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SESAME NO DESTRUCTIVE GROWTH ANALYSIS UNDER DIFFERENT CROP EVAPOTRANSPIRATION LEVELS[1]

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SUMMARY: Evaluating the BRS 196 CNPA G4 sesame growth in four irrigation levels (L_1-40, L_2-70, L_3-100 and L_4-130% of crop evapotranspiration), it was outlined, at Embrapa Cotton, Barbalha, CE, Brazil, in 2012, an experiment in randomized blocks with three replications. It was measured and estimated, at 27, 48, 69 and 90 days after emergence (DAE), the Height, the Stem Diameter, the Leaf Area and the Absolute and Relative Height, Stem Diameter, Fresh Biomass Epigeous and Leaf Area Growth Rates and the Leaf Area Index. It was concluded that: a) the crop evapotranspiration levels did not affect the absolute height and leaf area growth rates and the relative leaf area growth rate; b) the height, the leaf area and the leaf area index, growing throughout crop cycle, were influenced by all crop evapotranspiration levels, presenting, only in the two lasts, proportional to the evapotranspiration levels; c) the stem diameter that was only affected by 40% of the evapotranspiration also increased throughout crop cycle; d) the relative height and stem diameter growth rates and the absolute stem diameter growth rate, decreased, but not in proportion to the crop evapotranspiration levels which influenced them, and; e) the absolute and relative fresh biomass epigeous growth rates were proportional to the increasing crop evapotranspiration levels which influenced them.

KEYWORDS: *Sesamum indicum* L., water consumption, growth rates.

ANÁLISE DE CRESCIMENTO NÃO DESTRUTIVA DO GERGELIM SOB DIFERENTES NÍVEIS DE EVAPOTRANSPIRAÇÃO DA CULTURA

RESUMO: Objetivando avaliar o crescimento do gergelim BRS 196 CNPA G4 em quatro níveis de irrigação (L_1-40, L_2-70, L_3-100 e L_4-130% da evapotranspiração da cultura), conduziu-se, na Embrapa Algodão, Barbalha, CE, em 2012, experimento delineado em blocos casualisados com três repetições. Mediu-se e estimou-se, aos 27, 48, 69 e 90 dias após a emergência (DAE), a Altura, o Diâmetro Caulinar, a Área Foliar e as Taxas de Crescimento Absoluta e Relativa da Altura, do Diâmetro Caulinar, da Fitomassa Fresca Epígea, da Área foliar e o Índice de Área Foliar. Concluiu-se que: a) as evapotranspirações da cultura aplicadas não afetaram as taxas de crescimento absoluto da altura e da área foliar e a taxa de crescimento relativo da área foliar; b) a altura, a área foliar e o índice de área foliar, crescentes em todo o ciclo, foram influenciados por todas as evapotranspirações da cultura, apresentando-se, as duas últimas, proporcionais a estas; c) o diâmetro caulinar, também crescente, só foi afetado pelo nível de 40%; d) as taxas de crescimento relativas da altura e do diâmetro caulinar e a taxa de crescimento absoluto do diâmetro caulinar decresceram não proporcionalmente às evapotranspirações de influência, e; e) as taxas de

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crescimento absoluto e relativo da fitomassa fresca epígea foram crescentes e proporcionais às evapotranspirações de influência.

PALAVRAS-CHAVE: *Sesamum indicum* L., consumo de água, taxas de crescimento.

INTRODUCTION

Semi-arid region is characterized by low and erratic rainfall, high evaporation and soils with deficiency of essential nutrients (LIMA, 2011). Therefore, the addition of technologies to increase productivity for sesame (*Sesamum indicum* L.) crop are necessary, as the use of the irrigation technique, because it stands out for its socio-economic importance, especially in arid and semi-arid agricultural regions, where it is used to supplement natural rainfall in the crop water requirements (FARIAS et al., 2000).

For estimating crop water requirements - ETc (ETc = ET_0 x Kc), the Penman-Monteith method is the recommended by FAO for providing relatively accurate and consistent results of ET_0 in any geographic and climatic context for considering physiological and aerodynamic parameters in equation (ALLEN et al., 2006).

But, besides knowing the amount of water crop water requirements, it is also necessary to check the crop behavior due to different amounts of water and identify the stages of development of greater consumption beyond the critical periods when the lack or excess cause production (BERNARDO et al., 2009) and growth decreases.

Thus, the plant growth can be measured in several ways. In this sense, the growth analysis, aims to describe and interpret the performance of a given species growing in natural or controlled environment (FONTES et al., 2005; BARCELOS et al., 2007), presenting as a technique to study the production bases physiological and highlight the environmental, genetic and agronomic influences by variables (SILVA et al., 2000). Growth analysis in this case evaluates the effectiveness of these managements, being widely used by researchers in the agricultural area (CARDOSO et al., 2006).

The study aimed to evaluate the performance of height, stem diameter, leaf area and some more estimated growth rates of the BRS 196 CNPA G4 sesame in different levels of irrigation based on crop evapotranspiration (ETc).

MATERIALS AND METHODS

The study was conducted at Embrapa Cotton Experimental Station, located in the Barbalha County, CE State, Brazil (Geographical coordinates: 07º19' S, 39º18' W and 409 m above the mean sea level - RAMOS et al., 2009), in the Ceará South Mesoregion and the Ceará Cariri Microrregion, in the period from August 04th to November 7th, 2012, in an area of Fluvic Neossoil, whose chemical characterization (0-20 cm), according to Bulletin Nº 33/2012 of the Embrapa Cotton Soil Laboratory, Campina Grande, PB State, Brazil, was as follows: pH of 6.8, 95.3, 49.2, 2.8, 1.4 and 0.0 $mmol_c$ dm^{-3} of calcium, magnesium, sodium, potassium and aluminum, respectively, 5.4 mg dm^{-3} of phosphate and 12.3 g kg^{-1} of organic matter. Soil texture, in turn, on the surface layer (0-30 cm) was characterized as Clay Loam (33.67, 20.17 and 46.16% of sand, silt and clay, respectively, as sample Nº 33738 of the UFCG Irrigation and Salinity Laboratory, Campina Grande, PB State, Brazil). Average values of maximum and minimum temperatures and air relative humidity, obtained at the place and time of the experiment are shown in Figure 1.

The experimental area measured 6.912 m^2. The design was randomized blocks with four treatments (T_1-Irrigation with 40%, T_2-70%, T_3-100%, and T_4-130% of crop evapotranspiration - ETc), corresponding to applied total net water depths of 305.29, 435.80, 567.50 and 698.01 mm respectively, and three replications, totaling 12 experimental plots with the plots of each treatment measuring 18 x 12 m (216 m^2) and each block, 12 x 72 m (864 m^2), with an useful area of 14 m^2 per plot.

Soil preparation consisted of one plowing with chisel plowing. Foundation fertilization was taken at the bottom of the planting furrow as chemical soil analysis and recommendations for the culture in the region, i. e., 123 - 152 - 30 kg ha^{-1}. It was used in foundation (on August 05th, 2012) 300 kg ha^{-1} of Monoammonium Phosphate fertilizer - MAP (11% N and 46% P_2O_5). Nitrogen was fractionated into two more times (44.5% of the dose after thinning and 44.5%, 25 days later, on September 05th and 27th, 2012, respectively), each time applying 100 kg $ha^{-1}$of Urea N fertilizer (45% N), while the K was all applied after thinning (on September 05th, 2012) at the rate of 50 kg ha^{-1} of Potassium Chloride (60% K_2O). Fertilization coverage was made in the lateral furrows of planting rows. Sowing was held on August 4th, 2012 with five seeds per hill and at an average depth of 2 cm, using the BRS 196 CNPA G4 sesame cultivar, 0.70 x 0.20 spaced, with final density of 8-10 plants per meter of row. The thinning was done in 2 steps: first, when plants had 4 leaves (pre-thinning) and the second when 15 cm tall (final thinning). The weed control was performed with 3 hand weedings.

Irrigations, in the total number of 22 in the cycle, were performed using conventional sprinkler system, considering a 75% irrigation system efficiency, using sprinklers with 5.0 x 4.6 mm nozzle, with a 0.34 MPa service pressure, 18 x 12 m spaced, with a 10.54 mm h^{-1} average precipitation, applying water until 0.40 m, which according to Amaral e Silva (2008), corresponds to the required soil profile effective depth by the root system of the sesame. Before planting, irrigations were performed in the entire area in order to bring the soil at field capacity and promote germination. Later, irrigations were performed every 3 and 4 days, due to clay soil textural characteristics of the area favoring slow water infiltration, promoted for all treatments for full crop establishment, until 19 DAE, when treatments differentiation were implemented. From the beginning of the maturation stage (67 DAE) to the cycle finishing, irrigations became weekly.

At each irrigation event, the water replacement ($ETc = ET_0 * Kc$) for each treatment was a function of ET_0 estimated by the Penman-Monteith method, from respective period, using weather data from automatic weather station of the Instituto Nacional de Meteorologia – INMET, in Barbalha, CE State, Brazil, distant 500 m from experimental area and, of crop coefficients (Kc) given in FAO-56 (ALLEN et al ., 2006). The Kc average for the different stages of growth, were as follows: Phase I – planting/establishment - the period between emergence and 10% ground cover (1-5 DAE): 0.63. The values around average were obtained by the simplified equation by Albuquerque et al. (2002); Phase II - growth - period 10% ground cover to the beginning of flowering (6-32 DAE): 0.79. The values around average were obtained by the equation Kc = 0.0147 + 0.5125 * DAE; Phase III – development/floration - the period between flowering and early maturation (33-66 DAE): 1.10; and, Phase IV - maturation - the period from early to late maturation (67-90 DAE): 0.25. The values around average were obtained by the equation Kc = -0.0425 + 4.075 * DAE.

Periodically, at 27, 48, 69 and 90 DAE, was measured in 4 plants per plot, properly identified since the beginning of the measurements, the height, the stem diameter and the leaf area. Plant height (H) was determined by measuring, in centimeters, with a graduated scale, the distance of the pointer from the base to the main stem of the plant. The stem diameter (SD) was measured in millimeters with a caliper at the base of the main stem of the plant, at 1 cm of soil. The leaf area (LA) per plant was determined by measuring the longitudinal length (in cm) of 10 leaves, these localized at node stem of the plant (SEVERINO et al., 2002), and counting the total number of leaves per plant, applying the equation $S = 0.3552 * C^2$ (SILVA et al., 2002 where S = leaf area - cm^2 and C = leaf longitudinal length - cm), multiplying the leaf area by the total number of leaves per plant to obtain the total leaf area per plant (cm^2).

Based on measurements of these primary values, at each time interval, considering Reis & Muller (1978) information and using Silva et al. (2000) adapted equations, some more growth rates were estimated: Absolute Growth Rate of the Height - AGRH (cm d^{-1}), Relative Growth Rate of the Height - RGRH (cm cm^{-1} d^{-1}), Absolute Growth Rate of the Stem Diameter – AGRSD (cm d^{-1}), Relative Growth Rate of the Stem Diameter – RGRSD (cm cm^{-1} d^{-1}), Absolute Growth Rate of the Fresh Biomass Epigeous - AGRFBE (cm^3 d^{-1}), Relative Growth Rate of the Fresh Biomass Epigeous - RGRFBE (cm^3 cm^{-3} d^{-1}), Absolute Growth Rate of the Leaf Area - AGRLA (cm^2 d^{-1}), Relative Growth Rate of Leaf Area - RGRLA (cm^2 cm^{-2} d^{-1}) and Leaf Area Index - LAI (m^2 m^{-2}).

To explain the growth rates according to the applied levels of ETc to the irrigated sesame, nonlinear regression models were used, the Sigmoidal-Logistic [Equation (1)] and the Peak-Log Normal [Equation (2)]:

$$\bar{y} = a / [1 + (x / x_0)^b)] \ (1) \quad e \quad \bar{y} = a / x \{ -0,5 \{ [\ln (x / x_0) / b]^2 \} \} \ (2)$$

Where x is the number of days after plants emergence (DAE) and x_0, a and b are coefficients of the adjusted regression model.

Harvesting (cutting, bracing and drying of the plants), held at 90 DAE, and processing (thrashing, sieving and ventilation), 15 days later, were done manually.

The primary characteristics of growth (height, diameter stem and leaf area) at each time of measurement, were subjected to variance analysis by F test (0.01 and 0.05 probability) and regression, using polynomial regression and regression models referenced above. Statistical analyzes were performed using the statistical software SISVAR (FERREIRA, 2011) and regression models were applied to all variables, primary and estimated growth rates, by the Sigma Plot software (SIGMA PLOT, 2011).

RESULTS AND DISCUSSION

By analysis of variance applied to the primary variables of growth analysis, ETc levels did not differ among themselves in any of the variables. Applied polynomial regression, only the height and the leaf area at 90 DAE were affected by the levels of ETc studied (Table 1). Moreover, the statistical significance of the regression deviations of all variables indicates the existence of other regression models that can explain the biological behavior of these variables. Thus, of the applied non-linear regression models only Sigmoidal-logistic and Peak-log normal were adjusted to the height (H), the RGRH, the stem diameter (SD), the AGRSD, the RGRSD, the AGRFBE, the RGRFBE, the Leaf Area (LA) and to the Leaf Area Index (LAI) estimated, respectively, with excellent coefficients of determination (R^2) (Figures 2 to 6).

Regarding to the growth rates estimated from the primary variables (height, stem diameter and leaf area), measured for the growth analysis, the AGRH, the AGRLA and the RGRLA suffered no influence of ETc levels studied.

The height was influenced by all ETc levels, showing sharp upward trend in their values throughout the cycle. The 100% level showed higher values for height, followed by 130% of ETc level from approximately 37 DAE, while the level of 40% of ETc showed values higher than 70% to approximately until 66 DAE. Comparing the highest with the lowest level of irrigation, it was found a difference of about 33%, possibly caused by water deficit imposed plants in the treatments with the lowest levels of irrigation (Figure 2A). This same trend was observed by Souza et al. (2000) and by Mesquita et al. (2013). It is evident also that the maximum water depths were those that maximized the plant height, as observed by Sousa (2011), Viana et al. (2012) and Mesquita et al. (2013). It was observed at all levels of ETc, intense height growth only at the end of the growth phase (27-32 DAE) and throughout the development/floration stage (33-66 DAE) and a tendency to stabilize at the final stage (maturation), at the average height of 180 cm. Except for the behavior of the initial growth, the other observed results agree with those obtained by Severino et al. (2002) and by Grilo Junior & Azevedo (2013). Perin et al. (2010) obtained 156 cm. Mesquita (2010) found values up to 240 cm. Severino et al. (2002), with sesame CNPA G4 in Campina Grande, PB State, Brazil, reached a maximum height of 200 cm.

The RGRH at all levels through which was affected, decreased throughout the cycle, more pronounced until approximately 48 DAE. The RGRH values at the level of 70% always stood out from the others, followed by the levels of 130 and 40% (Figure 2B).

The stem diameter was influenced only by the level of 40%, presenting an upward trend throughout the cycle, intense between 27 and 48 DAE, moderate between 49 and 68 DAE and slow for the end of the cycle. The average values were 7.2, 13.1, 18.6 and 18.3 mm at 27, 48, 69 and 90 DAE, respectively (Figure 3A). Santos et al. (2010), with the CNPA G3 and CNPA G4, found lower values at 30 and 90 DAE. The values obtained for Grilo Junior & Azevedo (2013) were similar to those observed in this experiment.

The AGRSD values, at 100%, the one which influenced it, decreased throughout the cycle, strongly until 66 DAE (Figure 3B). The RGRSD also showed decreasing behavior in a marked manner until approximately 48 DAE at 100%, making it slow from 66 DAE. The RGRSD values at 100% were greater than 40% approximately between 27 to 45 DAE and 55 DAE to the end of the cycle (Figure 4A).

The values of AGRFBE, however, were growing throughout the cycle, but with more intense growth of 48 to 66 DAE and at all levels of ETc that influenced it, especially, about from 48 DAE, at the AGRFBE values of the 130, 100 and 40% levels, respectively (Figure 4B). The RGRFBE also showed increasing values throughout the cycle and in the levels that influenced it with marked increases until about 48 DAE, where the RGRFBE moderate values between ETc levels began to differentiate, highlighting the values of 130, 100 and 40% respectively (Figure 5A). Unlike, Severino et al. (2002), with sesame CNPA G4 in Campina Grande, PB, Brazil, observed that increasing dry biomass was more intense between 30 and 75 days, maintaining approximately constant for the remainder of the cycle.

The leaf area was also affected by all levels of ETc studied, all of them featuring high trend of increasing values of approximately between 48 to 66 DAE, among which it highlights the values of the levels of 130, 100, 70 and 40% respectively. Also it was observed, in all ETc levels, trend of increase of the leaf area and then decrease of it, just because, from about 70 DAE (Figure 5B), as also reported by Severino et al. (2002), some leaves, the older ones (on the plant lower positions), starts fall, causing a reduction in leaf area. Also according to Severino et al. (2002), at the end of the cycle, sesame plants have a large number of upper leaves but little total leaf area. Mean values for leaf area obtained by ETc level have been 3255, 6859, 7155 and 11699 cm^2, respectively. There was also a significant increase in sesame leaf area proportional to the increase in irrigation levels based on ETc (Figure 5B). This difference can be explained by the reduced leaf elongation and subsequent distribution of less photosynthates for vegetative tissues. So, the ETc treatments of 40 and 70% presented lower leaf area values. Meneghetti et al. (2008) with maize concluded that the increase in irrigation also resulted in higher values of LA. Unlike the present work, Severino et al. (2002), with sesame CNPA G4 in Campina Grande, PB State, Brazil, observed that the leaf area reached a peak around 80 days.

The leaf area index (Figure 6) showed the same behavior of the leaf area. The evolution of the same followed characteristic pattern of annual plants with slow initial phase (up to approximately 45 DAE) followed by a phase of fast growth (up to approximately 67 DAE at the 40% ETc level, extending further up approximately 75 DAE at 130, 100 and 70% ETc levels). The third phase was characterized by maximum LAI (67-75 DAE) and the last phase characterized by a decrease in the values of LAI, starting at 76 DAE, and remained decreasing until the end of the crop cycle, due to senescence and fall of leaves. According to Allen et al. (2006), the LAI values for a given culture, vary over the cycle, reaching maximum value usually before or in full flowering. Meneghetti et al. (2008) in maize, testing various levels of irrigation, also found these differences in the values of LA and LAI.

CONCLUSIONS

a) The applied crop evapotranspiration levels did not affect the height and the leaf area absolute growth rates and the leaf area relative growth rate of the sesame BRS 196 CNPA G4; b) the plant height, the leaf area and the leaf area index were influenced by all applied crop evapotranspiration levels with increasing values throughout the cycle of sesame BRS 196 CNPA G4, especially, in this first variable, the values of 100% ETc, and in the last two ones, were proportional to the applied crop evapotranspiration levels; c) the stem diameter, which also increasing values throughout the cycle of sesame BRS 196 CNPA G4, was only affected by the level of 40% of crop evapotranspiration; d) the height and the stem diameter relative growth rates and the stem diameter absolute growth rate were decreasing throughout the cycle of BRS 196 CNPA G4 sesame but not in proportion to the applied crop evapotranspiration levels which influenced them, and; e) the absolute and relative growth rates of the fresh biomass epigeous were increasing during the sesame cycle and proportional to the applied crop evapotranspiration levels which influenced them.

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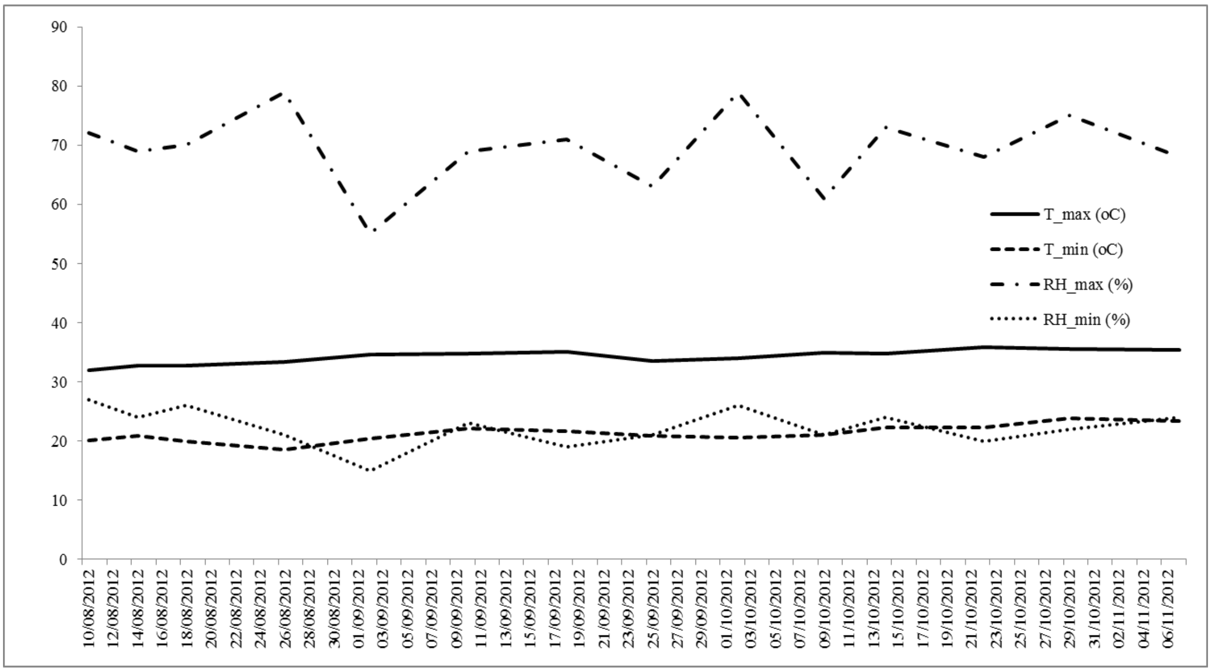


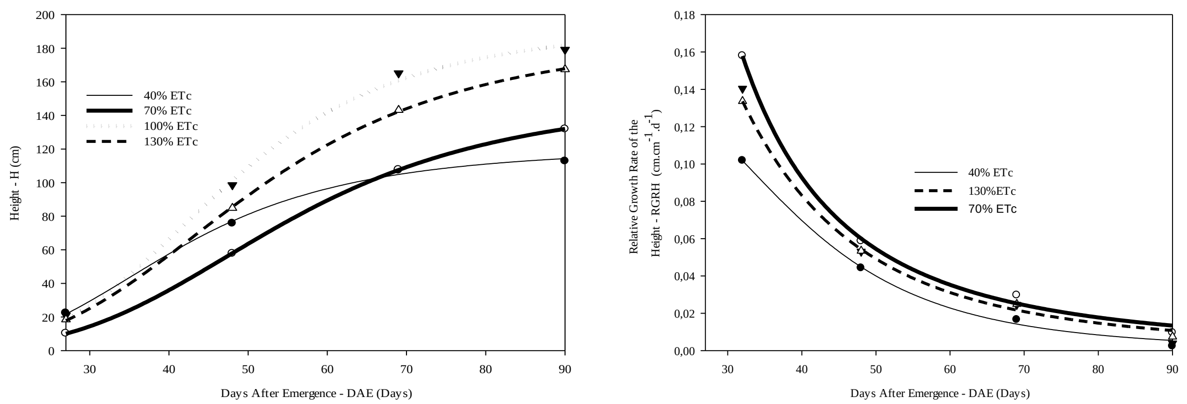
Figure 1. Average values of maximum (T_max) and minimum (T_min) temperatures and of maximum (RH_max) and minimum (RH_min) air relative humidity, obtained at the place and time of the experiment. Barbalha, CE, Brazil. 2012.

Table 1. Summary of variance analyzes for the variables height (H), stem diameter (SD) and leaf area (LA) according to the applied ETc levels. Barbalha, CE State, Brazil. 2012.

Variation Source	DF	Mean Squares											
		Days After Emergence (DAE)											
		27	48	69	90	27	48	69	90	27	48	69	90
		Growth variables											
		H (cm)				SD (mm)				LA (cm²)			
Blocks	2	58.0ns	657.0ns	83.3ns	38.5ns	6.0ns	2.1ns	4.2ns	1.9ns	4525.0ns	3.7E+04ns	9.6E+07ns	6.2E+07ns
ETc levels	3	88.3ns	879.4ns	2416.0ns	2843.6ns	0.8ns	0.4ns	37.3ns	9.9ns	1038.3ns	1.4E+05ns	1.5E+08ns	1.3E+08ns
Linear		0.2ns	695.3ns	4079.6ns	6678.1*	0.1ns	0.1ns	4.1ns	26.6ns	863.9ns	2.9E+05ns	4.2E+08ns	3.4E+08*
Quadratic		71.3ns	13.5ns	376.9ns	713.0ns	2.2ns	0.9ns	14.5ns	0.1ns	2231.5ns	6.0E+04ns	6.8E+06ns	1.3E+05ns
Cubic		193.5ns	1929.5ns	2791.4ns	1139.7ns	0.1ns	0.2ns	93.4ns	3.1ns	19.4ns	5.7E+04ns	2.1E+07ns	4.8E+07ns
Deviations		0.0**	0.0**	0.0**	0.0**	0.0**	0.0**	0.0**	0.0**	0.0**	0.0**	0.0**	0.00**
Residual	6	44.1	571.0	1261.7	1102.9	3.6	7.5	21.0	15.8	3042.6	1.4E+05	1.3E+08	4.6E+07
CV (%)	-	36.9	30.2	27.1	22.5	26.2	20.9	24.6	21.7	48.0	47.8	66.3	61.5
Media	-	18.0	79.2	130.8	147.8	7.2	13.1	18.6	18.3	114.8	769.6	17062.4	11021.0

CV = Coefficient of variation, *Significant ($p<0.05$). **Significant ($p<0.01$). ns Not significant ($p>0.05$)

A) B)



A) $\bar{y}_{40\%\ ETc} = 121.10 / (1+(x / 41.11)^{-3.60})$ ($p<0.05$; $R^2 = 0.99$)

A) $\bar{y}_{70\%\ ETc} = 152.14 / (1+(x / 54.61)^{-3.76})$ ($p<0.01$; $R^2 = 1.00$)

A) $\bar{y}_{100\%\ ETc} = 194.68 / (1+(x / 47.05)^{-4.07})$ ($p<0.05$; $R^2 = 0.99$)

A) $\bar{y}_{130\%\ ETc} = 189.13 / (1+(x / 50.63)^{-3.59})$ ($p<0.01$; $R^2 = 0.99$)

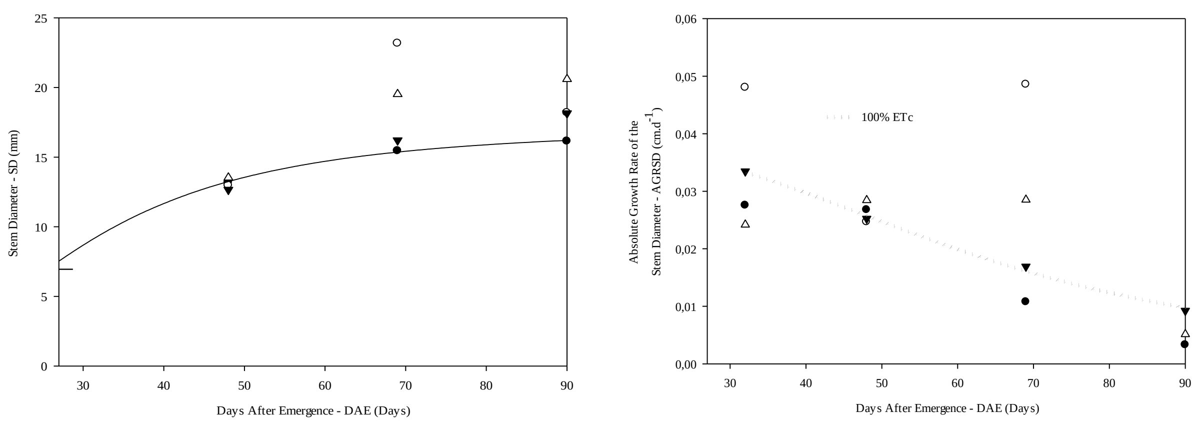
B) $\bar{y}_{40\%\ ETc} = 0.15 / (1+(x / 38.04)^{3.83})$ ($p<0.05$; $R^2 = 0.99$)

B) $\bar{y}_{70\%\ ETc} = 461087.62 / (1+(x / 0.06)^{2.38})$ ($p<0.05$; $R^2 = 0.99$)

B) $\bar{y}_{130\%\ ETc} = 0.47 / (1+(x / 22.60)^{2.73})$ ($p<0.05$; $R^2 = 0.99$)

Figure 2. Adjusted curves and equations A) of the height and, B) of the height relative growth rate, in function of the applied crop evapotranspiration levels to the irrigated sesame BRS 196 CNPA G4. Barbalha, CE, Brazil. 2012.

A) B)



A) $\bar{y}_{40\%\ ETc} = 17.17 / (1+(x / 29.76)^{-2.54})$

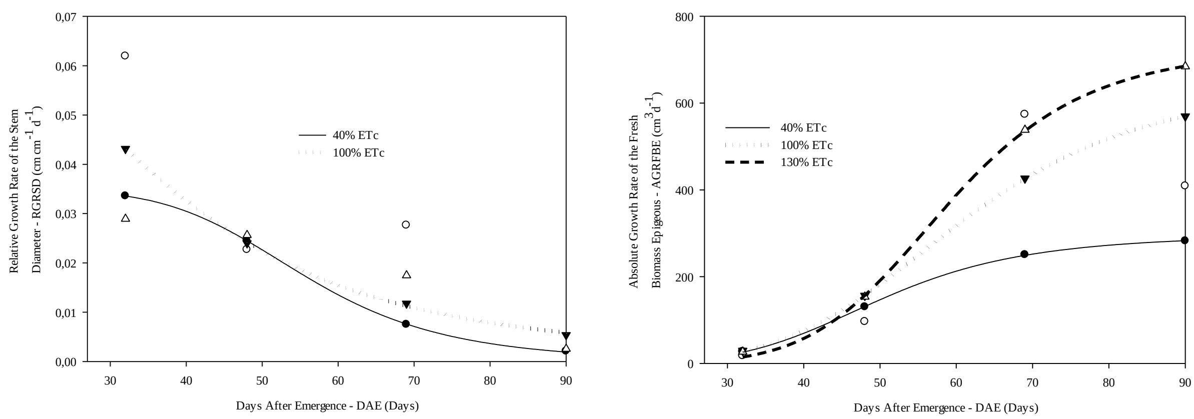
($p<0.01$; $R^2 = 0.99$)

B) $\bar{y}_{100\%\ ETc} = 0.04 / (1+(x / 61.29)^{2.82})$

($p<0.05$; $R^2 = 0.99$

Figure 3. Adjusted curves and equations A) of the stem diameter, and B) of the stem diameter absolute growth rate, in function of the applied crop evapotranspiration levels to the irrigated sesame BRS 196 CNPA G4. Barbalha, CE, Brazil. 2012.

A) B)



A) $\bar{y}_{40\%\ ETc} = 0.03 / (1+(x / 55.50)^{5.87})$

($p<0.01$; $R^2 = 1.00$)

A) $\bar{y}_{100\%\ ETc} = 0.06 / (1+(x / 38.74)^{2.81})$

($p<0.05$; $R^2 = 0.99$)

B) $\bar{y}_{40\%\ ETc} = 296.27 / (1+(x / 50.17)^{-5.21})$

($p<0.01$; $R^2 = 0.99$)

B) $\bar{y}_{100\%\ ETc} = 652.21 / (1+(x / 60.65)^{-4.90})$

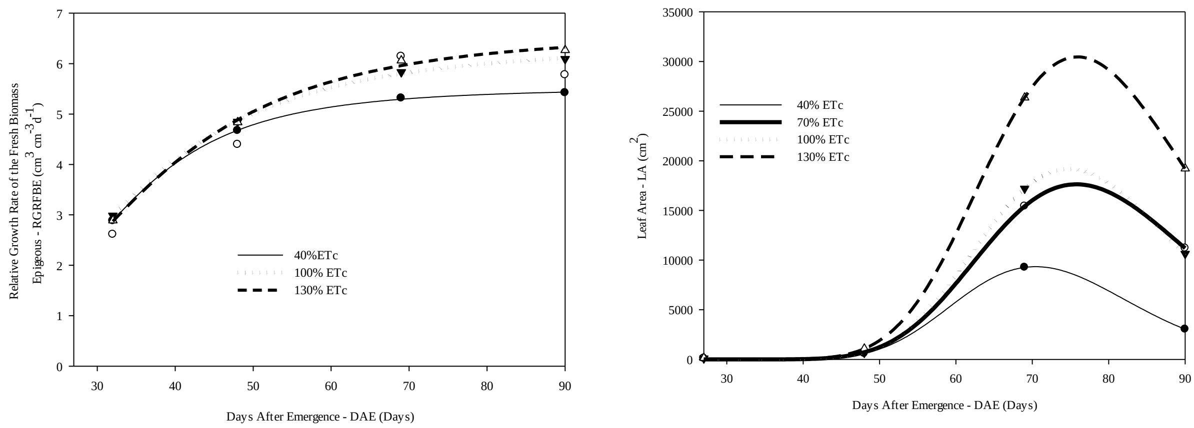
($p<0.01$; $R^2 = 1.00$)

B) $\bar{y}_{130\%\ ETc} = 731.42 / (1+(x / 58.87)^{-6.36})$

($p<0.05$; $R^2 = 0.99$)

Figure 4. Adjusted curves and equations A) of the stem diameter relative growth rate, and B) of the fresh biomass epigeous absolute growth rate, in function of the applied crop evapotranspiration levels to the irrigated sesame BRS 196 CNPA G4. Barbalha, CE, Brazil. 2012.

A) B)



A) $\bar{y}_{40\%\ ETc} = 5.51 / (1+(x / 31.29)^{-4.03})$

($p<0.01$; $R^2 = 0.99$)

A) $\bar{y}_{100\%\ ETc} = 6.35 / (1+(x / 33.27)^{-3.21})$

($p<0.01$; $R^2 = 0.99$)

A) $\bar{y}_{130\%\ ETc} = 6.62 / (1+(x / 34.77)^{-3.21})$

($p<0.05$; $R^2 = 0.99$)

B) $\bar{y}_{40\%\ ETc} = (666456.22 / x)\ [-0.5\ [(\ln(x / 72.33)) / 0.16]^2]$

($p<0.01$; $R^2 = 0.99$)

B) $\bar{y}_{70\%\ ETc} = (1358357.60 / x)\ [-0.5\ [(\ln(x / 78.28)) / 0.18]^2]$

($p<0.01$; $R^2 = 0.99$)

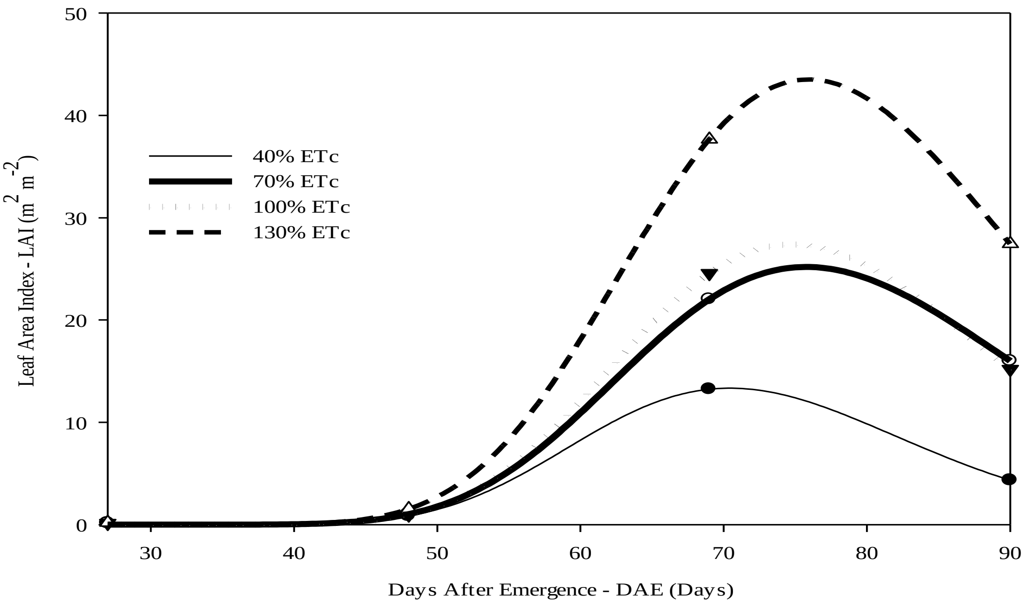
B) $\bar{y}_{100\%\ ETc} = (1454389.19 / x)\ [-0.5\ [(\ln(x / 76.95)) / 0.17]^2]$

($p<0.01$; $R^2 = 0.99$)

B) $\bar{y}_{130\%\ ETc} = (2349400.05 / x)\ [-0.5\ [(\ln(x / 78.33))/0.17]^2]$

($p<0.01$; $R^2 = 1.00$)

Figure 5. Adjusted curves and equations A) of the fresh biomass epigeous relative growth rate, and B) of the leaf area, in function of the applied crop evapotranspiration levels to the irrigated sesame BRS 196 CNPA G4. Barbalha, CE, Brazil. 2012.



$\bar{y}_{40\%\ ETc} = (952.08 / x)\ [-0.5\ [(\ln(x / 72.33)) / 0.16]^2]$ (p<0.01; $R^2 = 0.99$)

$\bar{y}_{70\%\ ETc} = (1940.50 / x)\ [-0.5\ [(\ln(x / 78.28)) / 0.18]^2]$ (p<0.01; $R^2 = 0.99$)

$\bar{y}_{100\%\ ETc} = (2077.69 / x)\ [-0.5\ [(\ln(x / 76.95)) / 0.17]^2]$ (p<0.01; $R^2 = 0.99$)

$\bar{y}_{130\%\ ETc} = (3356.28 / x)\ [-0.5\ [(\ln(x / 78.33))/0.17]^2]$ (p<0.01; $R^2 = 1.00$)

Figure 6. Adjusted curves and equations of the leaf area index, in function of the applied crop evapotranspiration levels to the irrigated sesame BRS 196 CNPA G4. Barbalha, CE, Brazil. 2012.