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UTILIZAÇÃO DE POLÍMERO HIDRORETENTOR E LÂMINAS DE IRRIGAÇÃO PARA RACIONALIZAÇÃO DE RECURSOS HÍDRICOS NO CULTIVO DO PIMENTÃO

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1 RESUMO

Avaliou a influência de diferentes doses de polímero hidroretentor em função de diferentes lâminas de irrigação no cultivo de pimentão. O experimento foi conduzido em casa de vegetação no Instituto Federal Goiano, em Urutaí, Goiás. O delineamento foi em blocos ao acaso, em esquema fatorial 4 × 4 com quatro repetições, sendo quatro lâminas de irrigação (50, 75, 100 e 125%) obtidas diariamente junto ao tanque Classe A e quatro doses de solução de hidrogel (0, 200, 400, 600 mL). As mudas de pimentão foram adquiridas de viveiro comercial registrado. O hidrogel foi diluído 50g para cada 10 litros de água, fornecido na cova de transplantio. Foram avaliadas as variáveis: número de folhas (NF), altura de planta (HP), espessura da casca (EC), total de produção (TP), comprimento do fruto (CF), diâmetro do fruto (DF), peso médio dos frutos (PMF) e número de frutos comerciais (NFC). O uso de solução hidroretentora em pimentão, cultivar Magali R, interferiu significativamente no aumento do peso médio dos frutos, sendo a dosagem recomendada correspondente a 400mL de solução.

Palavras-Chave: *Capsicum annum*, gotejamento, hidrogel.

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USE OF WATERPROOFING POLYMER AND IRRIGATION BLADES FOR RATIONALIZING WATER RESOURCES IN PEPPER GROWING

2 ABSTRACT

It evaluated the influence of different doses of water-retaining polymer as a function of different irrigation depths in sweet pepper cultivation. The experiment was carried out in a greenhouse at Instituto Federal Goiano, in Urutaí, Goiás. The design was in randomized blocks, in a 4 × 4 factorial scheme with four replications, with four irrigation depths (50, 75, 100 and 125%)

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obtained daily next to the Class A tank and four doses of hydrogel solution (0, 200, 400, 600 ml). These pepper seedlings were purchased from a registered commercial nursery. The hydrogel was diluted 50g for every 10 liters of water being supplied in the transplant pit. The variables were evaluated: the number of leaves (NF), plant height (HP), bark thickness (EC), total production (TP), fruit length (CF), fruit diameter (DF), average weight of fruits (PMF) and number of commercial fruits (NFC). It was concluded that the use of water-retaining solution in sweet pepper, cultivar Magali R, significantly interfered in the increase in the average weight of the fruits, with the recommended dosage corresponding to 400mL of solution.

Keywords*:* *Capsicum annum*, drip, hydrogel.

3 INTRODUCTION

The bell pepper (*Capsicum annuum* L.) of the Solanaceae family is among the most consumed fruit vegetables in the country and is important because of its nutritional value and high production profits (IBGE, 2017). With increasing demand, cultivation in Brazil is carried out both in protected environments and in open soil.

As with most vegetables, a regular water supply during the production cycle is essential for pepper cultivation (EMBRAPA, 2015). Scarce or excessive water availability can be detrimental to the crop, favoring the incidence of diseases, reduced production, root and plant collar rot, flower abortion, nutritional imbalance, etc. (SEZEN; YAZAR; EKER; 2006; CARVALHO et al., 2016).

According to Salomão (2012), improper irrigation management has significant effects on fruit productivity and quality, making irrigation management essential for crop success. Therefore, it is necessary to adopt management techniques to aid decision-making. Another crucial point in irrigation management is the use of soil and water conservation methods, since irrigated agriculture accounts for 52% of the total volume of water extracted from surface and groundwater sources. This makes it essential to use the most sustainable techniques possible to minimize the waste of water resources, as this sector has the greatest growth prospects until 2030 (AYRIMORAES, et al., 2020).

In this scenario, the adoption of sustainable techniques begins with the choice of irrigation methods. According to Almeida (2012), drip irrigation systems have been cited as the most efficient and economical for replenishing soil water. Hansen (2015) emphasized that, when well managed, they can reach 90% water efficiency. In addition to minimizing the use of water resources by providing the necessary amount of water, making better use of fertilizers when applied via fertigation, it does not wet the aerial part of the plant, which helps prevent fungal diseases (ESTEVES et al., 2012).

In addition to proper irrigation management systems, other technologies, such as water-retaining polymers (hydrogels), have been used to increase the efficiency of water resources. According to Marques; Cripa; Martinez (2013), polymers are capable of retaining between 150 and 400 times the mass of water, increasing the volume by up to 100 times. However, according to Navroski et al. (2015), when added to the soil, the hydrogel affects several soil and management factors, such as pH, irrigation, solution salinity, humidity and temperature. According to Bernardi et al. (2012), the hydrogel slowly makes nutrients available to plants due to absorption cycles, decreases nutrient losses through leaching and water losses through deep percolation, and in sandy soils, provides better performance for management with split fertilization (fertigation).

The use of hydrogels in irrigated agriculture has shown promise, as has been reported in the literature. However, further studies are needed, as there are no concrete methodologies for the use of these substances in terms of dosage or how much water is applied and the distribution of fertilization can be reduced. Given the above, the objective of this study was to evaluate the performance of bell pepper (*Capsicum annum*) depending on the volume of water-retaining polymers and irrigation depth.

4 MATERIALS AND METHODS

The experiment was conducted in a greenhouse located at the Horticulture Production Educational Unit (UEP) of the Instituto Federal Goiano (IF Goiano), Urutaí Campus -GO, whose geographic coordinates are 17° 29' 10" S latitude, 48° 12' 38" W longitude and average altitude of 697 meters. The climate of the region, according to Köppen and Geiger (1928), is Aw, characterized as a humid tropical climate with a dry season in winter and a rainy summer. The average temperature is 23°C, with average rainfall between 1000 and 1500 mm and an average relative humidity of 71%.

The soil used in the test was collected from a bank at a depth of 0–20 cm. The analysis results are expressed in Table 1 and are classified as sandy clay loam (Santos et al., 2018).

Table 1. Results related to soil analysis.

Soil Analysis								
Sample	K^+	P	S	Zn	B	Ass	Faith	Mn
cm	mg dm^{-3}							
0-20	18.3	4.7	7.9	4.0	0.19	1.6	190	107
	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al	CTC	V	MO	$pHCaCl_2$
	cmolc dm^{-3}				g dm^{-3}	%	g dm^{-3}	
	3.7	1.9	0.0	2.4	8.48	71.66	35	5.8

Source: Santos (2018)

Corrective fertilizer was previously homogenized into the soil, nutrients were corrected, and base saturation was increased to 80% prior to transplanting, as recommended (Trani et al., 2014). Topdressing fertilization is performed through fertigation, which, according to Yuri et al. (2016), is a practice widely adopted for this cultivation system because of its greater efficiency.

The experimental design was randomized blocks in a 4 × 4 factorial scheme with four replicates. The first factor evaluated was four irrigation depths (50, 75, 100, and 125%) obtained daily from the Class A tank, and the second factor was four volumes of hydrogel solution (0, 200, 400, and 600 mL). Pots with a capacity of 14 L (30 cm height and 25 cm diameter) were used for cultivation. The seedlings were purchased from a registered commercial nursery; the chosen cultivar was the hybrid Magali-R, which has characteristics such as resistance to mosaic virus Y, high productivity, and excellent uniformity (FILGUEIRA, 2008). Transplanting was carried out 30 days after sowing, when the seedlings reached 8 cm in height and had four defined leaves, with a spacing of 1 m between plants and 0.80 m between rows.

When the solution was prepared, 50 g of the hydrogel was diluted with Forth Gel® every 10 liters of water according to the manufacturer's recommendations, after which it was allowed to hydrate for a minimum of 10 minutes. During transplanting, small holes were manually dug into the soil of the pots, and the corresponding doses of the water-retaining solution were added. The material was subsequently covered with soil, and the seedlings were inserted into the strip above the hydrogel.

For irrigation, a drip system consisting of 16 mm-thick polyethylene main and lateral distribution lines was adopted. The dippers were spaced 0.2 m apart, with a flow rate of 2.2 L h^{-1} operating at a working pressure of 10 mca. The pumping system consisted of a 1 hp motor pump, a 120 mesh disc filter, valves, and a pressure gauge. Individual valves were installed to control the irrigation depth.

For irrigation management, the reference evapotranspiration demand (ETo) was adopted from the daily evaporation (EV) of the Class A tank, which was installed inside the protected environment and has a height of 24 cm and a diameter of 52 cm. EV readings were taken daily in the morning (9:30 am) with the aid of a micrometric screw with an accuracy of 0.02 mm.

The crop coefficient (Kc) was used according to the crop development phase, with phases I, II, III and IV being 0.75, 0.95, 0.85 and 0.80, respectively, according to Trani et al. (2011). To calculate the irrigation time, the methodology presented by Santos and Pereira (2004) was used. The differentiation between the irrigation depth treatments occurred from the 10th day after transplanting (DAT). At 93 days after transplanting, the first harvest was carried out, at which time the plants reached vegetative development, as described by Trani et al. (2014).

To calculate the application uniformity, a precipitation kit with dimensions of 8 cm in diameter and 10.2 cm in height was used. The flow rate calculation was performed via the volumetric method according to Salomão (2008). The uniformity of the irrigation system was determined from an adaptation of the methodology of Denículi et al. (1980), who reported a water distribution uniformity of 97%.

The experimental evaluation consisted of three harvests, and the following variables were analyzed: number of leaves (NF), plant height (HP), peel thickness (EC), total production (TP), fruit length (CF), fruit diameter (DF), mean fruit weight (PMF), and number of commercial fruits (NFC). The data were subsequently subjected to analysis of variance, and the data regarding hydrogel volume and irrigation depth were subjected to regression analysis. Pearson's correlations were used to investigate cause–and–effect relationships between the evaluated variables. All the statistical analyses were performed via R statistical software (R CORE TEAM, 2016).

5 RESULTS AND DISCUSSION

According to the analysis, no significant effects were observed from the interaction between the irrigation depth and hydrogel volume factors for the analyzed characteristics. Thus, the results were evaluated through regression analysis. Table 2 summarizes the variance and regression analyses, which indicate a significant effect of irrigation level ($p < 0.05$) on the number of leaves (NL). However, for plant height (HP) and bark thickness (EC), there was no significant difference.

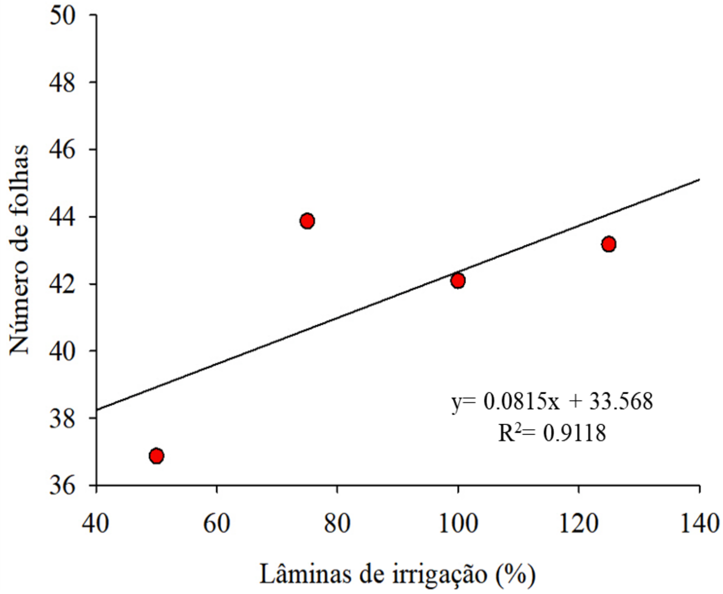
Table 2. Summary of the analysis of variance and regression analysis for the variables number of leaves (NF), plant height (HP) and bark thickness (EC).

		F values		
Source of	GL	NF	HP	EC
Block	3	5.35 **	1.67 NS	1.16 NS
Volume (V)	3	2.65 NS	2.32 NS	0.56 NS
Blade (L)	3	3.07 *	1.01 NS	1.15 NS
V*L	9	1.29 NS	0.78 NS	0.70 NS
Residue	45	---	---	---
Total	63	---	---	---
Average	---	41.50	18.10	3.77
CV (%)	---	17.46	15.45	35.2
		Regression Analysis for Volumes		
Linear	---	1.11 NS	5.36 NS	0.38 NS
Quadratic	---	2.17 NS	1.56 NS	0.78 NS
		Regression Analysis for Blade		
Linear	---	4.48 *	2.30 NS	2.08 NS
Quadratic	---	2.66 NS	0.02 NS	1.34 NS

NS: not significant; * significant at 5%; ** significant at 1%; CV%: coefficient of variation.
Source: Santos (2018)

Figure 1 shows the behavior of the number of leaves (NL) as a function of irrigation depth. The linear regression curve depicts the constant growth of the aerial part according to water availability, with the NL variable presenting a mean value of 42.09 under the irrigation depth of 100% of the ETo. Lima Júnior et al. (2010), working with American lettuce in protected cultivation, also reported an increase in the number of internal leaves of the lettuce up to depths of 197.2 mm, which is equivalent to 98% of the replacement depth, reaching, at this point, maximum values of 15 leaves. Félix; Sousa; Oliveira (2018), working with Chinese cabbage, also reported that irrigation depth significantly influenced the number of leaves, reaching depths of 150.22%, an increase of 53.31% in relation to the irrigation depth of 40%. Lima and Zomerfeld (2017), in research with radishes, reported that, in relation to the applied blades (50%, 75% and 100%), there was a significant effect for all the variables evaluated and that, regarding the number of leaves, better averages were obtained under the 50% Eto blade.

Figure 1. Regression analysis for the number of leaves as a function of irrigation depth.



Source: Santos (2018)

A joint analysis (Table 3 and Figure 2) revealed that, for the variables total production, fruit length, fruit diameter and number of commercial fruits, there was no significant effect of irrigation dose or depth. However, the variable average fruit weight had a significant effect ($p<0.05$) on the hydrogel volume.

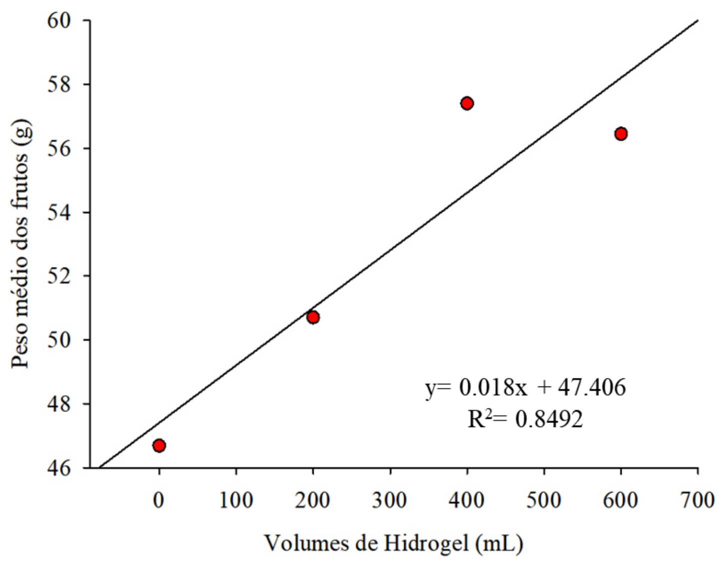
Figure 2 shows that the average fruit weights for hydrogel volumes of 0, 200, 400, and 600 mL were 46.69, 50.70, 57.40, and 56.46, respectively. Therefore, with the second dose of hydrogel, the weight of the fruit increased in relation to the highest dose used. This fact demonstrates that using an excess dose will not necessarily be advantageous, as it may imply a lower absorption of nutrients in deeper layers of the soil due to water retention in the soil with a hydrogel. However, the use of polymers in other vegetables, such as pumpkins, had the opposite effect, according to Azambuja et al. (2015), with plant height being greater at higher doses. For example, Kumaran (2016) reported that, throughout the crop cycle, the use of hydrogels led to an increase in the number of branches, length of the root system, root dry weight, fruit weight and dry mass productivity in tomato plants.

Table 3. Summary of analysis of variance and regression analysis for the variables total production (TP), fruit length (CF), fruit diameter (DF), average fruit weight (PMF) and number of commercial fruits (NFC).

			F values			
Source of Variation	GL	TP	CF	DF	FAQ	NFC
Block	3	1.41 NS	0.76 NS	0.26 NS	0.08 NS	1.57 NS
Volume (V)	3	0.15 NS	1.06 NS	1.51 NS	2.35*	0.13 NS
Blade (L)	3	1.10 NS	0.53 NS	0.33 NS	1.06 NS	1.95 NS
V*L	9	0.53 NS	0.29 NS	0.42 NS	0.34 NS	0.59 NS
Residue	45	---	---	---	---	---
Total	63	---	---	---	---	---
Average	---	2.28	9.50	15.22	52.81	2.21
CV (%)	---	24.41	20.80	19.41	24.94	25.37
			Regression Analysis for Volume			
Linear	---	0.002 NS	2.18 NS	3.38 NS	5.98*	0.02 NS
Quadratic	---	0.41 NS	0.001 NS	0.01 NS	0.57 NS	0.36 NS
			Regression Analysis for Blade			
Linear	---	3.18 NS	0.003 NS	0.40 NS	0.96 NS	5.38 NS
Quadratic	---	0.03 NS	0.84 NS	0.11 NS	2.08 NS	0.02 NS

NS: not significant; * significant at 5%; CV%: coefficient of variation.
Source: Santos (2018)

Figure 2. Regression analysis for average fruit weight as a function of hydrogel dose.

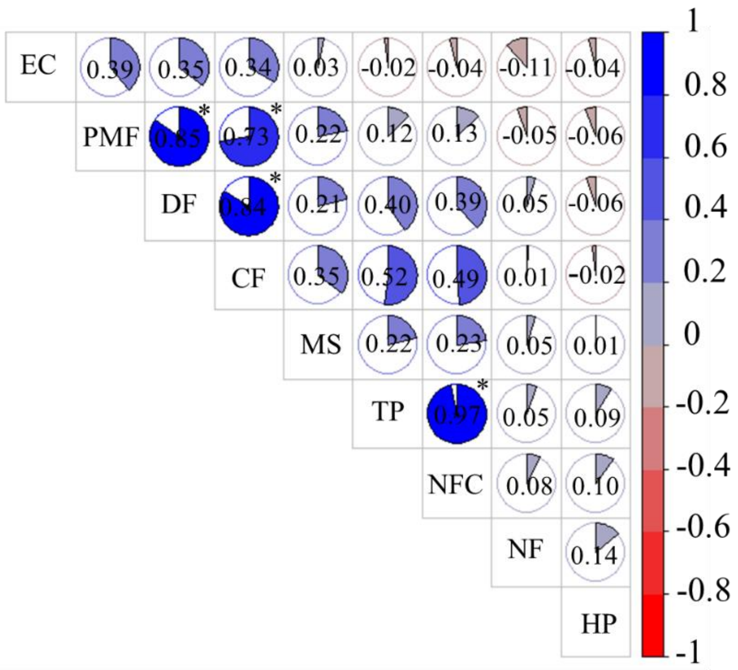


Source: Santos (2018)

According to Devore's classification (2006), there was a strong and significant positive correlation between PMF and DF (*r = 0.85; p<0.05*), between CF and DF (*r = 0.84; p<0.05*) and between CF and PMF (*r = 0.73; p<0.05*) (Figure 3). The values of PMF, DF, and CF are related to each other due to the development of the fruit, an important parameter that defines size and shape, making it attractive to consumers.

Carvalho et al. (2019) reported similar agronomic performance when analyzing the reuse of water in terms of average fruit mass (MMF), fruit length (CP), fruit diameter (DP) and the length–diameter ratio (RCD).

Figure 3. Pearson correlations between peel thickness (EC), average fruit weight (PMF), fruit diameter (DF), fruit length (CF), dry matter (DM), total production (TP), number of commercial fruits (NFC), number of leaves (NF), and plant height (HP) were calculated. (n = 64). *: significant (*p < 0.05*).



Source: Santos (2018)

There was a weak positive correlation between PMF and EC (*r = 0.39*), DF and EC (*r = 0.35*) and between CF and EC (*r = 0.34*), contradicting the findings of studies by Charlo et al. (2011), who highlighted the importance of fruits having thicker skin, acquiring greater resistance to transportation, having a longer postharvest duration and having greater mass yield.

Finally, there was a very strong correlation between NFC and TP (*r = 0.97; p < 0.05*), indicating that the fruits followed characteristics according to genetic material, with the majority of fruits being standardized, disregarding fruits that presented severe defects and thus obtaining efficient production. Notably, the influence of cultivation in a protected environment greatly helps increase production. The relationship between the total and commercial productivities obtained from pepper production using wastewater was similar, corresponding to 91.69% of the total productivity (CARVALHO et al., 2019).

6 CONCLUSION

No significant effect was observed between the irrigation depth and the hydrogel dose on any of the analyzed characteristics. The application of the highest irrigation depth (125%) resulted in a greater number of leaves. The use of a water-redeeming solution in bell peppers (Magali R cultivar) significantly increased the average fruit weight, with the recommended dose being 400 mL of solution.

7 ACKNOWLEDGMENTS

To the Federal Institute of Goiás – Urutaí Campus.

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