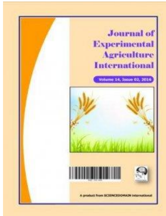

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Effect of Saline Concentrations in Melon under Different Substrates in Hydroponic System

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Authors' contributions

This work was carried out in collaboration between all authors. Author IDEC designed the study, performed the statistical analysis, wrote the protocol. Authors CCAP, AQM, FATR and FSS contributed to the evaluation activities. Author JS was responsible for translation and drafting. Authors RAM and DM were the guided research. All authors read and approved the final manuscript.

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ABSTRACT

The results show that the culture of the melon in hydroponic medium using different substrates, and increasing concentration of $NaCl^-$ salts, indicated that when the electrical conductivity (EC) levels increases as 2.0; 5.0; 8.0 and 11.0 $dS.m^{-1}$, the melon growth was higher by 2.88 cm per day, with EC of 2 Sm^{-1}. Thereafter, decreases the growth rate of melon as 2.33, 1.77 and 1.23 cm per day, when EC's goes from 5, 8 and 11 dS.m-1, respectively. In addition, the substrates sand, coconut

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powder and the commercial substrate (Basaplant) or salts-substrates, had no-effect on melon growth. The EC of 2 d.Sm^{-1} presented a higher growth rate, with a mean growth of 2.88 cm per day, the EC's of 5, 8 and 11 dS.m^{-1}, respectively presented a growth rate of 2.33; 1.77 and 1.23 cm per day. The increase in salt concentration in the solution negatively influenced the morphology and color of the melon leaves. The substrates washed sand, coconut powder and Basaplant presented no significant difference in the effects on the melon culture. The substrate type did not influence the effect of the salt on the melon.

Keywords: Salinity; Cucumis melo L.; electrical conductivity.

1. INTRODUCTION

The melon is the fruit of one of the cultivated species of greater importance for Brazil, being a vegetable, but its fruits marketed as fruit. In 2017, 224688 tons of the fruit (40% of the total produced) were exported, totalizing US$ 148,741,470. The states of Rio Grande do Norte and Ceará represent 98% of national exports of crops [1,2,3,4].

The main poles producing melon are in semi-arid regions, which have a favorable climate for the development of culture, however this same climate leads to the formation of some adverse factors, such as soil salinity, which is a natural process intensified by anthropic action. In the Brazilian Northeast, there are approximately 23,000 hectares of irrigated perimeters, of which 25% are already salinized. The Brazilian Northeast is the main region producing melon, with the semi-arid regions as highlight. These regions present edaphoclimatic characteristics that induce the process of salinization, hindering the exploitation of plant species [5,6].

Plants subjected to saline stress undergo changes throughout their structure, cellular metabolism, physiological activities, altering the growth rate and consequently production. Melon is considered a moderately tolerant to salinity, but tolerance depends on several factors, such as genotype, salt type, salt concentration, period of exposure to salt, substrate in which the plant is fixed, among other factors [7,8].

High concentrations of salts in the soil or water used cause changes in soil, substrate and solution, and consequently in the plant, these alterations go from decreasing of the pH, alterations of the physical and chemical properties, among others. It’s important to know the soil or substrate and the water used, because the greater the electrical conductivity of the solution, the higher the toxicity indexes in the plants due to the accumulation of salts in the leaves [9,10].

In hydroponic melon crops it is common for water to have a high level of salinity depending on the origin, so it is important to define the maximum electrical conductivity that plants support without losing their characteristics. Another important point is the choice of the substratum for plant fixation, which may be sand, sawdust, coconut fiber, among other materials, each of which may increase the negative effect of salinity on plants [11].

The objective of this work was to evaluate the effect of salt concentrations in melon under different substrates in a hydroponic system.

2. MATERIALS AND METHODS

The experiment was conducted in the Department of Agronomy, planting area of the Rural Federal University of Pernambuco, Campus Dois Irmãos, Recife-PE (8°01'09" S and 34°56'43" W), between July and August 2016, being carried out in a greenhouse of the arch type, with 20 m of length, 8 m of width, right foot of 3.0 m, with side protection with 50% shading and ceiling covered with 150-micron thick low density polyethylene film.

The experimental design was completely randomized in the scheme of subdivided plots, the plots being the four salt concentrations and the subplots the three substrates, in four replications. Each plot consisted of four 400 ml pots, with perforations at the base, in which they had two plants in each.

The salinity levels were 2.0; 5.0; 8.0 and 11.0 dS.m^{-1}, which were applied on hydroponic masonry benches 5 m long and 2 m wide, with slope of 12%. The salt used was Iodine Sodium Chloride (NaCl), which consists of 360 mg/+^{1}. The pH of this solution ranged from 6.0 to 6.5, being controlled with the use of caustic soda

(NaOH). The automated hydroponic system emitted water on the bench for 15 min, with an interval of 45 min. The water used to make the solution had the characteristics shown in Table 1.

Table 1. Physical-chemical parameters of water

Parameters analyzed	Results
Total alkalinity (mg/L $CaCO_3$)	32,00
Ammonia (mg/L Cl)	5,86
Chlorides (mg/L Cl)	83,90
Apparent color (mg/L Pt)	10,00
Total Hardness (mg/L $CaCO_3$)	104,00
Total iron (mg/L Fe)	11,10
Manganese (Mg/L Mn)	1,37
Nitrite (mg/L N-NO_2)	0,01
pH	6,33
Salinity ($dS.m^{-1}$)	0,13
Total dissolved solids (mg/L)	130,00
Turbidity (NTU)	0,21

The variety of melon (*Cucumis melo* L.) used was of the yellow type, the hybrid SF 10/00, used as commercial standard and because it is one of the most used in the Northeast of Brazil.

The variables evaluated were:

Seedling Emergency Percentage (SEP): Count of germinated seedlings, carried out at 4, 6 and 8 days after planting (DAP).

Burning of cotyledons (BC): Quantified by means of visual notes varying from 1 to 5 (1 - No burning, 2 - 0.1 to 25% of burning, 3, 26 to 50% of burning, 4 to 75% of burning, 5 to 76 to 100% of burning). The cotyledons evaluated at 10 DAS and leaves at 13, 16, 19 and 22 DAS.

Burning of leaves (BF): Quantified by means of visual notes varying from 1 to 5 (1 - No burning, 2 - 0.1 to 25% of burning, 3, 26 to 50% of burning, 4 to 75% of burning, 5 to 76 to 100% of burning). The cotyledons evaluated at 10 DAS and leaves at 13, 16, 19 and 22 DAS.

Change in the morphology of cotyledons and leaves: Quantified by means of visual notes varying from 1 to 3 (1 - no change, 2 - 0.1 to 60% of leaf closure, 61 to 100% of leaf closure) (graph 1). The cotyledons evaluated at 10 DAS and leaves at 13, 16, 19 and 22 DAS.

Plant height (PH): Measured using a millimeter ruler from the base of the plant to the height of the apical meristem, evaluated at 10, 13, 16, 19 and 22 DAS.

Leaf area (LA): Estimated by means of the equation $y = 0.826x^{1.89}$ ($R^2 = 0.97$), where y corresponds to leaf area ex average leaf width [12], being evaluated at 13, 16, 19 and 22 DAS.

Number of leaves (NL): Count the number of leaves at 13, 16, 19:22 DAS.

Fresh mass (FM): The fresh mass was evaluated at 22 DAS, in which the weighing of four plants was carried out in a precision scale.

Dry mass (DS): The dry mass was evaluated after drying the fresh mass of four plants in a greenhouse of negative flow at 72°C for 48 hours, being weighed in digital scale.

The leaf color was also evaluated at 22 days, using the Minolta CR-400 colorimeter, previously calibrated on a white surface according to the standards set by the manufacturer. The reading was performed in the median region of the leaf, about 1 cm of the central vein, were evaluated two leaves per plant, collected in the median region.

Three color parameters were evaluated: L*, a* and b*. The value of a* characterizes coloration in the region of red (+a*) to green (-a*), the value b* indicates coloring in the range of yellow (+b*) to blue (-b*). The value L gives us the luminosity, varying from white (L=100) to black (L=0).

Chroma is the relation between the values of a* and b*, where the real color of the analyzed object is obtained. Hue-angle is the angle formed between a* and b*, indicating the color saturation of the object. For the calculation of Chroma the mathematical formula (1) was used and, to calculate Hue-Angle, the formula (2) is used.

$$C = \sqrt{(a^2 + b^2)} \quad (1)$$

$$H° = arctg\ b/a \quad (2)$$

The statistical analyzes used were analysis of variance, polynomial regression for salt concentrations, Tukey test at 5% probability for the substrates. A correlation was performed by Pearson, verified by t test at 1 and 5% probability.

At 22 DAS, transplantation was carried out, for 5 L polyethylene vessel, with coconut powder substrate, in which it was conducted free, with spacing of 0.6 m between each vessel. In this stage the recovery of the plants after saline stress was evaluated, in which the nutrient solution was the same as in the previous step, but with electrical conductivity of 2 $dS.m^{-1}$.

In this step, a variance analysis was performed and polynomial regression for the electrical conductivities of the previous stage. The height of the main stem was evaluated at 10 and 20 days after transplanting, measuring from the lap of the plant to the apical meristem.

3. RESULTS AND DISCUSSION

In Table 2, show that the electrical conductivity (EC) of the solution influenced the germination only in the count at 4 days after sowing (DAS), the higher the EC, the lower the germination, represented by the equation $y = 39.98 + 11.22x - 1.16x^2$ (R^2 = 95.71%). Moreover, the salinity affected negatively the melon seeds germination, influencing the speed of germination. The germination at 6 and 8 DAS, there was no significant difference between the EC's, with respective average of 82.29 and 86.46% respectively.

The germination of the melon is impaired by the EC of the solution, in which EC's greater than 8 $dS.m^{-1}$, decrease seed germination, as the osmotic potential of the substrate is reduced, inducing less capacity of water absorption by the seeds, in addition to the toxic effect of salt, which hinder normal functioning of the vital structures of the seed [13,14].

As for the burns due to the excess of salt in the vegetative organs, only the cotyledons suffered damage because of the EC increase, being able the same is estimated by the equation $y = 1.06 - 0.03x + 0.007x^2$ (R^2 = 97.83). Cotyledons submitted to EC of 2.0, 5.0 and 8.0 $dS.m^{-1}$ presented minimal but increasing damages, while the EC 11.0 $dS.m^{-1}$ presented about 10% of burnings, in counterpart, the leaves did not undergo burning in any of the evaluation periods.

Morphological changes occurred at 22 DAS, it may be explained by the equation $y = 1.19 - 0.12x + 0.019x^2$ (R^2 = 100%), where the EC's of 2 and 5 $dS.m^{-1}$, showed no changes, in the EC of 8 $dS.m^{-1}$ there were small changes and in the EC of 11 $dS.m^{-1}$ the leaves presented great changes in the morphology, with tendency to foliar closure.

Graph 1 (A) shows the behavior of plant height (PH), which was influenced by the EC increase, in which in the EC of 2 $d.Sm^{-1}$ presented higher growth rate, with average growth of 2.88 cm per day, the EC's of 5, 8 and 11 $dS.m^{-1}$, presented a growth rate of 2.33; 1.77 and 1.23 cm per day. In all the epochs of evaluation the growth of the plants remained constant, presenting small variation at 10 DAS in growth, with a loss of 0.26 cm per unit increase in EC and a large increase over the cycle, being that at 22 DAS the loss was 2.46 cm per unit increase of the EC.

In graph 1 (b), the EC 's influence the number of leaves (NL) from DAS 16, at 13 DAS the number of leaves was 1 for all EC's. EC's 2 and 5 $dS.m^{-1}$ showed small variations in NL in the EC of 11 $dS.m^{-1}$, the decrease in the number of leaves compared with EC 2 $dS.m^{-1}$ was 1.05 unit at 22 after harvest DAS.

In graph 1 (c), leaf area (LA) of melon can be observed in the EC function, as the EC increases, the PH decreases for all epochs of evaluation. The LA at 22 DAS presented a reduction of 15.79 cm² per unit increment of the EC.

In graph 1 (d and e), it is observed that the fresh mass (FM) and dry mass (DM) presented similar behavior, presenting a reduction as the EC increased, for the FM, the unit loss of fresh mass was 14.11 g per unit of EC, having in the EC 2 $dS.m^{-1}$ 169.54 g and in EC 11 $dS.m^{-1}$ 42.54 g. The DM, the loss was 0.85 g per unit of increased EC, presenting 13.14 g in EC 2.0 $dS.m^{-1}$ and 5.44 in EC 11.0 $dS.m^{-1}$. The amount of water in the plants was also influenced by the EC, being 92.24; 91.69; 90.57 and 87.21% water respectively for the EC's 2.0; 5.0; 8.0 and 11.0 $dS.m^{-1}$, that is, the amount of water contained in the plants reduces with the increase in EC.

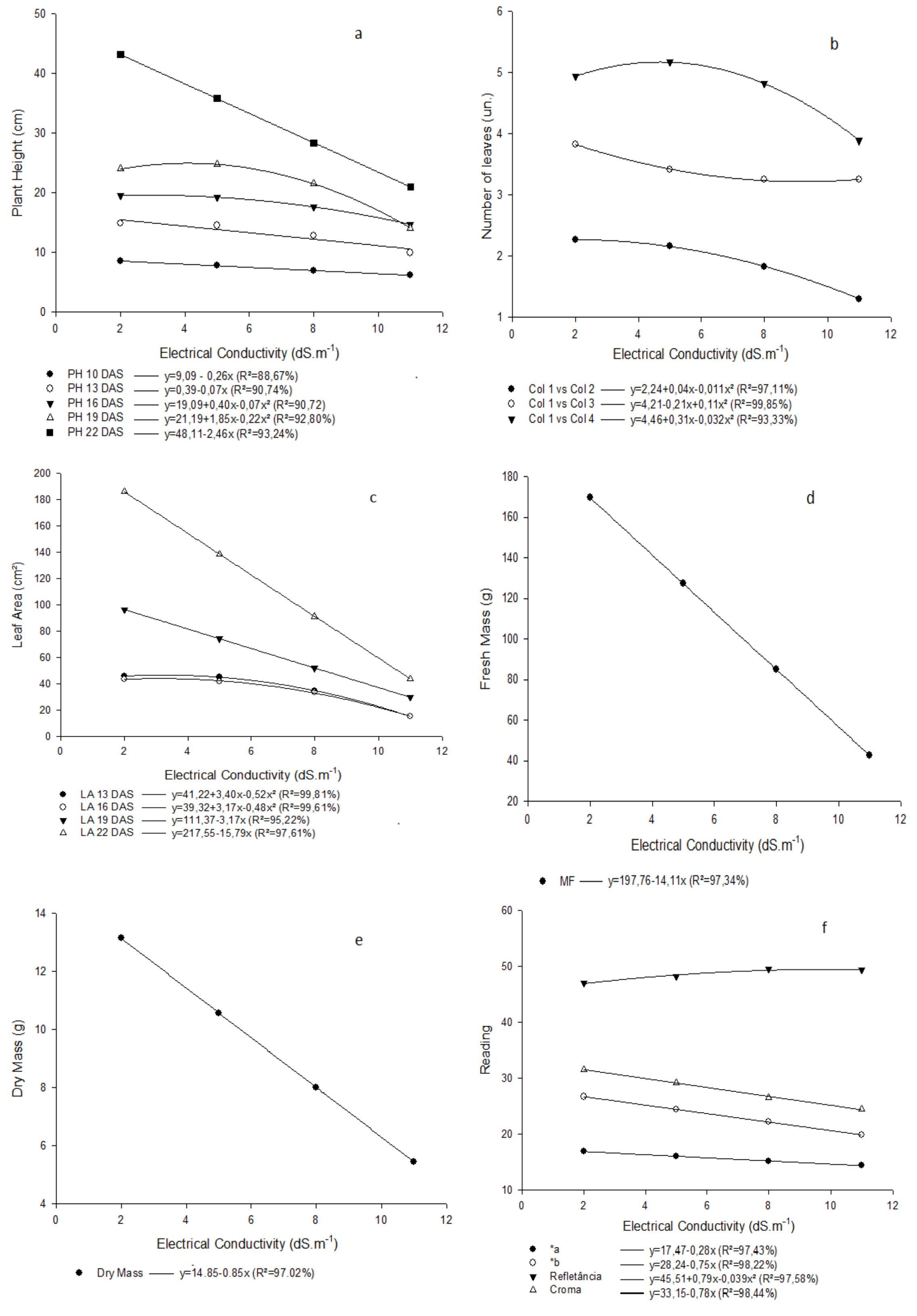
High concentrations of salts in soil and water cause morphological changes, structural and metabolic effects on melon seedlings, inhibit its growth and development, reducing the percentage of dry mass in plants, in fruit size and yield [15,16], similar results were found in this investigation.

The decrease in growth and dry mass is related to the reduction of the photosynthetic capacity of the plants, by means of ionic interactions

Table 2. Averages of germination, burning and morphological alteration as a function of CE

EC($dS.m^{-1}$)	Germ. 4 DAS	Germ. 6 DAS	Germ. 8 DAS	B. Cot	B. 13/16/ 19/22 DAS	M. Cot	M. 13/16/19 DAS	M. 22 DAS
2	57.81	80.21	83.64	1.01	1.00	1.00	1.00	1.00
5	67.19	83.33	85.52	1.04	1.00	1.00	1.00	1.00
8	55.72	80.21	87.39	1.21	1.00	1.00	1.00	1.33
11	23.43	85.41	89.27	1.48	1.00	1.00	1.00	2.00
Averages	-	82.29	86.46	-	0.00	0.00	0.00	-
Regression	$Y= 39.98 + 11.22x - 1.16x^2$	-	-	$Y=1.06 - 0.03x + 0.007x^2$	-	-	-	$Y=1.19-0.12x+0.019x^2$
R^2	95.71	-	-	97.83				100
C.V. (%) 1	26.24	12.05	6.58	5.56	0.00	0.00	0.00	4.93
C.V. (%) 2	26.95	20.01	8.86	6.72	0.00	0.00	0.00	5.78

EC - Electrical Conductivity. Germ. 4 DAS - Germination at 4 days after sowing; Germ. 6 DAS - Germination at 6 days after sowing; Germ. 8 DAS - Germination at 8 days after sowing; B. Cot - Burning of cotyledons; B. 13/16 DAS - Burning of the leaves at 13, 16 and 19 days after sowing. B. 22 DAS - Burning of the leaves at 22 days after sowing; M. Cot - Change in cotyledon morphology. M 13; 16; 19 and 22 - Change in leaf morphology at 13; 16; 19 and 22 days


a
Plant Height (cm)
Electrical Conductivity (dS.m-1)
PH 10 DAS y=9,09 - 0,26x (R²=88,67%)
PH 13 DAS y=0,39-0,07x (R²=90,74%)
PH 16 DAS y=19,09+0,40x-0,07x² (R²=90,72)
PH 19 DAS y=21,19+1,85x-0,22x² (R²=92,80%)
PH 22 DAS y=48,11-2,46x (R²=93,24%)
b
Number of leaves (un.)
Electrical Conductivity (dS.m-1)
Col 1 vs Col 2 y=2,24+0,04x-0,011x² (R²=97,11%)
Col 1 vs Col 3 y=4,21-0,21x+0,11x² (R²=99,85%)
Col 1 vs Col 4 y=4,46+0,31x-0,032x² (R²=93,33%)
c
Leaf Area (cm²)
Electrical Conductivity (dS.m-1)
LA 13 DAS y=41,22+3,40x-0,52x² (R²=99,81%)
LA 16 DAS y=39,32+3,17x-0,48x² (R²=99,61%)
LA 19 DAS y=111,37-3,17x (R²=95,22%)
LA 22 DAS y=217,55-15,79x (R²=97,61%)
d
Fresh Mass (g)
Electrical Conductivity (dS.m-1)
MF y=197,76-14,11x (R²=97,34%)
e
Dry Mass (g)
Electrical Conductivity (dS.m-1)
Dry Mass y=14.85-0.85x (R²=97.02%)
f
Reading
Electrical Conductivity (dS.m-1)
*a y=17,47-0,28x (R²=97,43%)
*b y=28,24-0,75x (R²=98,22%)
Refletância y=45,51+0,79x-0,039x² (R²=97,58%)
Croma y=33,15-0,78x (R²=98,44%)

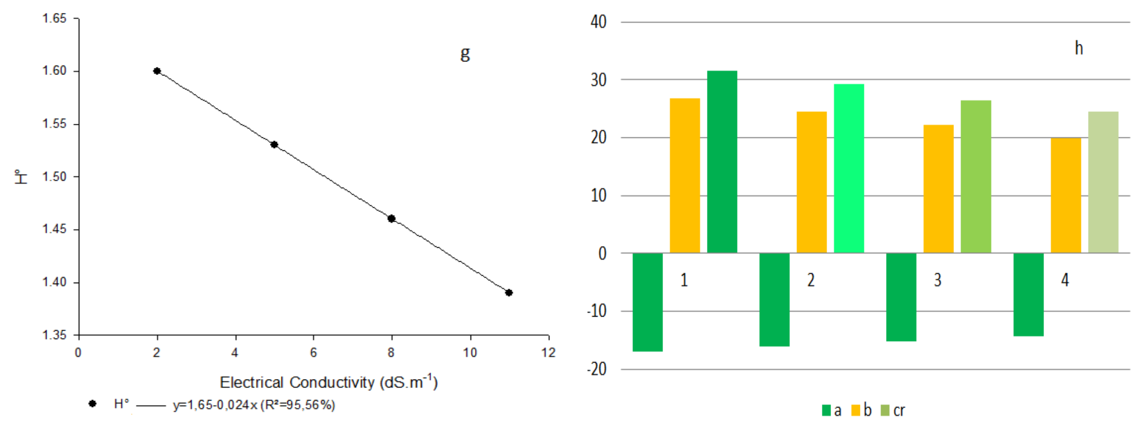


Fig. 1. Melon reactions to different electrical conductivities

a- Height of plants as a function of conductivity; b - Number of leaves per plant in function of the electrical conductivity; c - Leaf area in function of the electrical conductivity; d - Fresh mass depending on the electrical conductivity; e - Dry mass as a function of the electrical conductivity; f - Coloring Angle (H°) as a function of the electrical conductivity; h - combination of readings a, b and chroma in the different electrical conductivities

promoted by the excess of salts and sodium, thus causing the reduction in the accumulation of photoassimilates due to the small production, for this reason also provides greater energy cost, which occurs mainly due to the reduction of the osmotic potential, promoting the reduction of water availability for plant growth, in addition to the burning of the leaves extremities [17,18], similar results were found in this investigation.

Due to the toxic actions of the salt in the melon, there is a greater energy expenditure for plant maintenance, decrease in leaf number, and leaf area, which promotes a significant decrease in the photosynthetic area, causing greater physiological disorders in the chain, limiting the normal development of the crop.

In the graphs 1 (f and g), one can observe the results of the readings of the colorimeter, in which the reading *a, b, Chroma and H° presented reduction, because as the EC increases, it decreases the values of their readings, that is, the plant loses the intensity of green (graph 1 (h)), becoming opaque green. The reflectance was higher in the higher EC's, because due to change in the coloring of the leaf, the luminosity was more reflected, consequently less absorbed.

According to [17], the excess of salt in the plant tissues significantly changes the photosynthetic rate, which indirectly can be observed by the coloring of the leaves, because the proportion of chlorophyll and carotenoid pigments is altered. Then it was observed that with the increase of the concentration of salts in the plant the change of intensity of the green, prevents the penetration of light beams into the cells, which consequently decreases the production of photoassimilates.

Table 3. Averages of germination, burning and alteration in the anatomical as a function of the substrates

Substrate	Germ. 4 DAS	Germ. 6 DAS	Germ. 8 DAS	B. Cot	B. 13/16/ 19/22	M. Cot	M. 13/16	M. 19/22
Sand	46.09 b	82.81 b	86.72 ab	1.31b	1.00	1.00	1.00	1.38a
Coconut powder	28.91 a	67.96 a	75.78 a	1.00a	1.00	1.00	1.00	1.31a
Basaplant	78.21 c	96.09 b	96.88 b	1.25ab	1.00	1.00	1.00	1.31a
Averages	-	-	-	-	1.00	1.00	1.00	1.33

Averages followed by the same letter in the column do not differ each other by the Tukey test at 5% probability. EC - Electrical Conductivity. Germ 4 DAS - Germination at 4 days after sowing; Germ 6 DAS - Germination at 6 days after sowing; Germ 8 DAS - Germination at 8 days after sowing; B. Cot - Burning of cotyledons; B. 13/16 DAS - Burning of the leaves at 13, 16 and 19 days after sowing. B. 22 DAS - Burning of the leaves at 22 days after sowing

According to the Tukey test at 5% probability, it can be concluded that for germination at 4, 6 and 8 DAS the commercial substratum Basaplant (78.21%) showed a higher percentage of germination, differing from Sand (46.09%) at 4 DAS, and at 6 and 8 DAS Basaplant (96.09 and 96.88%) showed no significant difference with Sand (82.81 and 86.72%) (Table 3).

The start of burning occurred only in the cotyledons, in the sand substrates and Basaplant larger damages occurred, presenting respective notes of 1.31 and 1.25, already the coconut powder did not show burning. In the leaves, there was no burning in any of the evaluations.

The change in morphology did not occur in the cotyledons, neither in the leaves at 13, 16 and 19 DAS. At 22 DAS plants in the three substrates presented small morphological changes, but did not show any difference between them, with a mean score of 1.33.

Table 4 shows the comparative averages between the substrates used in the production of melon seedlings for some agronomic variables, which can be concluded that for plant height (PH) there was no significant difference in the PH assessed at 10, 13, 16 and 19 DAS, with averages of height of the melon of 7.37; 13.04; 17.80 and 21.09 cm. PH at 22 DAS was higher in the commercial substratum Basaplant (35.32 cm) without statistically differing coconut powder (30.93 cm).

The NL of the melon was not influenced by the substrates, which presented means of 1.0; 1.89; 3.31 and 4.72 un., respectively at 13, 16, 19 and 22 DAS.

For the leaf area of the melon at 13, 16 and 22 DAS there was no significant difference between the evaluated substrates, with respective means of 33.86; 35.28 and 14.88 cm². The leaf area at 19 DAS was higher in the plants fixed in the substrate Basaplant (67.85 cm²) and sand (61.85 cm²) (Table 5).

The fresh mass (FM) was influenced by the different substrates, presenting the coconut powder and Basaplant the best results, regarding the dry mass (DM), it can be observed that the different substrates did not show any statistical difference between them (Table 6).

According to the Tukey test at 5% probability for the unfolding of the substrates within each EC it can be concluded that the luminosity of the melon leaves submitted to EC of 2, 5 and 8 $dS.m^{-1}$ did not present difference in reflectance, with averages of 47.01; 48.28 and 49.55, respectively for EC's 2, 5 and 8. In EC 11 $dS.m^{-1}$ coconut powder and sand (51.32 and 49.45) presented higher reflectance, differing from Basaplant (47.45) (Table 7).

Table 8 shows the coloring parameters of the melon leaves, that did not present significant difference by the test of Tukey to 5% of probability, for none of the substrates submitted for fixing the melons, with averages of 15.64; 23.31; 48.83; 28.05 and 1.50 respectively for the variables *a, *b, L, Chroma and H°.

Table 4. Averages plant height and number of leaves at the evaluation times according to the substrates

Substrate	PH 10DAS	PH 13DAS	PH 16DAS	PH 19DAS	PH 22DAS	NL 13DAS	NL 16DAS
Sand	7.15a	12.81a	17.57a	20.34a	29.98a	1.00a	1.68a
Coconut powder	7.31a	12.77a	17.52a	21.41a	30.93ab	1.00a	2.00a
Basaplant	7.64a	13.54a	18.30a	21.52a	35.32b	1.00a	2.00a
Averages	7.37	13.04	17.80	21.09	-	1.00	1.89
C.V. (%) 1	10.63	6.27	4.59	7.80	12.58	20.47	22.47
C.V. (%) 2	9.49	10.03	7.36	8.49	16.82	17.96	18.66

Means followed by the same letter do not differ statistically by the Tukey test at 5% probability. PH 10 DAS - Plant Height at 10 days after sowing (cm); PH 13 DAS - Plant Height at 13 days after sowing (cm); PH 16 DAS - Plant Height at 16 days after sowing (cm); PH 19 DAS - Plant Height at 19 days after sowing (cm); PH 22 DAS - Plant Height at 22 days after sowing (cm); NL 13 DAS - Number of leaves at 13 days after harvest (un); NL 16 DAS - Number of leaves at 16 days post harvest (un). C.V. (%) 1 - Coefficient of Variation of the plots. C.V. (%) 2 - Coefficient of Variation of subplots

Table 5. Average number of leaves and leaf area at the evaluation times according to the substrates

Substrate	NL 19DAS	NL 22DAS	LA 13DAS	LA 16DAS	LA 19DAS	LA 22DAS
Sand	3.12a	4.65a	32.64a	33.73a	61.85ab	111.07a
Coconut powder	3.12a	4.75a	32.55a	33.75a	59.78a	109.43a
Basaplant	3.68a	4.75a	36.40a	38.37a	67.85b	124.14a
Averages	3.31	4.72	33.86	35.28	-	114.88
C.V. (%) 1	9.23	25.05	22.47	20.27	9.23	25.05
C.V. (%) 2	13.85	16.81	18.66	17.96	13.85	16.81

NL 19 DAS - Number of leaves at 19 days after harvest (un); NL 22 DAS - Number of leaves at 11 days post-harvest (un); LA 13 DAS - Leaf area at 13 DAS (cm²); LA 16 DAS - Leaf area at 16 DAS (cm²); LA 19 DAS - Leaf area at 19 DAS (cm²); LA 22 DAS - Leaf area at 22 DAS (cm²). C.V. (%) 1 - Coefficient of Variation of the plots. C.V. (%) 2 - Coefficient of Variation of subplots

Table 6. Average of substrates for fresh mass and dry mass

Substrate	FM	DM
Sand	95.00a	8.56a
Coconut powder	111.87b	9.94a
Basaplant	111.25ab	9.38a
Averages		9.29

Means followed by the same letter do not differ statistically by the Tukey test at 5% probability. FM - Fresh Mass (g); DM - Dry Mass (g)

Table 7. Substrate unfold within each electrical conductivity for the reflectance

	Refletance			
Substrate	Electrical Conductivity ($dS.m^{-1}$)			
	2.0	5.0	8.0	11.0
Sand	46.43a	49.48a	50.45a	49.45ab
Coconut powder	46.85a	47.48a	48.75a	51.32b
Basaplant	47.75a	47.88a	49.45a	47.45a
Averages	47.01	48.28	49.55	-

Averages followed by the same letter do not differ statistically in the column

Table 8. Averages of readings and colorimetric indexes

Substrate	Reading *a	Reading *b	L	Croma	Hº
Sand	15.43a	23.27a	48.95a	27.91a	1.51a
Coconut powder	15.61a	22.85a	48.60a	27.65a	1.48a
Basaplant	15.88a	23.81a	48.95a	28.59a	1.51a
Averages	15.64	23.31	48.83	28.05	1.50

Averages followed by the same letter do not differ statistically in the column. L - Reflectance; H - Hue-angle

In hydroponic crops, the substrates had little influence on the effects of salinity on plants, because due to the nutritive solution is the main source of electrical conductivity in function of the salts provided, due mainly to the osmotic potential of the solution. Already the substrates that could increase the negative effect of the excess of salt due to the matrix potential of the solid part, was minimized in this system, but along of long-lasting crops, these can accumulate salts.

The reduction of the osmotic potential due excess salt in the solution is one of the main factors that negatively influence the plant, because it accelerates the absorption and consequently the accumulation of salts in the plant cells. The presence of salts in the soil solution increases the retention forces by their osmotic effect and, therefore, the magnitude of the problem of water scarcity in the plant. The increase in osmotic pressure (OP) caused by excess soluble salts, may reach a level where the plants will not have sufficient suction forces to overcome this OP and, consequently, the plant will not absorb water, even from apparently moist soil (physiological dry) [19].

In graph 2, it can be observed that it was not possible to recover the plant that was submitted to high salt concentration. For even if the substrate is altered with the decrease of salt, in the cells of the vegetable there is still the accumulation of salt, in this way, it is not possible to have a full recovery of the development of the melon, influencing the mineral composition of the plant [7,19,20].

These results evidenced the possibility of the use of saline soil, of saline water in irrigation and use in hydroponic solutions, being necessary to develop cultivars that present a greater tolerance to the salinity, to further explore these resources through this culture, which naturally exhibits moderate tolerance to salinity, having sufficient variability to be exploited by breeding programs [9,21,22].

According to Pearson's correlation (Table 9), there was a high correlation between germination and plant height (0.71), germination and leaf area (-0.94), germination and chroma (0.95), alteration in morphology and fresh mass (-0.99), chroma and height (0.88), chroma and leaf area (-0.80), number of leaves and fresh mass (0.99), number of leaves and dry mass (0.93), and fresh mass and dry mass (0.93).

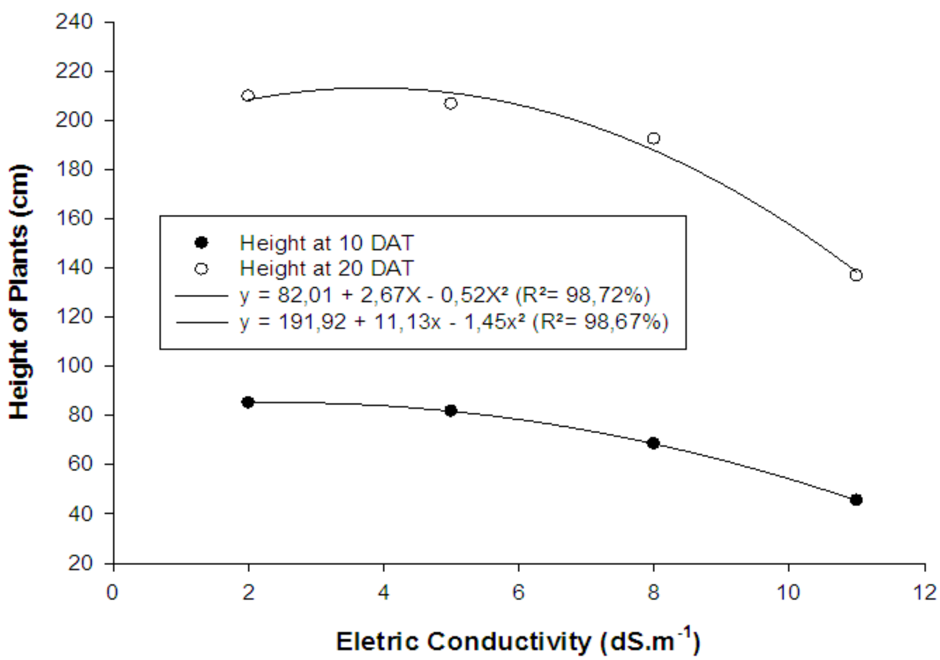


Fig. 2. Height of plants after transplanting as a function of the electrical conductivity

Table 9. Pearson correlation for the morphological variables and color intensity of the melon

Variables	Germ.	Morf.	PH	LA	NL	Croma	FM
Morf.	0.21						
PH	0.71*	-0.54					
LA	-0.94**	-0.54	-0.42				
NL	-0.21	-1.00	0.54	0.54			
Croma	0.95**	-0.08	0.88**	-0.80*	0.076		
FM	-0.24	-0.99**	0.51	0.57	0.99**	0.04	
DM	-0.56	-0.93**	0.18	0.81*	0.93**	-0.31	0.93**

*** Significant by t test at 1% probability; * Significant by t test at 5% probability. Germ. - Percentage of germination; Morf. - Alteration in morphology; PH - Height of plants; LA - Leaf area; NL - Number of leaves; Chroma; FM - Fresh mass; DM - Dry mass*

From the observed correlations, the variables that show correlation with chroma, are the most important in identifying toxicity, because they allow with the use of the colorimeter equipment to indirectly determine another character, which in this case for germination and plant height was positive, indicating that the more intense the color of the leaves, the higher the percentage of germination and the greater the height of plants. For the leaf area the correlation was negative, indicate that the greater the green intensity, the smaller the leaf area.

According to [15,16], plants submitted to salinity present reduced growth, so that according to the results found in this research can estimate the height and leaf area of the melon based on the value of chroma. The green pigmentation in the leaves is the result of the proportion of chlorophyll and carotenoids, so that plants with higher chlorophyll content present higher amounts of chloroplasts, responsible for carrying out the transformation of solar energy in organic energy [17,23,24].

In this study, plants with lower chroma value show reduced growth, in contrast the leaf area tends to be larger, in view of the melon strategy in storing the excess salt in the vacuoles [7,17].

4. CONCLUSION

The increase in the concentration of salts in the water influenced negatively the morphological and coloring characteristics of the melon leaves.

The substrates sand, coconut powder and Basaplant® did not present significant difference in the effects on the culture of the melon.

The intensity of leaf color can be used to measure and diagnose the salinity of the melon.

We propose to use saline soil and saline water in hydroponic, as well as, to develop cultivars with a greater tolerance to salinity for a better melon production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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