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Initial development of watermelon in fuction of substrates and irrigation with saline water

Desenvolvimento inicial de melancieira em função de substratos e irrigação com água salina

D. A. Carreiro[1*]; I. M. A. Silva[2]; J. T. Lobo[3]; J. O. S. Lino[1]; R. T. Fatima[3]; L. G. Sanches[1]; A. J. S. Santos[1]; L. E. D. Mudo[1]

[1]Federal University of São Francisco Valley, Agricultural Sciences Campus, 56300-990, Petrolina-PE, Brazil

[2] Federal University of Campina Grande, Agrofood Science and Technology Center, 58840-000, Pombal-PB, Brazil

[3] Federal University of Paraíba, Agricultural Sciences Campus, 58397-000, Areia-PB, Brazil

**daniel.almeida.sb@gmail.com*

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We evaluated the initial development of watermelon cv. Crimson Sweet seedlings grown in different organic substrates and electrical conductivity of irrigation water. The experiment was carried out in a greenhouse between January and March of 2017. The experimental design was in randomized blocks with factorial arrangement 3 x 5. The treatments were combinations of three substrates: soil + bovine manure (SBM) (1:1); soil + sheep manure (SSM) (1:1) and commercial substrate Basaplant® (CS), and five electrical conductivity of irrigation water (EC_{iw}): C1 – 0.3 dS m^{-1}; C2 – 1.5 dS m^{-1}; C3 – 2.7 dS m^{-1}; C4 – 3.9 dS m^{-1} and C5 – 5.1 dS m^{-1}. Plant height, number of leaves, stem diameter, root fresh mass, stem fresh mass, leaf fresh mass, root dry mass, stem dry mass, and leaf dry mass were evaluated at 37 days after sowing (DAS). The interaction between substrate x EC_{iw} significantly affected the variables plant height, number of leaves, stem fresh mass and leaf fresh mass; all the analyzed variables were affected by substrate factor, while plant height, number of leaves, root dry mass, stem dry mass, and leaf dry mass were affected by EC_{iw}. It is possible to produce watermelon cv. Crimson Sweet seedlings using water with electrical conductivity up to 2.86 dS m^{-1} associated with commercial substrate and up to 2.67 dS m^{-1} associated with sheep manure. It can be inferred that the use of commercial substrate is more suitable for the production of watermelon cv. Crimson Sweet seedlings.

Keywords: *Citrullus lanatus*, organic matter, salinity.

Nós avaliamos o desenvolvimento inicial de mudas de melancia cv. Crimson Sweet cultivadas em diferentes substratos orgânicos e irrigadas com água com diferentes níveis de condutividade elétrica. O experimento foi conduzido em casa de vegetação, entre janeiro a março de 2017. O delineamento experimental foi em blocos casualizados com arranjo fatorial 3 x 5. Os tratamentos consistiram em combinações de três substratos: solo + esterco bovino (SEB) (1:1); solo + esterco ovino (SEO) (1:1) e substrato comercial Basaplant® (SC), e cinco níveis de condutividade elétrica de água de irrigação (CEai): C1 – 0,3 dS m^{-1}; C2 – 1,5 dS m^{-1}; C3 – 2,7 dS m^{-1}; C4 – 3,9 dS m^{-1} e C5 – 5,1 dS m^{-1}. Altura da planta, número de folhas, diâmetro do caule, massa fresca de raiz, massa fresca de caule, massa fresca foliar, massa seca da raiz, massa seca do caule e massa seca foliar foram avaliados 37 dias após a semeadura (DAS). A interação entre o substrato x CEai afetou significativamente as variáveis altura da planta, número de folhas, massa fresca do caule e massa seca das folhas; todas as variáveis analisadas foram afetadas pelo fator substrato, enquanto altura da planta, número de folhas, massa seca da raiz, massa seca do caule e massa seca das folhas foram afetadas pela CEai. É possível produzir mudas de melancia cv. Crimson Sweet usando água com condutividade elétrica até 2,86 dS m^{-1} associada ao substrato comercial e até 2,67 dS m^{-1} associada ao esterco ovino. Pode-se inferir que o uso de SC é mais adequado para a produção de mudas de melancia cv. Crimson Sweet.

Palavras-chave: *Citrullus lanatus*, matéria orgânica, salinidade.

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1. INTRODUCTION

The watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] has great socioeconomic importance in Brazil, which is the fourth largest producer in the world with 2,314,700 tons produced in an area of 105,491 hectares [1]. Among the cultivars explored, the 'Crimson Sweet' is widely produced due to the high acceptance by the consumer market, which has a preference for large and round fruits, intense red color pulp, and a pleasant flavor [2].

In the watermelon production system, one of the main determining steps for a good stand establishment is the initial stage of seedlings development, which requires substrates capable of providing good aeration and maintenance for the plant root system, nutrient availability, and supply of water [3]. Aeration influences total length, root surface area, physiological and productive characteristics of the plant [4], while a balanced availability of nutrients will allow the formation of the plant with a better establishment in the field, and the quality of water used for irrigation interferes in the plant physiological and biochemical processes, nutrient and photoassimilate transport, and plant cell constitution [5].

In semiarid conditions, low rainfall and high annual evapotranspiration are some of the limitations for agricultural production [6]. Under these conditions, the use of low-quality water for irrigation is common, even with high salt content [7], which negatively affects plant physiological processes by reduction of cellular osmotic potential, excessive accumulation of toxic ions and nutritional unbalance [8].

Organic substrates have been used as attenuators of the deleterious effects caused by the excess of salts. A positive effect of organic matter of substrate on the reduction of saline stress for the production of pineapple (*Annona squamosa* L.) seedlings was observed [9]. The addition of organic matter to the substrate reduced the harmful effects on the melon (*Cucumis melo* L.) development under saline stress [10]. The use of humus in the substrate promoted high watermelon development under saline stress up to 27 days after emergence (DAS) [11].

This study evaluated the initial development of watermelon cv. Crimson Sweet grown in different organic substrates and electrical conductivity of irrigation water.

2. MATERIALS AND METHODS

The experiment was carried out in a greenhouse at the Federal University of Campina Grande, Pombal, Paraíba (6º47'20"S, 37º48'01"W and 174 m above sea level) between January and March 2017. The climate of the region is classified as "Bsh", characterized as a tropical climate with dry season [12]. The average relative air humidity was 70% and the average air temperature was 34°C during the experiment [13].

The experimental design was randomized blocks with four replications, in a 3 x 5 factorial scheme. The treatments were combinations of three substrates: SBM - soil + bovine manure (1:1); SSM - soil + sheep manure (1:1) and CS - Basaplant® commercial substrate, and five electrical conductivity of irrigation water (EC_{iw}): C1 – 0.3 dS m^{-1}; C2 – 1.5 dS m^{-1}; C3 – 2.7 dS m^{-1}; C4 – 3.9 dS m^{-1} and C5 – 5.1 dS m^{-1}.

The different electrical conductivity were prepared by addition of sodium chloride (NaCl), calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) in water with EC_{iw} of 0.3 dS m^{-1} in a proportion of 7:2:1, in which is commonly verified in water for irrigation in the Northeast of Brazil [14]. Soil and commercial substrate chemical attributes (Table 1) were determined in the Soil Laboratory of the Federal University of Campina Grande, according to the methods described by Donagema et al. (2011) [15].

Table 1. Chemical attributes of substrates used: SBM – soil + bovine manure (1:1); SSM – soil + sheep manure (1:1) and CS – Basaplant®. P: Phosphorus; K^+: Potassium; Na^+: Sodium; OM: Organic matter; SB: sum of bases (Ca^{2+} + Mg^{2+} + Na^+ + K^+); T: Cation exchange capacity: [Ca^{2+} + Mg^{2+} + Na^+ + K^+ + (H^+ + Al^{3+})].

Subs.	pH H_2O (1:2.5)	P -----mg dm^{-3}-----	K^+	Na^+ cmolc dm^{-3}	OM g kg^{-1}	
SBM	8.40	665.53	4,433.58	1.59	59.90	
SSM	8.00	708.96	2,988.95	1.47	115.36	
CS	5.80	3.15	464.10	6.60	8.25	
Subs.	Ca^{+2}	Mg^{+2}	Al^{+3}	$H+Al^{+3}$	SB	T
	--------------------------- cmolc dm^{-3} ---------------------------					
SBM	5.58	3.51	0.00	0.00	22.05	22.05
SSM	6.10	5.37	0.00	0.00	20.60	20.60
CS	15.60	9.50	0.00	0.00	33.00	33.00

Two seeds of watermelon cv. Crimson Sweet were sown in polyethylene bags with a capacity of 0.5 dm^3. Irrigation was performed daily applying EC_{iw} water of 0.3 dS m^{-1} as recommended by Marouelli et al. (2012) [16] until 22 days after sowing (DAS) when the plants had germination stability. After this period, thinning was done leaving only one plant per bag and began irrigation with different electrical conductivity of water.

At 37 days after sowing the following variables were evaluated: plant height (PH) measured from the base to the apex using a graduated ruler (cm); the number of fully expanded leaves (NL) and stem diameter (SD) measured at 1 cm from the substrate surface with a pachymeter (mm); root (RFM), stem (SFM) and leaf (LFM) fresh mass obtained by weighing in analytical balance (g); root (RDM), stem (SDM) and leaf (LDM) dry mass after drying in forced air circulation oven at 65 °C up to constant mass and weighed in analytical balance (g).

The data were submitted to analysis of variance by the F test and, when significant, the means related to the substrate factor were compared by the Tukey test at 5% of probability; and the means of the electrical conductivity of irrigation water – EC_{iw} were submitted to regression analysis. Software R was used for statistical analysis [17].

3. RESULTS AND DISCUSSION

Interaction between substrate x electrical conductivity of irrigation water was observed for plant height (PH), number of leaves (NL), stem fresh mass (SFM) and foliar fresh mass (FFM); all the analyzed variables were significantly influenced by substrate factor. However, only PH, NL, root dry mass (RDM), stem dry mass (SDM) and leaf dry mass (LDM) were considered significant for the electrical conductivity of the irrigation water - EC_{iw}.

For PH (Figure 1), when we evaluated the electrical conductivity of irrigation water - EC_{iw} within each substrate, it was observed that there was adjustment to the quadratic regression model only for the plants grown in the commercial substrate (CS), while in the soil substrate ($p = 0.07$) and the soil substrate + sheep manure (SSM), there were no adjustment of the values to the models evaluated (p linear = 0.66, p quadratic = 0.07). In the evaluation of the substrates within each electrical conductivity of irrigation water – EC_{iw}, the CS was superior in relation to the others, with the maximum response of 47.28 cm with the electrical conductivity of 2.98 dS m^{-1}.

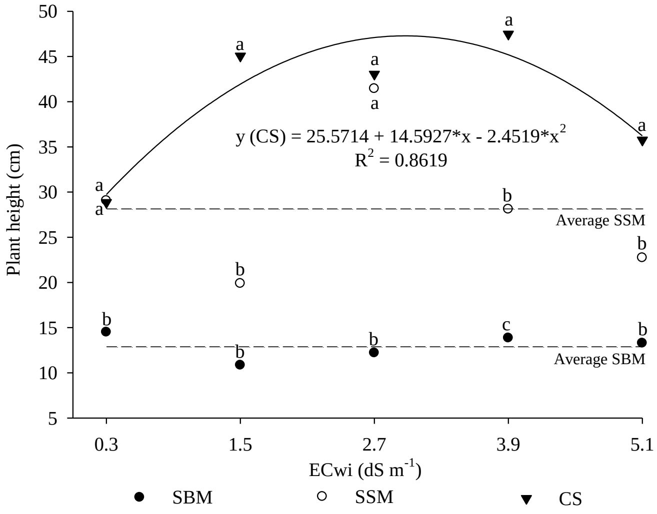

Figure 1. Watermelon plant height grown under different substrates and electrical conductivity of water. SBM: soil + bovine manure (1:1); SSM: soil + sheep manure (1:1) and CS: Basaplant® commercial substrate.

The superiority of the CS in relation to the other substrates can be justified by its pH that is close to what is considered adequate (5.8), and the other substrates were in conditions of alkalinity (pH> 8.0), therefore it could have a reduction in the availability of phosphorus to the plants due to the formation of insoluble calcium phosphate and of micronutrients such as Cu, Zn, Fe and Mn [18]. Moreover, the use of nutrients that compound the manure, both bovine and sheep, occurs through the mineralization process that demands a certain period of time [19], in this way, the application of these sources close to the date of sowing, allowed the full use of its nutritional potential.

For the number of leaves (NL), when we evaluated the electrical conductivity of irrigation water - EC_{iw} within each substrate, we noticed that only in the SSM there was difference and an adjustment of the averages to the quadratic regression model with the minimum value of 4.69 leaves at the EC_{iw} of 3.04 dS m^{-1} (Figure 2). For the SBM, there was no adjustment of the models evaluated (p linear = 0.17, p quadratic = 0.02, $R_2 = 0.35$) and for commercial substrate there was no difference between the doses studied (p = 0.47).

In the evaluation of the substrates within the doses, it was verified that only in the lower electrical conductivity of irrigation water (0.3 dS m^{-1}) the substrates promoted a change in the number of leaves, the increase that the SSM promoted was of 5.5 leaves in comparison with the result of CS.

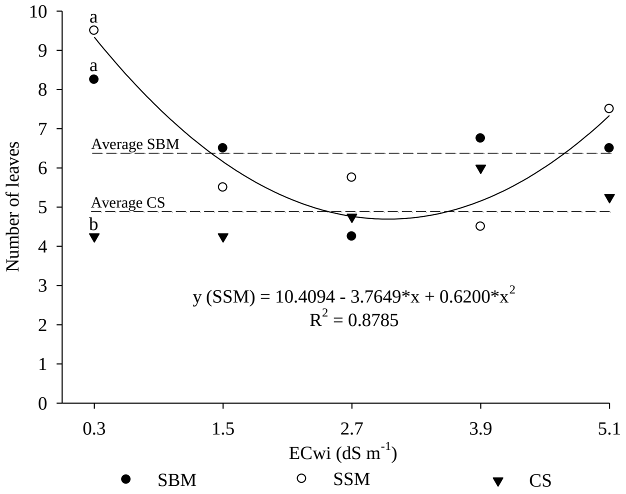

Figure 2. Number of leaves of watermelon plants grown under different substrates and electrical conductivity of irrigation water. SBM: soil + bovine manure (1:1); SSM: soil + sheep manure (1:1) and CS: Basaplant® commercial substrate.

The increase of salinity beyond the minimum value estimated promoted an increment in the number of leaves, as verified by Souza Neta et al. (2013) [20] in a study with arugula (*Eruca sativa*), who observed a variation in the number of leaves in response to the level of salinity and type of substrate used, corroborating with the data registered in the present study. According to the authors, the change in the concentration of salts in the substrate alters the physiological processes of plants, such as water absorption, meristematic activity, and consequent plant growth and development.

We observed different effects of the substrates on stem diameter, with the SSM and CS being statistically equal with an average of 4.61 mm and 1.46 mm superior than the SBM (Figure 3). Similar results were verified by Silva Júnior et al. (2017) [11] who, studying the development of watermelon grown in organic substrates under saline stress, could observe the influence of the substrate factor on the diameter of the stem, with emphasis on soil substrate + earthworm humus, demonstrating the efficiency of the organic substrate in mitigating salt stress.

The substrates independently affected the root fresh mass (Figure 4), there was an increase of 962.5% in the plants grown in the CS compared to the SBM, highest and lowest results, respectively. Therefore, probably CS had better physical and nutritional conditions for a greater accumulation of photoassimilates by the plants, which can justify the superior result obtained. Higher cation exchange capacity (CEC) promotes better nutrient availability in the soil solution, making the cations readily assimilable for plant absorption and utilization [21], which can have positively influenced this variable.

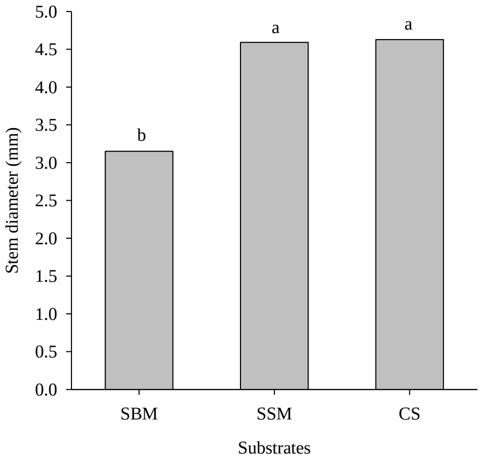

Figure 3. Stem diameter of watermelon plants grown under different substrates and electrical conductivity of irrigation water. SBM: soil + bovine manure (1:1); SSM: soil + sheep manure (1:1) and CS: Basaplant® commercial substrate.

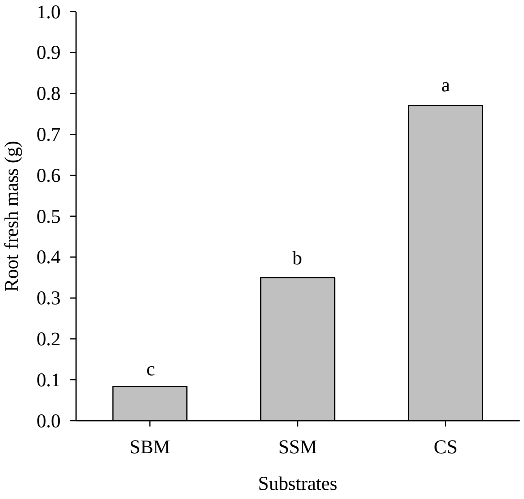

Figure 4. Root fresh mass of watermelon plants grown under different substrates and electrical conductivity of irrigation water. SBM: soil + bovine manure (1:1); SSM: soil + sheep manure (1:1) and CS: Basaplant® commercial substrate.

We observed that for stem fresh mass (Figure 5) there was an adjustment to the quadratic regression model for electrical conductivity of irrigation water - EC_{iw} in SSM and CS, with maximum values of 5.71 and 6.93 g, respectively for conductivity 2.59 and 3.70 dS m^{-1}; while for SBM no difference was observed ($p = 0.99$). The SSM and CS had greater results than SBM in all conductivity evaluated individually.

The commercial substrate (CS) allowed the irrigation using water with more concentration of salts without damage to this variable. When we evaluated the composition of the substrate, it was observed higher levels of Ca^{2+} and Mg^{2+} present in the CS, which can have contributed positively to the accumulation of mass in the stem even in higher saline conditions, since these nutrients compete for the same site of absorption of Na^{+} [4], thus reducing the deleterious effects of the salts.

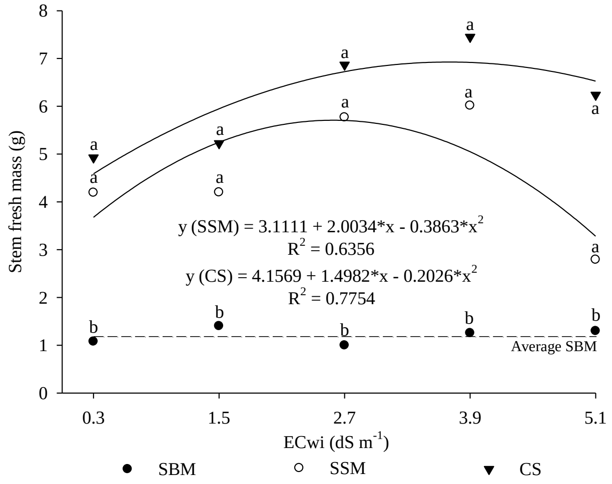

Figure 5. Stem fresh mass of watermelon plants grown under different substrates and electrical conductivity of irrigation water. SBM: soil + bovine manure (1:1); SSM: soil + sheep manure (1:1) and CS: Basaplant® commercial substrate.

Substrate and substrate interaction x EC_{iw} were observed for the leaf fresh mass (LFM), and there was no significant difference between the mean values for SBM (p = 0.97) and CS (p = 0.26), while for SSM the data were adjusted to the quadratic regression model, with a maximum value of 3.49 g for the electrical conductivity of irrigation water of 2.67 dS m^{-1} (Figure 6).

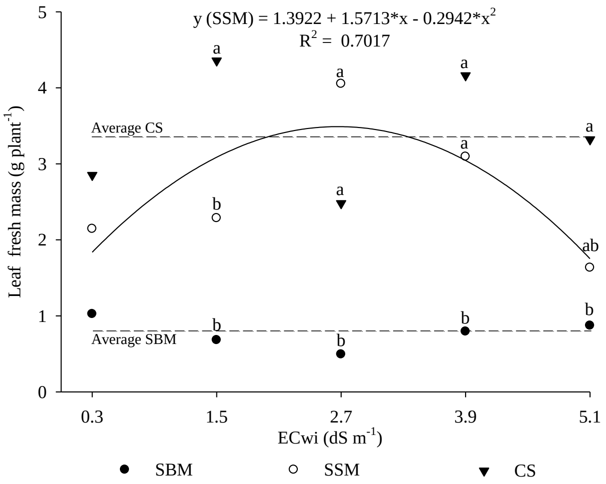

Figure 6. Leaf fresh mass of watermelon grown under different substrates and electrical conductivity of water. SBM: soil + bovine manure (1:1); SSM: soil + sheep manure (1:1) and CS: Basaplant® commercial substrate.

Lucena et al. (2011) [22] studying the development of watermelon cv. Quetzale grown under different electrical conductivy of irrigation water, could verify that the accumulation of mass at 44 days after sowing (DAS) was not affected by salinity between 0.6 and 3.98 dS m^{-1}. While Silva et al. (2017) [23] observed a decreasing for fresh mass accumulation of the shoot when increasing salinity levels in 'Crimson Sweet' watermelon. In this sense, it is noted that the tolerance of the species to the salinity varies according to the cultivar [24] and time of exposure to this condition [23].

This study indicates that irrigation with EC_{iw} of 2.67 dS m^{-1} in SSM from 22 DAS favors the accumulation of fresh mass in 'Crimson Sweet' watermelon. From this concentration, there is a tendency for decrease (Figure 6), due to the deleterious effects of excessive salt accumulation on the substrate, reducing the osmotic potential (making difficult root water absorption) and increasing the toxicity of specific ions such as sodium, boron and chlorine, which cause cellular osmotic imbalance, damage to the cytoplasm and impaired photosynthetic capacity of the plant [7].

In relation to the variables root dry mass (RDM), stem dry mass (SDM) and leaf dry mass (LDM), there was significant effect of the isolated factors substrate and electrical conductivity of irrigation water – EC_{iw} (Figure 7), being CS the one that best performed when compared to the other substrates, however there was no significant adjustment of regression models for electrical conductivity of irrigation water factor.

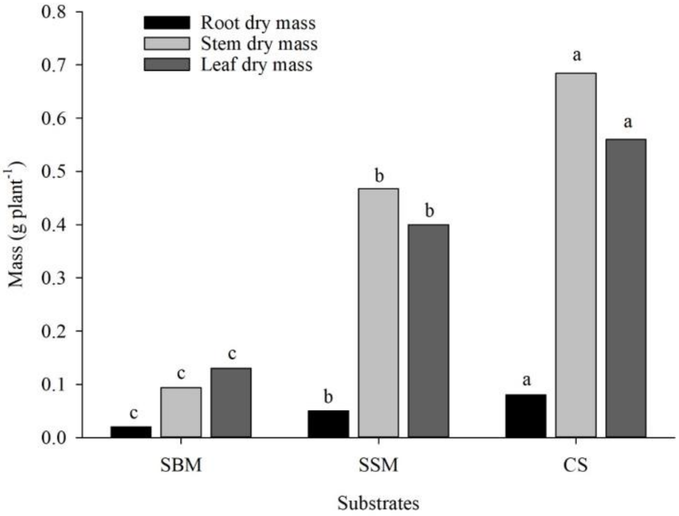

Figure 7. Root, stem, and leaf dry mass of watermelon grown under different substrates and electrical conductivity of irrigation water. SBM: soil + bovine manure (1:1); SSM: soil + sheep manure (1:1) and CS: Basaplant® commercial substrate.

The substrates used influenced similarly the variables root, stem, and leaf dry mass, yet the CS had 75.00%, 86.77%, and 76.90% of superiority compared to the SBM and 37.50%, 30.88%, 28.57% in relation to SSM. Among the alternative substrates, SSM performed the best results (60.00%, 80.85%, 67.50%) in relation to SBM for the aforementioned characteristics, respectively.

Silva et al. (2009) [6] in an experiment aiming the production of 'Crimson Select' watermelon seedlings in different substrates, could observe a superiority of the commercial substrate that provided higher values of root dry matter, aerial part and total in relation to treatments containing bovine or sheep manure combined with soil, clay or sand. Therefore, the weight of the dry matter indicates the substrate that provides nutrients in larger quantities [25].

Moreover, Ramos et al. (2012) [3] evaluating the production of watermelon seedlings in different substrates, observed the necessity for nutritional supplementation through a nutrient solution in the alternative substrates, which can be a disadvantage due to the increase on the final cost. However, the superiority of the commercial substrate in relation to the other substrates can be justified by the ready nutritional availability for root absorption and consequently, the development of the seedlings, being necessary for the other substrates the mineralization process of organic compounds for plant absorption [19].

4. CONCLUSION

Seedlings of watermelon cv. Crimson Sweet can be produced using water with electrical conductivity up to 2.86 dS m^{-1} associated with commercial substrate and up to 2.67 dS m^{-1} associated with the substrate composed by sheep manure. The use of commercial substrate is more suitable for the production of watermelon cv. Crimson Sweet seedlings than substrates containing bovine and sheep manure.

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