

## MAIZE SECOND SEASON IRRIGATED BY CENTER PIVOT IN SANDY SOIL

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**ABSTRACT:** The aim of this study is to evaluate the development of a corn (*Zea mays*) crop grown in Brazil on a sandy soil, in a Savannah climate, and under center pivot irrigation. A randomized complete block design with four replicates of three irrigation treatments including a rainfed control treatment ( $I_0$ ), a 100% replacement ( $I_1$ ), and a 200% replacement ( $I_2$ ) of crop evapotranspiration (ETc). The grain yield (P) and the plant characteristics including plant height (PH), corn cob insertion height (CIH), stem diameter (SD), and 100 grain mass (M100) were measured. The grain yield results were ( $I_2$ ) 9,634 kg ha<sup>-1</sup>, ( $I_1$ ) 7,680 kg ha<sup>-1</sup>, and ( $I_0$ ) 4,229 kg ha<sup>-1</sup>. All of the plant characteristic variables had higher values for irrigated treatments than for the rainfed treatment. For all except M100, the  $I_2$  treatment increased plant characteristic values the most. The  $I_1$  just treatment had the highest values for M100. The sandy soil has good drainage and a high soil infiltration rate, so the higher irrigation depth for  $I_2$  did not cause water logging and poor aeration in the soil. Maintaining a higher moisture content increased grain yield, but a cost-benefit analysis is needed to assess cost effectiveness from applying more water.

**KEY WORDS:** *Zea mays*, Grain Yield, Sandy Soil

## MILHO SEGUNDA SAFRA IRRIGADO VIA PIVO CENTRAL EM SOLO ARENOSO

**RESUMO:** O objetivo desse estudo foi avaliar o desenvolvimento da cultura do milho, (*Zea mays*), em solo arenoso na região do Cerrado Brasileiro, sob irrigação via sistema de Pivô Central. Utilizou-se delineamento experimental em blocos casualizados em área de Pivô Central, com quatro repetições de três tratamentos, sendo o sequeiro a Testemunha ( $I_0$ ), e as lâminas de 100% de reposição ( $I_1$ ) e 200% da reposição ( $I_2$ ) da Evapotranspiração da Cultura (ETc). Foram avaliadas as características morfológicas de Altura de Planta (AP), Altura de

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Inserção da Espiga (AIE), Diâmetro de Colmo (DC) e de produtividade, Massa de 100 grãos (M100) e Produtividade (P). A maior produtividade foi obtida no tratamento I<sub>2</sub>, atingindo 9.633,52 kg ha<sup>-1</sup>, seguido do I<sub>1</sub> com 7.679,99 kg ha<sup>-1</sup> e, o I<sub>0</sub> com 4.229,21 kg ha<sup>-1</sup>. Todas as variáveis analisadas superaram seus resultados nas condições irrigadas em relação ao sequeiro. Para todas as variáveis analisadas, exceto para M100, a lâmina de irrigação I<sub>2</sub> apresentou melhor desenvolvimento e expressou seu potencial produtivo. Já para M100 os maiores valores foram obtidos com a lâmina I<sub>1</sub>. Pôde-se concluir, que pelo fato do solo arenoso ter boa drenagem e alta velocidade de infiltração básica do solo, as lâminas I<sub>2</sub> não causaram excesso de água no solo. Os altos índices de umidade em solo arenoso podem contribuir para incrementos de produtividade, porém é necessário o estudo de viabilidade econômica para checar o custo benefício bem como a disponibilidade de recursos hídricos para se fazer isso.

**PALAVRAS-CHAVE:** *Zea mays*, Produtividade, Solo Arenoso.

## INTRODUCTION

The corn crop (*Zea mays*) presents great importance in the world, according to Ferreira et. Al., (2011), this is the result for the fact that it is destined to feed the human, animal and still serve as raw material for the industries. The use for animal feed is higher, it's between 60% and 80% of the country's production and it varies from year to year (Embrapa, 2008). Hybrids of this crop are adapted for cultivation both to first and second seasons, usually as a succession of soybean cultivation.

In the agricultural year 2015/16, according to Conab data, the total area of maize cultivation in Brazil reached 9,550,600 ha, which 64% were in the Midwest region and 16.9% in the state of Mato Grosso do Sul. South region, which in turn presents its largest area under Cerrado conditions with, generally, sandy soils, low natural nutrition and high acidity, the rainfall season is defined from September to April, and the other months are predominant dry.

Generally speaking, in these regions crop cultivation occurs in a rainfed system, and the main water supply comes from the rains that occur during its cycle. In the second season maize, it's common occurring drought periods, causing water stress and damaging the development of the plant, however, Silva et al., 2010, verified that under these conditions, when irrigation is used, increases the grain yield potential. According to Bergamaschi et al., 2006, the occurrence of water shortage from the pre-flowering period to the beginning of the grain filling, results a down in the grain yield.

Thus, an alternative to avoid water stress and low grain yield, is the supply of water to the crop at a time when rainfall is not sufficient to supply the water demand during its development and mainly in the reproductive phase, than it doesn't put down grain yield. Benjamin et. Al., 2014, emphasize that the rational use of irrigation guarantees sustainability and maximizes crop productivity.

Therefore the aim of this study is to evaluate the effect of different water depths in the maize in sandy soil in the Cerrado region of Mato Grosso do Sul.

### **MATERIAL AND METHODS**

The present research was carried out at Santo Antônio Farm, in the city of Paraíso das Águas - MS, with latitude 18°59'04 "South and longitude 52°54'60" West, and altitude of 664 meters.

The climate of the region is defined as tropical with dry season, according to a classification of Köppen, with average annual temperature of 25°C and average annual precipitation between 1600 and 1800 mm. The soil of the area is classified as Red Latosol (EMBRAPA, 2013).

The sowing of corn occurred on March 22, 2016, in cultural remains of soybeans, under center pivot system area. The hybrid used was the 2B810 PW.

A randomized block design with three irrigation levels (0, 100, 200% ETc) and four replications was set up in an area with two center pivots, where both were managed with 100% ETc replacement. However, in the area of overlap of these pivots, double water application was verified.

The experimental units consisted of 5 planting rows spaced at 0.45 m. In order to carry out the evaluation, 3 center lines with 4 m of length, totaling 5.4 m<sup>2</sup>, were classified as useful part.

The methodology for the management of irrigation was using meteorological data, through an automatic station of the National Institute of Meteorology (INMET), installed near the experimental area where the research was carried out. Estimates of ETo were obtained by the Penman Monteith-FAO method, according to Allen et al. (1998). The crop evapotranspiration (ETc) was obtained by the product of Reference Evapotranspiration (ETo) and the Cultivation Coefficient (Kc).

In order to monitor the water balance, the crop coefficients and depth of the root system of each subperiod (Table 1) were defined according to the recommendations of Detomini

(2009), where the gradual variation of the passage from one subperiod to the other was performed days after emergence.

The soil texture was classified as sandy (Table 2). Irrigations were performed only when the availability of groundwater approached the lower limit of the Readily available water (RAW), calculated by Equation 1.

$$RAW = (\theta_{FC} - \theta_{PMP}) * d * Z_r * p \quad (\text{Equation 1})$$

Where:

*RAW* – Readily available water, mm;

$\theta_{FC}$  – Water content at field capacity,  $\text{m}^3 \text{m}^{-3}$ ;

$\theta_{PMP}$  – Field Capacity,  $\text{m}^3 \text{m}^{-3}$ ;

*d* – Soil Density,  $\text{kg m}^{-3}$ ;

*Z<sub>r</sub>* – Effective Depth of Root System, m;

*p* – Depletion Fraction, adm.

Harvesting was carried out on August 03, 2015. The variables total plant height (PH), ear insertion height (EIH), stem diameter (SD), mass of one hundred grains (M100) and grain yield (GY) Were analyzed by the Tukey test at 5% probability.

## RESULTS AND DISCUSSION

Table 3 shows the relationship between the water depths applied in the treatments and the response of the culture to the variables evaluated. The low volume of rainfall during the crop cycle, directly affected the development of the crop in the rainfed treatment, Figures 1, 2 and 3, show the water balance of the period for each treatment.

In general, the best results came from the treatment with water depth of 200% ETc replacement, the plants developed very well, presenting higher plant height, stem insertion, stem diameter and productivity, this behavior can be explained by the better use of the nutrients by the plant, since it did not suffer from water stress, it had the favorable conditions, thus being able to express the maximum of its potential. The responses obtained with the 100% treatment of ETc replacement were intermediate to the other treatments, and the rainfed presented the lowest results.

The mass of 100 grains presented the best result in the water depth of 100% ETc replacement, the rainfed and 200% ETc replacement treatments showed no significant difference between them.

The highest grain yield, 9,633.52 kg ha<sup>-1</sup>, was obtained in the water depth of 200% ETc replacement. Due to the fact that the soil is sandy, it has a high drainage capacity and a basic infiltration velocity of the soil, so that the crop was able to take advantage of the available water more efficiently and for a longer period. Ibrahim et. Al., 2015, in a study with corn in sandy soil, also verified that the ideal replacement was a water depth above 100% of ETc, a result obtained in two consecutive harvests. The water depth of 100% ETc replacement had an intermediate productivity to the other treatments, 7,679.99 kg ha<sup>-1</sup>, but was also very high. It is now necessary to carry out an economic feasibility study and to check which is more profitable.

Gava (2014) also reports that in very sandy soils, water depths above 100% of ETc result in higher yields. Working with soybean he found a maximum yield in the ETc 150% and a tendency to increase beyond this value, which was the maximum value he tested in the work here cited.

On the other hand, rainfed grain yield was the smallest of all, as expected, due to the water deficit suffered during important stages of crop development.

## CONCLUSIONS

The water replenishment through irrigation made it possible to increase more than twice the grain yield in relation to the rainfed treatment.

The treatment with water depth of 200% ETc replacement showed the highest grain yield.

Irrigation in very sandy soils with water depths above 100% of ETc can result in higher yields.

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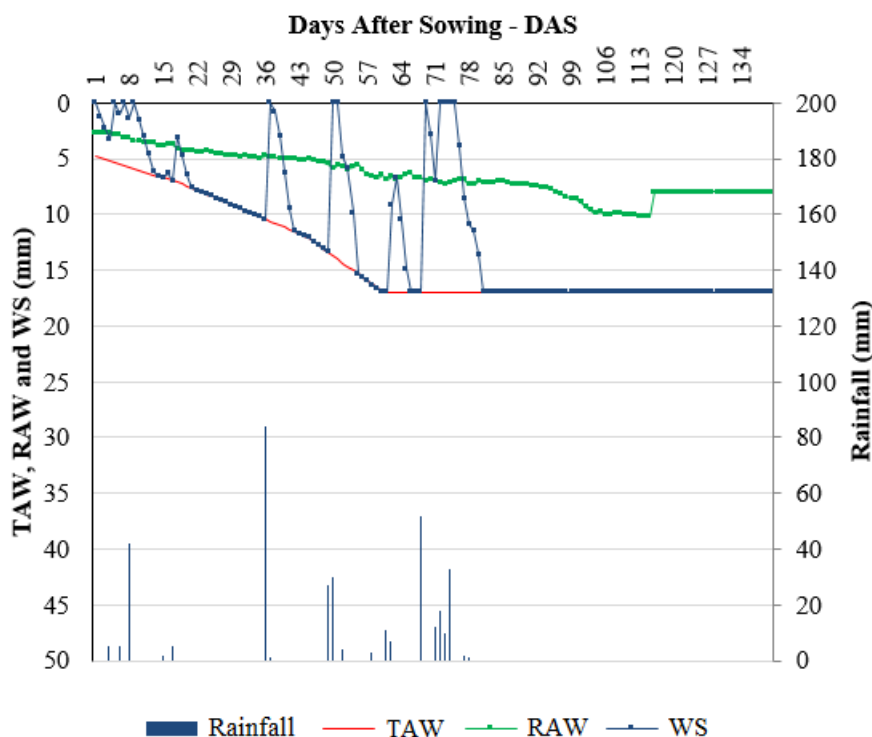
**Tabela 1** - Crop coefficients (Kc)

Stage (days after emergency)	Kc (adm.)
Up to 4 leaves visible (0-18)	0,32
4 to 8 leaves visible and still attached to the stem (19-37)	1,07
8 to 12 leaves visible and still attached to the stem (37-50)	1,50
Tasseling, flowering and pollination (51-64)	1,43
Pollination ending to Dough (64-77)	1,25
Dough to Dent (78-89)	1,01
Dent to mid-dent (90-99)	0,39
Mid-dent to maturity (100-110)	0,23

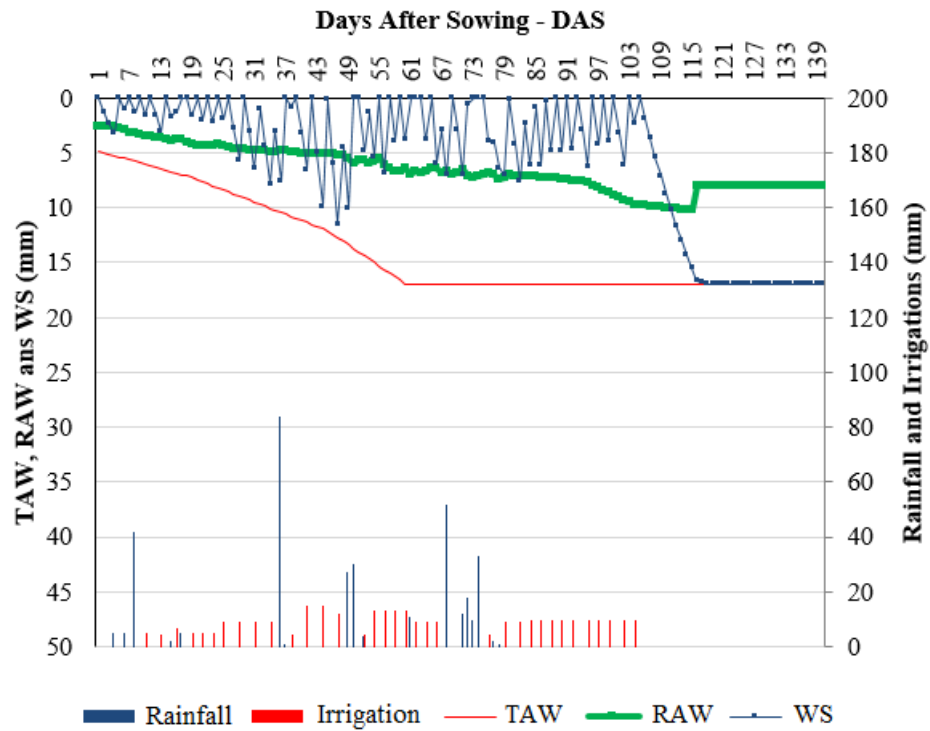
**Table 2** - Physical-water soil analysis.

Layer (cm)	$\theta_{FC}$ ( $\text{cm}^3 \text{cm}^{-3}$ )	$\theta_{PMP}$	WCA ( $\text{mm cm}^{-1}$ )	D ( $\text{g cm}^{-3}$ )	TP (%)	Fractions Granulometric			Textural Class
						Sand	Silt (%)	Clay	
0 – 10	0,185	0,048	3,15	2,3	16	87,5	2,5	10,0	Arenoso
10 – 20	0,197	0,050	3,38	2,3	14	88,0	2,5	9,5	
20 - 30	0,204	0,061	3,15	2,2	16	88,5	2,0	9,5	

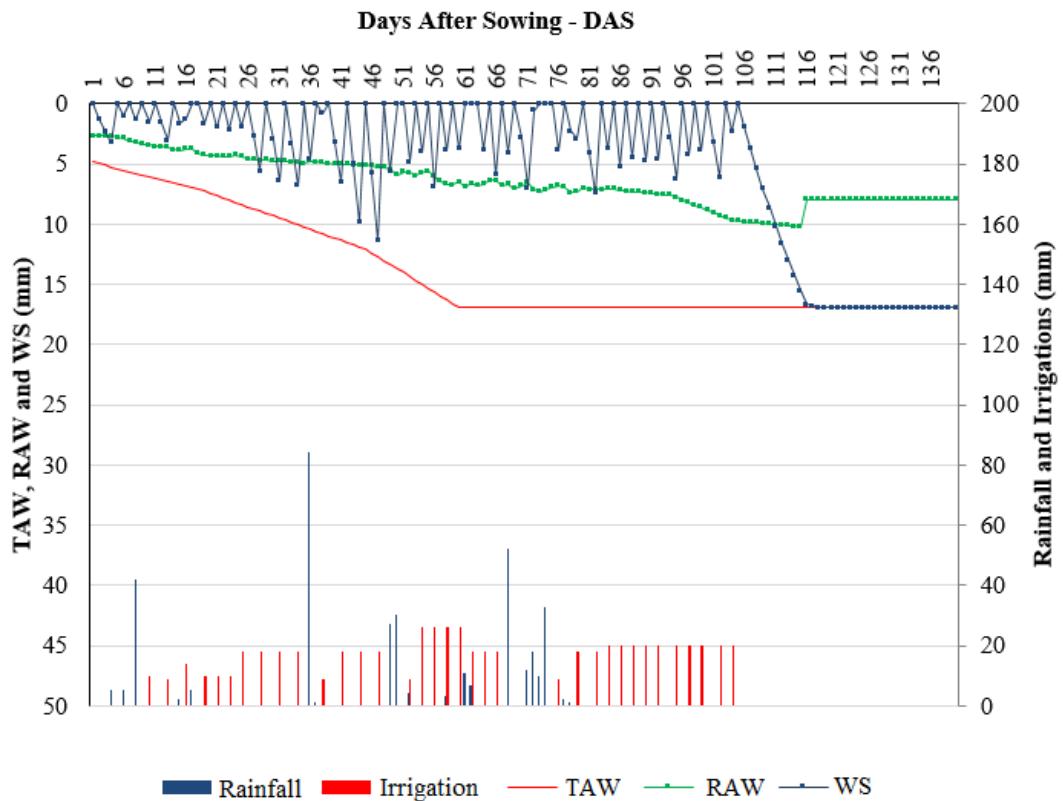
M - Moisture in the field capacity at the matric potential ( $\psi_m$ ) of 0.3 atm; PWP - Permanent wilting point in  $\psi_m$  of 15 atm; WCA - Water capacity available; SD - Soil Density; TP - Total soil porosity; \* Dp - Density of particles (The data of Density of particles were obtained from the work of Chaves (2009) that used this same type of soil).

**Figure 1.** Water balance with average values of rainfall, total available water (TAW), readily available water (ARC) and soil water storage (WS), according to the days after sowing (DAS) in rainfed.

**Figure 2.** Water balance with average values of rainfall, total available water (TAW), readily available water (ARC) and soil water storage (WS), according to the days after sowing (DAS) in the 100% ETC replacement area.



**Figure 3.** Water balance with average values of rainfall, total available water (TAW), readily available water (ARC) and soil water storage (WS), according to the days after sowing (DAS) in the 200% ETC replacement area.





**Table 3** - Average values of plant height, ear insertion height, stem diameter, one hundred grain mass and grain yield in function of water depths.

Variable	Water Depths (% ETC)		
	0	100	200
Plant Height (cm)	173,00b	220,74a	238,00a
Ear Insertion Height (cm)	58,12c	83,25b	92,18a
Stem Diameter (mm)	15,15c	19,07b	25,46a
One Hundred Grain Mass (g)	29,12b	37,81a	29,81b
Grain Yield (kg ha-1)	4229,21c	7679,99b	9633,52a

Means followed by lower case distinct letters in the line differ among themselves by the Tukey test ( $p < 0.05$ ).