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Classification of the coefficient of variation for experiments with eucalyptus seedlings in greenhouse[1]

Classificação do coeficiente de variação para experimentos com mudas de eucalipto em casa de vegetação

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ABSTRACT - In experimental statistics, the variability, which allows for conclusions related to experimental accuracy, is usually demonstrated by means of experimental coefficient of variation (CV). The aims of this study were to evaluate the distribution of CV in several experiments of eucalyptus growth, compare the existing classification ranges proposed in the literature (methods proposed by Garcia; Costa, Seraphin and Zimmermann, and Pimentel-Gomes), and define the better one to be used as reference for eucalyptus seedlings cultures in greenhouses or protected cultivation. For that, a blank test with 100 repetitions was conducted and evaluations were performed in 30, 60, 90 and 120 days. Moreover, previous data from literature were collected, for comparison proposes. The obtained results were submitted to Shapiro-Wilk and Kolmogorov-Smirnov tests, and the classification tables were submitted to adherence and heterogeneity tests. As a result, it was possible to conclude that data obtained with the experiments with eucalyptus in the present research did not fit the classification of Pimentel-Gomes and tables obtained by Costa, Seraphin and Zimmermann, while the tables related to the method proposed by Garcia would be preferably used.

Key words: Experimental precision. Experimental variation. Parametric tests. Non-parametric tests. *E. grandis* x *E. urophylla*.

RESUMO - Na estatística experimental, a variabilidade, que permite conclusões relacionadas à precisão experimental, é geralmente demonstrada por meio do coeficiente de variação experimental (CV). O objetivo deste estudo foi avaliar a distribuição do CV em diversos experimentos de crescimento de eucalipto, comparar as faixas de classificação existentes propostas na literatura (métodos propostos por Garcia; Costa, Seraphin e Zimmermann e Pimentel-Gomes), e definir o melhor a ser utilizado como referência para cultivo de mudas de eucalipto em estufas ou cultivo protegido. Para tanto, foi realizado um teste em branco com 100 repetições e avaliações realizadas em 30, 60, 90 e 120 dias. Além disso, foram coletados dados anteriores da literatura, para fins de comparação. Os resultados obtidos foram submetidos aos testes de Shapiro-Wilk e Kolmogorov-Smirnov, e as tabelas de classificação submetidas aos testes de aderência e heterogeneidade. Como resultado, foi possível concluir que os dados obtidos com os experimentos com eucalipto na presente pesquisa não se enquadram na classificação de Pimentel-Gomes e nas tabelas obtidas por Costa, Seraphin e Zimmermann enquanto as tabelas por meio do método proposto por Garcia seriam preferencialmente utilizadas.

Palavras-chave: Precisão experimental. Variação experimental. Testes paramétricos. Testes não paramétricos. *E. grandis* x *E. urophylla*.

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INTRODUCTION

The genus *Eucalyptus* is native of Australia and presents more than 700 cataloged species (SANTAROSA; PENTEADO; GOULART, 2014). Due to its economic importance, it is crucial to understand the possible variables related to the growing of eucalyptus crops.

In the experimental statistics, the variability allows the conclusion regarding the experimental precision, and it is frequently demonstrated through the coefficient of experimental variation (CV), which is an estimate of the experimental error in relation to the overall average of the experiment (CRUZ *et al*., 2012). Statistic tests may help the researcher to understand the behavior and make inferences related to the results obtained in their projects (CARGNELUTTI FILHO; LÚCIO; LOPES, 2009).

Lower estimated CVs correspond to higher experimental precision, as well as the higher precision, corresponds to greater quality of the experiments, leading to small differences between estimated averages (CRUZ *et al*., 2012). The CV is a measure of dispersion and its main advantage is the possibility of comparison of variables of different natures, as well as the comparison of different studies involving the same variable, which allows the quantification of the experimental accuracy.

According to Garcia (1989), it is important to analyze the CV because when obtaining measures of dispersion or variability, the analysis becomes more informative. The author emphasizes the need of evaluating not only the variable in question, but also the nature of the data and the type of the experiment implemented, in addition to the number of repetitions used in the experiment. The importance of CV classification tables are also highlighted, because they are used as reference to the researcher to verify if the results obtained are in a range of expected values, which may reflect in a good accuracy of the analysis.

The importance of normal distribution is evident, being an essential condition for analysis by several methods, such as parametric statistics. In those cases, when the assumption of normality is invalidated, corresponding non-parametric tests should be use, even if they are not so robust, because if the parametric technique is used, the interpretation and inferences may not be safe or adequate.

Pimentel-Gomes (2009) correlates the ranges of experimental accuracy according to his CV classification table, being high for low CV, good for medium CV, low for high CV and very low accuracy for very high CV. Cargnelutti Filho *et al.* (2018) uses this classification and states that CV lower than 10% can guarantee high accuracy of the experiment.

The CV classification was used in several cultures, such as tomato (CRUZ *et al*., 2012), sugarcane (COUTO; PETERNELLI; BARBOSA, 2013), eucalyptus (MORA; ARRIAGADA, 2016), papaya (FERREIRA *et al.*, 2016) and lettuce (SCHMILDT *et al*., 2017).

The aims of this study were to evaluate the distribution of CV in several experiments of eucalyptus seedlings growth, compare the existing classification ranges proposed in the literature, and define the better one to be used as reference for eucalyptus cultures in greenhouses or controlled environments.

MATERIAL AND METHODS

Plant material

The Coefficients of Variation (CV) were obtained from simulations of a blank test and from literature data. To obtain the data related to the blank test, 100 basic units (bu) of clones of the hybrid VR3 (*Eucalyptus grandis* x *Eucalyptus urophylla*) were used. The experiment was set up at UNESP/Campus Ilha Solteira (SP, Brazil), in protected cultivation conditions, from February to July 2014. The soil used was collected at a depth of 0.0 to 0.20 m, under eucalyptus plantations, located in the municipality of Três Lagoas (MS, Brazil) (Latitude: 20º 59'S and Longitude 51º 48' W).

The soil was sieved (4 mm) and packed in seedling bags 0.40 m high (8 kg of soil). Limestone and NPK were incorporated in the soil, according to the recommendation of use for that region, for the cultivation of eucalyptus (1.5 mg ha^{-1} of limestone, 0.5 mg ha^{-1} NPK – 12-20-16). The eucalyptus seedlings (*Eucalyptus* spp.), used as indicators, were donated by FIBRIA Ltda. The variables evaluated were: height (H), stem diameter at the base (DB), chlorophyll content in old leaves (ChlorO) and new leaves (ChlorN) at 30, 60, 90 and 120 days, dry mass of the aerial part (DMAP) and the root system (DMRS) at 120 days.

Data from literature were collected from 104 articles in national and international journals from the last 30 years with eucalyptus seedlings under protected cultivation. The variables evaluated were: height (H), stem at base diameter (DB), dry mass of leaves (DML), dry mass of the aerial part (DMAP), dry mass of the root system (DMRS), total dry mass (TDM), number of leaves (NL), leaf area (LA) and root length (RL).

Statistical analysis

The average CV values were obtained for each variable in the study, as well as their respective standard deviations (SD). The CVs were classified as: low, medium, high and very high according to the definition of limits proposed by Garcia (1989), Pimentel-Gomes (2009) and Costa, Seraphin and Zimmermann (2002) (Table 1).

Table 1 - Classification ranges of coefficients of variation (CV), according to Garcia (1989), Pimentel-Gomes (2009) and Costa, Seraphin and Zimmermann (2002)

Methods[1]	Value ranges for CV			
	Low	Medium	High	Very High
1	$< \overline{CV} - S$	$\overline{CV} - S$ to $\overline{CV} + S$	$\overline{CV} + S$ to $\overline{CV} + 2S$	$> \overline{CV} + 2S$
2	< 10%	10% to 20%	20% to 30%	>30%
3	< Md - PS	Md - PS to Md + PS	Md - PS to Md + 2PS	> Md + 2PS

[1]Garcia (1989); 2: Pimentel-Gomes (2009); 3:Costa, Seraphin and Zimmermann (2002); Methods

To analyze the normality of the data, two parametric adherence tests were used, which are commonly applied regardless of the sample size, being: Kolmogorov-Smirnov test (1933; 1936) and Shapiro-Wilk test (1965).

The CVs of the experiments were classified into ranges according to each method (Table 1), regardless the distribution presented by the normality test. Since the variables may present equality between the frequencies observed and expected by different methods (CRUZ *et al*., 2012), the CV classification ranges were calculated by the methodologies of Garcia (1989) and Costa, Seraphin and Zimmermann (2002).

Based on this assumption, classification tables were created for all methods regardless of the result of the normality test and, for greater robustness of the analysis, from the formulation, the tables for each method were compared in relation to the frequency of values of the original data by the adherence tests, to compare with the normal distribution and the heterogeneity test, to verify the differences between methods.

The adherence test was performed under the hypothesis of normality, with approximately 68% of the observations included in an arithmetic average ($\overline{x}$) range, plus or minus the standard deviation (*SD*), 95.4% of the observations in the interval $2SD \pm \overline{x}$ and 99.7% of those in the interval between $3SD \pm \overline{x}$ of the total area, corresponds to 1 (FONTELLES, 2012). For this test it was used the chi-square test (χ^2) (PEARSON, 1900), which is a non-parametric test that evaluates if the observed distribution of frequencies in the CV classification ranges in each method adjusted to the expected distribution (normal distribution). The CV values obtained were correlated with experimental accuracy from the corresponding expected frequencies, being: low - 15.9%, medium - 68.3%, high - 13.6% and very high - 2.3% according to De Mesquita Lopes, Branco and Soares (2013).

To compare the tests used, the heterogeneity test based on χ^2 and the Fisher's exact test (FISHER, 1922) was calculated for each CV classification range. The χ^2 was used when the cells had values greater than or equal to 6 and the number of samples was greater than 40. When the cells had values less than 5 and the number of samples less than 40, the Fisher's exact test was used (FONTELLES, 2012).

After performing those tests, a table was formulated for recommendation from the best method, verifying if it corroborated with the criteria for using the methods as recommended by the authors from the classification of the normality tests. In order to verify if there were differences between the recommendations of the classification tables from the blank test and from the literature data, the heterogeneity test was performed on the variables common to these two tables. Statistical analyses were performed using Microsoft Excel and R version 3.6.1 (R CORE TEAM, 2019).

RESULTS AND DISCUSSION

Kolmogorov-Smirnov and Shapiro-Wilk statistic tests for the blank test

According to the application of the Kolmogorov-Smirnov normality test (KS), all variables presented normal distribution. For the Shapiro-Wilk test (SW), only the variables height - H (at 30 days), stem diameter at the base - DB (at 30, 60 and 90 days), chlorophyll content in old leaves - ChlorO (at 30 days), chlorophyll content in new leaves ChlorN (at 30, 90 and 120 days), dry mass of the aerial part - DMAP (at 120 days) and dry mass of the root system - DMRS (at 120 days) presented a normal distribution; the others had a non-normal distribution, at 5% significance level, suggesting that the variables were analyzed by appropriate methodologies according to the distribution (normal and non-normal), since the observed and expected frequencies may or may not present equality in each method used (Table 2).

Regarding the classification of the distribution based on the data, the variables chosen were those presenting normality in both methods (SW and KS). Consequently, the classification was recommended following the SW (Table 2), the only one that did not show non-normality in the results, probably because it is more effective for all sample sizes. It is

Table 2 - Kolmogorov-Smirnov and Shapiro-Wilk normality tests for the variables studied

Variables[1]	Evaluations (days)	Tests				Distribution
		Kolmogorov-Smirnov		Shapiro-Wilk		
		Statistics	p-value	Statistics	p-value	
H	30	0.2083	0.4711	0.9412	0.3979	Normal
	60	0.1955	0.4757	0.8573	0.0139	Non-normal
	90	0.1841	0.5511	0.8323	0.0058	Non-normal
	120	0.3029	0.0701	0.8104	0.0028	Non-normal
DB	30	0.1180	0.9597	0.9589	0.6427	Normal
	60	0.2067	0.4424	0.9118	0.1246	Normal
	90	0.1834	0.5562	0.9037	0.0782	Normal
	120	0.2399	0.2699	0.8604	0.0233	Non-normal
ChlorO	30	0.1681	0.6620	0.8940	0.0540	Normal
	60	0.1619	0.7694	0.8615	0.0254	Non-normal
	90	0.2076	0.4012	0.8072	0.0026	Non-normal
	120	0.203	0.4647	0.8576	0.0177	Non-normal
ChlorN	30	0.0985	0.9908	0.9695	0.8095	Normal
	60	0.1995	0.4863	0.8409	0.0100	Non-normal
	90	0.1916	0.5008	0.9402	0.3210	Normal
	120	0.1908	0.5806	0.9093	0.1319	Normal
DMAP	120	0.1300	0.9012	0.9413	0.3345	Normal
DMRS	120	0.1895	0.3666	0.9161	0.1461	Normal

[1]H: height; DB: stem at base diameter; ChlorO: chlorophyll content in old leaves; ChlorN: chlorophyll content in new leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system

worth to mention that, despite robustness of the SW test being considered low for small sample sizes (TORMAN; COSTER; RIBOLDI, 2012), the test is still recommended for samples larger than 10 to continue the normality test (TORMAN; COSTER; RIBOLDI, 2012).

Tables of classification of the coefficient of variation by the methods of Garcia (1989), Costa, Seraphin and Zimmermann (2002) and Pimentel-Gomes (2009) for the blank test

According to the methodology 1, during all period of evaluation, for the variable H, the coefficients of variation presented values ranging from 5.67% to 19.93%. For DB, the experimental values ranged from 3.37% to 9.98%, while for ChlorO and ChlorN, values varied from 1.19% to 7.96% and from 3.71% to 9.00% respectively. At 120 days, the CV values for the variable DMAP and DMRS varied from 10.43% to 32.84% and from 6.44% to 21.59%, respectively (Table 3).

It was found that values obtained in each variation coefficient classification range are very particular for each variable, indicating that the variation classification proposed by Pimentel-Gomes (2009), commonly used in several types of research, presents results quite distinct to those obtained in this study, since values for the very high range, for example, are, in general, not greater than 30% (Tables 3 and 4). Thus, it is necessary to classify the CV considering each variable under study (COSTA; SERAPHIN; ZIMMERMANN, 2002; GARCIA, 1989).

However, the classification ranges proposed by Pimentel-Gomes (2009) were based not only on agricultural characteristics, but also on experimental designs, and should not be extended to any experiments.

According to methodology 3, during the evaluation period, the coefficients of variation for H range from 6.53% to 16.35%; for DB from 3.78% to 8.68%; for ChlorO 1.75% to 6.30%; for ChlorN from 4.2% to 7.77%; for DMAP from 10.84% to 29.86% and for DMRS from 8.09% to 18.68% (Table 4). Compared to the methodology of Pimentel-Gomes (2009), it was possible to state that the classification ranges are distinct since the low to very high ranges for the method of Costa, Seraphin and

Zimmermann (2002) would correspond to the low to average for Pimentel-Gomes (2009).

The amplitudes of the CV classifications between methods 1 and 3 presented 28 CV values below 1% and the highest value was 4.16, while for 1 and 2 only a unique CV value was below 1% and 28 were above 10%. For 2 and 3 no CV values below 1% were registered, while 32 CV values above 10% were found. This indicated the similarities between the methodologies calculated in this study. However, when compared to method 2, it can be suggest that the CV classifications are discrepant.

Table 3 - CV classification ranges calculated by Garcia's method (1989) at 30, 60, 90 and 120 days for the variables analyzed

Garcia (1989) Evaluations	Variable[1]	Low <	Medium			High			Very High >	Range
30 days	H	5.67	5.67	to	9.67	9.67	to	11.67	11.67	4.00
	DB	3.37	3.37	to	7.62	7.62	to	9.75	9.75	4.25
	ChlorO	1.19	1.19	to	5.71	5.71	to	7.97	7.97	4.52
	ChlorN	3.71	3.71	to	8.93	8.93	to	11.54	11.54	5.22
60 days	H	1.56	1.56	to	12.32	12.32	to	17.69	17.69	10.76
	DB	3.36	3.36	to	6.89	6.89	to	8.65	8.65	3.53
	ChlorO	1.58	1.58	to	3.39	3.39	to	4.30	4.30	1.81
	ChlorN	2.41	2.41	to	6.92	6.92	to	9.18	9.18	4.51
90 days	H	2.03	2.03	to	12.05	12.05	to	17.06	17.06	10.02
	DB	2.48	2.48	to	7.96	7.96	to	10.70	10.70	5.48
	ChlorO	0.64	0.64	to	6.71	6.71	to	9.75	9.75	6.07
	ChlorN	2.82	2.82	to	10.08	10.08	to	13.71	13.71	7.26
120 days	H	2.04	2.04	to	13.96	13.96	to	19.93	19.93	11.92
	DB	3.36	3.36	to	7.77	7.77	to	9.98	9.98	4.41
	ChlorO	2.05	2.05	to	5.99	5.99	to	7.96	7.96	3.94
	ChlorN	3.71	3.71	to	7.24	7.24	to	9.00	9.00	3.53
	DMAP	10.43	10.43	to	25.37	25.37	to	32.84	32.84	14.94
	DMRS	6.44	6.44	to	16.54	16.54	to	21.59	21.59	10.10
Pimentel-Gomes (2009)		<10	10	to	20	20	to	30	>30	20

[1]H: height; DB: stem at base diameter; ChlorO: chlorophyll content in old leaves; ChlorN: chlorophyll content in new leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system.

Table 4 - CV classification ranges calculated by the Costa, Seraphin and Zimmermann (2002) method at 30, 60, 90 and 120 days for the variables analyzed, and CV classification ranges recommended by Pimentel-Gomes (2009)

Costa, Seraphin and Zimmermann (2002) Evaluations	Variable[1]	Low <	Medium			High			Very High >	Range
30 days	H	6.53	6.53	to	8.86	8.86	to	10.03	10.03	3.50
	DB	3.78	3.78	to	7.12	7.12	to	8.79	8.79	5.01
	ChlorO	1.75	1.75	to	4.58	4.58	to	5.99	5.99	4.24
	ChlorN	4.20	4.20	to	8.36	8.36	to	10.44	10.44	6.24
60 days	H	2.10	2.10	to	9.92	9.92	to	13.83	13.83	11.73
	DB	3.62	3.62	to	6.58	6.58	to	8.06	8.06	4.44
	ChlorO	1.85	1.85	to	5.99	5.99	to	7.96	7.96	6.11
	ChlorN	2.81	2.81	to	6.16	6.16	to	7.83	7.83	5.02

Continuation table 4

90 days	H	2.07	2.07	to	9.29	9.29	to	12.90	12.90	10.83
	DB	2.66	2.66	to	7.01	7.01	to	9.19	9.19	6.53
	ChlorO	1.05	1.05	to	4.72	4.72	to	6.55	6.55	5.50
	ChlorN	3.44	3.44	to	8.35	8.35	to	10.80	10.80	7.36
120 days	H	2.49	2.49	to	11.73	11.73	to	16.35	16.35	13.86
	DB	4.04	4.04	to	7.14	7.14	to	8.68	8.68	4.64
	ChlorO	2.60	2.60	to	5.07	5.07	to	6.30	6.30	3.70
	ChlorN	4.40	4.40	to	6.65	6.65	to	7.77	7.77	3.37
	DMAP	10.84	10.84	to	23.52	23.52	to	29.86	29.86	19.02
	DMRS	8.09	8.09	to	15.15	15.15	to	18.68	18.68	10.59
Pimentel-Gomes (2009)		<10	10	to	20	20	to	30	>30	20

[1]H: height; DB: stem at base diameter; ChlorO: chlorophyll content in old leaves; ChlorN: chlorophyll content in new leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system.

Only the variable DMAP calculated in this study fits the method variable for both methods calculated in this study, the ranges found were equal to method 2; for the other variables the values were close between the calculated methods, but distinct from method 2.

Adherence and heterogeneity test for the blank test

To increase the experimental accuracy, the adherence and heterogeneity test was performed using Fisher's Exact Test for all variables in the blank test (Tables 5, 6, 7 and 8).

By the adherence test, at 30 days, all variables accepted the null hypothesis (frequencies observed equal to expected frequencies), *i.e.*, CV values following a normal distribution (CRUZ *et al.*, 2012), by methods 1 and 3, corroborating results obtained by the KS test; therefore, it is stated that these variables, by methods 1 and 3, did not depend on the KS test to obtain the CV classification table. For method 2, none of the variables followed a normal distribution (Table 5), which means that the observed frequencies were statistically different from the frequencies expected for a normal distribution. Moreover, for this method, normality tests are necessary to obtain the CV classification table.

At 30 days, for the heterogeneity test, all the variables analyzed were not significant between methods 1 and 3, indicating similarity between the proportions of CVs in the classification ranges of the compared methods. Therefore, it was concluded that there was no statistical difference in relation to the low, medium, high and very high limits for the methods used (CRUZ *et al.*, 2012). Thus, the classification ranges are similar. If no statistical differences exist, any of the methods for the classification of coefficient of variation ranges can be used for the data analyzed (Table 5).

For the other method comparison (2 and 3, 1 and 2) all the variables analyzed were significant different among each other (Table 5), showing that the classification ranges between the methods are different. Thus, it was possible to assert that these methods could be recommended, considering the nature of the data.

At the end of the 60 days, the adherence test shows the same behavior as in the 30 days *i.e*, the CV values calculated followed a normal distribution using methods 1 and 3. Regarding the method 2, none of the variables followed a normal distribution (Tabel 6). Thus, it is possible to affirm that even at 60 days, it is not necessary to perform normality tests by methods 1 and 3. However, the same pattern was not recorded for method 2.

By the heterogeneity test, at 60 days, the same pattern recorded in 30 days was observed. Between methods 1 and 3, it was possible to conclude that none were different and any of the methods could be recommended. For comparisons between 2 and 3 and 1 and 2, the proportions between the methods were similar, suggesting a specific approach in relation to the nature of the data (Table 6).

At 90 days, for the adherence test, by methods 1 and 3, the calculated CV values followed a normal distribution. Only for method 2 the variable did not follow a normal distribution (Table 7). This assessment followed the same behavior as previously recorded. Thus, it is possible to affirm that, considering methods 1 and 3, it is not necessary to perform normality tests. However, the same does not happen with method 2.

Table 5 - Comparison of the frequency of results of coefficients of variation (CV) for each variable in the classifications of Garcia (1989), Pimentel-Gomes (2009) and Costa, Seraphin and Zimmermann (2002) and the adherence and heterogeneity tests applied to variables at 30 days

		Classification of CV				Tests			
Range		Low	Medium	High	Very High	Adherence	Heterogeneity		
EFN (%)		15,7	68,3	13,6	2,3		Met		
Var	Met	Frequency obtained (%)					1	2	3
H	1	6.67	80	6.67	6.67	0.58^{ns}	-	0.00*	0.58^{ns}
	2	86.67	13.33	0.00	0.00	0.00*	-	-	0.00*
	3	20	66.67	0.00	13.33	0.36^{ns}	-	-	-
DB	1	18.75	62.50	12.50	6.25	1.00^{ns}	-	0.00*	1.00^{ns}
	2	93.75	6.25	0.00	0.00	0.00*	-	-	0.00*
	3	18.75	62.50	12.50	6.25	1.00^{ns}	-	-	-
ChlorO	1	11.76	76.47	5.88	5.88	1.00^{ns}	-	0.00*	0.69^{ns}
	2	100	0.00	0.00	0.00	0.00*	-	-	0.00*
	3	17.65	58.82	11.76	11.76	0.67^{ns}	-	-	-
ChlorN	1	11.76	76.47	5.88	5.88	1.00^{ns}	-	0.00*	0.86^{ns}
	2	94.12	5.88	0.00	0.00	0.00*	-	-	0.00*
	3	17.65	64.71	11.76	5.88	1.00^{ns}	-	-	-

1:Garcia (1989); 2:Pimentel-Gomes (2009); 3:Costa, Seraphin and Zimmermann (2002); H: height; DB: stem at base diameter; ChlorO: chlorophyll levels in old leaves; ChlorN: chlorophyll levels in new leaves. * significant and ^{ns} non-significant at 5% probability; EFN: Expected frequency of Normal (%); Var: Variables; Met: Methods.

Table 6 - Comparison of the frequency of results of coefficients of variation (CV) for each variable within the classifications of Garcia (1989), Pimentel-Gomes (2009) and Costa, Seraphin and Zimmermann (2002) and the adherence and heterogeneity tests applied to variables at 60 days

		Classification CV				Tests			
Ranges		Low	Medium	High	Very High	Adherence	Heterogeneity		
EFN (%)		15,7	68,3	13,6	2,3		Met		
Var	Met	Frequency obtained (%)					1	2	3
H	1	5.88	82.35	5.88	5.88	0.58^{ns}	-	0.00*	0.69^{ns}
	2	76.47	17.65	5.88	0.00	0.00*	-	-	0.00*
	3	11.76	64.71	11.76	11.76	0.22^{ns}	-	-	-
DB	1	12.50	75	6.25	6.25	1.00^{ns}	-	0.00*	1.00^{ns}
	2	100	0.00	0.00	0.00	0.00*	-	-	0.00*
	3	18.75	62.50	12.50	6.25	0.69^{ns}	-	-	-
ChlorO	1	6.67	86.67	0.00	6.67	0.20^{ns}	-	0.00*	0.68^{ns}
	2	100	0.00	0.00	0.00	0.00*	-	-	0.00*
	3	26.67	73.33	0.00	0.00	0.46^{ns}	-	-	-
ChlorN	1	6.25	75.00	6.25	0.00	0.49^{ns}	-	0.00*	0.73^{ns}
	2	100	0.00	0.00	0.00	0.00*	-	-	0.00*
	3	12.50	68.75	6.25	12.50	0.23^{ns}	-	-	-

1:Garcia (1989); 2:Pimentel-Gomes (2009); 3:Costa, Seraphin and Zimmermann (2002); H: height; DB: stem at base diameter; ChlorO: chlorophyll levels in old leaves; ChlorN: chlorophyll levels in new leaves. * significant and ^{ns} non-significant at 5% probability; EFN: Expected frequency of Normal (%); Var: Variables; Met: Methods.

Table 7 - Comparison of the frequency of results of coefficients of variation (CV) for each variable within the classifications of Garcia (1989), Pimentel-Gomes (2009) and Costa, Seraphin and Zimmermann (2002) and the adherence and heterogeneity tests applied to variables at 90 days

		Classification of CV				Tests			
Ranges		Low	Medium	High	Very High	Adherence	Heterogeneity		
EFN (%)		15.7	68.3	13.6	2.3		Met		
Var	Met	Frequency obtained (%)					1	2	3
H	1	0.00	82.35	11.76	5.88	0.31^{ns}	-	0.00*	1.00^{ns}
	2	76.47	17.65	5.88	0.00	0.00*	-	-	0.00*
	3	0.000	76.47	11.76	11.76	0.11^{ns}	-	-	-
DB	1	11.76	76.47	5.88	5.88	1.00^{ns}	-	0.00*	0.87^{ns}
	2	94.12	5.88	0.00	0.00	0.61^{ns}	-	-	0.00*
	3	11.76	64.71	11.76	11.76	0.67^{ns}	-	-	-
ChlorO	1	0.00	82.35	5.88	11.76	0.17^{ns}	-	0.00*	0.64^{ns}
	2	88.24	11.76	0.00	0.00	0.61^{ns}	-	-	0.00*
	3	11.76	64.71	5.88	17.65	0.59^{ns}	-	-	-
ChlorN	1	11.76	70.59	11.76	5.88	1.00^{ns}	-	0.00*	0.50^{ns}
	2	82.35	17.65	0.00	0.00	0.74^{ns}	-	-	0.00*
	3	17.65	64.71	0.00	17.65	0.49^{ns}	-	-	-

1:Garcia (1989); 2:Pimentel-Gomes (2009); 3:Costa, Seraphin and Zimmermann (2002); H: height; DB: stem at base diameter; ChlorO: chlorophyll levels in old leaves; ChlorN: chlorophyll levels in new leaves. * significant and ^{ns} non-significant at 5% probability; EFN: Expected frequency of Normal (%); Var: Variables; Met: Methods.

By the heterogeneity test, it was possible to concluded that, between methods 1 and 3, any of the methods can be recommended, while for the comparisons between methods 2 and 3 and 1 and 2, a more specific approach is recommended regarding the nature of the data (Table 7).

At 120 days, for the adherence test, using methods 1 and 3, all variables presented similarity with the normal distribution, while for method 2 only the variables DMAP and DMRS followed a normal distribution (Table 8).

From the heterogeneity test, it was possible to state that, between methods 1 and 3, a more specific approach is recommended in relation to the nature of the data, in all variables analyzed. For methods 2 and 3, any of the proposed methods could be used for the variable DMAP. Thus, it was concluded that between methods 1 and 2, a more specific approach is recommended in relation to variables H and DB. For the other variables, it was possible to concluded that any of the suggested methods can be used. Therefore, could be determine the method that best fits the data set, as well as the level of dependence on the classifications based on the normality tests (Table 8).

Since methods 1 and 3 were the most similar to normal (adherence test) and there was no difference among them or among evaluations (heterogeneity test), the recommendation of the CV classification table was based on the highest calculated values of adherence (Table 9). Therefore, the method 1 was recommended for the data calculated in the blank test.

Kolmogorov-Smirnov and Shapiro-Wilk for literature data

Regarding the data obtained in the literature, all variables presented normal distribution by the KS test. For the SW test, only the variables DML, LA and RL had a normal distribution, the others presented a non-normal distribution, at a significance level of 5% (Table 10).

Since for these data there were variables presenting different values in the two methods, following the criteria adopted, it was recommended the classification from the SW (Table 10), because the tests with the blank test were the only ones where it was found non-normality for some variables.

Tables of classification of the coefficient of variation by the methods of Garcia (1989), Costa, Seraphin and Zimmermann (2002) and Pimentel-Gomes (2009) for literature data

The CVs, by method 1, ranged from 9.08% to 41.19% for DMAP, 13.25% to 39.65%, 9.28% to 39.06% for DML, 9.25% to 31.12% for TDM, 9.11% to 42.15% for LA and 8.12% to 41.08% for RL. The smallest amplitudes are in variables H (19.92), DB (19.82) and TDM (21.87) (Table 11). As well as in the literature data related to the experiment in a blank test, it can also be seen that the values obtained in each range of classification of the variation coefficient are very peculiar for each variable, which indicates that the proposed variation of Pimentel-Gomes **classification** (2009) presents very different results when comparing to those obtained in this study (Tables 11 and 12). It can be highlighted the variables LA, RL, DMAP, and DMRS presented values greater than 30% in the average range, whereas for Pimentel-Gomes (2009) values greater than or equal to 30% should be considered very high.

Table 8 - Comparison of the frequency of results of coefficients of variation (CV) for each variable within the classifications of Garcia (1989), Pimentel-Gomes (2009) and Costa, Seraphin and Zimmermann (2002) and the adherence and heterogeneity tests applied to variables at 120 days

		Classification of CV				Testes			
Ranges		Low	Medium	High	Very High	Adherence	Heterogeneity		
EFN (%)		15,7	68,3	13,6	2,3		Met		
Var	Met	Frequency obtained (%)					1	2	3
H	1	0.00	88.24	5.88	5.88	0.30^{ns}	-	0.00*	1.00*
	2	76.47	17.65	5.88	0.00	0.00*	-	-	0.00*
	3	0.00	82.35	11.76	5.88	0.31^{ns}	-	-	-
DB	1	12.50	75	0.00	12.50	0.41^{ns}	-	0.00*	1.00*
	2	87.5	12.50	0.00	0.00	0.00*	-	-	0.00*
	3	18.75	68.75	0.00	12.50	0.36^{ns}	-	-	-
ChlorO	1	6.25	81.25	6.25	6.25	0.58^{ns}	-	0.00^{ns}	0.73*
	2	100	0.00	0.00	0.00	0.00*	-	-	0.00*
	3	18.75	62.50	6.25	12.50	0.67^{ns}	-	-	-
ChlorN	1	20	66.67	6.67	6.67	1.00^{ns}	-	0.00^{ns}	1.00*
	2	93.33	6.67	0.00	0.00	0.00*	-	-	0.00*
	3	20	66.67	6.67	6.67	1.00^{ns}	-	-	-
DMAP	1	11.76	70.59	11.76	5.88	1.00^{ns}	-	0.93^{ns}	1.00*
	2	11.76	58.82	23.53	5.88	0.68^{ns}	-	-	0.88^{ns}
	3	17.65	64.71	11.76	5.88	1.00^{ns}	-	-	-
DMRS	1	18.75	62.50	12.50	6.25	1.00^{ns}	-	0.87^{ns}	1.00*
	2	31.25	56.25	12.50	0.00	0.87^{ns}	-	-	0.69*
	3	25	56.25	6.25	12.50	0.62^{ns}	-	-	-

1:Garcia (1989); 2:Pimentel-Gomes (2009); 3:Costa, Seraphin and Zimmermann (2002); H: height; DB: stem at base diameter; ChlorO: chlorophyll levels in old leaves; ChlorN: chlorophyll levels in new leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system. * significant and ^{ns} non-significant at 5% probability; EFN: Expected frequency of Normal (%); Var: Variables; Met: Methods.

Table 9 - Recommendation of the coefficient of variation classification ranges for the blank test with Eucalyptus in a greenhouse

Variables	Low <	Medium			High			Very High >	Range
H	1.56	1.56	to	12.32	12.32	to	17.69	17.69	16.13
DB	3.37	3.37	to	7.62	7.62	to	9.75	9.75	6.38
ChlorO	1.19	1.19	to	5.71	5.71	to	7.97	7.97	6.78
ChlorN	3.71	3.71	to	8.93	8.93	to	11.54	11.54	7.83
DMAP	10.43	10.43	to	25.37	25.37	to	32.84	32.84	22.41
DMRS	6.44	6.44	to	16.54	16.54	to	21.59	21.59	15.15

H: height; DB: stem at base diameter; ChlorO: chlorophyll levels in old leaves; ChlorN: chlorophyll levels in new leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system.

Table 10 - Kolmogorov-Smirnov and Shapiro-Wilk normality tests for the variables found in the literature

Tests	Kolmogorov-Smirnov		Shapiro-Wilk		Distribution
Variables	Statistics	p-value	Statistics	p-value	
H	0.1406	0.0569	0.8358	0.0000	Non-Normal
DB	0.1270	0.1666	0.8812	0.0000	Non-Normal
DML	0.1156	0.9057	0.9457	0.2185	Normal
DMAP	0.2243	0.0655	0.8666	0.0007	Non-Normal
DMRS	0.1819	0.1015	0.7533	0.0000	Non-Normal
TDM	0.1848	0.3372	0.7761	0.0001	Non-Normal
LA	0.0968	0.9680	0.9496	0.2275	Normal
RL	0.1737	0.9978	0.8638	0.2782	Normal

H: height; DB: stem at base diameter; DML: dry mass of leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system; TDM: total dry mass; LA: leaf area; RL: root length

Table 11 - CV classification ranges calculated by Garcia's method (1989) for the variables found in the literature

Variables	Low <	Medium			High			Very High >	Range
H	5.81	5.81	to	19.09	19.09	to	25.73	25.73	19.92
DB	6.75	6.75	to	19.96	19.96	to	26.57	26.57	19.82
DML	9.28	9.28	to	29.13	29.13	to	39.06	39.06	29.78
DMAP	9.08	9.08	to	30.49	30.49	to	41.19	41.19	32.11
DMRS	13.25	13.25	to	30.85	30.85	to	39.65	39.65	26.40
TDM	9.25	9.25	to	23.83	23.83	to	31.12	31.12	21.87
LA	9.11	9.11	to	31.14	31.14	to	42.15	42.15	19.92
RL	8.12	8.12	to	30.09	30.09	to	41.08	41.08	19.82
Pimentel-Gomes (2009)	<10	10	to	20	20	to	30	>30	20

H: height; DB: stem at base diameter; DML: dry mass of leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system; TDM: total dry mass; LA: leaf area; RL: root length

The variations found by method 3 were: 3.81% to 24.54% for H, 6.06% to 22.11% for DB, 6.39% to 45.61% for DML, 8.71% to 35.12% DMAP, 13.39% to 38.42% for DMRS, 8.43% to 31.74% for TDM, 9.12% to 44.46% for LA and 12.31% to 31.67% for RL. The smallest amplitudes are in variables H (20.73), DB (16.05) and RL (19.36) (Table 12). Compared to the methodology of Pimentel-Gomes (2009), it was possible to assert that the classification ranges are distinct, with emphasis on the variables DMRS and RL, which for the low, medium, and high ranges present higher values than those proposed by Pimentel-Gomes (2009).

The amplitudes of the CV classifications between methods 1 and 3 presented 8 CV values below 1%, with the highest value registered of 9.41, while methods 1, 2 and 3 presented 6 CV values below 1% and 10 above 5%. In method 2 only one CV value was below 1%, while 12 CV values above 5% were registered. Thus, for most of the variables evaluated, there were similarities between the calculated classifications. Despite that, it was possible to affirm that those two were distinct from 2, because only for the variable TDM, in both tables, the ranges found were equal to 2, while for the other variables the values were different between the calculated methodologies and in relation to method 2.

Adherence and heterogeneity test for literature data

Using the adherence test, the probabilities for all variables were similar to the normal distribution by method 1, corroborating the KS test. For method 3, the variables DML, DMAP, DMRS, TDM, LA and RL were similar to normal distribution, while for method 2, only the variables DML, DMAP, TDM and LA. Variables H and DB were not similar to the normal distribution

Table 12 - CV classification ranges calculated by the Costa, Seraphin and Zimmermann methods (2002) for the variables found in the literature, and CV classification ranges recommended by Pimentel-Gomes (2009)

Costa, Seraphin and Zimmermann (2002) Variables	Low <	Medium			High			Very High >	Range
H	3.81	3.81	to	17.63	17.63	to	24.54	24.54	20.73
DB	6.06	6.06	to	16.76	16.76	to	22.11	22.11	16.05
DML	6.39	6.39	to	32.54	32.54	to	45.61	45.61	39.22
DMAP	8.71	8.71	to	26.32	26.32	to	35.12	35.12	26.41
DMRS	13.39	13.39	to	30.07	30.07	to	38.42	38.42	25.03
TDM	8.43	8.43	to	23.97	23.97	to	31.74	31.74	23.31
LA	9.12	9.12	to	32.68	32.68	to	44.46	44.46	35.34
RL	12.31	12.31	to	25.21	25.21	to	31.67	31.67	19.36
Pimentel-Gomes (2009)	<10	10	to	20	20	to	30	>30	20

H: height; SD: stem at base diameter; DML: dry mass of leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system; TDM: total dry mass; LA: leaf area; RL: root length

Table 13 - Comparison of the frequency of results of coefficients of variation (CV) for each variable within the classifications of Garcia (1989), Pimentel-Gomes (2009) and Costa, Seraphin and Zimmermann (2002) and the adherence and heterogeneity tests applied to variables in the literature

		Classification of CV				Tests			
Ranges		Low	Medium	High	Very High	Adherence	Heterogeneity		
EFN (%)		15.7	68.3	13.6	2.3		Met		
Var	Met	Frequency obtained (%)					1	2	3
H	1	10.11	74.16	12.36	3.37	2.88^{ns}	-	127.84*	8.07*
	2	46.07	40.45	11.24	2.25	61.63*	-	-	26.33*
	3	2.25	75.28	17.98	4.49	14.23*	-	-	-
DB	1	11.84	72.37	10.53	5.26	4.47^{ns}	-	38.87*	13.15*
	2	34.21	50.00	13.16	2.63	19.89*	-	-	53.84*
	3	10.53	67.11	7.89	14.47	52.91*	-	-	-
DML	1	16.67	62.50	20.83	0.00	0.91^{ns}	-	0.61^{ns}	1.45^{ns}
	2	20.83	29.17	41.67	8.33	0.38^{ns}	-	-	0.47^{ns}
	3	12.50	83.33	4.17	0.00	0.47^{ns}	-	-	-
DMAP	1	8.82	76.47	11.76	2.94	0.86^{ns}	-	0.70^{ns}	0.93^{ns}
	2	8.82	58.82	14.71	17.65	0.25^{ns}	-	-	0.79^{ns}
	3	8.82	73.53	5.88	11.76	0.34^{ns}	-	-	-
DMRS	1	16.28	67.44	13.95	2.33	0.01^{ns}	-	123.91^{ns}	2.06^{ns}
	2	2.33	39.53	41.86	16.28	72.52*	-	-	99.70^{ns}
	3	16.28	67.44	11.63	4.65	1.20^{ns}	-	-	-
TDM	1	16.00	68.00	12.00	4.00	1.00^{ns}	-	0.46^{ns}	1.00^{ns}
	2	20.00	48.00	28.00	4.00	0.46^{ns}	-	-	0.46^{ns}
	3	16.00	68.00	12.00	4.00	1.00^{ns}	-	-	-
LA	1	23.08	61.54	15.38	0.00	1.00^{ns}	-	0.16^{ns}	1.00^{ns}
	2	23.08	23.08	38.46	15.38	0.10^{ns}	-	-	0.16^{ns}
	3	23.08	61.54	15.38	0.00	1.00^{ns}	-	-	-

Continuation table 13

	1	10.11	74.16	12.36	3.37	2.88^{ns}	-	127.84*	8.07*
RL	2	46.07	40.45	11.24	2.25	61.63^{ns}	-	-	26.33*
	3	2.25	75.28	17.98	4.49	14.23^{ns}	-	-	-

1: Garcia (1989); 2:Pimentel-Gomes (2009); 3: Costa, Seraphin and Zimmermann (2002); H: height; SD: stem at base diameter; DML: dry mass of leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system; TDM: total dry mass; NF: number of leaves; LA: leaf area; RL: root length. * significant and ^{ns} not significant at 5% probability.

Table 14 - Recommendation of the classification ranges of the coefficient of variation with Eucalyptus data obtained in the literature

Variables	Low <	Medium			High			Very High >	Range
H	5.81	5.81	to	19.09	19.09	to	25.73	25.73	19.92
DB	6.75	6.75	to	19.96	19.96	to	26.57	26.57	19.82
DML	9.28	9.28	to	29.13	29.13	to	39.06	39.06	29.78
DMAP	9.08	9.08	to	30.49	30.49	to	41.19	41.19	32.11
DMRS	13.25	13.25	to	30.85	30.85	to	39.65	39.65	26.40
TDM	9.25	9.25	to	23.83	23.83	to	31.12	31.12	21.87
LA	9.11	9.11	to	31.14	31.14	to	42.15	42.15	33.04
RL	8.12	8.12	to	30.09	30.09	to	41.08	41.08	32.96

H: height; DB: stem at base diameter; DML: dry mass of leaves; DMAP: dry mass of the aerial part; DMRS: dry mass of the root system; TDM: total dry mass; LA: leaf area; RL: root length.

by methods 2 and 3, corroborating SW test (Table 13). Therefore, it is suggested that for the variables showing a normal distribution by the adherence test, the obtained data classification table does not depend on the normality of the test. Different behavior was recorded for other variables not preseting normality, whose observed frequencies were statistically different from those expected for a normal distribution, which means that only the adherence test is not enough to come to a conclusion and that normality tests are needed.

Although considering the heterogeneity test, only variables H, DB and RL were significant in the comparison between the tables of methods 2 and 3. For the comparison between methods 1 and 2, the same variables (H, DB, and RL) were significant. For comparison between methods 1 and 3, variables H, DB and RL were significant, meaning that the proportions between classification ranges among the methods tested presented different behavior for those variables, in all comparisons, for the highlighted variables. Therefore, it is necessary to consider the characteristics of the analyzed variables to determine the appropriate classification range. For the remaining variables, no significant differences were registered between the methods tested. Thus, it was possible to suggest that the classification ranges were similar (Table 13).

The method that best fits the data obtained in the literature was method 1, since it was the only method that resembled the normal distribution in all variables by the adherence test (Table 14).

Comparison between data obtained with blank test and literature data

In the heterogeneity test comparing the classification tables from the blank test (Table 9) and from the literature data (Table 14) no significant differences between the tables generated for the variables tested were registered. Therefore, using only these variables as standard, it was possible to suggest that there was no difference in using either of the two recommendation tables for the variables H, DB, DMAP and DMRS.

For the variables not evaluated in this study, care should be taken with the inferences made, because there are many factors that may change them. Because the nature of the data and the place where the study was conducted should be taken into account (CARGNELUTTI FILHO *et al.*, 2011), requiring, therefore, a specific classification of the CVs associated with each variable studied (SCHMILDT *et al.*, 2017).

According to the classification recommended in this study, the following studies presented a high precision, for the following variables: Tatagiba *et al.* (2015) and Salles *et al.*

(2012) with coefficients of variation of 3.5% and 6.75%, respectively for the variable H; Santos Junior *et al.* (2015) and Medeiros *et al.* (2016) with a CV of 3.79% and 7.95%, respectively for the variable DB; Stahl *et al.* (2013) and Dias *et al*. (2015) with a CV of 6.7% and 10.5%, in sequence, for the variable DMAP and Xavier *et al*. (2013) with a CV of 2.46% for the variable DMRS.

CONCLUSION

1. Data obtained with the experiments with eucalyptus in the present research did not fit the classification of Pimentel-Gomes (2009) and tables obtained by Costa, Seraphin and Zimmermann (2002), whereas the tables obtained by means of the method proposed by Garcia (1989) would be preferably used;
2. Results obtained with the present research may serve as a basis for assisting other researchers in choosing appropriate CV classification ranges to data sets with eucalyptus seedlings.

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