

Full Length Research Paper

Effect of different irrigation levels with different qualities of water and organic substrates on cultivation of pepper

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The amount of water needed to meet the water requirement of crops and use of alternative organic substrates affect the development of the plants' nutrients. The objective of this research is to evaluate the cultivation of pepper (*Capsicum chinense*) under different organic substrates and irrigation levels with supply water and wastewater. The experiment was conducted in a greenhouse at Campina Grande, Paraíba, Brazil. Biquinho BRS Moema pepper species was used. The experimental design was randomized block in a factorial design of 2 x 5 x 2. Two types of water (water supply and wastewater) and five water levels (L) were used based on the water requirement (WR) of the crop as follows: 100% WR (L5), 80% WR (L4), 60% WR (L3), 40% WR (L2) and 20% WR (L1); and two kinds of substrates (caprine and bovine) were also used, all in three replicates with two plants each. The germination percentage for bovine substrate averaged 44%, while for the caprine substrate, it was 18%. 24% increase in the number of leaves at level 4 was compared with that of level 5, where there was 20% reduction of WR of the plant. The pepper "Biquinho" irrigated with wastewater had better average, making it an alternative for irrigation. For the growth of pepper, it is not suitable to use irrigation values less than 40% of the water requirement for culture, because it influences negatively the development of the culture. For pepper, the ideal irrigation level is 80% of water requirement.

Key words: Water reuse, water demand, BRS Moema.

INTRODUCTION

The most commercialized vegetable crop consumed in the world is *Capsicum* pepper, and about a quarter of the world population consumes pepper as natural, liquid

sauces, canned or dehydrated (Silva et al., 2015). Also smaller sizes are used as ornamental plant; it is used as family farms, and for agribusiness (Xavier et al., 2006).

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Pepper is a crop with good productivity, and generally profitable for producers; it has greater rusticity on the field and longer cycle and may be harvested for more than one year (Hortifruti Brazil, 2015).

In Brazil pepper is the second most exported vegetable, contributing 13.5% of total production. Due to the increased consumption and interest of exporters, pepper cultivation is a trade of big importance, involving various sectors, from small to multinational farmers (Informa Economics F. N. P., 2012). In this way, pepper cultivation should be studied to provide quality and alternatives in its management. This information will be beneficial to its producers.

Organic substrates are an alternative to reduce costs in pepper cultivation. Almeida et al. (2012) state that the ideal substrate should be easily acquired, transported and have nutrient (Kusdra et al., 2008). The proper pH of the substrate must have good texture and structure (Silva et al., 2012).

The substrate must have bovine manure, because according to Silva et al. (2007), it is the main organic fertilizer used to improve the fertility of the Brazilian semiarid region soils. However, the use of caprine manure is a promising alternative for substrate composition (Pereira et al., 2012).

For pepper cultivation, the types of substrate and water used are important because they provide the proper environment and nutrients for the plant development. In regions with water shortage like the Brazilian semiarid regions, irrigation with wastewater is an alternative that helps the production of pepper, and also the environment, because it makes necessary the reuse of water. For Medeiros et al. (2008), the benefits of water reuse are conservation of available water, its wide availability, possibility of intake and nutrient recycling, preservation of the environment. There are few studies on pepper cultivation. It is important to consider the type of substrate and the amount of water needed at each stage of the cycle of the plant in order to obtain maximum development during the entire cycle in a sustainable manner with use of organic substrates and water reuse.

The efficiency of the use of water in irrigation reduces water loss and also supplies the water requirement of the plant for its best development. Irrigation management aims to supply the water requirement of the crop to some extent without deficit or excess. It is very important that irrigation management is done properly, to obtain success in yield and also preserves the environment (Gomes and Testezlaf, 2007).

The research was carried out to evaluate the cultivation of pepper (*Capsicum chinense*) under different organic substrates and irrigation levels with water supply and wastewater.

MATERIALS AND METHODS

The investigation was carried out in a greenhouse, at Campina

Grande, PB, Brazil, in 2014. The greenhouse is located at an altitude of 550m above mean sea level and it is 7°15'18" latitude and 35°52'28" longitude. The climate is classified as BswH according to the Köppen classification system, with an average annual temperature of 26.8°C and an average annual rainfall of 360 mm. Cultivar BRS Moema pepper "Biquinho" (*C. chinense*) seeds planted in a substrate by the company ISLA Seeds, were used in this experiment. For the propagation, seeds were planted directly on the cultivation site, 0.5 cm deep, as recommended by the company.

For the experiment 60 black plastic pots (no. 17) were used with a capacity of approximately 1.6 L, with the following dimensions: top diameter, 15 cm; bottom diameter, 9 cm and height, 14 cm. For the drainage six holes were made and a protection screen was placed at the bottom of the pots. They were then filled with crushed stones (no. 0), covering all the bottom and the substrate (soil: manure, 7:3); there was 70% soil and 30% manure, on a volume basis.

The experiment was laid out in a randomized block, in a 2 x 5 x 2 factorial design; it is composed of two types of water: supply water (A1) and wastewater (A2), five water levels based on crop water requirement and two types of substrate: bovine manure (S1) and caprine manure (S2). The five irrigation levels (L) using supply water and wastewater were treated by an up flow anaerobic sludge blanket reactor (UASB + WETLAND), based on crop water requirement (WR): 100% of WR (L5), 80% of WR (L4), 60% of WR (L3), 40% of WR (L2) and 20% of WR (L1).

They were evaluated daily until 14 days after sowing (DAS); the germination percentage (GP) was based on Labouriau and Valadares (1976) and the Emergence Speed Index (ESI) was determined by Maguire (1962). From 23 days after sowing (DAS) the following evaluations were carried out weekly: growth and development of the plant, plant height (PH) measured from the soil until the apex of the plant; stem diameter (SD) close to the soil; number of the leaves (NL).

Data were analyzed using the statistical software SISVAR (Ferreira, 2014) and the difference between treatment means was assessed by the Tukey test, at 5% probability.

RESULTS AND DISCUSSION

Figure 1 shows the germination percentage for bovine substrate averaged 44.4%, while for the caprine substrate, it was 18.64%. These results show the efficacy of bovine substrate in the early stages of the pepper. The use of bovine substrate increases the percentage of germination in about 26%. After 30 days of sowing percentage of germination of the varieties "Girl Finger" (TECNOSEED), "Tabasco" (TOP SEED), "Volcano 2011" and "Bishop Hat 2012" had, respectively, 34, 25, 5 and 0% germination (Silva et al., 2013).

While 14 days after sowing, the "Biquinho" pepper in organic substrates at different water levels was 36.3%, as shown in Figure 2. For the emergence speed index (ESI) the highest average, according to Figure 2, was L1 (20% WR) with 1.44 germination/day. Similar results of ESI were obtained by Magalhães et al. (2011) studying the emergency of Chili pepper at several concentrations of CO₂, with 2.23 to seedlings/day; whereas, for the "Girl Finger" pepper was 0.92 to 1.42 seedling/day, varying according to the carbon dioxide concentrations (550 and 360 ppm).

In the germination of Biquinho pepper, it was observed that only 20% of the water requirement of culture was

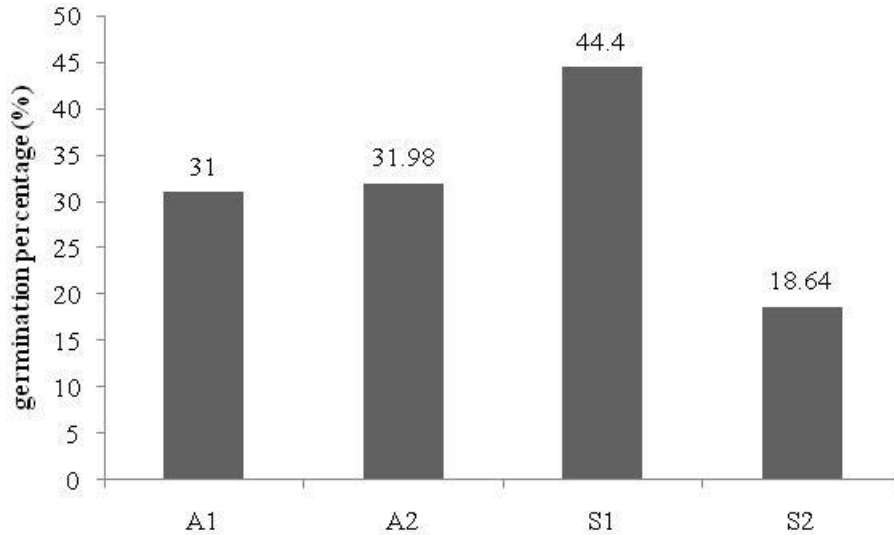


Figure 1. Variation of germination percentage (GP) of pepper Biquinho considering the mean of treatments.

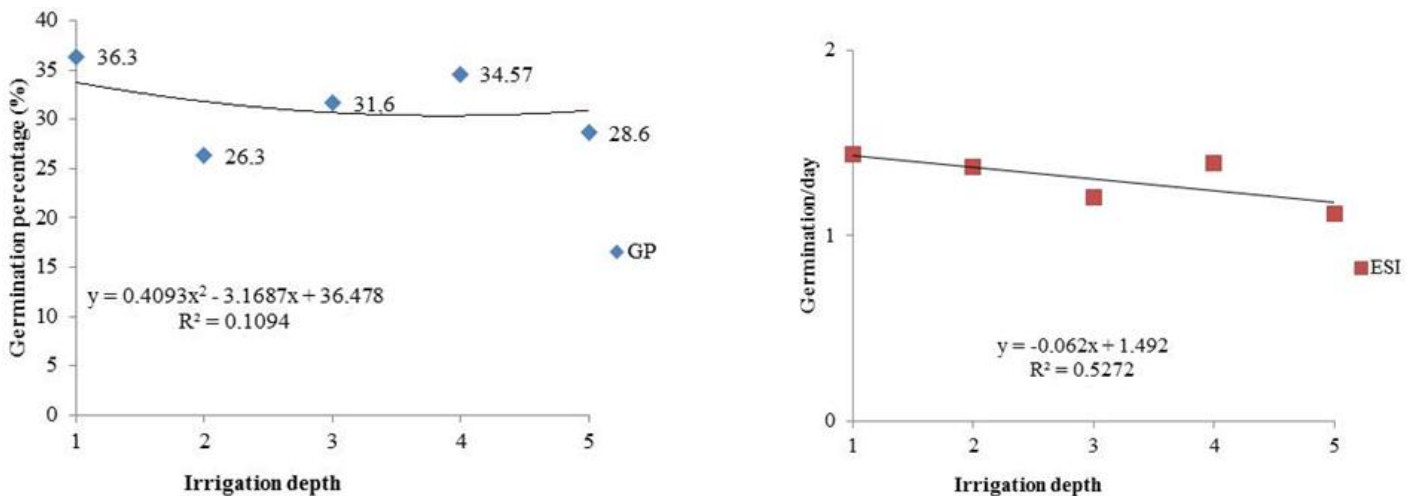


Figure 2. Germination percentage (GP) and emergence speed index (ESI) of “Biquinho” pepper seeds with organic substrates irrigated with different levels of treated wastewater and supply water.

sufficient in tolerating decreased water content in the soil; thus making the seeds to germinate under deficits water. Similar results were obtained by Silva et al. (2014) on the germination of irrigated Biquinho pepper with water blades and wastewater; they found best results at 20 to 80% of the water requirement. According to Paiva et al. (2012), irrigation using wastewater for chili resulted in better performance.

The use of wastewater and bovine substrate resulted in better average results for plant height in all assessments, with continued growth (Table 1). Using wastewater to produce pepper seedlings, okra and tomato, Oliveira et al. (2012a) and Alves et al. (2012) had higher crops. In

producing pepper seedlings Malagueta and Tequila Sunrise, Oliveira et al. (2012b) had better results, using 75% of wastewater. This study found positive effects with higher averages in plants irrigated with wastewater treated.

With bovine substrate, the plant height average was higher than that of caprine substrate, as shown in Table 1. Evaluating different substrate compositions (topsoil, washed sand, commercial substrate, caprine and bovine manure) in the yield of ornamental pepper (*Capsicum annum* L.), Da Silva et al. (2013) achieved lower results for the height of pepper. Silva et al. (2010) achieved lower mean for chili height (10.7 cm) in substrates whose

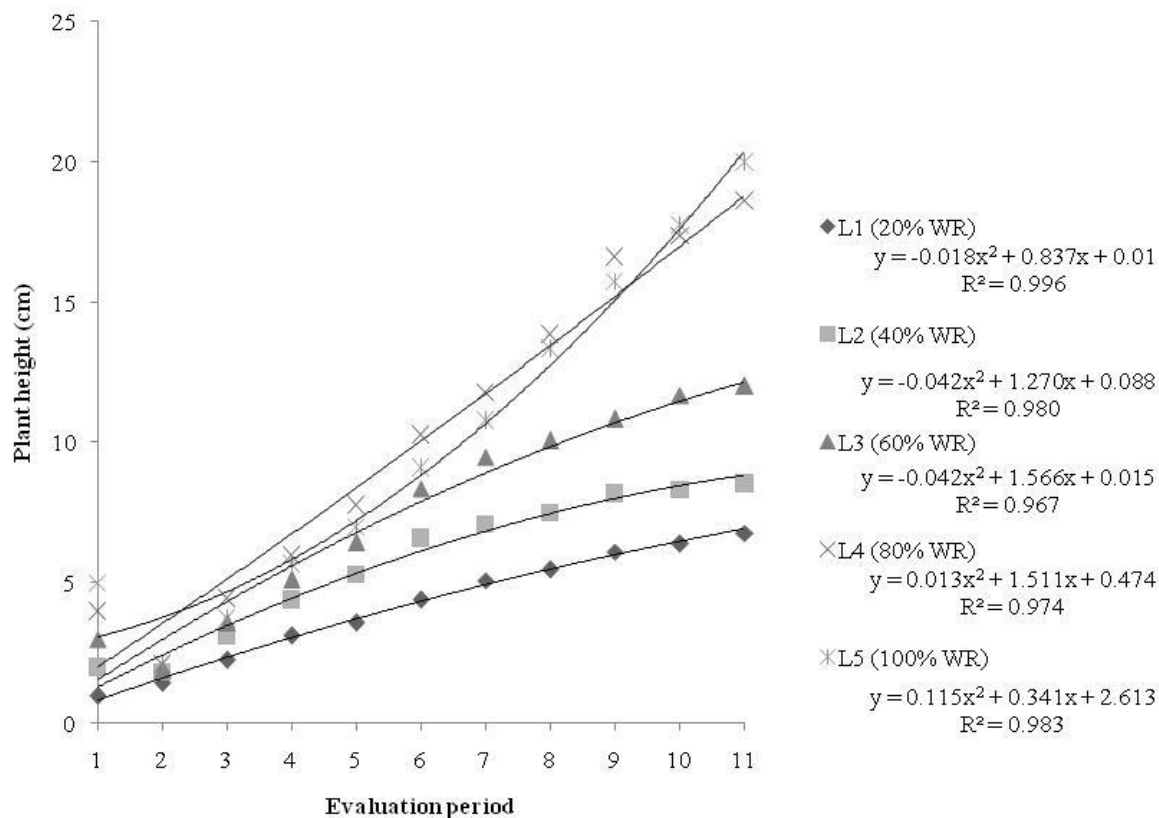


Figure 3. Regression of pepper "Biquinho" with high organic substrates irrigated with different water levels, and evaluation times of 30 (1), 44 (2), 58 (3), 72 (4), 86 (5), 100 (6), 114 (7), 128 (8), 142 (9), 156 (10) and 170 DAS (11).

Table 1. Plant height (PH) of pepper BRS Moema ("Biquinho"), with organic substrates irrigated levels with water supply and wastewater treated.

| Source of variation | Mean square plant height ¹ | | | | | | | | | | |
|--------------------------|---------------------------------------|-------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| | PH ₁ | PH ₂ | PH ₃ | PH ₄ | PH ₅ | PH ₆ | PH ₇ | PH ₈ | PH ₉ | PH ₁₀ | PH ₁₁ |
| Type of water | | | | | | | | | | | |
| Supply water (A1) | 1.84 ^a | 3.32 ^a | 4.51 ^a | 5.45 ^a | 6.91 ^a | 8.00 ^a | 9.11 ^a | 10.63 ^a | 11.60 ^a | 12.45 ^a | 13.39 ^a |
| Wastewater (A2) | 1.93 ^a | 3.54 ^a | 5.27 ^a | 6.68 ^b | 8.63 ^b | 9.71 ^b | 11.06 ^b | 12.37 ^a | 13.03 ^a | 13.98 ^a | 15.33 ^a |
| Type of substrate | | | | | | | | | | | |
| Cattle substrate (S1) | 2.25 ^b | 4.72 ^b | 6.95 ^b | 8.47 ^b | 10.26 ^b | 11.25 ^b | 12.01 ^b | 13.23 ^b | 13.93 ^b | 14.47 ^a | 15.24 ^a |
| Goat substrate (S2) | 1.52 ^a | 2.14 ^a | 2.84 ^a | 3.67 ^a | 5.28 ^a | 6.46 ^a | 8.06 ^a | 9.78 ^a | 10.70 ^a | 11.97 ^a | 13.48 ^a |

Means followed by the same letter in the column do not differ by Tukey test. 1Option of transformation: square root of $Y + 1.0$ - SQRT ($Y + 1.0$). Evaluation: 30 DAS (PH₁), 44 DAS (PH₂), 58 DAS (PH₃), 72 DAS (PH₄), 86DAS (PH₅), 100 DAS (PH₆), 114 DAS (PH₇), 128 DAS (PH₈), 142 DAS (PH₉), 156 DAS (PH₁₀) e 170 DAS (PH₁₁). Plant height (cm).

mixture had humus. Nascimento et al. (2015) analyzed the influence of water stress on the nozzle of pepper cultivated with goat substrate; they observed similar results with an average height of 14.53 to 13.70 cm using wastewater and supply water at 177 DAS.

As shown in Figure 3, the irrigation levels applied are directly proportional to plant height, and its linear growth.

The highest means were obtained in L5 (100% WR) and L4 (80% WR), providing better development in plants. Reduction of irrigation levels resulted in plants of smaller sizes. This result is interesting, because smaller plants are easily managed, and also for ornamental purposes. At 170 DAS (11), the pepper plant's height ranged from 7.43 to 23 cm (67.69%); it was checked to compare the

Table 2. Variable number of leaves (NL) of pepper BRS Moema (“Biquinho”), with organic substrates irrigated with water supply levels and wastewater treated.

| Source of variation | Mean square number of leaves ¹ | | | | | | | | | | |
|--------------------------|---|-------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| | NF ₁ | NF ₂ | NF ₃ | NF ₄ | NF ₅ | NF ₆ | NF ₇ | NF ₈ | NF ₉ | NF ₁₀ | NF ₁₁ |
| Type of water | | | | | | | | | | | |
| Supply water (A1) | 2.0 ^a | 4.4 ^a | 6.8 ^a | 8.63 ^a | 9.75 ^a | 10.78 ^a | 13.23 ^a | 13.35 ^a | 15.60 ^a | 13.86 ^a | 14.0 ^a |
| Wastewater (A2) | 2.3 ^a | 5.3 ^b | 7.95 ^a | 10.4 ^a | 13.03 ^b | 12.38 ^a | 15.08 ^a | 15.86 ^a | 14.76 ^a | 13.80 ^a | 12.90 ^a |
| Type of substrate | | | | | | | | | | | |
| Cattle substrate (S1) | 3.0 ^b | 6.71 ^b | 10.2 ^b | 13.4 ^b | 15.0 ^b | 13.8 ^b | 15.4 ^a | 14.81 ^a | 13.33 ^a | 10.16 ^a | 7.46 ^a |
| Goat substrate (S2) | 1.3 ^a | 2.98 ^a | 4.53 ^a | 5.67 ^a | 7.73 ^a | 9.36 ^a | 13.63 ^a | 14.40 ^a | 17.33 ^b | 17.50 ^b | 19.43 ^b |

Means followed by the same letter in the column do not differ by Tukey test. ¹Option of transformation: square root of $Y + 1.0 - \text{SQRT}(Y + 1.0)$. Evaluation: 30 DAS (LN₁), 44 DAS (LN₂), 58 DAS (LN₃), 72 DAS (LN₄), 86DAS (LN₅), 100 DAS (LN₆), 114 DAS (LN₇), 128 DAS (LN₈), 142 DAS (LN₉), 156 DAS (LN₁₀) e 170 DAS (LN₁₁). Number or leaves in units.

smaller and larger irrigation depth. It shows that by reducing the amount of water available to plant for drought stress, the metabolism of the culture is affected. The irrigation level for a higher average height “Biquinho” pepper is 100% WR in this study; it is similar to that achieved by Aragão et al. (2011), who studied different irrigation levels of Magali R. They observed a higher average height, using up to 100% of Eto. Barcelos et al. (2015) submitted that the red sweet pepper nozzle potassium doses reach 3.7 cm height.

In Table 2, the analysis of variance for the number of leaves (NL), and the source of water was significant at NL₂ (30 DAS) and NL₅ (86 DAS) reviews. Biquinho grown peppers with goat substrate and irrigated treated wastewater and supply averages were superior at 51 and 93 DAS; supply water had the best average until the end of the experiment; at 177 DAS, it ranges from 16.33 to 19.13 leaves per plant (Nascimento et al., 2015).

In research conducted with commercial substrate in the yield of seedlings of three black pepper genotypes, Serrano et al. (2012) observed the number of leaves for an average of 11.1 (Gajarina), 11.0 (laçara) and 12.9 (Singapore). Corroborating with the results of these authors, the “Biquinho” pepper with bovine substrate produced an average of 15.4 leaves at 144 DAS, and with caprine substrate an average of 19.34 leaves at 170 DAS; indicating that organic substrates used propitiated conditions favorable to the crop.

As shown in Figure 4, there was a quadratic regression trend in the number of leaves. The L4 level (80% WR) and L5 level (100% WR) had better results when compared to other irrigation levels. By regression analysis, there was a 24.44% increase in the number of leaves in the L4 when compared with L5, where there was reduction of 20% of water available to the plant. When comparing L3 with L4, improving water availability by 20%, there is an increase in the number of leaves of 55.2%. The L4 irrigation level was considered adequate influencing positively the amount of pepper leaves. In the number of sheets of the nozzle pepper there was an

increase in the number of sheets when there is increased availability of water based on the water requirement (80% (L4) and 100% (L5)).

By studying the tomato growth rates at different irrigation levels, Soares et al. (2011) had lower results; they reported an increase in the number of leaves, increase in water availability (20%) of the reference evaporation. There was an increase of 29.45% in the amount of leaves between irrigated plants. Silva et al. (2012), studying lettuce growing culture, saw a greater amount in number of leaves of plants irrigated with the blade, 125% ET0.

The plants irrigated with wastewater had the best averages and bovine substrate had superior results when compared to the substrate goats. At 170 (SD11), the nozzle pepper irrigated with wastewater had an average of 5.39 mm, and when irrigated with the average supply of water it is 5.17 mm and approximately 0.22 mm difference (Table 3). The wastewater had in all evaluations higher values when compared to the water supply. Costa et al. (2009) confirmed it on studying the stem diameter of the corn stalk. SD was higher for plants receiving wastewater compared to the results of plants that received water supply.

Comparing the values obtained with the stem diameter of the “Biquinho” pepper under different types of fertilizers obtained by Pagliarini et al. (2014), there was an average of 3.07 to 4.44 mm; while the values obtained in this experiment with bovine and caprine substrate under different water levels were higher. Silva et al. (2013), in producing ornamental pepper (*C. annuum* L.) with different substrate compositions, observed that the stem diameter of the pepper changed from 2.2 of 4.4 mm. According to Figure 5, L4 (80% WR) and L5 (100% WR) had better average as compared to other levels. To reduce 20% of the water requirement, there was a decrease of 15.8% in stem diameter in L4 levels and L3 levels. Comparing L2 with L1, there was an increase of 13.16% in stem diameter. It is noted that the highest means were obtained with irrigation levels of 80% of the

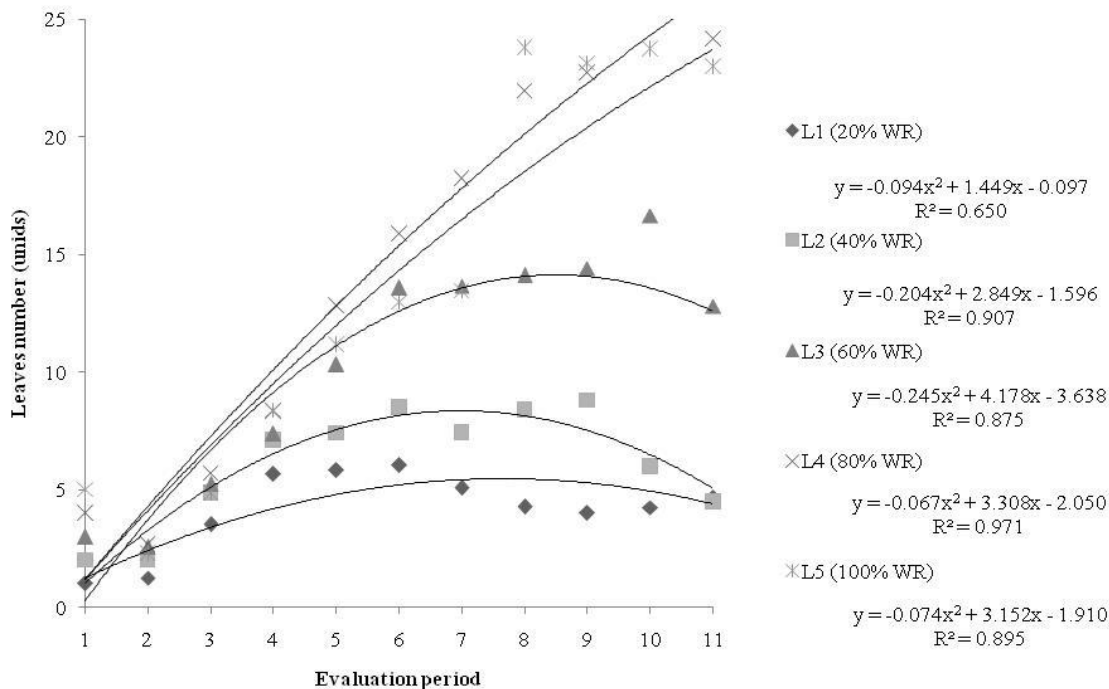


Figure 4. Regression of number of leaves of “Biquinho” pepper with organic substrates irrigated with different water levels, and evaluation times of 30 (1), 44 (2), 58 (3), 72 (4), 86 (5), 100 (6), 114 (7), 128 (8), 142 (9), 156 (10) and 170 DAS (11).

Table 3. Means the stem diameter (SD) of pepper BRS Moema (“Biquinho”), with organic substrates irrigated with water supply levels and wastewater treated.

| Source of variation | Mean square stem diameter ¹ | | | | | | | | | | |
|--------------------------|--|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| | SD ₁ | SD ₂ | SD ₃ | SD ₄ | SD ₅ | SD ₆ | SD ₇ | SD ₈ | SD ₉ | SD ₁₀ | SD ₁₁ |
| Type of water | | | | | | | | | | | |
| Supply water (A1) | 1.03 ^a | 1.38 ^a | 1.78 ^a | 2.02 ^a | 2.59 ^a | 2.91 ^a | 3.42 ^a | 3.87 ^a | 4.28 ^a | 4.54 ^a | 5.17 ^a |
| Wastewater (A2) | 1.06 ^a | 1.45 ^a | 1.87 ^a | 2.12 ^a | 2.72 ^a | 3.10 ^a | 3.65 ^a | 4.07 ^a | 4.64 ^a | 5.10 ^b | 5.39 ^a |
| Type of substrate | | | | | | | | | | | |
| Cattle substrate (S1) | 1.13 ^b | 1.70 ^b | 2.34 ^b | 2.64 ^b | 3.40 ^b | 3.79 ^b | 4.33 ^b | 4.85 ^b | 5.18 ^b | 5.51 ^b | 5.96 ^b |
| Goat substrate (S2) | 0.96 ^a | 1.13 ^a | 1.32 ^a | 1.50 ^a | 1.91 ^a | 2.21 ^a | 2.73 ^a | 3.09 ^a | 3.75 ^a | 4.12 ^a | 4.60 ^a |

Means followed by the same letter in the column do not differ by Tukey test. ¹Option of transformation: square root of Y + 1.0 - SQRT (Y + 1.0). Evaluation: 30 DAS (SD₁), 44 DAS (SD₂), 58 DAS (SD₃), 72 DAS (SD₄), 86DAS (SD₅), 100 DAS (SD₆), 114 DAS (SD₇), 128 DAS (SD₈), 142 DAS (SD₉), 156 DAS (SD₁₀) e 170 DAS (SD₁₁). Stem diameter in mm.

water requirement of the crop.

Silva et al. (2012), studying the effect of percentages (125, 100, 75, 50 and 25%) on the actual daily evapotranspiration of lettuce, Saia Veia (*Lactuca sativa* L.), it was found that plants irrigated with different water levels had significantly different stem diameter in treatments 25, 50 and 125% of Eto; there was increased stem diameter in the blade at 125% of Eto. The nozzle pepper increased in all slides, but the greatest diameter was for the replacement of 80 and 100% of the water requirement.

Reducing the diameter of the stem is directly related to increased water replacement levels. Soares et al. (2011) found similar results for tomato cultivation; so drought in the vegetative and reproductive phase provides lower height of plants, number of leaves and stem diameter. Analyzing the development of the coffee conilon it was found that drought reduced the stem diameter of this species (Dardengo et al., 2009). In rosemary-pepper cultivated at different irrigation levels, Alvarenga et al. (2012) and Figueiredo et al. (2009) observed better growth occurring with greater water availability.

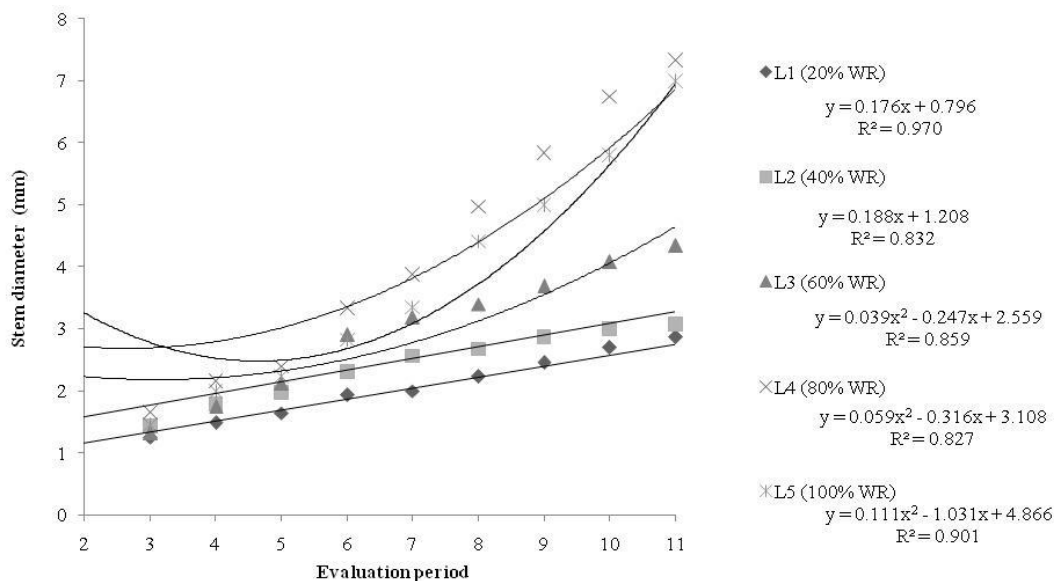


Figure 5. Regression of stem diameter of “Biquinho” pepper with organic substrates irrigated with different water levels and evaluation times of 30 (1), 44 (2), 58 (3), 72 (4), 86 (5), 100 (6), 114 (7), 128 (8), 142 (9), 156 (10) and 170 DAS (11).

Conclusions

The bovine substrate used in BRS Moema pepper cultivation had the best results for the development of the crop. The caprine substrate can be applied, but the pepper trees would be small, making it ideal for ornamentation.

The wastewater used for irrigation of pepper is an alternative of water reuse in agriculture, reducing costs, providing nutrients for the plants and resulting in better averages, so, more shrubby pepper. The L4 irrigation (80% WR) and L5 (100% WR) were the water supply needs of pepper BRS Moema; they are favorable conditions for the crop. So, the plants irrigated with 80% WR allows for proper development of the pepper, saving water.

Conflict of Interests

The authors have not declared any conflict of interests.

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