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JAPANESE CUCUMBER CROP UNDER DIFFERENT IRRIGATION DEPTHS IN GREENHOUSE

Cultivo do pepino japonês sob lâminas de irrigação em ambiente protegido

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Resumo – O pepino japonês apresenta elevado valor econômico e ciclo vegetativo curto, por isso é um dos produtos hortícolas mais cultivados em ambiente protegido. O presente trabalho foi conduzido para avaliar o efeito de lâminas de irrigação na produção, crescimento e eficiência de utilização da água de pepino japonês cultivado em ambiente protegido. O experimento foi conduzido no inverno e primavera, no Centro Técnico de Irrigação da Universidade Estadual de Maringá, localizado em Maringá, Paraná, Brasil. Quatro níveis de reposição das lâminas da evapotranspiração da cultura foram testados (50, 75, 100 e 125% ETc). Adotou-se delineamento inteiramente casualizado com quatro repetições. A colheita foi realizada entre 33 a 96 dias após o transplantio, sendo os frutos colhidos em dias alternados. O crescimento das plantas de pepino foi avaliado através da altura, número de nós e diâmetro do colo. Os resultados indicaram que houve resposta linear crescente na produção e crescimento devido a aplicação das lâminas. Os resultados também indicaram que a lâmina 125% ETc obteve em média maior produção e crescimento, mas não obteve maior eficiência de utilização da água, pois esta foi obtida com a lâmina 50% ETc.

Palavras-Chave – *Zea mays*; Tocantins; Populações de polinização aberta; Nitrogênio.

Abstract– Japanese cucumber shows high economic value and short growth cycle, thus it is one of the most commonly grown vegetables in protected environment. This study aimed to evaluate the effect of irrigation depths in yield, growth and efficiency of water use in japanese cucumber cultivated in greenhouse. The experiment was conducted during winter and spring, at the Irrigation Technical Center of the State University of Maringá, located in Maringá, Paraná, Brazil. Four levels of replacement of crop evapotranspiration depths were tested (50, 75, 100 and 125% ETc). A completely randomized design with four replications was adopted. Harvest was performed between 33 and 96 days after transplanting, and the fruits were harvested on alternate days. The growth of the cucumber plants was evaluated measuring height, number of nodes and stem diameter. The results indicated that there was an increased linear response in yield and growth due to application of the irrigation depths. The results also indicated that the depth of 125% ETc obtained, on average, higher yield and growth, but it did not present the highest efficiency of water use, as this was ached with the depth of 50% ETc.

Keywords – *Zea mays*; Tocantins; Open-pollinated; Nitrogen.

INTRODUCTION

The cucumber (Cucumis sativus L.) is a vegetable of fruits belonging to the family Cucurbitaceae, in Brazil, he has been obtaining growth in her commercialization and importance among the vegetables, due her consumption as component of raw salads (SILVA et al., 2014).

Protected cultivation allows the producer to modify environments for the proper development of plants. In this type of cultivation it is possible to control variables such as, soil, temperature, susceptibility to diseases and pests (REIS et al., 2013).

The use of irrigation in protected environment is essential for the supply of water in appropriate quantity and period, since the cover of the protected

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environment does not allow the entry of rain. Another important factor in a protected environment is the knowledge of the growth of each culture and its water requirement for each phenological phase (GAVA et al, 2016).

The deficit irrigation is a technique that is used for some crops, as it allows to increase the efficiency of water use, applying enough water in the phases of higher water demand (flowering and grain filling) and, in the other stages, it is applied a depth lower than recommended. Rahil and Qanadillo (2015) verified that elevated depths may decrease the efficiency of water applied.

Increases in water use efficiency (WUE) are obtained by reducing percolation losses and direct evaporation of the soil. Phogat et al. (2013) verified that EUA is higher in treatments with irrigation deficit than in treatments with 100% ETc replacement.

The additional water applied to full irrigation contributed relatively more to drainage and evaporation losses and relatively less to plant uptake. Other ways to increase WUE are growing crops inside a greenhouse and providing a soil mulching (YAGHIA et al., 2013).

Considering the importance of cucumber and the scarcity of information on the effect of water deficit, this study aimed to evaluate the yield, growth and water use efficiency in different irrigation depths.

MATERIAL AND METHODS

The experiment was conducted from July 10th, 2015 to October 13th, 2015, in protected environment at the Irrigation Technical Center of the State University of Maringá, in Maringá, Paraná, Brazil. The climate, according to Köppen classification, is Cfa Mesothermal Humid, with abundant rainfall in the summer and dry winters. The soil of the experimental area is classified as Dystrophic Red Nitosol (EMBRAPA, 2013), and its chemical characteristics are shown in Table 1.

Table 1. Result of the chemical analysis of the soil performed before the implementation of the crop.

pH	P	K^+	Ca^{+2}	Mg^{+2}	H^++Al^{3+}	CTC	SB
H_2O	g dm^{-3}	cmol$_c$ dm^{-3}					
6,9	36,9	0,3	6,5	1,9	2,7	11,4	8,7

Soil analysis done at the soil analysis laboratory of the Rural Union of Maringá.

For the fertirrigation, according to the classification of Trani (2014), the values found in soil analysis required fertilization with 120 kg N ha^{-1}, 180 kg P_2O_5 ha^{-1} and 120 kg K_2O ha^{-1} to provide the ideal amount of nutrients for optimal crop development. The phosphorus fertilization was performed at transplanting and the other nutrients in coverage, as recommended by Trani (2014).

The Japanese cucumber seedlings, Hokushin cultivar, were grown in 162 cell trays. The crop was conducted in beds (experimental unit) spaced 0.80 m, with the dimensions of 0.20 m width, 0.20 m height and 3.0 m in length. Each experimental unit was composed of six plants and the four central plants were evaluated.

Drip system was used for micro-irrigation. Two pressure compensating drippers per plant were installed, with 8 L h^{-1} flow, operating at 15 mca. The experimental design was completely randomized (CRD) with four replenishment levels of depths related to the ETc (50, 75, 100 and 125%) and four replications each.

The irrigations were carried out according to the calculation of the evapotranspiration (ETc). The ETc is the product of the reference evapotranspiration (ET_0) and the crop coefficient (Kc). Therefore it was necessary to calculate ET_0 by Penman-Monteith-FAO (ALLEN et al., 1998). The meteorological variables were obtained from an automatic meteorological station installed inside the protected environment. The use of the plastic cover in the protected environment may have contributed to the reduction of solar radiation levels and consequently the reduction of water losses, but in the experiment a pyranometer was used inside the greenhouse.

The Kc for the cucumber crop, used for irrigation management, possesses initial value of 0.52 increasing up to 50 days and is maintained 1.52 until the end of the crop cycle (BLANCO; FOLEGATTI, 2003).

The determination of the soil water retention curve was carried out by nine tensiometers and nine TDR equipment's. Both methodologies consist of the installation of a series of tensiometers in conjunction with the TDR equipment at the relevant depth (0.15 m) and it is proceeded estimating volumetric soil moisture values and tension values (ALMEIDA; ARAUJO; SOUZA, 2010).

Initially the soil was saturated and, after 6 hours, readings started to be taken and continued for a period of 72 hours. It was calculated that to raise the water potential from -30 to -10 kPa it was necessary to apply a 24 mm irrigation depth to the 0 to 0.3 m layer. The obtained values were adjusted to the Van-Genuchten model.

$$\theta = 0.2191 + \frac{0.4334 - 0.2191}{\left[1 + \left(0.1738 \times \psi m\right)^{1.9320}\right]^{0.6911}}$$

In which:
θ – soil moisture, cm^3 cm^{-3};
Ψm – water tension in the soil, kPa.

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Measurements of water depth and water balance of the crop in the plots, related to the treatment with the depth of 100% ETc, were performed daily.

At 63 days after transplant (DAT) height (ALT) and number of nodes (NN) were measured, considering that cucumber crop shows accelerated growth rate up to 60 days of cultivation, which reduces at the final stages, when the plant starts the senescence process (CARDOSO; SILVA, 2002).

Stem diameter (DC) of the plant was measured at the end of the cycle with a digital caliper. The production variables analyzed were mass of commercial fruits (MFC) and number of commercial fruits (NFC).

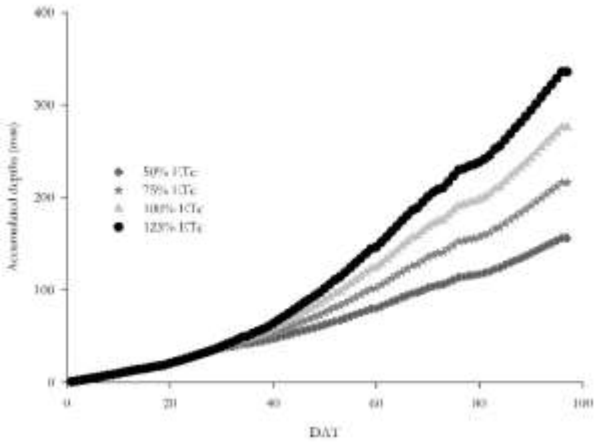
Fruit harvest was performed on alternate days between 33 and 96 DAT. The point of harvest of fruits and their classification as commercial and non-commercial followed the recommendations of Carvalho et al. (2013).

The water use efficiency was determined by the ratio between the yield values and the respective amounts of water consumed in each treatment.

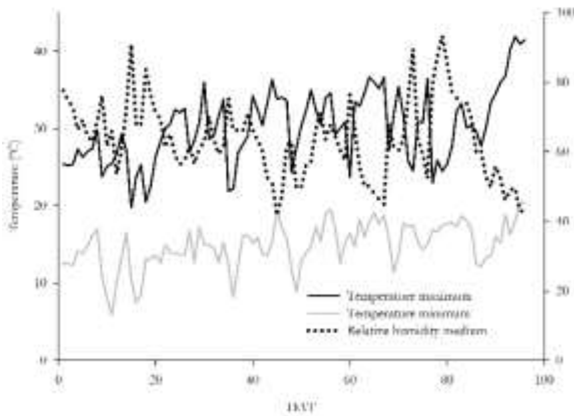
Data were subjected to analysis of variance ($p < 0.05$) using the statistical software SISVAR (FERREIRA, 2014). In the event of significant difference between treatments, regression analysis was carried out. The response variable which was not explained by regression was subjected to the average test (Tukey) at 0.05 level.

RESULTS AND DISCUSSION

The accumulated depths were 156.11; 215.98; 275.86 and 335.74 mm corresponding, respectively, to the replenishment of 50, 75, 100 and 125% of the ETc of the Japanese cucumber crop (Figure 1a). The highest temperature recorded in the experimental period was 41.87 ° C, the minimum was 5.80 ° C and the average was 20.15 ° C. For maximum, minimum and average air relative humidity, 93.25; 41.75 and 63.44% were found, respectively (Figure 1b).



a)



b)

Figure 1 a) accumulated depths and b) maximum and minimum temperatures and air relative humidity medium occurred during the crop cycle

The humidity varies within the greenhouse because the sides are with anti-aphid screen, thus allowing air to enter through the sides.

When subjected to the F test at 5% probability, all studied variables showed significant differences (Table 2).

Table 2 Analysis of variance for height (cm), number of nodes, stem diameter (cm), number of commercial fruit, mass of commercial fruit (kg plant^{-1}) and water use efficiency (kg plant^{-1} mm^{-1}) for Japanese cucumber crop.

Change source	Variables					
	ALT	NN	DC	NFC	MFC	WUE
F value	41,4*	21,1*	12,4*	71,0*	16,2*	4,1*
General average	51,8	11,5	0,7	19,3	2,94	10,4
C. V. (%)	6,9	7,2	8,1	7,5	12,7	10,4

* Significant at 5% probability by the F test

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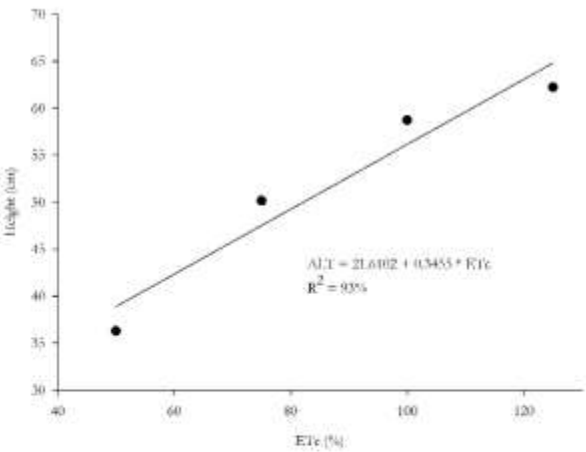
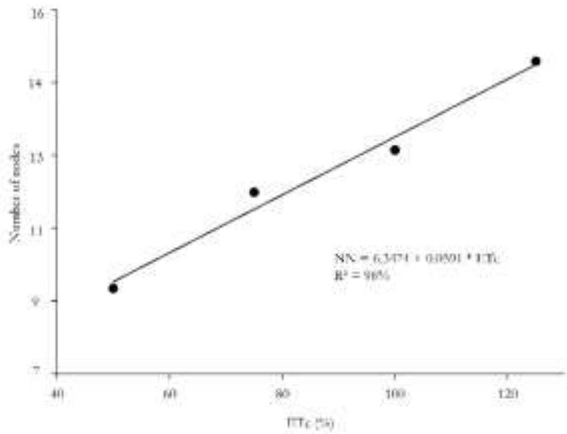
Subjected to regression analysis, it was possible the adjustment of an increasing linear model to the variables ALT, NN and DC (t <0.05) (Figure 2).



a)



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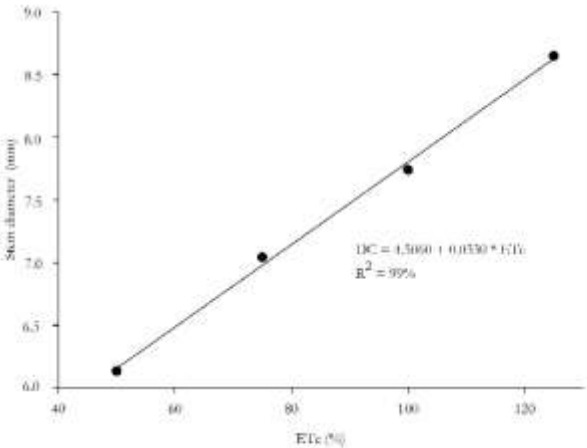

c)

Figure 2 Height (a), number of nodes (b) and stem diameter (c) of Japanese cucumber crop in relation to the levels of ETc replenishment.

Based on the results it was verified that the treatment with 125% replenishment of ETc promoted an increase of approximately 50% in height compared to the replenishment depth of 50%. The plant growth is related to cell division and expansion and the water is part of this process, therefore, the high availability of water was one of the factors that promoted the increase in height with the application of the irrigation depths (TAIZ; ZEIGER, 2013).

Blanco, Folegatti e Nogueira (2002), researching cucumber crop, obtained linear growth of the crop in the same assessed period, however, with no significant difference between the two tested depths. The height values obtained for the same period (exceeding 2 m) were higher than the ones found in the present study.

The highest number of nodes (13.80) was obtained with the application of 125% of the required depth. With the increase of 25% of the ETc it was observed an increment of 2.27 nodes in cucumber plants (Figure 2), generating approximately 100% increase in the number of nodes per plant. Sediyama et al. (2014) studying different prunings, it verified that in their treatments the number of fruits, the mass of fresh fruits and nor the productivity of cucumber fruits was not influences for his/her treatment and obtaining productivity.

The cucumber is a native plant of temperate areas and the great temperature for growth locates among 15-32 °C (ALSADON et al., 2016), influencing in a smaller growth of the plant in this experiment. The experiment had 47 days with minimum temperatures lower than recommended, possibly due to this the crop was affected in its growth.

It was observed that for each 25% increased on the ETc the plant stem diameter was increased by 1.3 mm in thickness. The depth of 125% resulted in higher plant stem diameter, 8.6 mm (Figure 2). Silva et al. (2011) found stem diameter of 8.6 mm for japanese cucumber crop with the replenishment of 100% of the ETc and all necessary and required nutrients.

The regression analysis concluded that the best model adjusted for the variables NFC and MFC was the increasing linear model (t <0.05) (Figure 3).

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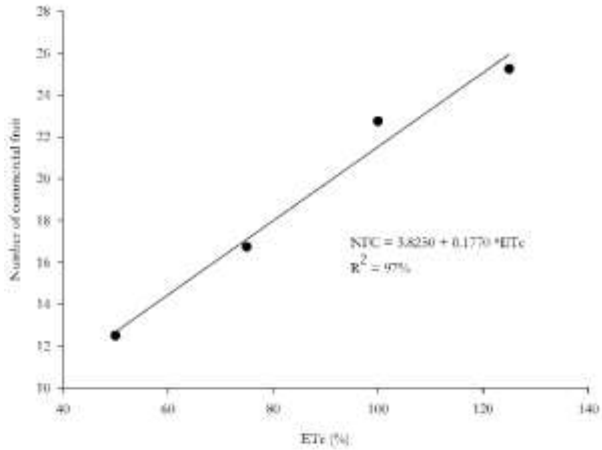
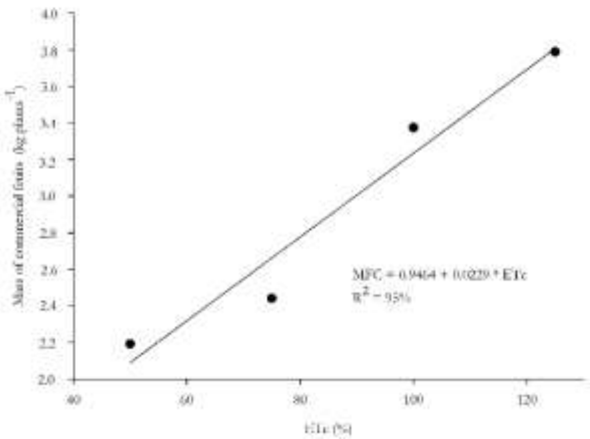


a)



b)

Figure 3 Number of commercial fruits (a) and mass of commercial fruits (b) of japanese cucumber plants according to the different levels of ETc replenishment.

The highest value found for the variable number of fruits per plot was 25.25. The increment rate was 5.62 fruits for each 25% of the ETc.

Oliveira et al. (2011) studying the economic viability of the cucumber crop obtained number of fruits (20.9) close to what was found in this study, though, the optimal replenishment depth found by the authors was 100% of the ETc. For the treatment with 150% of the ETc, however, there was a decrease, possibly due to the saturation of the soil, aeration deficiency and loss of water and nutrients by percolation.

The highest yield obtained was 3.7 kg plant^{-1}, applying a depth of 125% of the ETc (335.74 mm). Thus, it is verified that the increasing in the depth resulted in increased productivity. Caldas (2008) cultivating cucumber, Hokuho cultivar, obtained yields higher than the ones found in this study, which are 1.0 kg plant^{-1} and 1.11 kg plant^{-1}, respectively, with 100% ETc replenishment.

Santi et al. (2013), achieved yield of 3.4 kg plant^{-1}, next value that was found in this study. According to Carvalho et al. (2013) cucumber crop productivity can vary between 1 and 5 kg plant^{-1}, depending on the crop conduction period.

The average test made it possible to conclude that the efficiency of water utilization for the 156.11 mm depth was greater than for the depths 215.98 and 335.74 mm (Figure 4).

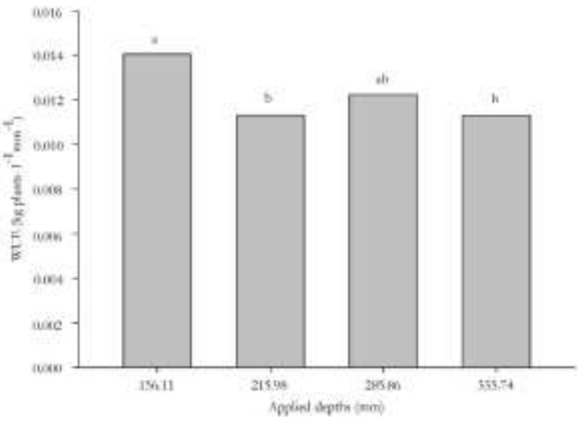


Figure 4 Efficiency of water use of Japanese cucumber crop in relation to the applied depths. Different letters represent different averages at 0.05 level by the Tukey test.

Oliveira et al. (2011), studying the economic optimum depth for cucumber crop, of optimal water use values with 319.5 mm.

Considering cucumber production, Buttaro et al (2015) did not find significant difference comparing irrigation when the soil presented matric potential of -30 and -10 kPa. However, irrigation management with the lowest potential resulted in water savings of 46%. These results allow us to infer that excess irrigation does not promote crop benefits and leads to waste of water and energy. Moreover, Çakir et al (2017) verified that WUE decreased with the increase in the irrigation water applied in solar greenhouse.

Growing crops inside a greenhouse results in higher WUE than in a open field because evaporative demand in the former is lower than the latter (WILFRIED et al., 2013).

CONCLUSIONS

All growth and yield variables obtained better adjustment to the increasing linear model. The depth of 125% ETc was the one that promoted the highest values.

The highest value for water use efficiency was achieved with the application of the depth of 50% ETc, indicating that for the purpose of optimizing the

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optimum depth for irrigation must be carried out with deficit.

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