Reuse of treated domestic sewage for biquinho pepper cultivation

Reúso de aguas domésticas tratadas en el cultivo de la pimienta de pico

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Abstract

This study aimed to evaluate the reuse of treated domestic sewage in biquinho pepper (*Capsicum chinense L.*) cultivation under different irrigation regimes. The experiment was carried out in a greenhouse, in a randomised block design with a 3 x 4 factorial scheme, with four replications. Forty-eight pepper plants were subjected to three treated domestic sewage concentrations (0, 50, and 100%) and four irrigation depths (75, 100, 125, and 150% of the crop evapotranspiration - ETc). Data for ETc estimation were obtained from an automatic meteorological station, which was installed in the greenhouse. The results showed that irrigation depths corresponding to 125 and 150% of the ETc at a concentration of 100% treated domestic sewage resulted in higher plants. Moreover, longer fruits were obtained when plants were subjected to 100% ETc at 100% treated domestic sewage. The studied irrigation depths influenced pepper fruit total weight and yield. No treated domestic sewage concentrations significantly influenced the variables analysed. Treated domestic sewage reuse can constitute an alternative for quality water saving and for chemical fertilisation of biquinho pepper crop.

Keywords
Capsicum chinense L. • water reuse • evapotranspiration • greenhouse

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Resumen

Este estudio tuvo por objeto evaluar el reúso de aguas domésticas tratadas en el cultivo del pimiento de pico (*Capsicum chinense L.*) sometido a diferentes niveles de reposición de agua. El experimento se llevó a cabo en un invernadero en un diseño de bloques aleatorios en un esquema factorial 3 x 4, con cuatro repeticiones. Cuarenta y ocho pimientas fueron sometidas a concentraciones de 0, 50 y 100% de reúso de aguas domésticas tratadas y cuatro niveles de reposición de agua correspondientes al 75, 100, 125 y 150% de la evapotranspiración del cultivo (ETc). Los datos para la estimación de la evapotranspiración de los cultivos se obtuvieron de una estación meteorológica automática instalada dentro del invernadero. Los niveles de reposición de agua del 125 y 150% de la evapotranspiración de los cultivos con una concentración del 100% de reúso de aguas domésticas tratadas proporcionaron mayores alturas de las plantas. Se obtuvieron mayores longitudes del fruto del pimiento cuando se sometió a una ETc del 100% con una concentración del 100% de reúso de agua domésticas tratadas. Los niveles de reposición de agua influyeron en la producción total y la productividad de los frutos del pimiento. Las concentraciones de reúso de agua domésticas tratadas no influyeron significativamente en las variables analizadas. El reúso de agua domésticas tratadas puede ser una alternativa para reducir el uso de agua de mejor calidad y la fertilización química en el cultivo del pimiento de pico.

Palabras clave

Capsicum chinense L. • reúso de agua • evapotranspiración • invernadero

Introduction

Pepper cultivation has assumed great importance for the Brazilian and world populations. Biquinho is a pepper variety (*Capsicum chinense* L.) widely grown by small farmers due to its high yield potential, gastronomic value, market acceptance, and financial return (3). It stands out for adding commercial value depending on the region of sale and has been increasingly valued in the consumer market, especially for consumption in the form of pickles and for a mild flavour and absence of pungency (9). Crop evapotranspiration knowledge during different phenological stages helps determine crop water requirements and water use efficiency (5).

The cultivation of peppers in north-eastern Brazil is affected by local water scarcity due to irregular rainfall and high evapotranspiration rates (13). In this sense, irrigation constitutes a valuable alternative for its production in this region. However, due to low water availability, crop irrigation is not always possible (18). Thus, reusing treated water in irrigated agriculture is a way of providing good quality water in optimum amounts for this purpose, seeking to save water for human and animal consumptions (14).

Reuse of water for irrigation purposes can benefit crops in terms of nutrient supply, reducing the need for synthetic fertilisers (2). Queiroz *et al.* (2015) observed that, despite several benefits, unrestricted irrigation with urban effluent may imply health and environmental risks. Besides supplying organic matter and nutrients to the soil, it also increases salt contents, which, depending on the concentration, can compromise crop quality and reduce soil osmotic potential, thus limiting productive capacity.

Several studies on wastewater reuse in agriculture have been conducted on chilli pepper (18), okra (15), papaya (10), white oats (4), and lettuce (8). Therefore, this study aimed to evaluate the effect of reusing treated domestic sewage in biquinho pepper (*Capsicum chinense L.*) growth under different irrigation regimes.

Material and methods

The experimental area is located at 30 m above sea level. According to Köppen's classification, the local climate is humid tropical with a dry season in the summer. The region has an average annual temperature of 25.2°C and rainfall of 1300 mm, which is concentrated from April to September. The soil used is classified as Ultisols (17).

Forty-eight biquinho pepper (*Capsicum chinense L.*) plants were grown in 21-L plastic containers arranged on a bench inside a greenhouse. The experiment was carried out in a randomized block design and arranged in a 3 x 4 factorial scheme, with three treatments and four replications. The plants were subjected to three treated domestic sewage concentrations (0, 50, and 100%) and four irrigation regimes (depths), which corresponded to 75, 100, 125, and 150% of the crop evapotranspiration (ETc).

The plants were fertilised at transplanting time according to soil analysis, applying: urea (1 g pot^{-1}), P_2O_5 (4.2 g pot^{-1}), and K_2O (1.5 g pot^{-1}). After 30 days, topdressing was performed by applying urea (0.5 g pot $^{-1}$) and K_2O (0.75 g pot^{-1}). After transplantation, the plants were supplied with 100% water. Weather data used for reference evapotranspiration were obtained from an automatic meteorological station, which was installed in the greenhouse. Crop coefficients of greenhouse-grown pepper used to determine crop evapotranspiration were 0.74, 1.38, 1.40, 1.17, and 1.02 (16).

The parameters evaluated were plant height, fruit length, and stem diameter, which were measured with a millimetre ruler and a pachymeter. Fruit weight was determined by collecting and drying fruit in an oven at 60°C for 24 hours. Then, the material was weighed on a precision scale to an accuracy of 0.01g. Pepper yield (kg ha^{-1}) was obtained according to fruit production per plant and the area occupied by each plant.

Data were submitted to ANOVA analysis of variance, and means were compared by Tukey's test. Regression equations were generated for the parameters fruit weight and yield. Statistical analyses were performed using the statistical software SISVAR 5.6 (7).

Results and discussion

ANOVA showed that all irrigation regimes had significant effects on the studied parameters at 1% significance by the F-test (table 1). The sewage concentrations had no significant effect on the evaluated parameters, but their interaction with irrigation regimes had a significant effect on plant height and fruit length.

Table 1. ANOVA for plant height (cm), fruit length (cm), and stem diameter (cm) in response to irrigation regimes and treated domestic sewage concentrations.

Tabla 1. Resumen del ANOVA para altura de la planta (cm), longitud del fruto (cm) y diámetro del tallo (cm) en respuesta a los niveles de reposición de agua y las concentraciones de reúso de aguas domésticas tratadas.

		Average square		
Variation Source	**DF**	**Plant height**	**Fruit length**	**Stem diameter**
Irrigation level (L)	3	117.69**	0.22287 **	4.55608 **
Sewage concentration (C)	2	24.00 ns	0.08100 ns	1.37479 ns
Interaction (L x C)	6	51.65 *	0.25642 **	1.25004 ns
Treatment	11	64.63 **	0.21538 **	2.17437 *
Block	3	42.07 ns	0.00266 *	0.55655 ns
Residue	33	20.47	0.03859	0.77309

(**) *p-value* ≤ 0.01; (*) p-value ≤0.05; (ns) non-significant at 5% probability level by the F-test.

(**) Efecto significativo al nivel de probabilidad del 1%; (*) significativo al 5% de probabilidad; (s) no significativo al nivel de probabilidad del 5% por la prueba F.

Tavares *et al.* (2019) found no significant effect of treated wastewater irrigation on pepper height, but on stem diameter and leaf number. Faccioli *et al.* (2017) also found no significant effect of treated wastewater on cowpea bean height, thus differing our study (table 1). Silva *et al.* (2019) verified no significant effect of different wastewater irrigation depths on chilli pepper fruit length, unlike our results. Tukey's test (p≤0.05) showed that sewage concentrations significantly affected plant height for L_1 at C_3 (table 2, page 179).

Table 2. Tukey's test for average plant height and fruit length in response to irrigation regimes and concentrations of treated domestic sewage.

Tabla 2. Prueba de Tukey para la altura media de la planta y la longitud media del fruto en respuesta a los niveles de reposición de agua y las concentraciones de reúso de aguas domésticas tratadas.

Plant height (cm)			
Sewage concentration			
Irrigation regime (mm)	C_1	C_2	C_3
L_1	31.00 aA	35.21 aA	24.96 bB
L_2	33.00 aA	31.58 aA	29.12 bA
L_3	32.17 aA	36.12 aA	39.62 aA
L_4	35.67 aA	36.71 aA	36.87 aA
Fruit length (cm)			
Sewage concentration			
Irrigation regime (mm)	C_1	C_2	C_3
L_1	1.64 bA	1.87 aA	1.64 bA
L_2	1.75 bB	2.15 aA	2.15 aA
L_3	2.12 aA	1.88 aA	1.92 aA
L_4	2.19 aA	2.06 aA	1.86 aB

L_1: 75 %, L_2: 100 %, L_3: 125 %, and L_4: 150 % of the crop evapotranspiration (ETc). C_1: 0% of treated domestic sewage + 100% water supply, C_2: 50% treated domestic sewage + 50% of water supply, C_3: 100% treated domestic sewage. Means followed by the same letter, lower-case in the column and upper-case in the row, did not differ statistically.

L_1: 75%, L_2: 100%, L_3: 125% y L_4: 150% de la evapotranspiración del cultivo (ETc). C_1: 0% de reúso de aguas domésticas tratadas y 100% de agua del sistema de suministro, C_2: 50% de reúso de aguas domésticas tratadas + 50% de agua del sistema de suministro, C_3: 100% de reúso de aguas domésticas tratadas. Los promedios seguidos de las mismas letras no difieren estadísticamente. En columna letras minúsculas y en la línea letras mayúsculas.

L_3 and L_4 irrigation regimes had effects on plant height only in plants receiving C_1, thus increasing plant heights. When analysing different irrigation depths for biquinho pepper cultivation on different substrates, Silva *et al.* (2016) found that an irrigation depth of 100% of the ETc produced higher plants (23 cm), which is significantly lower than our result (39.62 cm) at L_3. However, opposite to our study, these authors found higher plants when 100% water was applied (table 2). Nascimento *et al.* (2021) observed that water stress caused by deficit irrigation reduced plant height, seed mass, and pod yield of peanut, while full irrigation (100% of crop evapotranspiration replacement) led to yields of 4,141 to 5,102 kg ha^{-1}, approximately three times higher than those obtained with the lowest irrigation level (8% replenishment of crop evapotranspiration).

In our study, the longest fruits (2.19 cm) were obtained at L_4, with C_1, thus longer than that of C_3. Conversely, the smallest fruits (1.64 cm) were produced when the plants were subjected to L_1 and at C_3.

The irrigation regime effect was significant at a 5% probability for average fruit weight and yield. No significant effect was observed for concentrations of treated domestic sewage or their interactions with irrigation regimes for the studied parameters (table 3).

Table 3. Summary of ANOVA for data on average fruit weight and yield in response to irrigation regimes and concentrations of treated domestic sewage.

Tabla 3. Resumen del ANOVA de los datos del peso promedio de la fruta y la productividad en respuesta a los niveles de reposición de agua y las concentraciones de reúso de aguas domésticas tratadas.

		Mean square	
Variation Source	DF	Fruit weight	Fruit yield
Irrigation regime (L)	3	1035.68369 *	161825.57892 *
Sewage concentration (C)	2	411.52465 ns	64300.73272 ns
Interaction (L x C)	6	439.82768 ns	68723.06810 ns
Treatment	11	597.18786 ns	93310.60098 ns
Block	3	465.54059 ns	72740.71853 ns
Residue	33	356.50274	55703.55354

(**) *p-value* ≤ 0.01; (*) *p-value* ≤0.05; (ns) non-significant at 5% probability level by the F-test

(**) Efecto significativo al nivel de probabilidad del 1%; (*) significativo al 5% de probabilidad; (s) no significativo al nivel de probabilidad del 5% por la prueba F.

Regression equations were adjusted to express changes in average fruit weight (g) and yield (t ha^{-1}) as a function of the irrigation depths, respectively (figure 1).

Maximum yield of biquinho pepper was 14.3 t ha^{-1}, achieved by applying 143.4% ETc irrigation (figure 1). This result is lower than that found by Barroca *et al.* (2015), who obtained a maximum production of 43.6 t ha^{-1} for the variety 'Pimenta-de-Cheiro' when applying 119.6% ETo. However, the same authors found a lower value for the variety 'Dedo-de-Moça', which was 15.8 t ha^{-1} when applying 113.6% ETo. In our study, maximum average fruit weight was 99.5 g for a water supply of 142.5% ETc (figure 1).

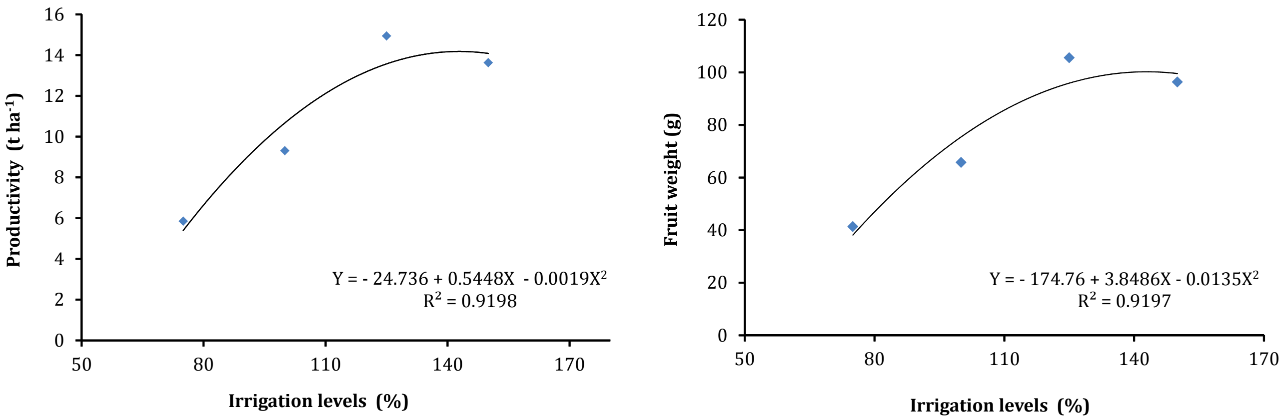

Figure 1. Regression analysis for average yield (a) and average fruit weight (b) of biquinho pepper plants as a function of irrigation regimes.

Figura 1. Análisis de regresión para productividad (a) y peso medio de la fruta (b), en función de los niveles de reposición de agua para el pimiento de pico.

Conclusion

Growth of biquinho pepper with treated domestic sewage can bring benefits in terms of crop nutrient supply, while environmental impact can be reduced by replacing chemical fertilisers. Treated domestic sewage reuse can constitute an alternative both for quality water saving and for chemical fertilization of biquinho pepper crops.

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