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Sugarcane cultivation submitted to water replacement via irrigation bar

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From the hypothesis that during the development of sugarcane, the water regime affects the morphological performance and this affects the productivity. The objective of this work was to evaluate the growth, development, productivity and yield of sugarcane during the cycle the planting sugarcane (variety SP83-5073), under different water replacements. The experiment was established in the Boa Vista mill located in Quirinópolis – GO, Brazil, on a distroferric Red Latosol cerrado phase. The experimental design was a randomized complete block, analyzed in a split plot scheme with four replications. Irrigation was carried out by a hose-drawn traveller sprinkler systems coupled to an irrigation bar. The evaluated variables were plant height, stem diameter, number of leaves and leaf area of two plants located in the useful area of each plot. The results were submitted to analysis of variance by F test at 5% probability, and in cases where significant difference were observed, regression analysis was performed on the water replacement levels and the evaluation dates, using the statistical software SISVAR. The growth of sugarcane was influenced positively by water replacement, depending on the season and applied blade, for plant height variables, stem diameter, leaf number and leaf area. The sugarcane yield obtained maximum increases of 61.07% and 81.52 t ha^{-1} on the blade 86.16% of water replacement with a productivity of 133.5 t ha^{-1}.

Key words: Irrigation depth, biometry, water deficit, yield.

INTRODUCTION

Brazil is the world's largest producer of sugarcane and its derivatives, sugar and alcohol. The expansion of the sugarcane area is arguably growing, so is the demand for knowledge encompassing the adaptability and the production of this crop in new cultivation areas (Silva et al., 2015). Such agricultural areas regularly have specific climatic conditions, especially water scarcity, which interferes with the growth and development of plants, due

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to the biochemical, physiological and morphological changes (Silva et al., 2007).

Dantas et al. (2006), Farias et al. (2008) and Wiedenfeld and Enciso (2008) stated that the use of the irrigation technology is essential to achieve high productivities, reaching the genetic potential of the crop. According to Inman-Bamber and Smith (2005), the morphological and physiological characteristics modified by water stress are of great importance to achieve high plant yield. Thus, an appropriate knowledge of how plants respond to such abiotic stress is one of the prerequisites to choose both the best variety and the best management practices, aiming mainly at improving the exploitation of natural resources (Smit and Singels, 2006).

Inman-Bamber (2004) pointed out that the time of exposure to drought adversely affects the shoot growth, especially the leaf production, accelerating the essence of the leaf and of the plant as a whole. This exposure may also lead to a reduction in the interception of radiation, in the water use efficiency and in the photosynthesis, as well as to an increase in the radiation transmitted to the ground surface.

The production of sugarcane can be affected significantly when there is a reduction in the emission and survival of tillers (Silva et al., 2014). Decrease in the expansion of leaves and stem usually occur before the reduction of leaves and subsequently affects the accumulation of dry matter and soluble solids in the juice (Inman-Bamber, 2004). On the other hand, cultivars that maintain better performance of these variables under water stress have the potential to be more productive under this water regime (Silva et al., 2008).

According to Arantes (2012), the water deficit is not limited only to arid and semi-arid regions of the world, since even in areas considered climatically humid, the uneven distribution of rainfall may, in some periods, limit growth. For the efficient use of water by sugarcane, it is essential to identify the water requirement responsible for maximum production (Wiedenfeld and Enciso, 2008).

In this context, from the hypothesis that during the development of sugarcane, the water regime affects the morphological performance and this affects the productivity. The objetive this work was evaluate the growth, development, productivity and yield of sugarcane during the cycle the plant cane (variety SP83-5073), under different water replacements.

MATERIALS AND METHODS

The experiment was carried out in July 2013, during the crop cycle the plant cane of the variety SP83-5073 in the Boa Vista mill located in the municipality of Quirinópolis - GO. The experimental area comprises the Glebe 10.211 belonging to the Vilela farm located in the neighboring municipality of Paranaiguara - GO, at the margins of the Lago Azul (Blue Lake) owned by CEMIG, which has a soil classified as distroferric Red Latosol cerrado phase, according to Embrapa (2013). The climate is (according to Köppen climate classification) classified as tropical savanna with dry winter and rainy summer (Aw), with an annual average rainfall between 1430 and 1650 mm, and drought period well defined between May and October (Table 1).

The experimental design was randomized complete block, analyzed in a split plot scheme with four replications. The factors evaluated in the plots consisted of five water replacement depths (100, 75, 50, 25 and 0% of the required irrigation). The subplots were represented by six evaluation periods (30, 90, 150, 210, 270 and 330 days after planting - DAP). The internode length variable was measured from 90 to 270 DAP and the number of plants from 150 to 330 DAP. The variables total recoverable sugars and stem productivity were evaluated punctually at the end of the cycle to 330 DAP.

The experimental plots, that is the proportion of the area wetted by the irrigation equipment, were 50.0 m long and 50.0 m wide (33 crop lines with 1.5 m spacing), with a total area of 2500.0 m^2. The subplots were composed of 5.0 m of 2 lines, located in the center of the plot.

The planting fertilizer was recommended based on the soil analysis and the application process was made according to the management method adopted in every commercial cultivation area cultivation of the mill. During soil preparation, spread fertilization was carried out by incorporation of average grade of about 15 cm deep. The recommendation was 200 Kg ha^{-1} of P_2O_5 in the form of single superphosphate. As for the K and N sources, they were used in a concentrated stillage enriched with urea, totaling equivalent to 180 kg ha^{-1} K_2O and 100 kg ha^{-1} nitrogen. For micronutrients, it was used in a dose of 100 kg ha^{-1} in the form of granulated FTE, being used as 4kg ha^{-1} zinc, 2 kg ha^{-1} boron and 2 kg ha^{-1} copper. The nitrogen coverage fertilization was performed 60 days after planting. 120 kg ha^{-1} N (urea) was applied on both sides of the lines combined with the “break-back” operation.

Irrigation was carried out by a hose-drawn traveller sprinkler systems of Irrigabrasil brand, model 140/GSV/350-4RII. The sprinkler was coupled to an irrigation bar brand Irrigabrasil, model 48/54; MDPE tube with 140 mm outer diameter and length of 350 m; wall thickness of 10.3 mm, with lattices 24.5 m long on each side, totaling 49.0 m of adjustable structure, thus allowing the irrigation of the sugarcane to about 4.0 m high. With height compensation system through telescopic wheels installed along the lattices, the central car of the bar was operated with 3.0 m width. Senniger emitters spaced at 1.85 m were used, totaling 26 emitters; the working pressure in the bomb was 10 Kgf cm^{-2} while it was 5 Kgf cm^{-2} in the reel. The reel was operated with an average wind speed of 14.5 m s^{-1}.

In software, the weather monitoring was used to estimate daily water consumption of sugarcane generating daily water balance and calculating the water depth to be applied, allowing the control of the appropriate time to irrigate. The readings were taken daily, enabling the assessment of crop water consumption with respect to the used water depth (100% of the available water), and the reference evapotranspiration (ET0) was calculated according to Penman-Monteith-FAO / 56 (Allen et al., 1998) (Table 2).

At the end of the irrigation period, a detailed report of the irrigation management was generated, calculating the accumulated water deficit and the irrigation depths applied during the irrigation period of the experiment (Table 3).

In the central lines of the subplots, the following morphological characteristics were evaluated in relative to plant height (PH); diameter of stem (DS); number of leaves (NL); leaf area (LA); number of internodes (NI); number of tillers (NT) and number of plants (NP). The plant height was measured, with a tape measure, from the ground to the collar of the +1 leaf (+1 leaf is that in which the collar can be completely visualized); and then expressed in cm. The stem diameter was determined with a caliper rule in the middle third of the plant, and expressed in mm.T

The number of leaves was determined by counting the fully expanded leaves with a minimum of 20% of green area, they were counted from the +1 leaf; then the leaf area was determined by

Table 1. Physical, water and chemical characteristics of the soil in the experiment area.

Physical and water characteristics								
Layer	FC	PWP	Micro	Macro	TP	PD		PR
m	%				cm^3	$g.cm^{-3}$	Sd	Mpa
0.00-0.20	66.5	45.39	67.28	24.30	42.97	2.24	1.28	5.04
0.10-0.20	70.75	41.14	71.16	23.68	47.47	2.39	1.25	3.17
0.20-0.40	56.5	34.92	56.84	13.33	43.51	2.27	1.28	5.19

Granulometry				Textural Class
	Clay (%)	Silt (%)	Sand (%)	
0.00-0.20	27.50	6.90	65.60	Sandy
0.20-0.40	45.06	4.04	50.90	Sandy

Chemical characteristics											
Layer	pH	O.M	P	K	Ca	Mg	Al	H+Al	SB	T	V
(m)	in $H_2$0	(g kg^{-1})	(mg dm^{-3})			(mmol dm^{-3})					(%)
0.00-0.20	6.1	60.42	8.16	3.04	21.30	15.70	0.0	55.75	45.80	95.50	45.90
0.20-0.40	6.3	45.47	2.15	4.19	15.40	14.20	0.0	45.55	35.69	75.20	40.50

FC, Field capacity; PWP, Permanent Wilting Point; Micro, Microporosity; Macro, Macroporosity; TP, Total Porosity; PD, Particle Density; Sd, Soil density; PR, Penetration Resistance; pH in distilled water. P and K, extractor Mehlich^{-1}. O.M, Organic Matter; T - Cation exchange capacity; SB - Sum of bases and V, Saturation per base.

Table 2. Monthly averages of agrometeorological data during the irrigation period.

Year	Month	Tmax	Tmin	Tave	RH	Rainfall	ET_0
		ºC			%	mm	mm day^{-1}
2013	6	31.08	17.94	24.51	66.91	11	4.12
	7	29.11	13.94	21.53	60.90	0	3.99
	8	31.12	14.02	22.57	45.47	0	4.61
	9	33.41	18.60	26.00	58.44	13	5.05
	10	33.47	20.92	27.20	55.66	121	5.18
	11	32.20	21.07	26.64	79.25	105	4.88
	12	32.52	22.30	27.41	84.13	235.6	5.00
2014	1	29.4	20.4	23.21	77.99	206.0	5.3
	2	30.4	19.7	23.64	74.39	376.0	5.1
	3	28.7	19.14	23.11	82.54	315.0	4.8
	4	27.9	18.8	23.20	81.37	165	4.7
	5	26.7	18.4	21.37	70.49	40	4.5

Tmax, Maximum temperature; Tmin, Minimum temperature; Tave, Average temperature; RH - relative humidity; ET_0, Reference evapotranspiration (Penman-Monteith-FAO/56 (Allen et al., 1998)).

counting the number of green leaves (fully expanded leaf with minimum of 20% green area, counted from the +1 leaf) (Benincasa, 2003).

The number of plants was determined by counting all plants containing more than six fully expanded leaves. The number of tillers was determined from the count of all plants containing less than six fully expanded leaves; the number of internodes was obtained by counting throughout the stem of the plants from the posting of the first stems.

The monitoring of the sugarcane ºBrix was conducted in the field, in the last three weeks prior to the harvest in each crop cycle. When the Maturation Index (MI = Top °Brix/ Base °Brix) was between 0.9 and 0.95, samples of three stems of each plot were collected, totaling twelve complete stems per treatment; and submitted for evaluation in the industrial quality laboratory of the mill, for the determination of total recoverable sugars (TRS), which was expressed in kg ton^{-1}.

Stem productivity was determined by the total weight of stems present in the respective subplots. In order to quantify the weight of the stems present in 1.5 m of the two central lines, whose value was extrapolated to ton ha^{-1}, the cut was performed as close as possible to the ground. The straw was then removed from stems and the index was highlighted. Then the stems were weighed on a hook-type digital scale, brand Soil Control (precision = 0.02 kg), with capacity of 50 kg.

The results were submitted to analysis of variance by F test at 5% probability, and in cases where significant differences were observed, regression analysis was performed on the water replacement levels and the evaluation dates, using the statistical software SISVAR (Ferreira, 2011).

Table 3. Fortnight averages of accumulated water deficit and irrigation depths applied during the irrigation period of the experiment.

Month	Phase*	Kc**	Accumulated water déficit (mm)				Applied depths (mm)			
			25%	50%	75%	100%	25%	50%	75%	100%
06	II	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
06	III	0.40	2.40	4.79	7.19	9.58	10.00	20.00	30.00	40.00
07	III	0.70	4.18	8.35	12.53	16.71	10.00	20.00	30.00	40.00
07		0.70	4.94	9.87	14.81	19.74	10.00	20.00	30.00	40.00
08	III	0.70	10.02	20.03	30.05	40.07	11.00	22.00	33.00	44.00
08		0.70	9.51	19.02	28.53	38.04	11.00	22.00	33.00	44.00
09	III	0.70	10.53	21.06	31.60	42.13	11.00	22.00	33.00	44.00
09		0.70	7.16	14.32	21.48	28.64	0.00	0.00	33.00	44.00
10	III	1.25	12.54	25.07	37.61	50.14	13.00	26.00	39.00	52.00
10		1.25	12.56	25.12	37.69	50.25	13.00	26.00	39.00	52.00
11	III	1.25	6.49	12.98	19.47	25.96	13.00	26.00	39.00	52.00
11		1.25	12.54	25.07	37.61	50.15	13.00	26.00	39.00	52.00
12	IV	1.25	17.64	35.28	52.92	70.56	0.00	0.00	0.00	0.00
12		1.25	22.06	44.12	66.19	88.26	0.00	0.00	0.00	0.00
	Total		132.57	265.08	397.68	530.23	115.0	230.0	378.0	504.0

*According to Diola and Santos (2012), wherein the stages of development of sugarcane are divided into four, namely: (i) Budding and establishment of the culture; (II) Tillering: Extends from the end of the budding up to 120 days after planting; (III) Vegetative development and stem growth; begins immediately after the tillering phase up to 270 days after planting; (IV) Maturation: Phase of synthesis and accumulation of sugar, which lasts from 270 to 300 up to 360 days after planting. **Kc - Culture coefficient, described by Doorenbos and Kassam (1994).

Table 4. Summary of the analysis of variance for plant height (PH), diameter of stem (DS), number of leaves (NL) and leaf area (LA) as a function of water replacement factors (WR) and days after planting (DAP) of sugarcane, Quirinópolis - GO, 2013/14.

SV	DF	MS			
		PH	DS	NL	LA
WR	4	12400.53**	20.79**	1.00*	1109746.96**
Block	3	1001.21*	1,88^{ns}	0.66^{ns}	127177.53^{ns}
Residue^{a}	12	207.52	3.56	0.28	137706.32
DAP	5	218432.90**	398.67**	21.68**	44993206.77**
WR x DAP	20	522.63*	15.62**	0.70^{ns}	593389.05*
Residue^{b}	75	285.41	5.22	0.44	295129.95
CV a (%)		8.62	7.24	8.06	10.29
CV b (%)		10.11	8.77	10.14	15.06

^{ns} non-significant; **,* significant, respectively, at 1 and 5% probability by F test. SV, Sources of Variation; DF, Degree of Freedom; MS, Mean Square; CV, Coefficient of Variation.

RESULTS

In summary, in the variance analysis, it is observed that there was a significant interaction between the factors: water replacement (WR) and days after planting (DAP) for the variables: plant height (PH), diameter of stem (DS) and leaf area (LA), and there was isolated significant effect on number of leaves (NL) (Table 4).

In analyzing the unfolding of the interaction of PH as a function of WR, the observation was a linear increase at 90 and 150 DAP, with increasing up to 0.54 and 0.56 m, respectively, with 100% WR. Yet at 210, 270 and 330 DAP, there was a quadratic behavior of maximum increase obtained with 100.0, 93.50 and 79.50% WR, respectively, corresponding to values 2.75, 3.22 and 2.81 m as in Figure 1A. For the PH as a result of DAP, it was observed that there was a linear increase of up to 2.93, 2.57, 3.13, 3.06 and 3.10 m at 330 DAP for 0, 25, 50, 75 and 100% WR, respectively (Figure 1B). Thus, the highest PH increase due to WR was observed at 210 DAP with 103.0% of the required irrigation. For PH due to WR, the highest values were observed at 270 DAP, reaching 3.22 m. For PH as a function of DAP, it was observed the highest increase and value of PH with 50% WR, reached 3.13 mm.

In the analysis of the interaction of the DS as a result of

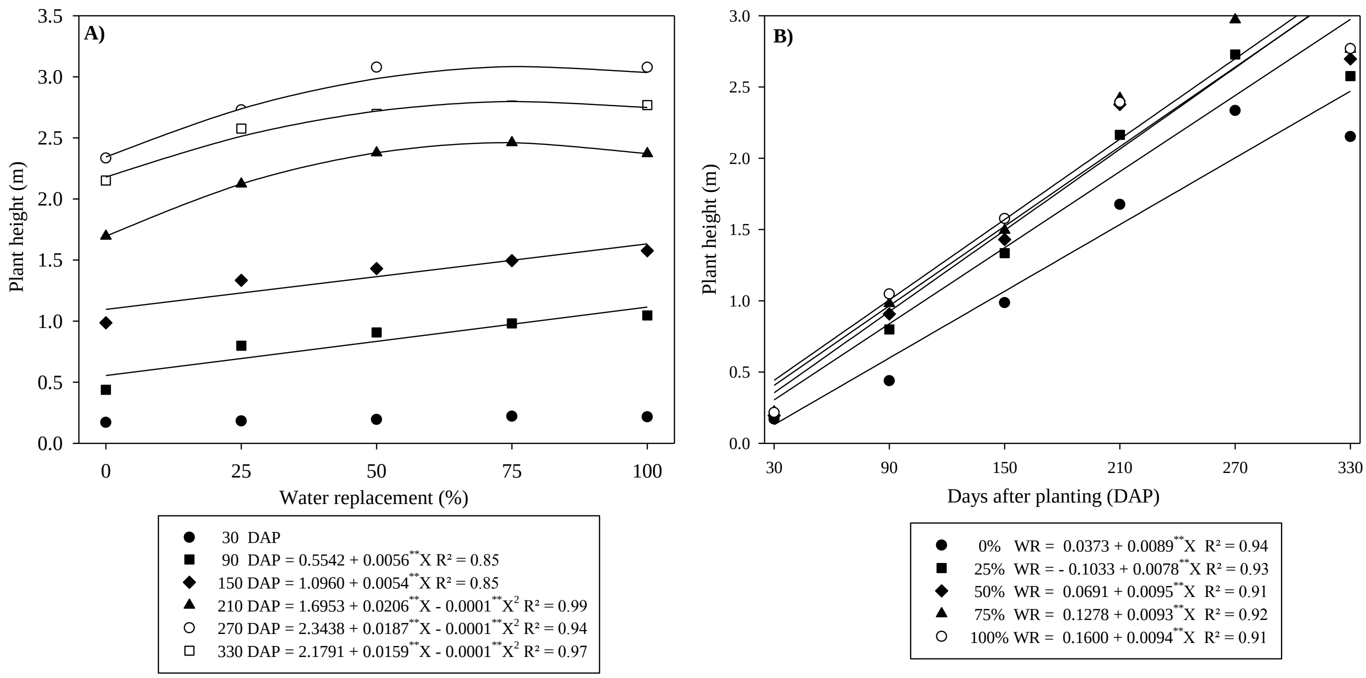

Figure 1. Plant height of sugarcane as a function of water replacement (A) and days after planting (B), Quirinópolis - GO, 2013/14.

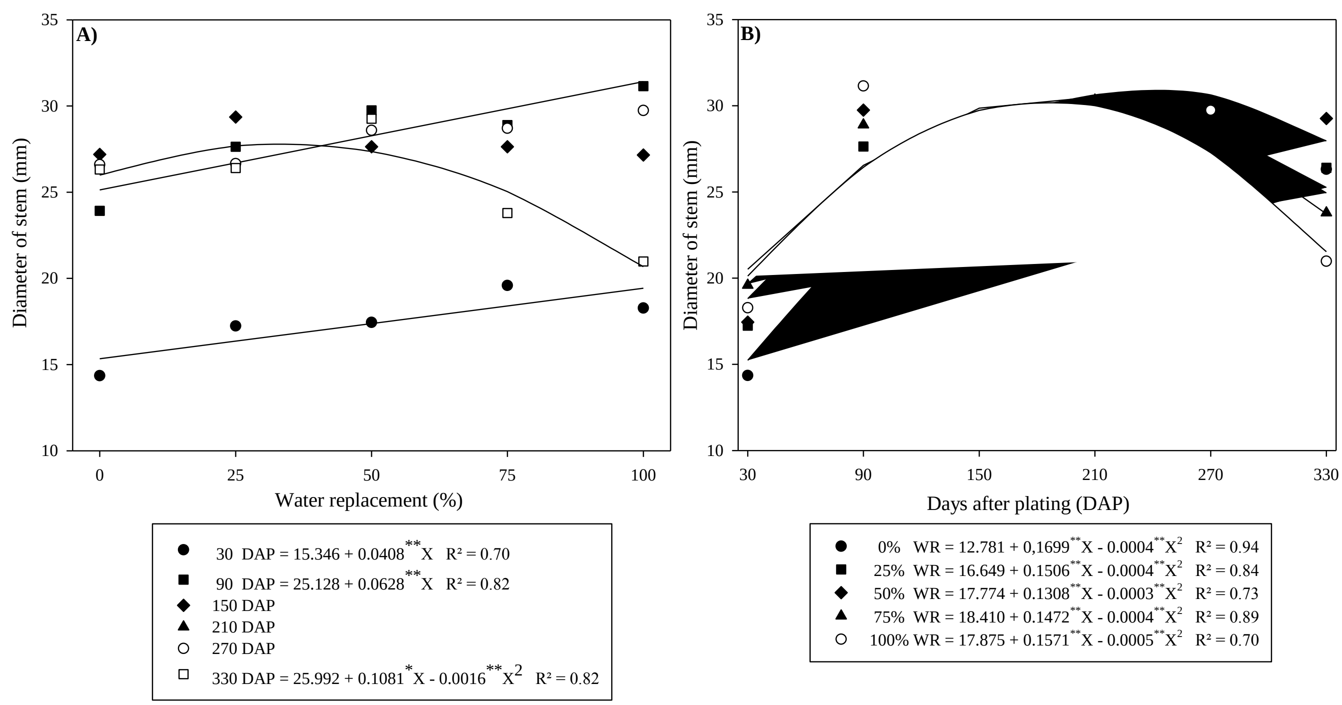

Figure 2. Diameter of sugarcane stem in function of (A) water replacement and (B) days after planting, Quirinópolis - GO, 2013/14.

WR, it was observed that there were linear increases at 30 and 90 DAP, and the increases were up to 4.08 and 6.08 mm, respectively, with 100% WR. Yet at 330 DAP, there was a quadratic behavior of maximum increase obtained with 33.78% WR, respectively corresponding to a value of 27.81 mm (Figure 2A). For the DS as a function of the DAP, it is observed that there was a quadratic behavior with 0, 25, 50, 75 and 100% WR, with

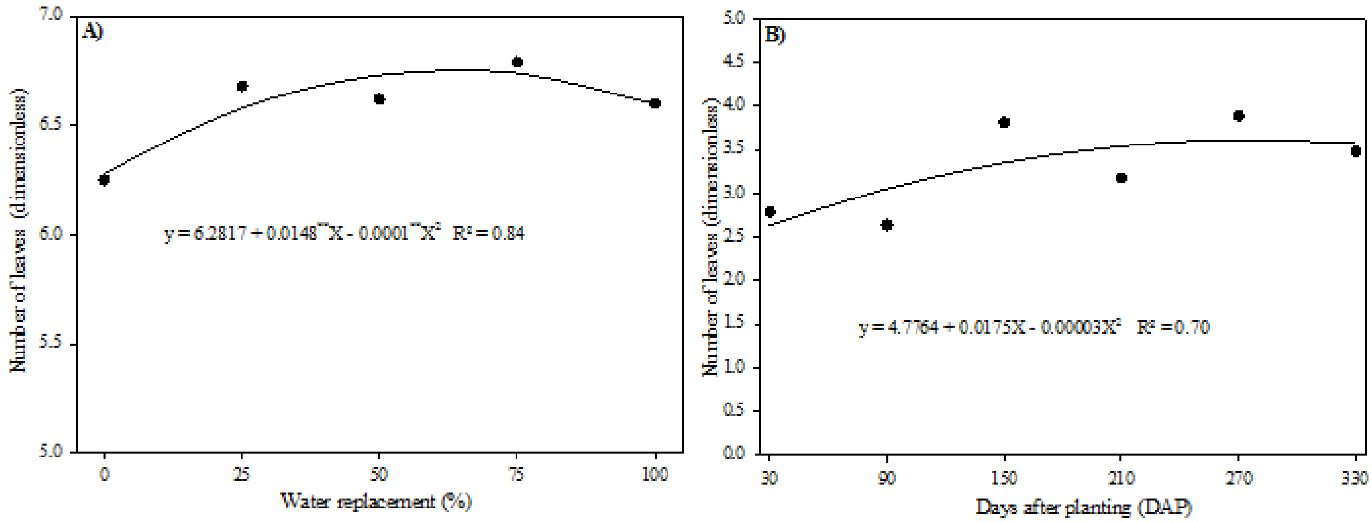

Figure 3. Number of sugarcane leaves in function of (A) water replacement and (B) days after planting, Quirinópolis - GO, 2013/14.

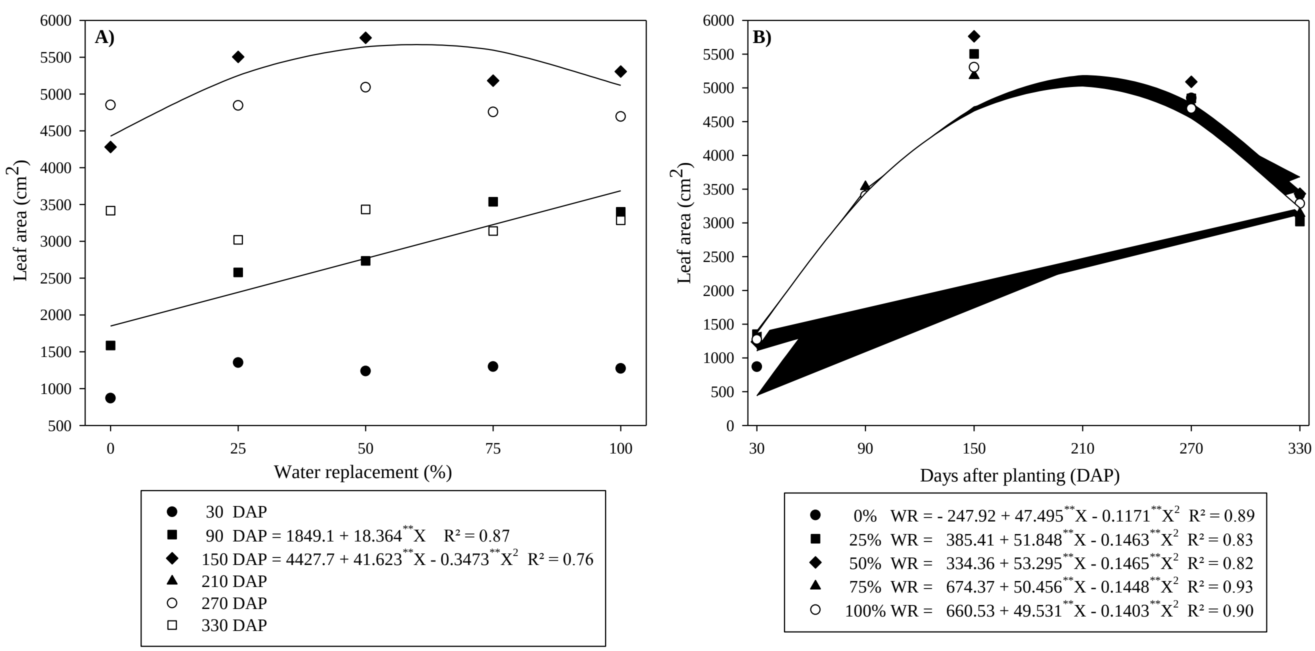

Figure 4. Leaf area in function of the water replacement (A) and days after planting (B) sugarcane, Quirinópolis - GO, 2013/14.

maximal increases obtained at 212, 188, 218, 184 and 157 DAP, respectively, corresponding to values of 30.82, 30.83, 32.03, 31.95 and 30.27 mm (Figure 2B). Thus, for the DS as a function of the WR, the largest increases and values were observed at 90 DAP, reaching 31.20 mm. For the DS as a function of DAP, the largest increases and values of DS were observed with 75% WR at 184 DAP, reaching up to 31.95 mm.

In the isolated analysis of NL as a function of WR, it was observed that there was a quadratic behavior with maximal increase at 74.5% WR, reaching the values of 6.82 leaves as in Figure 3A. For NL as a function of DAP, a quadratic behavior with maximum increasing at 291 DAP, with values of 7.32 leaves was noted (Figure 3B).

In the analysis of the interaction of LA as a function of WR, a linear increase was observed at 90 DAP, the increase was up to 50.17 with 100% WR, corresponding to a value of 1836.40 cm^2. Yet at 150 DAP, there was a quadratic behavior of maximum increase obtained at 59.92% WR, corresponding to a value of 5666.32 cm^2 (Figure 4A).

For the LA as a function of the DAP, there was a

Table 5. Summary of the analysis of variance for length of internodes (LI) and number of plants (NP), fluid replacement factors (WR) and days after planting (DAP) of sugarcane, Quirinópolis - GO, 2013/14.

SV	DF	MS	
		LI	NP
WR	4	23.39**	45.61*
Block	3	5.80^{ns}	5.78^{ns}
Residue^{a}	12	2.83	12.07
DAP	3	32.73**	184.43**
WR x DAP	12	2.37^{ns}	3.36^{ns}
Residue^{b}	45	3.60	6.60
CV a (%)		10.96	22.41
CV b (%)		12.37	16.57

^{ns} non-significant; **,* significant, respectively, at 1 and 5% probability by F test. SV, Sources of Variation; DF, Degree of Freedom; MS, Mean Square; CV, Coefficient of Variation.

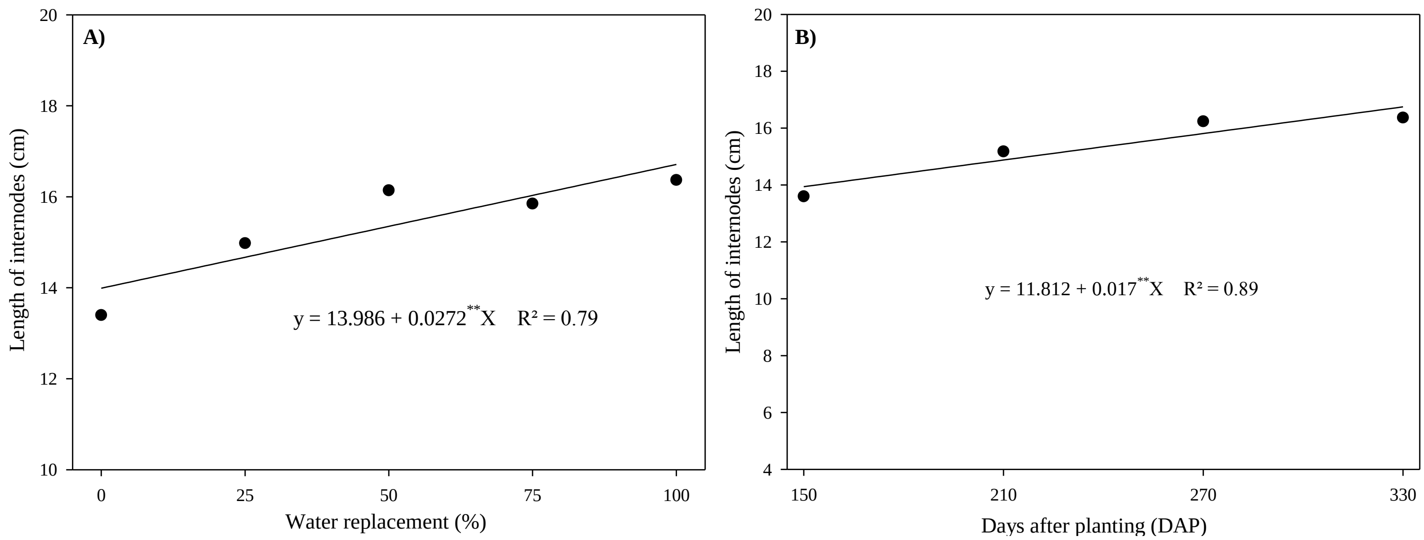

Figure 5. Lergth internodes of sugarcane in function of (A) water replacement and (B) days after planting, Quirinópolis - GO, 2013/14.

quadratic increase of 0, 25, 50, 75 and 100% WR, with increases of up to 202, 177, 181, 174 and 176 DAP, respectively, corresponding to values of 4567.92, 4979.07, 5181.27, 5069.75 and 5032.05 cm^2 (Figure 4B). Thus, for the LA as a function of the WR, the largest increases and values were observed at 150 DAP, reaching increases of about 3740.16 cm^2 with 59.92% WR. For the LA as a function of DAP, the largest increases and values of LA were observed with 50% WR at 181 DAP, reaching 5181.27 cm^2.

In the summary of the analysis of variance, there was no significant interaction between the factors WR and DAP for the variables length of internodes (LI) and number of plants (NP), though there was significant isolated effect of these variables both for WR as DAP (Table 5). In the isolated analysis of LI as a function of WR, a linear behavior was observed with increases of about 19.44% at 100% WR, corresponding to a value of 2.72 cm (Figure 5A). For the LI as a function of DAP, there was a linear behavior with increases of about 12.58% at 100% WR, corresponding to a value of 1.70 cm (Figure 5B).

In the isolated analysis of the NP as a function of the WR, it was observed that there was a linear behavior with increasing about 28.18% with 100% WR, corresponding to a value of 3.83 plants (Figure 6A). For the NP as a function of the DAP, a linear behavior with increasing up to 45.38% with 100% WR was noted. This corresponds to a value of 4.16 plants (Figure 6B).

In the summary of the analysis of variance, it was observed that there was a significant effect of the WR factor for the variables total recoverable sugars (TRS) and stem productivity (SP) (Table 6).

In the isolated analysis of TRS as a function of WR, a

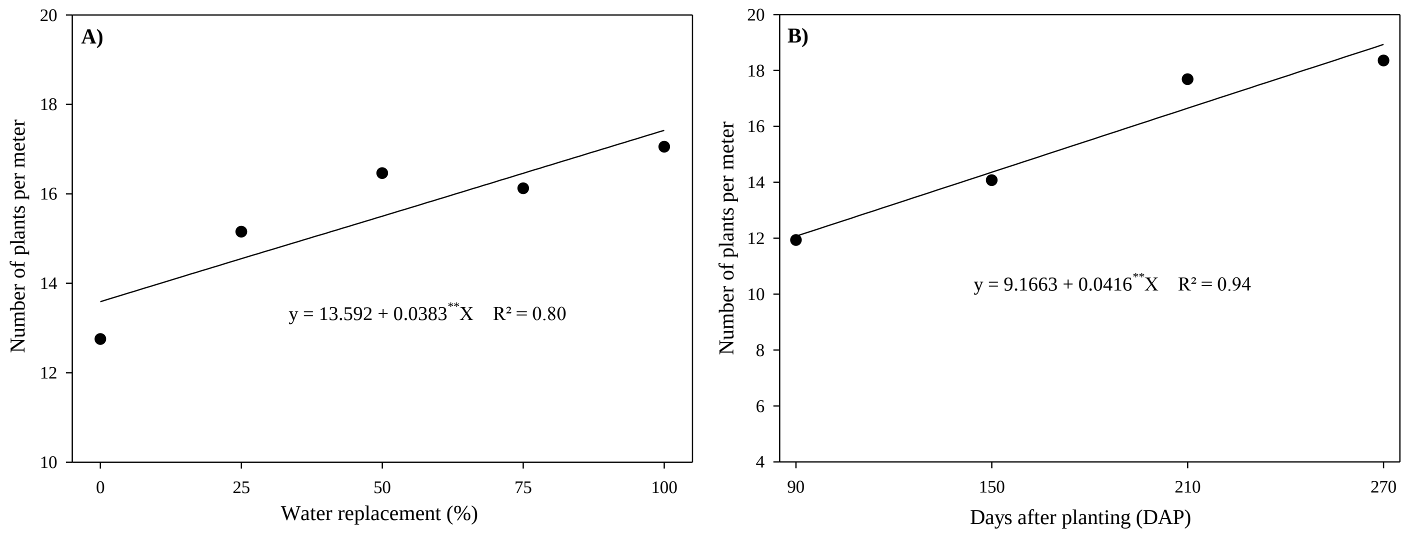

Figure 6. Number of plants per meter in function of the (A) water replacement and (B) days after planting of sugarcane, Quirinópolis - GO, 2013/14.

Table 6. Summary of the analysis of variance for the variable amount of total recoverable sugar (TRS) and stem productivity (PC) according to fluid replacement factors (HR), Quirinópolis - GO, 2013/14.

SV	DF	MS	
		TRS	SP
WR	4	62.47**	2357.66**
Block	3	27.97^{ns}	2357.66^{ns}
Residue	12	12.68	396.88
CV (%)		2.25	16.94

^{ns} non-significant; **,* significant, respectively, at 1 and 5% probability by F test. SV, Sources of Variation; DF, Degree of Freedom; MS, Mean Square; CV, Coefficient of Variation.

linear behavior was observed with increasing about 6.28 to 100% WR, corresponding to a value of 9.64 kg t^{-1} (Figure 7A).

In the isolated analysis of SP as a function of WR, it was observed that there was a quadratic profile with maximal increases obtained with 86.16% WR, corresponding to a value of 133.49 t ha^{-1}, which corresponds to 81.52 increment t ha^{-1} (61.07%) (Figure 7B).

DISCUSSION

In crop year 2013/14 precipitation in the experiment site was 1587.60 mm, as shown in Table 2, high enough value for the development of sugarcane, but the same does not occur with regularly throughout the season, as this precipitation occurred during the months of 11/2013 to 05/2014 thus months successors to planting 06/2013 to 10/2013 precipitation is insufficient, and the culture period depends on the volume total water added via the irrigation was 0, 115, 230, 378 and 504 mm. respectively for fluid resuscitation of 0, 25, 50, 75 and 100% of the required irrigation.

Studying the growth rates of sugarcane, variety SP 79-1011, under irrigation and rain fed regimes, Farias et al. (2008) found for irrigated sugarcane, a maximum height of 152.80 cm at 193 days, and growth rate in height, at 280.0 DAP, of 0.5457 cm day^{-1}. As for the culture subjected to the rainfed system, this maximum height was 148.19 cm at 236.20 days, the growth rate in height of the plants subjected to this management, at 280.0 DAP, was 0.5292 cm day^{-1}. Gonçalves (2008) and Pincelli (2010) also found different height response in four cultivars of sugarcane submitted to water stress. Silva et al. (2008) considered that plant height as one of the components to form the production potential of sugarcane, and state that the irrigation empowers the responsive varieties to best express their genetic potential.

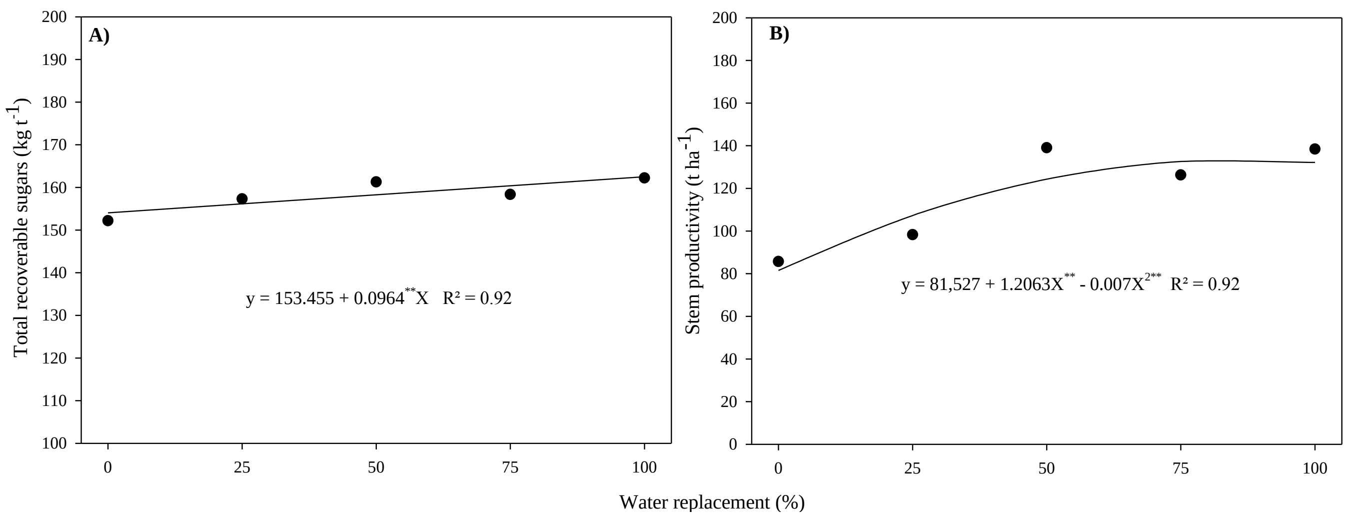

Figure 7. Total recoverable sugars in sugarcane in function of (A) water replacement and (B) stem productivity sugarcane, Quirinópolis - GO, 2013/14.

The increase in the diameter of stem in accordance with the evaluation periods was also observed by Oliveira et al. (2010) and Arantes (2012), they reported that not with standing, the following reduction of this morphological parameter from 291.0 days after cutting.

Machado et al. (2009) observed a significant reduction in the amount of leaves due to the water deficit. Smit and Singels (2006) reported that leaf senescence is responsive to water deficit and occurs after the reduction in leaf emergence. The reduction of leaves regarding plants with water deficit (Inman-Bamber, 2004; Pimentel, 2004) was attributed to the strategy by reducing the transpiring surface and the metabolic expenditure for the maintenance of tissues (Inman-Bamber and Smith, 2005; Smit and Singels, 2006; Inman-Bamber et al., 2008).

Results found by Chaves et al. (2008) and Pincelli (2010) demonstrated a reduction in the leaf area of those under water stress, because when subjected to water stress conditions, plants have a number of morphological and physiological changes such as leaf rolling, alteration of the leaf angle and reduction of the leaf area. Farias et al. (2007) observed an increase of approximately 46.0% in the leaf area index of sugarcane with full irrigation. The role of the crop canopy is an important factor in the yield of crops, as it intercepts the solar radiation that drives the processes of photosynthesis and evaporation, in addition to causing shading on weeds (Smit and Singels, 2006). Results showed that the photosynthetic capacity of sugarcane decreases drastically due to reduced leaf area (Inman-Bamber et al., 2009).

Machado et al. (2009) observed contradictory results, he observed that the internode length increased ($p<0.05$) in response to water deficit such that the greater the deficit, the greater the length of the internode. Inman-Bamber and Smith (2005) reported that the susceptibility of sugarcane to water stress is greater when plants are in the phase of elongation of the stems. In sugarcane, the growth is affected by water deficit by restrictions both in the cell division and in the cell elongation.

Oliveira et al. (2010) stated that the tillering in sugarcane grows up to six months after planting/cutting and from this period a reduction begins, resulting from competition for light, area, water and nutrients, reflecting thus in the reduction and stoppage of the process, in addition to the death of the younger tillers. According to Silva et al. (2014), tillering is a component for forming the production potential of sugarcane in conjunction with the length and diameter of stems, and the irrigation enables the responsive cultivars to better express their genetic potential.

Farias et al. (2008) analyzed the effect of irrigation water slides in the industrial quality of sugarcane, and found a strong correlation between the variables. There was a tendency of increase in TRS for higher water values applied. Oliveira et al. (2011) found no changes in the TRS to the total amount of water available to the culture. Inman-Bamber and Smith (2005) reported that the susceptibility of sugarcane to water stress is greater when plants are in the elongation phase of the stem, which causes serious damage in sucrose yield.

Study by Oliveira et al. (2011), with 11 varieties of cane sugar in two water regimes (rainfed and irrigated), found that there were productivity increase of up to 151% in irrigated regime. Gava et al. (2011) studied three genotypes (RB86-7515, RB85-5536 and SP80-3280) found average stem production of 132.2 t ha^{-1} for irrigation management and 106.5 t ha^{-1} for dryland management, in the first cycle. In studies by other authors, it was found that sugarcane genotypes respond differently to increased water availability (Inman-Bamber and Smith, 2005; Smit and Singels, 2006; Silva et al., 2007).

The use of irrigation promoted greater growth and productivity of sugarcane, reducing the effects of drought in the dry season in the planting area, indicating technical feasibility of this management as an alternative to increase productivity, as well as industrial quality sugarcane.

Conclusion

The growth of sugarcane was influenced positively by water replacement, depending on the season and applied blade, for plant height variables, stem diameter, leaf number and leaf area. The response of the variable length of internode and plant number showed no dependence on irrigation during periods evaluated. The plant height, stem diameter, leaf number and leaf area linearly responded to fluid replacement to around 150 days after planting and from then on the influence of high rainfall committed differentiation of fluid replacement blades. The stem diameter, leaf area and leaf number had its maximum growth until 218 days after planting and plant height to 270 days after planting, with an average water replacement of 76%. The length of internode number and plant due to the fluid replacement had average linear increases of 20 to 100% water replacement. The number of plants depending on the time tended to increase up to 197 days after planting, with 26.42% increase. The total recoverable sugars obtained respective increases of 6.28% in the depth of 100% of fluid replacement. The sugarcane yield obtained maximum increases of 61.07% and 81.52 t ha^{-1} on the blade 86.16% of water replacement with a productivity of 133.5 t ha^{-1}.

Conflict of Interests

The authors have not declared any conflict of interests.

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