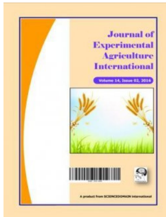

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Sample Size and Pearson's Correlation on the Characteristics of the Crambe and Sunflower Plants

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Authors' contributions

This work was carried out in collaboration between all the authors. Authors LGSL, WKOM, RLLO, RTLS, LEFM, designed, performed a statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors WKOM, WCP, GMA and LFOR were able to analyze the study. The authors SKAS, EGS managed the bibliographic research. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Determine the sample size and the Pearson correlation between the characteristics of the crambe and sunflower plants.

Study Design: Samples were collected from 108 crambe and sunflower plants.

Place and Duration of Study: The research was carried out at the Federal Rural University of Amazonia from November 2014 to February 2015.

Methodology: The data for 108 plants was subjected to a descriptive analysis of each variable and, subsequently, the sample size was estimated (η), with a mid-range of the confidence intervals of 1%, 5%, 10%, 15%, and 20% of the average (m) and a 95% coefficient of confidence. The sample size was obtained through the expression $t_{\alpha/2}$, which it is the critical value of the Student t distribution, whose area, on the right, is the same as $\alpha/2$, thus, the value of t, such that $P\left[t > t_{\alpha/2}\right] = \alpha/2$, with $(n-1)$ degrees of freedom, with $(\alpha > 5\%)$ of margin of error, and s^2 is the variance estimate.

Results: The analyzed data displayed relatively high coefficients of variation for some parameters, while the number of grains of the lower raceme and the number of grains of the higher raceme demonstrated superior dispersal data for the crambe. For the sunflower, the number of seeds by section, and the mass of the section with and without seeds displayed high variability, and consequently, higher sampling demand numbers. Supplementary relevant points were that there were strong correlations between the mass of the section without seeds as opposed to the mass of the section with seeds.

Conclusion: Of the characteristics of the crambe and sunflower plants that were observed, the sample sizes required are larger than the ones analyzed here in order to properly estimate the parameters and Pearson's linear correlation coefficient.

Keywords: Agronomic experimentation; Crambe abyssinica; Helianthus annuus L; oleaginous.

1. INTRODUCTION

A significant amount of the energy used world widely is obtained from non-renewable sources, however, the increasing pursuit of renewable energy sources has led to studying plants that could be used to produce biodiesel [1]. The cultures of crambe and the sunflower plants can serve as excellent alternatives for use as raw material for the production of energy which can generate less pollution, and increase the value of these oilseeds in national and international economic scenarios [2]. Given this context, the studies regarding these cultures became relevant mainly due to the measurement of several characteristics, which are common and of great importance, given that time, labor, financial and human resources, often limit the evaluation of a great number of plants, especially, when a large amount of characteristics need to be measured [3-4]. In this study, the sample size has been analyzed in order to estimate the characteristics of several cultures, such as: soy [5]; corn [6-7]; beans [8]; sugar-cane [9]; castor beans [10], and crambe [11] and the tomato crop in portion numbers [12]. Therefore, this experiment was conducted to generate information about these cultures for the local authority of Capitão Poço, given the economic potential of these specimens, along with the fact that the current literature lacks works that addresses this subject in the region.

Therefore, the determination of an appropriate number of experimental units is of significant relevance to reduce experimental error, consequently, increasing statistical precision of the estimate of the characteristics of plant growth and production. The objective of this work was to ascertain the sample size(s) and Pearson's correlation for selected characteristics of crambe and sunflower plants.

2. MATERIALS AND METHODS

2.1 Area of Study

The experiment was performed in a greenhouse, on the campus of Capitão Poço of the Federal Rural University of the Amazon, state of Pará (Brazil). Below, in Fig. 1, the microclimate of the interior of the greenhouse used is displayed.

2.2 Soil Characteristics for the Experiment

The soil utilized is classified as yellow latosol ('Latossolo Amarelo') [13]. The curve of soil moisture was determined, and expressed the relationship between the contents in the water, on a basis of mass or volume, and the matrix potential of water in the soil, i.e., the bond strength between the water molecules and the soil particles. The physical and chemical characteristics are as follows: pH of water = 4,5; electrical conductivity = 0.25 (1000 micro Siemens per centimeter) dS m^{-1}; Ca^{2+} = 0.70 centimoles per kilogram ($cmolc.Kg^{-1}$); Mg^{2+} = 0.60 $cmolc.Kg^{-1}$; In^{+} = 0,05 $cmolc.Kg^{-1}$; K^{+} = 0.09 $cmolc.Kg^{-1}$; H^{+} + Al^{3+} = 4.46 $cmolc.Kg^{-1}$; Al^{3+} = 0.0 $cmolc.Kg^{-1}$; S = 1.4 $cmolc.Kg^{-1}$; T = 5.9 $cmolc.Kg^{-1}$; C = 8.52 $g.Kg^{-1}$; N = 0.86 $g.Kg^{-1}$; C/N = 10; organic matter = 14.69 (gram per kilogram) $g.Kg^{-1}$; cation exchange capacity = 2.2 $cmolc.Kg^{-1}$; V = 24%; m = 36%; P-Assimilable = 8 (milligram per kilogram) $mg.kg^{-1}$; θFC (100 kPa) = 17.82%; θWP (1500 kPa) = 7.13%; ds = 1.93 (grams per cubic centimeter) $g.cm^{-3}$; dp = 2.85 $g.cm^{-3}$.

2.3 Experimental Procedures

The planting of crambe to cultivate 'Brilliant FMS' was carried out in November of 2014, when 108 plants were cultivated, while the sunflower cultivation occurred on the 20th of October of 2014, with 139 experimental units (Fig. 2). The total space provision for the units of both cultures was 0.7 m X 0.5 m, between lines and plants respectively. The amount of fertilizer applied for planting was 35 kilograms per hectare ($kg.ha^{-1}$) of N; 140 $kg.ha^{-1}$ of P_2O_5, and 140 $kg.ha^{-1}$ of K_2O (for Crambe), and 80 $kg.ha^{-1}$ of P_2O_5; 80 kg/ha^{-1} of K_2O and 60 kg/ha^{-1} of N, (for Sunflower) respectively [14-15]. The measured characteristics of the crambe and sunflower plants can be found in Table 1.

2.4 Statistical Procedures

Initially, for each character, the measures of central tendency, variability, asymmetry, and kurtosis were calculated, and the normality was verified through the Kolmogorov-Smirnov test [16]. The data was subjected to the descriptive analysis of each variable, and subsequently, the sample size was estimated (η), with a mid-range of the confidence interval of 1%, 5%, 10%, 15%, and 20% of the average (m), and a 95% coefficient of confidence.

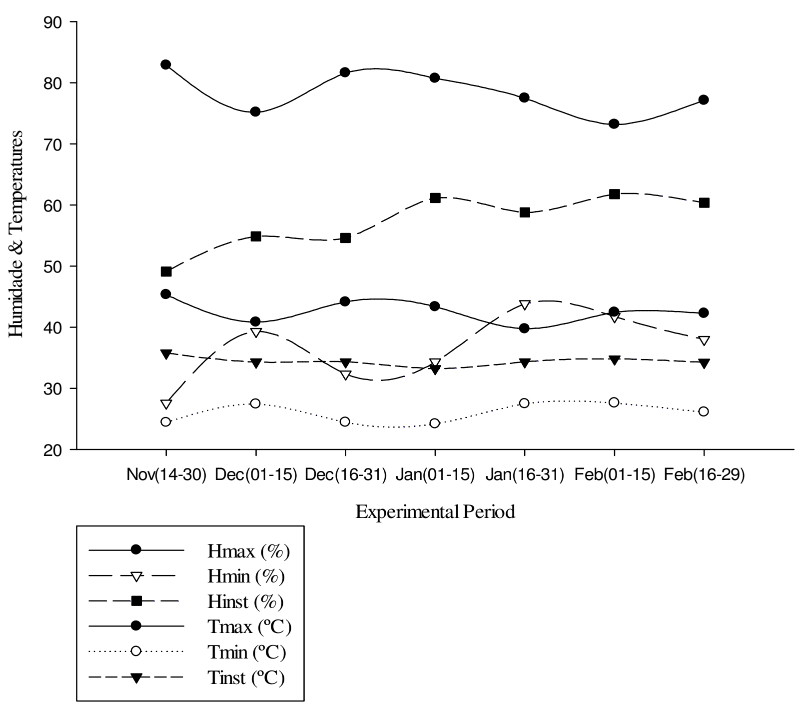

Fig. 1. Monitoring of the microclimate of the greenhouse during the cycle of sunflower and crambe plants, with a biweekly average, from November 2014 to February 2015

Parameters are: Maximum temperature (Tmax); minimum temperature (Tmin), instantaneous temperature (Tinst), maximum humidity (Hmax), minimum humidity (Hmin), instantaneous humidity (Hinst)

Fig. 2. Illustration of the space distribution in the experimental units for the Crambe and Sunflower crop

Table 1. Abbreviation and units for 13 evaluated characteristics of 108 crambe and 139 sunflower plants respectively

Crambe		
Characteristics	**Abbreviation**	**Unit**
Height of the Crambe	HC	Cm
Length of the plants' main racemes	LPR	Cm
Number of racemes	NR	Un
Length of the racemes of the inferior third	LRI	Cm
Length of the racemes of the middle third	LRM	Cm
Length of the racemes of the superior third	LRS	Cm
Number of grains of the racemes of the inferior third	NGI	Un
Number of grains of the racemes of the middle third	NGM	Un
Number of grains of the racemes of the superior third	NGS	Un
Mass of the grains of the racemes of the inferior third	MGI	g plant^{-1}
Mass of the grains of the racemes of the middle third	MGM	g plant^{-1}
Mass of the grains of the racemes of the superior third	MGS	g plant^{-1}
Total mass of the racemes' grains	TM	g plant^{-1}
Sunflower		
Characteristics	Abbreviation	Unit
Total seed mass	SM	g plant^{-1}
Seed length	SL	Mm
Seed width	SW	Mm
Diameter of the gathering	D	Cm
Leaf area	LA	cm^2
Height of the Sunflower plant	HSP	Cm
Height of the flower bud	HF	Cm
Numbers of Leaves	NL	Un
Diameter of the Chapter	DC	Cm
Numbers of seeds by section	NSS	Un
Mass of the section with seeds	MSW	g plant^{-1}
Mass of the section without seeds	MSWS	g plant^{-1}
Sunflower Yield	SY	g plant^{-1}

The sample size was obtained through the following expression:

$$n = \frac{t^2_{\alpha/2} \quad s^2}{(estimation\ of\ error\ )^2}$$

[17-18], in which $t_{\alpha/2}$ is the critical value of distribution of Student t, whose area, on the right, equals $\alpha/2$, thus, the value of t, hence $P\left[t > t_{\alpha/2}\right] = \alpha/2$ degrees of freedom, with $\alpha = 5\%$ of error probability, and s^2 is the variance estimate. The analyses were performed using the Microsoft Office Excel® (2012) electronic spreadsheet, and Sisvar software [19].

3. RESULTS AND DISCUSSION

3.1 Crambe Crop

Based on the assessed characteristics of the crambe culture, it was possible to obtain, the mean, maxim, minimum, median, variance, kurtosis, asymmetry, standard deviation, and interval for the characteristics of the crambe plants (Table 2).

Based on the results generated by the descriptive statistics of the data (Table 2), five of the studied variables had a high coefficient of variation, being: NR, MGI, MGM, MGS and TMG, thus showing that among the studied variables these showed a greater dispersion of the data. This increase in the coefficient of variation suggests that the sample to estimate these variables should be higher because according to [20] the coefficient of variation is used to measure this instability of a certain variable since it is responsible for quantifying the variability of the data representing the average. The variability can occur between characters and between environments, so the higher the coefficient of variation, the larger the data collection should be in order to estimate the average with the same precision of the other variables [21].

Note that among the studied variables the coefficient of variation was high in productive characters, when compared to the morphological variables. Similar results were found [22] in the cultivar of the guandu Bean, in the tomato crop by Lúcio et al. [12] and Lúcio et al. [23] in crambe.

The set of characters presented adequate indexes of normality, characterized mainly by the positive asymmetry of the data distribution (Table 2). The MGM, MGS, and TMG, besides positive asymmetry, presented kurtosis different from three, which characterizes the degree of flattening distribution as leptocúrtica [24].

For the crambe culture, the magnitudes ranged from [r] -0.19 to 0.92, where 15% of the pairs presented negative correlation, and 85% of the analyzed pairs obtained a positive regression function with a mean of magnitude [r] of 0.27 (Table 3). According to Lúcio et al. [23] this oscillation of the magnitude reveals that respectively there was absence of linear relationship and perfect positive linear relationship between the evaluated characters. With the increase in the number of sample units, the estimates of r are believed to increase precision, and thus, linear associations of low magnitude (r close to zero) are significant [25].

The half-amplitude when the experimental precision reduction at the 20% level of error showed that the characters: LPR, LRI and LRM, were the characters that presented the lowest unit requirement experimental, where with only three plants was enough to accurately estimate the characters (Table 4). Works performed by [26], also with the crambe crop presented similar results to that of the present study, where for the 20% error, for the characters plant height and length of the main racemo, presented a minimum number of 3 to 5 plants to estimate the data. The study conducted for [22] found that the variability of the sample size in the pigeon pea crop is subdivided into morphological and productive characters, and for the latter it is necessary to increase the number of experimental units to obtain the same accuracy of the characters morphological. However, for [23], they observed in papaya the increasing size of the sample according to the biometric variable studied.

The estimation of the sample size for the crambe production characters, and the semi-amplitude, shows the relation with degree of impact in the experiment, as evidenced in Table 4. With an estimate of 1% of error, the following variables: NGM, NGS and MGI, showed a greater need of plants per sample, being contrary to these, the length of the main leaves and the length of the lower average leaves, since the statistical lower requirement of experimental units.

Studies developed by Cargnelutti et al. [27], showed that the sample size to evaluate plant height, collection diameter, and plant height / diameter ratio of canjerana seedlings is dependent on the age of evaluation, and according to this study, the tubetes, substrates, ages of evaluation and 18 plants per experimental unit are sufficient, for estimation of the average of these characters, for an error of estimation equal to 10%. In this case, to obtain greater statistical precision, a larger number of samples would be necessary. Cargnelutti et al. [8] observed that in order to improve the accuracy of character evaluation in bean plants, a greater number of replicates and at least 10 plants per experimental unit should be used. In soybean the same author observed that to use a greater number of repetitions and at least 12 plants per experimental unit is enough also to have greater accuracy of the evaluated characters [28].

3.2 Culture of Sunflower

From the characteristics evaluated for the sunflower culture, the mean, maximum, minimum, median, variance, kurtosis, asymmetry, standard deviation, and the interval between the sunflower's characteristics are shown in (Table 5).

The variables, number of seed per chapter, seeded and seedless mass presented high variability, which consequently demanded larger sample numbers, since the same influence directly on the sampling in relation to the experimental precision (Table 5). According to Facco [22], this result suggests that a larger sample size (number of plants) is necessary to estimate the mean of these variables. In his research Cargnelutti et al. [29], it was concluded that the sample size to evaluate MF, MC, MA, DL, and DT of pecan fruits is cultivar-dependent and will be larger for cultivars with greater variability and vice versa.

Table 2. Descriptive statistics: the mean (Med), maximum (Max), minimum (Min), median (Medi), variance (Var), kurtosis (Kur), asymmetry (Ass), standard deviation (SD), interval (Int), and coefficient of variation (CV%) of 108 crambe plants

Characteristics(1)	Med	Max	Min	Medi	Var	Kur	Ass	SD	Int	CV%
HC	29.11	50.12	13.48	28.64	39.01	0.3	0.33	6.27	0.43	21.55
LPR	76.48	126.0	39.9	76.5	232.7	0.3	0.15	15.33	1.04	20.04
NR	37.57	99.0	12.5	34.00	245.41	2.00	1.21	15.74	1.07	41.89
LRI	27.5	57.9	17.3	25.7	49.42	3.16	1.55	7.06	0.48	25.68
LRM	22.97	38.0	15.2	21.9	22	0.86	1.02	4.71	0.32	20.51
LRS	19.35	36.0	10.6	19.1	19.18	1.79	0.9	4.4	0.3	22.74
NGI	28.18	59.0	18.0	26.4	50.59	3.27	1.56	7.15	0.49	25.36
NGM	23.68	39.0	4.0	23	25.9	2.18	0.36	5.11	0.35	21.59
NGS	20.12	37.0	1.0	20	22.1	3.24	0.18	4.72	0.32	23.47
MGI	0.9	3.0	0.14	0.7	0.41	1.78	1.56	0.65	0.04	71.53
MGM	0.58	2.21	0.01	0.4	0.17	5.00	2.25	0.42	0.03	72.13
MGS	0.36	2.0	0,00	0.36	0.08	12.47	2.73	0.29	0.02	80.0
TMG	1.84	6.82	0.15	1.44	1.47	4.26	1.95	1.22	0.08	66.2

(1)Abbreviations are defined in Table 1

Table 3. Pearson Linear correlation matrix for 13 characteristics of crambe

Characteristics	HC	LPR	NR	LRIT	LRM	LRS	NGI	NGM	NGS	MGI	MGM	MGS	TM
HC		0.62	0.54	0.20	0.25	0.18	0.19	0.12	0.00	0.11	0.14	0.12	0.15
LPR	**		0.55	0.09	0.11	0.09	0.25	0.26	0.04	0.18	0.18	0.20	0.21
NR	**	**		-0.06	-0.09	-0.03	0.35	0.23	-0.04	0.20	0.18	0.18	0.24
LRI	**	ns	ns		0.43	0.23	-0.18	-0.19	-0.05	-0.06	0.20	0.09	0.02
LRM	**	ns	ns	**		0.66	0.04	-0.06	0.18	0.07	0.15	-0.01	0.09
LRS	**	ns	ns	**	**		0.10	-0.06	0.00	0.06	0.11	-0.03	0.04
NGI	**	**	**	**	Ns	ns		0.72	0.07	0.71	0.41	0.34	0.75
NGM	ns	**	**	**	Ns	ns	**		0.10	0.63	0.58	0.55	0.74
NGS	ns	ns	ns	ns	**	ns	ns	ns		0.05	0.06	0.03	0.06
MGI	ns	*	**	ns	Ns	ns	**	**	ns		0.46	0.42	0.92
MGM	*	**	**	**	*	ns	**	**	ns	**		0.52	0.63
MGS	ns	**	*	ns	Ns	ns	**	**	ns	**	**		0.63
TM	*	**	**	ns	Ns	ns	**	**	ns	**	**	**	

*** Significant at the level of 1% of probability (P ≤ 0.01), * significant at the level of 5% of probability (P ≤ 0.05), 'ns' stands for 'not significant' (P ≤ 0.05). (1) Abbreviations defined in Table 1*

Table 4. Sample size required to estimation of the mean, with mid-range of the confidence interval of 95% equal to 1%, 5%, 10%, 15%, and 20% of the average (errors) of the characteristics of 108 crambe plants

Error(1)	HC	LPR	NR	LRI	LRM	LRS	NGI	NGM	NGS	MGI	MGM	MGS	TM
1%	1752	1376	7934	1355	1873	5312	56210	39946	577192	53019	46589	63252	38459
5%	70	55	317	54	75	212	2248	1598	23088	2121	1864	2530	1538
10%	18	14	79	14	19	53	562	399	5772	530	466	633	385
15%	8	6	35	6	8	24	250	178	2565	236	207	281	171
20%	4	3	20	3	5	13	141	100	1443	133	116	158	96

(1) Abbreviations defined in Table 1

Table 5. Descriptive statistics: the mean (Med), maximum (Max), minimum (Min), median (Medi), variance (Var), kurtosis (Kur), asymmetry (Ass), standard deviation (SD), interval (Int), and coefficient of variation (CV%) for 139 sunflower plants

Characteristics(1)	Med	Max	Min	Medi	Var	Kur	Ass	SD	Int	CV %
D	7.78	10.45	5.45	7.71	0.68	0.76	0.28	0.83	0.05	10.63
NL	14.4	18.6	9.91	14.6	1.85	1.44	-0.29	1.36	0.08	9.44
LA	725.53	1739.3	296.13	705.94	39378.3	5.07	1.26	199.16	11.39	27.45
HSP	60.32	161.1	44.63	59.83	104.8	67.33	6.9	10.28	0.59	17.03
HFB	79.5	99.9	62.2	79.1	53.6	0.01	0.3	7.35	0.42	9.23
DC	85.2	155.4	32	85.12	291.2	2.66	0.58	17.13	0.98	20.1
MSW	51.44	265.1	6.5	39.06	1565.4	7.27	2.13	39.71	2.27	77.19
MSWS	39.14	237.5	3.51	28.95	1229.8	9.97	2.53	35.2	2.01	89.93
TMS	6.47	34.2	1.12	5.71	16.9	15.5	3.04	4.14	0.24	63.9
NSS	369.22	810	100	378	24345.7	0.1	0.46	156.6	8.96	42.41
SY	0.02	0.06	0.01	0.02	0	3.21	1.91	0.01	0	67.4
CL	10.2	30.3	7	10	3.99	73.4	7.34	2.01	0.11	19.5
SW	5.29	6.92	3.4	5.24	0.63	-0.45	0.05	0.79	0.05	15

(1) Abbreviations defined in Table 1

Table 6. Pearson linear correlation matrix for 13 sunflower characteristics

Characteristics(1)	D	NL	LA	HSP	HFB	DC	SY	NSS	MSW	MSWS	TMS	SL	SW
D		0.47	0.80	0.14	0.21	-0.26	0.06	-0.02	-0.22	-0.20	0.00	-0.07	-0.17
NL	**		0.46	0.17	0.34	-0.14	-0.09	0.05	-0.11	-0.14	0.04	-0.27	-0.24
LA	**	**		0.10	0.09	-0.25	-0.01	-0.07	-0.22	-0.21	-0.05	-0.09	-0.11
HSP	ns	*	ns		0.52	0.00	-0.03	0.07	0.01	0.00	0.04	-0.09	-0.07
HFB	**	**	ns	**		-0.19	0.10	0.13	-0.19	-0.21	0.08	-0.13	-0.26
DC	**	ns	**	ns	*		-0.11	0.17	0.86	0.83	0.34	0.26	0.44
SY	ns	ns	ns	ns	Ns	ns		0.10	-0.08	-0.08	0.04	0.61	-0.45
NSS	ns	ns	ns	ns	Ns	*	ns		0.06	0.05	0.32	-0.08	-0.22
MSW	**	ns	**	ns	*	**	ns	ns		0.98	0.26	0.28	0.42
MSWS	**	ns	**	ns	**	**	ns	ns	**		0.20	0.28	0.42
TMS	ns	ns	ns	ns	Ns	**	ns	**	**	**		0.07	0.03
SL	ns	**	ns	ns	Ns	**	**	ns	**	**	ns		0.41
SW	*	**	ns	ns	**	**	**	**	**	**	ns	**	

*** Significant at the level of 1% of probability (P ≤ 0.01), * significant at the level of 5% of probability (P ≤ 0.05), 'ns' stands for 'not significant' (P ≤ 0.05). (1) Abbreviations defined in Table 1*

Sunflower characters had correlations ranging from (r = -0.45 to .98), where 55% of the pairs showed positive values, and the other associations 45% had negative intensities (Table 6).

Significant linear correlations among sunflower variables are weak, corroborating descriptive descriptions. Other relevant points were the very strong correlations between the mass of the seedless chapter as a function of the mass of the seed chapter (r = 0.98), the diameter of the chapter as a function of the mass of the seed and seed chapter, where the approximation factor between both were of (r = 0.86 and 0.83), the other variables presented a very weak to moderate correlation (Table 6). In theory, the value of p is a continuous measure of evidence, but in practice it is usually trichotomized approximately in highly significant, marginally significant, and not statistically significant at conventional levels, as cutoff point p≤0.01, p≤0.05 and p> 0,10 [29].

In sunflower cultivation at 1% of the average, the mass characters of the seed and seedless chapter, seed number per chapter, grain yield per plant and total seed mass, showed high demand in sample unit, to determine with Statistical analyzes were performed, and when the values followed for reduced levels of half-amplitude, the unit requirements were minimal (Table 7). For Cargnelutti et al. [30], working with pecan culture, observed high numbers of samples to estimate 1% of the MF, MC, MA, DL and DT characters in six cultivars, and concluded that it is difficult to high number of fruits to be measured. In black oat for the estimation of morphological and productive characters, for a maximum estimation error of 20% of the mean, with a confidence level of 95%, 47 plants are sufficient [31]. Toebe et al. [32] reported that

Table 7. Sample size for estimating the mean, with mid-range of the 95% confidence interval equal to 1%, 5%, 10%, 15%, and 20% of the average (ERROR) of the characteristics for 139 sunflower plants

Error(1)	D	NL	LA	HSP	HFB	DC	MSW	MSWS	TMS	NSS	SY	SL	SW
1%	431	341	2874	1107	166	1542	22725	30847	15616	6861	17237	1462	862
5%	17	14	115	44	7	62	909	1234	625	274	689	58	34
10%	4	3	29	11	2	15	227	308	156	69	172	15	9
15%	2	2	13	5	1	7	101	137	69	30	77	6	4
20%	1	1	7	3	0	4	57	77	39	17	43	4	2

(1) Abbreviations defined in Table 1

different sample sizes are expected due to the intrinsic variability between the variables and between the cultures. It is up to the researcher to evaluate the availability of time, financial and human resources, which is the tolerated error limit, and consequently, what is the appropriate sample size based on the results of the work.

There is variability between some characteristics analyzed to estimate the size of samples required to estimate characteristics with precision, since there is a demand for a higher number of experimental units to increase the experimental reliability. It was observed that to estimate the average of production and morphological characteristics of white lupin, with a confidence interval of 95%, equal to 25% of the estimate of the average, 81 plants are necessary [33]. Additionally, to estimate the median with the same precision, 129 plants are sufficient. In corn plants, the sample size may vary between hybrids, harvests and characteristic pairs. Larger sample sizes are necessary to estimate the coefficient of correlation, for weakly correlated characteristics, a small sample size is required to estimate the coefficient of correlation between highly correlated characteristics [34].

4. CONCLUSION

For the characteristics of the crambe and the sunflower, a larger sample size is necessary that what was used in this study, in order to estimate the parameters, and the Pearson correlation coefficient with finer statistical precision.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Santos RF, Borsoi A, Delai JM, & Siqueira JAC. Arranjo produtivo e econômico de produção de biodiesel pela agricultura familiar no Oeste do Paraná. Acta Iguazu. 2014;3(1):126-134.
2. Amaro HTR, David AMSS, Neta ICS, Assis, MO, Araújo EF, Araújo RF. Accelerated aging testin seeds of crambe (*Crambe abyssinica* Hochst), cultivar FMS Brilhante. Revista Ceres. 2014;61(2):202-208.
   Available:http://dx.doi.org/10.1590/S0034-737X2014000200007
   (Accessed on November 30, 2018)
3. Cruz CD, Carneiro PCS. Modelos biométricos aplicados ao melhoramento genético. Viçosa: UFV. 2003;585.
4. Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL. Multivariate analysis of data. 6. ed. Porto Alegre: Bookman; 2009.
5. Cargnelutti Filho A, Evangelista DHR, Gonçalves ECP, Storck L. Character sample size of soybean genotypes. Ciência Rural. 2009;39(04):983-991. Available: http://dx.doi.org/10.1590/S0103-84782009005000016
   (Accessed on November 30, 2018)
6. Catapatti TR. Sample size and number of replicates for evaluation of agronomic characters in corn popcorn. Science and Agrotechnology. 2008;32(03):855-862. Available:http://dx.doi.org/10.1590/S1413-70542008000300023
   (Accessed on November 30, 2018)

7. Storck L, Lopes SJ, Cargnelutti Filho A, Martini LFD, Carvalho MP. Sample size for single, double and thee-way hybrid corn ear traits. Scientia Agrícola. 2007;64(01):30-35.
Available: http://dx.doi.org/10.1590/S0103-90162007000100005
(Accessed on November 30, 2018)
8. Cargnelutti Filho A, Ribeiro ND, Storck L, Jost E, Poersch NL. Character sample size of bean cultivars. Ciência Rural. 2008;38(03):635-642.
Available:http://dx.doi.org/10.1590/S0103-84782008000300007
(Accessed on November 30, 2018)
9. Leite, MSDO, Peternelli LA, Barbosa MHP, Cecon PR, & Cruz CD. Sample size for full-sib family evaluation in sugarcane. Pesquisa Agropecuária Brasileira. 2009; 44(12):1562-1574.
10. Cargnelutti Filho A, Toebe M, Silveira TR, Casarotto G, Haesbaert FM, Lopes SJ. Sample size and linear relations of the morphological characters and production of crambe. Ciência Rural, Santa Maria. 2010;40(11):2262-2267.
Available: http://dx.doi.org/10.1590/S0103-84782010001100003 - Accessed on November 30, 2018.
11. Cargnelutti Filho A, Lopes SJ, Silveira TR, Schwantes IA. Sample size for estimation of the Pearson correlation coefficient between *Crambe abyssinica* characters. Agronomic Science Journal. 2011;42(1):149-158.
Available: http://dx.doi.org/10.1590/S1806-66902011000100019 - Accessed on November 30, 2018.
12. Lúcio AD, Haesbaert FM, Santos D, Schwertner DV, Brunes RR. Tamanhos de amostra e de parcela para variáveis de crescimento e produtivas de tomateiro. Horticultura Brasileira 2012;30:660-668. Available: http://dx.doi.org/10.1590/S0102-05362012000400016 - Accessed on November 30, 2018.
13. EMBRAPA - Brazilian Company of Agricultural Research. Brazilian system of soil classification. 3.ed. Brasília, 2013. 353p.
14. Holanda JS, Alves MCS, Chagas MCM (2008). Recomendações técnicas para o cultivo do girassol. – Natal, RN: EMPARN, 27 p. – (Sistemas de produção; 1). ISSN: 1983-280-X.
15. Toebe M, Lopes SJ, Storck, L, Silveira TR, Milani M, Casarotto G. Estimation of plastochron in crambe. Ciência Rural. 2010;40(4):793-799.
Available: http://dx.doi.org/10.1590/S0103-84782010005000054 - Accessed on November 30, 2018.
16. Campos H. de. Estatística experimental não-paramétrica. 4 ed. Piracicaba: Esalq; 1983.
17. Bussab WO, Morettin PA. Basic statistics. 5.ed. São Paulo: Saraiva; 2004.
18. Spiegel MR, Schiller JJ, Srinivasan RA. Probability and Statistics. 2 ed. Porto Alegre: Bookman; 2004.
19. Ferreira DF. Sisvar: a computer statistical analysis system. Science and Agrotechnology. 2011;35(6):1039-1042. Available: http://dx.doi.org/10.1590/S1413-70542011000600001 Accessed on November 30, 2018.
20. SAMPAIO IBM. Estatística aplicada a experimentação animal**.** Belo Horizonte: Fundação de Estudo em Medicina Veterinária e Zootecnia. 2002;265.
21. Stuker H & Boff P. Tamanho da amostra na avaliação da queima-acinzentada em canteiros de cebola. Horticultura Brasileira, Brasília, 1998, 16(1):110-113,. Disponível em:<http://www.abhorticultura.com.br/biblioteca/arquivos/Download/biblioteca/hb_16_1.pf>. Accessed on November 30, 2018.
22. Facco G. Tamanho de amostra para caracteres morfológicos e produtivos de feijão guandu. 2014. 51f. Dissertação (mestrado) – Universidade Federal de Santa Maria, Centro de Ciências Rurais, Programa de Pós – Graduação em Agronomia, RS, 2014.
23. Lúcio AD, Haesbaert FM, Santos D, Schwertner Dv, Brunes Rr. Tamanhos de amostra e de parcela para variáveis de crescimento e produtivas de tomateiro. Horticultura Brasileira. 2012;30:660-668. Available: http://dx.doi.org/10.1590/S0102-05362012000400016 - Accessed on November 30, 2018.
24. Cargnelutti Filho A, Lopes SJ, Brum B, Toebe M, Silveira TR, Casarotto G. Sample size of the characters in castor bean. Ciência Rural. 2010;40(2):280-287. Available: http://dx.doi.org/10.1590/S0103-84782010000200005 - Accessed on November 30, 2018.
25. Fonseca JS, Martins GA. Course of statistics. 5. ed. São Paulo: Atlas; 1995.

26. HAIR, J.F.; ANDERSON, R.E.; TATHAM, R.L.; BLACK, W.C. Análise multivariada de dados. 5.ed. Porto Alegre: Bookman, 2005. 593p.
27. Cargnelutti Filho A, Toebe M, Burin C, da Silveira TR, Casarotto G. Tamanho de amostra para estimação do coeficiente de correlação linear de Pearson entre caracteres de milho. Pesquisa Agropecuária Brasileira. 2011;45(12): 1363-1371. Available: http://dx.doi.org/10.1590/S0100-204X2010001200005 - Accessed on November 30, 2018.
28. Cargnelutti Filho A, Araujo MM, Gasparin E, Avila AL. Sampling design for height evaluation in diameter of *Cabralea canjeran* seedlings. Ciência Rural. 2012;42(7):1204-1211. Available: http://dx.doi.org/10.1590/S0103-84782012000700011 - Accessed on November 30, 2018.
29. Cargnelutti Filho A, Ramos Evangelista DH, Piffer Gonçalves EC, Storck, L. Tamanho de amostra de caracteres de genótipos de soja. Ciência Rural. 2009;39(4):983-991. Available: http://dx.doi.org/10.1590/S0103-84782009005000016 - Accessed on November 30, 2018.
30. Cargnelutti Filho A, Toebe M, Alves BM, Burin, C, Santos GO, Facco G, Neu IMM. Sampling design to evaluate morphological and productive characteristics of black oats during evaluation periods. Ciência Rural. 2015;45(1):9-13. Available: http://dx.doi.org/10.1590/0103-8478cr20140504 - Accessed on November 30, 2018.
31. Gelman, Andrew. Commentary: P values and statistical practice. Epidemiology. 2012;24(1):69-72.
32. Toebe M, Both V, Cargnelutti Filho A, Brackmann A, Storck L. Dimensionamento amostral para avaliar firmeza de polpa e cor da epiderme em pêssego e maçã. Revista Ciência Agronômica. 2011;42(4):1026-1035.
33. Burin C, Cargnelutti Filho A, Toebe M, Alves BM, Fick AL. Sample size for the estimation of the mean and median characters of white lupine (*Lupinus albus* L.). Comunicata Scientiae. 2014;5(2):205-212.
34. Toebe M, Cargnelutti Filho A, Lopes SJ, Burin C, Silveira, TR, Casarotto G. Sampling design for estimation of correlation coefficients in maize hybrids, harvests and precision levels. Bragantia. 2015;74(1):16-24. Available: http://dx.doi.org/10.1590/1678-4499.0324 - Accessed on November 30, 2018.

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