Determination of the optimum plot size for tomato seedlings[1]

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ABSTRACT

The objectives of this work were to determine the optimum plot size for tomato seedlings by Hatheway's method, using the Mestiço and Ozone cultivars, and verify the possibility to obtain the optimum plot size only by non-destructive characteristics. Non-destructives (aerial part height, stem diameter, number of leaves and leaf area) and destructives (aerial part dry matter, root dry matter, total dry matter and Dickson quality index) characteristics were evaluated. For each characteristic evaluated, experimental plans were simulated in a randomized block design with the combination of I treatments (I = 3, 4, 5, ..., 10, 15, 20 and 25) and R repetitions (R= 3, 4, 5, 6 and 7). The optimum plot size ranged according to the characteristic evaluated. Considering the number of treatments, repetitions and the same experimental accuracy, the stem diameter showed the highest size plot. Thus, the stem diameter can be used as a basis characteristic for the non-destructives characteristics, without the need to destroy the seedling.

Keywords: *Solanum lycopersicum*; experimental precision; experimental planning; experimental design.

INTRODUCTION

Regarding experiments with tomato seedling production, there is no standardization in the plot size. There are works with one plant per plot (Soares *et al*., 2013), 5 plants per plot (Sirtoli *et al*., 2011), 16 plants per plot (Bernardes *et al*., 2011) and 24 plants per plot (Nadai *et al*., 2015).

It points out that the demand for research with tomato seedlings is enormous due to the constant evolution of the production process, with the need to evaluate new substrates, new active pesticide principles, fertilizing seedlings, new cultivars, among others. Thus, the determination of the optimum plot size based on scientific criteria is extremely important to give greater credibility to the experimental results (Storck *et al*., 2011).

The most often method used to determine the optimum plot size is the modified maximum curvature, according to Meier & Lessman (1971). Another method that has been widely used in recent years is the method of maximum curvature of the coefficient of variation (Paranaíba *et al*., 2009), which has the great advantage of reducing calculations to determine the optimum plot size. Recently, bootstrap simulation has been incorporated into some methods, among which we can mention: incorporation to Paranaíba *et al*. (2009) method made by Santos *et al*. (2012) and Storck *et al*. (2014); incorporation of the linear response plateau method by Brito *et al*. (2014); and, incorporation to Meier & Lessman's (1971) method made by Leonardo *et al*. (2014). All of these methods, with or without bootstrap simulation, allow us only to determine the optimum plot size, without giving resources to determine the number of plots involved, which can be obtained, however, by Hatheway's (1961) method. Through this method, the wishes of the researcher who wants to know the optimum plot size for his research reality can be satisfied, which also includes the number of treatments and repetitions, the experimental design used and the precision of the experiment. The data necessary to use

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Hatheway's method are obtained from blank test and the optimum plot size can be determined for any experimental designs. Celanti *et al*. (2016b) used Hatheway's method for completely randomized design, randomized block design and Latin square.

Studies that determine the optimum plot size with tomato seedlings were not found in literature. Thus, the objectives of this work were to determine the optimum plot size and verify the possibility to obtain the optimum plot size only by non-destructive characteristics, for tomato seedlings.

MATERIAL AND METHODS

This work used seedlings of Mestiço and Ozone cultivars. The seedlings were produced by the company Top Mudas®, located in the municipality of Venda Nova do Imigrante, State of Espírito Santo.

The seedlings were produced in polyethylene trays with 200 cells, whose capacity of each cell was of 18 cm^3, containing Carolina Soil® substrate. The substrate was composed by *Sphagnum* peat, expanded vermiculite, dolomitic limestone, gypsum and NPK fertilizer. Three seeds per cell were used to obtain the seedlings and, after reaching about 3 cm, thinning was carried out, selecting the seedling in better condition, being kept in a nursery with anti-phallic mesh.

The 200 seedlings of Mestiço cultivar were evaluated on September 25, 2017, 31 days after sowing, and the seedlings of Ozone cultivar were evaluated on March 12, 2018, 24 days after sowing. The seedlings of each cultivar were evaluated as blank test. For each evaluated characteristic, experimental plans were simulated in a randomized block design, for the scenarios formed by the combinations of I treatments (I = 3, 4, 5,..., 10, 15, 20 and 25) , R repetitions (r = 3, 4, 5, 6 and 7) and D differences between treatment averages to be detected as significant at 5% probability, expressed as a percentage of the overall uniformity test mean (D = 10, 20, 30 and 40%).

The following evaluations were conducted at the end of each experiment at each seedling: aerial part height (APH), determined with a ruler graduated in cm; stem diameter (SD), measured with a digital caliper, in mm; number of leaves (NL), by counting the final developed leaves; leaf area (LA), measured with the aid of the ImageJ® Software (Schindelin *et al*., 2015) from the scanned leaves in 75 tif in an HP Deskjet F4480 multifunctional; aerial part dry matter (APDM), in g; root dry matter (RDM), in g; total dry matter (TDM), by the sum of APDM and RDM, in g; Dickson quality index (DQI) according to Dickson *et al*. (1960), through the equation: DQI = TDM/{(APH/SD) + (APDM/RDM)}. For determining the APDM and RDM per plant, the seedlings were dried, separately, in a forced circulation oven (FANEM Mod.320 SE) at 70 °C until constant mass, and then, their masses obtained on a precision scale (BEL ENGINEERING MARK M214A).

After, the data collection were analyzed, generating descriptive statistics and normality test using the Shapiro-Wilk test. These analyzes were carried out with the purpose of characterizing two blank tests, for Mestiço and Ozone cultivars, and verifying their suitability for the study of optimum plot size.

The possibility of reducing the number of characteristics to be evaluated to determine the plot size through the study of correlations was evaluated. Thus, Pearson's linear correlation was determined, applying the same in the relationships between the eight characteristics, two by two, for the two varieties, totaling 28 correlation values for each variety studied. Pearson's correlation analysis had the statistical significance verified by 5% and 1% t test, and the magnitudes classified according to Shimakura & Júnior (2012), where, regardless of the sign, a correlation is considered very weak between 0.00 to 0.19; weak between 0.20 to 0.39; moderate between 0.40 to 0.69; strong between 0.70 to 0.89 and very strong between 0.90 to 1.00.

Based on Pearson correlation values obtained, the correlation matrices were structured for analysis by the canonical correlation, with two groups being established: the seedlings destructive characteristics (APDM, RDM, TDM and DQI) and non-destructive characteristics (APH, SD, NL and LA). The analysis of the correlation between the two groups was carried out only after verifying the presence of multicollinearity. The statistical significance of the canonical correlation was performed by chi-square test.

With the results, the characteristic that contributed most to its existence was eliminated from the analysis of the canonical correlation. By the result of the analysis of the canonical correlation, it was tried to detect if any of the non-destructive characteristics can be used in substitution to the destructive characteristics in determining the optimal plot size.

To determine the optimal plot size (X_0), the method according to Hatheway (1961) was used, using R software (R Development Core Team, 2018), using bootstrap simulation. The equation is given by $x_0 = \sqrt[b]{2\,(t_1 + t_2)^2\,\frac{CV^2}{RD^2}}$, whose: b = Smith's heterogeneity index (1938); CV = estimative of the coefficient of variation between the portions of a UEB of size, in percentage; R = number of repetitions considered; D = difference between treatment averages to be detected as significant at 5% probability, expressed as a percentage of the overall average of the uniformity test; t_1 = tabulated value of t for tests of significance (bilateral test at 5%), with df degrees of

freedom; t_2 = tabulated value of t, bilateral, corresponding to an error of 2 (1-p), with df degrees of freedom, with p = 0.80 the probability of obtaining significant results.

The tabulated values of the t distribution were obtained with df degrees of freedom of the residue, depending on the I treatments and R repetitions, with df =

Table 1: Minimum, maximum, mean, standard deviation (SD), coefficient of variation (CV) and p-value of Shapiro-Wilk normality test (SW) for eight characteristics evaluated in tomato seedlings (*Solanum Iycopersicum*), Mestiço and Ozone cultivars

Characteristics [1]	Minimum	Maximum	Mean [2]	SD	CV (%)	SW [3]
APH, 'Mestiço'	3.85	9.00	7.26a	0.80	11.05	< 0.01
APH, 'Ozone'	3.70	8.00	6.63b	0.55	8.37	< 0.01
SD, 'Mestiço'	0.77	3.92	2.37a	0.58	24.26	0.01
SD, 'Ozone'	1.43	3.21	2.25a	0.27	12.19	0.33
NL, 'Mestiço'	2.00	4.00	2.99a	0.34	11.44	< 0.01
NL, 'Ozone'	2.00	3.00	2.15b	0.36	16.65	< 0.01
LA, 'Mestiço'	16.96	49.34	36.52a	5.12	14.01	< 0.01
LA, 'Ozone'	3.98	28.71	17.41b	3.75	21.56	0.68
APDM, 'Mestiço'	0.10	0.22	0.15a	0.03	19.6	< 0.01
APDM, 'Ozone'	0.02	0.13	0.08b	0.02	23.9	0.61
RDM, 'Mestiço'	0.03	0.10	0.06a	0.02	26.82	0.04
RDM, 'Ozone'	0.01	0.05	0.03b	0.01	29.92	0.02
TDM, 'Mestiço'	0.15	0.31	0.21a	0.04	19.53	< 0.01
TDM, 'Ozone'	0.03	0.17	0.10b	0.02	22.09	0.54
DQI, 'Mestiço'	0.02	0.06	0.04a	0.01	27.19	0.11
DQI, 'Ozone'	0.01	0.03	0.02b	0.005	27.06	0.29

[1] APH = aerial part height (cm); SD = stem diameter (mm); NL = number of leaves; LA = leaf area per seedling (cm^2); APDM = aerial part dry matter (g); RDM = root dry matter (g); TDM = total dry matter (g); DQI = Dickson quality index.

[2] Means for the same trait, evaluated between two cultivars, followed by the same letter, do not differ statistically from each other by t test at 5% probability.

[3] p-value above 0.05 indicates normality of the data at 5% probability.

Table 2: Pearson (r) linear correlation coefficients matrix between eight characteristics of tomato seedlings (*Solanum Iycopersicum*), Mestiço and Ozone cultivars

Characteristic [1]	Mestiço cultivar							
	APH	SD	NL	LA	APDM	RDM	TDM	DQI
APH	1.00	0.09	0.06	0.29	0.24	0.18	0.24	-0.01
SD	0.09[2]	1.00	0.14	0.17	0.09	-0.05	0.05	0.52
NL	0.06	0.14	1.00	0.37	0.12	0.12	0.14	0.18
LA	0.29	0.17	0.37	1.00	0.47	0.34	0.47	0.34
APDM	0.24	0.09	0.12	0.47	1.00	0.57	0.94	0.59
RDM	0.18	-0.05	0.12	0.34	0.57	1.00	0.81	0.76
TDM	0.24	0.05	0.14	0.47	0.94	0.81	1.00	0.73
QDI	-0.01	0.52	0.18	0.34	0.59	0.76	0.73	1.00
Characteristic [1]	**Ozone cultivar**							
	APH	SD	NL	LA	APDM	RDM	TDM	DQI
APH	1.00	0.50	0.29	0.61	0.60	0.32	0.60	0.36
SD	0.50[2]	1.00	0.23	0.50	0.50	0.28	0.50	0.49
NL	0.29	0.23	1.00	0.40	0.30	0.12	0.28	0.17
LA	0.61	0.50	0.40	1.00	0.80	0.42	0.79	0.55
APDM	0.60	0.50	0.30	0.80	1.00	0.44	0.95	0.61
RDM	0.32	0.28	0.12	0.42	0.44	1.00	0.68	0.96
TDM	0.60	0.50	0.28	0.79	0.95	0.68	1.00	0.81
QDI	0.36	0.49	0.17	0.55	0.61	0.96	0.81	1.00

[1] APH = aerial part height (cm); SD = stem diameter (mm); NL = number of leaves per plant; LA = leaf area (cm^2); APDM = aerial part dry matter (g); RDM = root dry matter (g); TDM = total dry matter (g); DQI = Dickson quality index.

[2] Very weak correlation between 0.00 to 0.19; weak between 0.20 to 0.39; moderate between 0.40 to 0.69; strong between 0.70 to 0.89; and very strong between 0.90 to 1.00, according to Shimakura & Júnior (2012). Critical value for statistical significance of the correlations: $r \geq 0.181$, significant at 1%; $r \geq 0.138$, significant at 5%. The following hypotheses were used for correlation: H_0: $\rho = 0$ and H_1: $\rho \neq 0$.

Table 3: Canonical correlations (r) and canonical pairs estimated between destructive characteristics (group I) and non-destructive characteristics (group II) from tomato seedlings (*Solanum Iycopersicum*), Mestiço and Ozone cultivars

Characteristic [1]	Canonical pairs, 'Mestiço'		Canonical pairs, 'Ozone'	
	1°	2°	1°	2°
	Group I		**Group I**	
APDM	0.29	0.86	-0.50	1.29
RDM	1.20	0.15	1.34	3.61
DQI	-1.60	0.08	-1.70	-4.18
	Group II		**Group II**	
APH	0.40	0.19	0.14	0.86
SD	-0.96	0.07	-0.53	-0.97
NL	-0.02	-0.08	0.06	0.00
LA	0.04	0.94	-0.74	0.36
r	0.95** [2]	0.49**	0.82** [2]	0.81**
Degrees of freedom	12	6	12	6

[1] APH = aerial part height (cm); SD = stem diameter (mm); NL = number of leaves per plant; LA = leaf area (cm²); APDM = aerial part dry matter (g); RDM = root dry matter (g); TDM = total dry matter (g); DQI = Dickson quality index.

[2] Significant at 1% by chi-square test.

Table 4: Optimum plot size (X_0), in number of plants, to evaluate the aerial part height, estimated by Hatheway's method, in an experiment disposed by a randomized block design in different scenarios formed by combinations between number of treatments (I) and number of repetitions (R) in tomato seedlings (*Solanum Iycopersicum*) with error of 10%, 20%, 30% and 40% around the average

I	R	D = 10%	D = 20%	D = 30%	D = 40%	I	R	D = 10%	D = 20%	D = 30%	D = 40%
1	3	7	8	2	1	1	15	2	16	4	2
2	4	5	10	3	2	1	15	3	15	4	2
3	4	6	8	2	1	1	15	4	11	3	2
4	4	7	7	2	1	1	15	5	9	3	1
5	5	4	13	4	2	1	15	6	8	2	1
6	5	5	10	3	2	1	15	7	7	2	1
7	5	6	8	2	1	1	20	2	16	4	2
8	5	7	7	2	1	1	20	3	15	4	2
9	6	4	12	3	2	1	20	4	11	3	2
10	6	5	10	3	2	1	20	5	9	3	1
11	6	6	8	2	1	1	20	6	8	2	1
12	6	7	7	2	1	1	20	7	7	2	1
13	7	3	17	5	2	2	25	2	16	4	2
14	7	4	12	3	2	1	25	3	15	4	2
15	7	5	10	3	2	1	25	4	11	3	2
16	7	6	8	2	1	1	25	5	9	3	1
17	7	7	7	2	1	1	25	6	8	2	1
18	8	3	16	4	2	1	25	7	7	2	1
19	8	4	12	3	2	1	30	2	15	4	2
20	8	5	9	3	1	1	30	3	15	4	2
21	8	6	8	2	1	1	30	4	11	3	2
22	8	7	7	2	1	1	30	5	9	3	1
23	9	3	16	4	2	1	30	6	8	2	1
24	9	4	12	3	2	1	30	7	6	2	1
25	9	5	9	3	1	1	35	2	15	4	2
26	9	6	8	2	1	1	35	3	15	4	2
27	9	7	7	2	1	1	35	4	11	3	2
28	10	2	18	5	2	2	35	5	9	3	1
29	10	3	16	4	2	1	35	6	7	2	1
30	10	4	12	3	2	1	35	7	6	2	1
31	10	5	9	3	1	1	40	2	15	4	2
32	10	6	8	2	1	1	40	3	15	4	2
33	10	7	7	2	1	1	40	4	11	3	2

$(I - 1) * (R - 1)$ for randomized blocks experiment. In this equation, the values of the coefficient of heterogeneity (b) and the coefficient of variation (CV) for each characteristic were obtained by bootstrap simulation, with 2000 resamples, according to Celanti *et al.* (2016a), being, in this case, b = 1.0. For each characteristic, X_0 was determined only for one tomato cultivar, which presented the greatest data variability, measured by coefficient of variation, according to Cargnelutti Filho *et al.* (2015).

As it is a discrete random variable, the optimum plot size will be presented by an integer, adopting the correct rounding criterion (Pimentel-Gomes, 1984). The analyzes of descriptive statistics, Pearson correlation and canonical were performed using the Genes program (Cruz, 2016) and the determination of the optimum plot size through the R program (R Core Team, 2017).

RESULTS AND DISCUSSION

The table 1 shows the data of the descriptive statistics for the eight characteristics evaluated. The differences between the cultivars were evident, the only characteristic that the average did not differ statistically between one cultivar and another was the stem diameter. In this work, a greater variation is noticed for the variables root dry matter and Dickson quality index, showing a high dispersion among the data, according to Pimentel-Gomes (1985) classification. This variation in the root weight may have been influenced by uneven conditions (temperature, water, etc.) of the seedlings, which can affect germination, emergence and rooting being irregular (Melo *et al.*, 2007).

The phenotypic correlations between the eight characteristics, in the two tomato cultivars, evaluated by Pearson's correlation, are shown in Table 2. The Mestiço

Table 5: Optimum plot size (X_0), in number of plants, to evaluate the stem diameter, estimated by Hatheway's method, in an experiment disposed in a randomized block design in different scenarios formed by combinations between number of treatments (I) and number of repetitions (R) in tomato seedlings (*Solanum lycopersicum*), with error of 10%, 20%, 30% and 40% around the average

I	R	D = 10%	D = 20%	D = 30%	D = 40%	I	R	D = 10%	D = 20%	D = 30%	D = 40%
3	7	17	5	2	2	15	2	38	10	5	3
4	5	23	6	3	2	15	3	35	9	4	3
4	6	19	5	3	2	15	4	26	7	3	2
4	7	16	4	2	1	15	5	20	5	3	2
5	4	29	8	4	2	15	6	17	5	2	2
5	5	22	6	3	2	15	7	15	4	2	1
5	6	18	5	2	2	20	2	36	9	4	3
5	7	15	4	2	1	20	3	34	9	4	3
6	4	28	7	4	2	20	4	25	7	3	2
6	5	22	6	3	2	20	5	20	5	3	2
6	6	18	5	2	2	20	6	17	5	2	2
6	7	15	4	2	1	20	7	14	4	2	1
7	3	39	10	5	3	25	2	35	9	4	3
7	4	27	7	3	2	25	3	34	9	4	3
7	5	21	6	3	2	25	4	25	7	3	2
7	6	18	5	2	2	25	5	20	5	3	2
7	7	15	4	2	1	25	6	17	5	2	2
8	3	38	10	5	3	25	7	14	4	2	1
8	4	27	7	3	2	30	2	35	9	4	3
8	5	21	6	3	2	30	3	34	9	4	3
8	6	17	5	2	2	30	4	25	7	3	2
8	7	15	4	2	1	30	5	20	5	3	2
9	3	37	10	5	3	30	6	17	5	2	2
9	4	27	7	3	2	30	7	14	4	2	1
9	5	21	6	3	2	35	2	35	9	4	3
9	6	17	5	2	2	35	3	34	9	4	3
9	7	15	4	2	1	35	4	25	7	3	2
10	2	41	11	5	3	35	5	20	5	3	2
10	3	36	9	4	3	35	6	17	5	2	2
10	4	26	7	3	2	35	7	14	4	2	1
10	5	21	6	3	2	40	2	34	9	4	3
10	6	17	5	2	2	40	3	33	9	4	3
10	7	15	4	2	1	40	4	25	7	3	2

cultivar presented most of the correlations ≤ at 0.40, demonstrating a low linear association and, consequently, low magnitude, in contrast with the Ozone cultivar, which presented, in general, the majority of correlations ≥ at 0.40, with correlations ranging from moderate to very strong, demonstrating a significant linear association and of good magnitude (Hair *et al*., 2005). Divergence between such cultivars can be explained by the difference between their characteristics, the 'Mestiço' presented a larger size than 'Ozone', in addition to the more varied number of leaves and higher dry matter weight, the Ozone cultivar showed, in general, greater uniformity, mainly regarding the number of leaves and dry matter among a plant and another, i.e., in 'Mestiço', 71% of the correlations were significant at 5% by the t test and, in 'Ozone', 96% of the correlations were significant at 5% by the t test. However, considering that the size of each sample is considered large, n = 200 seedlings, a correlation with r value ≥ 0.138 is considered significant and, according to Shimakura & Júnior (2012) classification, a correlation up to 0,19 is considered very weak.

Considering only the correlations considered moderate or higher (r ≥ 0.40), these are found in 32% of the 'Mestiço' correlations and 68% of the 'Ozone' correlations. For non-destructive characteristics, the correlations between these characteristics were more expressive in 'Ozone'. The most expressive correlations, in both cultivars, were between the dry matter characteristics and these with Dickson quality index, showing that, if it is necessary to determine the optimum plot size for these characteristics, which are destructive, there is no need to use all of them.

Table 6: Optimum plot size (X_0), in number of plants, for assessing the number of leaves per plant, estimated by Hatheway's method in an experiment disposed in a randomized block design in different scenarios formed by combinations between number of treatments (I) and number of repetitions (R) in tomato seedlings (*Solanum Iycopersicum*) with error of 10%, 20%, 30% and 40% around the average

I	R	D = 10%	D = 20%	D = 30%	D = 40%	I	R	D = 10%	D = 20%	D = 30%	D = 40%
1	3	7	8	2	1	1	15	2	16	4	2
2	4	5	10	3	2	1	15	3	15	4	2
3	4	6	8	2	1	1	15	4	11	3	2
4	4	7	7	2	1	1	15	5	9	3	1
5	5	4	13	4	2	1	15	6	8	2	1
6	5	5	10	3	2	1	15	7	7	2	1
7	5	6	8	2	1	1	20	2	16	4	2
8	5	7	7	2	1	1	20	3	15	4	2
9	6	4	12	3	2	1	20	4	11	3	2
10	6	5	10	3	2	1	20	5	9	3	1
11	6	6	8	2	1	1	20	6	8	2	1
12	6	7	7	2	1	1	20	7	7	2	1
13	7	3	17	5	2	2	25	2	16	4	2
14	7	4	12	3	2	1	25	3	15	4	2
15	7	5	10	3	2	1	25	4	11	3	2
16	7	6	8	2	1	1	25	5	9	3	1
17	7	7	7	2	1	1	25	6	8	2	1
18	8	3	16	4	2	1	25	7	7	2	1
19	8	4	12	3	2	1	30	2	15	4	2
20	8	5	9	3	1	1	30	3	15	4	2
21	8	6	8	2	1	1	30	4	11	3	2
22	8	7	7	2	1	1	30	5	9	3	1
23	9	3	16	4	2	1	30	6	8	2	1
24	9	4	12	3	2	1	30	7	6	2	1
25	9	5	9	3	1	1	35	2	15	4	2
26	9	6	8	2	1	1	35	3	15	4	2
27	9	7	7	2	1	1	35	4	11	3	2
28	10	2	18	5	2	2	35	5	9	3	1
29	10	3	16	4	2	1	35	6	7	2	1
30	10	4	12	3	2	1	35	7	6	2	1
31	10	5	9	3	1	1	40	2	15	4	2
32	10	6	8	2	1	1	40	3	15	4	2
33	10	7	7	2	1	1	40	4	11	3	2

Pearson's correlation coefficients, although important, only make the linear relationship between two characteristics at a time. In order to relate the set of destructive characteristics with that of non-destructive ones, the analysis of canonical correlations was carried out, whose results are expressed in Table 3. In these canonical correlations, the total dry matter characteristic does not appear because it showed multicollinearity with other destructive characteristics and was discarded from the analyzes. Canonical correlations were significant by the chi-square test. This demonstrates that the two groups of characters are related in a dependent way (Cruz & Regazzi, 2001). Consequently, the first two canonical pairs are of interest to the study. By studying the coefficients of the first canonical pair, in 'Mestiço', it is evident that the larger the diameter of the seedling collection, the greater the Dickson quality index. This same relationship is also valid when studying the second canonical pair in 'Ozone'.

Thus, in this work, it was found that there is a possibility to determine the optimum plot size only by non-destructive characteristics.

Considering that two cultivars were evaluated and that there is different phenotypic variability between the two cultivars, detected by dispersion measurements (Table 1) and by linear correlations (Table 2), it was decided to use, in determining the optimum plot size , only the highest coefficient of variation values, understanding that they express the greatest variability of the data, as suggested by Cargnelutti Filho *et al*. (2017). Thus, for the determination of the optimum plot size for the seedling aerial part height (Table 4) and stem diameter (Table 5), the data obtained in 'Mestiço' seedlings were used and, to determine the optimum plot size for number of leaves

Table 7: Optimum plot size (X_0), in number of plants, for leaf area assessment, estimated by Hatheway's method in an experiment disposed in a randomized block design in different scenarios formed by combinations between number of treatments (I) and number of repetitions (R) in tomato seedlings (*Solanum Iycopersicum*) with error of 10%, 20%, 30% and 40% around the average

I	R	D = 10%	D = 20%	D = 30%	D = 40%	I	R	D = 10%	D = 20%	D = 30%	D = 40%
1	3	7	13	4	2	1	15	2	30	8	4
2	4	5	18	5	2	2	15	3	27	7	3
3	4	6	15	4	2	1	15	4	20	5	3
4	4	7	13	4	2	1	15	5	16	4	2
5	5	4	23	6	3	2	15	6	13	4	2
6	5	5	18	5	2	2	15	7	12	3	2
7	5	6	14	4	2	1	20	2	28	7	4
8	5	7	12	3	2	1	20	3	27	7	3
9	6	4	22	6	3	2	20	4	20	5	3
10	6	5	17	5	2	2	20	5	16	4	2
11	6	6	14	4	2	1	20	6	13	4	2
12	6	7	12	3	2	1	20	7	11	3	2
13	7	3	30	8	4	2	25	2	28	7	4
14	7	4	22	6	3	2	25	3	27	7	3
15	7	5	17	5	2	2	25	4	20	5	3
16	7	6	14	4	2	1	25	5	16	4	2
17	7	7	12	3	2	1	25	6	13	4	2
18	8	3	30	8	4	2	25	7	11	3	2
19	8	4	21	6	3	2	30	2	27	7	3
20	8	5	17	5	2	2	30	3	26	7	3
21	8	6	14	4	2	1	30	4	20	5	3
22	8	7	12	3	2	1	30	5	16	4	2
23	9	3	29	8	4	2	30	6	13	4	2
24	9	4	21	6	3	2	30	7	11	3	2
25	9	5	17	5	2	2	35	2	27	7	3
26	9	6	14	4	2	1	35	3	26	7	3
27	9	7	12	3	2	1	35	4	20	5	3
28	10	2	32	8	4	2	35	5	16	4	2
29	10	3	29	8	4	2	35	6	13	4	2
30	10	4	21	6	3	2	35	7	11	3	2
31	10	5	16	4	2	1	40	2	27	7	3
32	10	6	14	4	2	1	40	3	26	7	3
33	10	7	12	3	2	1	40	4	20	5	3

(Table 6) and leaf area per seedling (Table 7), data from the cultivar Ozone was used.

Observing the results from Table 4 to 7, it can be seen that the plot size is different among the evaluated characteristics, as also observed by Celanti *et al*. (2016b), with papaya seedlings. Considering the same number of treatments, repetitions and the same experimental precision, the largest required plot size was for the characteristic stem diameter. Thus, if the experimenter wants to evaluate the non-destructive characteristics in his experiment, just consult table 4. As an example, if he wants to establish an experiment with tomato seedlings with 10 treatments and 4 repetitions, with an accuracy of 20% around the average, he will have to evaluate seven seedlings per plot.

CONCLUSIONS

The characteristics showed variability, so the optimum plot size varies according to the character evaluated. As the Dickson quality index had a relationship with the stem diameter, considering that it is a destructive variable, it can be dispensed with the determination of the optimum plot size, being used instead the stem diameter.

The stem diameter can be used as a basis for all non-destructives characteristics, without the need to destroy the seedlings.

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