ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 09, pp.38750-38755, September, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

DIFFERENT SUBSTRATES AND IRRIGATION LEVELS IN THE FORMATION PHYTOMASS AT ORGANIC PEPPER

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ARTICLE INFO

Article History:
Received 22nd June, 2016
Received in revised form
24th July, 2016
Accepted 07th August, 2016
Published online 30th September, 2016

Key words:
Water deficit,
Wastewater,
BRS Moema.

ABSTRACT

The semiarid region is characterized by poor rain distributions and prolonged droughts. Water recycling and organic waste are alternative to enable the pepper cultivation. In this context, the research was conducted to analyze the different substrates and irrigation levels in organic pepper formation and the allocation of phytomass with wastewater and water supply. The treatments were based on five irrigation levels (L) using water supply and wastewater as the water requirement of the crop (WR), they are: 100% WR (L5), 80% WR (L4), 60% WR (L3), 40% WR (L2) and 20% WR (L1). After 177 days of sowing, the following formation were evaluated: fresh phytomass of shoot (FPS) and dry phytomass of shoot (DPS), fresh phytomass of root (FPR) and dry phytomass of root (DPR), total fresh phytomass (TFP) and total dry phytomass (TDP), and length of the root (LR). With rising water levels there was increase in the formation of phytomass. The cultivation of BRS Moema pepper in bovine substrate increased the length of the root with 3.2 cm. Through the analysis of the variables, it was found that the pepper has an impressive ability to adapt to drought.

Citation: Silva, V. F., Nascimento, E. C. S., Lima, V. L. A., Andrade, L. O., Castro, C. U. B. and Oliveira, H. 2016. "Different substrates and irrigation levels in the formation phytomass at organic pepper", *International Journal of Current Research*, 8, (09), 38750-38755.

INTRODUCTION

The Brazilian semiarid region is characterized by scarce and irregular rainfall, in addition to prolonged droughts. The problem of drought in the region has a number of variables that interact and form recurring disasters in the environment (Andrade & Nunes, 2014). Azevedo (2012) affirm that lack of water always existed and it could be prevented through monitoring and management of water resources. Silva & Thiel (2012) reported that water is vital for economic activities and the maintenance of its quantity and quality is necessary for good management. Family farming is practiced on small farms in semiarid region and the lack of water during dry seasons makes the crops water deficient (Andrade & Nunes, 2014), thus application of wastewater to irrigate crops becomes an alternative for small farmers. Recycling of water decreases the surface water demand or subsurface due to the use of water with low quality in agriculture, consequently drinking water can be conserved by the reuse. Increased demand together with shortage of water indicates that the water recycling should be a priority for agricultural activities. With that, the yield will become sustainable; generate funds for producer; final product with quality and affordable price for consumers; and also increases the acreage and agricultural production (Silva & Thiel, 2012). The fusion of animal manure in the soil and the recycling of low quality water is an alternative for waste generated in small or large properties in operation of gardens, ornamental plant, seedling production, fertilization, among others. Araújo (2010) opines that pepper cultivation is opportunity for small produces to interact with bigger businesses because pepper farming is done majorly by family farms; and as a result, the substrate composition, water types, container size are important for the improvement of pepper cultivation. The amount of water used for crop irrigation can influence the plant development. In line with that, Lima *et al.* (2012), is of the opinion that, water requirement varies among species and throughout their cycle, so knowing the behavior of the species in each development stage is imperative for proper management planning and also taking into account the rational use of available hydric resources. Gomes & Testezlaf (2007) confirm the importance of proper irrigation management for maximum production and preservation of the environment. Using natural resources in the appropriate manner by applying soil and water conservation techniques will minimize the impacts caused by agriculture. The research was carried out in order to analyze different substrates and irrigation levels in the

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formation of organic pepper and the allocation of phytomass with wastewater and supply water.

MATERIALS AND METHODS

Site description

The research was done in an experimental area of 72 m^2 in Federal University of Campina Grande - UFCG, located in the city of Campina Grande – PB. The geographical coordinates is 7º13' south latitude and 35º52'west longitude at an altitude of 550 m above sea level (Oliveira *et al*., 2013). According to Jacome *et al*. (2009) the climate is AWi type according to and is characterized with tropical climate, with rainfall of 802,7 mm, Köeppen rating. The annual air temperature is around 23.3 °C, with a maximum of 30.9 °C, minimum 18.4 °C and relative humidity ranging between 75% and 83% (Medeiros *et al*., 2011).

Cultivation and Treatment

The vegetal material cultivated in this experiment was BRS Moema pepper (*Capsicum chinense*), developed by the ISLA seeds company from propagation via seeds. 120 black plastic vases, with a capacity of approximately 1.9 L, with the following dimensions: 15 cm of top diameter, 9 cm of bottom diameter and 14 cm of height were used. Six holes and a protecting screen were placed at the bottom of the pots that were filled with crushed stones (nº 0), covering all the bottom, and the substrate (soil: manure, 7:3), thus, 70% soil and 30% manure, on a volume basis, were made for the drainage. The drained water volumes from vessels in the lysimeters were measured and the water requirement of the crop at 100% relied on the difference between the average level of irrigation applied and the average volume drained in the lysimeters. The experiment was laid out in a randomized block design, in a 2x5x2 factorial, 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 water supply and wastewater treated by anaerobic up flow sludge blanket (UASB + WETLAND) based on water requirements of the crop (WR), are as follows: 100% WR (L5), 80% WR (L4), 60% WR (L3), 40% WR (L2) and 20% WR (L1). After the removal of soil, it was evaluated at 177 days of sowing the fresh phytomass of root (FPR) obtained with the immediate weight of the root system. This was done with the help of fine mesh strainer and rinsed with distilled water, with no portion of the roots discarded. The fresh phytomass of shoot (FPS) was composed by weight leaf, petiole and stem, obtained by weighing immediately after using a stylus to make the cut in the ground surface boundary. The total fresh phytomass (TFP) was obtained by summing the FPR with FPS. Immediately after obtaining fresh phytomass, the material was allocated separately in paper bag with side holes and then placed in an oven with a constant temperature of 62 °C over a 72 hour period by weighing the following until constant weight to obtain dry phytomass of shoot (DPS) and dry phytomass of roots (DPR). The sum of these two dry phytomass (DPS + DPR) resulted in total dry phytomass (TDP). The length of root (LR) was measured with a graduated ruler after the removal of organic substrates. The results were evaluated by analysis of the variance and the means were subjected to Tukey test at 5% significance with the help of System Computer Program for Analysis of Variance - SISVAR 2.5 (FERREIRA, 2014).

RESULTS AND DISCUSSION

Application of different water qualities in irrigation pepper plant, as shown in Table 1, shows no significant effect the shoot and the root length on fresh phytomass of the crop and it is significant for other variables. The source of variation substrate, the phytomass and total dry matter of the shoot were not statistically significant.

Table 1. Mean of fresh phytomass of shoot (FPS) and root (FPR), total fresh phytomass (TFP), dry phytomass of shoot (DPS) and root (DPR), total dry phytomass (TDP) and length of root (LR) of BRS Moema pepper on different substrates and irrigation levels

	Mean Square[1]						
Source of Variation	**FPS**	**FPR**	**TPF**	**DPS**	**DPR**	**TDP**	**LR**
Type of water							
Supply water (W1)	5.32a	3.52a	8.84a	0.83a	0.92a	1.75a	25.95a
Wastewater (W2)	6.82a	5.74b	12.56b	1.11b	1.47b	2.6b	27.65a
Tipo de Substrato							
Cattle substrate (S1)	4.76a	4.94b	9.7a	0.95a	0.83a	1.78a	28.4b
Goat substrate (S2)	7.37b	4.32a	11.69a	0.99a	1.56b	2.56b	25.18a

LR (cm); FPS (g); FPR (g), TFP (g); DPS (g); DPR (g); TDP (g); Means followed by the same letter vertically do not differ from Tukey test.1 Option transformation: Square root of Y + 1.0 - SQRT (Y + 1.0)

Melo *et al*. (2014) analyzed the influences of biofertilizer concentration and irrigation levels on phytomass accumulation in pepper and they found that for concentrations of biofertilizer, there was a significant influence on the dry mass of the root. Linhares *et al*. (2014) studied the effect of organic fertilizer on phytomass accumulation of Italian sweet pepper (*Capsicum*) and observed that there was no significant effect of treatments on the dry mass of Italian sweet pepper crops. The Table 1 notes that the waste water to pepper phytomass accumulation had higher average when related to pepper irrigated with water supply. The root length increased by 1.7 cm compared to wastewater. Bovine substrate for total fresh phytomass and total dry phytomass had lower average in the caprine substrate. The pepper cultivation in bovine substrate increased by 3.2 cm in root length, averaging 28.4 cm, whereas with caprine substrate, the average was 25.1 cm. Oliveira *et al*. (2012), obtained lower results in the study of the growth of Chilli pepper (*C. frutescens*) and Tequila sunrise (*C. annuum* L.) fertigated in different contents with domestic effluent, with the root size of chilli pepper ranging from 5.5 cm to 10.5 cm, and 5.5 cm to 9.8 cm for tequila sunrise pepper. Barcelos *et al*. (2015) analyzed different substrates in two species of "Beak" sweet pepper and found that substrate composed of 20% of Tecnomax® and 80% of ravine soil caused major root growth with approximately 0.15 g of dry mass of root and result for bovine substrate (0.83 g), caprine substrate (1.56 g), water supply (0.92 g) and treated wastewater (1.47 g) is lower than that obtained in this study. Lower results were tested by Costa *et al*. (2015) in the production of ornamental pepper with composition of vermiculite substrate and manure, noting that dry phytomass of shoot to crop Etna was 0.016 g and 0.017 g to crop Pyramid, also, the dry phytomass of root and total dry phytomass for both crops were lower. In the studies by Crispin *et al*. (2015) divergent results were gotten using different substrates in cultural tract of pepper (*Capsicum* spp.) and it was found that the composition of washed sand substrate with bovine manure for total fresh mass variable (TFM) obtained 7.6 g, 3.4 g for fresh matter of shoot (FMS) and 2.0 g for total dry matter (TDM). In the above study, the constitution of caprine manure substrate with topsoil and washed sand observed higher means with 14.4 g (TFM), 9.0 g (FMS) and 3.7 g (TDM). Studying the effect of different substrates in the yield of pepper, Coelho *et al*. (2013) found that the total dry matter ranged from 0.025 g to 0.037 g. Dourado *et al*. (2013) discovered that caprine manure achieved the best results in the fresh weight of radish leaf. Irineu *et al*. (2014) by means of bovine manure and caprine manure in the production of biomass Italian sweet pepper (*C. annum* L.) with organic fertilizer in the hinterland of the state of Paraíba - Brazil for total fresh weight, reached greater means with the substrate compound. From the analysis of the regression of the fresh phytomass shoot of BRS Moema pepper in Figure 1, it is observed that by increasing the amount of water applied in irrigation there is steady growth in the production of fresh phytomass of the "Beak" pepper. However, when considering the irrigation level of 40% WR, it was noted that there was loss of phytomass, with the smallest average of 1.42 g. When comparing pepper irrigated with only 20% WR (L1) and 100% WR (L5), there is a significant reduction of 88.7% of fresh matter of shoot that is, for the leaves and stem the crops can be seen. Relating L3 irrigation level (60% WR) to L4 (80% WR), there is an increase of 20% of the water requirement of the crop, increase of 36.5% in FPS, when the amount of irrigation level passes to 40% WR, that is, comparing L3 with L5 (100% WR), there is increase of 72.2% approximately.

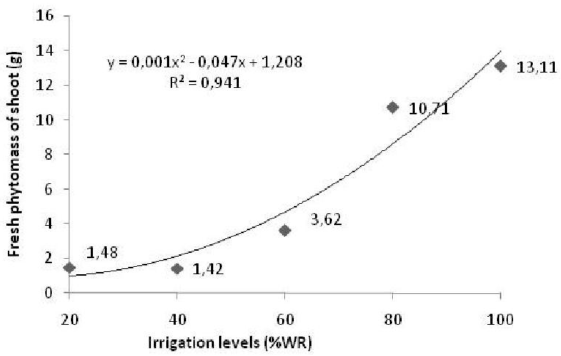

Figure 1. Regression of the formation of fresh phytomass of shoot (FPS) in BRS Moema pepper plant under different water qualities and irrigation levels with cattle and goat substrate

Paiva *et al*. (2012) in the application of different domestic sewage concentrations in Chilli pepper cultivation obtained values of 4.7 g to 5.9 g for weight of fresh shoots, and were lower than those found in this study during irrigation and levels with 80% and 100% WR. Azevedo *et al*. (2005) evaluated the fresh weight of pepper according to irrigation levels 40, 60, 80,100 and 120% of water evaporation in tank class A (ECA) found in relation to FPS; the largest absolute value occurred with the 100% level of the ECA and lower value with 40% level of the ECA. The results are similar, because with the application of irrigation level with 100% WR resulted in higher mean with 13.1 g, while the lowest was with 1.4g (L2). Equally, to Santos *et al*. (2001), the fresh phytomass of shoot increases with the availability of water to the crop, and the greater the amount of the number of leaves and branches of production compared to photosynthesis, more are expected to elevate photosynthate translocation by enabling the improvement of the production of harvested stalks, and also a greater number of flowers. In the organic cultivation of pepper seen in Figure 2, the amount of water applied became evident with 100% WR (L5) and with results that enhances the production of fresh phytomass of root. In 20% of irrigation levels, there was progressive increase in production.

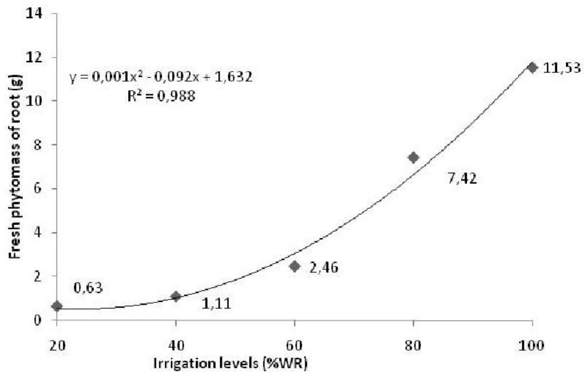

Figure 2. Regression of the fresh phytomass of root (FPR) formation in ornamental pepper plant on different water qualities and irrigation levels with cattle and goat substrate

Comparing the results obtained in the lower level of irrigation (L1) with the greater availability of water to the crop (L5), diminishing fresh phytomass of root is 94.5%. By reducing the 20% level WR, that is, the level of irrigation applying 80% WR (L4), there is decrease of 35.64%, approximately, by treating with L5, as shown in Figure 5. The following results were obtained for fresh phytomass of root: 0.63 g (L1), 1.11 g (L2), 2.46 g (L3), 7.42 g (L4) and 11.53 g (L5). In the application of different domestic sewage concentrations in chili pepper, Paiva *et al*. (2012) obtained 2.36 to 3.76 g root values of fresh matter. The correctly applied irrigation offers the necessary amount of water for the development the crop according to Figure 3. The BRS Moema pepper had total fresh phytomass formation in irrigation levels of 80% and 100% of the water requirement of pepper, being the amount of water that amounts the demand of the "Beak" pepper.

Increase of 6.51g while the associated irrigation levels L4 to L5 is boosted by 20% WR. In comparing L1 to L5, there is an increase in the total fresh phytomass of approximately 91.4%. Paiva *et al*. (2012) obtained lower values in the chili pepper cultivation with different concentrations of sewage to the variables' total fresh matter, ranging from 7.3 g to 9.4 g. Oliveira *et al*. (2012), Chili pepper and Tequila Sunrise was studied with different contents of treated effluent; fresh of weight shoot averages 11.4 g and 10.1 g, weight of fresh root 0.9 g and 4.4 g, and total fresh weight averages 12.3 g and 14.6 g for Chili peppers and Tequila Sunrise, respectively. The

Figure 4, for dry phytomass of shoot, sets the regression quadratic equation and it is noted that the application of irrigation level (L1) obtained the lowest average, thus ascertains that the quantity of available water is decreased DPS.

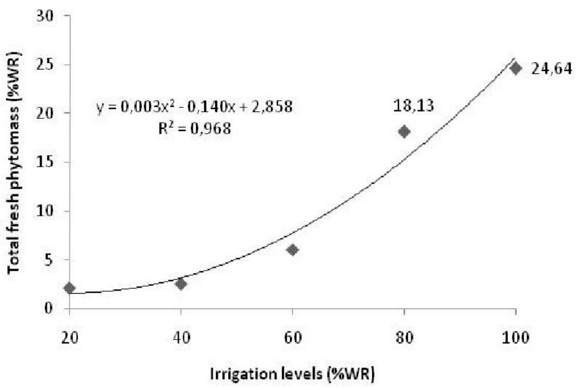

Figure 3. Regression of the total fresh phytomass formation (TFP) of BRS Moema pepper plant in different water qualities and irrigation levels, with cattle and goat substrate

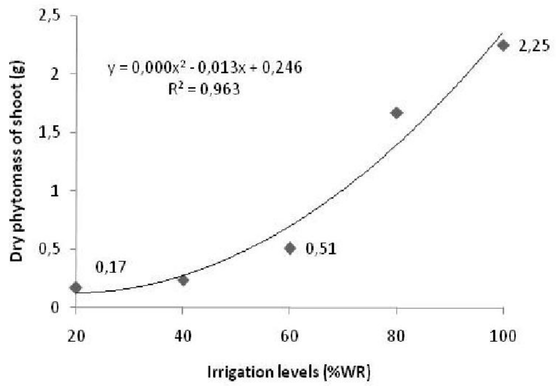

Figure 4. Analysis of the regression in dry phytomass of shoots (DPS) in the "Beak" pepper with different water qualities and irrigation levels by means of cattle and goat substrate

By way of evaluating the effect of different levels of domestic wastewater, Nobre *et al*. (2010) observed that the regression equation of linear correlation with the replacements of water requirement is applicable to the dry phytomass of shoot. The level of irrigation with 100% WR (L5) had a higher average with 2.2 g and when compared to other irrigation levels applied to the "Beak" pepper, there is a decrease of 2.08 g (L1), 2.01 g (L2), 1.7 g (L3) and 0.6 g (L4), in accordance with Figure 4. Soares *et al*. (2012) studied different irrigation levels in tomato cultivation and realized that the dry phytomass of shoot set the quadratic regression equation and showed decreases between 60% and 120% of the reference evapotranspiration (ETr); it also verified that the application level of 97% of ETr provided increased production to dry mass of shoot for tomato and the results are equivalent to those obtained in this study. According to Linhares *et al*. (2014), high results were observed in the phytomass yield of Italian sweet pepper on different sources of fertilizers and by that, it was found that bovine manure obtained for dry phytomass of shoot was 46.9 g, dry phytomass of root 2.6 g, caprine manure change to dry phytomass of shoot 48.4g and dry phytomass of root 2.54 g. In the Figure 5, water availability was increased by 20% WR and based on the regression equation, a quadratic increase occurred in the dry phytomass of the root in "Beak" pepper to L1 (0.25 g), L2 (0.28 g), L3 (0.6 g), L4 (1.9 g) and L5 (2.88 g). Lima *et al*. (2013) obtained a different result in the cultivation of pepper (*C. annum* cv. Treasures Red) with coconut fiber and 4.19 g for variable dry weight of root.

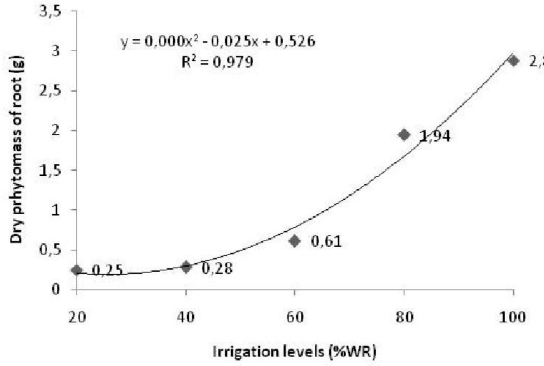

Figure 5. Regression analyses in dry phytomass root (DPR) of "Beak" pepper (BRS Moema); using different water qualities and irrigation levels with cattle and goat substrate

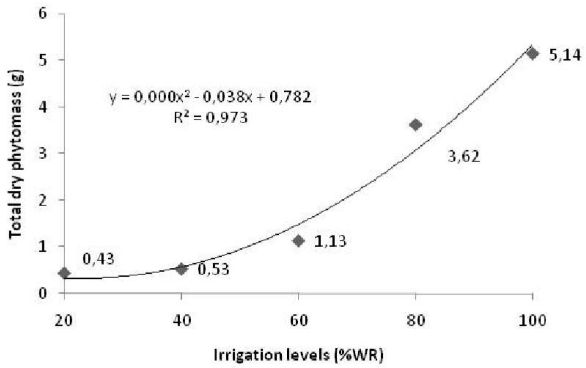

Figure 6. Regression yield of total dry phytomass (TDP) in the "Beak" pepper plant on different water qualities and irrigation levels with cattle and goat substrate

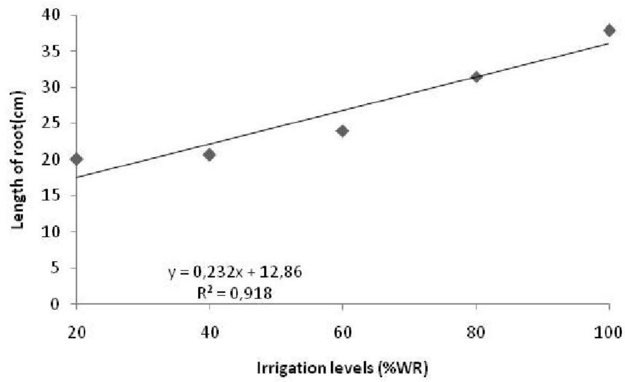

Figure 7. Regression of ornamental pepper plant (BRS Moema) root length (LR) using different water qualities and irrigation levels with cattle and goat substrate

Regarding the yield of total dry phytomass, the maximum average obtained, occurred at an irrigation level of 100% WR (L5) in pepper; the yield of phytomass was reduced with lower water levels, as a result of the influence of the amount of water in the yield of phytomass in pepper (Figure 6). Pepper irrigated with 60% WR had a phytomass yield below those that were irrigated with 80% WR, down 2.49 g. Using regression analysis, with 20% WR addition, an increase of 29.6% in the yield of phytomass by comparing the levels L5 and L4 is noted. There was a decrease in the total yield of dry phytomass by 89.7%, comparing L2 to L5 in Figure 6. A better development result was achieved by Aragão *et al*. (2011) by increasing the amount of water applied to analyze the effect of different irrigation levels in chili pepper; and it was discovered that crop responded in linear fashion by way of irrigation levels in vegetative growth. By irrigating sunflower crop with different water qualities, Brito *et al*. (2014) discovered that treated wastewater, being an alternative to irrigation of the crop, stimulated significant additions to sunflower formation.

As stated in Figure 7, with the addition of water levels there is an increase in root length ornamental pepper. When L5 is applied with the available water to 100% WR, the length of the root (LR) which is 37.8 cm will be reduced by 20%, that is, L4 (80% WR) the LR is 31.5 cm, with a reduction of 16.67%. In the application of L1 (20% WR) there was an increase of 10% in the length of the root compared to the L3 (60% WR) with an increase of 40% due to water availability. It can be seen that by increasing the amount of water used in irrigating the crops, the length of the root increases also.

On the word of Xavier *et al*., the root length average of 22.86 cm was obtained while evaluating Gion red pepper (*C. annum*) variety grown in hydroponics with nutrient solutions. (2006).

Conclusion

The irrigation levels indicated are 100% of the water requirement (L5) of “Beak” pepper for the formation of phytomass and length of root, also the use of wastewater is recommended. To achieve better results regarding the length of the total fresh phytomass root formation and total dry phytomass, goat manure substrate should be used in pepper cultivation. The “Beak” peppers have an impressive ability to adapt to drought and can be used in areas with water shortages.

Conflict of Interest

The authors have not declared any conflict of interest.

Acknowledgements

This work is a part of the research project financially supported by the National Counsel of Technological and Scientific Development.

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