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Salinity tolerance of tomato fertigated with different K^+/Ca^{2+} proportions in protected environment[1]

Tolerância do tomateiro à salinidade quando fertigado com diferentes proporções de K^+/Ca^{2+} em ambiente protegido

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HIGHLIGHTS:

Cultivation of tomato in coconut fiber promotes greater tolerance to salinity.
Higher doses of potassium and calcium increase salt stress in tomato fertigated with saline nutrient solutions.
Adequate nutritional management with Ca^{2+} and K^+ allows the use of saline water in tomatoes grown in coconut fiber.

ABSTRACT: Adequate potassium and calcium nutrition is a strategy to reduce salt stress on tomatoes, as it reduces nutritional imbalance in plants. With the objective of evaluating tomato production using irrigation with saline waters and fertigation with different potassium-calcium proportions, an experiment was carried out in a protected environment in Mossoró, RN, Brazil. The experimental design used was randomized blocks, in a 5 x 4 factorial scheme, with four replicates. The treatments consisted of the combination of four electrical conductivity of nutrient solution (ECns) (1.75; 3.25; 4.75; and 6.25 dS m^{-1}) combined with five ionic proportions (m/m) of potassium and calcium (F1 = 2.43:1; F2 = 2.03:1; F3 = 1.62:1; F4 = 1.30:1 and F5 = 1.08:1). The response variables were: number of fruits, mean fruit weight, fruit production per plant and relative yield. It was possible to identify satisfactory results of production when higher salinity was used. Fertigation with low K^+/Ca^{2+} proportions intensifies the effect of salinity on tomato crop.

Key words: *Lycopersicon esculentum* Mill, nutrition, potassium, calcium, salt stress

RESUMO: Adequada nutrição potássica e cálcica é uma estratégia para reduzir o estresse salino sobre o tomateiro, pois reduz o desbalanço nutricional nas plantas. Com o objetivo de avaliar a produção do tomate utilizando irrigação com águas salinas, e fertigação com diferentes proporções potássio-cálcio, realizou-se um experimento em ambiente protegido em Mossoró, RN. O delineamento experimental utilizado foi em blocos casualizados, em esquema fatorial 5 x 4, com quatro repetições. Os tratamentos consistiram em combinações de quatro condutividade elétricas da solução nutritiva (ECns) (1,75; 3,25; 4,75 e 6,25 dS m^{-1}) com cinco proporções iônicas (m/m) de potássio e cálcio (F1 = 2.43:1; F2 = 2.03:1; F3 = 1.62:1; F4 = 1.30:1 and F5 = 1.08:1). As variáveis resposta foram: número de frutos, peso médio de fruto, produção de frutos por planta e produção relativa. Foi possível identificar resultados de produção satisfatórios quando se usa uma maior salinidade. O uso de fertigação com baixas proporções K^+/Ca^{2+} potencializa o efeito da salinidade sobre a cultura do tomateiro.

Palavras-chave: *Lycopersicon esculentum* Mill, nutrição, potássio, cálcio, estresse salino

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most cultivated and consumed vegetables in Brazil, standing out due to its important economic value for the country. In addition to being very healthy, it is a vegetable consumed all over the world for being a source of vitamins A and C and rich in lycopene and various minerals such as potassium and magnesium, which are beneficial to human health (Xiaohui et al., 2019).

Tomato is cultivated in different periods of the year and under different management systems, virtually in all regions of Brazil (Matos et al., 2012), but its yield can be affected by various abiotic stresses. Salinity is one of the greatest abiotic stresses that have progressively reduced yield of crops, especially in arid and semi-arid regions, characterized by reduced rainfall and high evapotranspiration (Schmöckel et al., 2017; Abdelaziz et al., 2019). Due to difficulties of production in some periods of the year, cultivation in protected environment has been increasing, because it allows improving yield and quality of agricultural products, providing better profitability, besides promoting greater savings and water use efficiency (Santi et al., 2013).

The quality of water used in irrigation is a primary factor for plants to express their maximum development and production potential (Guedes et al., 2015). When irrigated with saline water above a threshold salinity, tomato crop shows physiological, biochemical and nutritional changes, which lead to reductions in growth and yield, due to a decrease in the number and weight of fruits (Guedes et al., 2015; Islam et al., 2018; Chen et al., 2019).

Some studies have been conducted to evaluate the effect of calcium and potassium nutrition on plants subjected to salt stress, for instance those conducted with bell pepper (Rúbio et al., 2009; Silva et al., 2020) and eggplant (Santos et al., 2018), which showed that the enrichment of the growing medium with potassium and/or calcium may alter the response of plants to salinity. Thus, supplementation of the nutrient solution with potassium and calcium can promote higher tolerance of plants to salinity, as it will promote mutual competition between two ions (Na^+ and K^+/Ca^{2+}) for a transport site (Zhang et al., 2016).

In view of the above, the objective of this study was to evaluate the yield of tomato crop subjected to salt stress and fertigation with different K^+/Ca^{2+} proportions in a protected environment.

Material and Methods

The experiment was carried out in a protected environment, in the experimental area of the Department of Environmental and Technological Sciences of the Federal Rural University of the Semi-Arid Region (UFERSA), in Mossoró, RN, Brazil (5º 12' 04" S and 37º 19' 39" W and mean altitude of 18 m).

The climate of the region, according to the Köppen-Geiger classification, is BSwh' (hot and dry), with very irregular rainfall, averaging 673.9 mm year^{-1}, mean temperature of 27.4 °C, mean relative air humidity of 68.9%, mean daily insolation of 7.83 hours and mean annual insolation of 2771.27 hours of sunlight, and mean wind speed of 0.84 m s^{-1} (Alvares et al., 2013).

The statistical design used was in randomized blocks, in a 5 × 4 factorial scheme, with four replicates, and the experimental unit was represented by a container with a capacity of 15 L, containing one plant. The treatments were formed by the combination of five ionic proportions (m/m) of potassium and calcium (K^+/Ca^{2+}) (F1 = 2.43:1; F2 = 2.03:1; F3 = 1.62:1; F4 = 1.30:1 and F5 = 1.08:1), with four values of electrical conductivity of the water used to prepare the nutrient solution (S1 - 0.5; S2 - 2.0; S3 - 3.5 and S4 - 5.0 dS m^{-1}). After preparation, the nutrient solutions had the following electrical conductivities: 1.75, 3.25, 4.75 and 6.25 dS m^{-1}.

The lowest electrical conductivity (S1 - 0.5 dS m^{-1}) was obtained using tap water from the supply system of the UFERSA campus. To obtain the other salinity proportions (S2, S3, S4 and S5), sodium chloride was added in the tap water.

The quantities of nutrients for 500 L of nutrient solution, supplied through fertigation, followed the recommendation of Castellane & Araújo (1995), for tomato crop in hydroponic system with necessary adaptation for K and Ca doses except F3 (Table 1), which correspond to the standard nutrient solution.

The nutrient solutions were prepared using the following fertilizers: calcium nitrate, calcium sulfate, calcium chloride, potassium sulfate, potassium chloride, potassium nitrate and monoammonium phosphate (MAP), plus a micronutrient compound (EDTA-chelated nutrients, containing 0.28% Cu, 7.5% Fe, 3.5% Mn, 0.7% Zn, 0.65% B and 0.3% Mo). For all treatments, the same doses of nutrients were applied, except for potassium and calcium, making the balance between the sources used.

Seedlings of the Supera F1 tomato hybrid were produced in expanded polystyrene trays with a capacity of 128 cells, by planting three tomato seeds, with thinning performed at five days after emergence, leaving the most vigorous seedling in each cell. After thinning, daily fertigation was performed through a floating system, using standard nutrient solution diluted to 70%.

When the plants had about three to four true leaves (32 days after sowing), they were transplanted to 15-L plastic containers, one plant per container, containing 13 L of coconut fiber (Golden Mix Granulated), composed of 100% fine-textured coconut fiber, without basal fertilization. This substrate was chosen because it is widely used by scholars for studies in this cultivation system, especially the cultivation of fruit vegetables, such as tomato (Santos et al., 2016), bell pepper (Silva et al., 2020) and cucumber (Oliveira et al., 2017).

The containers were distributed inside the greenhouse in four rows at spacing of 1.50 m between rows and 0.50 m between pots, equivalent to the population of 13,333 plants ha^{-1}. Each pot had a drainage system at its base formed by a 2-cm-thick layer of crushed stone + geotextile to facilitate the drainage. The first two containers at the beginning of each row served as borders, in which plants were grown using F3 fertigation and irrigation with water of lowest salinity. Wooden posts were installed inside the

Table 1. Concentrations of nutrients (mg L^{-1}) in the fertigation treatments used in the experiment

Fertigation	N	P	K	Ca	Mg	S
F1-K^+/Ca^{2+} = 2.43:1	184	21	372	153.0	43	47.5
F2-K^+/Ca^{2+} = 2.03:1	184	21	310	153.0	43	47.5
*F3-K^+/Ca^{2+} = 1.62:1	184	21	248	153.0	43	47.5
F4-K^+/Ca^{2+} = 1.30:1	184	21	248	191.2	43	47.5
F5-K^+/Ca^{2+} = 1.08:1	184	21	248	229.5	43	47.5

* - Castellane & Araújo (1995)

greenhouse, and galvanized iron wires (number 14) were stretched at 2.00 m height and fixed to their ends to support plants.

A drip irrigation system was adopted, working as an independent irrigation system for each type of water applied, formed by a reservoir (500-L water tank and a Metalcorte/Eberle self-venting circulation electric pump, model EBD250076), driven by a single-phase motor, with 210 V voltage and 60 Hz frequency, hoses (16 mm) and microtubes with mean flow rate of 2.5 L h^{-1}.

Irrigation management was performed using a timer (Digital Timer, TE-2 model, Decorlux®) adopting the daily frequency of six irrigations, adjusting the time of each irrigation according to the need of the crop, so that drainage occurred in all treatments.

Harvests were carried out twice a week, by picking the physiologically ripe fruits. The fist harvest was performed 90 days after transplanting. The fruits were counted and weighed individually and, based on these data, the following yield components were determined: number of fruits, mean fruit weight, fruit production and relative yield, discarding the fruits with mechanical injury and/or physiological disorders.

Fruit production data in all treatments were used to determine the tolerance of the crop to salinity for each fertigation treatment, through the salinity threshold (ST) and the coefficient of relative yield loss (b) per unit increment in the electrical conductivity above the salinity threshold [(Y = 100 - b (ECse - ST)]. Salinity threshold was determined by adopting a decrease in potential yield of up to 10%, i.e., the salinity level that allows the production of a minimum relative yield of 90% (Ayers & Westcot, 1999). The electrical conductivities that enabled the maximum yield of the plants were highlighted, as well as the loss of yield per unit increment of EC (% per dS m^{-1}), according to the methodology used by Silva et al. (2020).

The obtained data were subjected to analysis of variance. The results regarding the effect of fertigation treatments were analyzed through the means comparison test (Tukey). The effect of salinity was analyzed by regression analysis. Statistical analyses were performed using the statistical program Sisvar (Ferreira, 2014).

Results and Discussion

According to the analysis of variance, there was a significant effect of the interaction between the factors (salinity x fertigation) on the variables number of fruits (NFR) and production (PROD) ($p \leq 0.01$), as well as on the mean fruit weight (MFRW) ($p \leq 0.05$). It was also observed that these variables were significantly affected by the fertigation factor at $p \leq 0.01$, while the salinity factor affected NFR and MFRW ($p \leq 0.05$) and PROD ($p \leq 0.01$) (Table 2).

Table 2. Summary of analysis of variance for number of fruits (NFR), mean fruit weight (MFRW) and production (PROD) of tomato subjected to salinity of irrigation water and fertigation with calcium and potassium

Sources of variation	DF	Mean squares		
		NFR	MFRW	PROD
Salinity (S)	3	25.38*	145.02*	82465.82**
Fertigation (F)	4	56.35**	194.49**	77015.46**
S x F	12	36.20**	103.35*	63178.32**
Block	3	4.42^{ns}	15.88^{ns}	16902.19^{ns}
Residual	57	7.13	45.62	19869.95
CV (%)		18.80	17.16	19.96

ns; *; ** - Not significant, significant at $p \leq 0.05$ and $p \leq 0.01$, respectively, by F test; DF - Degrees of freedom

By analyzing the number of fruits per plant (NFR), it was found that, except at the highest salinity (6.25 dS m^{-1}), there was a difference between fertigation treatments at all the other levels of salinity. When plants were fertigated with the nutrient solution prepared with water of lowest salinity (1.75 dS m^{-1}), the highest values were obtained in fertigation treatments F4 and F5. However, for the salinity levels of 3.25 and 4.75 dS m^{-1}, the fertigation treatments F2, F3 and F4 promoted a higher number of fruits (Table 3).

By analyzing the effect of salinity on the number of fruits (NFR), it was verified that there were different responses according to the fertigation used. For the fertigation treatments F1, F4 and F5, the increase in salinity caused a linear reduction in the NFR, with losses of 0.80 (F1), 1.81 (F4) and 1.94 (F5) fruits per plant, for each unit increase in salinity, resulting in total losses of 18.1, 30.4 and 36.4% for F1, F4 and F5, respectively. Thus, the effect of salinity was more severe on the number of fruits in plants subjected to excess Ca, compared to excess K (Table 3).

In bell pepper, Silva et al. (2020) also found that the nutrient solution with the highest Ca proportion increased the occurrence of small fruits, without commercial quality, when plants were subjected to higher salinities.

For the fertigation treatments F2 and F3, quadratic responses were observed, with the highest values obtained for both cases at salinity of 3.7 dS m^{-1}, with maximum values of 22 and 24 fruits per plant, respectively. Compared to the values obtained at the lowest salinity, there were gains of 18.6 and 16.3% for F2 and F3, respectively (Table 3). Thus, it was verified that the adoption of these fertigation treatments was efficient to mitigate the effect of salinity on this variable.

These results demonstrate that the fertigation treatments F1, F4 and F5, which applied higher concentrations of either K (F1) or Ca (F4 and F5), were not efficient to mitigate the effect of salinity on NFR, thus being consistent with the result observed by Tuna et al. (2007) and Santos et al. (2018), when working with

Table 3. Number of fruits per plant of tomato subjected to salinity of irrigation water and fertigation with different potassium and calcium proportions

Fertigation	Nutrient solution EC (dS m^{-1})				Regression equations	R^2
	1.75	3.25	4.75	6.25		
F1-K^+/Ca^{2+} = 2.43:1	20.2 b	18.5 b	17.0 b	16.7 a	y (F1) = -0.80**x + 21.30	0.93
F2-K^+/Ca^{2+} = 2.03:1	18.5 b	22.4 a	20.7 a	16.5 a	y (F2) = -0.90**x^2 + 6.69*x + 9.71	0.98
*F3-K^+/Ca^{2+} = 1.62:1	20.4 b	23.4 a	22.8 a	17.8 a	y (F3) = -0.89**x^2 + 6.55*x + 11.62	0.99
F4-K^+/Ca^{2+} = 1.30:1	26.3 a	24.7 a	21.0 a	18.5 a	y (F4) = -1.81**x + 29.85	0.98
F5-K^+/Ca^{2+} = 1.08:1	25.0 a	20.1 ab	17.7 b	16.1 a	y (F5) = -1.94**x + 27.48	0.94

Means followed by the same letters in the columns do not differ significantly by Tukey test ($p \leq 0.05$); *, ** - Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively, by F test hydroponic tomato and eggplant plants, respectively, subjected to salinity and calcium levels in nutrient solution. These authors also found that the increase in calcium concentration did not reduce the effect of salt stress on the number of fruits.

Negative effects of salinity on the NFR of tomato have also been reported by several authors (Guedes et al., 2015; Santos et al., 2016; El-Mogy et al., 2018). The effect of salinity on the reduction of NFR may be due to changes in the osmotic potential of the substrate solution, reducing the consumption of water and nutrients by plants, decreasing not only the number of flowers (El-Mogy et al., 2018), but also the number and viability of pollen grains, consequently resulting in higher rate of abortion of flowers and small fruits (Ghanem et al., 2009).

Regarding the mean fruit weight (MFRW), there was a significant difference between the fertigation treatments at all salinity levels. For salinities of 1.75 and 3.25 dS m^{-1}, the highest values were obtained in plants subjected to fertigation with higher concentration of K (F1). At salinity of 4.75 dS m^{-1}, only F2 differed from the others, showing a lower value, while at salinity of 6.25 dS m^{-1} the fertigation treatments F1 and F5 led to highest and lowest MFRW, respectively, not differing from the other treatment (Table 4).

It is possible to observe that fertigation with the highest doses of K, compared to the standard fertigation (F3), was efficient to mitigate the effects of 3.25 dS m^{-1} salinity on MFRW, but there was no positive response at the highest water salinity (Table 4), corroborating the results presented by Yurtseven et al. (2005), who evaluated the effect of salinity and potassium fertilization on tomato plants and observed that the effect of potassium fertilization on fruit weight occurred due to the beneficial effect of the nutrient itself, so it was not possible to affirm that this nutrient had a direct effect in inhibiting the effect of salinity.

On the other hand, the highest doses of Ca were harmful to MFRW and did not mitigate the effect of salinity. These results are similar to those obtained by Sangtarashani et al. (2013) and Silva et al. (2020), who studied cherry tomatoes and bell pepper, respectively, and found no significant gains in MFRW as a function of the increase in K and Ca concentrations in plants subjected to salt stress.

Regarding the effect of salinity on the mean fruit weight, it was found that the increase in the electrical conductivity of the nutrient solution caused a linear reduction in MFRW for plants fertigated with higher K concentration (F1), with a loss of 2.69 g $fruit^{-1}$ per unit increase in salinity, leading to a total reduction of 22.6%. For the other fertigation treatments, quadratic responses were observed, but with contrasting behavior between F2 and the others (Table 4).

In F2 fertigation, the increase in salinity initially caused a reduction in MFRW up to the level of 4.36 dS m^{-1} (34.2 g $fruit^{-1}$), showing an increase at the highest salinity. For the fertigation treatments F3, F4 and F5, the MFRW increased as the electrical conductivity increased up to 4.0, 4.2 and 4.4 dS m^{-1}, with maximum values of 46.9, 41.9 and 41.9 g $fruit^{-1}$, equivalent to gains of 22.2, 19.8 and 28.5%, respectively (Table 4).

These results show that the use of saline water can cause reduction in fruit size, confirming the information presented by other authors (Santos et al., 2016; El-Mogy et al., 2018), as observed in other solanaceous crops, such as eggplant (Santos et al., 2018) and bell pepper (Oliveira et al., 2018; Dias et al., 2019; Santos et al., 2019; Silva et al., 2020).

The reduction in MFRW in response to salt stress occurs, among other factors, due to the reduction in the absorption of water and nutrients by plants, decreasing cell division. In addition, plants subjected to salt stress show reduced vegetative growth, resulting in less accumulation of photoassimilates and later their translocation to the fruits (Ahmed et al., 2017).

For fruit production (PROD), different responses were observed according to the salinity level used. At the lowest salinity, the highest values of production were obtained in the fertigation treatments F1 and F4, and F4 did not differ significantly from the others (Table 5).

For salinity of 3.25 dS m^{-1}, the highest production was obtained in the fertigation treatments F1, F3 and F4, while at salinity of 4.75 dS m^{-1} the fertigation treatments F3 and F4 promoted higher PROD. When plants were subjected to the highest salinity, only F5 with lowest PROD differed from the others. In general, it was verified that the standard fertigation promoted higher fruit production when salinized water was used to prepare the nutrient solutions (Table 5).

Table 4. Mean fresh weight of fruits (g $fruit^{-1}$) of tomato fertigated with nutrient solutions of different electrical conductivities and K^+/Ca^{2+} proportions

Fertigation	Nutrient solution EC (dS m^{-1})				Regression equations	R^2
	1.75	3.25	4.75	6.25		
F1-K^+/Ca^{2+} = 2.43:1	53.7 a	50.6 a	43.2 a	42.7 a	y (F1) = -2.69**x + 58.32	0.91
F2-K^+/Ca^{2+} = 2.03:1	43.3 b	42.4 b	34.9 b	38.8 ab	y (F2) = 1.31**x^2 - 11.42*x + 59.12	0.99
*F3-K^+/Ca^{2+} = 1.62:1	39.2 b	43.5 b	48.4 a	37.4 ab	y (F3) = -1.70**x^2 + 13.57*x + 19.84	0.81
F4-K^+/Ca^{2+} = 1.30:1	35.7 b	40.5 b	45.9 a	37.0 ab	y (F4) = -1.52**x^2 + 12.79*x + 17.22	0.82
F5-K^+/Ca^{2+} = 1.08:1	32.9 b	40.1 b	41.9 a	33.2 b	y (F5) = 1.77**x^2 + 14.31*x + 13.01	0.98

Means followed by the same letters in the columns do not differ significantly by Tukey test ($p \leq 0.05$); *, ** - Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively, by F test

Table 5. Fruit production (g per plant) of tomato fertigated with nutrient solutions of different electrical conductivities and K^+/Ca^{2+} proportions

Fertigation	Nutrient solution EC (dS m^{-1})				Regression equations	R^2
	1.75	3.25	4.75	6.25		
F1-K^+/Ca^{2+} = 2.43:1	1084.7 a	936.10 ab	734.4 b	713.09 a	y (F1) = -87.77**x + 1212.10	0.93
F2-K^+/Ca^{2+} = 2.03:1	801.0 b	792.90 b	722.4 b	640.20 a	y (F2) = -36.86**x +886.57	0.91
*F3-K^+/Ca^{2+} = 1.62:1	799.7 b	1017.90 a	1103.5 a	665.70 a	y (F3) = -72.89**x^2 + 562.02*x + 19.85	0.94
F4-K^+/Ca^{2+} = 1.30:1	938.9 ab	1000.30 a	963.9 a	684.50 a	y (F4) = -37.87**x^2 + 249.63*x + 610.76	0.98
F5-K^+/Ca^{2+} = 1.08:1	822.5 b	806.01 b	741.6 b	534.50 b	y (F5) = -21.18**x^2 + 107.54**x + 694.43	0.99

Means followed by the same letters in the columns do not differ significantly by Tukey test ($p \leq 0.05$); *, ** - Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively, by F test

Analyzing the effect of salinity on fruit production, it was found that, in plants subjected to fertigation treatments F1 and F2, the increase in the electrical conductivity of nutrient solutions promoted a linear reduction in PROD, with reductions of 87.77 and 36.86 g $plant^{-1}$ per unit increase in salinity, while in plants subjected to the highest salinity there were total losses of 37.3 and 20.2% for F1 and F2, respectively (Table 5).

For fertigation treatments F3, F4 and F5, there were quadratic responses to the increase in salinity, with the highest PROD obtained at the levels of 3.8, 3.3 and 2.5 dS m^{-1}, which led to maximum PROD of 1103.2, 1022.1 and 785.9 g $plant^{-1}$, respectively. Although these fertigation treatments caused quadratic responses, the highest percentage gains in PROD were obtained with F3 (41.4%) and F4 (9.7%) compared to the values obtained at the lowest salinity. For F5 fertigation, despite the quadratic response, there was little increase in PROD (Table 5).

In a study conducted with cherry tomatoes, Sangtarashani et al. (2013) found that the increase in K and Ca concentrations did not inhibit the effect of salinity on fruit production. In addition, these authors observed that high concentrations of calcium caused a reduction in this variable. On the other hand, Kaya & Higgs (2003), in a study conducted with the bell pepper crop subjected to salinity and potassium supplementation, using KNO_3, observed significant response in fruit production only in plants cultivated under salt stress, with an increase in production as the KNO_3 doses increased.

Thus, it can be verified that the extra doses of K and Ca were not efficient to mitigate the effect of salinity on this variable, corroborating the results observed by Santos et al. (2018) and Silva et al. (2020), studying the interaction between salt stress and K^+/Ca^{2+} proportions in eggplant and bell pepper, respectively.

The absence of a positive response from the extra addition of calcium and potassium as a salt stress relieving agent can be attributed to the increase in the electrical conductivity of the nutrient solution, caused by the increase in the concentration of fertilizers. The high ionic concentration reduces osmotic potential and hinders the absorption of water and plant nutrients.

Figure 1 shows the data of relative yield (%), salinity threshold (ST) and coefficient of potential yield loss (b) per unit increase in the electrical conductivity of the water used to prepare the nutrient solutions. It was verified that plants subjected to standard fertigation (F3) had greater tolerance to salinity, while the fertigation treatments with increment of K

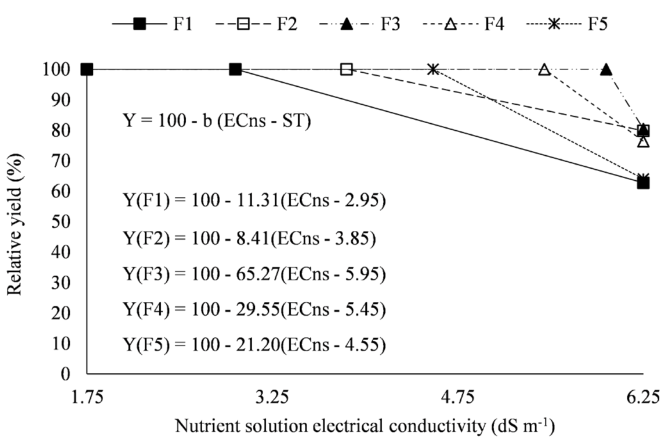

Figure 1. Relative yield of tomato as a function of electrical conductuivity of the nutrient solution and K^+/Ca^{2+} proportions in the fertigation solution

(F1 and F2) reduced the salinity threshold of tomato, despite causing lower relative loss. On the other hand, it was found that the increase in Ca concentration also reduced the tolerance of plants to salt stress.

In general, it was verified that the salinity threshold of tomato obtained in the present study was higher than that indicated in the literature for the classification regarding salinity tolerance, which is 2.5 dS m^{-1} (Ayers & Westcot, 1999). However, it should be noted that this classification considers electrical conductivity of the saturation extract (EC_{se}). In addition, other studies have already confirmed that the cultivation in inert substrate enables greater tolerance of plants to salinity, because the substrate provides more favorable conditions for growth of the root system and, therefore, the morphological and physiological properties of the roots can also determine crop yield response (Gomes et al., 2011; Silva et al., 2020).

Conclusions

1. Fertigation containing higher potassium concentration increased fruit production in the absence of NaCl in the nutrient solution.

2. Fertigation with low K^+/Ca^{2+} proportions intensifies the effect of salinity on tomato crop.

3. The standard nutrient solution (F3-K^+/Ca^{2+} = 1.62:1) promotes greater tolerance of tomato to salinity of nutrient solution.

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