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Soluble solids monitored in the clusters in minitomato hybrids from dwarf lines

Sólidos solúveis monitorado em pencas de híbridos de minitomate provenientes de linhagens anãs

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Abstract: On minitomatoes, the soluble solids content (SSC) is a fundamental characteristic for commercialization. During the productive cycle of the crop several harvests are realized, resulting in variations in the SSC from different genotypes. The objective of the experiment was to evaluate the genetic variability and to monitor SSC in the clusters of different minitomato hybrids from dwarf lines. The SSC of the fruits were evaluated according with their position of the clusters, being the values expressed in ^{0}Brix. The genetic diversity was obtained by multivariate analyzes, using the generalized distance of Mahalanobis, utilizing different grouping methods (UPGMA and Tocher). The hybrids performance for SSC was checked by the Scott-Knott test (p=0.005). The cluster's position influenced on the SSC of the minitomatoes fruits and the first cluster of all hybrids that were evaluated, presented the highest SSC. Besides that, the highest ^{0}Brix variability among the genotypes occurred when the fruits were harvested on the fifth and first cluster. Most hybrids originated from dwarf lines did not presented a reduce on ^{0}Brix values during the harvests.

Keywords: brix, dwarfism, germplasm bank, *Solanum lycopersicum,*

Resumo: Em minitomates, o teor de sólidos solúveis (TSS) é característica fundamental para possibilitar a comercialização. Durante o ciclo produtivo da cultura várias colheitas são realizadas podendo resultar em variações no TSS em diferentes genótipos. Objetivou-se com este trabalho avaliar a variabilidade genética e monitorar o TSS nas pencas de diferentes híbridos de minitomate provenientes de linhagens anãs. Foi avaliado o TSS dos frutos de acordo com a posição da penca, sendo os valores expressos em °Brix. A divergência genética foi obtida por meio de análises multivariadas utilizando-se a distância generalizada de Mahalanobis, empregando-se diferentes métodos de agrupamento (UPGMA e Tocher). O desempenho dos híbridos quanto ao TSS foi comparado pelo teste Scott-Knott (p= 0,05). A posição da penca influenciou o TSS dos frutos de minitomate. O TSS na primeira penca foi maior em todos os híbridos provenientes de linhagens anãs avaliados. A maior variabilidade de °Brix entre os genótipos ocorreu quando os frutos foram colhidos na terceira penca, sendo que a menor variabilidade ocorreu quando os frutos foram colhidos na quinta e primeira penca. A maioria dos híbridos provenientes de linhagens anãs não apresentou redução nos valores de °Brix durante as colheitas.

Palavras-chave: banco de germoplasma, brix, nanismo, *Solanum lycopersicum*

Introduction

The tomato (*Solanum lycopersicum* L.) is one of the most economically important vegetables in the world, being classified in different groups: Santa Cruz, Caqui, Salada, Saladette (Italian) and Minitomato (Alvarenga, 2013). Among these, the minitomatoes group reached R$ 2,883,800.00 in the seed market in 2012, being cultivated in more than 327,70 hectares (ABCSEM, 2014).This segment is characterized by lower fruit size and sweeter taste than other types of tomato. With its increasing demand, more tomato breeding programs have been designed in order to develop new minitomato hybrids (Maciel et al., 2016), mainly with more soluble solids content (SSC).

The SSC is expressed in ºBrix, which in turn represents the sugars and acids that are present in the fruit and directly influences the flavor of it, when *in natura* consumption (Ferreira et al.,

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2006). The higher the SSC, sweeter is the taste of the fruit, which are preferred by consumers (Schwarzet et al., 2013, Maciel et al., 2015a). Several factors can influence the SSC in tomato fruits, as the growth habit, which reflects directly on the phenological stage of the crop (Piotto and Peres, 2012; Maciel et al., 2016).

In addition to the growth habit, the dwarf size also changes the architecture of the plants. The dwarfism, which coding small plants, assume great importance in the development of modern tomato hybrids (Maciel et al., 2015b). One of the main advantages of the incorporation of dwarf genes, in tomato, is the presence of reduced internodes, which makes plants with a more compact structure (Gardner and Panthee, 2012; Panthee and Gardner, 2013a,b) and a greater number of clusters per linear meter of stems, with increase of productivity for minitomato hybrids from dwarf lines (Finzi et al., 2017).

One of the major obstacles faced by producers of minitomatoes is the changes in SSC content of the fruit during the harvest, which are presented by commercial cultivars (Maciel, et al., 2015a). For this reason, it is essential to evaluate the genetic divergence of genotypes based on the SSC, as well as the variation of SSC as a function of the position of the clusters. However, information of these effects on hybrids, from highly contrasting lines (normal lines versus dwarf lines), are scarce.

The objective of the experiment was to evaluate the genetic variability and to monitor SSC in the clusters of different minitomato hybrids from dwarf lines.

Materialand Methods

The experiment was conducted at the Vegetables Experimental Station of the Federal University of Uberlândia - Monte Carmelo campus, from May to November, 2015 (18º42'43,19" S and 47º29'55,8" W, 873 m altitude). The plants were grown on a greenhouse of arc type, measuring7 x 21 m and headroom of 4 meters, covered with transparent polyethylene film of 150 micra, additivated against ultraviolet rays, and anti-aphid white side curtains.

The treatments were consisted of 13 minitomato hybrids (UFU-1502, UFU-1505, UFU-1506, UFU-1507, UFU-1510, UFU-1511, UFU-1512, UFU-1514, UFU-1516, UFU-1518, UFU-1519, UFU-1520 and Mascot). All materials, except the commercial hybrid Mascot, were obtained from crossing normal lines with dwarf lines and all belong to the tomato germplasm bank of the Federal University of Uberlândia. The dwarf lines are characterized by presenting red fruits of grape type, indeterminate growth habit, measuring approximately 30 cm (Maciel et al., 2015b). The commercial hybrid Mascot was used as check treatment, presenting red fruits of grape type, and indeterminate growth habit.

The seeding was carried out in polystyrene trays (128 cells) on May 27, 2015, and the transplanting occurred 31 days after sowing for plastic containers with a capacity of five liters. Both trays and vessels were used commercial substrate based on coconut fiber. Each experimental plot was composed of six plants (0.8 m²), the two central plants being considered for analysis (0.32 m²), distributed in double rows at a spacing of 0.4 x 0.4 m. Among the double rows (carriers) was used the spacing of 0.8 m, totaling 312 plants in the greenhouse, equivalent to 2.12 plants m^{-2} [312 plants / (147 m² of greenhouse area)].

During all the conduction of the experiment, the cultural treatments were carried out as recommended for the cultivation of tomato cultivated in a protected environment (Alvarenga, 2013). The plants were conducted vertically with two stems with narrow ribbon. The pest control was performed by monitoring using ecological adhesive traps evenly distributed throughout the greenhouse in a representative manner (one trap per 50 m²). The pesticides were applied only when necessary, according to the number of insects fixed on the adhesive tapes.

A SPAGHETTI PEBD microtube drip fertigation system was used, with an arrow dripper per plant with a flow rate of 4.0 L h^{-1}. The irrigation was performed daily, fractionated in three or four applications according to the need of plants. After the transplant, between the first and eighth week (plant formation period), commercial macronutrients were used in the proportion of 1.0:1.2:1.0 NPK. From the ninth week, the fertigation protocol was changed to nutrient solution using NPK 1.0:0.7:2.0.

The fruits were harvested twice a week, between August 29th and October 21st, 2015, totaling 16 harvests. The SSC quantification was

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performed on the mature fruits harvested from the first to the fifth clusters of fruits (inflorescence), on the two stems of the plant. Fifteen mature fruits (totally red) were harvested in each shoot. The TSS mean was then evaluated for each evaluated portion of tomato clusters. After harvesting, the fruits were ground in a blender and analyzed for SSC using a Portable Digital Refractometer (Atago PAL-1 3810), being the values expressed as °Brix.

The experimental design was a completely randomized design (CRD) using a subdivided plot scheme (13x5), where the factor of the plot were the evaluated hybrids (13 hybrids), and the factor of the subplot the position of the tomato clusters (1º, 2º, 3º, 4º e 5º clusters of fruits, on the two stems) in which the fruits were harvested, and four repetitions. The SSC data (° Brix) were submitted to analysis of variance (ANOVA), and the sums of the average squares were compared by the F test (p=0.05). The averages were compared by the Scott-Knott test (p=0.05).

After that, the data were submitted to multivariate analysis with the objective of determining the genetic dissimilarity between the genotypes. The dissimilarity matrix was obtained by the genetic distance of Mahalanobis (D^2_{ii}), and from this matrix the genetic divergence was represented by a dendrogram obtained by the hierarchical method Unweighted Pair-Group Method Using Arithmetic Averages (UPGMA), validated by the cophenetic correlation coefficient (CCC), calculated by the Mantel test (1967), and by the Tocher optimization method. The relative contribution of the quantitative traits was calculated according to Singh (1981). These analyzes were performed using the software Genes (Cruz, 2013). In order to compare the SSC for the position of the fruit clusters, contrasts of interest were performed, using the Scheffé test (p=0.05 e 0.01), performed by the statistical program SISVAR (Ferreira, 2011).

Results and Discussion

There was a significant effect of the interaction between the hybrids and the clusters position (p = 0.05). It can be stated that the SSC of the minitomato fruit was influenced by the genetic material (hybrid) and the position of the cluster in which the fruits were harvested (1st, 2nd, 3rd, 4th and 5th clusters). There are reports that in tomato, genetic factors can influence SSC in tomatoes (Garcia and Barrett, 2006), industry (Schwars et al., 2013) and also in minitomatoes hybrids (Maciel et al., 2015a). These variations in SSC between different genotypes may be attributed to the genetic differences in the capacity of importing photo assimilates by fruits. The position of the clusters in which the fruits are harvested can also influence the SSC (Table 1).

All evaluated hybrids showed fruits with SSC above the commercially desired in all clusters (≥ 6°Brix). However, the highest values were found in fruits of the first cluster (between 6.75 and 8.32 °Brix) as demonstrated in the contrast 1. On the other hand, Casa and Evangelista (2009), when studying the influence of harvesting period on the quality of tomato fruits of the salad type, observed lower values of soluble solids in the first harvest, which coincides with the first cluster.

The commercial hybrid (Mascot) obtained a high value in the SSC of the fruits when they were harvested in the first and second clusters (8.32 and 7.60 ºBrix, respectively). However, in the fruits harvested from the third, fourth and fifth clusters (7.01, 6.63 and 6.32 ºBrix, respectively), there was a reduction of 16, 20 and 24%, respectively, in the SSC. Similar to what occurred for these hybrids, Maciel et al. (2015a) also observed reduction in SSC when the minitomato fruits were harvested at 90, 120 and 150 days after sowing. It is worth mentioning that the quality of the fruits in tomato cultivars is influenced by several factors, having as main conditions the climatic conditions, fertility (Ferreira et al., 2006), stage of maturation at the harvest time (Paula et al., 2015), genetic constitution (Garcia and Barrett, 2006) and growth habit (Vicente et al., 2015; Maciel et al., 2016).

On the other hand, in the hybrids from dwarf lines, fruits harvested from the first to fifth clusters did not present a significant reduction in SSC, except the hybrids UFU-1506, UFU-1520 e UFU-1514. In these materials, the soluble solids reduction was on average 11% in the fruits harvested from the fifth cluster. In the UFU-1520 and UFU-1506 hybrids, a mean reduction of 9% in the SSC of fruits harvested from the fourth cluster was also observed. Although these reductions were significant, the decrease in the SSC of the commercial hybrid (Mascot) was twice as large considering the same clusters (fourth cluster: 20%>9%; fifth cluster: 24>11%).

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Table 1. The content of soluble solids (°Brix) in fruit of mini tomato hybrids according to plant clusters location

Hybrids[1]		Position of the clusters				
		T14= 1º	T15= 2º	T16= 3º	T17= 4º	T18= 5º
T1	UFU-1502	7.42 Ba	7.38 aA	7.01 bA	6.98 bA	6.92 bA
T2	UFU-1505	7.39 bA	7.47 aA	7.13 bA	7.15 bA	7.09 bA
T3	UFU-1506	7.49 bA	7.33 aA	7.14 bA	6.68 bB	6.55 cB
T4	UFU-1507	7.52 bA	6.99 bA	7.19 bA	7.27 bA	6.89 bA
T5	UFU-1510	8.25 aA	7.91 aA	7.69 aA	8.08 aA	8.02 aA
T6	UFU-1511	7.36 bA	7.30 aA	7.13 bA	6.85 bA	7.01 bA
T7	UFU-1512	7.37 bA	7.09 bA	7.06 bA	6.87 bA	7.26 bA
T8	UFU-1514	7.87 aA	7.60 aA	7.62 aA	7.72 aA	7.09 bB
T9	UFU-1516	6.75 cA	6.97 bA	6.86 bA	6.46 bA	6.69 cA
T10	UFU-1518	7.45 bA	7.04 bA	7.21 bA	7.08 bA	6.91 bA
T11	UFU-1519	6.90 cA	6.78 bA	6.73 bA	6.51 bA	6.33 cA
T12	UFU-1520	7.48 bA	7.60 aA	7.65 aA	7.04 bB	6.84 bB
T13	Mascot	8.32 aA	7.60 aB	7.01 bC	6.63 bD	6.32 cD
KS[2]: **0,055**		F(levene): **1,488**		CV(%) plot: 7,77		CV(%) subplot: 5,19

Contrasts of interest	Estimates of contrasts of interest
	Clusters Position
C1=[(T14)-(T15+T16+T17+T18)/4]	0.39**
C2=[(T15)-(T14+T16+T17+T18)/4]	0.15^{ns}
C3=[(T16)-(T14+T15+T17+T18)/4]	-0.01^{ns}
C4=[(T17)-(T14+T15+T16+T18)/4]	-0.21*
C5=[(T18)-(T14+T15+T16+T17)/4]	-0.33**

[1]Means followed by distinct letters, lowercase in the column and upper case in the row, differ by Scott-Knott test at 0.05 probability level[1] (p=0,05).[2]KS, F: statistics of the Kolmogorov and Levene tests; bold values indicate residues with normal distribution and homogeneous variances (p=0,01), respectively; *, ** = significant for p = 0.05 and 0.01, respectively, by the Scheffé test; ns = not significant.

This demonstrates the effect of the use of the dwarf lines in obtaining the minitomato hybrids of this study. The majority of the hybrids from dwarf lines did not show significant reduction in °Brix values during the course of the harvests. As the soluble solids content is one of the most important characteristics in minitomatoes, obtaining uniformity in this variable throughout the harvest should be one of the objectives of breeding programs. For producers, ºBrix stability on fruits harvested at different times represents a great advantage, mainly for maintaining the high quality of minitomato fruits.

Some authors have already evaluated hybrids of minitomatoes from dwarf lines (Gardner and Panthee, 2012; Panthee and Gardner, 2013a,b), but the effect of the position of the cluster about SSC on the fruits of these hybrids was scarce.

Among all evaluated hybrids, UFU-1510 stood out. This hybrid obtained high SSC in the fourth and fifth clusters (with 8.08 and 8.02 ºBrix, respectively), while the other hybrids obtained lower values (between 6.63 and 7.72 ºBrix in the fourth cluster, and between 6.32 and 7.26 °Brix in the fifth cluster) (Table 1). In general, the results found in the study indicate a greater effect of the genetic factor as a source of variation in the SSC of the hybrids.

In addition to comparing individual performance, the separation of genotypes into distinct groups by the use of measures of dissimilarity may help breeders to select the best

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parents (Araujo et al., 2016). The measures of genetic dissimilarity estimated by the generalized distance of Mahalanobis ($D^2_{ii'}$) among the 32 tomato genotypes indicated a great variability in relation to the brix and the fruit harvest points in the plants (Figure 1).

The group formation represented by dendrogram using the UPGMA method (Figure 1) showed a cophenetic correlation coefficient of 83%, being significant to the t test ($p < 0.01$). Thus, it can be affirmed that the dendrogram reproduced in a satisfactory way the information contained in the matrix and consequently in the formation of the groups. The groups were separated by the delimitation of a cut line of 20%, established at the place of occurrence of the abrupt change in the branches present in the dendrogram (Cruz et al., 2012). With this cut the genotypes constituted six distinct groups indicative of influence on the concentration of °Brix in the fruits related to the harvest point. The hybrid Mascot was in the same group of hybrids UFU-1511, UFU-1506 and UFU-1518.

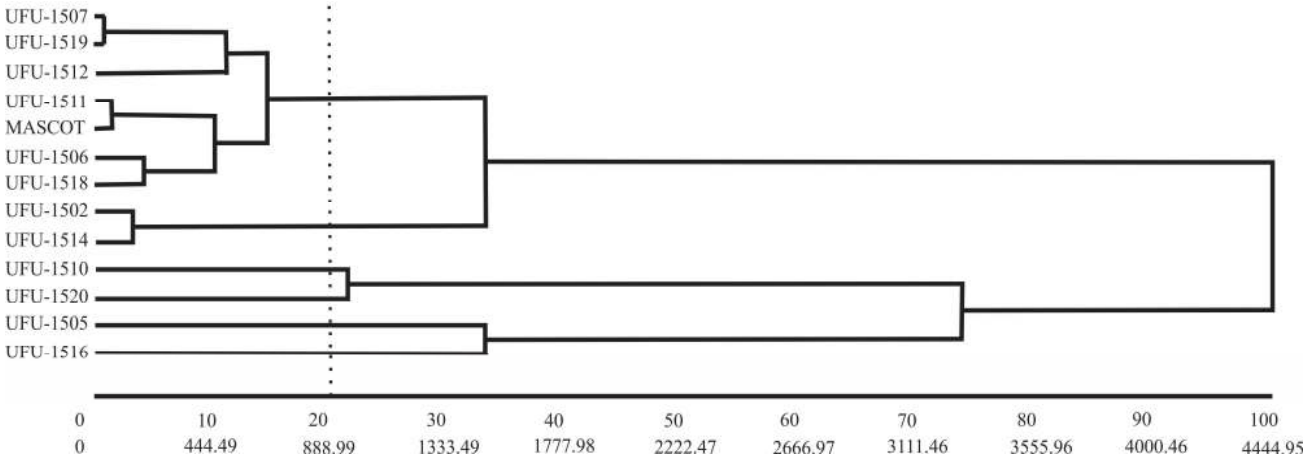


Figure 1. Dendrogram of the genetic divergence among 13 hybrids of minitomato as a function of soluble solids contents (ºBrix) in the fruits obtained from the harvest realized in different clusters

There was no consistency of results when comparing the Tocher method with the UPGMA method. By the Tocher method, there were 4 distinct groups (Table 2).

As the commercial control (Mascot hybrid), genotype UFU-1510 behaved differently from the other groups indicating a distinct behavior in relation to the effects provided by performing the harvest at different plant locations. Despite the lack of consistency between the methodologies, it was evident that there was a distinct among the evaluated genotypes in relation to the °Brix content in the fruits. The univariate analyzes using the Scott-Knott test did not allow the explicit visualization of divergent groups, and it was advantageous to associate univariate and multivariate techniques to determine the variability among tomato genotypes, as observed by Araújo et al. (2016).

Table 2. Representation of the grouping generated by the Tocher Optimization method based on the Mahalanobis distance, estimated from five variables, analyzed in 13 minitomato hybrids as a function of soluble solids content (ºBrix) in fruits obtained from the harvest performed in different clusters

Groups	Hybrids
I	UFU-1507, UFU-1518, UFU-1511, UFU-1512, UFU-1502, UFU-1505, UFU-1503, UFU-1520 e UFU-1514
II	UFU-1516, UFU-1519
III	Mascot (commercial checkplot)

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The soluble solids content is a fundamental characteristic in minitomato because it can limit the commercialization. Higher soluble solids content in minitomato fruits results in a greater expression of the sweet taste in the fruits, which are preferred by consumers (Schwarz et al., 2013; Maciel et al., 2015a). In fact, there is a possibility of introgression of genes via genetic improvement aiming to increase the content of solids soluble in tomato fruits (Garcia and Barret, 2006; Schwars et al., 2013; Maciel et al., 2015a). However, strategies aimed at enhancing genetic effects are fundamental to better exploit the genetic potential of each cultivar. It can be verified that fruits harvested in the third cluster contributed mainly (23%) to the variation between the genotypes (Table 3).

Table 3. Relative contribution of five variables characters for genetic divergence of 13 minitomato hybrids in function of the soluble solids contents (ºBrix) in the fruits obtained from the harvest in different plots, according to Singh criteria (1981)

Variables	S.j	S.j (%)
First cluster	12.43	19.46
Second cluster	12.86	20.12
Third cluster	14.93	23.36
Fourth cluster	13.13	20.55
Fifth cluster	10.53	16.48

This predominance reinforces that the beginning of the harvest of the third cluster can be considered the moment of greater differentiation among the evaluated genotypes. On the other hand, fruits harvested in the first and fifth cluster showed the lowest relative contributions of characters (19.46 and 16.48%) being an indicative of lower dissimilarity among the genotypes. These results reinforce greater demands by phytotechnians in the search for new alternatives to be able to homogenize the Brix among the genotypes able to assure the °Brix content throughout the harvests.

Conclusions

The solids soluble content of the first cluster was higher for all minitomato hybrids from dwarf lines evaluated.

The greater variability of °Brix content among the genotypes occurred when harvesting fruits of the third cluster and the smaller variability occurred when harvesting fruits of the fifth and first cluster.

The majority of the hybrids from dwarf lines did not show significant reduction in °Brix values during the course of the harvests.

References

ALVARENGA, M. A. R. Tomate: produção em campo, em casa-de-vegetação e em hidroponia. Lavras: Editora UFLA, 2013. 455 p.

ARAUJO, J. C.; TELHADO, S. F. P.; SAKAI, R. H.; LEDO, C. A. S.; MELO, P. C.T. Univariate and multivariate procedures for agronomic evaluation of organically grown tomato cultivars. **Horticultura Brasileira**, v. 34, n. 3, p. 374-380, 2016.

Associação Brasileira do Comércio de Sementes e Mudas – ABCSEM. 2014. Dados do setor Pesquisa de mercado de sementes de hortaliças. Disponível em: <http://www.abcsem.com.br/dadosdosegmento.php>. Acesso em: 25 jun. 2015.

CASA, J.; EVANGELISTA, R. M. Influência da época de colheita na qualidade de tomate cultivado em sistemas alternativos. **Semina: Ciências Agrárias**,v. 30, n. 1, p. 1101-1108, 2009.

CRUZ, C. D. GENES: a software package for analysis in experimental statistics and quantitative genetics. **Acta Scientiarum**, v. 35, n. 3, p. 271-276, 2013.

CRUZ, C. D.; REGAZZI, A. J.; CARNEIRO, P. C. S. Modelos biométricos aplicados ao melhoramento genético. Viçosa: Editora UFV, 2012, 514p.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, v. 35, n. 6, p. 1039-1042, 2011.

FERREIRA, M. M. M.; FERREIRA, G. B.; FONTES, P. C. R.; DANTAS, J. P. Qualidade do tomate em função de doses de nitrogênio e da adubação orgânica em duas estações. **Horticultura Brasileira**, v.24, n. 2, p. 141-145, 2006.

FINZI, R. R.; MACIEL, G. M.; SILVA, E. C.; LUZ, J. M. Q.; BORBA, M. E, A. Agronomic performance of mini-tomato hybrids from dwarf lines. **Ciência e Agrotecnologia**, v. 41, n. 1, p. 15-21, 2017.

GARCIA, E.; BARRETT, D. M. Assessing lycopene content in California processing tomatoes. **Journal of Food Processing and Preservation**,v. 30, n. 1, p. 56-70, 2006.

GARDNER, R. G.; PANTHEE, D. R. 'Mountain Magic': An early blight and late blight-resistant specialty type F1 hybrid tomato. **Hortscience**, v. 47, n. 2, p. 299–300, 2012.

KRIEGER, U.; LIPPMAN, Z. B.; ZAMIR, D. The flowering gene SINGLE FLOWER TRUSS drives heterosis for yield in tomato. **Nature Genetics**, v. 42, n. 5, p. 459-463, 2010.

MACIEL, G. M.; FERNANDES, M. A. R.; HILLEBRAND, V., AZEVEDO, B. N. R. Influência da época de colheita no teor de sólidos solúveis em frutos de minitomate. **Scientia Plena**, v. 11, n. 12, p. 1-6, 2015a.

MACIEL, G. M.; FERNANDES, M. A. R.; MELO, O. D.; OLIVEIRA, C. S. Potencial agronômico de híbridos de minitomate com hábito de crescimento determinado e indeterminado. **Horticultura Brasileira**, v. 34, n. 1, p. 144-148, 2016.

MACIEL, G. M.; SILVA, E. C.; FERNANDES, M. A. R. Ocorrência de nanismo em planta de tomateiro do tipo grape. **Revista Caatinga**, v. 28, n. 4, p. 259-264, 2015b.

MANTEL, N. The detection of disease clustering and a generalized regression approach. **Cancer Research**, v. 27, n. 2, p. 209-220, 1967.

PANTHEE, D. R.; GARDNER, R. G. 'Mountain Honey' hybrid grape tomato and its parent NC 6 grape breeding line. **Hortscience**, v. 48, n. 9, p. 1192–1194, 2013a.

PANTHEE, D. R.; GARDNER, R. G. 'Mountain Vineyard' hybrid grape tomato and its parents: NC 4 Grape and NC 5 Grape tomato breeding lines. **Hortscience**, v. 48, n. 9, p. 1189–1191, 2013b.

PAULA, J. T.; RESENDE, J. T. V.; FARIA, M. V.; FIGUEIREDO, A. S. T.; SCHWARZ, K..; NEUMANN, E. R. Características físico-químicas e compostos bioativos em frutos de tomateiro colhidos em diferentes estádios de maturação. **Horticultura Brasileira**, v. 33, n. 4, p. 434-440, 2015.

PIOTTO, F. A.; PERES, L. E. P. Base genética do hábito de crescimento e florescimento em tomateiro e sua importância na agricultura. **Ciência Rural**, v. 42, n. 11, p. 1941-1946, 2012.

SCHWARZ, K.; RESENDE, J. T. V.; PRECZENHAK, A. P.; PAULA, J. T.; FARIA, M. V.; DIAS, D. M. Desempenho agronômico e qualidade físico-química de híbridos de tomateiro em cultivo rasteiro. **Horticultura Brasileira**, v. 31, n. 3, p. 410-418, 2013.

SINGH, D. The relative importance of characters affecting genetic divergence. **Indian Journal of Genetic and Plant Breeding**, v. 41, n. 2, p. 237-245, 1981.

VICENTE, M. H.; ZSÖGÖN, A.; TAL, L.; LOPO DE SÁ, A. F. L.; RIBEIRO, R. V.; PERES, E. P. Semi-determinate growth habit adjusts the vegetative-to-reproductive balance and increases productivity and water-use efficiency in tomato (*Solanum lycopersicum*). **Journal of Plant Physiology**, v. 177, p. 11-19, 2015.