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CROP PRODUCTION

Number of replicates required to accurately evaluate the productivity and soluble solids in melon hybrids of the Inodorus group

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ABSTRACT. Determining the number of replicates required to produce statistically testable results based on previously conducted tests is important to minimize labor costs via the use of existing information. The objective of this work was to determine the number of repetitions necessary to evaluate the characters of productivity and soluble solids in hybrids of two types of Inodorus melons. The study consisted of 20 experiments: 12 evaluated 10 hybrids of honeydew melons and 8 evaluated 13 hybrids of yellow melons. The experimental design consisted of randomized blocks with three replicates. Analysis of variance was performed to estimate the repeatability and genotypic determination coefficients. Variability in accurately predicting the genotype was observed for different number of repetitions between the evaluated characters and melon types. In the yellow melon, experiments with three repetitions allowed the accurate identification of superior genotypes with 81.1 and 61.9% certainty for productivity and soluble solids, respectively. In the honeydew melon, 62.4 and 71.2% accuracy was obtained for productivity and soluble solids, respectively.

Keywords: *Cucumis melo* L.; experimental planning; experimental precision; repeatability.

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Introduction

The cultivation of melons is of social and economic importance for northeast Brazil, specifically for the states of Rio Grande do Norte and Ceará, which together form the main fruit-producing region in Brazil. The region mainly produces melons of the Inodorus group and their various types owing to their longer storage period than the Cantalupensis group (Fontes & Puiatti, 2019). In 2018, melon exports totaled 197.6 thousand tons, which resulted in a revenue of U$ 136.05 million, representing the largest volume exported and the second largest in revenue for fresh fruit exports, second only to mango (Abrafrutas, 2019).

Owing to the high potential for melon cultivation in the northeast, new melon cultivars are introduced every year in Brazil. For example, as of July 2019, there were 698 records of melon cultivars in the National Cultivar Protection System (MAPA, 2021). These materials are tested in the main production regions to select the most promising ones.

For this process to be carried out reliably, it is necessary to develop experimental protocols with the greatest possible precision so that the differences observed are attributed to the effect of genotypes and not to chance, thus, allowing the identification of superior genotypes adapted to local edaphoclimatic conditions.

To achieve the desired experimental precision, researchers must adequately size the number of repetitions based on the character of interest, estimated from tests conducted in previous years (Torres, Sagrilo, Teodoro, Ribeiro, & Cargnalutti Filho, 2015, Storck et al., 2007). For this purpose, the repeatability coefficient can be used to determine how many phenotypic observations must be made in each individual so that phenotypic selection is efficient, with minimum cost and labor (Cruz, Regazzi, & Carneiro, 2012). This coefficient can be estimated when the measurement of a character is repeated in the same individual and can be used for choosing superior genotypes. This analysis technique takes advantage of existing experimental data to redefine or maintain experimental plans (Cargnelutti Filho & Gonçalves, 2011).

The repeatability coefficient has been used in dimensioning the required number of repetitions to evaluate characters in different crop cultivations, such as soy (Cargnelutti Filho & Gonçalves, 2011), corn (Cargnelutti Filho & Storck, 2009), cowpea (Torres et al., 2015), sugarcane (Cargnelutti Filho, Braga Junior, & Lúcio, 2012a), and rice (Cargnelutti Filho, Marchesan, Silva, & Toebe, 2012b), and variability has been observed in the required number of repetitions between different characters to obtain the same precision.

However, to our knowledge, reports on the use of this technique to estimate the required number of repetitions for production characteristics of melons from the Inodorus group are not found in the literature. Therefore, this study was developed to determine the number of measurements (repetitions) necessary to evaluate the productivity and soluble solids content in melon hybrids (honeydew and yellow) of the Inodorus group and to estimate the variability of the number of replicates between characters to obtain the same precision.

Material and methods

Twenty-three hybrids belonging to the botanical group Inodorus Naudin were evaluated. Ten honeydew hybrids were evaluated from four municipalities over three consecutive years (2015 to 2017) and 13 yellow hybrids were evaluated from four municipalities in 2017 and two growing seasons, totaling 12 and 8 experiments, respectively, for each type of melon. All trials were carried out in the municipalities of Agropolo Mossoró-Assu, Rio Grande do Norte State, the main producer and exporter of melons nationally.

The tests were conducted using a randomized block design with three replicates. The plot consisted of two lines of 5 m, with 2.0 x 0.5 m spacing, totaling 20 plants per plot, with the plants at the ends being considered headland borders. Cultural practices, such as the application of pesticides and weeds, were carried out according to the needs of the crop in compliance with the recommendations for management and cultural practices of melon cultivation in the State of Rio Grande do Norte (Nunes, Costa Filho, Silva, Carneiro, & Dantas, 2011).

Commercial productivity and soluble fruit solids were evaluated as they are considered the most crucial characteristics of a melon crop from a commercial point of view, according to the producers. Commercial productivity was determined by weighing all commercial fruits of each type of melon harvested from the plot. The total soluble solid content was measured by taking a sample of approximately 2/3 of the pulp thickness from the equatorial region of the fruit in the direction of the cavity. The sample was pressed manually until a part of the juice was deposited in a digital refractometer (Digital Refractometer Palette 100®), in which the content of soluble solids was determined. Eight fruits were sampled per plot to measure the soluble solid content.

For each experiment, analysis of variance was performed with a nominal level of significance $\alpha = 0.05$, using the statistical model $y = Xr + Zg + e$, where y is the vector of the data, r is the vector of the effects of repetition (assumed to be fixed) plus the general average, g is the vector of genotypic effects (assumed to be random), and e is the vector of errors or residuals (random). Capital letters represent incidence matrices (Resende, 2007).

From the results of the analysis of variance, the estimates of the mean square of the block (MS_B), the mean square of the genotype (MS_G), the mean square of the error (MS_E) and the value of the F test for genotype ($F_G = MS_G/MS_E$) were obtained. The overall average of the experiment (m) and coefficient of variation ($CV=100\sqrt{MS_E}/m$) were also calculated. The selective accuracy (SA) was then estimated using the expression: $SA = \sqrt{1 - {}^{1}/_{F_G}}$. Subsequently, based on the SA values, experimental precision was evaluated according to the class limits established by Resende and Duarte (2007).

The evaluations in each block were considered measurements performed on the same individual (genotype), and the repeatability coefficient (r) was estimated for each character and experiment through analysis of variance. In this study, the repeatability coefficient corresponded to the intraclass correlation coefficient for genotypes and was estimated using the expression $r = \frac{(MS_G - MS_E)/J}{(MS_G - MS_E)/J + MS_E}$, where J refers to the number of measurements or repetitions (Cruz et al., 2012).

The number of measurements or repetitions (J) necessary to accurately predict the value of the individuals (genotypes), based on pre-established genotypic determination coefficients (R^2) (0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, and 0.95), was calculated using the expression $J = \frac{R^2(1-r)}{(1-R^2)r}$ (Cruz et al., 2012). The genotypic determination coefficient (R^2), which represents the certainty of the prediction of the real value of the selected genotypes, based on J measurements performed, was obtained by the expression $R^2 = \frac{Jr}{1+r(J-1)}$, where J is the number of measurements performed (J = 3 blocks, in this study) and r is a repeatability coefficient (Cruz et al., 2012).

Based on the repeatability coefficient (r) between the experiments carried out for each type of melon, in each of the characters, a genotypic determination coefficient (R^2) was calculated as a function of different numbers of repetitions (J ranging from 0 to 50). Although tests with 0 repetitions have no practical meaning and 50 repetitions are practically unfeasible to perform, these limits were chosen to demonstrate the behavior of the relationship between R^2 and J based on a fixed value of r (r = average of the tests for each type of melon). Statistical analyses were performed using the SELEGEN program (Resende, 2007) and Microsoft Office Excel.

Results and discussion

Honeydew Melon

For the 24 cases evaluated (2 characters and 12 trials), no effect of the block was observed in the F test of the analysis of variance, indicating that the blocks were not heterogeneous and, therefore, a completely randomized design could have been used. However, blocks are preferable because they control possible sources of heterogeneity if it occurs.

The effect of genotypes was observed in 7 and 8 tests of the 12 tests performed for productivity and soluble solids, respectively (Table 1). In cases where a significant effect of genotype was observed for productivity, the average values for F_G, SA, r, and R^2, based on the three replications, were 4.441, 0.855, 0.494, and 0.734, respectively. In cases in which this effect was not observed, the mean values for F_G, SA, r, and R^2 were 1.645, 0.532, 0.163, and 0.337, respectively.

Table 1. Analysis of variance containing degrees of freedom and the mean square (MS) for the sources of variation, mean, coefficient of experimental variation (CV), F test value for genotype (F_G), selective accuracy (SA) and experimental precision for productivity and soluble solids of 10 honeydew melon hybrids evaluated in 12 trials. Mossoró, Rio Grande do Norte State, Brazil, 2020.

Trial	MS (ANOVA)			Mean	CV (%)	F_G	SA	Precision[1]
	Block (2)	Genotype (9)	Error (18)					
Productivity (t ha^{-1})								
1	40.686^{ns}	399.692*	156.203	43.920	28.460	2.559	0.781	High
2	51.601^{ns}	17.091^{ns}	16.907	19.845	20.720	1.011	0.104	Low
3	120.367^{ns}	311.274*	79.101	52.443	16.959	3.935	0.864	High
4	2.558^{ns}	333.491*	36.777	33.224	18.253	9.07	0.943	Very high
5	328.176^{ns}	278.183^{ns}	125.689	49.976	22.433	2.213	0.740	High
6	211.106^{ns}	221.455^{ns}	103.954	31.095	32.790	2.130	0.728	High
7	8.343^{ns}	450.876*	147.991	55.167	22.052	3.047	0.820	High
8	11.025^{ns}	451.476*	89.461	34.728	27.236	5.047	0.896	High
9	11.883^{ns}	287.025^{ns}	217.182	31.616	46.613	1.322	0.493	Low
10	132.584^{ns}	441.918*	164.125	34.737	36.881	2.693	0.793	High
11	113.732^{ns}	323.260*	68.22	32.995	25.034	4.738	0.888	High
12	161.332^{ns}	478.789^{ns}	309.536	40.691	43.237	1.547	0.595	Moderate
Soluble solids (°Brix)								
1	0.0943^{ns}	1.397*	0.274	8.383	6.239	5.104	0.897	High
2	0.433^{ns}	0.724^{ns}	0.633	7.680	10.357	1.144	0.355	Low
3	0.500^{ns}	0.732^{ns}	0.725	8.907	9.561	1.009	0.096	Low
4	1.172^{ns}	1.518^{ns}	0.734	10.607	8.078	2.067	0.719	High
5	0.532^{ns}	1.156*	0.233	10.330	4.674	4.959	0.894	High
6	0.842^{ns}	1.805^{ns}	0.765	10.113	8.648	2.359	0.759	High
7	0.409^{ns}	2.260*	0.452	10.830	6.210	4.997	0.894	High
8	0.060^{ns}	6.991*	1.158	8.633	12.465	6.037	0.913	Very high
9	0.025^{ns}	2.501*	0.535	7.880	9.282	4.674	0.887	High
10	0.472^{ns}	4.538*	0.723	9.493	8.957	6.275	0.917	Very high
11	0.680^{ns}	5.034*	0.987	10.037	9.897	5.102	0.897	High
12	0.325^{ns}	6.799*	0.881	9.010	10.419	7.715	0.933	Very high

[1]Class limits established by Resende and Duarte (2007): Very High (SA ⩾ 0.90), High (0,70 ⩽ SA < 0.90), Moderate (0.50 ⩽ SA < 0.70), and Low (AS < 0.50). *Significant effect of F test at 5% probability. ^{ns} Not significant.

For cases with significant effects of genotypes with respect to soluble solids, the mean values for F_G, SA, r, and R^2 were 5.608, 0.904, 0.600, and 0.817, respectively. For cases in which there was no significant effect, the mean values for F_G, SA, r, and R^2 were 1.645, 0.482, 0.156, and 0.307, respectively. Based on these values, it can be stated that the failure to verify the effect of genotypes using the F test may be associated with low experimental precision and not the lack of genetic variability.

The SA statistic ranged between 0.096 (soluble solids; Trial 3) to 0.943 (productivity; Trial 4). Regarding the class limits established in Resende and Duarte (2007), of the 24 cases evaluated, 4 had very high experimental precision (SA ⩾ 0.90), 15 had high precision (0.70 ⩽ SA < 0.90), 1 had moderate precision (0.50 ⩽ SA < 0.70), and 4 had low experimental precision (SA < 0.50). These results show that there is variability in the experimental precision between the characters and experiments.

The magnitude of the estimate of the repeatability coefficient (r) varied between 0.003 and 0.729, regardless of the character and experiment. The values for coefficient of genotypic determination (R^2) ranged between 0.009 and 0.889 (Table 2). The existing variability between the experiments regarding these values is particularly important in this study because it represents different real-life situations and thus allows inferences regarding the required number of measurements (Torres et al., 2015), considering that experiments with a low repeatability coefficient require a larger number of measurements (repetitions) to accurately predict the value of a given character (Cruz et al., 2012). Experiments that could be discarded were retained, according to the criteria of Cargnelutti Filho and Storck (2009), due to their insufficiencies in experimental precision; thus, the estimates of the number of repetitions (J) may be inflated in trials with low experimental precision.

The average r values of the 12 tests were 0.356 and 0.452 for productivity and soluble solids, respectively. The genotypic determination coefficient estimated from this average value of r varied between 0.6243 (productivity) and 0.712 (soluble solids), indicating that three replications made it possible to accurately detect genotypic differences with 62.43 and 71.22% certainty for productivity and soluble solids, respectively.

These results indicate that determination of the number of replicates is specific to each character, and it is important to define it from the most interesting. This variation in the accuracy prediction of a character as a function of a certain number of replicates was also observed in soybean cultivation, where experiments with three repetitions allowed the identification of superior genotypes with accuracy varying from 17.52% certainty, regarding the insertion of the first pod, to 61.07% certainty for the number of nodes per plant (Cargnelutti Filho & Gonçalves, 2011).

Table 2. Estimates of repeatability coefficients (r), genotypic determination coefficients (R^2), and number of measurements (repetitions) (J)[1] associated with different R^2 values for productivity and soluble solids of 10 honeydew melon hybrids evaluated in 12 experiments, Mossoró, Rio Grande do Norte State, Brazil, 2020.

Statistic	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	Trial 11	Trial 12	Average r
						Productivity (t ha^{-1})							
r	0.3419	0.0036	0.4945	0.7289	0.2880	0.2737	0.4055	0.5743	0.0968	0.3607	0.5548	0.1542	0.3564
R^2	0.6092	0.0108	0.7459	0.8897	0.5482	0.5306	0.6718	0.8018	0.2433	0.6286	0.7889	0.3535	0.6243
						J estimated							
R^2=0.50	1.92	275.36	1.02	0.37	2.47	2.65	1.47	0.74	9.33	1.77	0.80	5.49	1.81
R^2=0.55	2.35	336.55	1.25	0.45	3.02	3.24	1.79	0.91	11.40	2.17	0.98	6.71	2.21
R^2=0.60	2.89	413.04	1.53	0.56	3.71	3.98	2.20	1.11	13.99	2.66	1.20	8.23	2.71
R^2=0.65	3.57	511.38	1.90	0.69	4.59	4.93	2.72	1.38	17.32	3.29	1.49	10.19	3.35
R^2=0.70	4.49	642.50	2.38	0.87	5.77	6.19	3.42	1.73	21.77	4.14	1.87	12.80	4.21
R^2=0.75	5.77	826.07	3.07	1.12	7.42	7.96	4.40	2.22	27.99	5.32	2.41	16.46	5.42
R^2=0.80	7.70	1101.43	4.09	1.49	9.89	10.62	5.86	2.97	37.32	7.09	3.21	21.95	7.22
R^2=0.85	10.91	1560.35	5.79	2.11	14.01	15.04	8.31	4.20	52.86	10.04	4.55	31.09	10.23
R^2=0.90	17.32	2478.21	9.20	3.35	22.25	23.89	13.19	6.67	83.96	15.95	7.22	49.38	16.25
R^2=0.95	36.57	5231.78	19.42	7.06	46.98	50.43	27.85	14.09	177.25	33.68	15.25	104.24	34.31
						Soluble solids (°Brix)							
r	0.5777	0.0458	0.0031	0.2623	0.5689	0.3117	0.5713	0.6267	0.5505	0.6375	0.5776	0.6912	0.4520
R^2	0.8041	0.1259	0.0093	0.5162	0.7983	0.5761	0.7999	0.8343	0.7861	0.8406	0.8040	0.8704	0.7122
						J estimated							
R^2=0.50	0.73	20.84	319.94	2.81	0.76	2.21	0.75	0.60	0.82	0.57	0.73	0.45	1.21
R^2=0.55	0.89	25.47	391.04	3.44	0.93	2.70	0.92	0.73	1.00	0.70	0.89	0.55	1.48
R^2=0.60	1.10	31.25	479.91	4.22	1.14	3.31	1.13	0.89	1.22	0.85	1.10	0.67	1.82
R^2=0.65	1.36	38.69	594.18	5.22	1.41	4.10	1.39	1.11	1.52	1.06	1.36	0.83	2.25
R^2=0.70	1.71	48.62	746.53	6.56	1.77	5.15	1.75	1.39	1.91	1.33	1.71	1.04	2.83
R^2=0.75	2.19	62.51	959.82	8.44	2.27	6.62	2.25	1.79	2.45	1.71	2.19	1.34	3.64
R^2=0.80	2.92	83.34	1279.76	11.25	3.03	8.83	3.00	2.38	3.27	2.27	2.93	1.79	4.85
R^2=0.85	4.14	118.07	1813.00	15.93	4.29	12.51	4.25	3.38	4.63	3.22	4.14	2.53	6.87
R^2=0.90	6.58	187.52	2879.47	25.31	6.82	19.87	6.75	5.36	7.35	5.12	6.58	4.02	10.91
R^2=0.95	13.89	395.87	6078.88	53.43	14.40	41.95	14.26	11.32	15.51	10.81	13.90	8.49	23.03

[1]Estimates less than 1 should be interpreted as 1.

Yellow melon

There was a significant effect of the blocks by the F test in trial 1 for productivity and soluble solids, as well as in trials 3, 5, and 6 for soluble solids, which represented 31.25% of the evaluated cases (Table 3). These results confirm the need to work with this design, even if this effect was not observed in other cases, as it made it possible to remove the effects from the environment, which, according to Cruz et al. (2012), could be confused with variation within the genotypes and, thus, contribute to an underestimation of the repeatability coefficient if a completely randomized design was adopted instead of the randomized blocks.

Table 3. Analysis of variance containing degrees of freedom and the mean square (MS) for the sources of variation, mean, coefficient of experimental variation (CV), F test value for genotype (F_G), selective accuracy (SA), and experimental precision for productivity and soluble solids of 13 yellow melon hybrids evaluated in 8 trials. Mossoró, Rio Grande do Norte State, Brazil, 2020.

Trial	MS (ANOVA)			Mean	CV (%)	F_G	SA	Precision[1]
	Block (2)	Genotype (12)	Error (24)					
Productivity (t ha^{-1})								
1	33.529*	45.894*	9.666	27.861	11.159	4.748	0.889	High
2	12.952^{ns}	78.027*	9.013	34.092	8.806	8.657	0.941	Very high
3	4.259^{ns}	59.501*	7.946	34.781	8.105	7.488	0.931	Very high
4	30.410^{ns}	65.687*	11.458	35.340	9.578	5.733	0.909	Very high
5	14.204^{ns}	62.582*	10.851	27.114	12.149	5.768	0.909	Very high
6	0.396^{ns}	11.028^{ns}	7.087	24.652	10.799	1.556	0.598	Very high
7	34.267^{ns}	70.255*	10.985	35.344	9.378	6.396	0.919	Very high
8	23.781^{ns}	86.521*	9.522	35.118	8.787	9.086	0.943	Very high
Soluble solids (°Brix)								
1	2.379*	0.751^{ns}	0.410	14.583	4.389	1.834	0.674	Moderate
2	1.056^{ns}	0.472^{ns}	0.466	14.355	4.753	1.013	0.113	Low
3	0.742*	0.777*	0.196	14.323	3.091	3.965	0.865	High
4	1.536^{ns}	1.624*	0.554	13.766	5.406	2.933	0.812	High
5	2.328*	3.120*	0.321	13.446	4.214	9.721	0.947	Very high
6	5.443*	1.945*	0.872	11.599	8.049	2.231	0.743	High
7	0.920^{ns}	1.406^{ns}	0.724	13.822	6.154	1.944	0.697	Moderate
8	0.869^{ns}	1.166*	0.359	12.385	4.838	3.248	0.832	High

[1]Class limits established by Resende and Duarte (2007): Very High (SA ⩾ 0.90), High (0.70 ⩽ SA < 0.90), Moderate (0.50 ⩽ SA < 0.70), and Low (AS < 0.50). *Significant effect of F test at 5% probability. ^{ns} Not significant.

A significant effect of the genotypes was observed in 12 of the 16 evaluated cases: 7 and 5 out of the 8 cases for productivity and soluble solids, respectively. From the values of F_G, SA, r, and R^2, it was observed that experimental precision varied according to the experiment and the evaluated character.

The average values of F_G and SA in the significant cases for productivity were 6.839 and 0.919, respectively, which, according to Resende and Duarte (2007), provide a very high experimental precision. However, in the case where there was no significant effect of the genotype, the values of F_G and SA were 1.556 and 0.598, respectively, with the experimental precision being considered moderate ($0.50 \leqslant SA < 0.70$).

In the cases related to the soluble solid content, when the effect of the genotypes was observed, the average values of F_G and SA were 4.419 and 0.839, respectively. In cases in which this effect was not observed, the average values of FG and SA were 1.557 and 0.495, respectively. An F value below 1.96 reflects an SA of less than 0.70, giving moderate or low (SA < 0.50) experimental precision (Resende & Duarte, 2007). Therefore, failure to observe a significant effect of genotypes in these cases may be linked to low experimental precision.

The values of r, considering all evaluated cases of yellow melon, ranged from 0.004 to 0.744, regardless of the character evaluated. The average values of r for productivity and soluble solids were 0.589 and 0.352, respectively. Higher values of the character repeatability coefficient indicate that it is possible to accurately predict an individual's value with a relatively small number of measurements, indicating that there will be little gain in accuracy with an increase in the number of measurements (Neves, Bruckner, Cruz, & Barelli, 2010; Manfio et al., 2011).

The estimates of R^2 from the average value of r were 0.811 and 0.619 for productivity and soluble solids, respectively. These values indicate that the use of three replicates made it possible to accurately detect genotypic differences for productivity and soluble solids with 81.13 and 61.94% certainty, respectively. For accurate prediction of the value of the genotype with greater than 80% certainty in soluble solids, more than seven repetitions would be necessary. However, it was observed that the increments in R^2 beyond five replicates reflected inexpressive gains in the accuracy of the prognosis of the genotype (Table 4).

Table 4. Estimates of repeatability coefficients (r), genotypic determination coefficients (R^2), and number of measurements (repetitions) (J)[(1)] associated with different R^2 values for productivity and soluble solids of 13 yellow melon hybrids, evaluated in 8 trials. Mossoró, Rio Grande do Norte State, Brazil, 2020.

Statistic	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Average r
					Productivity (t ha^{-1})				
r	0.5554	0.7185	0.6838	0.6120	0.6138	0.1563	0.6427	0.7294	0.5890
R^2	0.7894	0.8845	0.8665	0.8256	0.8266	0.3573	0.8436	0.8899	0.8113
					J estimated				
R^2=0.50	0.80	0.39	0.46	0.63	0.63	5.40	0.56	0.37	0.70
R^2=0.55	0.98	0.48	0.57	0.77	0.77	6.60	0.68	0.45	0.85
R^2=0.60	1.20	0.59	0.69	0.95	0.94	8.09	0.83	0.56	1.05
R^2=0.65	1.49	0.73	0.86	1.18	1.17	10.02	1.03	0.69	1.30
R^2=0.70	1.87	0.91	1.08	1.48	1.47	12.59	1.30	0.87	1.63
R^2=0.75	2.40	1.18	1.39	1.90	1.89	16.19	1.67	1.11	2.09
R^2=0.80	3.20	1.57	1.85	2.54	2.52	21.59	2.22	1.48	2.79
R^2=0.85	4.54	2.22	2.62	3.59	3.57	30.58	3.15	2.10	3.95
R^2=0.90	7.20	3.53	4.16	5.70	5.66	48.57	5.00	3.34	6.28
R^2=0.95	15.21	7.44	8.79	12.04	11.96	102.53	10.56	7.05	13.26
					Soluble solids (°Brix)				
r	0.2176	0.0043	0.4970	0.3919	0.7440	0.2910	0.2393	0.4283	0.3517
R^2	0.4548	0.0127	0.7478	0.6591	0.8971	0.5518	0.4855	0.6921	0.6194
					J estimated				
R^2=0.50	3.60	232.75	1.01	1.55	0.34	2.44	3.18	1.33	1.84
R^2=0.55	4.40	284.47	1.24	1.90	0.42	2.98	3.89	1.63	2.25
R^2=0.60	5.39	349.13	1.52	2.33	0.52	3.66	4.77	2.00	2.77
R^2=0.65	6.68	432.25	1.88	2.88	0.64	4.53	5.90	2.48	3.42
R^2=0.70	8.39	543.08	2.36	3.62	0.80	5.69	7.42	3.11	4.30
R^2=0.75	10.79	698.25	3.04	4.66	1.03	7.31	9.54	4.00	5.53
R^2=0.80	14.38	931.00	4.05	6.21	1.38	9.75	12.72	5.34	7.37
R^2=0.85	20.38	1318.92	5.73	8.79	1.95	13.81	18.02	7.56	10.45
R^2=0.90	32.37	2094.75	9.11	13.97	3.10	21.93	28.61	12.01	16.59
R^2=0.95	68.33	4422.25	19.23	29.48	6.54	46.30	60.41	25.36	35.03

[(1)]Estimates less than 1 should be interpreted as 1.

Therefore, for tests in yellow melons, observation of the effect of the genotypes under the experimental conditions employed proved to be more effective for productivity than for soluble solids, showing that the estimate of the required number of repetitions may vary with the character evaluated. It is up to the researcher to determine the character of greatest interest and thus establish the number of repetitions necessary to identify superior genotypes with the desired level of accuracy.

This variation in precision as a function of the evaluated character was also observed in an experiment carried out with the cultivation of beans, in which the use of three repetitions promoted the achievement of different levels of accuracy, varying from 68.6% certainty in the accurate prediction of the number of pods per plant in the cultivar to 91.2% for the number of days from emergence to harvest (Cargnelutti Filho & Ribeiro, 2010).

Based on the average value of r, an increase in the value of R^2 owing to the increase in the number of repetitions for the types of melons studied was observed. In general, it was demonstrated that the use of three repetitions proved to be inefficient to accurately predict the value of productivity and soluble solids for the experiments with honeydew melon and the value of productivity for yellow melon hybrids with more than 80% certainty. It was observed that tests with a lower repeatability coefficient required a greater number of repetitions to accurately predict the value of a character with desired precision (Figure 1).

Tests with an R^2 greater than 80%, which result in an SA equal to or greater than 90% (Resende & Duarte, 2007) and regarded as very high experimental precision (Cargnelutti Filho et al., 2012b), should be aimed at. Therefore, for more accurate inferences about the effect of hybrids, a greater number of repetitions would be necessary; however, it was observed that the increments observed in the accuracy of the prediction of the value beyond five repetitions resulted in minor and inexpressive gains in precision.

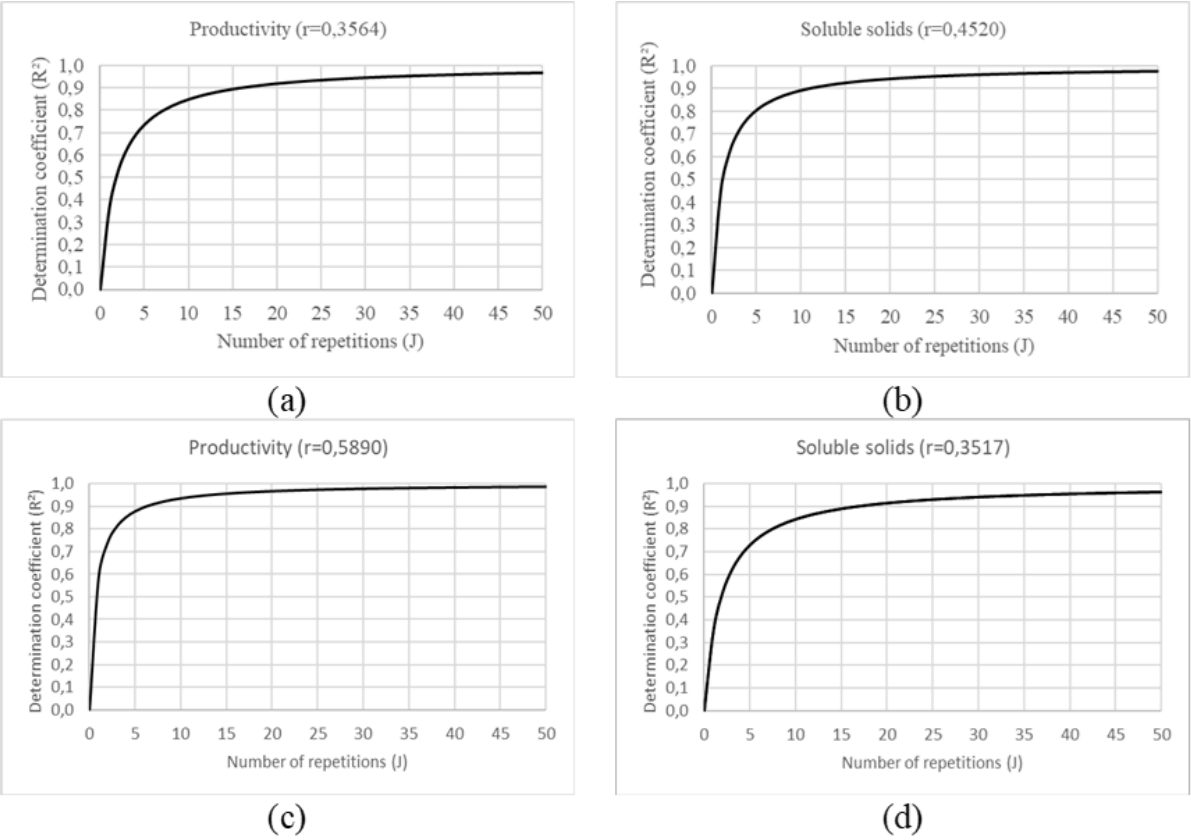

Figure 1. Estimation of the genotypic determination coefficients (R^2) for productivity and soluble solids as a function of the number of measurements/repetitions (J), based on the average repeatability coefficient (r) of 12 trials with 10 honeydew melon hybrids (a and b) and 8 trials with 13 yellow melon hybrids (c and d).

Conclusion

The number of replicates necessary to identify superior melon genotypes with the same level of accuracy may vary depending on the type of melon and character evaluated. To obtain a genotypic determination coefficient equal to or greater than 80% in experiments to evaluate productivity, the use of three replications is sufficient for the yellow melon; however, for honeydew melons, more than seven repetitions would be necessary to obtain the same accuracy. To evaluate the soluble solid content, more than seven repetitions would be necessary for experiments with yellow melon; however, for the honeydew type, five repetitions would be sufficient.

References

Abrafrutas. (2019). *Exportações brasileiras de frutas de janeiro a dezembro 2018*. Retrieved on July 26, 2019 from https://abrafrutas.org/2019/05/09/exportacoes-brasileiras-de-frutas-janeiro-a-dezembro-2018/

Cargnelutti Filho, A., & Gonçalves, E. C. P. (2011). Estimativa do número de repetições para a avaliação de caracteres de produtividade e de morfologia em genótipos de soja. *Comunicata Scientiae*, *2*(1), 25-33. DOI: https://doi.org/10.14295/cs.v2i1.81

Cargnelutti filho, A., Braga Junior, R. L. C., & Lúcio, A. D. (2012a). Medidas de precisão experimental e número de repetições em ensaios de genótipos de cana-de-açúcar. *Pesquisa Agropecuária Brasileira*, *47*(10), 1413-1421. DOI: https://doi.org/10.1590/S0100-204X2012001000001

Cargnelutti filho, A., Marchesan, E., Silva, L. S., & Toebe, M. (2012b). Medidas de precisão experimental e número de repetições em ensaios de genótipos de arroz irrigado. *Pesquisa Agropecuária Brasileira*, *47*(3), 336-343. DOI: https://doi.org/10.1590/S0100-204X2012000300004

Cargnelutti Filho, A., & Ribeiro, N. D. (2010). Número de repetições para avaliação de caracteres de produção, fenologia e morfologia de cultivares de feijão. *Ciência Rural*, *40*(12), 2446-2453. DOI: https://doi.org/10.1590/S0103-84782010001200002

Cargnelutti Filho, A., & Storck, L. (2009). Medidas do grau de precisão experimental em ensaios de competição de cultivares de milho. *Pesquisa Agropecuária Brasileira*, *44*(2), 111-117. DOI: https://doi.org/10.1590/S0100-204X2009000200001

Cruz, C. D., Regazzi, A. J., & Carneiro, P. C. S. (2012). *Modelos biométricos aplicados ao melhoramento genético* (4. ed.). Viçosa, MG: UFV.

Fontes, P. C. R., & Puiatti, M. (2019). Cultura do melão (2. ed.). In P. C. R. Fontes, & C. Nick (Eds.), *Olericultura: teoria e prática* (p. 555-579). Viçosa, MG: UFV.

Manfio, C. E., Motoike, S. Y., Santos, C. E. M., Pimentel, L. D., Queiroz, V., & Sato, A. Y. (2011). Repetibilidade em características biométricas do fruto de macaúba. *Ciência Rural*, *41*(1), 70-76. DOI: https://doi.org/10.1590/S0103-84782011000100012

MAPA. (2021). *CultivarWeb*. Retrieved on Feb. 9,2021 from http://sistemas.agricultura.gov.br/snpc//cultivarweb/cultivares_registradas.php

Neves, L. G., Bruckner, C. H., Cruz, C. D., & Barelli, M. A. A. (2010). Avaliação da repetibilidade no melhoramento de famílias de maracujazeiro. *Revista Ceres*, *57*(4), 480-485. DOI: https://doi.org/10.1590/S0034-737X2010000400007

Nunes, G. H. S., Costa Filho, J. H., Silva, D. J. H., Carneiro, P. C. S., & Dantas, M. S. M. (2011). Divergência genética entre linhagens de melão pele de Sapo. *Revista Ciência Agronômica*, *42*(3), 765-773. DOI: https://doi.org/10.1590/S1806-66902011000300024

Resende, M. D. V. (2007). *Software SELEGEN-REML/BLUP*: sistema estatístico e seleção genética computadorizada via modelos lineares mistos. Colombo, PR: Embrapa Florestas.

Resende, M. D. V., & Duarte, J. B. (2007). Precisão e controle de qualidade em experimentos de avaliação de cultivares. *Pesquisa Agropecuária Tropical*, *37*(3), 182-194. DOI: https://doi.org/10.5216/pat.v37i3.1867

Storck, L., Ribeiro, N. D., Lopes, S. J., Cargnelutti Filho, A., Carvalho, M. P., & Jost, E. (2007). Persistência do plano experimental em ensaios de avaliação de germoplasma elite de feijão. *Ciência Rural*, *37*(6), 1549-1553. DOI: https://doi.org/10.1590/S0103-84782007000600007

Torres, F. E., Sagrilo, E., Teodoro, P. E., Ribeiro, L. P., & Cargnelutti Filho, A. (2015). Número de repetições para avaliação de caracteres em genótipos de feijão-caupi. *Bragantia*, *74*(2), 161-168. DOI: https://doi.org/10.1590/1678-4499.0393.