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VIABILITY OF TOMATO GRAFTED WITH *SOLANUM PANICULATUM* L. AND *SOLANUM LYCOPERSICUM* VAR. CERASIFORME IN PROTECTED CULTIVATION

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ABSTRACT

The objective of this study was to evaluate the viability of tomato grafted with Solanum paniculatum L. and Solanum lycopersicum var. cerasiform in protected cultivation. The experiment was conducted in a greenhouse at the Agricultural Sciences Center of the Federal University of Alagoas, in the municipality of Rio Largo, AL. The statistical design was completely randomized, with three treatments (Santa Adélia tomato without grafting, grafting of Santa Adélia tomato with Solanum lycopersicum var. cerasiform and grafting of Santa Adélia tomato with Solanum paniculatum L.) and ten replicates, each plot being represented by a bottled plant. The following variables were analyzed: plant height, shoot dry matter weight, compatibility index, leaf area index and plant productivity, to evaluate plant growth and development. The canopy tomatoes grafted on Solanum lycopersicum cerasiforme and Solanum paniculatum L. represent viable alternatives for the production of tomato cv. Santa Adélia. However, the plant grafted with Solanum paniculatum L. showed higher yield of commercial fruits (37,400.00 kilograms per hectare).

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INTRODUCTION

Tomato is one of the most important vegetables in the world, due to its socioeconomic and nutritional content (BRITO JUNIOR, 2012). Belonging to the Solanaceae family, the tomato fruit (*Solanum lycopersicum* L.) has been consolidating, in fresh and industrialized consumption, by the mild and low acid taste that gives it acceptance in the list of preference of world consumers. According to IBGE research (2018), tomato is a product that has great price variation, in terms of seasonality, and the estimated production for 2018 was 4.5 million tons, providing an increase of 3.1%. compared to 2017. São Paulo, with a 20.8% share in the country's production and Goiás with 32.0%, are the largest producers of the fruit, which requires large investments for its cultivation, notably modern planting technology, crop treatment, pest and disease control and need for irrigation. The plant has tolerance to moderate acidity, producing in the pH range 5.5 to 6.5 (FILGUEIRA, 2007). Research shows that the tomato plant is very susceptible to climate factors, water stress, weed infestation and pest and disease attack. All these factors usually interfere with the growth and development of the culture, either by the destruction of its cells or by the disruption of nutrient and photoassimilated displacement. Not infrequently, pathogenicity, nutrient deficiency and environmental stress drastically reduce tomato yield. The use of alternative techniques for pest and disease control has been widespread in the agricultural environment, mainly to avoid the inconvenience caused by the indiscriminate use of pesticides. In order to control phytosanitary problems in tomato crops, especially those related to soil, some cultivation techniques need to be improved. With this, one can resort to the grafting technique (ZEIST, 2015). Grafting is a technique that consists in the union between the graft and the rootstock, which can have a positive effect on the susceptible plant, thus

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increasing the tolerance to biotic and abiotic stresses, and also increases the plant vigor (RIBEIRO *et al*. 2005). The identification of disease resistant rootstocks with abiotic stress tolerance is of paramount importance for the continued success of grafting, as well as studies on the compatibility, productivity and fruit quality obtained from the rootstock and rootstock combinations. under different environmental conditions (VILELA, 2016). Several species of solanaceae are more resistant to the biotic and abiotic influences, among them are the jurubeba (*Solanum paniculatum* L.) and the cherry tomato (*S. lycopersicum* var. Cerasiforme). Jurubeba is a rustic plant with deep root system, often considered weed for its competitive action with cultivated plants. On the other hand, cherry group tomatoes have some rusticity and strong resistance to soil diseases (FONSECA, 2017). From this perspective, this work predisposed to study the viability of exploitation of grafted tomato with native jurubeba and cherry tomato, in the context of plant growth and development in its vegetative and reproductive stages, focusing on agronomic valorization. The choice of tomato crop for this research is due not only to its agricultural and economic importance, but also to its enormous vulnerability to various biotic and abiotic factors.

MATERIALS AND METHODS

The experiment was conducted in a chapel greenhouse at the Center for Agricultural Sciences of the Federal University of Alagoas (CECA / UFAL), Rio Largo, AL, (09 ° 28'02” S and 35 ° 49'43” W, 127 m altitude). The statistical design used was completely randomized, with three treatments and ten repetitions, spacing 1.0m X 0.50m. Each plot (experimental unit) consisted of one pot with one plant, in a total of 30 plants, grafted with jurubeba and cherry tomatoes and the control without grafting. The temperatures observed during the experiment, inside the greenhouse, showed an average of 27.2ºC, as well as an average relative humidity of 79%, according to information provided by the plant physiology laboratory of CECA / UFAL, through the season. WS-GP1 Automatic Weather System (Delta-T Devices Ltd®, England).
As rootstocks were chosen two species of solanaceae: *S. paniculatum* L. and *S. lycopersicum* var. cerasiform. As a graft (crown), *S. lycopersicum* cv. Santa Adelia. The seeds of tomato species (*S. lycopersicum* var. Cerasiforme., *S. lycopersicum* cv. Santa Adelia and *S. Paniculatum* L.) were taken to the weed laboratory where they were processed and extracted in water. then immediately sown in trays to avoid loss of germination power as they are considered recalcitrant.
Jurubeba seeds were sown thirty days before the crown variety (cv. Santa Adélia) and cherry tomatoes. These seeds were planted in a 128 cell polyethylene tray containing natural soil. Fifteen days after germination, the seedlings were subcultured to 1kg polyethylene bags containing soil with organic matter in a 3: 1 ratio. Thirty days after transplanting the plants were grafted, and at sixty days they were placed in 18 L pots containing sterilized substrate in a forced ventilation chamber at 75º C for 72 hours. For the grafting was used appropriate knife with sharp cutting blade and transparent plastic films for protection of the grafting point. The plants were grafted at 10 cm above ground level. The length of the rootstocks ranged from 10 to 12 cm in such a way as to allow the ideal fit between the rootstock and the rootstock in the full slit forking method. Plant tillage occurred immediately after transplanting the seedlings to the definitive site in order to avoid tipping and consequent damage to the root system. For the staking were used bamboo sticks with approximately 2.0m in length and 3.0cm in diameter each. With cotton twine, the plants were tied to the bamboo tutor and tied every 30 cm along the developing stem. Irrigation was carried out by applying 20 mm per week in the winter season and 40 mm per week in the late winter season. Concerning fertilization, chemical and organic fertilizer were applied. In the chemical fertilization the formulation of 60-00-120 NPK was used, which gives an availability of 300 kg ha^{-1} of ammonium sulphate and 200 kg ha^{-1} of potassium chloride, beyond 50 kg ha^{-1} of Zinc. For organic fertilization, 3: 1 tanned manure (three parts of soil to one part of manure) was used. To establish viability parameters of the treatments, the growth and development of the plants was taken into account. Thirty days after grafting, the measurement of the analyzed items began, aiming to evaluate the following variables: plant height, shoot dry weight, compatibility index, leaf area index and plant productivity. The compatibility index was verified by measuring the diameter of the rootstock and the rootstock at ± 2 cm above and below the grafting point. Marked in Simões *et al*. (2014), the compatibility index (CI) was estimated by the ratio between diameters above the grafting point (DS) and diameters below the grafting point (DI), by the formula IC = DS / DI. According to Costa (2012) the variable compatibility index can be said that the closer the value of 1, the greater the compatibility between species. The plant height corresponded to the stem length, and was determined from the measurement that extended from the soil surface to the apical meristem end of the stem. For the determination of the dry matter weight of the aerial part of the plants, which were removed close to the soil surface and placed in paper bags, then placed in a drying oven with forced air circulation at 75^{o} C for 72 hours, until get constant weight.

During the experimental period, the dried leaves of the useful plants were collected, placed in paper bags, dried and weighed together with the respective treatments. The leaf area was measured by adapting to the method used by Campos (2013), which measured the leaf area from the length dimensions and the largest leaf width. The operation was performed on three leaves per plant and the average result of these leaves was multiplied by the total number of leaves of the plant. The result found was divided by the available area for each plant. Commercial fruit yield (Kg ha^{-1}) was obtained by multiplying the average fruit weight of each treatment by the amount of fruit harvested in each treatment. Fruit collection began at sixty days after transplantation (DAT). The fruits were harvested when they were already yellow, orange or reddish. Then the non-commercial fruits were discarded, using only the fruits under commercial conditions. They were then identified for counting and weighing. The results were submitted to analysis of variance, and the treatments were evaluated by polynomial regression, choosing among the significant models, by means of the F test ($p \leq 0.05$), which presented the highest coefficient of determination and with physiological meaning. The mean effects of each treatment were compared with the responses obtained with the control treatment and with each other by the Tukey test. Statistical analyzes were performed using Sisvar software version 5.6 (Build 86).

RESULTS

Table 1 shows that in four of the five variables analyzed, there was a significant difference at 5% probability level, by the F test, in at least one of the evaluated treatments. The compatibility index (CI), which measures the affinity between the rootstock and rootstock stems at the grafting point, was better in the treatment of tomato cv. development, production and quality of "Chonto" tomatoes grafted on cherry tomato accessions, found that the three rootstocks (IAC391, IAC426 and LA2076) showed positive

Table 1. Analysis of variance and Tukey test for compatibility index (CI), plant height (AP), shoot dry weight (PMS), leaf area index (IAF) and yield (PDE) of tomato cv. Santa Adélia submitted to grafting treatments with *S. Paniculatum* (EJ) and S. *lycopersicum* vc. cerasiform (ET), in protected cultivation, Rio Largo, AL, 2019

FV	AVERAGE SQUARE				
	IC	AP	PMS	IAF	PDE
TR	0,1135**	6606,2422**	240167,2352^{ns}	0,0490**	376242597,5882**
RES	0,0087	238,49808	196153,8582	0,0076	42363094,0445
TOTAL	0,1222	6844,7403	436321,0934	0,0566	418605691,6327
AVERAGE TREATMENTS					
EJ	1,2140 b	79,7500 a	2132,1200 a	0,2538 a	37374,7388 b
TT	1,0000 a	94,4925 a	1752,8800 a	0,2900 ab	26881,2982 a
ET	0,9600 a	135,2000 b	1866,8800 a	0,4028 b	22364,0820 a
CV (%)	9,10	14,32	23,63	26,62	23,95

FV: Source of variation; RES: Residue; TR: Treatments; TT: Witness treatment.
** Significant at 1% probability by F test; ns: not significant;
CV (%) Percentage of the coefficient of variation.
Means followed by distinct lowercase letters in the columns differ significantly from each other by the Tukey test.

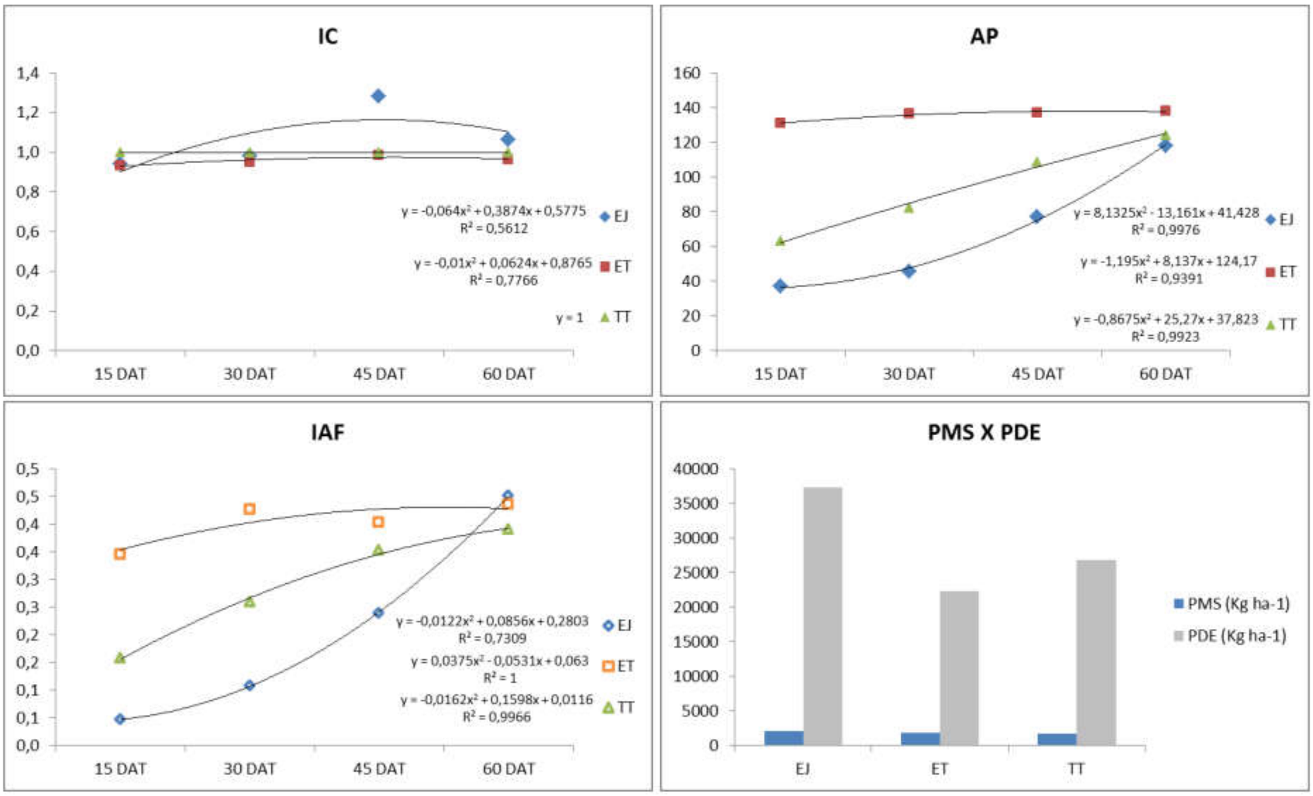

Figure 1. Summary of regression and correlation between treatments and elapsed time (days after transplantation) for compatibility index (CI), plant height (AP), leaf area index (LAI), and comparison of averages for shoot dry matter weight (PMS) and tomato yield (PDE) cv. Santa Adélia, submitted to grafting treatments with *S. Paniculatum* (EJ) and *S. lycopersicum* vc. cerasiform (ET), in protected cultivation, Rio Largo / AL, 2019.

Santa Adélia with cherry tomato (CI = 0.960), while the CI of the grafting treatment of the same cultivar with jurubeba measured 1.214, which indicates a slight departure from the established control parameter (1.00), however, not causing developmental impairment. of cultivar crown. Similar result was found by Simões *et al.* (2014), who, studying tomato compatibility under different rootstocks and organic system grafting methods, found an average compatibility of 1.40 for the jurubeba rootstock for the tomato cultivar IPA-6.

Farias (2012), by evaluating tomato cultivation under different rootstocks in organic production system, found a compatibility index of 1.52 for red jurubeba with the cultivar Santa Adélia, thus strengthening the idea of lower affinity. grafting between different species. Franco *et al.* (2018) evaluating the compatibility (1.05, 1.05 and 1, 07, respectively) for graft fusion. Regarding the height of the plant, the cherry tomato rootstock presented a longer length, reaching an average of 135.2 cm, while the jurubeba rootstock and the control reached an average of 79.7 cm and 94.5 cm, respectively. Higher result than found by Campos (2013), who, evaluating organic and mineral fertilization on tomato yield characteristics, cultivate Santa Cruz in a protected environment, found, at the maximum dose of 100% organic matter, a maximum height of 86.1 cm, and similar to that obtained by Fayad *et al.* (2001) that, evaluating tomato growth and fruit yield, cultivate Santa Clara, under field conditions and in a protected environment, observed that the plants had a growing development until the end of the experiment, reaching values of 146.0 cm under field conditions and 84.7 cm under greenhouse conditions. Similarly, Maia *et al*. (2013), analyzing organic fertilization in cherry group tomatoes, found a cauline length of 144.0 cm, with an application of 400 g kg-1 manure. In contrast, Brito Junior (2012), evaluating tomato (*S. lycopersicum* L.) production by reusing substrates under protected cultivation in the municipality of Iranduba, AM, It was observed that plant height at 36 DAT did not show statistical differences for the cultivars and also for the substrates used in the experiment.

The leaf area index had better development in cherry tomato rootstock (IAF = 0.4028), Then came the witness with 0.1900 and finally the rootstock with jurubeba with 0.2538. An index close to the highest index found in this experiment was found by Zeist (2015) who, evaluating the agronomic and physiological characteristics of tomato in function of rootstocks and grafting methods, found 0.204 m^2 of average leaf area, by the full slit method, with the species *Solanum habrochaites* var *hirsutum*. Fayad *et al*. (2001) evaluating tomato fruit growth, cultivate Santa Clara, under field conditions and in a protected environment reported having found leaf area index of 4.12, at 58 days, reaching the end of the cycle with 0.17, indicating period of senescence and leaf abscission. Duarte *et al*. (2010) analyzing tomato cultivated under organic fertilization in a protected environment, found that at stage IV, which lasted 35 days, the plants reached the highest leaf area index (0.77) which required higher cycle water consumption, when they used 51% of the total water. Therefore, far superior to the results found in this experiment. Equally higher were the values found by Campos (2013), when evaluating organic and mineral fertilization on tomato yield characteristics, cultivate Santa Cruz in a protected environment, which found an average of 0.916 m^2 of $plant^{-1}$ leaf area, applying 100% organic matter.

With respect to shoot dry matter weight, although the treatment with the jurubeba rootstock had a mass of 2,132.12 kg ha^{-1}, whereas cherry tomato rootstock and control presented 1,866.88 Kg ha^{-1} and 1,752.88 Kg ha^{-1}, respectively, statistically these values do not represent significant difference by the F test, as shown in table 1. The results were divergent when compared to those obtained by Grave, Andriolo and Bartz (2001), evaluating the dry matter accumulation of tomato cultivated on substrate with different doses of fertilizers, who found a plant with 332.05 g of dry matter using the highest weekly dose. Equally different were the maximum values found by Fayad *et al*. (2002), which reached 406.3 g $plant^{-1}$ with cv. Santa Clara in field conditions, and 397.9 g $plant^{-1}$ of the hybrid EF-50 in protected environment. Cordeiro *et al*. (2017) evaluating the accumulation of dry matter in tomato submitted to saline stress and fertigated with different ratios Potassium: Calcium, found 197.9 g plant-1, no salt stress, at the ionic ratio F1-K^+ / Ca^{2+} = 1.5: 1, surpassing the highest average result found in this experiment. Yield was more representative in the treatment that used as rootstock the Jurubeba, with an average of 37,374.74 kg ha^{-1}, followed by the control treatment with 26,881.3 kg ha^{-1}, and, lastly, the treatment with cherry tomato rootstock with 22,364.1 kg ha^{-1}. Similar values were reached by Peixoto *et al*. (1999) when they evaluated the yield of tomato cultivars for industrial processing in Goiás, found an average production of 32,100.00 kg ha^{-1}, with cultivar Santa Adélia. Similarly, Malia *et al*. (2012) studying the agronomic evaluation of tomato varieties in the Umbeluzi valley, Mozambique, concluded that the average yields obtained were 36,900.00 kg ha^{-1} in Spring / Summer cultivation with the HTX-14 hybrid and 54,200.00 kg ha^{-1} in IPA 6, Marglobe and Floradade varieties in the Autumn / Winter cultivation. In the same work, the authors found an average yield of Santa Adélia cultivar of 36,005.00 kg ha^{-1} in spring / summer cultivation and 35,720.00 kg ha^{-1} in autumn / winter cultivation. Ferreira *et al*. (2003) evaluating tomato yield as a function of nitrogen rates and organic fertilization in two growing seasons, observed that the maximum total productions, commercial and extra were 108,740.00; 870,080.00 and 780,900.00 kg ha^{-1}, obtained at doses of 589.6; 575.3 and 557.4 kg ha-1 of nitrogen, respectively, with addition of organic matter in the fall-spring experiment. In figure 1 it is possible to verify a temporal behavior of each treatment in relation to three variables analyzed, as well as the comparison between means of two other variables, so that the following can be inferred:

Analyzing the compatibility index (CI), we note that the treatment of cherry tomato grafting (ET) very similarly followed the parameter established by the control treatment (TT), while the graft treatment with jurubeba deviated a little from the parameter. This may have been due to the higher affinity between varieties of the same species. According to Peil (2003) the greater the botanical affinity between species, the greater the probability of graft survival. It can be seen that the average plant height (AP) of the three treatments has the same behavior as the IAF, thus demonstrating a very strong positive correlation between these variables. This can be directly linked to the different senescence cycles and phases of the plants involved. At 15 days after transplanting, the leaf area index (LAI) of the cherry tomato grafted treatment (ET) was higher than the other two treatments. However, this initial growth did not continue at the same rate. So, at 60 days after transplantation the IAF of all treatments almost equaled. There is a direct comparison between the shoot dry matter weight (PMS) and the fruit yield (PDE) of the treatments. In this comparison, it is possible to notice that both variables do not correlate, because, while there is similarity between treatments in relation to PMS, the PDE of all treatments are totally different. This fact is compatible with the different forms of nutrient transfer between source and drain in the treatments used in this experiment. In this case, it is necessary to emphasize that the plants were fertilized according to the recommendations from the soil analysis.

CONCLUSION

Given the analysis of the variables of the evaluated treatments, it can be verified that there is viability of using the rootstocks of jurubeba and cherry tomato in combination with tomato canopy cv. Saint Adelia. However, as regards fruit yield, the Jurubeba rootstock is the most suitable for use with tomato cv. Saint Adelia. Under these conditions the tomato cv. Santa Adelia is not indicated for cultivation without the use of rootstock, since the control yield was below the yield of the grafted plants.

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