Rev. FCA UNCUYO. 2017. 49(2): 117-126. ISSN impreso 0370-4661. ISSN (en línea) 1853-8665.

Tifton 85 production under deficit irrigation

Efecto del riego deficitario sobre la producción de Tiftón 85

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Originales: *Recepción:* 20/11/2015- Aceptación: 30/11/2016

Abstract

Deficit irrigation consists of application of amounts of water less than plant requirements for satisfying water deficiencies of the crop, and this may maximize efficiency of water use. The aim of this study was to evaluate the effect of deficit irrigation on production of Tifton 85 grass. The experiment was carried out on the Santa Helena Farm in the municipality of Bom Despacho, MG, Brazil. Five levels of irrigation were used as treatments (28%, 42%, 57%, 71%, and 85% of the crop coefficient value) in randomized blocks with three replications. The following variables were evaluated: dry matter production (kg ha^{-1}), leaf/stem ratio, height (cm), dead plant material (%), leaf area index, leaf area ratio (m^2 kg^{-1}), leaf weight ratio (kg kg^{-1}), and specific leaf area (m^2 kg^{-1}). A difference was observed for Tifton 85 production in which the greatest average yield (6126.35 kg ha^{-1}) was obtained through application of 71% Kc. For the other characteristics, there was no difference for any of the variables evaluated.

Keywords
crop coefficient • *Cynodon dactylon* x *Cynodon nlemfuensis* cv. Tifton 68 • irrigation management

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Resumen

El riego deficitario consiste en la aplicación de láminas inferiores a las necesarias para satisfacer las deficiencias hídricas de un cultivo, además que puede maximizar la eficiencia en el uso del agua. El objetivo de este trabajo fue estudiar el efecto del riego deficitario en la producción del cultivo Tifton 85. El experimento fue realizado en la Hacienda Santa Helena situada en el municipio de Bom Despacho, Minas Gerais (MG) Brasil. Los tratamientos utilizados fueron: cinco láminas de riego (28%, 42%, 57%, 71% y 85% del valor de coeficiente de cultivo) en bloques aleatorios con tres repeticiones. Fueron evaluadas las siguientes variables: producción de materia seca (kg ha^{-1}), relación hoja/altura, altura (cm), materia muerta (%), índice de área foliar, relación de área foliar (m^2 kg^{-1}), relación de peso foliar (kg kg^{-1}) y área foliar especifica (m^2 kg^{-1}). Se observó una diferencia en la producción de Tifton 85, donde el mayor promedio de producción (6126.35 kg ha^{-1}) se obtuvo con la aplicación de las láminas 71% Kc. Para las demás características no hubo diferencia en ninguna de las variables estudiadas.

Palabras clave
coeficiente de cultivo • manejo de riego • *Cynodon dactylon* x *Cynodon nlemfuensis* cv. Tifton 68

Introduction

Irrigation is an agricultural input and it constitutes the largest use of water in Brazil. In 2010, 5.4 million hectares were irrigated, with draw off of 1270 m^3 s-1 for irrigation purposes, which represents 54% of total demands for consumptive use of water resources (4).

One of the aims of water resource management is the adoption of irrigation practices for adequate use of water. To maximize water use efficiency, deficit irrigation may be adopted, which consists of application of amounts of water less than the water requirements of the crop (18).

Rains interfere in various ways in forage plant development, and may compromise yield. In most of Brazil, annual rainfall distribution is irregular, meaning there are periods without rain. These dry periods may significantly reduce forage crop production. The aim of irrigating pastures is to reduce the seasonal variation in production and produce a greater amount of forage throughout the year (25).

The Tifton 85 hybrid (*Cynodon dactylon* x *Cynodon nlemfuensis* cv. Tifton 68) is a forage widely used in Brazil. It was launched in the United States and emerged from the crossing of South Africa (PI 290884) and Tifton 68 (10). Among the genus *Cynodon*, Tifton 85 is the most cultivated in Brazil. This forage plant is perennial, stoloniferous, rhizomatoza and has high potential for forage production with quality (21). Thus the forage is very suitable for highly intensive fertirrigated systems. Characteristics such as plant height; leaf/stem ratio; leaf area ratio, which is broken down into specific leaf area and leaf weight ratio; and leaf area index are related to forage yield (23).

Through advances from studies on pasture irrigation, the need for determining the capacity of different species and cultivars in responding to amounts of irrigation water becomes clear (9). Several studies have been carried out to evaluate the behavior of grasses under irrigated conditions; however, responses have been varied, depending on the region, the forage species, the irrigation system, and the inputs used. For Andrade *et al.* (2012), irrigation led to a forage accumulation rate of 122 kg ha^{-1} day^{-1} for Tifton 85 during the fall. Alencar *et al.* (2009a) evaluated the influence of irrigation on production of some forage crops and, for Estrella grass, they obtained mean production in fall/winter of 6300 kg ha^{-1}, with water replacement corresponding to 100% of reference evapotranspiration.

The practice of irrigation in pastures, in general, has been used, without scientific basis and empirically, most often using constant water slides throughout the area. It is necessary to define management strategies that optimize the productivity of forage species submitted to irrigation variation, based on scientific knowledge. It is believed that the use of deficit irrigation may be an alternative for forage production in Brazil.

Within this context, the aim of this study was to evaluate the effect of five levels of deficit irrigation on production of Tifton 85 grass in the municipality of Bom Despacho, MG, Brazil.

Materials and methods

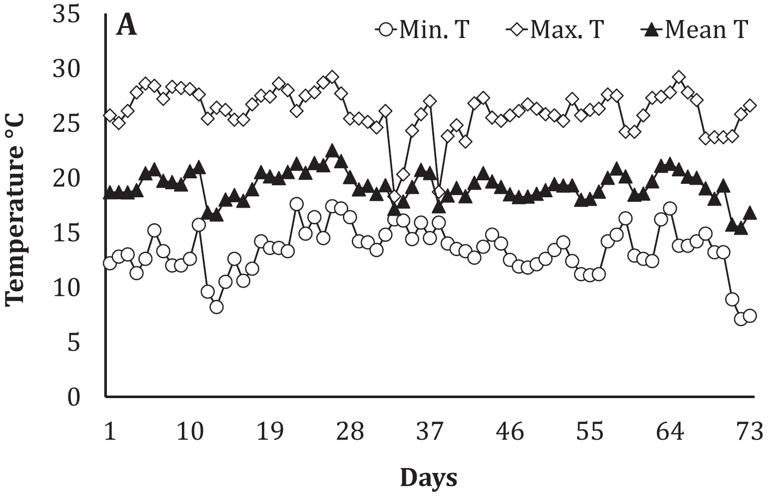
This study was developed in the area of the Santa Helena farm in the municipality of Bom Despacho, MG, Brazil (19°44' S and 45°15' W, at 768 m altitude) from July 6 to September 16, 2013. The climate in the region, according to the Köppen classification, is Cwa type, humid temperate climate with dry winter and hot summer. Rainfall during the experimental period was 14 mm. Daily minimum, mean, maximum temperatures and reference evapotranspiration were registered by an automatic climatological station within the experimental area (figure 1, page 120).

Soil in the experimental area is classified as a Latossolo Vermelho distroférrico (14) (Oxisol). The results of chemical analysis of samples from the 0-0.20 m depth layer were: 5.7 for pH (in water); 56% base saturation; 2.7% aluminum saturation; 2.3 dag kg^{-1} of organic matter; 1.8 mg dm^{-3} of phosphorus - P (Mehlich 1); and 22.0 mg dm^{-3} of potassium - K (Mehlich 1). On August 7, the experimental area was fertilized with 58 kg ha^{-1} of N and K_2O in the fertilizer formulation 25-00-25.

For determination of soil bulk density, particle density, and total porosity, undisturbed soil samples, with three replications, were taken from soil layers at the depths of 0-0.20, 0.20-0.40, and 0.40-0.70 m through the use of soil sample rings of determined volume. Soil bulk density was 1.20, 1.14, and 1.17 g cm^{-3}; particle density was 2.69, 2.71, and 2.63 g cm^{-3}; and total porosity was 55.39, 57.93, and 55.51% in the 0-0.20, 0.20-0.40, and 0.40-0.70 m soil layers, respectively.

From the mean values of matric potential and volumetric moisture, water retention curves were worked out. These values were fitted to the model of Van Genuchten (1980).

A randomized block experimental design was adopted, with five treatments and three replications. The treatments consisted of different water depths applied according to percentages of crop coefficient values recommended by Allen *et al.* (1998) for Bermuda grass. Treatments 1, 2, 3, 4, and 5 corresponded to irrigation water depths of 28%, 42%, 57%, 71%, and 85% of the crop coefficient value, respectively.



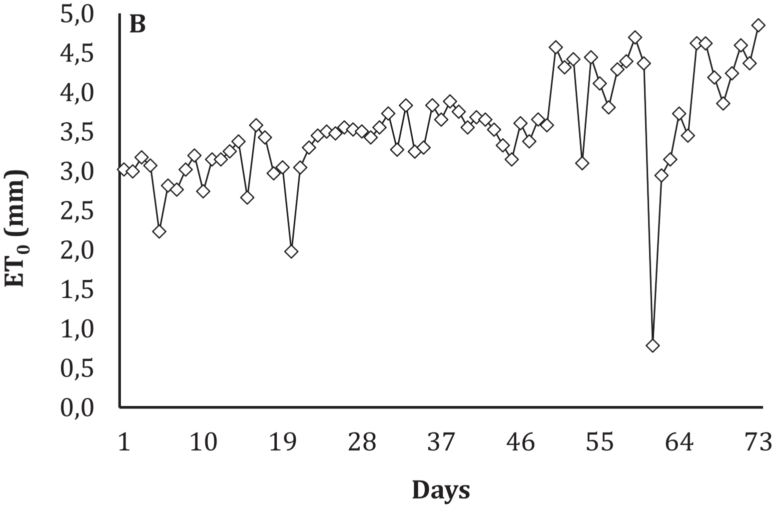


Figure 1. Maximum, mean, minimum temperatures (A) and reference evapotranspiration (B) observed during the experimental period in Bom Despacho, MG, Brazil.

Figura 1. Temperaturas máximas, promedios y mínimas (A) evapotranspiración de referencia (B) observadas durante el período experimental en Bom Despacho, MG, Brasil.

A treatment without irrigation (dryland treatment) was not carried out because, as a hay production farm, the use of a center pivot without irrigating the entire area was not possible. Water availability on the property was not enough to satisfy the total needs of the crop; therefore, it was not possible to carry out a treatment with water replacement of 100% of Kc.

For irrigation we used the center pivot system consists of 5 spans and balance totaling a ray of 282.40 m. The three central spans (2, 3 and 4) correspond to blocks 1, 2 and 3, respectively. To obtain variation in the water depth for the five treatments, 45 nozzles of the center pivot system were exchanged, with 6.90 m wide portions. To border effect have been disregarded 0.50 m between the start of each treatment parcel useful width of 5.90 m. Tifton 85 grass has been planted for 20 years and since then has been cut to hay. Levels of irrigation were applied based on the daily records of local reference evapotranspiration obtained at the automatic climatological station located in the experimental area. The crop coefficient values used during the three developmental stages of Tifton 85 were 0.55, 1.00, and 0.85 (3).

According to Evangelista *et al.* (2013), Watermark soil moisture sensors may be used to monitor water matric potential in the soil. Thus, matric sensors were set up and connected to dataloggers whose data were stored hour by hour. The sensors were set up at three depths (0.20, 0.40, and 0.70 m). A series of 3 sensors per replication were set up, for a total of 45 sensors.

The following variables were evaluated: production of dry forage matter, leaf/stem ratio, height, dead plant material, leaf area index, leaf area ratio, leaf weight ratio, and specific leaf area. Due to the timing of the hay production, Tifton 85 was cut 73 days after the previous harvest. For evaluation of dry forage matter, a 0.25 m^2 (0.5 x 0.5 m) square frame was cast at random three times in each plot. The grass was cut at ground level and the green matter collected was weighed in the field to determine fresh matter. Samples were taken (approximately 0.5 kg) from this fresh matter and dried in a laboratory oven at 105°C for 24 hours to obtain dry matter (13). The amount of dry forage matter (FM) was determined from Equation 1.

$$FM = \frac{GM \times \%DM}{100} \quad (1)$$

where:
FM = dry forage matter (kg ha^{-1})
GM = green matter (kg ha^{-1})
DM = dry matter (%)

Canopy height was measured with a ruler. Readings were made at each sampling point before the cut with the aid of an acetate sheet, which was placed over the surface of the grass to obtain a mean height value per plot.

We cut the grass at ground level and collected the biomass in an area of 0.25 m^2 for each replication for determination of leaf area index. The material harvested was weighed for determination of green matter production per area. A subsample composed of 20 plants was then removed and the green blades of the plants were detached and scanned in a leaf area meter (LI-3100 - Licor, Lincoln).

The leaf, stem, and dead plant material fractions were separated in a green matter subsample. They were then placed separately in paper bags and dried in an air circulation laboratory oven at 65°C for 72 hours.

Based on the leaf:stem ratio, the dry matter weight of the leaf blades (DWB) present in 1 m^2 of usable plot area was estimated. The estimate of total leaf area (green blades) of the plants (TLA) present in the usable area was obtained by multiplying the DWB by the leaf area of 20 plants and dividing the product by the dry matter weight of leaf blades from 20 plants. The leaf area index (LAI) was then determined according to Equation 2.

$$LAI = \frac{TLA}{SA} \qquad (2)$$

where:
LAI = leaf area index
TLA = total leaf area (m^2)
AS = soil area (m^2)

Leaf area ratio, specific leaf area, and leaf weight ratio were calculated based on the values of shoot dry matter, total leaf area, and leaf dry matter. Leaf area ratio, specific leaf area, and leaf weight ratio were calculated based on the values of shoot dry matter, total leaf area, and leaf dry matter. That way, leaf area ratio (LAR), specific leaf area (SLA), and leaf weight ratio (LWR) were obtained by Equations 3, 4, and 5, respectively.

$$LAR = \frac{TLA}{TDM} \qquad (3)$$

$$SLA = \frac{TLA}{LDM} \qquad (4)$$

$$LWR = \frac{LDM}{TDM} \qquad (5)$$

where:
LAR = leaf area ratio ($m^2\ kg^{-1}$)
SLA = specific leaf area ($m^2\ kg^{-1}$)
LWR = leaf weight ratio ($kg\ kg^{-1}$)
TLA = total leaf area (m^2)
TDM = total dry matter (kg)
LDM = leaf dry matter (kg)

The data were analyzed through analysis of variance with significance $p<0.05$ and, for mean values, analysis of regression was carried out. The software SISVAR® 4.6 de Análise Estatística from the Universidade Federal de Lavras (16) was used for analyses.

Results and discussion

There was a significant difference only for production. Variation of the water depths of irrigation did not affect height, dead plant material, leaf/stem ratio, leaf area index, leaf weight ratio, leaf area ratio, and specific leaf area (table 1, page 123).

There was a significant difference in production of Tifton 85 grass; greater production was observed in the treatment with 71% replacement of the Kc value (table 2, page 123).

Low production of Tifton 85 was observed in comparison to Balieiro Neto *et al.* (2007), who obtained a mean yield of irrigated Tifton 85 in the period from April to July of 10880 kg ha^{-1}.

Alencar *et al.* (2009b) highlight that response in productive capacity of pastures in accordance with irrigation is directly related to climatic factors, especially temperature and photoperiod. For high dry matter yield, the plant needs not only soil moisture but also ideal temperatures to reach maximum production. While soil moisture is important for plant development and production, ideal temperature favors development through assimilation of CO_2, water, and nutrients. Reduced production of grasses in the dry season (winter) is highly influenced by lower temperatures of winter and the shorter photoperiod. Thus, as plant metabolism varies in direct ratio to temperature, the colder it is, the lower the growth rate.

Table 1. Analyses of variance for production, height, dead plant material, leaf/stem, leaf area index, leaf area ratio, leaf weight ratio and specific leaf area of Tifton 85 under deficit irrigation conditions in Bom Despacho, MG, Brazil.

Tabla 1. Análisis de varianza de la altura, material muerto, hoja/altura, índice de área foliar, relación de área foliar, relación de peso foliar y área foliar especifica de Tifton 85 sobre condiciones de riego deficitario en Bom Despacho, MG, Brasil.

Source of variation	D.F.	Mean squares							
		Production	Height	Dead plant material	Leaf/stem	Leaf area index	Leaf area ratio	Leaf weight ratio	Specific leaf area
Treatments	4	925582.0371 *	2.5207 ns	28.5329 ns	0.0252 ns	0.2617 ns	0.5886 ns	0.0032 ns	0.4396 ns
Blocks	2	24382.5388 *	9.3551 ns	74.9489 ns	0.0021 ns	0.5114 ns	1.4876 ns	0.0010 ns	5.7265 ns
Error	8	134461.9878	1.2220	128.0306	0.0150	0.6810	1.4095	0.0052	1.1696
Grand means		5389.94	10.56	26.66	0.86	2.34	4.23	0.34	12.33
Coefficient of variation (%)		6.8	10.47	42.44	14.22	15.42	28.13	21.13	8.77

**; * Significant at 1% and 5%, respectively, by the F test; ns= non-significant.

**; * Significativo al 1% y 5%, respectivamente, por la prueba de F, ns= no significativo.

Table 2. Mean values observed and ± standart error of height, dead plant material, leaf/stem ratio, leaf area index, leaf area ratio, leaf weight ratio, and specific leaf area of Tifton 85 under deficit irrigation conditions in Bom Despacho, MG, Brazil.

Tabla 2. Promedios observados y ± error estándard de altura, material muerto, hoja/altura, índice de área foliar, relación de área foliar, relación de peso foliar y área foliar específica de Tifton 85 sobre condiciones de riego deficitario en Bom Despacho, MG, Brasil.

Variable	Treatments				
	28% Kc	42% Kc	57% Kc	71% Kc	85% Kc
Height (cm)	9.53 (±0.67)a	10.75 (±1.25)a	9.67 (±0.60) a	11.47 (±0.98)a	11.37 (±1.20) a
Dead plant material (%)	24.84 (±0.39)a	27.94 (±0.19)a	31.46 (±0.26) a	25.19 (±0.08)a	23.85 (±0.33) a
Leaf:stem	0.92 (±0.05)a	0.80 (±0.01)a	0.77 (±0.04) a	0.83 (±0.09)a	0.99 (±0.10) a
Leaf area index	2.19 (±0.29)a	2.26 (±0.43)a	1.99 (±0.33) a	2.49 (±0.49)a	2.76 (±0.68) a
Leaf area ratio (m^2 kg^{-1})	4.62 (±0.54)a	4.12 (±0.67)a	3.64 (±0.58) a	4.05 (±0.61)a	4.71 (±0.96) a
Leaf weight ratio (kg kg^{-1})	0.36 (±0.03)a	0.32 (±0.02)a	0.30 (±0.03) a	0.34 (±0.04)a	0.38 (±0.05) a
Specific leaf area (m^2 kg^{-1})	12.75 (±0.47)a	12.70 (±1.16)a	12.07 (±0.83) a	11.88 (±0.70)a	12.25 (±0.84) a
Production (kg ha^{-1})	4691.41 (±250.56)b	5014.23 (±144.17)b	5505.74 (±28.77)ab	6126.35 (±318.72)a	5611.97 (±37.81)ab

Means followed by the same letter do not differ each other by the Tukey test at $\alpha = 0.05$.

Medias seguidas por la misma letra no difieren entre sí por la prueba Tukey al $\alpha = 0,05$.

According to Alencar *et al.* (2009b), winter temperature greater than 15°C does not reduce pasture growth rate. During the experimental period, there were 16 days with a minimum temperature less than the base temperature (figure 1, page 120), which, according to Villa Nova *et al.* (2004), is 10°C, which possibly limited the production of the forage crop evaluated (7). According to Müller *et al.* (2009), plants require temperature above the basal temperature since, at lower temperatures, metabolic processes cease or occur at a speed so low that they may be disregarded for plant development.

Tifton 85 is a fertilizer-intensive forage, and the low yield may also be related to the low soil phosphorus content only 1.8 mg dm^{-3} of phosphorus-P (Mehlich 1), according to Oliveira (2003) soils with phosphorus levels of less than 5 mg dm^{-3} should receive maintenance fertilization of 60 kg ha^{-1} of P_2O_5 for the production of Tifton. This did not occur during the experiment.

Deficit irrigation did not lead to a significant difference (table 1 and table 2, page 123) in plant height (10.56 cm), in the leaf/stem ratio (0.86), content of dead plant material (26.66%), LAI (2.34), LAR (4.23 m^2 kg^{-1}), LWR (0.34 kg kg^{-1}), and SLA (12.33 m^2 kg^{-1}) of Tifton 85.

The dead plant material represents part of the biomass not selected by the animal and, at high proportions, it may indicate that the cycle should be reduced (25). Thus, it is possible to make the same correlation with pasture height, suggesting that the forage crop that had the greatest dead matter content could have been cut at a lower height. Lower contents of dead plant material for irrigated Tifton 85 are cited by Balieiro Neto *et al.* (2007), with a mean value of 18.12% for the period from December to March. The same authors further cite contents of dead plant material of 25.92% for the winter period, results that are similar to the result obtained in this study.

In Prudente de Morais, MG, Balieiro Neto *et al.* (2007) found a mean value for the leaf/stem ratio of 0.24 in the winter for irrigated Tifton 85, a value lower than that observed in this study.

Pereira *et al.* (2011), studying Coastcross grass in Viçosa, MG, obtained a mean value of 0.99 (from 3 cuttings) for the leaf/stem ratio. In another study with Tifton 85 with and without irrigation in the rainy season, no difference was found for stem production (17).

Alencar *et al.* (2009a), in a study of some grasses, observed for Estrela grass that in the fall/winter season, the irrigation depth had a positive linear effect ($p < 00.5$), *i.e.*, the increase in the irrigation depth led to an increase in plant height, which did not occur in this study. Among the advantages of using grass height as a criterion for cutting management, its high association with leaf area index and interception of light by the canopy stand out (26).

For Reis *et al.* (2013), the critical values of LAI for pastures is normally situated from 3 to 5, and in this range, light interception would be around 95%. Genera that have more horizontally directed leaves, as is the case of Tifton 85, have lower values of LAI.

The LAI values are lower in the period considered as winter and higher in the summer, a fact related to what is called seasonality of the forage crop throughout the year, showing the influence of climatic factors (12).

The LAI values found were similar to the values obtained by Borges *et al.* (2011) when they studied some irrigated forage crops in the municipality of Uberaba, MG. They found a mean value of 2.96 for LAI for Tifton 85 over ten cycles. Pereira *et al*. (2011), studying Coastcross grass in Viçosa, MG, obtained a mean value of 3.07 (from 3 cuttings) for leaf area index.

The leaf area ratio consists of a morphophysiological characteristic that indicates the quantity of leaf area usable for photosynthesis in relation to the total weight of the forage plant (22).

The values of LAR, LWR, and SLA obtained in this study are below the values found by Pereira *et al.* (2011) for Coastcross grass. The authors obtained mean values from November to March with cutting of 42 days of 8.3 m^2 kg^{-1}, 0.50, and 16.6 m^2 kg^{-1} for LAR, LWR, and SLA, respectively. These lower values obtained were probably due to climatic conditions less favorable to growth in this season of the year.

The LWR value corroborates with Carvalho *et al.* (2012), who obtained LWR of 0.31 during the winter for three cultivars of the genus Cynodon. The same author obtained a mean value of LAR of 0.22 m^2 g^{-1}, also during the winter.

Conclusions

Deficit irrigation affected the production of Tifton 85. The irrigation depth of 71% of the crop coefficient value led to the greatest production of Tifton 85.

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Acknowledgment

The authors wish to thank the following Brazilian institutions that provided support for this research project: FAPEMIG- Fundação de Amparo à Pesquisa do Estado de Minas Gerais, CAPES - Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, UFLA - Universidade Federal de Lavras and Fazenda Santa Helena.