Hydroponic cultivation of coriander intercropped with rocket subjected to saline and thermal stresses in the root-zone

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ABSTRACT

An experiment was carried out in a randomized blocks design, aiming at evaluation of the cultivation of coriander intercropped with rocket subjected to saline and thermal stresses in the root-zone. Six treatments were evaluated, as follows: four treatments consisted of the combinations of two levels of electrical conductivity of water (ECw 0.3 and 6.5 dS m⁻¹) with two root-zone temperatures – RZT (ambient: < 25 °C and constant at 30 °C). The respective waters were used to prepare the nutrient solution and to replenish the water consumed. In the other two treatments the cultivation was performed at ambient RZT, one with 0.3 dS m⁻¹ level used to prepare the solution and 6.5 dS m⁻¹ level to replenish the consumption, and other with 6.5 dS m⁻¹ level used to prepare the solution and 0.3 dS m⁻¹ level to replenish the water consumed. Plant height, stem diameter, water content in shoot, fresh and dry matter of shoot, and tolerance index of saline and thermal stresses were evaluated. The coriander was more tolerant to combined stresses than the rocket. For the isolated stresses, there was a greater reduction in the production of both crops as a function of salinity than by thermal stress.

Keywords: Coriandrum sativum L.; Eruca sativa Mill.; heat stress; marketable production; salt stress.

INTRODUCTION

In many parts of the world, coriander (Coriandrum sativum L.) (Nguyen et al., 2020) and rocket (Eruca sativa Mill.) (Bonasia et al., 2017) are consumed in green salads. In rural communities in the Brazilian semi-arid region, the cultivation of these leafy vegetables, as well as others (e.g., chives and lettuce), has been the main source of income for small family farming. Due to the scarcity of fresh water in this region, brackish waters have often been used for irrigation of these vegetables (Silva et al., 2018). However, this type of water should be used rationally, as it has generally reduced crop yield.

To mitigate the negative effects of salinity on crop yield (Kitayama et al., 2020), different strategies have been used: for example, the alternation in the use of fresh and brackish waters according to crop growth stage (Li et al., 2019), as well as the transition to other cultivation systems, such as hydroponics (Atzori et al., 2019; Santos et al., 2019; Bione et al., 2021). In hydroponic cultivation, it takes into account the following hypothesis: there is no retention energy (matric potential) when plants are directly cultivated in nutrient solution (Silva et al., 2020a), conferring a possible higher tolerance of plants to salinity compared to traditional soil cultivation (Freitas et al., 2019).

Under hydroponic conditions, several studies have been conducted with different strategies aimed at the combined use of fresh and brackish waters, such as: using fresh water in the preparation of the nutrient solution and brackish waters only to replenish the water consumed by plants, e.g., coriander (Silva et al., 2015); using brackish waters only in the preparation of the solution and fresh water to replenish the water consumed, e.g., rocket (Jesus et al., 2015), parsley (Martins et al., 2019) and chives (Sil-
Hydroponic cultivation of coriander intercropped with rocket subjected to saline and thermal stresses...

va Júnior et al., 2019); and exclusive use of brackish waters, e.g., lettuce (Soares et al., 2015), coriander (Silva et al., 2016a; Silva et al., 2018; Silva et al., 2020a), rocket (Campos Júnior et al., 2018) and chicory (Alves et al., 2019; Silva et al., 2020b).

The high temperatures in arid and semi-arid regions may be a limitation for the hydroponic cultivation when brackish waters are used, because the rise in temperature of the nutrient solution further increases salinity in the cultivation medium (Cocetta et al., 2018), as a consequence of the increase in root-zone temperature. Several studies have been conducted with different plant species to evaluate the effect of root-zone temperature, such as those with lettuce (Sakamoto & Suzuki, 2015; Silva et al., 2016b), spinach (Ito et al., 2013), rocket (He et al., 2016), and coriander (Nguyen et al., 2019; Nguyen et al., 2020; Silva et al., 2020a).

Despite the large number of studies involving the isolated effects of salt or thermal stresses in the root-zone, under natural conditions plants are often exposed to complex interactions that may involve the combination of different abiotic stresses. In this context, this study was conducted with the aim to evaluate the effects of combined stress of salinity and root-zone temperature on the growth, production, and quality of intercropped coriander and rocket plants under different strategies of brackish water use.

MATERIALS AND METHODS

Study site description

One experiment was conducted concomitantly with coriander (Coriandrum sativum L.) and rocket (Eruca sativa Mill.) under hydroponic conditions in a greenhouse, from June to July 2018 (winter season). The study site was in the experimental area of the Post Graduate Program in Agricultural Engineering of the Federal University of Recôncavo of Bahia, Cruz das Almas, Bahia, Brazil (12°40’19” S, 39°06’23” W, and at an altitude of 220 m above mean sea level).

During the experiment, inside the greenhouse, the air temperature and relative air humidity varied from 19.0 to 34.5 °C and 42.5 to 95.7%, with mean values of 22.1 ± 3.0 °C and 83.1 ± 12.7%, respectively. The data were continuously monitored using a HMP45C thermohygrometer sensor (Vaisala Inc., Helsinki, Finland) connected to a CR 1000 model datalogger (Campbell Scientific Inc., Logan, Utah, USA).

Experimental design and structure used

The experiment was carried out in a randomized block design, with five replicates. Six treatments were evaluated, as follows: four treatments consisted of the combinations of two levels of electrical conductivity of water (ECw 0.3 dS m⁻¹ – low salinity water and 6.5 dS m⁻¹ – brackish water containing NaCl) with two root-zone temperatures – RZT (ambient: < 25 °C and constant at 30 °C). The respective waters were used to prepare the nutrient solution and to replenish the water consumed. In the other two treatments the cultivation was performed at ambient RZT, one with ECw of 0.3 dS m⁻¹ used to prepare the solution and ECw of 6.5 dS m⁻¹ to replenish the evapotranspiration, and other with ECw of 6.5 dS m⁻¹ used to prepare the solution and ECw of 0.3 dS m⁻¹ to replenish the water consumed by plants, as described in Table 1.

In principle, these last two treatments would be under constant RZT of 32 °C (without salt stress – 0.3 dS m⁻¹ and with salinity water – 6.5 dS m⁻¹) according to a previous study (Silva et al., 2020a). However, a day before the transplanting, when the heating of the nutrient solutions started, there was some problem in the electrical installations, thus, it was not possible for all heaters to function simultaneously, as per respective treatments. Therefore, these strategies were employed to combine low salinity and brackish waters.

The water salinity level of 6.5 dS m⁻¹ was adopted based on a previous study (Silva et al., 2018), corresponding to a relative fresh matter yield of approximately 60% for coriander under hydroponic conditions.

A hydroponic system with the Nutrient Film Technique (NFT) was used, with 6-m long channels made of PVC pipes of 0.075 m in diameter, and a 3.0% slope. More details of the experimental structure can be seen in Silva et al. (2020a), including the details of the heating system of nutrient solution.

Crop conduction and nutrient solution management

The coriander cultivar Verdão and rocket cultivar Fo-lha Larga (Feltrin® Sementes, Farroupilha, Brazil) were sown on June 1, 2018. The sowing was performed in 80-mL plastic cups containing coconut fiber substrate of home fabrication (with 15 seeds per cup), procedure similar to that adopted by Silva et al. (2020a).

Table 1: Description of treatments, root-zone temperature (RZT) and strategies for use of fresh and brackish waters to prepare the nutrient solution (Psol) and/or for replenishment of the water consumed (Rwc)

| Treatments | RZT     | Psol | Rwc |
|------------|---------|------|-----|
|            | ECw (dS m⁻¹) at 25 °C |
| T1         | Ambient | 0.3  | 0.3 |
| T2         | Ambient | 6.5  | 6.5 |
| T3         | 30 °C   | 0.3  | 0.3 |
| T4         | 30 °C   | 6.5  | 6.5 |
| T5         | Ambient | 0.3  | 6.5 |
| T6         | Ambient | 6.5  | 0.3 |
The rocket seedlings were irrigated daily with tap water (ECw of 0.3 dS m\(^{-1}\)) during the first five days; for another five days the nutrient solution of Furlani et al. (1999) for leafy vegetables at 50% concentration was applied to prevent nutritional deficiencies. For the coriander, the seedlings were irrigated with tap water until transplanting to the hydroponic system. Based on previous studies (Silva et al., 2016a; Silva et al., 2018; Silva et al., 2020a), in the production of coriander seedlings, there was no need to apply a nutrient solution before transplanting.

At 10 days after sowing (DAS), coriander and rocket seedlings were transplanted into the hydroponic system. Thinning was previously performed, leaving 10 seedlings per cup for rocket, according to Jesus et al. (2015), and 12 seedlings per cup for coriander, as recommended by Silva et al. (2016c). Ten cups with seedlings of each crop were distributed alternately in each hydroponic channel and maintained alternately in each hydroponic channel and maintaining a distance of 0.25 m between plants.

The brackish water (ECw of 6.5 dS m\(^{-1}\)) was prepared by addition of NaCl in tap water (ECw of 0.3 dS m\(^{-1}\)). After that, fertilizer salts were added to these waters, using as reference the standard nutrient solution recommended by Furlani et al. (1999), and the observed electrical conductivity of the solutions (ECsol) are shown in Table 2. More details of the preparation and management of the solution can be seen in Silva et al. (2020a).

**Variables evaluated**

Harvests were carried out at 10, 15, 20 and 25 days after transplanting (DAT). The strategy of performing four harvests along the experiment was to assess the possibility of early harvest (in the case of the treatments without salt and thermal stresses) or to maintain plants in the hydroponic system over a long exposure period of these stresses (until to reach the ideal weight for marketing).

In each harvest (in each plot), two bunches of each crop (coriander and rocket) were collected, to determine: stem diameter (SD), plant height (PH), and shoot fresh matter (SFM) and shoot dry matter (SDM) of the bunch of plants. In each bunch the SD was measured of three plants individually at height of 3 cm above the substrate level. The measurements of PH, SD and SDM were carried out according to Silva et al. (2020a).

The water content in shoot (WCS) based on the relationship ([SFM – SDM]/SFM) × 100) was determined, as described Nguyen et al. (2020).

The tolerance index (TI) based on the SFM and SDM also was determined, obtained for each treatment of isolated or combined stresses of salinity and root-zone temperature compared to the control (without salt and ambient RZT stress), based on the relationship described by Al-Garni et al. (2019).

**Statistical analysis**

The data were subjected to analysis of variance by F-test (p < 0.05) and the means were compared by the Scott-Knott test (p < 0.05). All statistical analyses were performed using R-statistical software version 3.6.3.

**RESULTS AND DISCUSSION**

**Visual quality of the plants**

According to visual aspect of coriander (Figure 1A) and rocket (Figure 1B) plants, there were no symptoms of toxicity due to salinity and/or high constant RZT of 30 ºC. These results are important as the visual quality of leafy vegetables is a fundamental requirement of the consumer market because. This is a characteristic to be considered for the commercialization of plants (D’Imperio et al., 2016), especially when plants are grown under salt stress (D’Imperio et al., 2018).

Under hydroponic conditions, the root-zone temperature plays an important role, in which, during the hot season the temperature of the nutrient solution could be too different from that required for optimum plant growth (Costa et al., 2011). In the present study, the bulky aspect and light color of roots (Figures 1A and 1B) can be one indicative that the dissolved oxygen (DO) levels in the nutrient solution were adequate for plant growth. This is an important point to be highlighted, because the DO levels in the solution are inversely correlated with RZT (Sakamoto et al., 2016). In other words, with the increase

| Treatments | ARZT (ºC) | ECsol\(_{\text{init}}\) (dS m\(^{-1}\)) | ECsol\(_{\text{end}}\) (dS m\(^{-1}\)) at 25 ºC | Variations in ECsol |
|------------|----------|--------------------------------|---------------------------------|------------------|
| T1         | 23.90 ± 0.36* | 2.50                             | 1.92                            | - 0.58           |
| T2         | 24.00 ± 0.55  | 8.90                             | 9.75                            | + 0.85           |
| T3         | 30.17 ± 0.32  | 2.50                             | 2.77                            | + 0.27           |
| T4         | 30.35 ± 0.24  | 8.90                             | 11.10                           | + 2.20           |
| T5         | 23.51 ± 0.33  | 2.50                             | 3.12                            | + 0.62           |
| T6         | 24.26 ± 1.03  | 8.90                             | 8.60                            | - 0.30           |

Details of treatments T1, T2, T3, T4, T5 and T6 are described in the Table 1. * mean ± standard deviation.
in temperature during the day, there is a reduction in DO concentration, as observed in an earlier experiment with coriander (Silva et al., 2020c).

The growing period in the year also influences the quality of plants produced under salt and/or heat stresses. An example of this is that Bonasia et al. (2017) observed a better visual quality of rocket plants in the autumn-winter period (from the mid cycle until the harvest, temperatures frequently dropped below 5 °C as minimum values) compared to winter-spring (maximum temperatures were frequently higher than 20 °C) under salinity of 3.5 and 4.5 dS m⁻¹ (with NaCl), respectively. In the study conducted by Nguyen et al. (2020) with coriander for 18 days, plants subjected to RZT at 35 °C during the last six days of the cycle showed yellowish leaves and dark roots.

**Growth parameters**

The plant height of coriander (Figure 2A) and rocket (Figure 2B) was significantly affected (p < 0.01) by treatments in all evaluated periods. There was also a significant effect (p < 0.01) on the stem diameter of both crops, except at 10 DAT for coriander (Figure 2C) and at 15 DAT for rocket (Figure 2D).

The results show that the plant height (Figure 2B) and stem diameter (Figure 2D) of rocket decreased more drastically under the combined stresses (T4). For coriander (Figures 2A and 2C), the reduced growth patterns were similar for T2, T4 and T6. In the case of T6, the replacement with fresh water (ECw of 0.3 dS m⁻¹) along the coriander cycle did not promote any growth gain when compared to the exclusive use of brackish water with ECw of 6.5 dS m⁻¹ (T2).

In studies with the same crops used in the present study, different responses to salinity in the vegetative growth have been reported (Silva et al., 2015; Silva et al., 2016a; Silva et al., 2018; Ahmad & Souri, 2018; Ghazi, 2018). The different results show that the effect of salt stress varies among species (Ashraf et al., 2020), among their organs (Bulgari et al., 2019; Alisofi et al., 2019), and also as a function of the duration of salt stress imposition (Negrão et al., 2017; Shaukat et al., 2019).

In the present study, under RZT of 30 °C (T3) the means of plant height and stem diameter of the coriander (Figures 2A and 2C, respectively) and rocket (Figures 2B and 2D, respectively) were similar to T1 (ECw of 0.3 dS m⁻¹ and ambient RZT). These results reinforce those of the other studies, which reported no significant changes in the growth parameters of several plant species subjected to different RZT, such as leaf area and number of leaves in lettuce (Sun et al., 2016), stem diameter in lettuce (Sakamoto & Suzuki, 2015), and plant height in coriander under RZT up to 30 °C (Nguyen et al., 2020).

**Figure 1:** The visual aspect of the coriander (A) and rocket (B) plants subjected to stresses of root-zone temperature and salinity and different strategies of use of brackish water, at harvest (25 days after transplanting).

Details of treatments T1, T2, T3, T4, T5 and T6 are described in the Table 1.
Water content in shoot

Water content in shoot (WCS) of coriander (Figure 3A) and rocket (Figure 3B) plants was significantly affected by treatments, except at 15 DAT for coriander. For coriander, at 10 DAT (T1 and T3), 20 DAT (T1, T3 and T5) and 25 DAT (T1 and T5), these treatments stood out with the highest means of WCS. For rocket, at 10 DAT the lowest values of WCS were observed only in T4, while at 15 and 20 DAT were observed in T2 and T4. At 25 DAT, the highest means of WCS were obtained for T1 and T5.

The water content is associated with the water holding capacity in the tissue of plants, and the higher this content, the better their water status (Souza et al., 2020). In the present study, the values of WCS varied between 90 and 94% for coriander (Figure 3A) and between 92 and 95% for rocket (Figure 3B). These values point to a large amount of water stored in plant tissues, which is an important result because in various regions of the world, the part of greatest commercial interest in these crops is the fresh matter.

With the exposure of plants to salt stress, there was a reduction in water content due to the dehydration of cells (Azizi et al., 2017; Mehrabani et al., 2018). In the present study, the greatest reductions in WCS occurred at 25 DAT under combined stresses (T4), compared to the means of T1 and T5, of the order of 1.77 and 1.93% for coriander (Figure 3A) and rocket (Figure 3B), respectively.

These reductions in WCS of coriander (Figure 3A) and rocket (Figure 3B) plants recorded in the present study can be considered low, reinforcing the results of Silva et al. (2013), who reported a 1.87% decrease in the WCS of rocket under higher EC$_{\text{sol}}$ level (10.5 dS m$^{-1}$ with NaCl) in comparison to the control (EC$_{\text{sol}}$ of 1.8 dS m$^{-1}$) in NFT hydroponics.

Considering the isolated effects, in general, the WCS was lower under salinity with exclusive use of brackish water (T2) compared to T1, while only at 25 DAT there were reductions due to constant RZT at 30 °C (T3) for both coriander (Figure 3A) and rocket (Figure 3B). The absence of significant difference between the means of the WCS as a function of the root-zone temperatures up to 20 DAT reinforces the results obtained in other studies with coriander. Under RZT varying between 25 °C (Nguyen et al., 2019) and 30 °C (Nguyen et al., 2020) verified values of WCS of approximately 90%.

Biomass production and tolerance index

The shoot fresh matter (SFM) and shoot dry matter (SDM) of coriander (Figures 4A and 4C) and rocket (Figures 4B and 4D), and the tolerance index based on the SFM...
(TI-SFM) and SDM (TI-SDM) of coriander (Figures 5A and 5C) and rocket (Figures 5B and 5D) were significantly affected (p < 0.01) by treatments in all evaluated periods.

As expected, the combination of stress (T4) had a more negative effect on commercial production (SFM) (Figures 4A and 4B). However, for coriander this was only observed in the last evaluation (Figure 4A). In this case, up to 20 DAT the combined effect of stresses was similar to the isolated effect of salinity (T2 and T6). For rocket (Figure 4B), from 15 DAT the means of SFM obtained in T4 were always lower compared to those of the other treatments.

In general, for SDM of coriander (Figure 4C), the effects of the treatments were divided into two groups, with the highest means in T1, T3 and T5. For rocket (Figure 4D), the effects of the treatments on SDM followed the same trend as those observed in SFM.

The results observed in the present study reinforce those found in the literature, which show the different

Details of treatments T1, T2, T3, T4, T5 and T6 are described in the Table 1; CV - coefficient of variation; * and ** - significant at p < 0.05 and p < 0.01 and ns - not significant by F-test; means followed by the same letter are not significantly different at p = 0.05 by Scott-Knott test; vertical bars indicate the means ± standard deviation (n = 5).

**Figure 3:** Mean water content of shoot of coriander (A) and rocket (B) under stresses of root-zone temperature and salinity and different strategies using fresh and brackish waters at 10, 15, 20 and 25 days after transplanting, in a NFT hydroponic system.

Details of treatments T1, T2, T3, T4, T5 and T6 are described in the Table 1; CV - coefficient of variation; * and ** - significant at p < 0.05 by F-test; means followed by the same letter are not significantly different at p = 0.05 by Scott-Knott test; vertical bars indicate the means ± standard deviation (n = 5).

**Figure 4:** Mean fresh matter - SFM and dry matter of shoot - SDM of coriander (A and C) and rocket (B and D) plants, respectively, under stresses of root-zone temperature and salinity and different strategies using fresh and brackish waters at 10, 15, 20 and 25 days after transplanting, in a NFT hydroponic system.
impacts of abiotic stresses on crops (Incrocci et al., 2019; Ashraf et al., 2020) and according to the stage of development (Ahmadi & Souri, 2018; Bulgari et al., 2019). Under saline conditions, in the short term, the reduction of plant growth is an immediate effect caused by the osmotic component, resulting from the high concentration of solutes in the root zone (Carillo et al., 2019), which reduces cell expansion (Bekhradi et al., 2015; Franzoni et al., 2020).

In the present study, under the combination of stresses (T4), the SFM production of coriander was 36.13 g (bunch of 12 plants) at 25 DAT (Figure 4A). In the study conducted by Silva et al. (2020a), the SFM for the same coriander cultivar was of same magnitude (34.16 g for a bunch of 12 plants) also under the combination of salt stress (ECw of 6.5 dS m⁻¹) and constant RZT of 30°C, in NFT hydroponics for 25 DAT.

Under T2 and T6 (statistically similar), the reduction in coriander SFM at 25 DAT was approximately 50% compared to T1 (Figure 4A). Reduction of the same magnitude has been observed in other studies with coriander grown in pots with soil, under ECw of 6.25 dS m⁻¹ in comparison to ECw of 0.45 dS m⁻¹ (Ghazi, 2018) and under irrigation water salinity equivalent to 75 mM NaCl in comparison to the control (0 mM NaCl) (Al-Garni et al., 2019). In the study conducted by Elhindi et al. (2016), the reduction was approximately 28% under irrigation water salinity corresponding to 80 mM NaCl compared to the control (0 mM NaCl).

For rocket (Figure 4B), the SFM production obtained at 25 DAT was compatible with that observed by Jesus et al. (2015), approximately 37 g (bunch of 10 plants) under ECw of 6.5 dS m⁻¹ (under exclusive use of brackish water) at 25 DAT in NFT hydroponics.

The reduction in rocket SFM at 25 DAT under T2 and T6 compared to T1 and T5 was approximately 36% (Figure 4B). Reduction of the same magnitude in rocket SFM was observed by Silva et al. (2013) under ECsol of 8.5 dS m⁻¹ (with NaCl) compared to the ECsol of 1.8 dS m⁻¹ (without NaCl), in NFT hydroponics for 30 DAT.

Oliveira et al. (2018) and Cordeiro et al. (2019) verified reductions in SFM of rocket as a function of salinity. In the first study, the reduction was approximately 64% under ECsol of 7.3 dS m⁻¹ (with NaCl, EC ~ 5.2 dS m⁻¹) compared to the ECsol of 2.1 dS m⁻¹ (without NaCl). For the second study, the reduction was approximately 42% under ECsol of 5.1 dS m⁻¹ (with NaCl) compared to the ECsol of 2.3 dS m⁻¹ (without NaCl). In these studies, the cultivation was performed in coconut fiber substrate for 40 and 37 days, respectively.

Details of treatments T1, T2, T3, T4, T5 and T6 are described in the Table 1; CV - coefficient of variation; ** - significant at p < 0.01 by F-test; means followed by the same letter are not significantly different at p = 0.05 by Scott-Knott test; vertical bars indicate the means ± standard deviation (n = 5).

Figure 5: Mean tolerance index of the fresh matter - TI-SFM and dry matter - TI-SDM of shoot of coriander (A and C) and rocket (B and D) plants, respectively, under stresses of root-zone temperature and salinity and different strategies using fresh and brackish waters at 10, 15, 20 and 25 days after transplanting, in a NFT hydroponic system.
In summary, different responses of coriander and rocket to salt stress can be related to growing season, level of salinity used, type of stress applied and cultivation method. Additionally, the response of the species to salt stress depends on the type of salts to which they are subjected (Kurunc et al., 2020). As an example, in the study of Ahmadi & Souri (2018) with coriander irrigated using saline water and different salt mixtures, there was a reduction of approximately 35% in SFM under ECw of 4.0 dS m\(^{-1}\) (with NaCl) compared to the same level of ECw with mixture of KCl + NaCl + CaCl\(_2\).

The results of the present study show that the effect of salt stress provoked by ECw of 6.5 dS m\(^{-1}\) was more pronounced than that of heat stress, when these were evaluated separately. Regarding the heat stress, SFM values were approximately 16% lower for coriander (Figure 4A) and 21% lower for rocket (Figure 4B) under constant RZT at 30 °C (T3) compared to control (T1). Reduction in coriander SFM of the same magnitude was verified by Nguyen et al. (2020), of approximately 15% under RZT at 30 °C in the last six days of the cycle compared to the control condition (RZT at 25 °C along the entire 18-day cycle).

The effect of RZT varies within the same species, as observed by Silva et al. (2020a). These authors verified a reduction in SFM (at 25 DAT) for the same coriander cultivar used in the present study of approximately 37% under constant RZT at 32 °C compared to ambient RZT, while for cultivar Tabocas there was no significant difference between the means as a function of RZT.

Regarding the strategies for the use of brackish water under ambient RZT, the use of fresh water to replenish the water consumed (T6) of coriander (Figure 4A) and rocket (Figure 4B) plants did not bring any gain in fresh biomass production, compared to the exclusive use of brackish water (T2). In this case, among the strategies used, it is preferable to use fresh water to prepare the solution and brackish water to replenish water consumed (T5).

Regarding the tolerance index (TI), for coriander the values based on SFM (Figure 5A) and SDM (Figure 5C) were above 0.5, except for the cultivation under combined stresses (T4) at 20 and 25 DAT, when the recorded values of TI-SFM were around 0.4. Similar results were observed for rocket (Figure 5B); however, the lowest value of TI-SFM (0.35) was recorded at 25 DAT. Behavior similar to that recorded for TI-SFM was also observed for TI-SDM for both coriander (Figure 5C) and rocket (Figure 5D), with the lowest TI values around 0.5.

When the plants were subjected to stresses of root-zone temperature and salinity for more time, there were greater reductions in TI, and the effects were more pronounced on SFM of coriander (Figure 5A) and rocket (Figure 5B). In other words, this index concerns the relative reduction in yield compared to T1. In another study with coriander, Sá et al. (2016) reported salinity TI for SDM of 0.32 and 0.53 for two cultivars when irrigated with saline water of ECw of 3.0 dS m\(^{-1}\) compared to the ECw of 0.3 dS m\(^{-1}\).

**CONCLUSIONS**

In NFT hydroponic cultivation, the effect of heat stress (root-zone temperature of 30 °C) was mild compared to salt stress (ECw of 6.5 dS m\(^{-1}\)), especially for coriander. When these stresses were combined, the negative effect was clearly greater in rocket.

Despite the reduced fresh matter yields obtained under the combination of salt and heat stress caused by root-zone temperature of 30 °C, the visual quality of the plants produced remained within the commercial standards.

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