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ORIGINAL ARTICLE

# Development and quality of melon fruits grown under salt stress[1]

## Desenvolvimento e qualidade de frutos de melão amarelo sob estresse salino

Beatriz de A. Araújo[2*], Elaine F. Celin[3], Rafael S. da Costa[4], Amanda S. F. Calvet[4], Humberto H. de Carvalho[5] & Marlos A. Bezerra[6]

[1] Research developed at Embrapa Agroindústria Tropical, Pacajus, CE, Brazil
[2] Universidade Federal do Ceará/Centro de Ciências Agrárias/Departamento de Engenharia Agrícola, Fortaleza, CE, Brazil
[3] Universidade Federal da Grande Dourados/Faculdade de Ciências Agrárias, Dourados, MS, Brazil
[4] Universidade Federal do Ceará/Centro de Ciências Agrárias/Departamento de Fitotecnia, Fortaleza, CE, Brazil
[5] Universidade Federal de Ceará/Centro de Ciências/Departamento de Bioquímica e Molecular Biologia, CE, Brazil
[6] Embrapa Agroindústria Tropical/Laboratório de Fisiologia Vegetal, Fortaleza, CE, Brazil

*HIGHLIGHTS:*

*Irrigation water salinity reduces plant growth, but does not interfere with the fruit production of 'Goldex' yellow melon.*
*Irrigation with 4.0 dS m$^{-1}$ saline water does not impair the post-harvest quality of 'Goldex' melon fruits.*
*Total soluble solids is directly linked to fruit ripening stage and not to water salinity.*

**ABSTRACT:** The need for studies that allow the use of brackish water in irrigated agriculture and the socioeconomic importance of melon cultivation in Brazil, especially for the Northeast region, which concentrates most of the national production and faces problems with the availability of good quality water for irrigation, motivated the present study. In this context, the objective of present study was to evaluate the growth, production and fruit quality of the 'Goldex' (yellow-type hybrid F1) melon under salt stress conditions. The experiment was performed in a completely randomized design, with two salinity levels of irrigation water (0.8 and 4.0 dS m$^{-1}$) and eight evaluation times (52, 54, 56, 58, 60, 62, 64, and 66 days after transplanting). Variables of plant growth and development, production and quality of melon fruits were evaluated throughout the cycle. Plants had delayed growth characteristics and less development with the increase in irrigation water salinity, showing reductions of more than 20% in shoot dry weight, leaf area, number of branches and length of secondary branches and 16.7% in length of the main branch. In addition, salinity caused a delay in fruit development and a 16% reduction in final fruit weight, without significantly modifying carbohydrate and total soluble solids contents. Along the development, there was an increase in the total soluble solids content of the fruits, especially due to the increment of sucrose at the final stages of development.

**Key words:** growth inhibition, irrigation, salinity, post-harvest

**RESUMO:** A necessidade de estudos que possibilitem a utilização de águas salobras na agricultura irrigada e a importância socioeconômica da cultura do melão no Brasil, especialmente para a região Nordeste, que concentra a maior parte da produção nacional e apresenta problemáticas com disponibilidade de água de boa qualidade para irrigação, norteou o presente estudo. Nesse contexto, o objetivo do presente estudo foi avaliar o crescimento das plantas, a produção e a qualidade de frutos do híbrido de melão amarelo 'Goldex' (híbrido F1 tipo amarelo) sob condições de estresse salino. A pesquisa foi conduzida em delineamento inteiramente casualizado, contendo dois níveis de salinidade da água de irrigação (0,8 e 4,0 dS m$^{-1}$) e oito épocas de avaliação (52, 54, 56, 58, 60, 62, 64 e 66 dias após o transplantio). Foram avaliadas variáveis de crescimento e desenvolvimento das plantas, de produção e de qualidade dos frutos de melão ao longo do ciclo. As plantas tiveram as características de crescimento retardadas e menor desenvolvimento em função do aumento da salinidade da água de irrigação, apresentando redução superior a 20% para a o peso seco da parte aérea, área foliar, número de ramos, comprimento de ramos secundários e 16,7% para o comprimento do ramo principal. Além disso, a salinidade provocou atraso no desenvolvimento dos frutos e redução de 16% no seu peso final, sem modificar significativamente os teores de carboidratos e sólidos solúveis totais. Ao longo do desenvolvimento houve aumento no teor de sólidos solúveis totais dos frutos, especialmente em função do acréscimo de sacarose nos estádios finais de desenvolvimento.

**Palavras-chave:** inibição de crescimento, irrigação, salinidade, pós-colheita

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* Corresponding author - E-mail: bia10_pcj@hotmail.com
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## Introduction

Melon (*Cucumis melo* L. - Cucurbitaceae) is a cucurbit that has morphological characteristics of herbaceous plants, and its part of interest is the fruit, which is consumed mainly fresh (Du et al., 2022). Among the commercial types, the most traditionally consumed in Brazil is yellow melon, which has no noticeable aroma, even when ripe (Oliveira et al., 2019).

The Brazilian Northeast has favorable climatic conditions for melon cultivation, because the high temperature and luminosity allow full development of the fruits and reduce crop cycle, which causes the region to be considered suitable for irrigated cultivation (Valnir Junior et al., 2013; EMBRAPA, 2017). For these reasons, the region emerges as the main producer and exporter of melon in Brazil, responsible for 92% of the national production, with the states of Rio Grande do Norte and Ceará accounting for 86.9% of the regional percentage (IBGE, 2021).

Despite the good production results, much of the water that is used for irrigation in this region has excess salts, which contributes to the accumulation of salt in the soils and can cause stress conditions, inhibiting plant growth and reducing yield (Li et al., 2019). Initial growth and flowering are the melon development stages most sensitive to salinity; in these stages, salt stress limits gas exchange and the production of photoassimilates, due especially to the difficulty in absorbing and transporting nutrients from the soil, reducing plant growth and yield (Sousa et al., 2020). In this context, to reduce the effects of salts on the melon crop, one of the strategies is to choose in which stages of the cycle there is less effect on its development and productivity.

Thus, the objective of the present study was to evaluate plant growth, production and fruit quality of the 'Goldex' yellow melon grown under salt stress at different times of development.

## Material and Methods

### Location, soil and climate

The experiment was performed at the Pacajus Experimental Farm, belonging to Embrapa Tropical Agroindustry, in Pacajus, Ceará, Brazil. The geographical coordinates are 4° 10' S and 38° 27' W, at altitude of 60 m, and the soil is classified as Quartzipsamment (USDA, 1999), whose characteristics are presented in Table 1.

### Experimental arrangement

The experimental arrangement consisted of a random scheme of eight cultivation rows spaced at 2 m, each containing 26 plants, at spacing of 0.8 m. Two lateral rows were added as a border, one at the beginning and the other at the end of the experimental area.

The experimental design was completely randomized with four replications in split-plot, which consisted of two levels of electrical conductivity of the irrigation water - (ECw - 0.8 dS $m^{-1}$ - control and 4.0 dS $m^{-1}$ with NaCl) in the main plots and eight evaluations in time as sub-plots (52, 54, 56, 58, 60, 62, 64, and 66 days after transplantation - DAT).

### Crop management, irrigation management, fertigation and cultural practices

Seedlings were obtained by sowing yellow melon 'Goldex' (yellow-type hybrid F1). The seeds were commercially purchased (TOPSEED, Agristar Ltda, Lot: 065119, germination: 90%, and purity: 99%). The seeds were placed for germination in polypropylene trays with 200 cells containing a substrate composed of coconut fiber, peat, and humus (1:1:1 - volume basis). The seedlings were acclimated in a greenhouse and irrigated twice a day. After 13 days, when the seedlings had two true leaves, they were transplanted to the experimental area at the end of the day. Four days after the transplant, the ECw treatments (0.8 and 4.0 dS $m^{-1}$) were applied.

Prior to planting, basal fertilization was carried out in the area, based on soil analysis, applying 15 $m^3$ $ha^{-1}$ of cattle manure, 1.7 kg $ha^{-1}$ of urea (nitrogen), 20 kg $ha^{-1}$ of triple superphosphate (phosphorus), and 3.0 kg $ha^{-1}$ of potassium chloride (potassium). Fertigation was performed three times a week, using a nutrient solution prepared in a 20 L container, applied by a Venturi injector in a bypass system. The nutrient sources used in fertigation, considering the entire plant cycle, were 16.7 kg of urea (nitrogen), 32.6 kg of MAP (phosphorus and nitrogen) and 32.3 kg of potassium chloride (potassium), split and applied in nine weeks. The nutrients were distributed according to EMBRAPA's Melon Production System (EMBRAPA, 2017).

Irrigation was applied using a drip system, with one line of drippers per row, which was covered with double-sided plastic mulching: black side facing down and silver side facing up. The seedlings were spaced in the cultivation row every 0.8 m.

Crop water requirement was calculated using an electronic spreadsheet, which considered data collected in an automatic weather station installed near the experimental area, to determine the reference evapotranspiration (ETo) according to the Penman-Monteith methodology proposed by FAO (Allen et al., 1998). In addition to the ETo mentioned, the crop coefficients (Kc) for the melon crop, determined specifically for the conditions of the Ceará state (Miranda et al., 1999), were considered. Crop evapotranspiration (ETc) was calculated as the product between ETo and Kc. The total irrigation required (TIR) for the melon crop, applied daily, was determined by the product between ETc and percentage of wetted area (PWA) divided by coefficient of uniformity of distribution (CUD) of 95.5%. Irrigation time was defined by the product of the spacing between drippers, spacing between rows and TIR, divided by the drip flow rate, in L $h^{-1}$ (Bernardo et al., 2008).

**Table 1.** Physical-chemical characteristics of the soil of the experimental area

| Layer | P | OM | pH | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+$ | $H^++Al^{3+}$ | $Al^{3+}$ | SB | CEC | V | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (cm) | (mg $dm^{-3}$) | (g $kg^{-1}$) | $H_2O$ | (mmol$_c$ $dm^{-3}$) | | | | | | | | (%) | |
| 0 -20 | 88 | 9 | 5.7 | 7.1 | 19 | 10 | 5 | 17 | 0 | 41 | 58 | 71 | 0 |

SB - Sum of exchangeable bases; CEC - Cation exchange capacity; V - Base saturation percentage; m - Aluminum saturation percentage

The electrical conductivities of irrigation water of 0.8 and 4.0 dS $m^{-1}$ were respectively obtained using well water available at the Farm with electrical conductivity of 0.8 dS $m^{-1}$ and well water with addition of sodium chloride (NaCl). The amount of salt used to obtain the salinity level was 10 mM of NaCl for every 1 dS $m^{-1}$. Adjustments were performed after measurement with a portable conductivity meter. The solutions were prepared in 5000 L water tanks and pumped to the plants by a 0.5 hp motor pump set through PVC pipes with diameter of ¾" for main lines and 16 mm for drip lines. The irrigation lines had Katif pressure-compensating drippers from Revulis® (Minas Gerais, BR) with flow rate of 4.0 L $h^{-1}$ spaced 0.8 m apart, corresponding to one dripper per plant.

### Plant growth analysis

Dry weight of the aerial part (SDW - g), leaf area (LA - $cm^2$), number of branches (NB), length of the main branch (LMB - cm) and length of secondary branches (LSB - cm) were evaluated along the cycle considering eight development times (52, 54, 56, 58, 60, 62, 64 and 66 days after transplanting).

The leaf area of all leaves was obtained using a photoelectric integrator (LI-3000 LICOR) and the dry weight of the aerial part was considered considering the dry matter of the leaves and branches. The number of agencies was calculated considering the sum of the main agency and secondary agencies. The length of the main branch and secondary branches was measured with a measuring tape graduated in cm. To measure the length of secondary branches, all those with a size ≥ 20 cm were considered.

### Fruit analysis

The harvest was conducted at 2-day intervals, commencing when the majority of the fruits were fully developed (52, 54, 56, 58, 60, 62, 64, and 66 DAT), selecting only the plants containing fruits with predominantly yellow color. This harvesting interval was chosen with the aim of identifying potential post-harvest quality changes in the fruits and determining the most suitable harvest time for total soluble solids content. The entire plant, including the fruits, was harvested.

### Growth

The following variables were measured: number of fruits per plant (NF), average fruit weight, on a semi-analytical scale, with results expressed in g; longitudinal and transverse diameters and pulp thickness in mm, using a digital caliper.

### Quality

For melon fruit pulp, the total soluble solids content (°Brix) was evaluated, using a digital refractometer (Atago®) and the color of the fruit pulp was measured by reflectance, using a MINOLTA CR 300 colorimeter, with a light source D65 with 8 mm opening, in the C. I. E. (Commission Internacionale de L'Eclaraige) standard. Objective color characterization was carried out using the CIELAB system (L*a*b*), in which the L* axis (brightness) varies from 0 (black) to 100 (white), the a* axis varies from green (- a) to red (+a), and the b* axis varies from blue (-b) to yellow (+b) (McGuire, 1992). Furthermore, the hue angle was calculated using the expression tan-1 (b*/a*), defined as color hue, where °hue values close to 180° represent greener fruits, which become more yellow as they tend at 90°, and chromaticity, expressed by the equation $C = [(a^*)2 + (b^*)2]^{1/2}$, which indicates the intensity of the color, being the distance from the center to the edge of the diagram (Mattiuz & Durigan, 2001).

### Statistical analysis

Analysis of variance (ANOVA) of the data was performed using the F test. Significant means of the saline treatment were compared using the Tukey test (p≤0.05) and regression analysis was performed for the harvest time using the computer program SISVAR version 5.8 (Ferreira, 2019). The graphs were constructed using the SigmaPlot program (version 11.0). The multivariate statistical analysis of plant growth and fruit growth and quality data was performed using principal component analysis (PCA). Analyses were performed using R statistical software (R Core Team, 2017).

## Results and Discussion

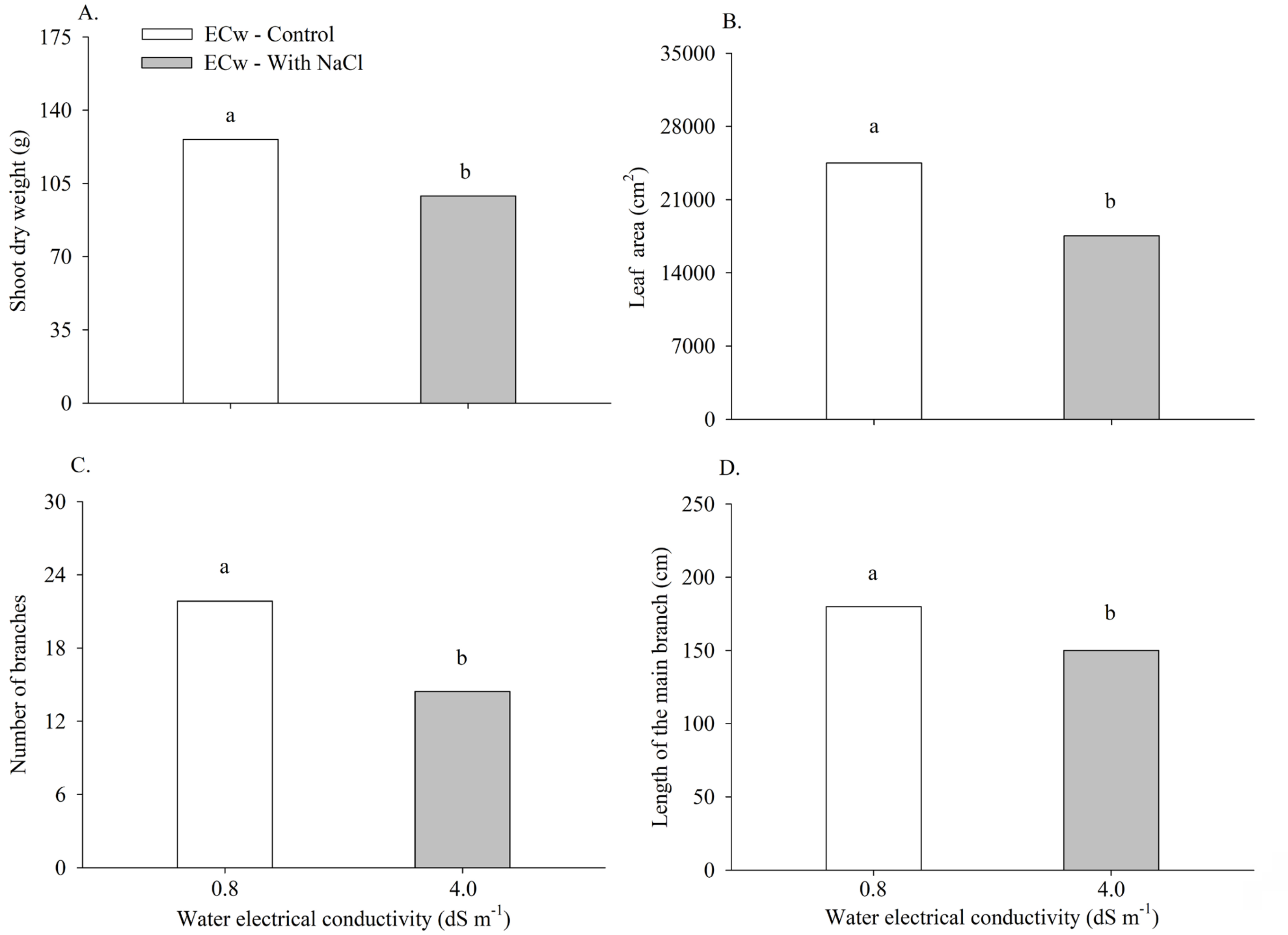
The electrical conductivity of water influenced all growth characteristics of melon plants, regardless of the harvest time. Evaluations were conducted during the fruiting stage, when the plants had already completed their vegetative development and were currently investing their photosynthates in fruit development. Significant variation was observed for the length of secondary branches (LSB) among different times (Table 2).

Increase in the electrical conductivity of irrigation water negatively influenced the variables shoot dry weight, leaf area, number of branches, and length of the main branch, causing reductions of 21, 28, 34, and 17%, respectively (Figure 1). These reductions confirm the negative influence of the accumulation

**Table 2.** Summary of analysis of variance of shoot dry weight (SDW), leaf area (LA), number of branches (NB), length of the main branch (LMB), and length of secondary branches (LSB) of irrigated melon under two electrical conductivity of water - ECw (0.8 and 4.0 dS $m^{-1}$) and at eight evaluation times (52, 54, 56, 58, 60, 62, 64 and 66 DAT)

| Sources of variation | DF | Mean squares | | | | |
|---|---|---|---|---|---|---|
| | | SDW (g) | LA ($cm^2$) | NB | LMB (cm) | LSB (cm) |
| ECw | 1 | 979278.47** | 774673801.52* | 877.64* | 14400.00* | 5701947.01** |
| Residual a | 6 | 10975.70 | 60739252.33 | 75.99 | 1804.58 | 388970.68 |
| Times | 7 | 155112.55* | 103192340.71$^{ns}$ | 105.58$^{ns}$ | 1206.28$^{ns}$ | 803030.76* |
| ECw x Times | 7 | 186157.20* | 91459171.75$^{ns}$ | 53.24$^{ns}$ | 523.85$^{ns}$ | 346254.87$^{ns}$ |
| Residual b | 42 | 61153.37 | 59055686.82 | 59.38 | 804.4471125.00 | 342960.58 |
| Total | 63 | 6002462.65 | 4982008749.48 | 4939.73 | 71125.00 | 30485115.23 |
| CV a | - | 7.78 | 37.06 | 48,06 | 25.77 | 45.85 |
| CV b (%) | - | 18.35 | 36.54 | 42,48 | 17.20 | 43.05 |

DF - degrees of freedom; CV- coefficient of variation; * - Significant at 0.05, ** - significant at 0.01% level of probability and ns - not significant; DAT - Days after transplanting




* Means followed by different letters differ significantly by Tukey test ($p<0.05$)

**Figure 1.** Shoot dry weight (SDW), leaf area (LA), number of branches (NB), and length of the main branch (LMB) of melon as a function of the electrical conductivity of irrigation water (ECw)

of salts in the mesophyll cells of the leaves, the main site of synthesis of photosynthetic assimilates. The marked effects of high salt concentration on plants cause a reduction in water absorption. Consequently, the osmotic gradient of water is modified between the soil and the plant. By increasing the salt concentration in the soil, the osmotic potential decreases, and the plant's water absorption may be reduced. Stress and high salinity cause physiological drought conditions and ionic toxicity that affect plant growth and development (Zhao et al., 2020).

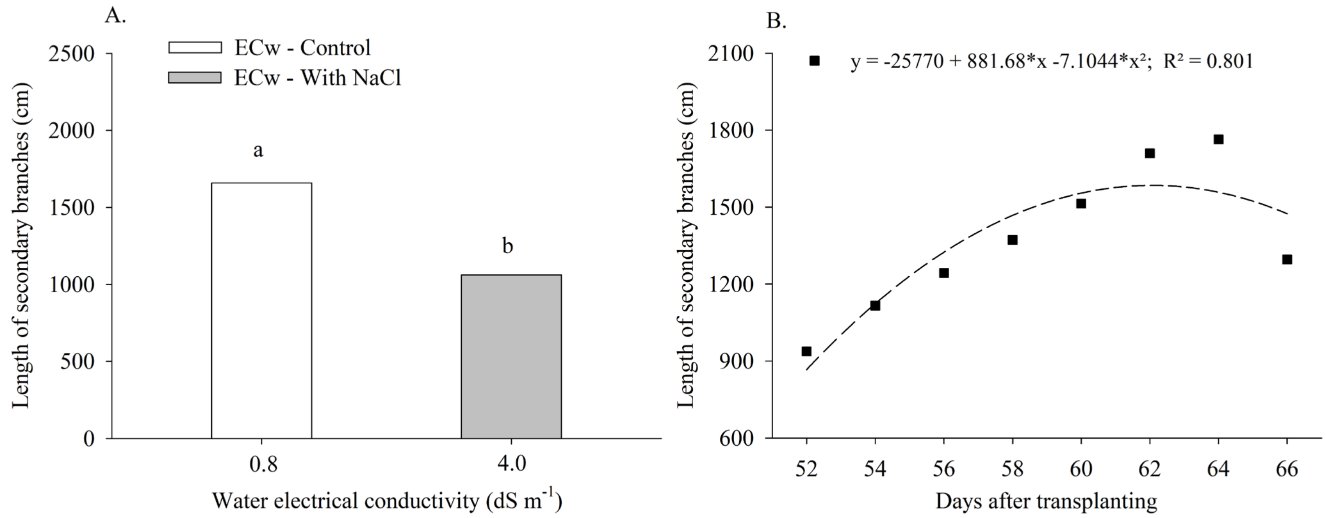
The reduction in plant growth due to the increase in water conductivity (ECw 0.8 to 4.5 dS $m^{-1}$) corroborate those reported by Lopes et al. (2017), who observed reduced growth and dry matter accumulation in melon plants with increasing salinity of irrigation water (0.3 to 4.5 dS $m^{-1}$). The little influence of the development stages on plant growth was due to the sampling period, which began at 52 DAT, the age at which the plants were already in full development and from which they drastically reduce their vegetative development due to the high demand for photoassimilates by the fruits in growth and maturation, which is more evident by changes only in the length of secondary branches (LSB).

The length of secondary branches (LSB) was also reduced with the increase in ECw, by 36% (Figure 2A). Which means that in conditions of high concentration of NaCl (4.5 dS $m^{-1}$) the plants invested less in vegetative growth, which consequently reduced the size of their secondary branches and this is due to the plant's adaptation to stress, where it tends to guarantee better quality fruit and under these conditions it has invested more in fruit development. Regarding the evaluation times, it adjusted to a quadratic equation, finding a maximum point on the curve of 1584.87 cm at 62.05 DAT, and from that point there was a decrease, probably due to the senescence of some of these branches (Figure 2B).

During harvests, salinity did not affect plant growth, contrary to what was observed by Lima et al. (2020) showing a reduction of more than 50% in the stem length of the SV1044 hybrid when salinity increased from 0.5 to 5.0 dS $m^{-1}$. Salinity tolerance can vary due to genetic factors, developmental stage, irrigation management, and water quality. Plants also respond differently to salinity under different growing conditions (Soares Filho et al., 2016).

In the current study, stability was observed at most evaluation times (Figure 2B), both for plants irrigated with water of low (0.8 dS $m^{-1}$) and high electrical conductivity (4.0 dS $m^{-1}$).

On the other hand, growth and development throughout the cycle was reduced when plants were irrigated with saline water (4.0 dS $m^{-1}$). This was possibly due to the fact that salinity affects the performance of melon plants, reducing water




* Significant at 0.05, ** significant at 0.01 probability level. Means followed by different letters differ by Tukey test (p<0.05)

**Figure 2.** Length of secondary branches (LSB) of melon as a function of the electrical conductivity of irrigation water - ECw (A) and eight evaluation times (B)

availability and interfering with the ionic balance inside the cells, causing molecular damage, interruption or retardation of growth, and cell death (Sarabi et al., 2017).

With regard to the variables number of fruits (NF), average fruit weight (FW), fruit longitudinal diameter (LD), fruit transverse diameter (TD), pulp thickness (PT), and total soluble solids content (TSS), the analysis of variance showed effects of salinity on FW and TD, while the evaluation times did not influence only TD, and there were also effects of the interaction between the factors on NF and FW (Table 3).

In plants grown under irrigation water - ECw (0.8 dS $m^{-1}$), the number of fruits per plant increased throughout the development stages, verifying a maximum point of 4.4 fruits at 63 DAT. In plants grown under conditions of irrigation water - ECw (4.0 dS $m^{-1}$), found a maximum point of 4.5 fruits at 60 DAT, from that point on there was a decrease (Figure 3A). It should be noted that the total number of fruits does not translate into number of marketable fruits and that, in commercial orchards, there is a management strategy aimed at avoiding excessive number of fruits per plant (kept around 2.0 to 2.5 fruits per plant), which could attenuate this negative effect of salinity.

In addition to the data presented above, it was observed that plants irrigated with good quality water continued to produce fruits even at the end of the cycle, highlighting that, although there was no retardation of vegetative growth, the reductions in leaf area and plant growth caused by salinity led to a lower supply of photoassimilates to the reproductive buds, which resulted in a smaller number of fruits produced.

When evaluating the influence of salinity on fruit production, significant reduction was observed only in the last stage of development (Figure 3A). According to Lima et al. (2020), reductions in the production and quality of melon fruits are mediated by toxic effect, mainly caused by Na and Cl ions, which accumulate in the soil and in melon leaves, reducing gas exchange, leading to nutritional imbalance and reduction in water absorption (osmotic effect).

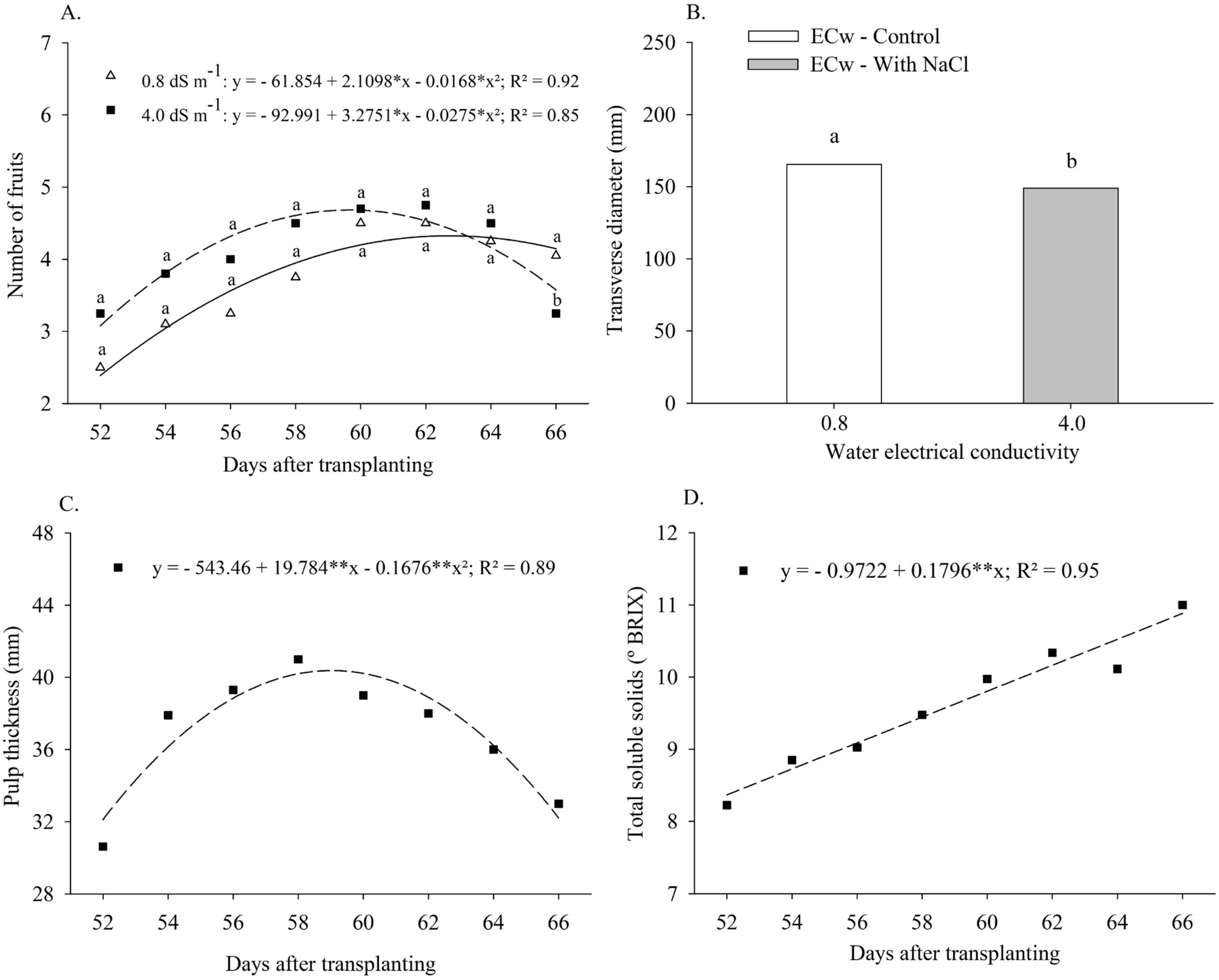
Although the interaction between the factors (electrical conductivity of water - ECw x evaluation times) had a significant influence on fruit weight, these differences were observed only at 52 and 62 DAT, when plants irrigated with water of ECw= 4.0 dS $m^{-1}$ had the lowest values. The mean values of fruit weight ranged from 1.129 to 1.433 kg at 52 and 64 DAT, respectively, with an overall average weight of 1.378.5 kg. For this variable, the regression equations were: $y = -5.3276x^2 + 628.99x - 16982$ and $R^2 = 0.19$ and $y = -4.2854x^2 + 515.31x - 14172$ and $R^2 = 0.32$, for ECw of 0.8 and 4.0 dS $m^{-1}$, respectively. As $R^2$ was less than 0.6, the graphs have not been inserted.

The fact that irrigation with saline water can enable melon production shows that water of this nature can become a potential resource for irrigation in areas that do not have good

**Table 3.** Summary of analysis of variance for the number of fruits (NF), average fruit weight (FW), fruit longitudinal diameter (LD), fruit transverse diameter (TD), pulp thickness (PT), and total soluble solids content (TSS) of irrigated melon under two electrical conductivity of water - ECw (0.8 and 4.0 dS $m^{-1}$) and at eight evaluation times (52, 54, 56, 58, 60, 62, 64 and 66 DAT)

| Sources of variation | DF | Mean squares | | | | | |
|---|---|---|---|---|---|---|---|
| | | NF | FW (g) | LD (mm) | TD (mm) | PT (mm) | TSS (ºBRIX) |
| ECw | 1 | 0.01$^{ns}$ | 979278.47** | 355.08$^{ns}$ | 2617.60$^{ns}$ | 26.09$^{ns}$ | 0.01$^{ns}$ |
| Residual a | 6 | 1.01 | 10975.70 | 399.08 | 473.86 | 53.09 | 1.16 |
| Times b | 7 | 4.05* | 155112.55* | 540.26* | 121.91$^{ns}$ | 82.35** | 6.51** |
| ECw x Times | 7 | 3.47* | 186157.20* | 195.54$^{ns}$ | 86.62$^{ns}$ | 13.37$^{ns}$ | 1.33$^{ns}$ |
| Residual b | 42 | 1.38 | 61153.37 | 219.47 | 194.16 | 17.69 | 1.22 |
| Total | 63 | 116.98 | 6002462.65 | 17118.13 | 15075.56 | 1757.88 | 113.44 |
| CV% a | - | 25.29 | 7.78 | 15.57 | 13.65 | 20.29 | 11.22 |
| CV% b | - | 29.53 | 18.35 | 11.55 | 8.74 | 8.74 | 11.51 |

DAT - Days after transplanting; DF - degrees of freedom; CV- coefficient of variation; * - Significant at 0.05, ** - significant at 0.01 probability and ns - not significant




* Significant at 0.05, ** significant at 0.01 probability. Means followed by different letters differ by Tukey test (p<0.05)

**Figure 3.** Number of melon fruits as a function of interaction between irrigation water salinity and evaluation times (A), pulp thickness (C), and total soluble solids (D) of melon as a function of the evaluation times and transverse diameter (B) as a function of the electrical conductivity of irrigation water (ECw)

quality water and in semi-arid areas of northeastern Brazil affected by water scarcity (Terceiro Neto et al., 2013). In this context, the results presented show that saline water can be used to strengthen cultivation of melon in the Northeast.

Longitudinal diameter differed between the evaluation times, with higher values at 64 DAT and an average of 143 mm, showing an increase of 10% compared to the overall average of all evaluations (128 mm). In this case, the quadratic regression model was $y = 0.0597x^2 - 7.052x + 335.22$, presented $R^2 = 0.02$, and therefore, the graph was not presented. The result found was below those reported by Pereira et al. (2021), who found maximum longitudinal diameter fruit diameter of 179 mm for Gladial melon, and by Simões et al. (2016), who observed value of 164 mm of diameter for the variety AF-682.

Transverse diameter (Figure 3B) was influenced by salinity, with a reduction of 10% when plants were irrigated with high-salinity water (4.0 dS $m^{-1}$). The mean values showed that there was no difference in fruit shape between treatments, with a flattened shape (shape ratio - SR<0.9), according to the shape classification proposed by Pedrosa (1982), which determines SR by calculating the ratio between longitudinal diameter and transverse diameter, classifying the fruits as: flattened (SR<0.9), spherical (0.9≤SR≤1.1), oblong (1.1≤SR≤1.7 and cylindrical (SR>1.7).

Regarding the postharvest variables, it was observed that the maximum longitudinal diameter and maximum transverse diameter of the fruits (17.93 and 15.33 cm, respectively) were higher than those obtained by Simões et al. (2016), who observed values of 16.40 and 13.80 cm (for the varieties SF 10/00 F1 and Goldmine). Pereira et al. (2021) found values higher than those found in this research, with 17.93 cm length and 15.33 cm for the width of melon fruits. These characteristics are important in the classification of fruits by type, which corresponds to the number of melons per standard box of 54 x 34 x 17 cm (Pereira et al., 2021). The melons in the present study were classified as types 6 or 7 (between 6 and 7 melons per box), which currently have same preference by domestic and foreign markets (Dantas et al., 2013).

The source of nitrogen fertilizer adopted in this study was urea, which may have been one of the causes for the fruits to have shown length and diameter greater than those recorded in the literature. Rodrigues et al. (2019) found increase of up to 175% in the biometric parameters of Cantaloupe melon fruits when urea was used as nitrogen source.

No significant results ($p>0.05$) were found for pulp thickness caused by irrigation water salinity. This result differed from that reported by Lima et al. (2020), who evaluated biometric parameters of Cantaloupe melon fruits under salt stress conditions and observed that pulp thickness showed a behavior inversely proportional to the increase in salinity. The authors found pulp thickness values ranging from 28 to 37 mm for the salinity levels of 5.0 and 0.5 dS $m^{-1}$, respectively.

However, pulp thickness was significantly ($p<0.05$) affected by the evaluation times finding the maximum point of 40.38 mm at 59 DAT, from that time on, the fruits showed smaller pulp thickness, which is related to the beginning of the maturation process, when the fruits had not yet fully developed their pulp. This can be justified by the pulp thickness values observed at 60, 62, 64, and 66 DAT, which increased and remained constant, with no significant variation between times (Figure 3C).

The average pulp thickness observed in the present study is higher than those obtained by Andrade et al. (2022) and Rangel et al. (2018), who evaluated the performance of Cantaloupe melon in greenhouse and observed averages of 3.76 and 3.45 cm, respectively.

The content of total soluble solids increased as a function of the evaluation times, reaching 11 °Brix for fruits at 66 DAT. However, when comparing TSS values between salinity levels, no significant influence of the treatments was observed (Figure 3D). This result corroborates those found by Lima et al. (2011), who also observed no influence of salinity (0.5 to 5.0 dS $m^{-1}$, utilizing drip irrigation system) on the average values of soluble solids of cantaloupe melon.

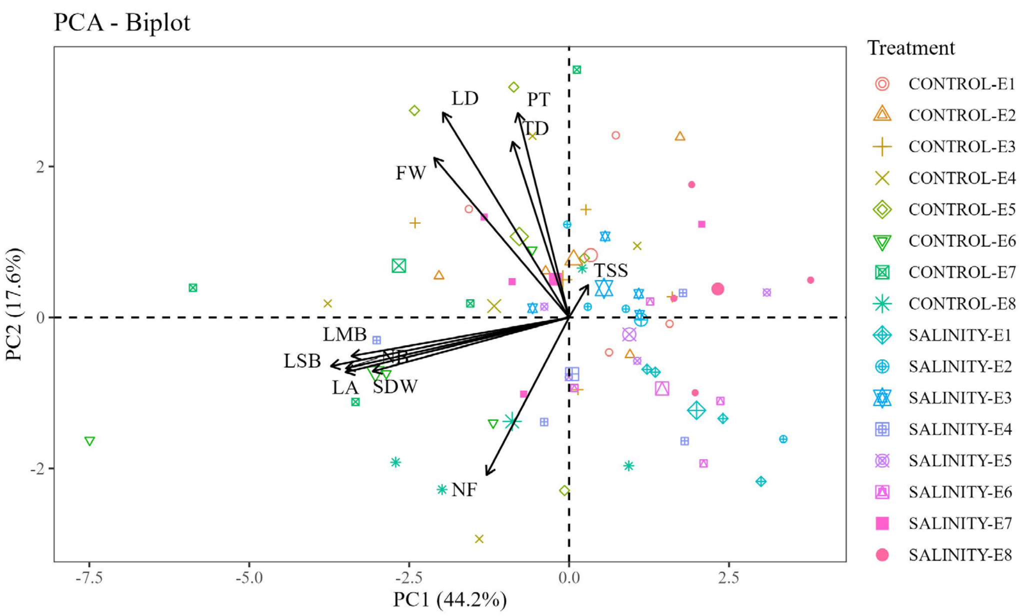
The TSS content of melons, to which sugars contribute to a large extent, has received greater attention in recent years due to its importance in determining the quality and, consequently, the marketing value of the fruits. For the international market, a minimum TSS content of 9.0 °Brix is recommended, and for yellow melon the required TSS content is from 10 to 12 °Brix (Souza et al., 2014), so the melons analyzed from 60 DAT are within the accepted standard. At 52 and 54 DAT, the fruits have not yet completed their maturation and, therefore, have TSS below 9 °Brix, so harvest for commercialization at this time of evaluation is not recommended.

The first two principal components (PC1 and PC2) represent 61.80% of the total variance (Figure 4). Principal component analysis revealed the effects of treatments on growth and postharvest variables, with the variables FW, LD, TD, and PT showing high correlation, especially in the control treatment over the evaluation periods, indicating little influence of water electrical conductivity (ECw 4.0 dS $m^{-1}$) on fruit quality and total soluble solids variables (Figure 4).

Conversely, plant growth variables were strongly and positively correlated with the angle between the vectors close to zero, demonstrating that salinity (ECw 4.0 dS $m^{-1}$) negatively affects these variables (Figure 4). In this perspective, Sousa et al. (2019), evaluating the effect of salinity on the growth and physiology of melon cultivars, found that salinity inhibited the fruit's growth. Therefore, we can associate the inhibition of melon growth with the deleterious effects of salinity, as plants under saline conditions tend to reduce their size, which can be confirmed through both univariate data (Figure 1) and PCA (Figure 4).

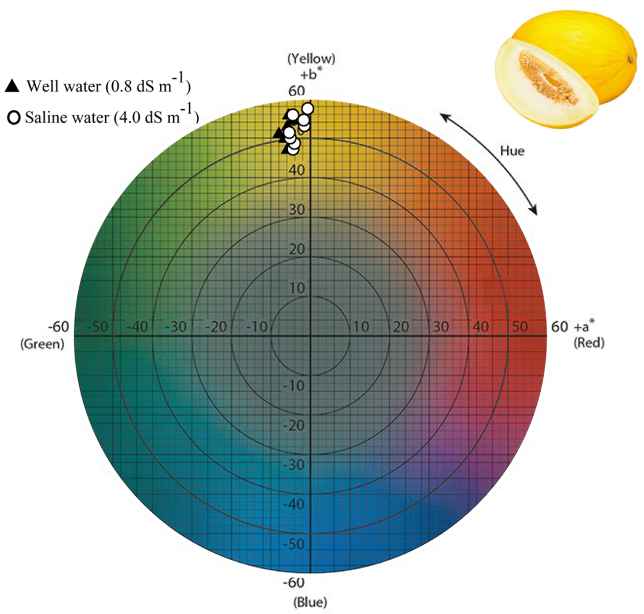
For melon fruit pulp color, measured by the °hue angle (H), which ranges from 0° to 360°, with 0° corresponding to red color, 90° corresponding to yellow, 180° to green, and 270° to blue, values lower than 100° were found at all evaluation times (DAT), which indicates that pulp color is greenish yellow (Figure 5A). A small difference in values was observed; the treatment with ECw of 0.8 dS $m^{-1}$ was always superior to the treatment with salinity (ECw 4.0 dS $m^{-1}$), values above 90° tending to 180°, leading the yellow color to be closer to the green color, indicating fruits with slightly delayed maturation when subjected to salt stress conditions (Figure 5).

Regarding the principal component analysis of the variables lightness (L), chromaticity (C), and Hue angle




Control - ECw 0.8 dS $m^{-1}$; Salinity - ECw 4.0 dS $m^{-1}$; E1, E2, E3, E4, E5, E6, E7, and E8 correspond respectively, 52, 54, 56, 58, 60, 62, 64 and 66 days after transplanting

**Figure 4.** Principal component analysis (PCA) scatterplot for the growth variables of 'Goldex' plants and fruits under different electrical conductivity of water and harvest times




Adapted from Konica Minolta Sensing Inc. (1998)

**Figure 5.** Mean values of hue angle - °Hue (A) (L*a*b color space), in the pulp of fruits of irrigated melon under two salinity levels (0.8 and 4.0 dS $m^{-1}$) and at eight evaluation times (52, 54, 56, 58, 60, 62, 64 and 66 DAT)

(H), it was observed that the first two principal components (PC1 and PC2) account for 88.4% of the total variance (Figure 6). Furthermore, PCA revealed that the variables L and H are closely correlated and were directly influenced by the control treatments, especially during the evaluation periods at 52, 54, 56, and 58 DAT, indicating little influence of electrical conductivity of water (ECw 4.0 dS $m^{-1}$) on these components. Zainal et al. (2019) report that postharvest variables such as color, texture, firmness, and nutritional value are closely related to factors such as temperature, water availability, and time. In this sense, we can observe that the time factor had a greater influence on the lightness (L), chromaticity (C), and Hue angle (H) variables than salinity. This is because as the fruits spend more time in the field, the ripening process advances, which in turn alters the post-harvest parameters.

All fruits evaluated, with and without saline treatment, had mean values of lightness (L) above 70. As the lightness scale ranges from 0 to 100, where 100 indicates white and 0 indicates absence of lightness, it can be seen that these fruits were brighter than opaque. On the other hand, the chromaticity of the fruit pulp was within the range of 18 to 24, indicating a weaker color intensity, closer to zero, assuming values close to zero for neutral colors (gray) and around 60 for vivid colors (McGuire, 1992). In summary, the small variation in color indices indicates that the physical characteristics of the fruit pulp are preserved, with little change due to maturation or to the presence of excess salts in plant tissues.

## Conclusions

1. Increased salinity of irrigation water negatively affected the growth of melon plants, regardless of the evaluation time.
2. ECw of 4.0 dS $m^{-1}$ does not reduce the fruit production of 'Goldex' melon until 64 days after transplanting.
3. The Principal Component Analysis (PCA) confirm the univariate results, showing fruit quality was not affected by irrigation water salinity, indicating that Goldex melon can be grown satisfactorily with ECw of 4.0 dS $m^{-1}$.

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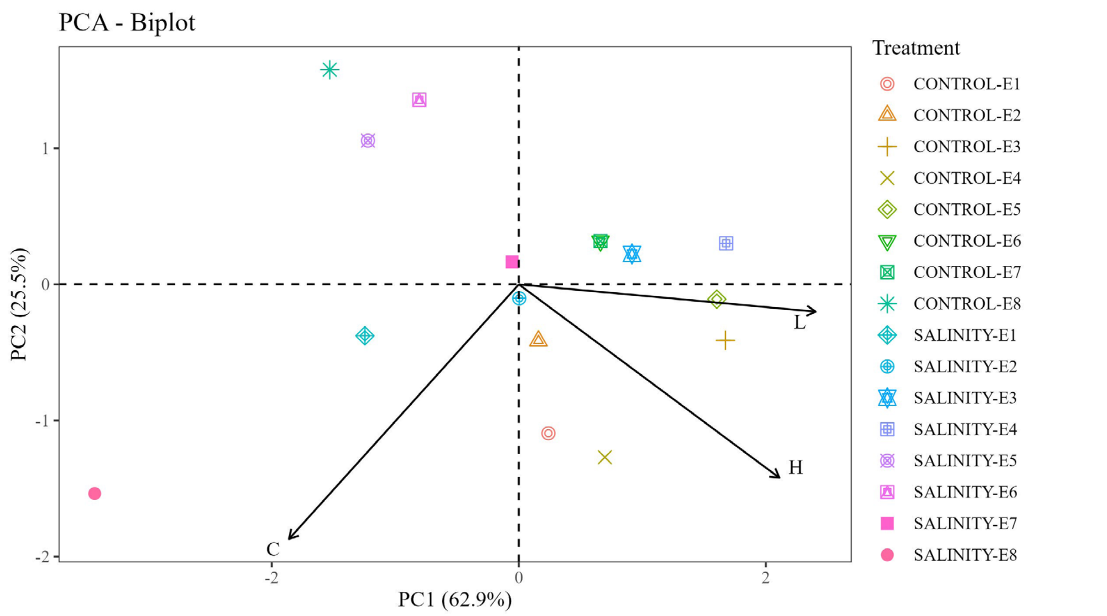


Control - ECw 0.8 dS $m^{-1}$; Salinity - ECw 4.0 dS $m^{-1}$; E1, E2, E3, E4, E5, E6, E7, and E8 correspond respectively, 52, 54, 56, 58, 60, 62, 64 and 66 days after transplanting

**Figure 6.** Principal component analysis of lightness, chromaticity and angle - °Hue (B) in the pulp of fruits of irrigated melon under two salinity levels (0.8 and 4.0 dS $m^{-1}$) and at eight evaluation times (52, 54, 56, 58, 60, 62, 64 and 66 DAT)

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