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IMPACTO DE DIFERENTES MANEJOS DE RIEGO SOBRE EL RENDIMIENTO DE CAÑA DE AZÚCAR

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TABLA DE CONTENIDO

1. INTRODUCCIÓN GENERAL

La caña de azúcar (*Saccharum officinarum*) se cultiva en regiones tropicales y subtropicales de todo el mundo, abarcando 100 países de los cuales 17 producen más de 10 millones de toneladas de caña fresca. Con un área de 24 millones de ha y un rendimiento promedio de 69,8 t ha^{-1}, los principales países productores de caña son Brasil, India, China, Tailandia y Paquistán, llegando a superar más del 70 % de la producción mundial (Steduto et al., 2012).

En la región de América del Sur se produce caña de azúcar en todos los países menos en Chile. En Uruguay, la caña de azúcar se desarrolla en el noroeste desde mediados del siglo XX. El área actual de cultivo de caña de azúcar es de 7,100 ha, con un rendimiento promedio de 62,69 t ha^{-1} (MGAP-DIEA, 2016).

Los rendimientos varían de región a región, dependiendo del potencial climático, el nivel de manejo, el ciclo de cultivo y de si la producción de caña es con riego o de secano (Steduto et al., 2012). De acuerdo a Almond y Sagardoy (1974), la zona de Bella Unión (latitud 30° S) es marginal para la producción de la caña y el riego es esencial para su producción debido a la distribución irregular de las lluvias. Los suelos de esta zona tienen la capacidad de almacenamiento de agua para proporcionar un crecimiento y desarrollo adecuado del cultivo, pero las precipitaciones erráticas durante el período de alta demanda de agua señalan la necesidad de riego suplementario.

La totalidad del área de cultivo de caña de azúcar en Uruguay se desarrolla bajo riego. El momento de aplicación del agua de riego es un factor que influye en forma decisiva en el rendimiento del cultivo. El volumen de agua aplicado en cada evento de riego está determinado por la capacidad de almacenamiento de agua en los horizontes donde se desarrollan las raíces (Corsi y Hofstadter, 1975). Por ello es necesario conocer la cantidad de agua disponible en el horizonte que alcanzan las raíces para programar el riego en función del contenido de agua en el suelo y la demanda atmosférica del cultivo.

El valor de agotamiento del agua en el suelo (p) como fracción del total de agua disponible en el suelo (TAW) es la cantidad de agua que se permite extraiga el cultivo para su consumo en la zona radicular antes de que la planta manifieste estrés hídrico (Allen et al., 2006). Conocer el volumen de agua fácilmente disponible (RAW) para los suelos de la zona en estudio contribuye a mejorar la eficiencia en el uso del agua.

Con una evapotranspiración durante la temporada de crecimiento de 5 a 6 mm/día^{-1}, el nivel de agotamiento durante el período vegetativo y de formación del rendimiento puede ser del 65 por ciento del total de agua disponible sin tener efectos serios sobre los rendimientos (p = 0,65) (FAO, 2013).

Dingre y Gorantiwar (2020) destacan que se han desarrollado investigaciones y programas para mejorar la eficiencia en el riego deficitario en varias regiones del mundo (Roberts et al., 1990, Singh y Mohan, 1994, Robertson y Donaldson, 1998, Singels et al., 2000, Inman-Bamber y Smith, 2005, Jangpromma et al., 2012, Zhao et al., 2010, 2013). Cuando estos programas son aplicados de forma correcta, se logra maximizar la productividad del agua manteniendo rendimientos y calidad de la caña de azúcar a niveles económicos aceptables.

Estudios de fenología y su relación con el riego, realizados en la zona cañera de Uruguay, mostraron que el cultivo de caña de azúcar en la brotación consume 40 % del agua evaporada en el tanque clase A. Durante el macollaje de la caña, el consumo aumenta a un 70 %, llegando a consumir el 100 % del agua evaporada por el tanque A cuando alcanza su máximo desarrollo vegetal con 100 % de intercepción de luz por parte del dosel vegetativo (Corsi y Hofstadter, 1975).

Estudios en la zona cañera de Bella Unión realizados por Almond y Sagardoy (1974) destacan que los agricultores riegan sin otra guía que su intuición personal sobre las necesidades de la planta, basada algunas veces en la observación de la planta, pero la mayoría lo hacen arbitrariamente. El hecho de que ocurran importantes precipitaciones en forma irregulares durante la época de riego ha dado lugar a que no existan criterios de aplicación ni de la frecuencia de los riegos. Este manejo del cultivo y el riego se mantiene hasta la actualidad. No existe una planificación del riego que considere la capacidad de almacenamiento hídrico de los suelos, la demanda atmosférica del cultivo y los aportes efectivos de la lluvia.

La planificación del riego permite la aplicación del riego cuando la cantidad de lluvia es insuficiente para compensar las pérdidas de agua por evapotranspiración. El objetivo principal del riego es la aplicación del agua en el momento preciso y con la cantidad de agua necesaria. El cálculo del balance hídrico diario del agua en la zona radicular del suelo permite que se puedan planificar las láminas y los momentos de aplicación del riego (Allen et al., 2006).

Poder manejar el cultivo y el riego con criterios técnicos siguiendo la metodología de balance hídrico, sería de gran utilidad para mejorar la eficiencia en el uso del agua en la zona cañera.

A diferencia de otras regiones regadas del mundo donde el recurso hídrico es escaso y su utilización está limitada, en Bella Unión, se riega como si el recurso no fuera limitante; esto lleva a un uso poco eficiente del recurso y altos costos energéticos, que representan la parte más importante del costo total de producción.

El conocimiento de las relaciones hídricas en el cultivo de caña de azucar podría utilizarse para mejorar la eficiencia en la gestión de los riegos Inman-Bamber and Smith (2005). La gestión del riego se considera fundamental para mejorar la productividad y la rentabilidad de la caña de azúcar y al mismo tiempo, reducir su impacto ambiental. Los productores de caña de azúcar de Uruguay carecen de información sobre los umbrales de agotamiento del agua del suelo que el cultivo puede tolerar a lo largo de la temporada, lo cual es necesario para determinar cuándo regar. Una mejor comprensión de cómo las condiciones climáticas y del suelo afectan los requerimientos de agua de los cultivos podría contribuir a mejorar la eficiencia en el uso de los recursos hídricos en la región.

Esta tesis está compuesta por un trabajo en formato artículo científico donde se evalúa cuál es el impacto de diferentes umbrales del riego en el rendimiento de materia seca del cultivo de caña de azúcar. La hipótesis nula: con umbrales de riego entre 40 % y 70 % del agua disponible en el suelo, el rendimiento no se afecta.

El trabajo tiene como objetivo contribuir al conocimiento de la respuesta que tiene el cultivo al agregado de agua según diferentes agotamientos de agua en el perfil del suelo. Los objetivos específicos fueron (i) relacionar el contenido de agua en el suelo y las variables de crecimiento del cultivo, (ii) estudiar los componentes determinantes del rendimiento y su correlación con el contenido de agua en el suelo y (iii) evaluar el uso de un balance de agua del suelo simple utilizando el método FAO 56.

2. RESPONSE OF THE CULTIVATION OF SUGARCANE TO DIFFERENT IRRIGATION WATER MANAGEMENT IN HUMID CLIMATE

2.1. RESUMEN

La caña de azúcar alcanza altos rendimientos en Uruguay cuando las lluvias, en combinación con el riego suplementario, permiten que la humedad del suelo satisfaga la demanda estacional de agua de los cultivos. Si bien se riega desde el inicio de la temporada de cultivo, faltan lineamientos técnicos para el manejo del riego de la caña de azúcar en las condiciones húmedas de Uruguay. Los productores deben saber cuándo regar y la cantidad del agua que deben aplicar. El presente estudio tiene como objetivo caracterizar la respuesta de la caña de azúcar al riego suplementario en las condiciones edafoclimáticas de una región productora de caña de azúcar en Uruguay. Se aplicaron cuatro tratamientos de agotamiento del agua del suelo (40, 50, 60 y 70 %) en relación con la capacidad hídrica del suelo. El diseño experimental fue de bloques completos al azar con 4 repeticiones en dos suelos de diferente textura. Se midieron los componentes del rendimiento de la planta y el contenido de agua del suelo para todos los tratamientos en el período de riego. Los resultados mostraron incrementos de materia seca a la adición de agua cuando el umbral de riego se estableció al 50 % de agotamiento, respecto a los demás tratamientos. Esto permite una mejor gestión de los recursos hídricos de riego y también un mejor aprovechamiento de las lluvias durante los meses de verano y el consiguiente ahorro energético.

Palabras clave: riego por surcos; evaluación de riego; caña de azúcar; balance hídrico

2.2. SUMMARY

High sugarcane yields are obtained in Uruguay when rainfall is combined with supplemental irrigation, as soil moisture satisfies the seasonal crop water demand. Despite the lack of technical guidelines for sugarcane irrigation management under the humid conditions of Uruguay, irrigation is applied from the beginning of the growing season. Nevertheless, farmers need to know when to irrigate and the depth of water that they need to apply. This study aimed at characterizing the response of sugarcane to the supplemental irrigation in a sugarcane producing region of Uruguay. Four soil water depletion treatments were applied (40, 50, 60 and 70 %) in relation to the soil water capacity. The experimental design was a completely randomized blocks with four replications in two different soils texture. Plant yield components and soil water content were measured for all treatments in the irrigation period. The results showed a high dry matter response to the addition of water when the irrigation threshold was set up at 50 % depletion, compared to the other treatments. This allows a better management of irrigation water resources as well as a better use of the rain-fall throughout the summer season and, as a result, energy savings.

Keywords: furrow irrigation; irrigation evaluation; sugarcane; water balance

2.3. INTRODUCTION

Sugarcane (*Saccharum officinarum*) is a perennial plant with C4 metabolism. It is grown in 100 countries in tropical and subtropical regions of the world, and it varies among production regions depending on the climate, crop management, crop cycle, and if the sugarcane production is irrigated or rainfed. The average biomass yield is 69.8 t ha^{-1} per year. To produce a large amount of biomass, the crop requires large amounts of water during its development. Sucrose is the main product extracted from the juice of sugarcane and it is used for sugar production. Additionally, sugarcane is used to produce energy (electricity by burning stem fiber and ethanol from fermented sugars) (Steduto et al., 2012).

In several regions of the semi-arid world with low rainfall and with water scarcity for irrigation and rainfall, uniform deficit irrigation strategies are applied throughout the growing season. The knowledge of the soil water content is key as it is related to physiological aspects of the plant. Inman-Bamber and Smith (2005) observed a strong relationship between height and elongation of stems with the soil water content. Robertson and Donaldson (1998) showed a linear correlation between biomass production and sugarcane yield. Severe moisture water deficit reduced the length of the internodes and the size of the internodes. Severe reductions in soil water content affect stem diameter and internodes (Dingre and Gorantiwar, 2020). Research works conducted in subtropical areas observed significant differences in the number of stems suitable for grinding. The individual weight of the stems and the number of internodes per stem in the yield of sugarcane were key components that measured the result (Singh y Mohan, 1994).

Supplemental irrigation mitigates periods of water stress (Henry, 1973, Baethgen and Terra, 2010) which reduce the leaf area and sugar yield (Inman-Bamber, 2004). Sagoo et al. (2011), in Pakistan, maximized yields and cost-benefit ratios by limiting the soil water depletion to 40 % of the total available water. According to simulations performed based of six years of weather data, Bahmani and Eghbalian (2018) did not observe differences in sugar yield when supplemental irrigation was replenished above 85 % of maximum crop evapotranspiration.

An important aspect is to have a good estimation of crop water demand to use water balance to supplementary crop irrigation (Kashyap and Panda, 2001). Several researches using the FAO 56 method have been developed in various sugarcane production areas with the objective of achieving better efficiency in water savings (Bahmani and Eghbalian, 2018, Inman-Bamber and Smith, 2005).

Studies of Wiedenfeld (2003) indicate that when irrigation is applied correctly, water productivity can be maximized while maintaining yields and the quality of sugarcane at acceptable economic levels. In tropical regions where supplemental irrigation was used complementary to rainfall, significant increases in sugarcane yield were observed with a direct relation to water consumption (Da Silva et al., 2013).

Irrigation management is considered critical to improve sugarcane productivity and profitability while reducing its environmental impact. However, in Uruguay, there is no available information on the levels of soil water depletion for sugarcane crops throughout the season. A better understanding of how weather and soil conditions affect crop water requirements could contribute to improving the efficiency of water resources.

Uruguay is located in the southern hemisphere's temperate zone, whose climate is characterized by high interannual, monthly and daily variability. Annual rainfall varies between 1100 and 1600 mm and increases from SE to NW. Although there is not a marked rainfall season pattern, rainfall variability produces periods of water deficit, mostly from the middle of spring until summer. This shortage limits the evapotranspiration of crops (MVOTMA, 2017). Agriculture in Uruguay is mostly rainfed, except for rice production, intensive horticulture, citrus and sugarcane. Sugarcane is traditionally irrigated with furrows (IICA, 2010) and irrigation efficiencies are typically low (Carnelli, 2010).

In the last four decades, only four years of irrigation studies were developed in Uruguay that emphasized the need to determine how and when to irrigate according to pan evaporation (Arocena et al., 1989, De la Peña and Martinez, 1989, Dapueto and Rodriguez, 1986). This kind of estimation is not accurate because soil water balance calculated by pan evaporation is outdated and sugarcane varieties were changed. So new studies of soil water depletion in relationship with the yield are needed using field water balance.

The aim of this work was to determine the effect of the critical level of soil water depletion on sugarcane yield at two sites with contrasting textures in A horizon. Specific objectives were (i) relate the water content in the soil and the growth variables of the crop, (ii) study the determinant components of yield and their correlation with the water content in the soil and (iii) to evaluate the use of a simple soil water balance using FAO 56 method.

2.4. MATERIALS AND METHODS

2.4.1. Location of the Experiment

The field experiments were conducted during the irrigation season of 2015-16 at two sites in the Bella Unión region of Uruguay (30° 20 ' S; 57° 36' W and 120 m above mean sea). The study was conducted from December 1, 2016, to March 1, 2017, which is the period when irrigation systems are in operation in the summer period. The soil is classified as Mollisols (Udolls) at site I and Vertisol (Uderts) at site II.

Figure 1 shows historical (1966 to 2018) average monthly air temperature, evapotranspiration and precipitation values.

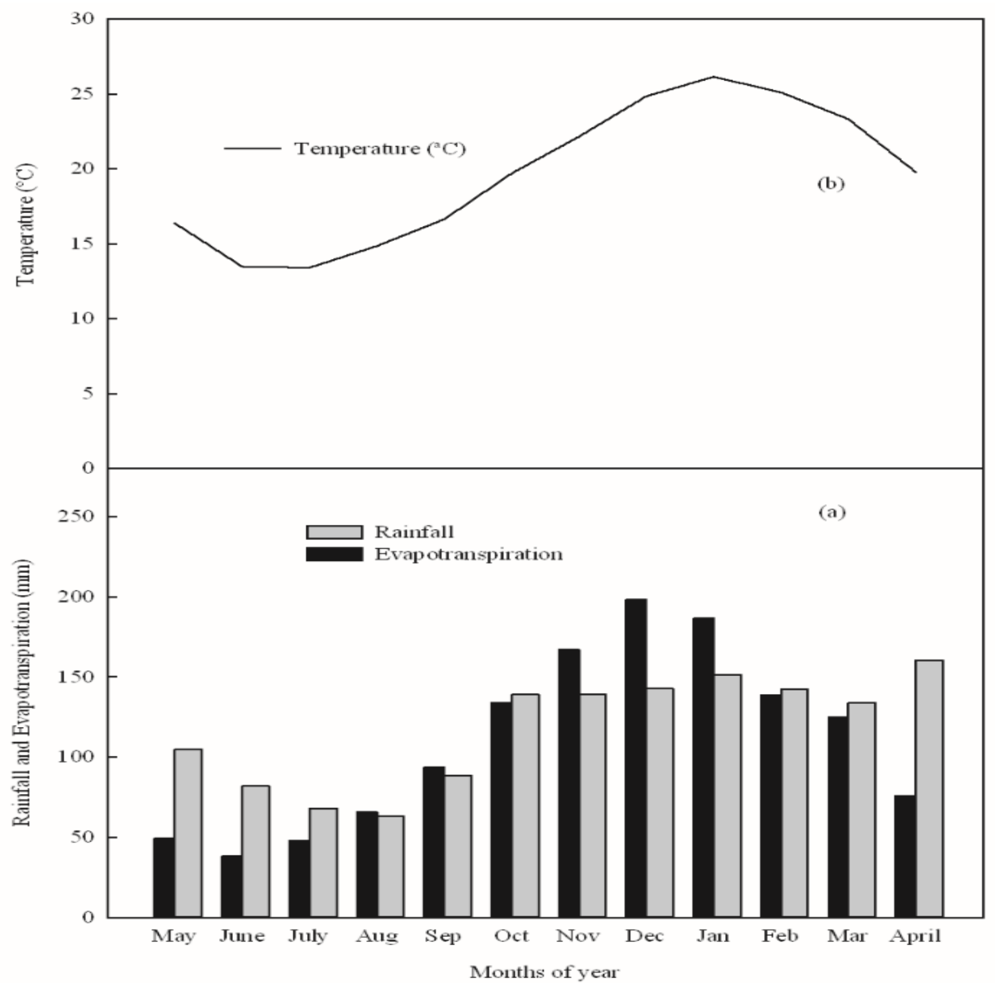

Figure 1. Average monthly rainfall; average monthly reference evapotranspiration (a) and average monthly air temperature (b). (1966-2018). Bella Unión, Uruguay.

The annual precipitation is 1416 mm. Monthly mean precipitation ranges from 63 to 160 mm (Figure 1 a). The annual reference evapotranspiration is 1321 mm (110 mm monthly average), while monthly average values range from 38.2 to 198 mm. Crop water shortages are typically observed starting late in the spring and throughout the summer months. Monthly average temperatures were calculated from the daily mean temperature values. Summer (December, January and February) temperatures average 26 °C and peak in January at 32.6 °C. In contrast, winter (June, July, August) temperatures average 14 °C, with the daily minimum reaching 8 °C in June.

2.4.2 Soil water measurement

Soil samples were collected in October 2016 at three depths (0-0.20; 0.20-0.40 and 0.40-0.60 m). The textural class of soil was determined using the international pipette method (Day, 1965). The soil water curve retention was characterized by measuring water content at tensions of 0.01, 0.033, 0.1 and 1.5 MPa using the Richards and Weaver methods (1944). Field capacity, permanent wilting point, bulk density and total available water were determined from the retention curve for the soil profile (0-0.60 m). Soil water content was measured with frequency domain reflectometry (FDR) sensors (Decagon Devices 10HS, Pullman, WA, USA). The sensors were installed in one replication for all treatments at soil depths of 0.075, 0.20 and 0.37 m. A data logger recorded sensor data every hour. The FDR water measurements were used to verify the water balance calculations throughout the irrigation season and the measured applied infiltration depths. Data recorded from FDR were not used to adjust the soil water balance. Calculation of the water balance and soil water monitoring began in December until March (90 days).

2.4.3. Calculation of the daily water balance

Depth of irrigation was based on the amount of water to refill to field capacity in the effective root zone (0.30 m). Daily water balance was used to calculate the soil water depletion (Allen et al., 1998, Pereira and Allen, 1999) according to equation (1)

$$Dr_i = Dr_{i-1} - Pe_i - I_i + ETc_i \qquad (1)$$

where:

Dr_i is the root zone depletion at the end of day i [mm];

Dr_{i-1} is the water content in the root zone at the end of the previous day, i-1 [mm];

Pe_i is the effective precipitation on day i [mm];

I_i is the net irrigation depth on day i that infiltrates the soil [mm];

ET_{ci} is the crop evapotranspiration on day i [mm].

Contributions by water table and capillary rise were neglected in the analysis. The subscript i and i-1 refer to the current and previous day, respectively.

Although following heavy rainfall or irrigation the soil water content might temporally exceed field capacity, the total amount of water above field capacity is assumed to be lost the same day by deep percolation, following any ET for that day (Allen et al., 1998).

The TAW (total available water) of each site was calculated as:

$$\mathrm{TAW} = (\mathrm{FC} - \mathrm{PWP}) \times \mathrm{Ze} \tag{2}$$

where, FC: field capacity; PWP: permanent wilting point; Ze: effective root zone.

The RAW (readily available water) for p = 40 %, p = 50 %, p = 60 %, p = 70 % of each site was calculated as:

$$\mathrm{RAW} = p \times \mathrm{TAW} \tag{3}$$

where, p: depletion factor (0.4, 0.5, 0.6, 0.7).

Crop evapotranspiration (ET_c) in Eq. 1 was calculated as the product of the reference evapotranspiration ET_o and a crop coefficient kc a stress coefficient k_s (Allen et al., 1998):

$$\mathrm{ET_c} = \mathrm{ET_o} \times k_c \times k_s \tag{4}$$

Soil water stress was estimated by calculating the stress coefficient (k_s) daily for each treatment from December 1 to March 1 using the following equation (Allen et at., 1998):

$$k_s = \frac{\mathrm{TAW}-\mathrm{Dr}}{(1-\mathrm{p})\mathrm{TAW}} \quad (5)$$

The reference evapotranspiration was determined with the Penman-Monteith (Allen et at., 1998) equation as implemented in the ET_o calculator program v. 3.2 (Raes et al., 2011). Inputs needed for the calculation were measured with an automated weather station (Davis Instruments Corp. Inc., CA, USA) located less than 2.6 km away from the experimental fields. Rain gauges were also installed at each experimental site. Since rainfall measured at those sites was almost the same as that measured at the weather station, and the surrounding topography is relatively flat, the meteorological variables measured at the weather station and the resulting ET_o can be assumed to be representative of the experimental fields.

Table 1 lists the growth phases of sugarcane crop, their duration and the kc values for each phase, as reported by Allen et al. (1998). The selection of the kc coefficients is the one proposed by FAO for this climate.

Table 1. Sugarcane growth phases, timing and Kc values.

Phases	Months	Days from Sowing	Irrigation period (days)	k_c*
Planting	February 10	0	-	-
Emergence	February 15	5	-	-
Growing period	February 16 – April 30	74	-	-
Latency period	May 1st - August 15	181	-	-
Initial growing period	August 16 – September 30	226	-	-
Sprouting	October 1st- November 14	271	-	0.5-0.70
Tillering	November 15- December 14	300	14	0.70-1.0
Grand growth period	December 15 – March 31	406	76	1.0-1.20
Maturation	April 1st – June 11	478	-	1.20-0.7
Harvest	June 12	479	-	-

*adapted from FAO 56 (Allen et al., 1998)

Effective precipitation was calculated by using the antecedent precipitation index (API) of Shaw (1963) to determine the runoff produced by a rainfall event. The API index has been used in research at the national level since the 1980s (INIA-GRAS, 2020) and accounts for rainfall from the previous six days, as described in Appendix A. The computed runoff was then subtracted from the gross precipitation to obtain an initial Pe. This initial Pe value was further reduced when the result was greater in absolute magnitude than the sum of ETi and Dr_{i-1}, which would make Dr_i negative. In such cases, Dr_i was set to zero and the excess precipitation was assumed to be lost by runoff and deep percolation. The same approach was used to account for irrigation depths in exceed of the soil water deficit.

2.4.4 Irrigation Management

Irrigation water was applied using poly-pipe with slide gates spaced at 2.40 m, with each gate irrigating two furrows. Since the fields had some slope and the furrows were open-ended, some irrigation water was lost by runoff. The gross irrigation depth was calculated by assuming an application efficiency of 75 %.

The irrigation cutoff time for each plot was determined as (Eq. 6)

$$t = \frac{d \text{ x } a}{q} \tag{6}$$

where, t = time in seconds, d = gross depth of water to be applied in m, a = plot area in m^2, q = inflow rate $m^3\ s^{-1}$. Since the same inflow rate was used for all irrigations, the application time varied depending on the water replacement depth.

Irrigation events that must be applied during weekends or holidays were advanced or delayed because the multi-farm irrigation system does not work at those times.

Washington State University flumes (Hudson, 1997) were used to measure both inflow and runoff rates in each furrow and each irrigation event. Infiltrated depth was calculated from the difference between the applied and run-off volume, divided by the plot area.

2.4.5. Root Zone Depth

Effective roots depth was considered the same throughout irrigation experiment season. Previous research works in Uruguay reported that the most of effective root zone is in the first layer of the profile (0.30 m). (De la Peña Ruiz and Martinez, 1989, Dapueto and Rodriguez, 1986). The measurements were obtained up to a depth of 0.50 m and a width of 0.50 m. In squares of 0.10 x 0.10 m, the distribution of the roots in the profile was determined.

2.4.6. Experimental Design

The experiment aimed to assess the effect of different levels of soil water depletion on sugarcane yield. The null hypothesis: with readily available water contents in the soil between 40% and 70%, yield is not affected. Water depletion levels (p) of 40, 50, 60 and 70 % were examined (Table 2).

Table 2. The experimental layout at the two sites.

BLOCK 1				BLOCK 2				BLOCK 3				BLOCK 4			
T1	T2	T3	T4	T3	T1	T4	T2	T1	T4	T3	T2	T1	T2	T3	T4
40	50	60	70	60	40	70	50	40	70	60	50	40	60	70	50

The experiment was conducted using a randomized complete block experimental design (RCBD) with four replicates, resulting in 16 experimental plots per experimental site. Each plot was 10 m by 7.2 m and consisted of 6 furrows spaced at 1.20 m centers.

2.4.7. Crop Management

The sugarcane cultivar used at both sites, TUCCP 77-42, has been a widely cultivated variety in Uruguay for many years. This cultivar has an average 275 days long growing cycle in the region, requiring around 20 days from sowing to emergence, 190 days to sprouting, 30 days to the beginning of tillering and 35 days to grand growing period. Crop management followed common regional practices. At both sites, the crop was planted on February 10 of 2016 using a row spacing of 1.2 m. Fertilizer was applied at planting at a rate of 112 kg ha^{-1} N, 44 kg ha^{-1} P_2O_5 and

66 kg ha^{-1} K_2O. A second N fertilizer dose was applied in November at 74 kg ha^{-1}. Pre-emergent herbicides (1.6 kg of metsulfuron-methyl, 2 l of 2,4-D and 2 l of acetochlor) were applied in September while a post-emergent herbicide (Glyphosate) was applied in October. No insect or disease problems were experienced during the experiment and, thus, no chemical treatments were used. The crop was harvested in June 2017.

2.4.8. Crop growth measurements

For each treatment site and plot, the height of 5 marked plants was measured weekly during the growing season, while the number of stems per square meter (m^2) was measured every 15 days. The root system depth was studied at the peak of crop height 220 days after planting (DAP). These measurements were obtained with profile walls method (Lee, 1927) 0.50 m long, 0.50 m wide and 0.1 m thick, with three replications at each site. Roots were counted in each division of 0.05 m by 0.05 m up to 0.5 m depth. The total number of roots obtained in the entire profile was divided as a percentage for each 0.010 m depth. The soil depth in which more than 70 % of the water intake and more than 80 % of total weight roots takes place was taken as the effective root zone for irrigation purpose (Amend, 2005, Michael, 2010).

Stem height and average diameter along the period were measured using 10 plants in 3 m along the inner row of each plot. The crop was harvested manually in the three inners rows of each plot (36 m^2) in June and used to determine total yield of stems (dry matter weight) and the length of the millable stems.

Total yield was calculated as:

$$y = \frac{ms \ x \ 10000}{1000 \ x \ 36} \quad (7)$$

where: ms = weight of millable stems in 30 m row (kg); y = yield (ton ha^{-1}); 36 = harvested area (m^2).

2.4.9. Statistical Analyses

The data obtained from the experimentation was analyzed for individual site and pooled for 2 sites. An analysis of variance (ANOVA) was conducted for total dry matter as a function of the treatments using the general linear model (GLM) procedure of the SAS/STAT statistical software (SAS, 2014). Given the experimental design, the statistical model was:

$$Y = \mu + Ti + \beta j + \delta ij + \varepsilon ij \quad (8)$$

Where Y: dry matter yield; μ = overall mean; T: treatment effect; β: block effect; δij = the additional effect (interaction) for the combination of levels i and j; ε = error effect. Similar analyses were conducted to evaluate treatments effects on plant height and stem number. The least significance difference (LSD) method was used to test differences between the treatment means. Effects were considered statistically significant if $p \leq 0.05$. Multiple regressions were used to examine the relationship between phenological variables (stem height), irrigation depth and total dry matter. Others statistical measures computed include the root-mean-square error (RMSE) and the coefficient of determination (r^2).

2.5. RESULTS

2.5.1. Weather Conditions

The effective rainfall received from December to March (90 days) was 272 mm. The occurrence of precipitation affected the depth of irrigation in different treatments of soil water depletion. Effective rainfall was 25 % less than the average historical effective precipitation. Monthly average precipitation was slightly less than the historical average (101 mm), but it varied over a wider range, from 241 mm in October to a minimum of January (83 mm). The reference evapotranspiration to the same period was 385 mm. The sugarcane evapotranspiration ranges depend on the region where the crop grows. In this study, annually reference evapotranspiration (ETo) was 1215 mm from April 2016 to March 2017 (Figure 2). Similar results were found by Dingre and Gorantiwar (2020) in the semiarid region of India. In the work, the variation of evapotranspiration in different regions of sugarcane where the values range between 950 to 1700 mm is analyzed. Doorenbos and Kassam (1979) reported water demand values from 1500 to 2500 mm. Nevertheless, Coelho et al. (2012) observed, in tropical areas, lower values than 1500 mm. Different estimated values of sugarcane evapotranspiration are found in the international literature depending on weather conditions, soil texture and duration of crop cycle. Maximum and minimum ETo values were observed in January (142 mm) and June (50 mm). Daily maximum reference evapotranspiration was observed in January (8.4 mm day^{-1}). Average daily reference evapotranspiration during irrigation season (from November to March) was 4.4 mm day^{-1}. Air temperature measured during sugarcane cycle followed the historical pattern (Figure 1b), with peak values of 25 °C in January.

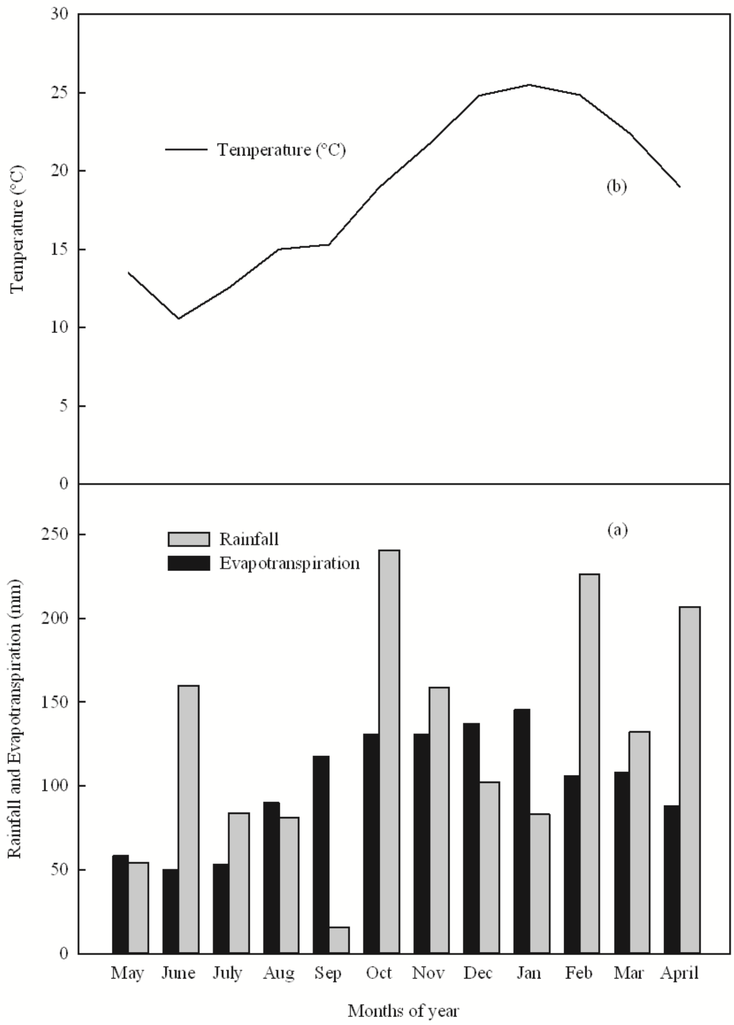

Figure 2. Total precipitation and reference evapotranspiration (FAO-PM) (a) and air temperature (b). May 2016-April 2017. Bella Unión, Uruguay.

2.5.2. Soil Available Water and Allowable Depletion

The soil at site I was described geologically as quaternary sand. The soil in horizon A contains a high sand fraction and is classified as a sandy clay loam (Table 3). In contrast, the soil at site II was a clay loam with similar sand, silt and clay fractions. The total available water (TAW) in site I was 45.3 mm, while in site II it was 63.3 mm. Most of the soils that sugarcane crop is developed in Uruguay have a very shallow horizon for root development (less than 0.40 m). This contrasts with the soils of some sugarcane producing areas in the world with a more developed horizon, as in the case of tropical areas in Brazil (Santos et al., 2016) with 1 m depth soil and 310 mm of TAW or in semiarid regions with more than 0.7 m depth of the A horizon (Dingre and Gorantiwar, 2020) and TAW of 225 mm.

Table 3. Soil water contents in percent on volume, bulk density and soil texture.

Site	Soil	Horizon	Depth	Soil textura	Sand	Silt	Clay	Bulk density	FC	PWP	TAW
			(m)			%		g cm^{-3}	% by volume		mm
I	Mollisols (Udolls)	A	0-0.3	SCL	69	10	21	1.36	27.8	12.7	45.3
II	Vertisol (Uderts)	A	0-0.3	CL	33	32	35	1.20	33.7	12.6	63.3

SCL: sandy clay loam; CL: clay loam; TAW: total available water; FC: field capacity; PWP: permanent wilting point

In general, these soils cannot store significant amounts of water to provide conditions to adequate crop development. The limited and erratic rainfall during the period of peak demand of crops indicates the need for supplementary irrigation during this phase of growth (Lugo-López et al., 1985). Table 4 summarizes the irrigation depths for different allowable water depletion levels at each site.

Table 4. Soil water depletion (p) according to available soil water in the profile (0.30 m) and irrigation depth to replace in each site.

Soil water depletion (p)	Site I RAW (mm)	Site II RAW (mm)
p = 40 %	18	25
p = 50 %	22	31
p = 60 %	27	37
p = 70 %	32	44

The water content in the root zone (Dri) differs from the estimated irrigation depth for each treatment (table 4) in some irrigation events, mainly in p = 4 0% due to announcements of high probability of rainfall or coincidence with weekends or holidays.

2.5.3. Soil Water Balance

Effective rainfall, crop evapotranspiration and irrigation depth applied were used according to different soil water depletion (p). Results are presented in figures 3 and 4 for site I and II, respectively. Differences in the amount of irrigation applied in each treatment are due to the soil water depletion. At sites I and II, the irrigation difference between the most contrasting treatments (p = 40 % and p = 70 %) was 81 and 121 mm, respectively.

Considering that crop evapotranspiration is the same at both sites and the effective rainfall presents little significant difference, the total irrigation amounts applied in each treatment are a product of the different water storage capacities in the soil profile of each site (Figures 3 and 4). At the moment of each rainfall event, the soil profile of each site had different levels of soil water content. This caused the total irrigation depth in both sites to be different than expected (Table 5).

The calculation of the daily water balance for the root zone of the soil made it possible to manage the timing and amount of water to be applied. Figures 3 and 4 present the daily soil water balances (Allen et al., 1998) that include soil field capacity, permanent wilting point, allowable soil water depletion, available soil water, effective precipitation and irrigations events. Irrigations were applied when the received rainfall was less to maintain soil moisture conditions established for each treatment.

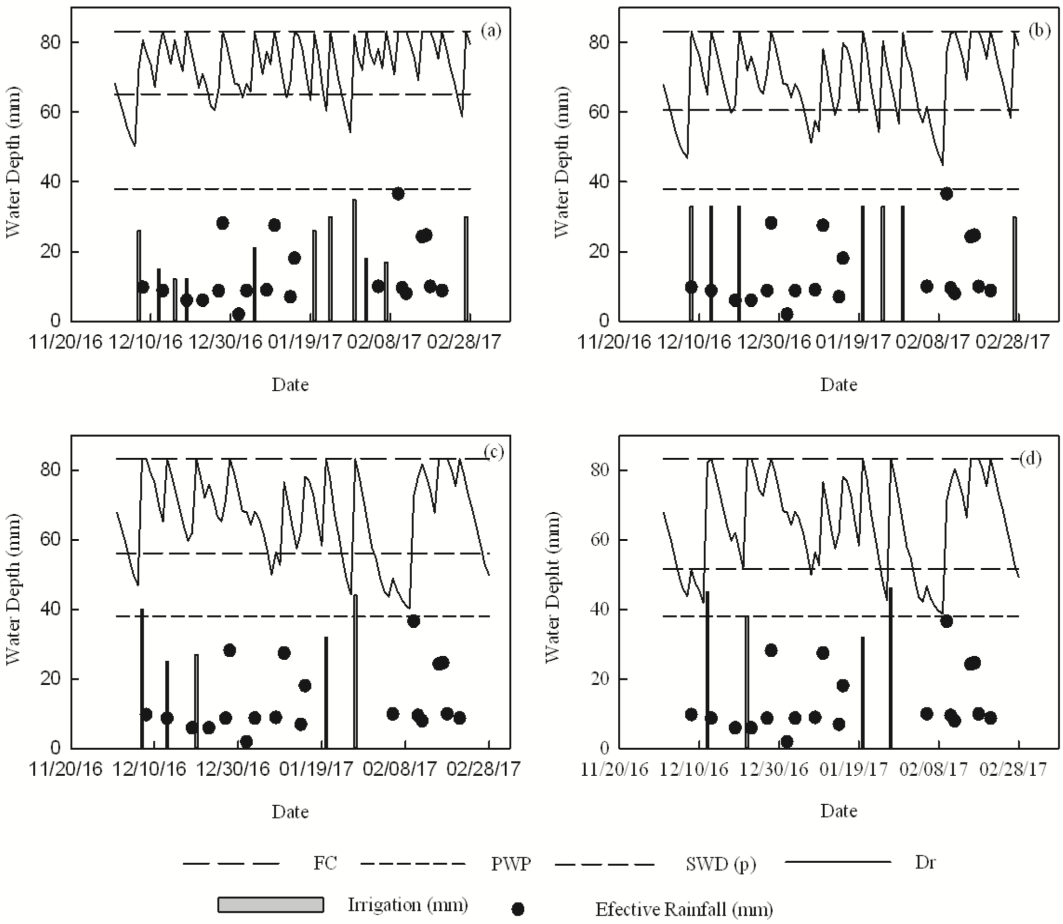

Figure 3. Irrigation water management for each soil water depletion (p) according to daily soil water balance. Site I, (a) p = 40 %; (b) p = 50 %; (c) p = 60 %; (d) p = 70 %. FC: field capacity; PWP: permanent wilting point; SWD (p) = soil water depletion; Dr = soil water balance at the root zone (mm).

At site I (Figure 3), it was observed at the end of November (beginning of the irrigation season) that the water content in the soil fell below allowed readily available water (RAW) in all treatments due to irrigation system not being in operation. There was another event at the end of December where the soil water content dropped below TAW because there were rainfall forecasts that occurred but in very low amounts and failed to complete the water content in the soil profile. Figures 3b, 3c and 3d show a drop below the allowable threshold in mid-February, when several rainfall events were recorded but were not significant enough to keep soil moisture levels within the allowable range. During the grand growth stage a high water requirement was observed (358.6 mm). In this stage, the application of irrigation was achieved in all treatments. This followed by tillering stage with 56.6 mm. Similar results were observed by Dingre and Gorantiwar (2020).

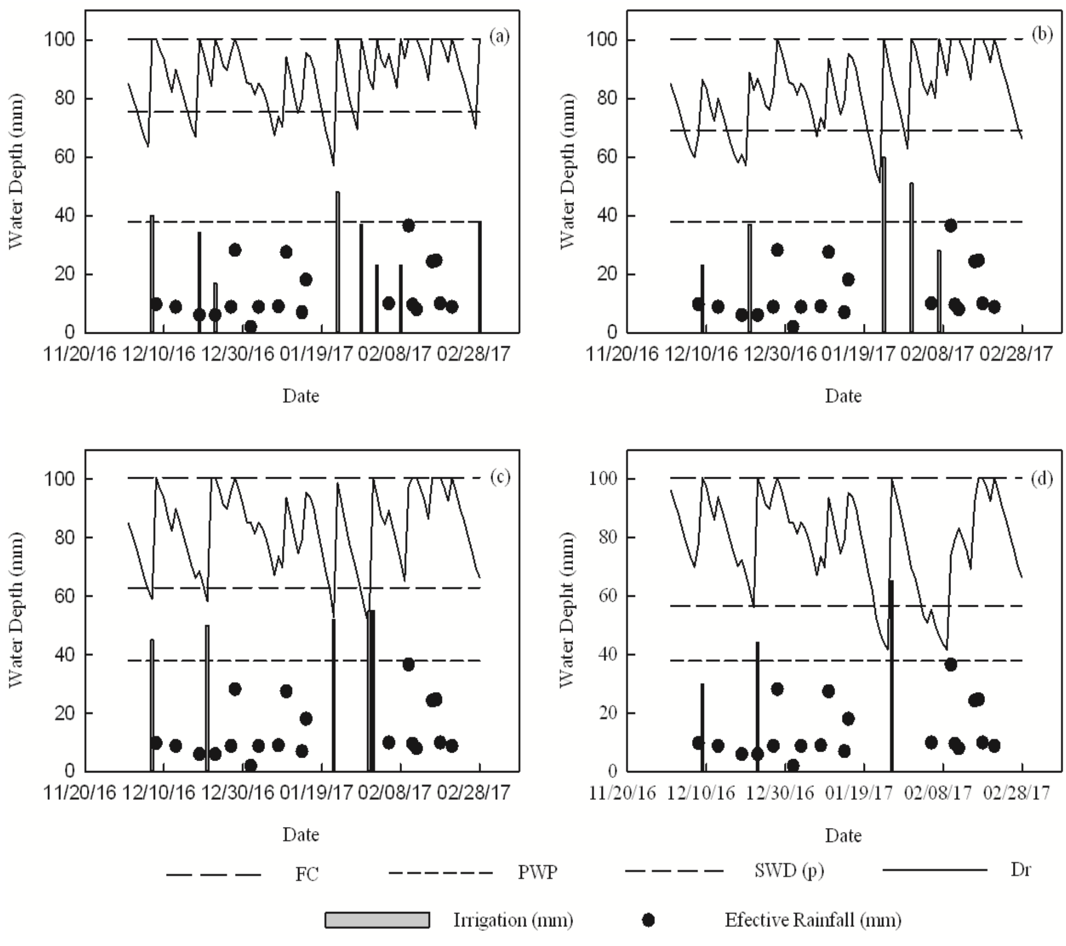

Figure 4. Irrigation water management for each soil water depletion (p) according to daily soil water balance.
Site II, (a) p = 40 %; (b) p = 50 %; (c) p = 60 %; (d) p = 70 %. FC: field capacity; PWP: permanent wilting point; SWD (p) = soil water depletion; Dr = soil water balance at the root zone (mm).

Treatments where soil water depletion of 40% and 50% are the treatment with more frequency of irrigation and greater volume of water applied in the whole season, so smaller irrigation depth in each irrigation event is applied. Treatments where greater depletion was allowed presented greater opportunity to use rainfall, so treatments p = 60 % and p = 70 % were irrigated only three times throughout the season with irrigation depth being greater than the other treatments. Differences in the number of irrigation events applied by treatment and site varied according to soil water depletion. It varied between three and eleven irrigation events during the season (Table 5). It was observed that the highest irrigation water requirements occurred in site I, compared to site II with the highest available water content in the soil, which required less irrigation depht. Water required and water applied in site II are very similar for the treatments p = 40 %, p = 50 % and p = 60 % of SWD, and showed differences of 2, 19 and 1 mm, respectively (Table 5). Although the number of irrigation in site I was higher than site II in all treatments, total depth irrigation applied was lower in site II.

The two experimental sites received different irrigation depths; it was expected due to the textural difference in the horizon A between the soils of both sites. In relation to the total irrigation event applied, it was not so different (11 in site I and 8 in site II, p = 40 %). This is due to the fact that there is a high dependence on the occurrence of rainfall, in a region where the distribution and amount of rain are highly variable between months and years.

Results for soil water balance for both sites are presented in the follow table (Table 5) where differences among treatments show irrigation management according soil water depletion.

Table 5. Soil water balance on both sites according to irrigation treatments.

Treatments (p)	40 %	50 %	60 %	70 %
Site I				
Required water depth (mm)	270	276	277	238
Applied water depth (mm)	242	228	168	161
Number of irrigations	11	7	5	4
ETc (mm)	415	415	415	415
ETc_{aj} (mm)	408.4	401	388	388
Effective rainfall (mm)	272	272	272	272
Site II				
Required water depth (mm)	258	238	201	189
Applied wáter depth (mm)	260	219	202	139
Number of irrigations	8	5	4	3
ETc (mm)	415	415	415	415
ETc_{aj}(mm)	408.4	409	412	395
Effective rainfall (mm)	272	272	272	272

The moisture content of the soil managed to satisfy the water demand of the plants. It decreased during development crop until the occurrence of rainfall or water irrigation application. Soil moisture content remained within the limits imposed by soil water depletion in the profile (p) for most of the experiment period (Figure 5). Below 0.45 m soil depth, water consumption throughout the period decreased slightly. Similar results were found by Dingre and Gorantiwar (2020). The authors observed increase in soil moisture content until 0.45 m of soil profile.

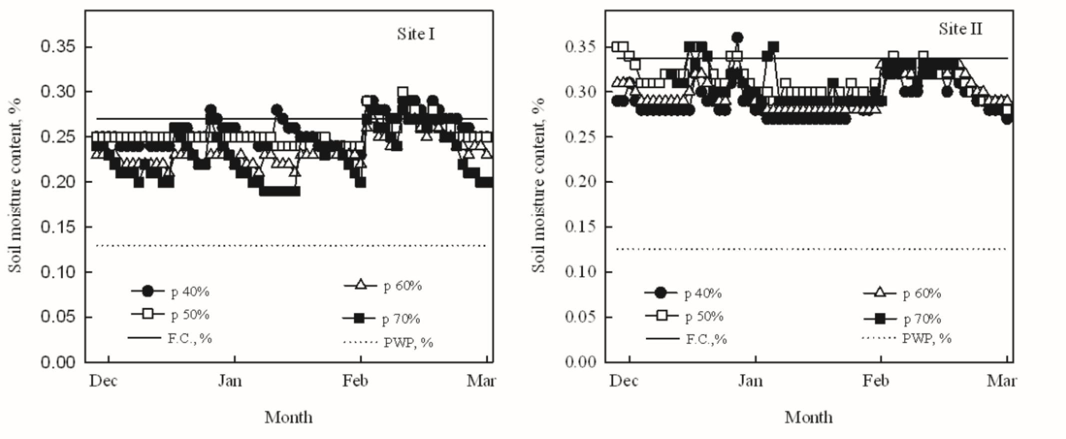

Figure 5. Soil moisture content in the soil profile for sugarcane in site I and site II during 2016-17 growing season.

FC: field capacity; PWP: permanent wilting point

2.5.4. Roots Depth

The effective depth of the root system is where 80 % of the root system is concentrated according to Bernardo et al. (2008). Roots distribution measurements for sites I and II are presented in table 6.

Table 6. Root distribution (%) every 0.10 m depth per site.

Depth (m)	Site I %	Site II %
0.00-0.10	60.0	49.0
0.10-0.20	22.5	29.6
0.20-0.30	11.0	10.4
0.30-0.40	3.5	7.7
0.40-0.50	3.0	3.3

At site I, 82.5 % of roots were observed in the first 0.20 m soil layer, which had a high sand content. An additional 11 % of roots were located between 0.20 and 0.30 m for a total of 93 % in the upper 0.30 m of soil. Similar results were obtained at site II (Figure 6). Almost 90 % of roots were observed in the upper 0.30 m, with nearly half located in the first 0.10 m of soil profile.

In both sites, it was observed that 90% of total roots were found in the upper layer (0-0.30 m). Several works in sugarcane corroborate the effective root depth observed in this study (Alvarez et al., 2000, Faroni and Trivelin, 2006, Farias et al., 2008, Sousa et al., 2013).

Data of roots concentration zone is important to determine total available water in the profile (Allen et al., 1998) and to calculate soil water depletion (Inman-Bamber, 1991, Smith et al., 2005). The maximum root depth observed in the field agreed also with Hoogenboom et al. (1987), who recorded more than 76 % of the root system in the top 0.40 m of the soil. Research conducted by Cunha et al. (2010) in Brazil observed that 80 % of the roots were within the effective rooting depth at the top of the soil horizon. Irrigation influences the development of the root system. When irrigated, a concentration of roots is seen in the surface layers of the soil during initial stages. Several crops (i.e.: sugarcane, corn, soybean, etc.) without irrigation develop more extensive and deeper root system during early growing stages to secure water (Montoya et al., 2017).

2.5.5. Plant Measurements

Plant height was affected by the level of soil water depletion. Maximum and minimum plants height were observed with 40 and 70 % of soil water depletion (p = 40 and p = 70), respectively, at the end of the growing crop cycle (just before harvest). Figure 7 shows the evolution of plant height growth for all treatments in site I and II, respectively.

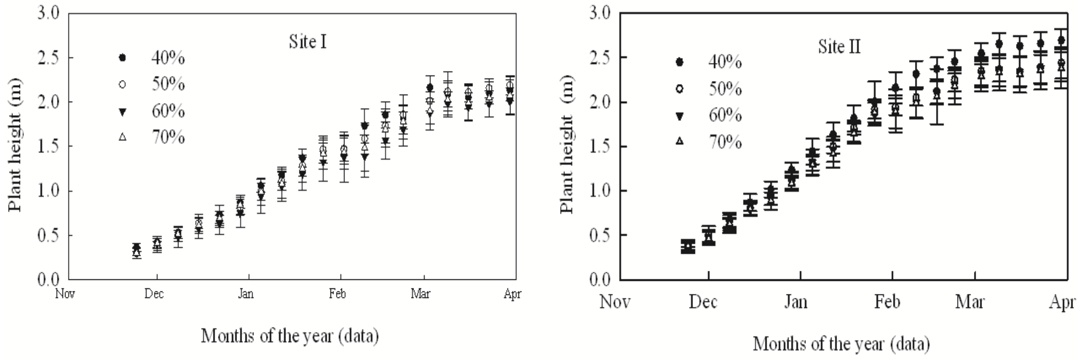

Figure 7. Evolution of plant height (m) during the development crop, site I and II (2016-17).

Plant growth of the plants begins in September (earlier spring). It can be observed rapid crop growth from December to March when no water deficit exists.

The vegetative period extends from September to November. During this period, the growth rates are low due to low air temperatures, few hours of sunshine and low daily evapotranspiration. From November to March, air temperatures begin to rise, sunshine hours increase and, as a result, greater evapotranspiration of the crop occurs. At this stage, tillering occurs in addition to gram growth period. From the end of March, the temperatures begin to decrease, producing the maturation of the crop. Highest standard deviation values are observed in the treatment of 70 % soil water depletion. The same situation was also observed for site II (Figure 7). The growth rate of the crop is related to the hydric conditions of the soil and the height of the stems with the dry matter yield of the crop. Alemán-Montes et al. (2021) observed that plant height is strongly related with sugarcane yield. The maximum difference was observed with soil water depletion of 70 % of the total available water (stem average of 2.34 m).

Figure 8 shows average stems millable cane height during irrigation season related to soil water depletion allowed for each site. Significant differences were seen among treatments of soil water depletion in the upper 0.25 m layer of soil profile. Linear regression was utilised to observe the relationship between this physiological parameter, wherein significant correlation was found between soil water depletion and stems millable cane height ($R^2 = 0.98$ and 0.89 in site I and II, respectively). Differences between stems millable cane height were manifested in crop yield at the end of the growing season. In the most irrigated treatments (p = 40 and p = 50) stems millable cane yilds were maximum in both sites. Treatments more irrigated (p = 40 and p = 50) stems millable cane was maximum in both sites. Similar results were observed by Dingre and Gorantiwar (2020). The authors found that variables that contribute to final yield were dependent on irrigation depth.

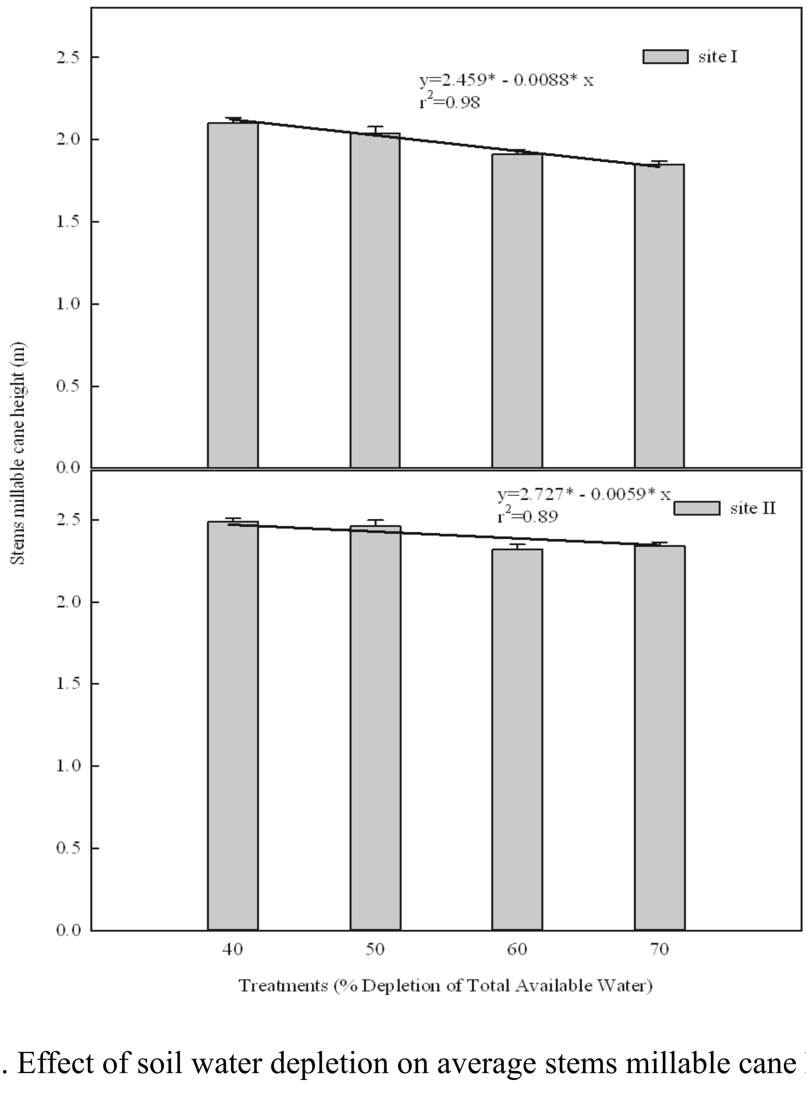

Figure 8. Effect of soil water depletion on average stems millable cane height at harvest (site I and II).

*significance at $P < 0.05$

2.5.6. Productive Performance

The dry matter production was affected by the frequencies of irrigation events. Treatments with more irrigation depth as p = 40 % and p = 50 % were observed highest productive yields on both sites (figure 9). Statistical analysis of comparison of means of dry matter production for site I and site II are showed in figure 9.

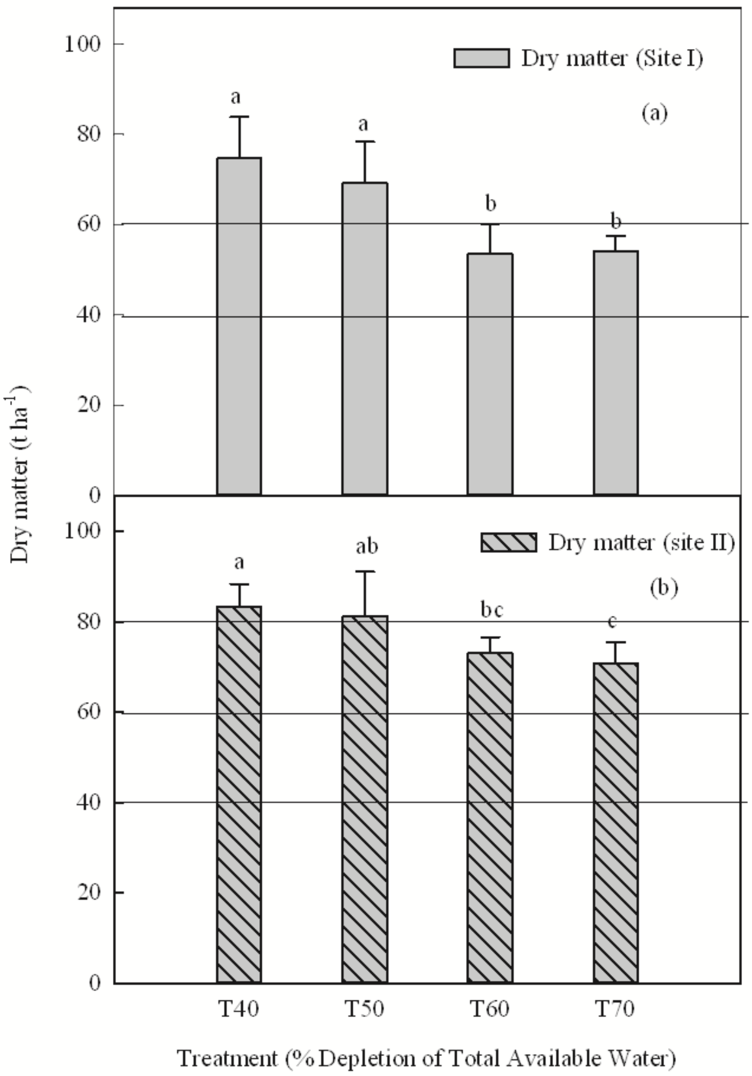

Figure 9. Response of dry matter production to different irrigation treatment site I (figure 9a) and II (figure 9b), LSD ($p \leq 0.01$): 12.8 t ha^{-1} and 9.8 t ha^{-1}, respectively. Means that followed the same letter do not differ significantly at 1 % level of probability. The block interaction by treatment was not significant.

It was observed that the dry matter production was affected by irrigation treatments in both sites (Figure 9). Different levels of soil water depletion at each site affected dry matter production significantly. In site I, significant differences were observed in dry matter production when there was more than 50 % of the soil water depletion (SWD), with no statistical differences between p = 40 % and p = 50 % treatments or between those of p = 60 % and p = 70 %. As can be observed in figure 9a, maximum dry matter production of 74.6 t ha^{-1} was obtained with SWD of 40 %. When soil water depletion was greater than 50 % (p = 50 %), yield down drastically impaired in 15.7 t ha t ha^{-1}. In site II, significant differences were observed (figure 9b) in dry matter yield between p = 40 % with respect to the p = 50 %, p = 60 % and p = 70 %. Research carried out by Allen et al. (2011), for a range of root depth between 1.2-2 m and evapotranspiration of 5 mm day^{-1}, observed a fraction of soil water depletion of 65 %.

Differences in soil texture class between site I and II affected dry matter yield in different ways, as can be observed in figure 9b. Maximum response expressed in stems productivity per hectare was obtained with less soil water depletion (p = 40 %). Yield obtained in p = 40 % was 83.3 t ha^{-1}, p = 70 % yielded 70.8 t ha^{-1} (Figure 9b).

The pooled mean of two sites of data showed that yield decreased when sugarcane crop received less amount of irrigation water (p = 60 % y p = 70 %). Results reported by Wahab (2010) working with different irrigation treatment based on (SWD) observed a significant reduction on sugarcane yield when applied 75 % of SWD. This is important because dry matter production is directly related to sugar production (t ha^{-1}) and the farmer is paid by sugar production.

Table 6. Dry matter production according irrigation treatment (site I and II).

Soil water depletion (treatment)	Average yield ($t\ ha^{-1}$)
40 %	78.9 a
50 %	75.3 a
60 %	63.4 b
70 %	62.4 b
LSD ($p \leq 0.01$)	10.7
c.v (%)	14.9

Means followed the same letter in a column do not differ significantly at 1 % level of probability.

To the extent that the water deficit increases and soil water content in the profile decreases, the yield is affected, as can be observed in the negative linear regression following showed. As soil water depletion increases, dry matter production decreases. A multiple regression of total yield (pooled mean of site I and II) during crop season on stem number accounted for over 70 % of the variation in yield of sugarcane. The regression equation was:

$$Y = 35.08^{*} - 6.81\ s^{*} - 4.061\ I^{**} + 4.142\ n^{**}$$

adj $r^2 = 0.72$, root mean square error (RMSE) = 6.5, n = 32, * significance at $P \leq 0.05$; ** significance at $P \leq 0.01$

where Y is dry matter ($t\ ha^{-1}$), s is site (site I = 1, site II = 0), I soil water depletion treatment and n is stem number m^{-2}.

The number of stems represented 64 % of the variation in sugarcane yield and the diameter of the stems measured at harvest insidiously 9% in yield. The reduction in dry matter production between treatments of p = 40 % and p = 70 % was almost

20 % (Table 6). Data obtained Portz et al. (2012) in sugarcane found a coefficient of determination (r^2) 0.91 between stem height and dry matter. The coefficient of determination (0.72) showed good agreement between the variables studied as irrigation depth and stem number.

In the case of site I, the difference between the calculated ETc and the ETcaj was greater in p = 70 % at 27 mm and minimum in p = 40 % at 7 mm. On average, the difference between both ETc (calculated and adjusted) was 4.5 % for all treatments. In site II, the difference in p = 70 % was 20 mm and in p = 40 % it was 6.6 mm with an average of 2 % difference for all treatments. Therefore, the water balance, although it was not performed using ETcaj, would not present great differences with that performed using ETc.

2.6. DISCUSSION

Uruguay has been cultivating sugarcane since 1940. Currently, the crop has grown on about 7100 ha and yields, on average, 62.69 t ha^{-1} per year (MGAP-DIEA, 2016). The sugarcane producing area is marginal in terms of temperature conditions. According to Inman-Bamber (1994), the base temperature for the growth of sugarcane is between 9 °C and 19 °C and the optimum between 30 °C and 35 °C, where the greatest growth of the crop occurs.

The data presented are from one year of study in two different soil textures that represent 80 % of the production area of the sugarcane crop. From the climate point of view, it was a year similar to the historical average of more than 50 years according to the showed data.

The effective rainfall used in the water balance was the same for all irrigation treatments. In future studies, methods for estimating effective precipitation that consider also irrigation water could be used, looking for differences in effective precipitation for different initial soil water conditions.

Irrigation management using the FAO-56 water balance resulted to be a good tool to achieve an efficient irrigation water use. In this study, the stress coefficient (ks) was not considered, as proposed by Allen et al. (1998). It could be included for future studies. Anyway, if ks had been included in the water balance calculation, the adjusted evapotranspiration for this season would have obtained similar results.

The irrigation system works at each irrigation season from December; this could generate water deficit in the early stages in case the rainfalls are not enough to satisfy the demand of the crop. The alternative to this situation is to start operating since the month of November. This would allow monitoring the crop water needs throughout the development cycle and, in the event of irrigation during the weekend or on holidays, soil water depletion would not reach lower levels than desirables.

The study contributed to knowing that the application of few irrigation events with an adequate irrigation depth applied at the beginning of the development of crop growth (December and January) had a very important effect on the final growth of sugarcane crop. This resulted in a greater production of dry matter and, therefore, a greater production of sugar in those treatments that received a greater amount of water. The precipitations that occurred in the summer season (January and February) were not enough to have a great impact on the growth of the crop, so the beneficial effects of the application of irrigation in the early stages of the crop were observed.

Soil water content was monitored throughout the growing season by FDR sensors installed in all treatments at different depths of the soil profile at both sites. This is key to proper irrigation management in order to maintain adequate soil water content, especially in situations of humid climate and highly variable rainfall during the summer. It also made it possible to verify that the soil water content remained constant below 0.40 m of soil depth, determining that there was no significant root development and, as consequence, there was null water demand below this depth.

The maximum dry matter production had significant correlation with irrigation water, being the factor that contributed the most to this performance, followed by the number of stems. Similar results were found by Santillán-Fernández et al. (2016) in Mexico and by Singh et al. (2018) in subtropical zone of India.

More research will be necessary to minimize the effects of climate variability (mainly rainfall) as well as to know the long-term production potential of this variety, which is the most sowing in the sugarcane zone in Uruguay.

2.7. CONCLUSIONS

A high correlation was observed (0.89 and 0.98 for sites I and II, respectively) between soil water depletion and stems millable cane height in the two sites studied. Maximum stems millable cane height was obtained with less soil water depletion (p = 40 % and p = 50 %).

As soil water content decreased, stems millable cane height stems were lower. The number of stems represents more than 70 % of the variation in sugarcane yield. Significant differences were observed in both studied sites in sugarcane yielded performance according to the level of soil water depletion.

Soil water depletion (SWD) up to 50% did not affect crop productivity on both sites. In treatments with SWD at 60 % and 70 % significantly yield decreased. Regardless of soil texture characteristics, irrigation response showed to be the same in both sites.

Field water balance using the standard FAO-56 methodology was useful and practical for the sugarcane region of Uruguay.

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3. <u>CONFLICT OF INTEREST</u>

There is no conflict of interest in this study.

4. CONCLUSIONES

Se observó una alta correlación (0,89 y 0,98 para los sitios I y II, respectivamente) entre el agotamiento del agua del suelo y la altura de los tallos molibles en los dos sitios estudiados. La máxima altura de tallos a cosecha se obtuvo con menor agotamiento de agua del suelo (p = 40 % y p = 50 %).

A medida que el contenido de agua del suelo disminuyó, la altura de los tallos molibles fue menor. El número de tallos representa más del 70 % de la variación en el rendimiento de la caña de azúcar. Se observaron diferencias significativas en ambos sitios estudiados en el rendimiento de la caña de azúcar según el nivel de agotamiento del agua del suelo.

La productividad de los cultivos no afectó hasta el 50 % del agotamiento del agua del suelo (SWD) en ambos sitios. En los tratamientos con SWD al 60 % y 70 %, disminuyó significativamente el rendimiento. Independientemente de las características de la textura del suelo, la respuesta al riego mostró ser la misma en ambos sitios.

El balance hídrico de campo utilizando la metodología estándar FAO-56 fue útil y práctico para la región cañera de Uruguay.

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6. ANEXOS

Calculo para la Precipitación Efectiva

API = PPo/2 + PP1 + PP2/2 + PP3/3 + PP4/4 + PP5/5 + PP6/6

where, PP1 to PP6; precipitation corresponding to day 1 (before the current date) to day 6 (6 days before the current date).

Run-off functions by API range: If the day's precipitation (PPo) is less than 12.5 mm, then the run-off is zero (0). For PPo values equal to or greater than 12.5 mm the following equations apply:
If API>69.8, then Run-off = -4.21 + 0.438 * PPo + 0.0018 * PPo2
If API>57.1, then Run-off = -3.17 + 0.32*PPo + 0.0024 * PPo2
If API>44.4, then Run-off = -2.78 + 0.25 * PPo + 0.0026 * PPo2
If API>31.7, then Run-off = -2.36 + 0.19* PPo + 0.0026 * PPo2
If API>19.0, then Run-off =-2.34 + 0.12 * PPo + 0.0026* PPo2
If API>6.3, then Run-off = -1.14 + 0.042 * PPo + 0.0026 * PPo2
If API<=6.3, then Run-off = 0.858 - 0.0895*PPo + 0.0028* PPo2

Pe = PPo – Run-off

where, PPo: day before precipitation and Pe: effective rainfall

BALANCE HIDRICO SITIO I. T 40 %

FECHA	Kc	ET0 (mm)	ETc (mm)	P_total (mm)	Esc. (mm)	P_efec. (mm)	ETa (mm)
01/12/2016	0,9	4,8	4,3				4,3
02/12/2016	0,9	4,7	4,2				4,2
03/12/2016	0,9	4,6	4,1				4,1
04/12/2016	0,9	5,7	5,1				5,1
05/12/2016	0,9	5,6	5,0				5,0
06/12/2016	0,9	4,7	4,2				12,9
07/12/2016	0,9	3,7	3,3				3,3
08/12/2016	0,9	2,4	2,2	16,0	6,2456	9,7544	2,2

09/12/2016	0,9	4,4	4,0				4,0
10/12/2016	1,0	3,1	2,9				2,9
11/12/2016	1,0	6,7	6,4				6,4
12/12/2016	1,0	5,1	4,8				4,8
13/12/2016	1,0	1,4	1,3	9,0	0,1581	8,8419	1,3
14/12/2016	1,0	4,8	4,6				4,6
15/12/2016	1,0	5,1	4,8				4,8
16/12/2016	1,0	5,4	5,1				5,1
17/12/2016	1,0	5,2	4,9				4,9
18/12/2016	1,0	4,2	4,0		0		4,0
19/12/2016	1,0	4,1	3,9	6,0	0	6	3,9
20/12/2016	1,0	4,9	4,9				4,9
21/12/2016	1,0	5,3	5,3				5,3
22/12/2016	1,0	6,0	6,0				6,0
23/12/2016	1,0	2,1	2,1	6,0	0	6	2,1
24/12/2016	1,0	3,9	3,9				3,9
25/12/2016	1,0	5,2	5,2				5,2
26/12/2016	1,0	1,5	1,5		0		4,7
27/12/2016	1,0	2,7	2,7	14,0	5,2496	8,7504	2,7
28/12/2016	1,0	4,8	4,8	36,0	7,8496	28,1504	4,8
29/12/2016	1,0	4,0	4,0				4,0
30/12/2016	1,0	5,3	5,3				5,3
31/12/2016	1,0	5,8	5,8				5,8
01/01/2017	1,0	2,2	2,2	2,0	0	2	2,2
02/01/2017	1,2	3,2	3,7				3,7
03/01/2017	1,2	4,4	5,1	9,0	0,1581	8,8419	5,1
04/01/2017	1,2	1,8	2,1				2,1
05/01/2017	1,2	3,5	4,0				4,0
06/01/2017	1,2	4,6	5,3				5,3
07/01/2017	1,2	5,8	6,7				6,7

08/01/2017	1,2	2,3	2,6	9,0	0	9	2,6
09/01/2017	1,2	3,1	3,6				3,6
10/01/2017	1,2	3,4	3,9	35,0	7,475	27,525	3,9
11/01/2017	1,2	5,5	6,3				6,3
12/01/2017	1,2	5,8	6,7				6,7
13/01/2017	1,2	5,2	6,0				6,0
14/01/2017	1,2	2,1	2,4	7,0	0	7	2,4
15/01/2017	1,2	1,8	2,1	19,0	0,8786	18,1214	2,1
16/01/2017	1,2	1,2	1,4				1,4
17/01/2017	1,2	3,4	3,9				3,9
18/01/2017	1,2	6,7	7,7				7,7
19/01/2017	1,2	5,8	6,7				6,7
20/01/2017	1,2	6,2	7,1				7,1
21/01/2017	1,2	5,2	6,0				6,0
22/01/2017	1,2	8,4	9,7				9,7
23/01/2017	1,2	5,5	6,3				6,3
24/01/2017	1,2	6,0	6,9				6,9
25/01/2017	1,2	6,0	6,9				6,9
26/01/2017	1,2	6,0	6,9				6,9
27/01/2017	1,2	4,5	5,2				5,2
28/01/2017	1,2	4,6	5,3				17,6
29/01/2017	1,2	5,5	6,3				12,9
30/01/2017	1,2	6,1	7,0				7,0
31/01/2017	1,2	5,9	6,8				6,8
01/02/2017	1,2	2,8	3,2				3,2
02/02/2017	1,2	5,4	6,2				6,2
03/02/2017	1,2	5,7	6,6				6,6
04/02/2017	1,2	2,6	3,0				3,0
05/02/2017	1,2	4,8	5,5	10,0		10	5,5

06/02/2017	1,2	4,9	5,6				5,6
07/02/2017	1,2	5,0	5,8				5,8
08/02/2017	1,2	5,1	5,9				5,9
09/02/2017	1,2	5,8	6,7				6,7
10/02/2017	1,2	3,5	4,0	132,0	95,4236	36,6	4,0
11/02/2017	1,2	3,9	4,5	10,0	0,41	9,59	4,5
12/02/2017	1,2	3,6	4,1	8,0	0	8	4,1
13/02/2017	1,2	3,1	3,6		0		3,6
14/02/2017	1,2	3,5	4,0		0		4,0
15/02/2017	1,2	5,5	6,3		0		6,3
16/02/2017	1,2	1,1	1,3	30,0	5,68	24,32	1,3
17/02/2017	1,2	1,4	1,6	33,0	8,3014	24,6986	1,6
18/02/2017	1,2	1,1	1,3	10,0	0	10	1,3
19/02/2017	1,2	2,7	3,1		0		3,1
20/02/2017	1,2	4,2	4,8		0		4,8
21/02/2017	1,2	0,5	0,6	9,0	0,1581	8,8419	0,6
22/02/2017	1,2	4,1	4,7		0		4,7
23/02/2017	1,2	4,9	5,6		0		5,6
24/02/2017	1,2	3,6	4,1		0		4,1
25/02/2017	1,2	4,5	5,2		0		5,2
26/02/2017	1,2	4,5	5,2		0		17,0
27/02/2017	1,2	4,9	5,6		0		5,6
28/02/2017	1,2	3,1	3,6		0		11,8

CC (mm)	**PMP (mm)**	**ADT (mm)**	**p**	**AFA (mm)**	**NAP (mm)**	**Dr (mm)**	**RIE-GO (mm)**	**Dri**
83,3	38,0	45,4	0,4	18,1	65,2	4,3		79,0

83,3	38,0	45,4	0,4	18,1	65,2	8,6		74,8
83,3	38,0	45,4	0,4	18,1	65,2	12,7		70,6
83,3	38,0	45,4	0,4	18,1	65,2	17,8		65,5
83,3	38,0	45,4	0,4	18,1	65,2	22,9		60,4
83,3	38,0	45,4	0,4	18,1	65,2	35,8		47,5
83,3	38,0	45,4	0,4	18,1	65,2	4,1	35	79,2
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	4,0		79,3
83,3	38,0	45,4	0,4	18,1	65,2	6,9		76,4
83,3	38,0	45,4	0,4	18,1	65,2	13,3		70,0
83,3	38,0	45,4	0,4	18,1	65,2	0,0	23	83,3
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	4,6		78,7
83,3	38,0	45,4	0,4	18,1	65,2	9,4		73,9
83,3	38,0	45,4	0,4	18,1	65,2	0,0	23	83,3
83,3	38,0	45,4	0,4	18,1	65,2	4,9		78,4
83,3	38,0	45,4	0,4	18,1	65,2	8,9		74,4
83,3	38,0	45,4	0,4	18,1	65,2	0,0	23	83,3
83,3	38,0	45,4	0,4	18,1	65,2	4,9		78,4
83,3	38,0	45,4	0,4	18,1	65,2	10,2		73,1
83,3	38,0	45,4	0,4	18,1	65,2	16,2		67,1
83,3	38,0	45,4	0,4	18,1	65,2	12,3		71,0
83,3	38,0	45,4	0,4	18,1	65,2	16,2		67,1
83,3	38,0	45,4	0,4	18,1	65,2	21,4		61,9
83,3	38,0	45,4	0,4	18,1	65,2	26,1		57,2
83,3	38,0	45,4	0,4	18,1	65,2	20,1		63,2
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	4,0		79,3
83,3	38,0	45,4	0,4	18,1	65,2	9,3		74,0
83,3	38,0	45,4	0,4	18,1	65,2	15,1		68,2

83,3	38,0	45,4	0,4	18,1	65,2	15,3		68,0
83,3	38,0	45,4	0,4	18,1	65,2	19,0		64,3
83,3	38,0	45,4	0,4	18,1	65,2	15,2		68,1
83,3	38,0	45,4	0,4	18,1	65,2	17,3		66,0
83,3	38,0	45,4	0,4	18,1	65,2	0,0	23	83,3
83,3	38,0	45,4	0,4	18,1	65,2	5,3		78,0
83,3	38,0	45,4	0,4	18,1	65,2	12,0		71,3
83,3	38,0	45,4	0,4	18,1	65,2	5,6		77,7
83,3	38,0	45,4	0,4	18,1	65,2	9,2		74,1
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	6,3		77,0
83,3	38,0	45,4	0,4	18,1	65,2	13,0		70,3
83,3	38,0	45,4	0,4	18,1	65,2	19,0		64,3
83,3	38,0	45,4	0,4	18,1	65,2	14,4		68,9
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	1,4		81,9
83,3	38,0	45,4	0,4	18,1	65,2	5,3		78,0
83,3	38,0	45,4	0,4	18,1	65,2	13,0		70,3
83,3	38,0	45,4	0,4	18,1	65,2	19,7		63,6
83,3	38,0	45,4	0,4	18,1	65,2	0,0	23	83,3
83,3	38,0	45,4	0,4	18,1	65,2	6,0		77,3
83,3	38,0	45,4	0,4	18,1	65,2	15,7		67,6
83,3	38,0	45,4	0,4	18,1	65,2	22,0		61,3
83,3	38,0	45,4	0,4	18,1	65,2	0,0	23	83,3
83,3	38,0	45,4	0,4	18,1	65,2	6,9		76,4
83,3	38,0	45,4	0,4	18,1	65,2	13,8		69,5
83,3	38,0	45,4	0,4	18,1	65,2	19,0		64,3
83,3	38,0	45,4	0,4	18,1	65,2	36,6		46,7
83,3	38,0	45,4	0,4	18,1	65,2	49,5		33,8
83,3	38,0	45,4	0,4	18,1	65,2	6,5	35	76,8

83,3	38,0	45,4	0,4	18,1	65,2	13,3		70,0
83,3	38,0	45,4	0,4	18,1	65,2	16,5		66,8
83,3	38,0	45,4	0,4	18,1	65,2	0,0	23	83,3
83,3	38,0	45,4	0,4	18,1	65,2	6,6		76,7
83,3	38,0	45,4	0,4	18,1	65,2	9,5		73,8
83,3	38,0	45,4	0,4	18,1	65,2	5,1		78,2
83,3	38,0	45,4	0,4	18,1	65,2	10,7		72,6
83,3	38,0	45,4	0,4	18,1	65,2	0,0	23	83,3
83,3	38,0	45,4	0,4	18,1	65,2	5,9		77,4
83,3	38,0	45,4	0,4	18,1	65,2	12,5		70,8
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	3,6		79,7
83,3	38,0	45,4	0,4	18,1	65,2	7,6		75,7
83,3	38,0	45,4	0,4	18,1	65,2	13,9		69,4
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	3,1		80,2
83,3	38,0	45,4	0,4	18,1	65,2	7,9		75,4
83,3	38,0	45,4	0,4	18,1	65,2	0,0		83,3
83,3	38,0	45,4	0,4	18,1	65,2	4,7		78,6
83,3	38,0	45,4	0,4	18,1	65,2	10,4		73,0
83,3	38,0	45,4	0,4	18,1	65,2	14,5		68,8
83,3	38,0	45,4	0,4	18,1	65,2	19,7		63,6
83,3	38,0	45,4	0,4	18,1	65,2	36,7		46,6
83,3	38,0	45,4	0,4	18,1	65,2	19,3	23	64,0
83,3	38,0	45,4	0,4	18,1	65,2	31,1		52,2

BALANCE HIDRICO SITIO I. T 50 %

FECHA	**Kc**	**ET0 (mm)**	**ETc (mm)**	**Pp total (mm)**	**Escurr (mm)**	**Pp efect (mm)**	**ETa (mm)**	**CC (mm)**	**PMP (mm)**	**ADT (mm)**
01/12/2016	0,9	4,8	4,3			0,0	4,3	83,3	38,0	45,4
02/12/2016	0,9	4,7	4,2			0,0	4,2	83,3	38,0	45,4
03/12/2016	0,9	4,6	4,1			0,0	4,1	83,3	38,0	45,4
04/12/2016	0,9	5,7	5,1			0,0	5,1	83,3	38,0	45,4
05/12/2016	0,9	5,6	5,0			0,0	5,0	83,3	38,0	45,4
06/12/2016	0,9	4,7	4,2			0,0	4,2	83,3	38,0	45,4
07/12/2016	0,9	3,7	3,3			0,0	3,3	83,3	38,0	45,4
08/12/2016	0,9	2,4	2,2	16,0	6,2	9,8	2,2	83,3	38,0	45,4
09/12/2016	0,9	4,4	4,0			0,0	4,0	83,3	38,0	45,4
10/12/2016	1,0	3,1	2,9			0,0	2,9	83,3	38,0	45,4
11/12/2016	1,0	6,7	6,4			0,0	6,4	83,3	38,0	45,4
12/12/2016	1,0	5,1	4,8			0,0	4,8	83,3	38,0	45,4
13/12/2016	1,0	1,4	1,3	9,0	0,2	8,8	1,3	83,3	38,0	45,4
14/12/2016	1,0	4,8	4,6			0,0	4,6	83,3	38,0	45,4
15/12/2016	1,0	5,1	4,8			0,0	4,8	83,3	38,0	45,4
16/12/2016	1,0	5,4	5,1			0,0	5,1	83,3	38,0	45,4
17/12/2016	1,0	5,2	4,9			0,0	4,9	83,3	38,0	45,4
18/12/2016	1,0	4,2	4,0		0,0	0,0	4,0	83,3	38,0	45,4
19/12/2016	1,0	4,1	3,9	6,0	0,0	6,0	3,9	83,3	38,0	45,4
20/12/2016	1,0	4,9	4,9			0,0	4,9	83,3	38,0	45,4
21/12/2016	1,0	5,3	5,3			0,0	5,3	83,3	38,0	45,4
22/12/2016	1,0	6,0	6,0			0,0	6,0	83,3	38,0	45,4
23/12/2016	1,0	2,1	2,1	6,0	0,0	6,0	2,1	83,3	38,0	45,4
24/12/2016	1,0	3,9	3,9			0,0	3,9	83,3	38,0	45,4

25/12/2016	1,0	5,2	5,2			0,0	5,2	83,3	38,0	45,4
26/12/2016	1,0	1,5	1,5		0,0	0,0	1,5	83,3	38,0	45,4
27/12/2016	1,0	2,7	2,7	14,0	5,2	8,8	2,7	83,3	38,0	45,4
28/12/2016	1,0	4,8	4,8	36,0	7,8	28,2	4,8	83,3	38,0	45,4
29/12/2016	1,0	4,0	4,0			0,0	4,0	83,3	38,0	45,4
30/12/2016	1,0	5,3	5,3			0,0	5,3	83,3	38,0	45,4
31/12/2016	1,0	5,8	5,8			0,0	5,8	83,3	38,0	45,4
01/01/2017	1,0	2,2	2,2	2,0	0,0	2,0	2,2	83,3	38,0	45,4
02/01/2017	1,2	3,2	3,7			0,0	3,7	83,3	38,0	45,4
03/01/2017	1,2	4,4	5,1	9,0	0,2	8,8	5,1	83,3	38,0	45,4
04/01/2017	1,2	1,8	2,1			0,0	2,1	83,3	38,0	45,4
05/01/2017	1,2	3,5	4,0			0,0	4,0	83,3	38,0	45,4
06/01/2017	1,2	4,6	5,3			0,0	5,3	83,3	38,0	45,4
07/01/2017	1,2	5,8	6,7			0,0	6,7	83,3	38,0	45,4
08/01/2017	1,2	2,3	2,6	9,0	0,0	9,0	2,6	83,3	38,0	45,4
09/01/2017	1,2	3,1	3,6			0,0	3,6	83,3	38,0	45,4
10/01/2017	1,2	3,4	3,9	35,0	7,5	27,5	3,9	83,3	38,0	45,4
11/01/2017	1,2	5,5	6,3			0,0	6,3	83,3	38,0	45,4
12/01/2017	1,2	5,8	6,7			0,0	6,7	83,3	38,0	45,4
13/01/2017	1,2	5,2	6,0			0,0	6,0	83,3	38,0	45,4
14/01/2017	1,2	2,1	2,4	7,0	0,0	7,0	2,4	83,3	38,0	45,4
15/01/2017	1,2	1,8	2,1	19,0	0,9	18,1	2,1	83,3	38,0	45,4
16/01/2017	1,2	1,2	1,4			0,0	1,4	83,3	38,0	45,4
17/01/2017	1,2	3,4	3,9			0,0	3,9	83,3	38,0	45,4
18/01/2017	1,2	6,7	7,7			0,0	7,7	83,3	38,0	45,4
19/01/2017	1,2	5,8	6,7			0,0	6,7	83,3	38,0	45,4
20/01/2017	1,2	6,2	7,1			0,0	7,1	83,3	38,0	45,4
21/01/2017	1,2	5,2	6,0			0,0	6,0	83,3	38,0	45,4
22/01/2017	1,2	8,4	9,7			0,0	9,7	83,3	38,0	45,4
23/01/2017	1,2	5,5	6,3			0,0	6,3	83,3	38,0	45,4

24/01/2017	1,2	6,0	6,9			0,0	6,9	83,3	38,0	45,4
25/01/2017	1,2	6,0	6,9			0,0	6,9	83,3	38,0	45,4
26/01/2017	1,2	6,0	6,9			0,0	6,9	83,3	38,0	45,4
27/01/2017	1,2	4,5	5,2			0,0	5,2	83,3	38,0	45,4
28/01/2017	1,2	4,6	5,3			0,0	5,3	83,3	38,0	45,4
29/01/2017	1,2	5,5	6,3			0,0	6,3	83,3	38,0	45,4
30/01/2017	1,2	6,1	7,0			0,0	7,0	83,3	38,0	45,4
31/01/2017	1,2	5,9	6,8			0,0	6,8	83,3	38,0	45,4
01/02/2017	1,2	2,8	3,2			0,0	3,2	83,3	38,0	45,4
02/02/2017	1,2	5,4	6,2			0,0	6,2	83,3	38,0	45,4
03/02/2017	1,2	5,7	6,6			0,0	6,6	83,3	38,0	45,4
04/02/2017	1,2	2,6	3,0			0,0	3,0	83,3	38,0	45,4
05/02/2017	1,2	4,8	5,5	10,0		10,0	5,5	83,3	38,0	45,4
06/02/2017	1,2	4,9	5,6			0,0	5,6	83,3	38,0	45,4
07/02/2017	1,2	5,0	5,8			0,0	5,8	83,3	38,0	45,4
08/02/2017	1,2	5,1	5,9			0,0	5,9	83,3	38,0	45,4
09/02/2017	1,2	5,8	6,7			0,0	6,7	83,3	38,0	45,4
10/02/2017	1,2	3,5	4,0	132	95	36,6	4,0	83,3	38,0	45,4
11/02/2017	1,2	3,9	4,5	10,0	0,4	9,6	4,5	83,3	38,0	45,4
12/02/2017	1,2	3,6	4,1	8,0	0,0	8,0	4,1	83,3	38,0	45,4
13/02/2017	1,2	3,1	3,6		0,0	0,0	3,6	83,3	38,0	45,4
14/02/2017	1,2	3,5	4,0		0,0	0,0	4,0	83,3	38,0	45,4
15/02/2017	1,2	5,5	6,3		0,0	0,0	6,3	83,3	38,0	45,4
16/02/2017	1,2	1,1	1,3	30,0	5,7	24,3	1,3	83,3	38,0	45,4
17/02/2017	1,2	1,4	1,6	33,0	8,3	24,7	1,6	83,3	38,0	45,4
18/02/2017	1,2	1,1	1,3	10,0	0,0	10,0	1,3	83,3	38,0	45,4
19/02/2017	1,2	2,7	3,1		0,0	0,0	3,1	83,3	38,0	45,4
20/02/2017	1,2	4,2	4,8		0,0	0,0	4,8	83,3	38,0	45,4
21/02/2017	1,2	0,5	0,6	9,0	0,2	8,8	0,6	83,3	38,0	45,4
22/02/2017	1,2	4,1	4,7		0,0	0,0	4,7	83,3	38,0	45,4

23/02/2017	1,2	4,9	5,6		0,0	0,0	5,6	83,3	38,0	45,4
24/02/2017	1,2	3,6	4,1		0,0	0,0	4,1	83,3	38,0	45,4
25/02/2017	1,2	4,5	5,2		0,0	0,0	5,2	83,3	38,0	45,4
26/02/2017	1,2	4,5	5,2		0,0	0,0	5,2	83,3	38,0	45,4
27/02/2017	1,2	4,9	5,6		0,0	0,0	5,6	83,3	38,0	45,4
28/02/2017	1,2	3,1	3,6		0,0	0,0	3,6	83,3	38,0	45,4

p (fracción de agota-miento)	**AFA (mm)**	**NAP (mm)**	**Dr (mm)**	**Dri**	**Riego Neto (mm)**
0,5	22,7	60,6	4,3	79,0	
0,5	22,7	60,6	8,6	74,8	
0,5	22,7	60,6	12,7	70,6	
0,5	22,7	60,6	0,0	83,3	24,7
0,5	22,7	60,6	5,0	78,3	
0,5	22,7	60,6	9,3	74,0	
0,5	22,7	60,6	12,6	70,7	
0,5	22,7	60,6	5,0	78,3	
0,5	22,7	60,6	9,0	74,3	
0,5	22,7	60,6	11,9	71,4	
0,5	22,7	60,6	18,3	65,0	
0,5	22,7	60,6	23,1	60,2	
0,5	22,7	60,6	15,6	67,7	
0,5	22,7	60,6	20,2	63,1	
0,5	22,7	60,6	25,0	58,3	
0,5	22,7	60,6	0,1	83,2	30
0,5	22,7	60,6	5,1	78,2	
0,5	22,7	60,6	9,1	74,2	
0,5	22,7	60,6	7,0	76,3	
0,5	22,7	60,6	11,9	71,4	

0,5	22,7	60,6	17,2	66,1	
0,5	22,7	60,6	23,2	60,1	
0,5	22,7	60,6	0,0	83,3	28,1
0,5	22,7	60,6	3,9	79,4	
0,5	22,7	60,6	9,1	74,2	
0,5	22,7	60,6	10,6	72,7	
0,5	22,7	60,6	4,5	78,8	
0,5	22,7	60,6	0,0	83,3	
0,5	22,7	60,6	4,0	79,3	
0,5	22,7	60,6	9,3	74,0	
0,5	22,7	60,6	15,1	68,2	
0,5	22,7	60,6	15,3	68,0	
0,5	22,7	60,6	19,0	64,3	
0,5	22,7	60,6	15,2	68,1	
0,5	22,7	60,6	17,3	66,0	
0,5	22,7	60,6	21,3	62,0	
0,5	22,7	60,6	26,6	56,7	
0,5	22,7	60,6	7,3	76,0	26
0,5	22,7	60,6	0,9	82,4	
0,5	22,7	60,6	4,5	78,8	
0,5	22,7	60,6	0,0	83,3	
0,5	22,7	60,6	6,3	77,0	
0,5	22,7	60,6	13,0	70,3	
0,5	22,7	60,6	19,0	64,3	
0,5	22,7	60,6	14,4	68,9	
0,5	22,7	60,6	0,0	83,3	
0,5	22,7	60,6	1,4	81,9	
0,5	22,7	60,6	5,3	78,0	
0,5	22,7	60,6	13,0	70,3	
0,5	22,7	60,6	19,7	63,6	

0,5	22,7	60,6	26,8	56,5	
0,5	22,7	60,6	6,0	77,3	26,8
0,5	22,7	60,6	15,7	67,6	
0,5	22,7	60,6	22,0	61,3	
0,5	22,7	60,6	28,9	54,4	
0,5	22,7	60,6	6,9	76,4	28,9
0,5	22,7	60,6	13,8	69,5	
0,5	22,7	60,6	19,0	64,3	
0,5	22,7	60,6	24,3	59,0	
0,5	22,7	60,6	6,3	77,0	24,3
0,5	22,7	60,6	13,3	70,0	
0,5	22,7	60,6	20,1	63,2	
0,5	22,7	60,6	23,3	60,0	
0,5	22,7	60,6	6,5	76,8	23
0,5	22,7	60,6	13,1	70,2	
0,5	22,7	60,6	16,1	67,2	
0,5	22,7	60,6	11,6	71,7	
0,5	22,7	60,6	17,2	66,1	
0,5	22,7	60,6	23,0	60,3	
0,5	22,7	60,6	5,8	77,5	23
0,5	22,7	60,6	12,5	70,8	
0,5	22,7	60,6	0,0	83,3	
0,5	22,7	60,6	0,0	83,3	
0,5	22,7	60,6	0,0	83,3	
0,5	22,7	60,6	3,6	79,7	
0,5	22,7	60,6	7,6	75,7	
0,5	22,7	60,6	13,9	69,4	
0,5	22,7	60,6	0,0	83,3	
0,5	22,7	60,6	0,0	83,3	
0,5	22,7	60,6	0,0	83,3	

0,5	22,7	60,6	3,1	80,2	
0,5	22,7	60,6	7,9	75,4	
0,5	22,7	60,6	0,0	83,3	
0,5	22,7	60,6	4,7	78,6	
0,5	22,7	60,6	10,4	73,0	
0,5	22,7	60,6	14,5	68,8	
0,5	22,7	60,6	19,7	63,6	
0,5	22,7	60,6	24,8	58,5	
0,5	22,7	60,6	5,7	77,6	24,8
0,5	22,7	60,6	9,2	74,1	

BALANCE HIDRICO SITIO II. T 40 %

FECHA	Kc	ET0 (mm)	ETc (mm)	Pp total (mm)	Esc. (mm)	Pp efec. (mm)	ETa (mm)	CC (mm)	PMP (mm)
01/12/2016	0,9	4,8	4,3				4,3	100	38
02/12/2016	0,9	4,7	4,2				4,2	100	38
03/12/2016	0,9	4,6	4,1				4,1	100	38
04/12/2016	0,9	5,7	5,1				5,1	100	38
05/12/2016	0,9	5,6	5,0				5,0	100	38
06/12/2016	0,9	4,7	4,2				4,2	100	38
07/12/2016	0,9	3,7	3,3				3,1	100	38
08/12/2016	0,9	2,4	2,2	16,0	6,2	9,8	2,2	100	38
09/12/2016	0,9	4,4	4,0				4,0	100	38
10/12/2016	1,0	3,1	2,9				2,9	100	38
11/12/2016	1,0	6,7	6,4				6,4	100	38
12/12/2016	1,0	5,1	4,8				4,8	100	38
13/12/2016	1,0	1,4	1,3	9,0	0,2	8,8	1,3	100	38
14/12/2016	1,0	4,8	4,6				4,6	100	38

15/12/2016	1,0	5,1	4,8				4,8	100	38
16/12/2016	1,0	5,4	5,1				5,1	100	38
17/12/2016	1,0	5,2	4,9				4,9	100	38
18/12/2016	1,0	4,2	4,0		0,0		4,0	100	38
19/12/2016	1,0	4,1	3,9	6,0	0,0	6,0	3,9	100	38
20/12/2016	1,0	4,9	4,9				4,9	100	38
21/12/2016	1,0	5,3	5,3				5,3	100	38
22/12/2016	1,0	6,0	6,0				6,0	100	38
23/12/2016	1,0	2,1	2,1	6,0	0,0	6,0	2,1	100	38
24/12/2016	1,0	3,9	3,9				3,9	100	38
25/12/2016	1,0	5,2	5,2				5,2	100	38
26/12/2016	1,0	1,5	1,5		0,0		1,4	100	38
27/12/2016	1,0	2,7	2,7	14,0	5,2	8,8	2,7	100	38
28/12/2016	1,0	4,8	4,8	36,0	7,8	28,2	4,8	100	38
29/12/2016	1,0	4,0	4,0				4,0	100	38
30/12/2016	1,0	5,3	5,3				5,3	100	38
31/12/2016	1,0	5,8	5,8				5,8	100	38
01/01/2017	1,0	2,2	2,2	2,0	0,0	2,0	2,2	100	38
02/01/2017	1,2	3,2	3,7				3,7	100	38
03/01/2017	1,2	4,4	5,1	9,0	0,2	8,8	5,1	100	38
04/01/2017	1,2	1,8	2,1				2,1	100	38
05/01/2017	1,2	3,5	4,0				4,0	100	38
06/01/2017	1,2	4,6	5,3				5,3	100	38
07/01/2017	1,2	5,8	6,7				6,4	100	38
08/01/2017	1,2	2,3	2,6	9,0	0,0	9,0	2,6	100	38
09/01/2017	1,2	3,1	3,6				3,6	100	38
10/01/2017	1,2	3,4	3,9	35,0	7,5	27,5	3,9	100	38
11/01/2017	1,2	5,5	6,3				6,3	100	38
12/01/2017	1,2	5,8	6,7				6,7	100	38
13/01/2017	1,2	5,2	6,0				6,0	100	38

14/01/2017	1,2	2,1	2,4	7,0	0,0	7,0	2,4	100	38
15/01/2017	1,2	1,8	2,1	19,0	0,9	18,1	2,1	100	38
16/01/2017	1,2	1,2	1,4				1,4	100	38
17/01/2017	1,2	3,4	3,9				3,9	100	38
18/01/2017	1,2	6,7	7,7				7,7	100	38
19/01/2017	1,2	5,8	6,7				6,7	100	38
20/01/2017	1,2	6,2	7,1				7,1	100	38
21/01/2017	1,2	5,2	6,0				5,7	100	38
22/01/2017	1,2	8,4	9,7				9,7	100	38
23/01/2017	1,2	5,5	6,3				6,3	100	38
24/01/2017	1,2	6,0	6,9				6,9	100	38
25/01/2017	1,2	6,0	6,9				6,2	100	38
26/01/2017	1,2	6,0	6,9				6,9	100	38
27/01/2017	1,2	4,5	5,2				5,2	100	38
28/01/2017	1,2	4,6	5,3				5,3	100	38
29/01/2017	1,2	5,5	6,3				6,3	100	38
30/01/2017	1,2	6,1	7,0				6,1	100	38
31/01/2017	1,2	5,9	6,8				6,8	100	38
01/02/2017	1,2	2,8	3,2				3,2	100	38
02/02/2017	1,2	5,4	6,2				6,2	100	38
03/02/2017	1,2	5,7	6,6				6,6	100	38
04/02/2017	1,2	2,6	3,0				2,7	100	38
05/02/2017	1,2	4,8	5,5	10,0		10,0	5,5	100	38
06/02/2017	1,2	4,9	5,6				5,6	100	38
07/02/2017	1,2	5,0	5,8				5,8	100	38
08/02/2017	1,2	5,1	5,9				5,9	100	38
09/02/2017	1,2	5,8	6,7				6,7	100	38
10/02/2017	1,2	3,5	4,0	132,0	95,4	36,6	4,0	100	38
11/02/2017	1,2	3,9	4,5	10,0	0,4	9,6	4,5	100	38
12/02/2017	1,2	3,6	4,1	8,0	0,0	8,0	4,1	100	38

13/02/2017	1,2	3,1	3,6		0,0		3,6	100	38
14/02/2017	1,2	3,5	4,0		0,0		4,0	100	38
15/02/2017	1,2	5,5	6,3		0,0		6,3	100	38
16/02/2017	1,2	1,1	1,3	30,0	5,7	24,3	1,3	100	38
17/02/2017	1,2	1,4	1,6	33,0	8,3	24,7	1,6	100	38
18/02/2017	1,2	1,1	1,3	10,0	0,0	10,0	1,3	100	38
19/02/2017	1,2	2,7	3,1		0,0		3,1	100	38
20/02/2017	1,2	4,2	4,8		0,0		4,8	100	38
21/02/2017	1,2	0,5	0,6	9,0	0,2	8,8	0,6	100	38
22/02/2017	1,2	4,1	4,7		0,0		4,7	100	38
23/02/2017	1,2	4,9	5,6		0,0		5,6	100	38
24/02/2017	1,2	3,6	4,1		0,0		4,1	100	38
25/02/2017	1,2	4,5	5,2		0,0		5,2	100	38
26/02/2017	1,2	4,5	5,2		0,0		5,2	100	38
27/02/2017	1,2	4,9	5,6		0,0		5,6	100	38
28/02/2017	1,2	3,1	3,6		0,0		3,0	100	38

ADT (mm)	**p (fracción de agota-miento)**	**AFA (mm)**	**NAP (mm)**	**RIEGO (mm)**	**Balance**
62,5	0,4	25,0	75,4		96,1
62,5	0,4	25,0	75,4		91,9
62,5	0,4	25,0	75,4		87,7
62,5	0,4	25,0	75,4		82,6
62,5	0,4	25,0	75,4		77,5
62,5	0,4	25,0	75,4		73,3
62,5	0,4	25,0	75,4	40,0	97,3
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		96,4
62,5	0,4	25,0	75,4		93,5

62,5	0,4	25,0	75,4		87,1
62,5	0,4	25,0	75,4		82,3
62,5	0,4	25,0	75,4		89,8
62,5	0,4	25,0	75,4		85,2
62,5	0,4	25,0	75,4		80,4
62,5	0,4	25,0	75,4		75,3
62,5	0,4	25,0	75,4		95,5
62,5	0,4	25,0	75,4		91,5
62,5	0,4	25,0	75,4		93,6
62,5	0,4	25,0	75,4		88,7
62,5	0,4	25,0	75,4		83,4
62,5	0,4	25,0	75,4		77,4
62,5	0,4	25,0	75,4		81,3
62,5	0,4	25,0	75,4		77,4
62,5	0,4	25,0	75,4		72,2
62,5	0,4	25,0	75,4		99,0
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		96,4
62,5	0,4	25,0	75,4		91,1
62,5	0,4	25,0	75,4		85,3
62,5	0,4	25,0	75,4		85,1
62,5	0,4	25,0	75,4		81,4
62,5	0,4	25,0	75,4		85,2
62,5	0,4	25,0	75,4		83,1
62,5	0,4	25,0	75,4		79,1
62,5	0,4	25,0	75,4		73,8
62,5	0,4	25,0	75,4	18,0	94,0
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		96,8

62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		94,1
62,5	0,4	25,0	75,4		87,4
62,5	0,4	25,0	75,4		81,4
62,5	0,4	25,0	75,4		86,0
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		99,0
62,5	0,4	25,0	75,4		95,1
62,5	0,4	25,0	75,4		87,4
62,5	0,4	25,0	75,4		80,7
62,5	0,4	25,0	75,4		73,6
62,5	0,4	25,0	75,4	27,0	94,7
62,5	0,4	25,0	75,4		85,0
62,5	0,4	25,0	75,4		78,7
62,5	0,4	25,0	75,4		71,8
62,5	0,4	25,0	75,4		94,2
62,5	0,4	25,0	75,4		87,3
62,5	0,4	25,0	75,4	27,0	82,1
62,5	0,4	25,0	75,4		76,8
62,5	0,4	25,0	75,4		70,5
62,5	0,4	25,0	75,4		94,3
62,5	0,4	25,0	75,4		87,5
62,5	0,4	25,0	75,4		84,3
62,5	0,4	25,0	75,4	27,0	78,1
62,5	0,4	25,0	75,4		71,5
62,5	0,4	25,0	75,4		97,7
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		94,8
62,5	0,4	25,0	75,4		89,0
62,5	0,4	25,0	75,4	26,0	83,2

62,5	0,4	25,0	75,4		76,5
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		96,8
62,5	0,4	25,0	75,4		92,8
62,5	0,4	25,0	75,4		86,5
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		97,3
62,5	0,4	25,0	75,4		92,5
62,5	0,4	25,0	75,4		100,4
62,5	0,4	25,0	75,4		95,7
62,5	0,4	25,0	75,4		90,1
62,5	0,4	25,0	75,4		85,9
62,5	0,4	25,0	75,4		80,7
62,5	0,4	25,0	75,4		75,6
62,5	0,4	25,0	75,4		69,9
62,5	0,4	25,0	75,4	30,0	97,4

BALANCE HIDRICO SITIO II. T 50 %

FECHA	**Kc**	**ET0 (mm)**	**ETc (mm)**	**Pp tota l (mm)**	**Esc. (mm)**	**Pp efec. (mm)**	**ETa (mm)**	**CC (mm)**	**PMP (mm)**
01/12/2016	0,9	4,8	4,3			0,0	4,3	100,4	37,9
02/12/2016	0,9	4,7	4,2			0,0	4,2	100,4	37,9
03/12/2016	0,9	4,6	4,1			0,0	4,1	100,4	37,9
04/12/2016	0,9	5,7	5,1			0,0	5,1	100,4	37,9

05/12/2016	0,9	5,6	5,0			0,0	5,0	100,4	37,9
06/12/2016	0,9	4,7	4,2			0,0	4,2	100,4	37,9
07/12/2016	0,9	3,7	3,3			0,0	3,3	100,4	37,9
08/12/2016	0,9	2,4	2,2	16,0	6,2	9,8	2,2	100,4	37,9
09/12/2016	0,9	4,4	4,0			0,0	4,0	100,4	37,9
10/12/2016	1,0	3,1	2,9			0,0	2,9	100,4	37,9
11/12/2016	1,0	6,7	6,4			0,0	6,4	100,4	37,9
12/12/2016	1,0	5,1	4,8			0,0	4,8	100,4	37,9
13/12/2016	1,0	1,4	1,3	9,0	0,2	8,8	1,3	100,4	37,9
14/12/2016	1,0	4,8	4,6			0,0	4,6	100,4	37,9
15/12/2016	1,0	5,1	4,8			0,0	4,8	100,4	37,9
16/12/2016	1,0	5,4	5,1			0,0	5,1	100,4	37,9
17/12/2016	1,0	5,2	4,9			0,0	4,9	100,4	37,9
18/12/2016	1,0	4,2	4,0		0,0	0,0	4,0	100,4	37,9
19/12/2016	1,0	4,1	3,9	6,0	0,0	6,0	3,9	100,4	37,9
20/12/2016	1,0	4,9	4,9			0,0	4,9	100,4	37,9
21/12/2016	1,0	5,3	5,3			0,0	5,3	100,4	37,9
22/12/2016	1,0	6,0	6,0			0,0	6,0	100,4	37,9
23/12/2016	1,0	2,1	2,1	6,0	0,0	6,0	2,1	100,4	37,9
24/12/2016	1,0	3,9	3,9			0,0	3,9	100,4	37,9
25/12/2016	1,0	5,2	5,2			0,0	5,2	100,4	37,9
26/12/2016	1,0	1,5	1,5		0,0	0,0	1,5	100,4	37,9
27/12/2016	1,0	2,7	2,7	14,0	5,2	8,8	2,7	100,4	37,9
28/12/2016	1,0	4,8	4,8	36,0	7,8	28,2	4,8	100,4	37,9
29/12/2016	1,0	4,0	4,0			0,0	4,0	100,4	37,9
30/12/2016	1,0	5,3	5,3			0,0	5,3	100,4	37,9
31/12/2016	1,0	5,8	5,8			0,0	5,8	100,4	37,9
01/01/2017	1,0	2,2	2,2	2,0	0,0	2,0	2,2	100,4	37,9
02/01/2017	1,2	3,2	3,7			0,0	3,7	100,4	37,9
03/01/2017	1,2	4,4	5,1	9,0	0,2	8,8	5,1	100,4	37,9

04/01/2017	1,2	1,8	2,1			0,0	2,1	100,4	37,9
05/01/2017	1,2	3,5	4,0			0,0	4,0	100,4	37,9
06/01/2017	1,2	4,6	5,3			0,0	5,3	100,4	37,9
07/01/2017	1,2	5,8	6,7			0,0	6,7	100,4	37,9
08/01/2017	1,2	2,3	2,6	9,0	0,0	9,0	2,6	100,4	37,9
09/01/2017	1,2	3,1	3,6			0,0	3,6	100,4	37,9
10/01/2017	1,2	3,4	3,9	35,0	7,5	27,5	3,9	100,4	37,9
11/01/2017	1,2	5,5	6,3			0,0	6,3	100,4	37,9
12/01/2017	1,2	5,8	6,7			0,0	6,7	100,4	37,9
13/01/2017	1,2	5,2	6,0			0,0	6,0	100,4	37,9
14/01/2017	1,2	2,1	2,4	7,0	0,0	7,0	2,4	100,4	37,9
15/01/2017	1,2	1,8	2,1	19,0	0,9	18,1	2,1	100,4	37,9
16/01/2017	1,2	1,2	1,4			0,0	1,4	100,4	37,9
17/01/2017	1,2	3,4	3,9			0,0	3,9	100,4	37,9
18/01/2017	1,2	6,7	7,7			0,0	7,7	100,4	37,9
19/01/2017	1,2	5,8	6,7			0,0	6,7	100,4	37,9
20/01/2017	1,2	6,2	7,1			0,0	7,1	100,4	37,9
21/01/2017	1,2	5,2	6,0			0,0	5,8	100,4	37,9
22/01/2017	1,2	8,4	9,7			0,0	7,7	100,4	37,9
23/01/2017	1,2	5,5	6,3			0,0	3,5	100,4	37,9
24/01/2017	1,2	6,0	6,9			0,0	6,9	100,4	37,9
25/01/2017	1,2	6,0	6,9			0,0	6,9	100,4	37,9
26/01/2017	1,2	6,0	6,9			0,0	6,9	100,4	37,9
27/01/2017	1,2	4,5	5,2			0,0	5,2	100,4	37,9
28/01/2017	1,2	4,6	5,3			0,0	4,7	100,4	37,9
29/01/2017	1,2	5,5	6,3			0,0	4,7	100,4	37,9
30/01/2017	1,2	6,1	7,0			0,0	4,1	100,4	37,9
31/01/2017	1,2	5,9	6,8			0,0	6,8	100,4	37,9
01/02/2017	1,2	2,8	3,2			0,0	3,2	100,4	37,9
02/02/2017	1,2	5,4	6,2			0,0	6,2	100,4	37,9

03/02/2017	1,2	5,7	6,6			0,0	6,6	100,4	37,9
04/02/2017	1,2	2,6	3,0			0,0	3,0	100,4	37,9
05/02/2017	1,2	4,8	5,5	10,0		10,0	5,5	100,4	37,9
06/02/2017	1,2	4,9	5,6			0,0	5,6	100,4	37,9
07/02/2017	1,2	5,0	5,8			0,0	5,8	100,4	37,9
08/02/2017	1,2	5,1	5,9			0,0	5,9	100,4	37,9
09/02/2017	1,2	5,8	6,7			0,0	6,7	100,4	37,9
10/02/2017	1,2	3,5	4,0	132,0	95,4	36,6	4,0	100,4	37,9
11/02/2017	1,2	3,9	4,5	10,0	0,4	9,6	4,5	100,4	37,9
12/02/2017	1,2	3,6	4,1	8,0	0,0	8,0	4,1	100,4	37,9
13/02/2017	1,2	3,1	3,6		0,0	0,0	3,6	100,4	37,9
14/02/2017	1,2	3,5	4,0		0,0	0,0	4,0	100,4	37,9
15/02/2017	1,2	5,5	6,3		0,0	0,0	6,3	100,4	37,9
16/02/2017	1,2	1,1	1,3	30,0	5,7	24,3	1,3	100,4	37,9
17/02/2017	1,2	1,4	1,6	33,0	8,3	24,7	1,6	100,4	37,9
18/02/2017	1,2	1,1	1,3	10,0	0,0	10,0	1,3	100,4	37,9
19/02/2017	1,2	2,7	3,1		0,0	0,0	3,1	100,4	37,9
20/02/2017	1,2	4,2	4,8		0,0	0,0	4,8	100,4	37,9
21/02/2017	1,2	0,5	0,6	9,0	0,2	8,8	0,6	100,4	37,9
22/02/2017	1,2	4,1	4,7		0,0	0,0	4,7	100,4	37,9
23/02/2017	1,2	4,9	5,6		0,0	0,0	5,6	100,4	37,9
24/02/2017	1,2	3,6	4,1		0,0	0,0	4,1	100,4	37,9
25/02/2017	1,2	4,5	5,2		0,0	0,0	5,2	100,4	37,9
26/02/2017	1,2	4,5	5,2		0,0	0,0	5,2	100,4	37,9
27/02/2017	1,2	4,9	5,6		0,0	0,0	5,6	100,4	37,9
28/02/2017	1,2	3,1	3,6		0,0	0,0	3,6	100,4	37,9

ADT (mm)	**p (fracción de agota-miento)**	**AFA (mm)**	**NAP (mm)**	**Dr (mm)**	**RIEGO TEORICO GR**	**Balance**

62,5	0,5	31,3	69,2	4,3		96,1
62,5	0,5	31,3	69,2	8,6		91,9
62,5	0,5	31,3	69,2	12,7		87,7
62,5	0,5	31,3	69,2	17,8		82,6
62,5	0,5	31,3	69,2	22,9	33,7	77,5
62,5	0,5	31,3	69,2	27,1		73,3
62,5	0,5	31,3	69,2	30,4		70,0
62,5	0,5	31,3	69,2	22,8		77,6
62,5	0,5	31,3	69,2	0,0		100,4
62,5	0,5	31,3	69,2	2,9		97,5
62,5	0,5	31,3	69,2	9,3		91,1
62,5	0,5	31,3	69,2	14,2		86,2
62,5	0,5	31,3	69,2	6,6		93,8
62,5	0,5	31,3	69,2	11,2		89,2
62,5	0,5	31,3	69,2	16,0		84,4
62,5	0,5	31,3	69,2	21,2		79,2
62,5	0,5	31,3	69,2	26,1		74,3
62,5	0,5	31,3	69,2	30,1		70,3
62,5	0,5	31,3	69,2	28,0		72,4
62,5	0,5	31,3	69,2	32,9		67,5
62,5	0,5	31,3	69,2	0,0	32,7	100,4
62,5	0,5	31,3	69,2	6,0		94,4
62,5	0,5	31,3	69,2	2,1		98,3
62,5	0,5	31,3	69,2	6,0		94,4
62,5	0,5	31,3	69,2	11,2		89,2
62,5	0,5	31,3	69,2	12,7		87,7
62,5	0,5	31,3	69,2	6,6		93,8
62,5	0,5	31,3	69,2	0,0		100,4
62,5	0,5	31,3	69,2	4,0		96,4
62,5	0,5	31,3	69,2	9,3		91,1

62,5	0,5	31,3	69,2	15,1		85,3
62,5	0,5	31,3	69,2	15,3		85,1
62,5	0,5	31,3	69,2	19,0		81,4
62,5	0,5	31,3	69,2	15,2		85,2
62,5	0,5	31,3	69,2	17,3		83,1
62,5	0,5	31,3	69,2	21,3		79,1
62,5	0,5	31,3	69,2	26,6		73,8
62,5	0,5	31,3	69,2	33,3		67,1
62,5	0,5	31,3	69,2	26,9	33,0	73,5
62,5	0,5	31,3	69,2	30,5		69,9
62,5	0,5	31,3	69,2	6,8		93,6
62,5	0,5	31,3	69,2	13,2		87,2
62,5	0,5	31,3	69,2	19,8		80,6
62,5	0,5	31,3	69,2	25,8		74,6
62,5	0,5	31,3	69,2	21,2		79,2
62,5	0,5	31,3	69,2	5,2		95,2
62,5	0,5	31,3	69,2	6,5		93,9
62,5	0,5	31,3	69,2	10,5		89,9
62,5	0,5	31,3	69,2	18,2		82,2
62,5	0,5	31,3	69,2	24,9		75,5
62,5	0,5	31,3	69,2	32,0		68,4
62,5	0,5	31,3	69,2	37,8		62,6
62,5	0,5	31,3	69,2	45,5	32,8	54,9
62,5	0,5	31,3	69,2	48,9		51,5
62,5	0,5	31,3	69,2	15,8		84,6
62,5	0,5	31,3	69,2	22,7		77,7
62,5	0,5	31,3	69,2	29,6		70,8
62,5	0,5	31,3	69,2	34,8		65,6
62,5	0,5	31,3	69,2	39,5	32,0	60,9
62,5	0,5	31,3	69,2	44,1		56,3

62,5	0,5	31,3	69,2	48,3		52,1
62,5	0,5	31,3	69,2	15,0		85,4
62,5	0,5	31,3	69,2	18,3		82,1
62,5	0,5	31,3	69,2	24,5		75,9
62,5	0,5	31,3	69,2	31,0		69,4
62,5	0,5	31,3	69,2	34,0		66,4
62,5	0,5	31,3	69,2	29,5	32,0	70,9
62,5	0,5	31,3	69,2	35,2		65,2
62,5	0,5	31,3	69,2	0,9		99,5
62,5	0,5	31,3	69,2	6,8		93,6
62,5	0,5	31,3	69,2	13,5		86,9
62,5	0,5	31,3	69,2	0,0		100,4
62,5	0,5	31,3	69,2	0,0		100,4
62,5	0,5	31,3	69,2	0,0		100,4
62,5	0,5	31,3	69,2	3,6		96,8
62,5	0,5	31,3	69,2	7,6		92,8
62,5	0,5	31,3	69,2	13,9		86,5
62,5	0,5	31,3	69,2	0,0		100,4
62,5	0,5	31,3	69,2	0,0		100,4
62,5	0,5	31,3	69,2	0,0		100,4
62,5	0,5	31,3	69,2	3,1		97,3
62,5	0,5	31,3	69,2	7,9		92,5
62,5	0,5	31,3	69,2	0,0		100,4
62,5	0,5	31,3	69,2	4,7		95,7
62,5	0,5	31,3	69,2	10,4		90,1
62,5	0,5	31,3	69,2	14,5		85,9
62,5	0,5	31,3	69,2	19,7		80,7
62,5	0,5	31,3	69,2	24,8		75,6
62,5	0,5	31,3	69,2	30,5		69,9
62,5	0,5	31,3	69,2	34,0		66,4

ANÁLISIS ESTADÍSTICO

Análisis de producción de caña de sitio II

Procedimiento GLM

Información de nivel de clase		
Clase	Niveles	Valores
block	4	1 2 3 4
trat	4	1 2 3 4

Número de observaciones leídas	16
Número de observaciones usadas	16

Procedimiento GLM

Variable dependiente:

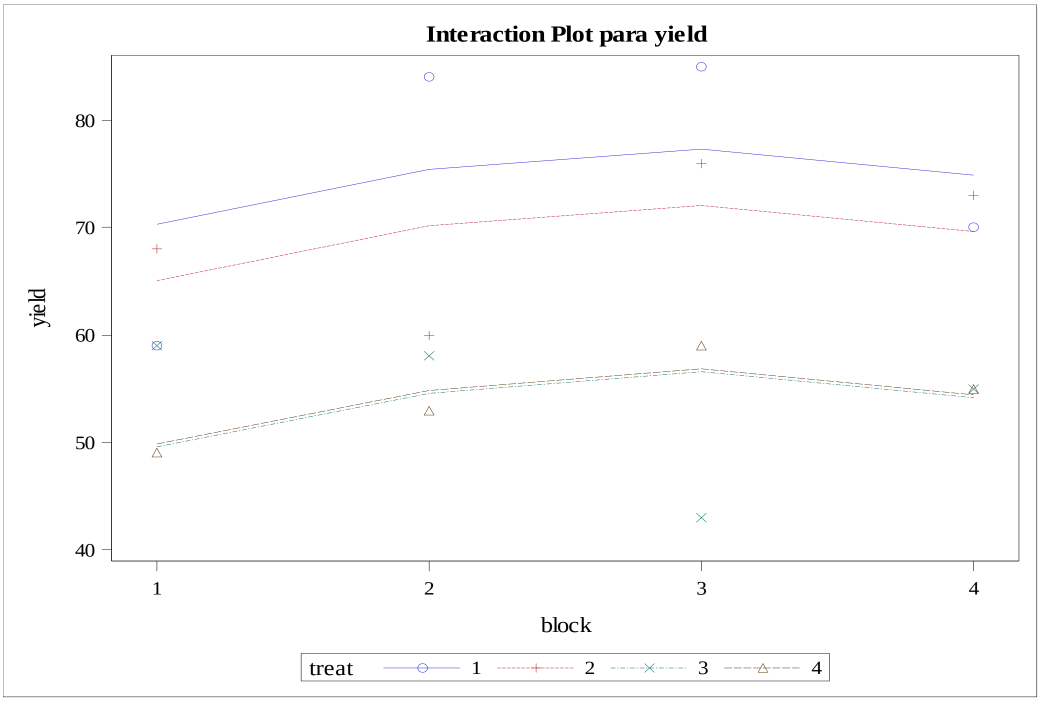
rendimiento

Fuente	DF	Suma de cuadrados	Cuadrado de la media	F-Valor	Pr > F
Modelo	6	1456,000000	242,666667	3,04	0,0653
Error	9	717,750000	79,750000		
Total corregido	15	2173,750000			

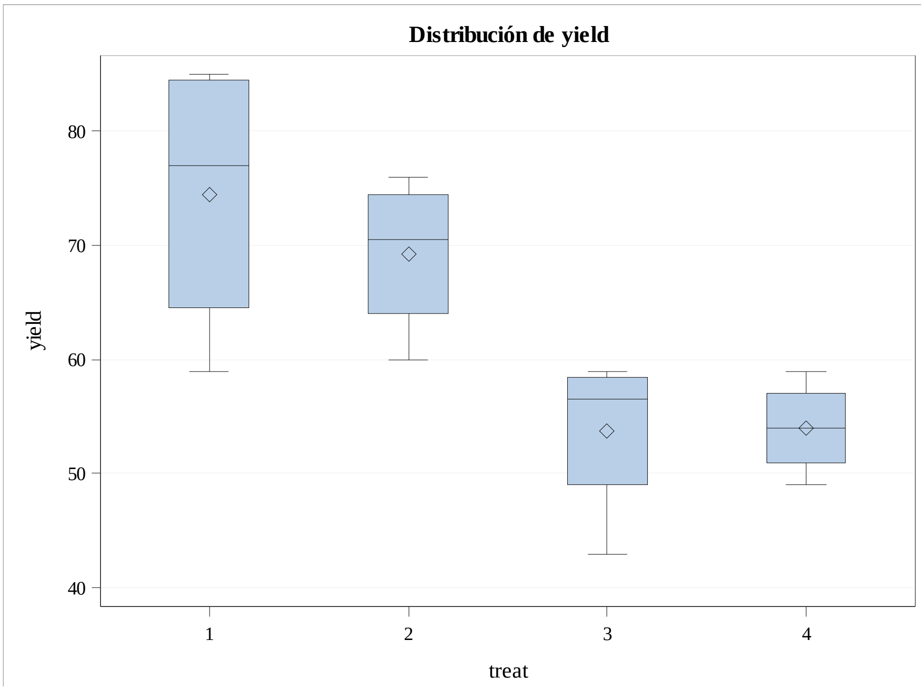
R-cuadrado	Coef Var	Raíz MSE	yield Media
0,669810	14,20324	8,930286	62,87500

Fuente	DF	Tipo I SS	Cuadrado de la media	F-Valor	Pr > F
block	3	104,750000	34,916667	0,44	0,7314
treat	3	1351,250000	450,416667	5,65	0,0187

Fuente	DF	Suma de cua-drados	Cuadrado de la media	F-Valor	Pr > F
Modelo	6	1456,000000	242,666667	3,04	0,0653
Block	3	104,750000	34,916667	0,44	0,7314
Tratamiento	3	1351,250000	450,416667	5,65	0,0187
Error	9	717,750000	79,750000		
Total corregido	15	2173,750000			



Procedimiento GLM



Procedimiento GL

t Tests (LSD) para rendimiento

Alpha	0,05
Grados de error de libertad	9
Error de cuadrado medio	79,75
Valor crítico de *t*	2,26216
Diferencia menos significativa	14,285

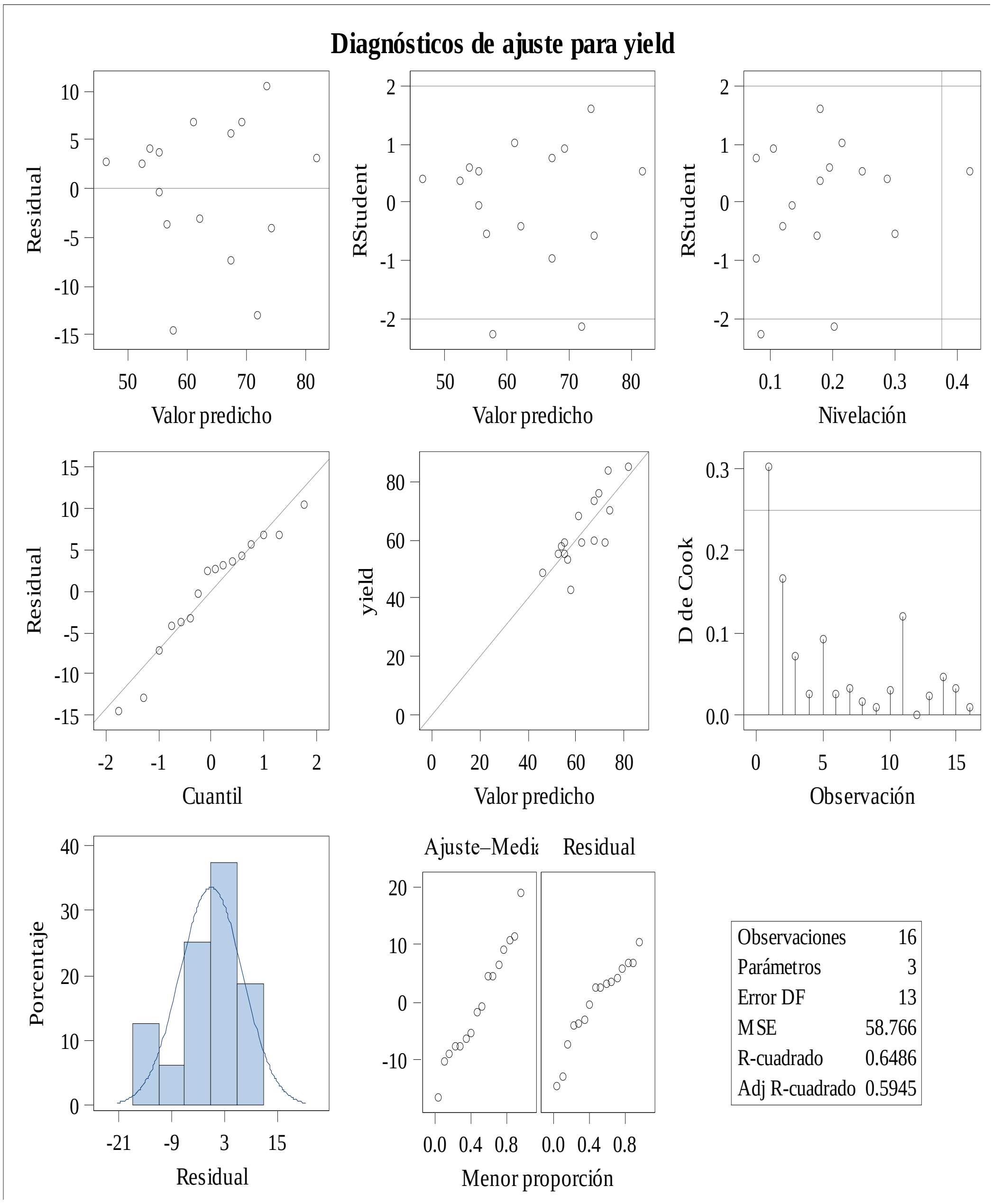
Procedimiento REG

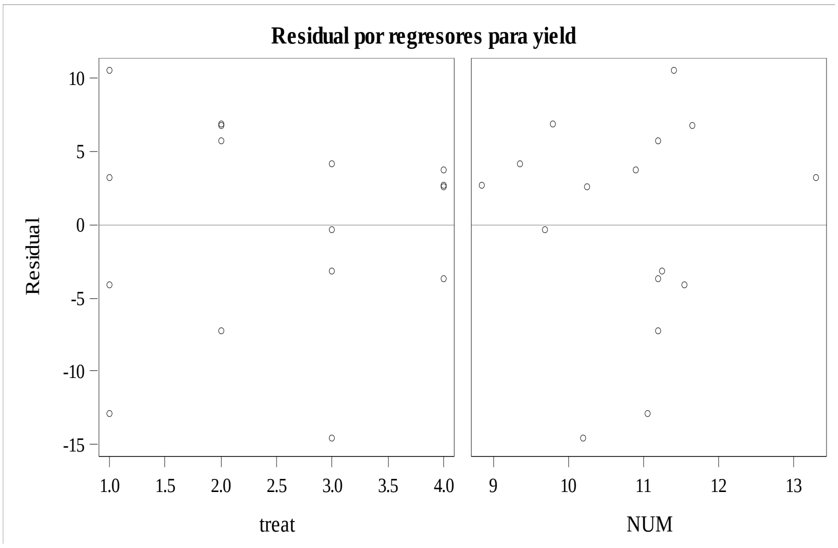
Modelo: MODEL1

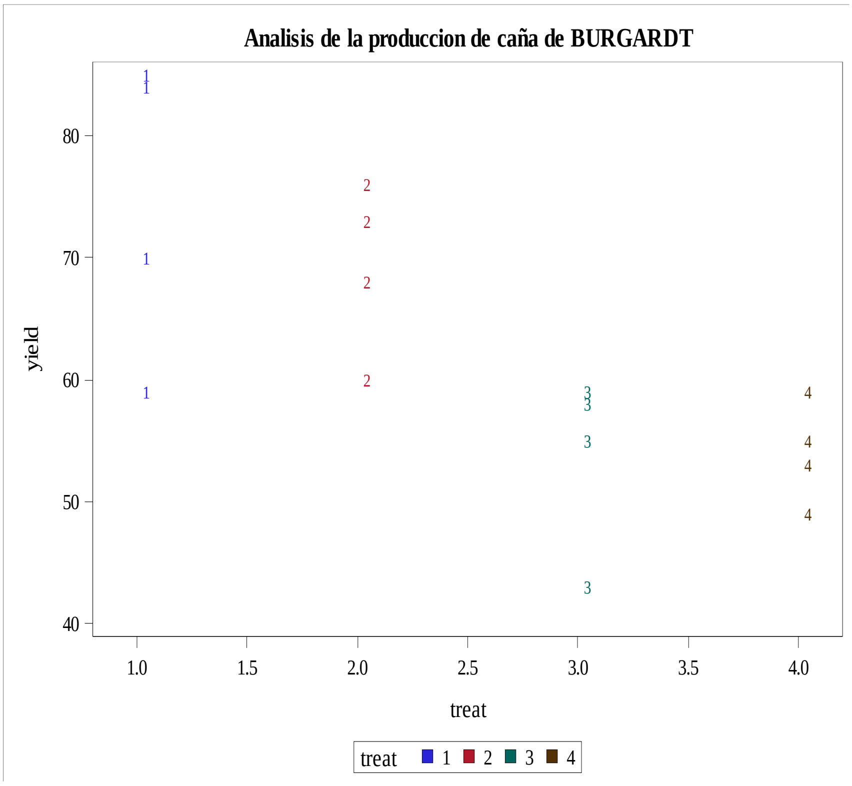
Procedimiento REG

Modelo: MODEL1

Variable dependiente: yield







Análisis de la producción de caña en los dos sitios

Procedimiento GLM

Información de nivel de clase		
Clase	Niveles	Valores
rep	4	1 2 3 4
trat	4	1 2 3 4
sitio	2	0 1

Número de observaciones leídas	32
Número de observaciones usadas	32

Procedimiento GLM

Variable dependiente: yield

Fuente	DF	Suma de cuadrados	Cuadrado de la media	F-Valor	Pr > F
Modelo	13	3603,656250	277,204327	4,49	0,0020
Error	18	1111,312500	61,739583		
Total corre-gido	31	4714,968750			

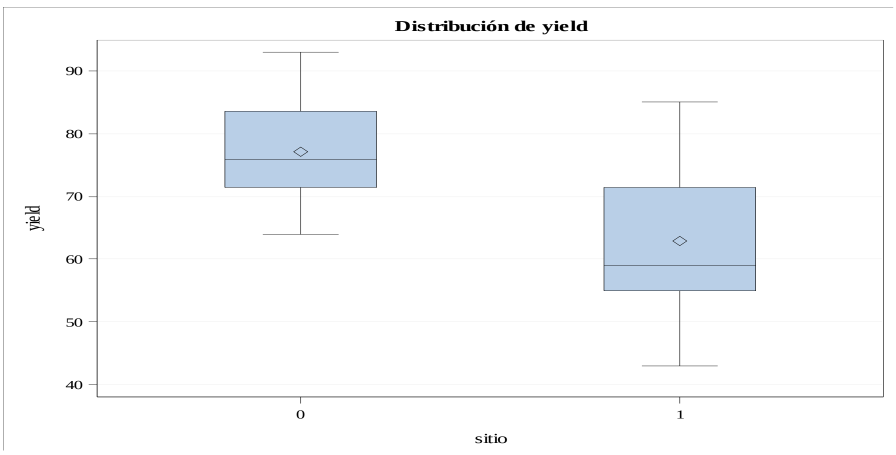
R-cuadrado	Coef Var	Raíz MSE	yield Media
0,764301	11,22995	7,857454	69,96875

Fuente	DF	Tipo I SS	Cuadrado de la media	F-Valor	Pr > F
sitio	1	1610,281250	1610,281250	26,08	<,0001

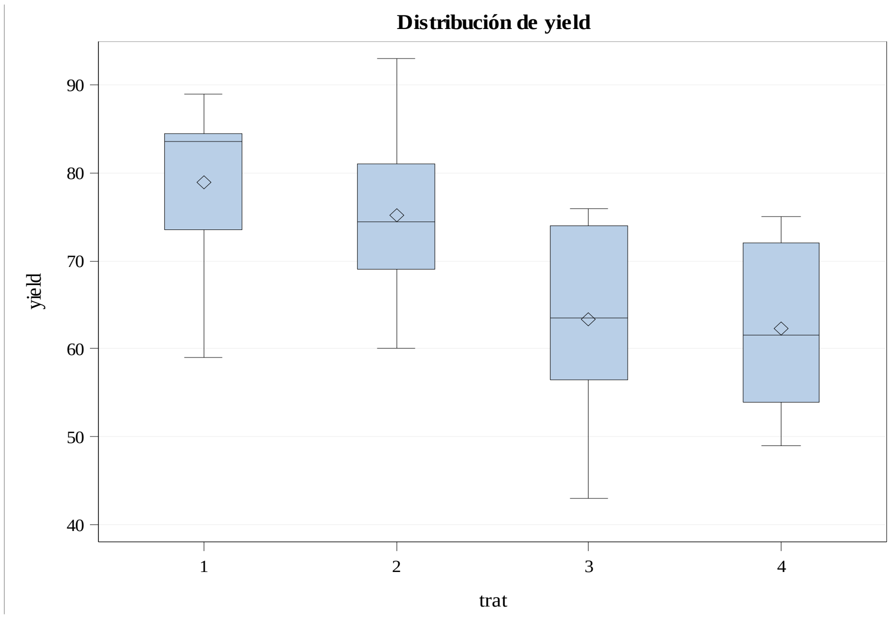
rep(sitio)	6	193,437500	32,239583	0,52	0,7841
trat	3	1666,843750	555,614583	9,00	0,0007
trat*sitio	3	133,093750	44,364583	0,72	0,5538

Fuente	DF	Tipo III SS	Cuadrado de la media	F-Valor	Pr > F
sitio	1	1610,281250	1610,281250	26,08	<,0001
rep(sitio)	6	193,437500	32,239583	0,52	0,7841
trat	3	1666,843750	555,614583	9,00	0,0007
trat*sitio	3	133,093750	44,364583	0,72	0,5538

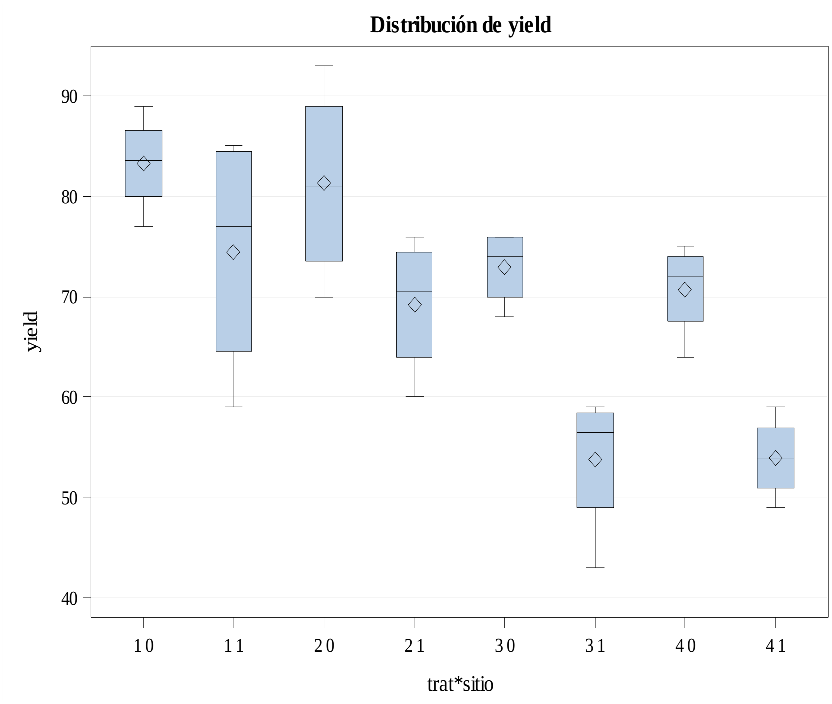
Procedimiento GLM



Nivel de sitio	N	yield	
		Media	Dev std
0	16	77,0625000	7,8779756
1	16	62,8750000	12,0381339



Nivel de trat	N	yield	
		Media	Dev std
1	8	78,8750000	9,9058064
2	8	75,2500000	10,2225242
3	8	63,3750000	11,6366109
4	8	62,3750000	9,8696866



Nivel de trat	Nivel de sitio	N	yield	
			Media	Dev std
1	0	4	83,2500000	4,9244289
1	1	4	74,5000000	12,3962360
2	0	4	81,2500000	9,9456858
2	1	4	69,2500000	6,9940451
3	0	4	73,0000000	3,8297084
3	1	4	53,7500000	7,3654599
4	0	4	70,7500000	4,7871355
4	1	4	54,0000000	4,1633320

Procedimiento GLM

Información de nivel de clase		
Clase	Niveles	Valores
trat	4	1 2 3 4

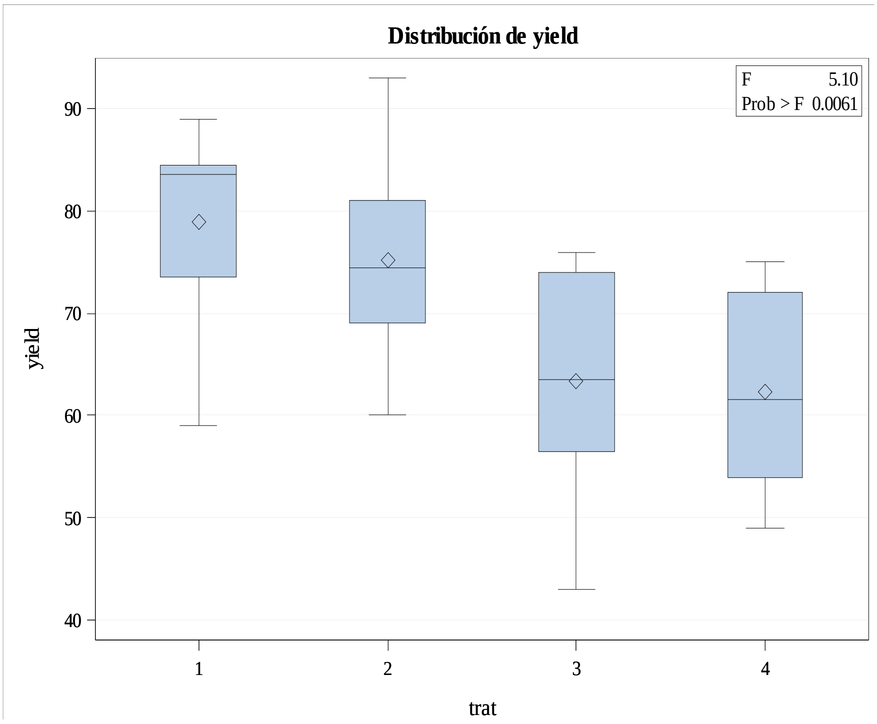
Número de observaciones leídas	32
Número de observaciones usadas	32

Variable dependiente: yield

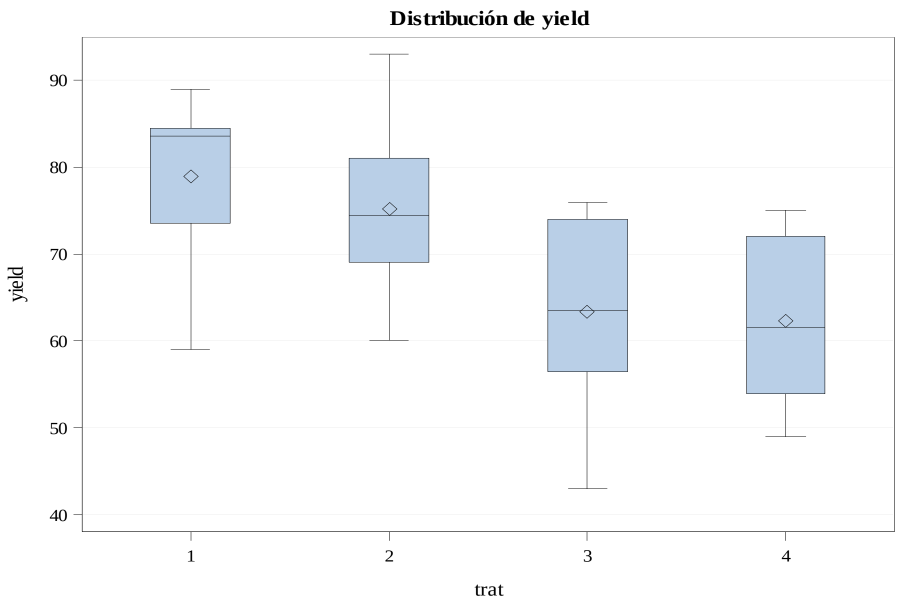
Fuente	DF	Suma de cuadrados	Cuadrado de la media	F-Valor	Pr > F
Modelo	3	1666,843750	555,614583	5,10	0,0061
Error	28	3048,125000	108,861607		
Total corregido	31	4714,968750			

R-cuadrado	Coef Var	Raíz MSE	yield Media
0,353522	14,91191	10,43368	69,96875

Fuente	DF	Tipo I SS	Cuadrado de la media	F-Valor	Pr > F
trat	3	1666,843750	555,614583	5,10	0,0061



Procedimiento GLM



Alpha	0,05
Grados de error de libertad	28

Error de cuadrado medio	108,8616
Valor crítico de *t*	2,04841
Diferencia menos significativa	10,686

Medias con la misma letra no son significativamente diferentes,			
t Agrupamiento	Media	N	trat
A	78,875	8	1
A			
A	75,250	8	2
B	63,375	8	3
B			
B	62,375	8	4

Análisis de la varianza					
Fuente	DF	Suma de cuadrados	Cuadrado de la media	F-Valor	Pr > F
Modelo	4	3612,38795	903,09699	22,12	<,0001
Error	27	1102,58080	40,83633		
Total corregido	31	4714,96875			

Raíz MSE	6,39033	R-cuadrado	0,7662
Media dependiente	69,96875	R-Sq Ajust	0,7315
Coef Var	9,13312		

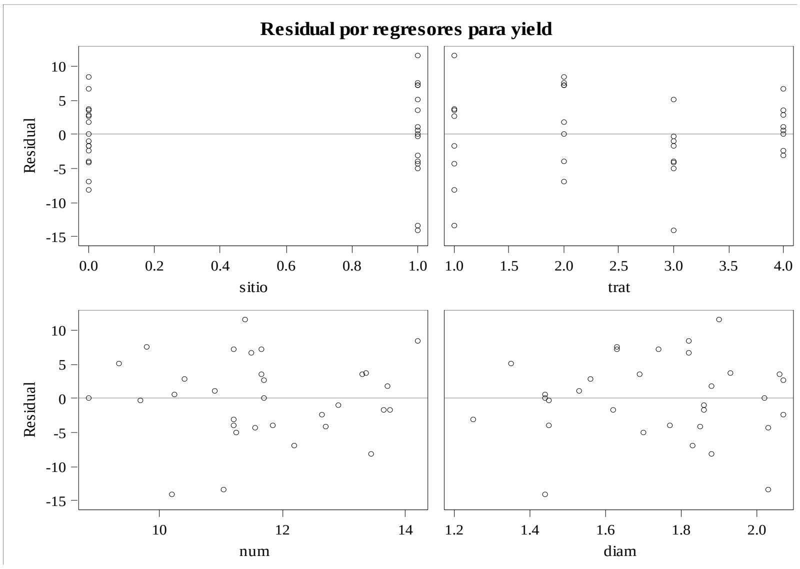
Estimadores de parámetros					
Variable	DF	Estimador del parámetro	Error estándar	Valor *t*	Pr > |*t*|
Intercept	1	15,75791	22,89115	0,69	0,4971
sitio	1	-4,97589	3,48993	-1,43	0,1654
trat	1	-2,87702	1,47213	-1,95	0,0611
num	1	3,86591	1,31280	2,94	0,0066
diam	1	10,75359	7,72414	1,39	0,1752

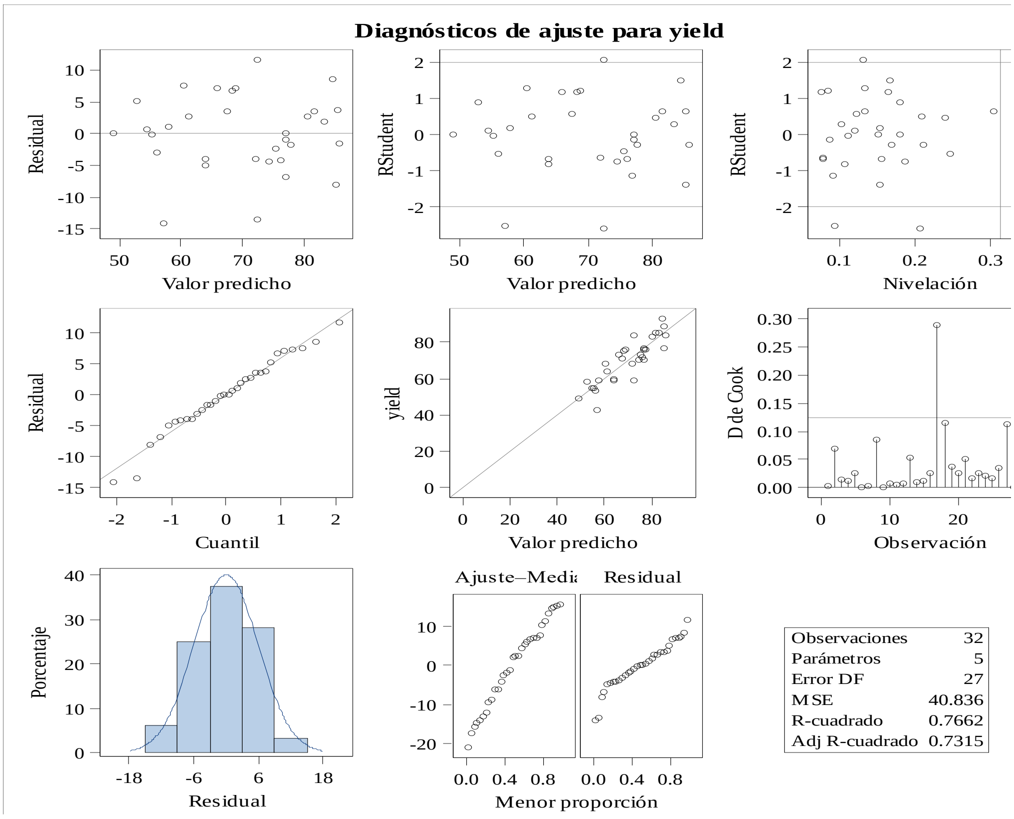
Procedimiento REG

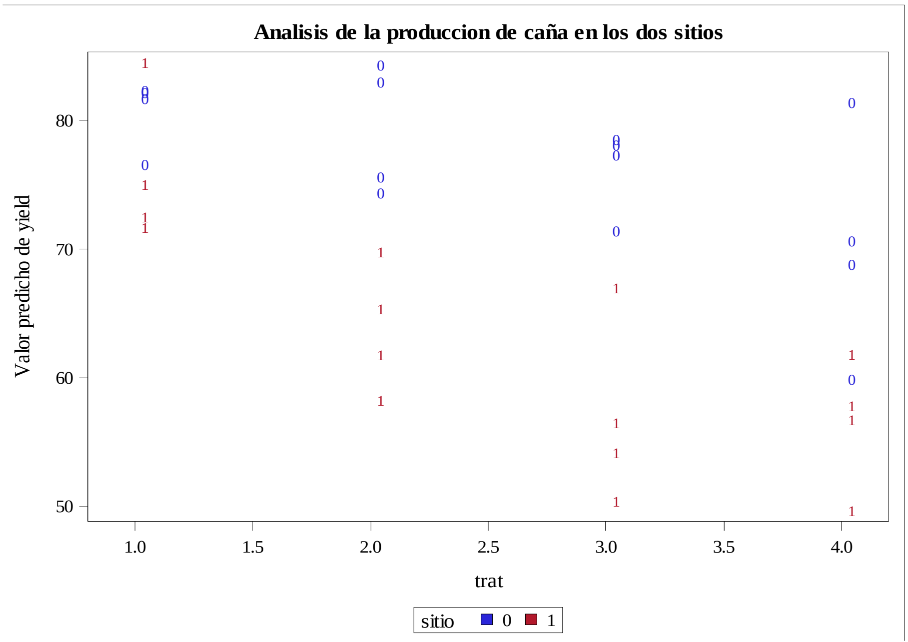
Modelo: MODEL1

Variable dependiente: yield

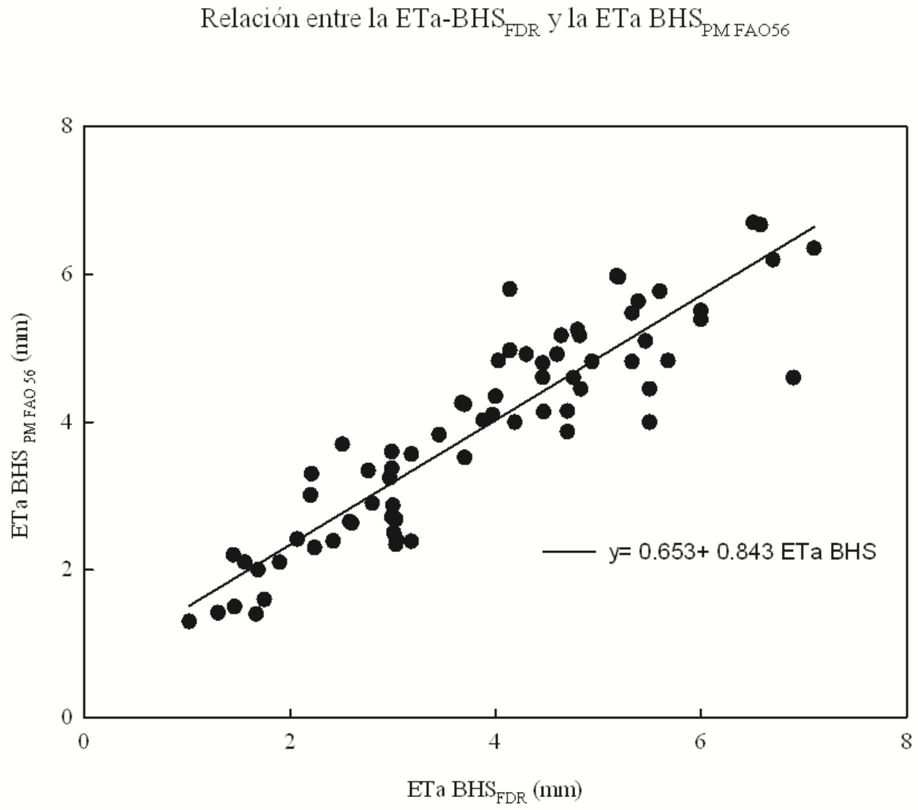
Número de observaciones leídas	32
Número de observaciones usadas	32




Diagnósticos de ajuste para yield
Residual
Valor predicho
RStudent
Nivelación
Cuantil
yield
D de Cook
Observación
Porcentaje
Residual
Ajuste–Medi
Residual
Menor proporción
Observaciones 32
Parámetros 5
Error DF 27
MSE 40.836
R-cuadrado 0.7662
Adj R-cuadrado 0.7315

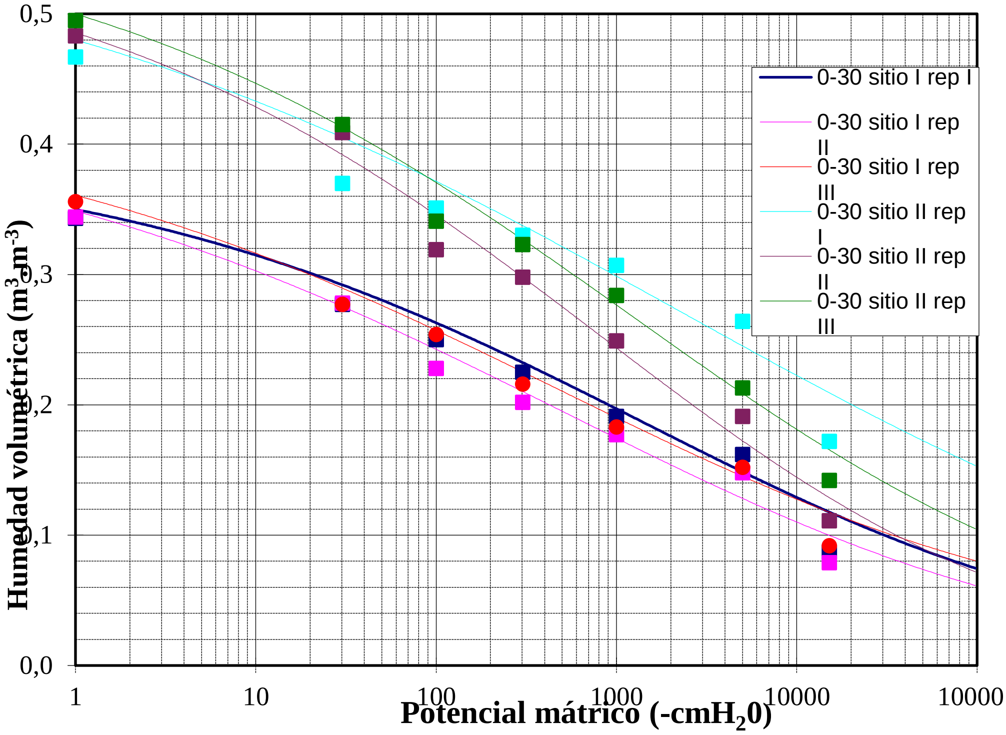

Analisis de la produccion de caña en los dos sitios
Valor predicho de yield
trat
sitio 0 1

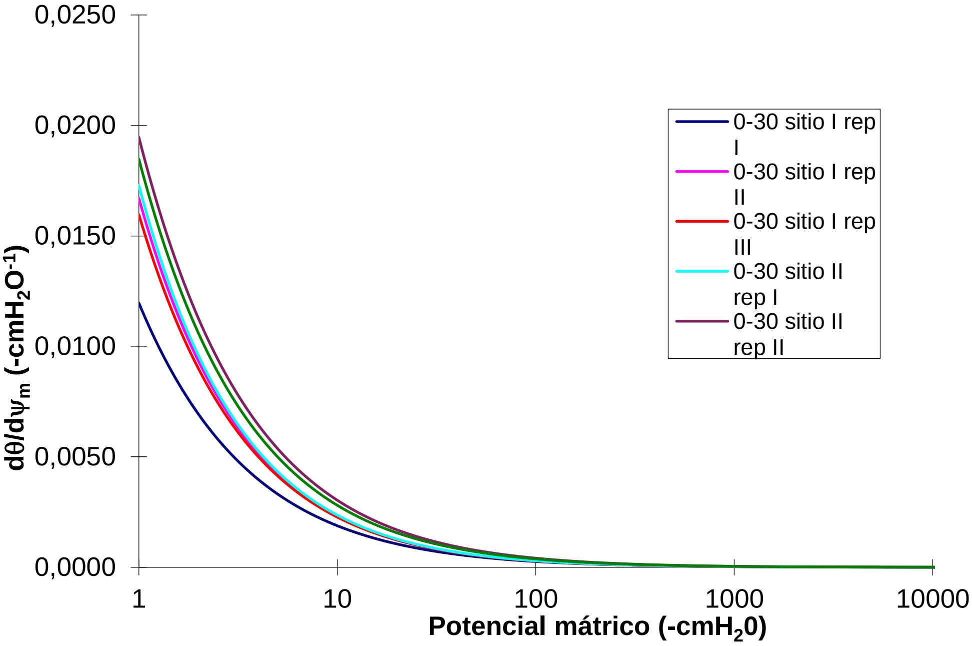
Evapotranspiración



PROPIEDADES HIDROFÍSICAS DEL SUELO

Curva de retención de humedad,


Humedad volumétrica ($m^3 m^{-3}$)
0,5
0,4
0,3
0,2
0,1
0,0
1
10
100
1000
10000
10000
Potencial mátrico ($-cmH_20$)
0-30 sitio I rep I
0-30 sitio I rep II
0-30 sitio I rep III
0-30 sitio II rep I
0-30 sitio II rep II
0-30 sitio II rep III


$d\theta/d\psi_m$ ($-cmH_2O^{-1}$)
0,0250
0,0200
0,0150
0,0100
0,0050
0,0000
1
10
100
1000
10000
Potencial mátrico ($-cmH_20$)
0-30 sitio I rep I
0-30 sitio I rep II
0-30 sitio I rep III
0-30 sitio II rep I
0-30 sitio II rep II