, período chuvoso, possibilitou maior produtividade e maior eficiência de uso da água na ‘Grande Naine’, formando mesmo agrupamento com a ‘BRS Princesa’ e a ‘Prata-Anã’.

Palavras-chave: *Musa* spp., manejo da irrigação, semiárido.

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PRODUCTION AND WATER USE EFFICIENCY IN BANANA CULTIVARS UNDER REGULATED DEFICIT IRRIGATION

2 ABSTRACT

This work aimed to evaluate the productivity, water use efficiency and fruit size of different banana cultivars under regulated deficit irrigation in the north of Minas Gerais. The experiment was conducted in the fourth cycle of banana production ‘Great Naine’, ‘Galil-18’ (FHIA-18), ‘BRS Platinum’, ‘Prata-Anã’ and ‘BRS Princesa’. Regulated deficit irrigation (RDI) of 70 and 50% of crop evapotranspiration (ETc) was conducted in one, two or three periods from July 2016 to July 2017. Regardless of cultivars, plant height was reduced when two 50% ETc deficits

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were applied, whereas leaf area increased when RDI was applied in one period, RDI with 70% ETc in two periods and RDI with 50% ETc in three periods. RDI of up to 50% of ETc in three periods during the crop cycle does not reduce yield in any evaluated cultivar compared to full irrigation. The RDI with 70% of ETc in only one period, between November and February, rainy season, enabled higher productivity and greater water use efficiency in ‘Grande Naine’, forming even grouping with ‘BRS Princesa’ and ‘Prata- Anã’.

Keywords: *Musa* spp., irrigation management, semi-arid.

3 INTRODUCTION

Bananas are highly important fruits for Brazilian agribusiness, making them among the world's largest producers. In 2017, the country's production reached 6,675,100 tons (IBGE, 2019), over 98% of which supplies the domestic market (KIST et al., 2018). Among all national production, 23% is obtained in the semiarid region, with northern Minas Gerais accounting for approximately 19% of the country's production (IBGE, 2019).

To achieve profitable banana yields in the semiarid region of Brazil, given the low availability and irregularity of water resources, irrigation is mandatory and requires precise management. Therefore, techniques that allow for a reduction in the amount of water applied (deficit irrigation) at some stage of crop development or during a period that does not significantly compromise fruit production and quality are recommended. Another option is to use cultivars that tolerate water deficit better and contribute to increased water use efficiency.

Among the deficit irrigation strategies, laterally alternating irrigation (SANTOS et al., 2017; COELHO et al., 2019) and controlled deficit irrigation (SANTOS et al., 2016, 2019) stand out. The latter consists of reducing the amount of water applied during crop development stages with less sensitivity to water deficit. This does not significantly compromise fruit production and quality and allows for greater water use efficiency. However, to recommend this technique to producers, it is necessary to conduct trials with different combinations of cultivars and deficit irrigation strategies to obtain scientific support. In studies with controlled deficit irrigation, Santos et al. (2016) used the Prata-Anã and BRS Platina cultivars, and Santos et al. (2019) used BRS Platina. Thus, the objective of this work was to evaluate the productivity, water use efficiency and fruit size of different banana cultivars under controlled deficit irrigation in northern Minas Gerais.

4 MATERIALS AND METHODS

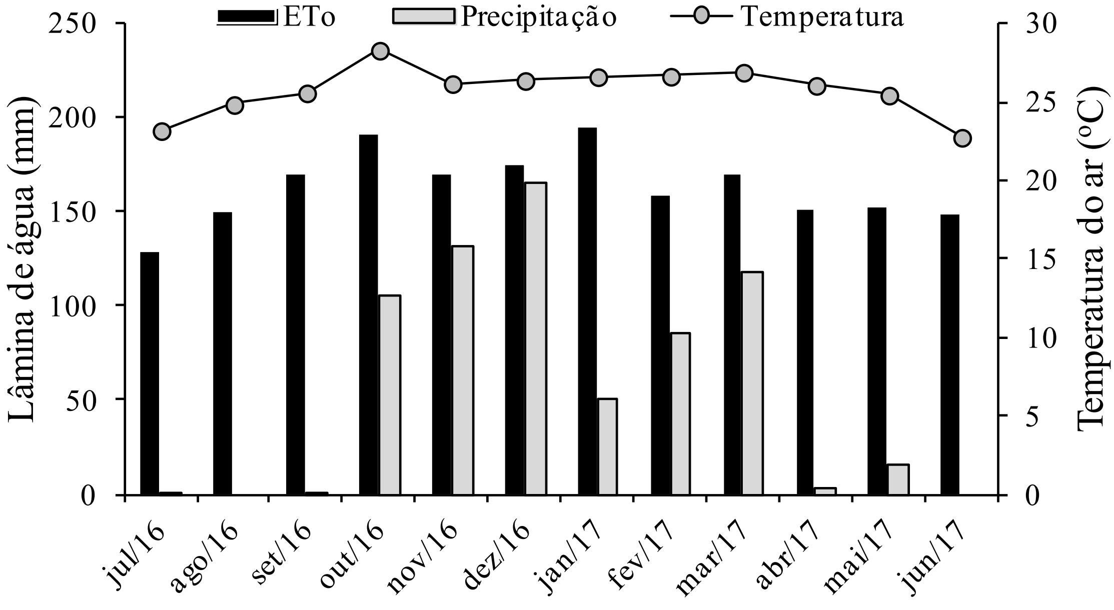
The experiment was conducted at the Gorutuba Experimental Center, belonging to EPAMIG (Minas Gerais Agricultural Research Corporation) North, in Nova Porteirinha, MG. The local altitude is 516 m, with latitude of 15° 47' 29" S, longitude of 43° 17' 88" E, average annual rainfall of 800 mm, and the climate is classified as Aw (tropical savanna), according to the Köppen-Geiger classification (ALVARES et al., 2013). The soil of the experimental area, whose physical–hydraulic characteristics are shown in Table 1, was classified as a dystrophic Red–Yellow Latosol of medium texture.

Table 1. Physical-hydric characteristics of the soil in the experimental area at depths of 0.00--0.20, 0.20--0.40 and 0.40--0.60 m, Nova Porteirinha, MG.

Physical/water characteristics	**Depth (m)**		
	0.00 - 0.20	**0.20 - 0.40**	**0.40 - 0.60**
Soil density (g cm^{-3})	1.43	1.53	1.34
Sand (g kg^{-1})	766	699	547
Silt (g kg^{-1})	61	47	81
Clay (g kg^{-1})	173	254	372
Macroporosity (%)	15.53	10.95	13.45
Microporosity (%)	15.09	17.79	19.79
Textural class	Sandy Franco	Sandy Clay Loam	Sandy Clay
Water content at - 10 KPa (m^3m^{-3})	0.268	0.265	-
Water content at - 1500 KPa (m^3m^{-3})	0.214	0.214	-

The average monthly temperatures, reference evapotranspiration and precipitation in the three periods from July (2016) to October (2016), November (2016) to February (2017) and March (2017) to June (2017) are presented in Figure 1.

Figure 1. Reference evapotranspiration (ETo), average monthly precipitation and average monthly temperature in the three periods of the year: between July 2016 and October 2016, between November 2016 and February 2017 and between March and June 2017.



The experiment was conducted in the fourth production cycle of five banana cultivars, namely, Grande Naine, Galil-18 (FHIA-18), BRS Platina, Prata-Anã and BRS Princesa, at a spacing of 2.0 × 2.5 m, under microsprinkler irrigation with one emitter for four plants. Plants of the different cultivars were chosen in the growth phase from July 2016 and were evaluated until July 2017.

Seven strategies for reducing the total irrigation water depth applied to five banana cultivars were evaluated, with each strategy being applied over a four-month period between July 2016 and July 2017. The experimental design was a randomized complete block design (RBD), with three replicates and six useful plants per experimental plot. To evaluate the strategies for reducing the gross water depth applied in relation to the cultivars, an RBD was used in a split-plot scheme with the gross water depth reduction treatment applied to the plot and the cultivar in the subplot.

Each irrigation strategy corresponded to a reduction of 30 or 50% of the calculated irrigation depth (LIC), which was imposed during three periods of the year: period 1 (P1), from July to October 2016; period 2 (P2), from November 2016 to February 2017; and period 3 (P3), from March to June 2017. In one strategy (E), a reduction of 30 or 50% was applied in only one period (P1, P2 or P3); in the other two periods, irrigation returned to the gross depth (full irrigation). The treatments represented by these irrigation depth reduction (RDI) strategies in these three periods of the year were P1R30 and P1R50, with irrigation rates of 70% and 50% of the ETc, respectively, in the period from November 2016 to February 2017 and full irrigation (PI) in the other two periods; P2R30 and P2R50, with irrigation rates of 70% and 50% of the ETc, respectively, in the period from March to June 2017; and P3R30 and P3R50, with irrigation rates of 70% and 50% of the ETc, respectively, in the period from July to October 2016; and in the other two periods, full irrigation. The seventh treatment, IP, corresponded to full irrigation (100% of ETc) in all three periods.

To evaluate the individual effects of the four-month period of the year in which each strategy was applied and the effects of the reduced blade size of each strategy on the five cultivars, DBC was adopted in a split-subdivided plot design. The three periods of the year were considered in the plots, and the five cultivars were arranged in the subplots: 'Grande Naine', 'Galil-18', 'BRS Platina', 'Prata-Anã', and 'BRS Princesa'. In the subsubplots, the percentage reduction in the calculated gross blade size was considered.

Irrigation scheduling was based on crop evapotranspiration estimated by daily reference evapotranspiration (ETo) measured at an automatic weather station and used crop coefficients according to Coelho et al. (2012) and location coefficients according to Bernardo, Soares, and Mantovani (2006). Irrigation was performed in two-day irrigation shifts. The irrigation depth differences were obtained via records at the irrigation system control head, which was located at the beginning of the experimental area, with each calculated irrigation depth reduction strategy corresponding to a derivation line.

Water use efficiency (WUE) was obtained from the relationship between productivity and the calculated gross irrigation depth, expressed in kg ha^{-1} mm^{-1}, according to Loomis (1983).

$$EUA = \frac{Prod}{LBA} \quad (1)$$

where:

EUA is the water use efficiency (kg ha^{-1} mm^{-1});

Prod is the productivity of bunches of each treatment (kg ha^{-1});

LBA is the gross applied depth corresponding to the crop evapotranspiration in each treatment on irrigation days (mm).

The biometric variables evaluated during the bunch emission period were as follows: plant height, corresponding to the length of the pseudostem, which ranges from the soil level to the stalk exit in the leaf rosette; pseudostem diameter, 0.20 m from the soil surface; and the number of live leaves and total leaf area, as used by Oliveira, Coelho Filho and Coelho (2013). At harvest, the following production data were collected: bunch weight, length and diameter of the median fruit of the second bunch of the second cycle. The stomatal conductance of the third leaf from the apex was measured during period 3 (the period in which crop evapotranspiration is highest).

Data on handpicked yield, fruit length, fruit diameter, fruit weight, number of hands per bunch, number of fruits per cluster, water use efficiency, pseudostem circumference, plant height (pseudostem length), number of leaves, and leaf area were subjected to analysis of variance. In the case of interaction between factors, splits were performed, and in the absence of interaction, independent effects were analyzed. In both cases, the means were grouped via the Scott–Knott criterion at the 5% significance level. Data on yield, number, fruit diameter and length, and water use efficiency were also organized for comparisons between the factors of deficit period and water depth reduction, regardless of cultivar; for comparisons between cultivars and water depth reduction, regardless of period, Tukey's test was applied at the 5% significance level.

5 RESULTS AND DISCUSSION

5.1 Vegetative variables of cultivars under controlled deficit irrigation

There was an interaction effect between controlled deficit irrigation (RDI) strategies and banana cultivar on pseudostem circumference. Among the cultivars, Grande Naine and BRS Princesa presented relatively small pseudostem circumferences, and this characteristic was not negatively influenced by the RDI (Table 2). On the other hand, BRS Platina and Prata-Anã presented the largest pseudostem circumferences, with no reduction under RDI. This behavior, considering the values, is compatible with the results of Arantes et al. (2017) and expresses the differences between varietal groups, whose pseudostem circumferences were smaller in 'Grande Naine ' and 'BRS Princesa' than in 'Prata-Anã', 'BRS Platina', and 'FHIA-18'.

Table 2. Average pseudostem circumference (m) of different banana cultivars at flowering under different irrigation strategies with controlled deficit, Nova Porteirinha, MG.

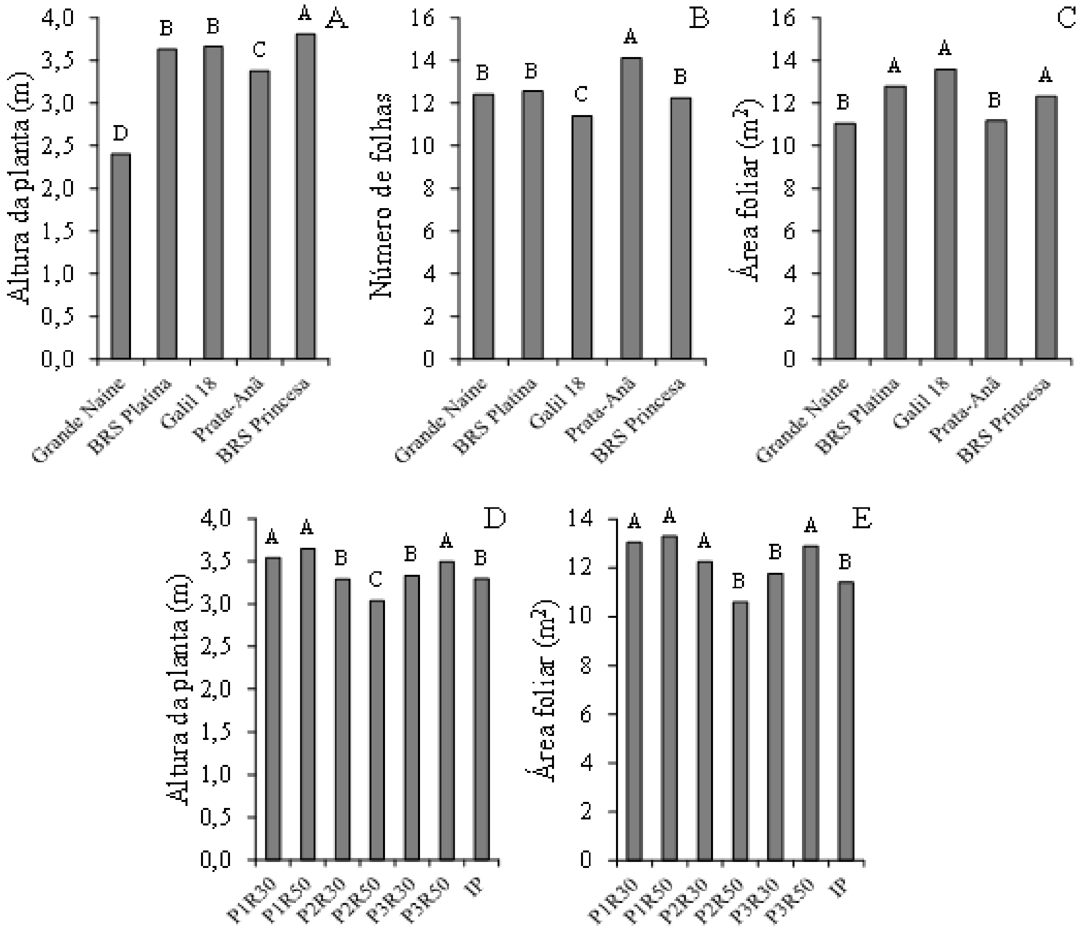
Cultivate	Irrigation strategy						
	P1R30	**P1R50**	**P2R30**	**P2R50**	**P3R30**	**P3R50**	**IP**
Grand Naine	0.80 Ba	0.76 Da	0.78 Ba	0.65 Ba	0.72 Ba	0.76 Da	0.71 Ba
BRS Platina	1.05 Ab	1.18 Aa	0.99 Ac	0.90 Ac	1.04 Ab	1.06 Ba	0.92 Ac
Galil 18	1.12 Aa	1.03 Bb	0.93 Ab	0.94 Ab	0.96 Ab	1.18 Aa	1.02 Ab
Silver Dwarf	1.04 Aa	1.08 Ba	0.94 Aa	0.96 Aa	1.01 Aa	0.98 Ca	0.99 Aa
BRS Princesa	0.88 Ba	0.87 Ca	0.79 Bb	0.73 Bb	0.97 Aa	0.92 Ca	0.80 Bb
CV = 15.85%							

P1R30: RDI with a 30% reduction in ETc from July to October 2016; P1R50: RDI with a 50% reduction in ETc from July to October 2016; P2R30: RDI with a 30% reduction in ETc from November 2016 to February 2017; P2R50: RDI with a 50% reduction in ETc from November 2016 to February 2017; P3R30: RDI with a 30% reduction in ETc from March to June 2017; P3R50: RDI with a 50% reduction in ETc from March to June 2017; IP: Full irrigation.
Knott criterion at 5% significance.

The variables plant height, number of leaves and total leaf area were not influenced by the interaction of cultivar and strategy factors (RDI); however, these variables varied with cultivar, regardless of irrigation strategy. 'Grande Naine ' had a lower plant height, and 'BRS Princesa' had a greater plant height (Figure 2A). Similar results were reported by Arantes et al. (2017), who reported that 'Grande Naine' resulted in a shorter plant height. Although 'Prata-Anã' had the greatest number of leaves (Figure 2B), it had the smallest total leaf area (Figure 2C). The RDI strategy, which resulted in a

50% reduction in ETc, had the greatest influence on plant height and leaf area in period II, from March to June (Figure 2D, 2E). During this period, however, there was no reduction in leaf area (LA) compared with that in the IP, although there was a reduction in plant height (Figure 2D). From March to June, the total amount of rainfall was 130 mm, with a frequency of 20 to 30 days. A lower average daily temperature and maximum evapotranspiration were observed and, consequently, lower crop evapotranspiration than those observed in period I (November to February).

Figure 2. Vegetative variables (A) Plant height (CV = 6.03%), (B) number of leaves per plant (CV = 8.99%), (C) total leaf area of different banana cultivars (CV = 13.62%), regardless of controlled deficit irrigation strategy; (D) plant height (CV = 6.76%), (E) total leaf area of banana plants under different controlled deficit irrigation strategies (CV = 14.94%), independent effects, Nova Porteirinha, MG.



where P1R30 represents RDI with a 30% reduction in ETc from July to October 2016; P1R50 represents RDI with a 50% reduction in ETc from July to October 2016; P2R30 represents RDI with a 30% reduction in ETc from November 2016 to February 2017; P2R50 represents RDI with a 50% reduction in ETc from November 2016 to February 2017; P3R30 represents RDI with a 30% reduction in ETc from March to June 2017; P3R50 represents RDI with a 50% reduction in ETc from March to June 2017; and IP represents full irrigation.

Knott criterion at 5% significance.

5.2 Production variables of cultivars under controlled deficit irrigation

A 30% reduction in the irrigation depth calculated in any of the three periods did not cause a reduction in the productivity of any cultivar compared with the productivity under full irrigation. A 50% reduction in the irrigation depth also did not result in a difference between the average productivity of the cultivars in any of the periods. However, these values were 12.56% and 6.94% lower in periods 1 and 2, respectively, when PRD (irrigation with partial root system drying) was reduced by 50% compared with full irrigation; for 'Grande Naine', the values were reduced by 5.40% and 8.45% in periods I and III, respectively, for 'BRS Platina' compared with full irrigation; and the values were reduced in period III by 4.48% and 16.94% for 'Galil 18' and 'BRS Princesa', respectively (Table 3).

Table 3. Average productivity of bunches of five banana cultivars under full irrigation throughout the cycle (IP), with a 30% LIC reduction (R30) and with a 50% LIC reduction (R50), in the periods of the year, P1, P2 and P3, that is, November–February, March–June and July–October, respectively; Nova Porteirinha, MG.

CULTIVATE	Irrigation Strategies						
	P1R30	**P1R50**	**P2R30**	**P2R50**	**P2R30**	**P2R50**	**IP**
	Handful productivity (t ha $^{-1}$)						
Grand Naine	62.00 aA	34.40 BC	48.12 aB	36.60 BC	40.01 BC	49.60 aB	39.33 Ac
BRS Platina	37.42 bA	46.99 aA	37.43 bA	35.70 aA	41.70 aA	33.54 bA	37.74 aA
Galil 18	43.16 bA	51.81 aA	43.09 aA	43.13 aA	43.73 aA	39.40 aA	41.25 aA
Silver Dwarf	31.68 cB	31.08 bB	31.30 bB	31.83 aB	42.88 aA	29.82 bB	28.65 bB
BRS Princesa	29.99 CA	29.10 bA	31.59 bA	23.30 bA	28.70 bA	19.27 cA	23.20 bA
CV = 15.20%							

P1R30: RDI with a 30% reduction in ETc from July to October 2016; P1R50: RDI with a 50% reduction in ETc from July to October 2016; P2R30: RDI with a 30% reduction in ETc from November 2016 to February 2017; P2R50: RDI with a 50% reduction in ETc from November 2016 to February 2017; P3R30: RDI with a 30% reduction in ETc from March to June 2017; P3R50: RDI with a 50% reduction in ETc from March to June 2017; IP: Full irrigation.
Knott criterion at 5% significance.

A comparison of the average productivity among the irrigation depth reductions in the three periods is presented in Table 4. The effects of the interaction between the time of year and the level of LIC reduction indicated that in period 2, from November to February, the average productivity in the plots with LIC reduction did not differ from each other and was greater than the average productivity without irrigation depth reduction. In the other periods, the 50% LIC reduction promoted significant decreases in the average productivity of the cultivars compared with the 70% application, with greater emphasis in the period from March to June (P3), followed by the period from July to October (P1). Compared with those under 50% LIC, the average productivity of the cultivars under 70% LIC was significantly lower than that under 50% LIC from November to February.

Table 4. Average hand-held productivity (t ha $^{-1}$) of the five cultivars between the periods of the year in which the LIC reduction was applied and between the levels of reduction in the calculated irrigation depth (LIC).

% LIC Reduction	Jul - Oct (P1)	Nov - Feb (P2)	Mar - Jun (P3)
No reduction	35,620 A ab	33.107 A b	33.107 A b
30%	39.405 A a	40.849 A a	38.304 A a
50%	34.325 AB b	38.676 A a	34.111 B ab
CV = 13.70%			

Lowercase and equal letters in columns and uppercase and equal letters in rows do not differ from each other according to Tukey's test at 5% significance.

Only the average productivity of 'BRS Platina' and 'Galil 18' differed because of the 30% or 50% reduction in LIC. The other cultivars presented a significant reduction in productivity when 70% to 50% LIC was applied (Table 5). The average productivity under full irrigation conditions at the applied depth was, in general, lower than that obtained with a 30% reduction in LIC, which can be attributed to the uniformity of the plants at the beginning of the crop management cycle (Table 4). The greatest loss in productivity due to the difference in the application of 70% to 50% LIC occurred for 'Grande Naine', which was expected given the greater water requirement of this cultivar (COELHO; LEDO; SILVA, 2006).

Table 5. Average hand-held productivity (t ha $^{-1}$) of five banana cultivars under different irrigation strategies with controlled water deficit, Nova Porteirinha, MG.

% LIC Reduction	Grand Naine	BRS Platina	Galil 18	Silver Dwarf	BRS Princesa
No reduction	39.33 A b	37.74 A a	41.25 A to	28.65 B b	23.20 B b
30%	50.04 A to	38.85 AB to	43.32 BC	35.29 CD a	30.09 D a
50%	40.20 A b	38.74 A a	44.78 A a	30.91 B ab	23.89 C b
CV = 13.70%					

Capital letters and the same letters in the columns and lowercase letters and the same letters in the rows form the same grouping according to the Tukey test at 5% significance.

The lack of difference between the average yields of all cultivars under 70% and 50% LIC application from November to February was due to better climatic conditions regarding day length, temperature, rainfall, higher evapotranspiration (Figure 1), and better soil water status during this period. The few irrigation events due to the aforementioned conditions overshadowed the effects of the 30% and 50% LIC reductions. In the other periods, there was a greater need for irrigation, especially from July to October, and the effects of the reductions were more pronounced. The period from March to June presented the lowest loss of water from the plant through transpiration and from the soil through evaporation due to the behavior of the climatic variables (Figure 1), which contributed to a smaller reduction in productivity from the application of 70% to 50% LIC (Table 2). In the period from July to October (P1), with increased evapotranspiration favored by increases in temperature, radiation and water supply to the crop only through irrigation, there was a significant difference in the average productivity of cultivars under the application of 70 to 50% of the LIC. In this period of absence of rain (July to October) and higher temperatures (Figure 1), with a consequently greater gradient of air vapor pressure (ARANTES et al., 2016; RAMOS et al., 2018), these factors are expected to influence productivity (ROBINSON; ALBERTS, 1986), which occurred with 'Grande Naine', 'Prata--Anã' and 'BRS Princesa'.

The productivity curves as a function of the applied water depths demonstrate a reduction in productivity at a lower intensity for continuous application of 70% and at a higher intensity for continuous application of 50% of the adequate depths in the cycle for 'Grande Naine ' and 'Prata-Anã' (FIGUEIREDO et al., 2006; COELHO; LEDO; SILVA, 2006; LUCENA, 2013). For ' Galil 18', Costa et al. (2012) applied irrigation depths equivalent to 30, 60, 90 and 120% of the ETc continuously in the cycle and reported that a depth of 60% of the ETc did not significantly reduce the productivity of this cultivar, which confirms the results of this work, in which the cultivar was not affected by the reduction in the LIC.

The sensitivity demonstrated by 'BRS Princesa' is not consistent with the results of Coelho et al. (2015), who reported less variation in productivity between the application of 50% ETc and the application of ETc throughout the crop cycle. 'BRS Princesa' is a tetraploid hybrid (AAAB), which can be recommended for use in cropping systems with water deficit, as it presents a low response to increased irrigation depth compared with Cavendish-type cultivars, for example, 'Grande Naine' (AAA). Cultivars with the B genome have greater synthesis of aquaporin proteins (HENRY et al., 2011), which form channels that are selective for water flow through the membrane, proline accumulation, and abscisic acid synthesis (VANHOVE et al., 2012).

Similarly, the lack of a reduction in 'BRS Platina' yield with the application of 50% LIC over a four-month period is inconsistent with the results reported by Santos et al. (2016), who reported a reduction in cultivar yield with a continuous reduction in LIC throughout the crop cycle. This reduced yield with a 50% reduction in LIC over four months was expected compared with the reduced yield with a reduction of nearly 50% in LIC throughout the crop cycle, since under these conditions, soil water stress is continuous throughout the cycle. However, since the reduction occurs only over four months, the effects on yield will depend on the banana plantation conditions in terms of density, soil cover, and weather conditions during the period.

Increasing crop density results in soil shading and lower stomatal conductance and transpiration of shaded leaves; soil cover significantly reduces evaporation, resulting in reduced crop evapotranspiration. This condition occurred throughout the growing season to prevent reduced growth and production caused by the four-month reduction in LIC. This condition was favored by periods of higher rainfall frequency and volume (November-February, P2) or periods of lower plant transpiration demand and soil evaporation, that is, from March to July (P3) (Figure 1). This condition became unfavorable, however, due to the lack of rainfall and rising temperatures (Figure 1), which led to increased evapotranspiration, which occurred from July to October (P1).

Fruit length was influenced only by the time of year when the LIC was reduced, particularly by 50%. That is, the 30% reduction did not cause a reduction in the average fruit length of the cultivars compared with the average fruit length under full irrigation throughout the cycle. The reduction in fruit length was more pronounced with the application of 50% LIC from July to October (Table 6). There was no effect of period on the average fruit length for any cultivar, and the LIC reduction was significant only for the cultivars Grande Naine and Galil 18 (Table 7). In the case of 'Grande Naine', the 50% LIC reduction reduced fruit length, which did not occur for

'Galil 18', whose average fruit length did not differ from the average under the 30% LIC reduction, with these average values being greater than those under full irrigation throughout the cycle (Table 7).

Table 6. Average fruit length (cm) of the five cultivars between the periods of the year in which the LIC reduction was applied and between the levels of reduction in the calculated irrigation depth (LIC).

% LIC Reduction	Jul - Oct (P1)	Nov - Feb (P2)	Mar - Jun (P3)
No reduction	19.44 A a	18.43 A a	18.43 A b
30%	19.52 A a	19.28 A a	19.05 A to
50%	17.16 B b	18.09 A a	19.12 A a
CV = 7.70%			

Lowercase and equal letters in columns and uppercase and equal letters in rows do not differ from each other according to Tukey's test at 5% significance.

Table 7. Average fruit length (cm) of five banana cultivars under different irrigation strategies with controlled water deficit, Nova Porteirinha, MG.

% Reduction LIC	Grand Naine	BRS Platina	Galil 18	Silver Dwarf	BRS Princesa
No reduction	23.20 A to	19.40 B a	18.80 B a	18.80 BC to	16.60 C to
30%	23.20 A to	19.50 B a	17.20 C b	17.20 C to	16.00 C to
50%	17.40 AB b	20.90 A to	18.90 A to	17.10 AB to	16.20 C to
CV = 7.70%					

Capital letters and the same letters in the columns and lowercase letters and the same letters in the rows form the same grouping according to the Tukey test at 5% significance.

The fruits of the cultivars Grand and Naine, Galil 18 and Prata-Anã differed in diameter between the periods of the year, regardless of the LIC reduction. 'Grande Naine' presented the largest diameter when the LIC decreased or did not decrease from November to February (P2), whereas 'Galil 18' and 'Prata-Anã' presented the largest diameters when the LIC decreased by 30 or 50% or not from July to October (P1) (Table 8). Only 'BRS Princesa' presented similar fruit diameters under 30% and 50% LIC reductions. All cultivars had similar fruit diameter means with and without 30% LIC reduction (Table 8).

Table 8. Average fruit diameter (mm) of five banana cultivars under different irrigation strategies with controlled water deficit, Nova Porteirinha, MG.

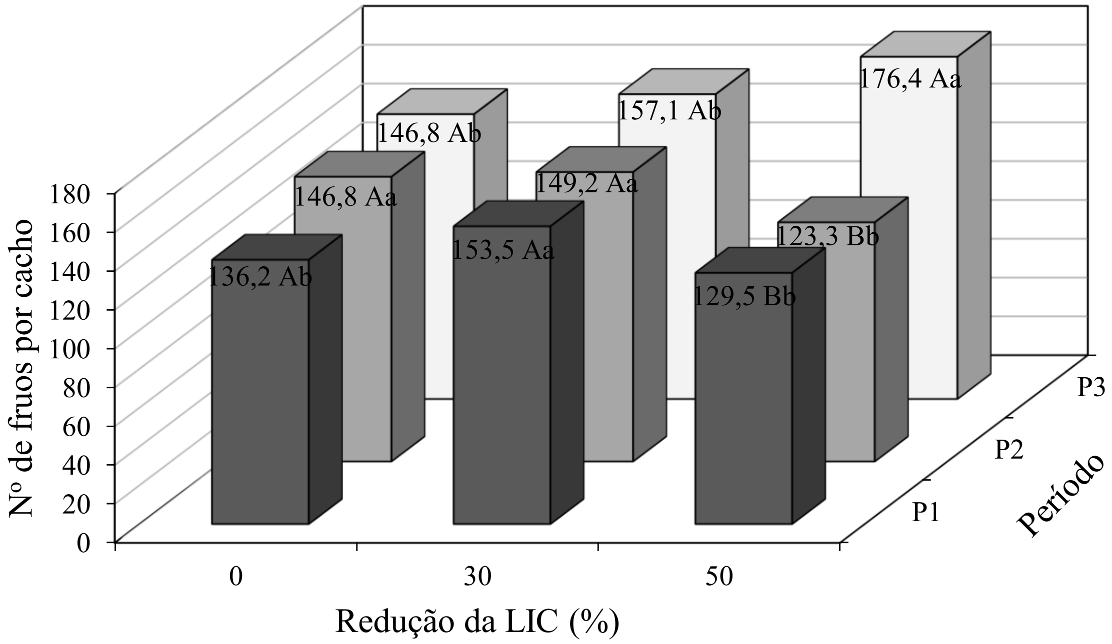
Period of the year	Grand Naine	BRS Platina	Galil 18	Silver Dwarf	BRS Princesa
Jul - Oct (P1)	31.0 C b	34.0 AB a	35.0 A to	33.0 AB a	31.0 C to
Nov - Feb (P1)	35.0 A to	32.0 AB a	32.0 AB b	30.0 B b	33.0 AB a
Mar - Jun (P1)	32.0 A b	34.0 A to	34.0 A ab	31.0 A ab	32.0 A to
CV = 5.8%					
LIC Reduction					
No reduction	33.0 A to	34.0 A ab	32.0 A b	33.0 A to	31.0 A to
30%	35.0 A to	31.0 AB b	34.0 AB ab	32.0 AB ab	33.0 AB a
50%	30.0 B b	35.0 A to	36.0 A to	30.0 B b	32.0 B a
CV = 7.40%					

Capital letters and the same letters in the columns and lowercase letters and the same letters in the rows form the same grouping according to the Tukey test at 5% significance.

These characteristics contribute to cultivar productivity in relation to the time of year and the level of water application reduction. A 30% reduction in LIC at any time of year did not reduce these morphological variables or, consequently, the productivity of any cultivar.

The number of fruits per bunch, combined with fruit morphological characteristics, supports the cultivars' yield results in relation to the period of the year in which the LIC reductions were applied. Fruit number was not affected by LIC reductions in the period from November to February (P2), with a higher average for the 50% LIC reduction, due to the few irrigation events and a greater predominance of rainfall. In the other two periods, with lower rainfall and adverse weather conditions, there was a greater effect on fruit number reduction, especially considering the application of 70% and 50% LIC, a behavior similar to that of the cultivar yield (Figure 3).

Figure 3. Average number of fruits per bunch of banana cultivars in three periods of the year from July to October (P1), from November to February (P2) and from March to June (P3) with and without reduction in the irrigation depth calculated in each period, Nova Porteirinha, MG.



P1: Period corresponding to July to October 2016; P2: Period corresponding to November 2016 to February 2017; P3: Period corresponding to March to June 2017; LIC: calculated irrigation depth.
The same capital letter on the period axis and the same lowercase letter on the horizontal axis indicate that the average number of fruits does not differ at the 5% level of significance according to Tukey's test. CV = 13.40%.

The cultivars Grand and Naine, BRS Platina and Galil 18 generally presented the highest productivity, and the cultivar BRS Princes presented the lowest productivity, regardless of the period and level of LIC reduction (Tables 3, 4, 5). This is justifiable, as it reflects the productive potential associated with the genomic groups of the respective cultivars (ARANTES et al., 2017). The differences between the morphological characteristics and number of fruits of 'Grande Naine', 'BRS Platina' and 'Prata-Anã' in this work are consistent with the results of other authors (SILVA; VALE; PEREIRA, 2019; ARANTES et al., 2017; SILVA et al., 2015; MARQUES et al., 2011).

Like productivity, fruit length was not affected by the 30% LIC reduction. The application of 50% LIC did not influence the fruit length of the cultivars, except for 'Grande Naine', which demonstrated greater sensitivity to 50% LIC reduction, even for four months, which is justified by its AAA genome (LUCENA, 2013; DONATO et al., 2015), which is more sensitive to soil water reduction. 'Grande Naine' and 'Prata-Anã' were the ones whose fruit diameter was most influenced by the 50% LIC reduction, which did not occur for the 30% reduction (Tables 7 and 8).

5.3 Water use efficiency

Water use efficiency (WUE) was not influenced by the time of year but rather by the reduction in LIC in each period (Table 9). Regardless of the time of year in which LIC reductions were applied, the highest WUE averages occurred for the 30% reduction but did not differ from the corresponding 50% reduction. The lowest averages occurred for the conditions without WUE reduction throughout the year. This behavior was repeated for each cultivar, and the differences between the WUE averages were significant for 'Grande Naine'. There was no significant difference between these reduction levels of 30 and 50% for the other cultivars (Table 10).

Table 9. Means of EUA (kg ha^{-1} mm^{-1}) of the five cultivars between the periods of the year in which the LIC reduction was applied and between the levels of reduction in the calculated irrigation depth (LIC).

% LIC Reduction	Jul - Oct (P1)	nov -nev (P2)	Mar - Jun (P3)
No reduction	16.96 A b	16.96 A b	16.96 A b
30%	21.25 A to	22.13 A a	20.71 A a
50%	20.40 A to	21.70 A to	19.21 A ab
CV = 14.66%			

Lowercase and equal letters in columns and uppercase and equal letters in rows do not differ from each other according to Tukey's test at 5% significance.

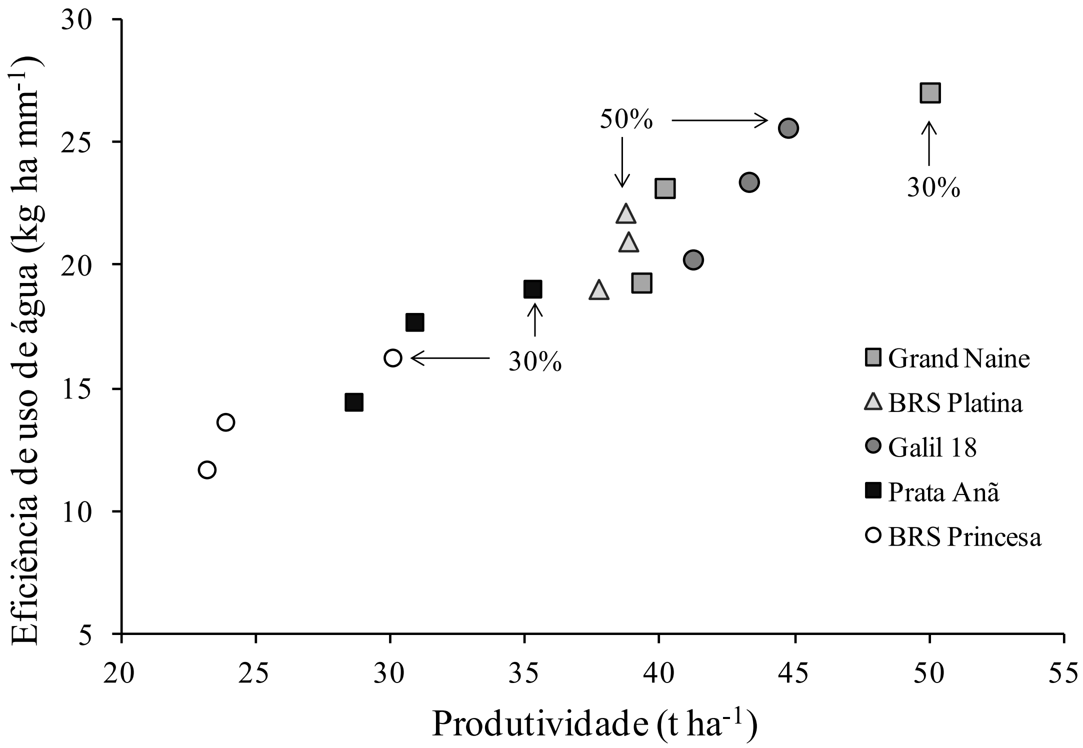
Table 10. Means of EUA (kg ha^{-1} mm^{-1}) of five banana cultivars under different irrigation strategies with controlled water deficit or between LIC reduction levels, Nova Porteirinha, MG.

% Reduction LIC	Grand Naine	BRS Platina	Galil 18	Silver Dwarf	BRS-Princesa
No reduction	19.32 A c	19.06 A a	20.26 A b	14.46 B b	11.71 B b
30%	27.06 A to	21.00 C to	23.42 A ab	19.07 CD a	16.27 D a
50%	23.17 A b	22.16 A to	25.62 A to	17.72 B a	13.65 C ab
CV = 14.66%					

Lowercase and equal letters in columns and uppercase and equal letters in rows do not differ from each other according to Tukey's test at 5% significance.

The cultivars BRS Platina and Galil 18 showed no reduction in productivity in any of the three periods compared with full irrigation throughout the year.' Galil 18' maintained high productivity associated with EUA, even with a 50% reduction in LIC. These findings suggest that these cultivars can be used with the irrigation deficit regulation method, both in advanced cycles and in this study, in periods of four consecutive months throughout the year, and may respond more frequently in shorter periods. However, the other cultivars presented greater EUAs and greater productivity when a 30% reduction in LIC was used for four consecutive months in a year (Figure 4).

Figure 4. Water use efficiency (WUE) as a function of productivity for five banana cultivars subjected to 30% and 50% reductions in irrigation depth calculated during four consecutive months of the year.



The highest productivities associated with the largest EUA occurred for 'Grande Naine' and 'Galil 18', which were between 25 and 30 kg mm $^{-1;}$ for 'BRS Platina', they were between 20 and 35 kg mm $^{-1}$; and for 'Prata-Anã' and 'BRS Princesa', they were between 15 and 20 kg mm $^{-1}$. Water use efficiency was greater for cultivars with greater productive potential in all layers because of the increase in productivity in response to the increase in soil water availability, whereas the opposite occurred for cultivars that were more tolerant of soil water deficit (LUCENA, 2013; DONATO et al., 2015). It is common to find EUA indicators above 20 kg mm $^{-1}$ and equal to or greater than 30 kg mm $^{-1,}$ corresponding to commercial productivity for banana trees of the Prata and Cavendish varietal types, respectively (SANTOS et al., 2016; COELHO et al., 2015; COSTA et al., 2012).

6 CONCLUSIONS

Controlled deficit irrigation applied during four consecutive months of the year with a calculated reduction in the irrigation depth of 30% did not result in a loss of productivity for the cultivars Grande Naine, BRS Platina, Galil 18, Prata Anã and BRS Princesa in the conditions of northern Minas Gerais.

The use of controlled deficit irrigation does not reduce the pseudostem circumference, plant height, number of leaves, or total leaf area at harvest.

The 50% reduction in the irrigation depth calculated over the four-month period, regardless of the time of year, contributed to a reduction in the productivity of the cultivars, except for BRS Platina and Galil 18.

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