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Sample Sufficiency for Estimation of the Mean of Rye Traits at Flowering Stage

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Abstract

The objective of this study was to determine the sample size to estimate the traits mean in cultivars and sowing times, at flowering of rye culture. Ten uniformity trials were performed combining two cultivars in five sowing times. In the flowering of culture, in 100 plants of each uniformity trial, eleven traits were evaluated. The descriptive statistics was calculated and it was determined the sample size to estimate the mean in levels of precision (amplitude of the confidence interval of 95% for 5, 10, …, 35% of the mean) by resampling with replacement. The cob length presented the lowest variability among the eleven traits and, consequently, smaller sample size in both cultivars and five sowing time. There is variability in the sample size to estimate the mean among the traits, cultivars and sowing times. The measurement of 425, 276, 189 and 138 plants in cultivar BRS Progresso and 642, 413, 285 and 211 plants in cultivar Temprano, are enough to estimate the mean amplitude of the confidence interval of 95% maximum of 20, 25, 30 and 35%, respectively, for all the traits and sowing times.

Keywords: experimental planning, *Secale cereale* L., resampling

1. Introduction

The rye culture is used for various purposes, among them in human food, as cover crop and forage for animals. As plant coverage, it plays an important role in the management of the agricultural sector, since it reduces nitrogen loss (Martinez-Feria, Dietzel, Liebman, Helmers, & Archontoulis, 2016), increases the retained water available in the soil (Basche et al., 2016) and assists in the control of soil erosion (Pantoja, Woli, Sawyer, & Barker, 2016).

Experiment is a study previously planned, which follows the basic principles of repetition, randomization and local control, in which comparisons are made of the effects of treatments. The experiment must consider the researcher's interests and the basic assumptions required for the validity of the statistical analysis (Banzatto & Kronka, 2013). During the execution of an experiment, often, for the evaluation of the traits it is not possible to sample the experimental unit in its entirety and, in this situation, it is recommended to use a representative sample of the experimental unit (Storck, Garcia, Lopes, & Estefanel, 2016).

The correct sample sizing is important for obtaining estimates with desired precision, optimization of labor, time and resources of the researcher. The sample size is directly proportional to the variability of the data and the degree of confidence desired, the later determined by the researcher (Bussab & Morettin, 2013). In addition, the sample size must be planned appropriately to validate the research (Brito, Grigoletto, Nóbrega, & Córdova, 2016), because it interferes in the estimates of distributions of statistics of interest (Ramírez, Barrera, & Correa, 2013).

The sample size was studied in crops, such as soybeans (Cargnelutti Filho, Evangelista, Gonçalves, & Storck, 2009), maize (Toebe, Cargnelutti Filho, Burin, Casarotto, & Haesbaert, 2014), forage turnip (Cargnelutti Filho et al., 2014), black oats (Cargnelutti Filho et al., 2015b) and sunflower (Silva, Santos, Oliveira, Sousa, & Fernandes, 2015). The objective of this study was to determine the sample size to estimate the traits mean in cultivars and sowing times, at flowering of rye culture.

2. Material and Methods

Ten uniformity trials were carried out, in the harvest of 2016, in the experimental area of the Crop Science Department of the Federal University of Santa Maria, Rio Grande do Sul with the cultivation of rye. The climate of the region, according to the classification of Köppen, is of Cfa humid subtropical type with hot summers and without a defined dry season (Heldwein, Buriol, & Streck, 2009) and the soil is classified as Paleudalf (Santos, Almeida, & Oliveira, 2013).

Uniformity trials were performed with two cultivars in five sowing times. The cultivars were BRS Progresso, intended for the production of grains, and Temprano, recommended as cover crop and grazing. The five sowing times were: May 3, 2016 (time 1), May 25, 2016 (time 2), June 7, 2016 (time 3), June 22, 2016 (time 4) and July 4, 2016 (time 5). In each sowing, the soil was prepared in a conventional manner, with light harrow, basic fertilization of 25 kg ha^{-1} of nitrogen (N), 100 kg ha^{-1} of phosphor (P), 100 kg ha^{-1} of potassium (K) and broadcasting with a density of 455 seeds m^{-2}.

In the first time, each cultivar was sown in an area of 320 m^2 (20 m × 16 m) and at other sowing times, each cultivar occupied 375 m^2 (25 m × 15 m). The crops treatments were performed uniformly throughout the experimental area. In the central area of each uniformity trial, a grid with 100 sampling points spaced from 1 m × 1 m was demarcated, with stakes, forming an array of ten rows and ten columns. It was chosen randomly, one plant per sampling point, and in the flowering of plants, the following traits were evaluated: number of tillers, obtained by counting the number of stalks except the main stalk (NT); number of ears (NE); length of ear (LE, in cm); fresh matter of leaf (FML, in g); fresh matter of stalk (FMS, in g); fresh matter of ear (FME, in g); fresh matter of plant (FMP = FML + FMS + FME, in g); dry matter of leaf (DML, in g); dry matter of stalk (DMS, in g); dry matter of ear (DME, in g); and dry matter of plant (DMP = DML + DMS + DME, in g).

For each trait, cultivation and sowing time, measures of central tendency, variability, of asymmetry and kurtosis were calculated and the data normality was verified by the Kolmogorv-Smirnov test and the randomness by run test (Campos, 1983). For each trait, cultivation and sowing time, 999 sample sizes were planned, whose initial size was of two plants and the others were obtained with the plant growth. Thus, planned sample sizes were 2, 3, 4, … 1,000 plants.

For each sample size planned, 10,000 resamplings were performed with replacement. In each resampling the mean was calculated. Based on 10,000 estimates of the mean, the percentile 2.5% and the percentile 97.5% were calculated. The amplitude of the confidence interval of 95% ($ACI_{95\%}$) was calculated, by the difference between the percentile 97.5% and percentile 2.5%.

For the determination of sample size (number of plants) required to estimate the average, maximum residue limits were fixed of $ACI_{95\%}$ at 5, 10, 15, 20, 25, 30 and 35% of the mean. Then, from the size of the initial sample (n = two plants), and is considered as an appropriate sample size (n) the number of plants from which the $ACI_{95\%}$ was less than or equal to the maximum limit established for each level of precision.

Graphically, it was represented the 2.5% percentile, the mean and 97.5% percentile, of the trait with the highest and lowest estimated sample size in both cultivars, for some of the planned sample sizes planned (n = 10, 20, …, 1,000 plants). Statistical analyzes were performed with the aid of the program R (R Core Team, 2017) and the application Microsoft Office Excel®.

3. Results and Discussion

The sowing time one and five showed the lowest averages for the traits, in both cultivars (Tables 1 and 2), demonstrating that the means were influenced by the sowing time. The mean values were higher than the median in cultivars BRS Progresso and Temprano in the majority of the traits in sowing times. This is due to the fact that some of the 100 plants evaluated presented high values of these traits, contributing to the asymmetric displacement to the right (Bussab & Morettin, 2013).

Table 1. Minimum (min), maximum (max), mean, median (med), standard deviation (sd), standard error (se), coefficient of variation (CV, in %), asymmetry (A), kurtosis (K) and p-value of the traits: number of tillers (NT); number of ears (NE); length of ear (LE, in cm); fresh matter of leaf (FML, in g); fresh matter of stalk (FMS, in g); fresh matter of ear (FME, in g); fresh matter of plant (FMP = FML + FMS + FME, in g); dry matter of leaf (DML, in g); dry matter of stalk (DMS, in g); dry matter of ear (DME, in g); and dry matter of plant (DMP = DML + DMS + DME, in g) in the sowing times of rye BRS Progresso

Statistic	NT	NE	LE	FML	FMS	FME	FMP	DML	DMS	DME	DMP
Sowing time 1 (May 3, 2016)											
min	0.00	0.00	0.00	0.19	1.86	0.00	2.21	0.04	0.43	0.00	0.52
max	7.00	6.00	16.70	18.20	60.69	6.06	78.89	3.29	9.99	1.72	13.19
mean	1.81	1.95	11.31	2.32	12.42	1.60	16.34	0.49	2.61	0.44	3.54
med	2.00	2.00	11.80	1.84	10.29	1.32	13.49	0.39	2.09	0.37	2.89
sd	1.61	1.10	3.23	2.20	9.39	1.15	12.23	0.43	1.86	0.33	2.50
se	0.16	0.11	0.32	0.22	0.94	0.12	1.22	0.04	0.19	0.03	0.25
CV (%)	88.74	56.16	28.58	95.10	75.61	72.01	74.83	88.20	71.08	74.70	70.59
A[(1)]	0.96*	0.71*	-1.73*	4.23*	2.29*	1.51*	2.25*	3.39*	1.76*	1.53*	1.74*
K[(2)]	0.98*	0.69 ns	4.22*	27.01*	7.65*	3.22*	7.34*	18.07*	3.71*	3.06*	3.51*
p-value	0.01	0.00	0.01	0.00	0.04	0.18	0.01	0.01	0.03	0.15	0.04
Sowing time 2 (May 25, 2016)											
min	0.00	0.00	0.00	0.55	6.74	0.00	8.58	0.16	0.90	0.00	2.06
max	13.00	13.00	22.40	27.93	132.56	17.37	175.22	4.28	19.95	4.60	28.83
mean	4.08	4.35	14.13	9.28	41.14	4.74	55.17	1.61	7.65	1.32	10.58
med	4.00	4.00	14.50	7.97	35.56	3.94	48.58	1.48	7.09	1.15	9.94
sd	2.30	2.24	3.41	5.61	24.04	3.11	32.06	0.90	4.30	0.85	5.90
se	0.23	0.22	0.34	0.56	2.40	0.31	3.21	0.09	0.43	0.09	0.59
CV (%)	56.46	51.49	24.14	60.44	58.42	65.67	58.11	56.34	56.26	64.50	55.75
A[(1)]	0.93*	0.68*	-1.96*	1.14*	1.20*	1.18*	1.22*	0.85*	0.78*	0.97*	0.81*
K[(2)]	1.48*	1.59*	7.25*	1.28*	1.87*	2.30*	1.89*	0.11 ns	0.23 ns	1.29*	0.33 ns
p-value	0.02	0.03	0.18	0.09	0.06	0.10	0.05	0.24	0.51	0.13	0.24
Sowing time 3 (June 7, 2016)											
min	0.00	1.00	7.00	0.39	4.69	0.17	5.61	0.10	0.95	0.03	1.34
max	11.00	6.00	19.80	7.82	59.20	6.19	72.43	2.04	14.55	2.13	18.04
mean	2.28	2.66	13.18	2.78	20.72	2.13	25.63	0.74	5.14	0.69	6.57
med	2.00	3.00	13.20	2.53	19.61	2.00	24.46	0.67	4.77	0.62	6.12
sd	1.54	1.03	2.38	1.58	10.05	1.18	12.42	0.41	2.78	0.43	3.50
se	0.15	0.10	0.24	0.16	1.01	0.12	1.24	0.04	0.28	0.04	0.35
CV (%)	67.45	38.61	18.09	56.77	48.53	55.50	48.46	55.16	54.14	62.94	53.36
A[(1)]	2.47*	0.27 ns	0.04 ns	1.10*	1.00*	1.04*	1.00*	0.96*	1.17*	1.08*	1.11*
K[(2)]	11.17*	0.46 ns	0.14 ns	1.26*	1.61*	1.10*	1.52*	0.69 ns	1.53*	0.95*	1.34*
p-value	0.00	0.00	0.98	0.05	0.46	0.26	0.39	0.07	0.18	0.22	0.16
Sowing time 4 (June 22, 2016)											
min	0.00	1.00	4.50	0.41	1.52	0.06	1.99	0.09	0.27	0.01	0.37
max	6.00	6.00	17.40	7.43	40.05	5.74	50.12	2.21	11.10	1.58	14.30
mean	1.83	2.53	12.76	2.63	17.24	1.83	21.70	0.76	4.58	0.59	5.92
med	2.00	2.00	12.95	2.20	14.83	1.53	18.71	0.65	4.04	0.51	5.17
sd	1.13	1.06	2.58	1.53	8.63	1.08	10.93	0.41	2.47	0.36	3.15
se	0.11	0.11	0.26	0.15	0.86	0.11	1.09	0.04	0.25	0.04	0.32
CV (%)	61.67	41.84	20.23	57.98	50.02	59.28	50.36	54.30	54.02	61.46	53.28
A[(1)]	1.03*	0.94*	-0.76*	1.18*	0.92*	1.03*	0.95*	1.15*	0.90*	0.97*	0.93*
K[(2)]	2.07*	1.35*	0.83 ns	0.91 ns	0.17 ns	0.95*	0.27 ns	1.14*	0.23 ns	0.40 ns	0.32 ns
p-value	0.00	0.00	0.48	0.01	0.01	0.01	0.01	0.01	0.07	0.01	0.07

Sowing time 5 (July 4, 2016)											
min	0.00	0.00	0.00	0.09	1.41	0.00	1.62	0.03	0.32	0.00	0.38
max	6.00	4.00	15.90	5.39	29.04	4.09	36.88	1.49	7.29	1.26	9.53
mean	1.08	1.71	10.39	1.45	9.72	1.11	12.28	0.46	2.58	0.38	3.42
med	1.00	1.00	10.50	1.18	8.33	0.83	11.01	0.40	2.01	0.30	2.77
sd	1.16	0.96	3.18	1.02	6.28	0.82	7.95	0.29	1.68	0.27	2.17
se	0.12	0.10	0.32	0.10	0.63	0.08	0.79	0.03	0.17	0.03	0.22
CV (%)	107.47	55.94	30.61	70.75	64.60	73.96	64.69	63.27	65.01	71.47	63.65
$A^{(1)}$	1.27*	0.62*	-1.29*	1.30*	1.04*	1.45*	1.09*	1.04*	0.90*	1.22*	0.90*
$K^{(2)}$	2.27*	-0.41 ^{ns}	2.87*	1.81*	0.61 ^{ns}	2.14*	0.73 ^{ns}	1.08*	0.22 ^{ns}	1.34*	0.18 ^{ns}
p-value	0.00	0.00	0.03	0.05	0.09	0.00	0.08	0.17	0.02	0.01	0.08

Note. $^{(1)}$ * Asymmetry differs from zero, using the t-test, at a 5% probability level. ns Non-significant. $^{(2)}$ * kurtosis differs from zero by means of the t-test, at a 5% probability level. ns Non-significant.

In the cultivar BRS Progresso, of 11 traits, ten, eight, eight, four and six traits, in times 1, 2, 3, 4 and 5, respectively, have leptokurtic behavior, *i.e.*, there is a higher concentration of values around the central value. Whereas in the cultivar Temprano, eight, eleven, two, eleven and eight of the eleven traits in times 1, 2, 3, 4 and 5, respectively, showed leptokurtic behavior.

Table 2. Minimum (min), maximum (max), mean, median (med), standard deviation (sd), standard error (se), coefficient of variation (CV, in %), asymmetry (A), kurtosis (K) and p-value of the traits: number of tillers (NT); number of ears (NE); length of ear (LE, in cm); fresh matter of leaf (FML, in g); fresh matter of stalk (FMS, in g); fresh matter of ear (FME, in g); fresh matter of plant (FMP = FML + FMS + FME, in g); dry matter of leaf (DML, in g); dry matter of stalk (DMS, in g); dry matter of ear (DME, in g); and dry matter of plant (DMP = DML + DMS + DME, in g) in the sowing times of rye Temprano

Statistic	NT	NE	LE	FML	FMS	FME	FMP	DML	DMS	DME	DMP
Sowing time 1 (May 3, 2016)											
min	0.00	0.00	0.00	0.02	2.67	0.00	2.98	0.01	0.79	0.00	0.91
max	9.00	7.00	16.80	5.88	45.93	6.19	53.01	1.56	12.99	2.27	15.27
mean	1.72	2.40	11.47	0.86	13.95	1.74	16.55	0.26	4.48	0.57	5.32
med	2.00	2.00	11.40	0.64	12.33	1.53	14.64	0.20	3.77	0.49	4.43
sd	1.58	1.38	2.48	0.88	8.18	1.08	9.65	0.25	2.64	0.38	3.13
se	0.16	0.14	0.25	0.09	0.82	0.11	0.96	0.03	0.26	0.04	0.31
CV (%)	92.05	57.42	21.63	101.98	58.63	62.10	58.28	94.64	58.84	66.55	58.79
$A^{(1)}$	1.36*	0.97*	-0.93*	2.64*	1.03*	1.25*	0.96*	2.12*	0.96*	1.57*	0.95*
$K^{(2)}$	3.58*	0.83 ^{ns}	3.61*	10.69*	1.32*	2.19*	0.99*	6.78*	0.83 ^{ns}	3.75*	0.71 ^{ns}
p-value	0.01	0.00	0.96	0.00	0.19	0.21	0.23	0.02	0.04	0.10	0.10
Sowing time 2 (May 25, 2016)											
min	0.00	0.00	0.00	0.45	4.23	0.00	5.26	0.15	0.89	0.00	1.22
max	33.00	23.00	20.00	51.70	147.58	17.01	185.35	12.60	39.64	5.64	51.73
mean	5.33	4.03	13.45	6.25	39.07	4.45	49.77	1.78	10.50	1.45	13.72
med	4.00	3.00	14.50	4.97	34.41	3.76	43.79	1.48	9.07	1.20	11.34
sd	4.84	3.44	4.55	6.22	26.32	3.55	33.47	1.59	7.71	1.24	9.85
se	0.48	0.34	0.45	0.62	2.63	0.36	3.35	0.16	0.77	0.12	0.98
CV (%)	90.75	85.34	33.82	99.56	67.38	79.86	67.25	89.53	73.46	85.58	71.77
$A^{(1)}$	3.04*	2.24*	-1.95*	4.49*	1.30*	1.16*	1.32*	3.79*	1.45*	1.23*	1.39*
$K^{(2)}$	12.89*	8.84*	3.75*	29.02*	2.36*	1.42*	2.36*	21.65*	2.35*	1.49*	2.20*
p-value	0.00	0.01	0.00	0.00	0.15	0.22	0.18	0.00	0.15	0.11	0.15
Sowing time 3 (June 7, 2016)											
min	0.00	0.00	0.00	0.20	2.91	0.00	3.40	0.03	0.83	0.00	0.96
max	8.00	6.00	19.90	9.02	51.29	7.72	63.83	2.20	17.40	2.51	21.56
mean	2.67	2.51	11.75	2.28	18.59	2.40	23.27	0.66	5.43	0.75	6.84
med	2.50	2.00	12.10	1.92	15.92	1.70	20.28	0.60	4.44	0.58	5.55

sd	1.91	1.52	3.32	1.77	11.23	1.81	13.91	0.46	3.53	0.61	4.35
se	0.19	0.15	0.33	0.18	1.12	0.18	1.39	0.05	0.35	0.06	0.44
CV (%)	71.43	60.59	28.30	77.67	60.40	75.58	59.78	69.96	65.04	81.50	63.65
A(1)	0.71*	0.63*	-1.17*	1.28*	0.95*	1.05*	0.94*	1.03*	1.11*	1.06*	1.08*
K(2)	0.03ns	-0.44 ns	3.20*	1.54*	0.34 ns	0.46 ns	0.40 ns	0.85 ns	0.79 ns	0.45 ns	0.73 ns
p-value	0.01	0.00	0.53	0.04	0.07	0.01	0.13	0.20	0.02	0.03	0.01
Sowing time 4 (June 22, 2016)											
min	0.00	0.00	0.00	0.05	4.26	0.00	5.21	0.01	0.97	0.00	1.18
max	16.00	8.00	17.80	8.83	86.57	8.34	96.84	1.90	17.12	2.68	20.90
mean	2.71	2.71	12.02	0.90	20.82	2.27	23.98	0.38	5.25	0.70	6.33
med	2.00	3.00	12.30	0.59	17.40	2.04	19.92	0.26	4.15	0.57	5.07
sd	2.28	1.50	3.30	1.18	13.66	1.55	15.57	0.30	3.34	0.51	3.98
se	0.23	0.15	0.33	0.12	1.37	0.16	1.56	0.03	0.33	0.05	0.40
CV (%)	84.29	55.33	27.48	131.72	65.62	68.56	64.91	79.14	63.59	72.52	62.85
A(1)	2.95*	0.84*	-1.87*	4.18*	2.15*	1.43*	2.08*	2.12*	1.53*	1.55*	1.52*
K(2)	12.52*	1.45*	5.09*	22.88*	6.20*	3.04*	5.68*	6.84*	2.33*	3.24*	2.28*
p-value	0.00	0.00	0.07	0.00	0.03	0.24	0.02	0.01	0.01	0.04	0.02
Sowing time 5 (July 4, 2016)											
min	0.00	0.00	0.00	0.09	2.09	0.00	2.44	0.03	0.71	0.00	0.84
max	9.00	5.00	15.60	6.08	30.91	4.66	38.12	1.61	8.18	1.75	10.33
mean	2.32	1.90	10.61	0.92	10.45	1.34	12.71	0.36	3.30	0.50	4.16
med	2.00	2.00	10.60	0.58	9.61	1.17	11.73	0.31	2.97	0.41	3.90
sd	2.01	1.03	3.01	1.09	5.19	0.89	6.24	0.27	1.65	0.39	2.07
se	0.20	0.10	0.30	0.11	0.52	0.09	0.62	0.03	0.17	0.04	0.21
CV (%)	86.83	54.20	28.38	117.73	49.65	66.11	49.09	76.57	50.06	76.97	49.72
A(1)	1.45*	0.66*	-1.61*	2.81*	1.42*	1.22*	1.40*	2.23*	0.88*	1.32*	0.87*
K(2)	2.04*	0.41 ns	4.29*	8.96*	3.36*	2.04*	3.47*	6.76*	0.42 ns	1.84*	0.48 ns
p-value	0.00	0.00	0.10	0.00	0.14	0.21	0.34	0.01	0.12	0.15	0.08

Note. (1) * Asymmetry differs from zero, using the t-test, at a 5% probability level. ns Non-significant. (2) * Kurtosis differs from zero by means of the t-test, at a 5% probability level. ns Non-significant.

For the cultivar BRS Progresso, the CV (%) ranged between 18.09 and 107.47% and to Temprano cultivar, between 21.63 and 131.72%. The LE exhibited a lower variability among the traits for both cultivars, which suggests a smaller sample size. In the cultivar BRS Progresso the feature that showed greater variability was the NT and to Temprano cultivar, the trait FML.

In the cultivar BRS Progresso, it was found that in the first and last sowing times, the variability of the data was greater than in intermediate sowing times. However, the cultivar Temprano did not exhibit this behavior pattern. Therefore, there were differences among the traits, cultivars and sowing times, suggesting that this variation is also seen in the sample size. The scenario of wide variability in the database is important, giving credibility to the study (Cargnelutti Filho et al., 2015a).

The deviations of the asymmetry and kurtosis contributed to the removal of the data in relation to the curve of normal distribution in nine, two, two, eight and six traits, in the cultivar BRS Progresso and five, five, seven, nine and four in the cultivar Temprano, in times one, two, three, four and five, respectively. In these cases, with a probability distribution is unknown, the bootstrap resampling technique with replacement is recommended (Ferreira, 2009).

The sample size to estimate the mean of each trait, with amplitude of the confidence interval of 95% ($ACI_{95\%}$) of 5% of the mean, ranged from 194 to more than 1,000 plants in cultivar BRS Progresso (Table 3) and 282 of the more than 1,000 plants in the cultivar Temprano (Table 4). In both cultivars and sowing times, for the trait LE, smaller sample sizes were found than the other traits (Figures 1A and 1C). Larger sample size is necessary for the trait NT in the cultivar BRS Progresso (Figure 1B) and to FML in cultivar Temprano (Figure 1D). These results are in accordance with the scenario of increasing variability observed for the traits NE, FMP, FMS, DMP, DMS, FME, DME, DML, in the FML, in this order (Tables 1 and 2).

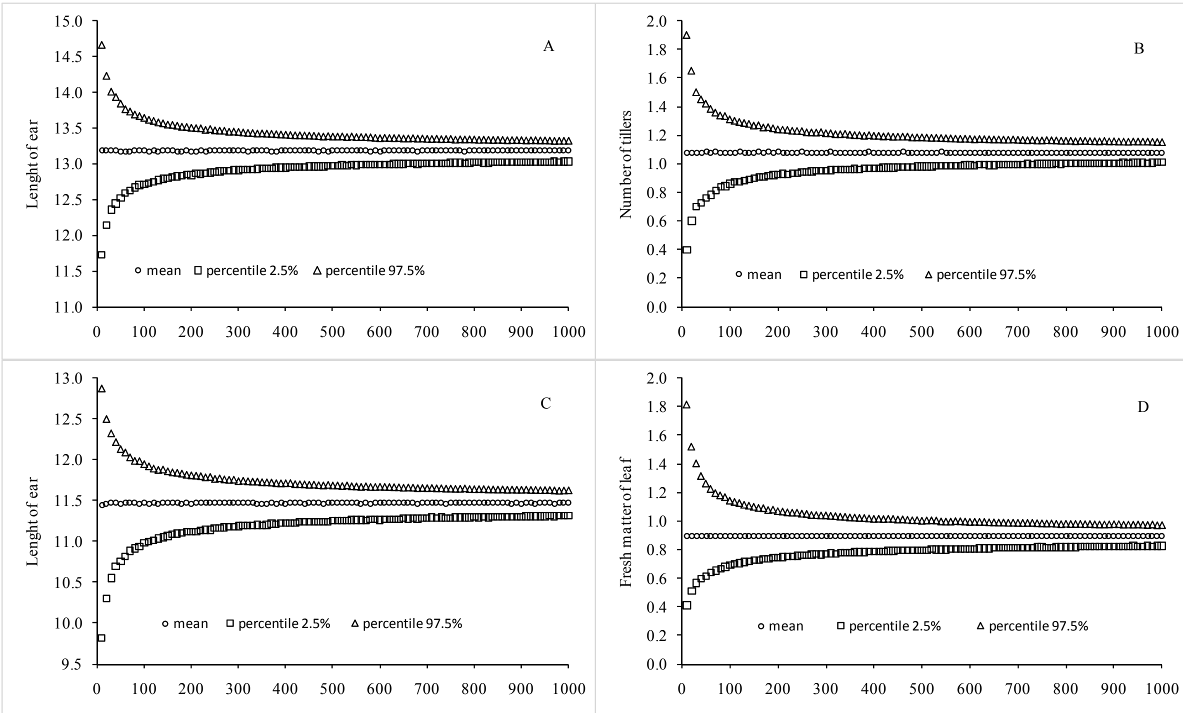

Figure 1. Percentile 2.5%, mean and percentile 97.5% of the 1,000 estimates of the mean of traits lenght of ear (LE, in cm) (A) and the number of tillers (NT) (B) in sowing times three and five, respectively, of cultivar BRS Progresso, lenght of ear (LE, in cm) (C) and fresh matter of leaf (FML, in g) (D) in sowing times five and four, respectively, of the cultivar Temprano, for sample sizes of 10, 20, 30, …, 1,000 plants of rye

Table 3. Sample size (number of plants) for the mean trait estimation, number of tillers (NT); number of ears (NE); length of ear (LE, in cm); fresh matter of leaf (FML, in g); fresh matter of stalk (FMS, in g); fresh matter of ear (FME, in g); fresh matter of plant (FMP = FML + FMS + FME, in g); dry matter of leaf (DML, in g); dry matter of stalk (DMS, in g); dry matter of ear (DME, in g); and dry matter of plant (DMP = DML + DMS + DME, in g) of the cultivar BRS Progresso, for the amplitude of the confidence interval ($ACI_{95\%}$) of 5, 10, 15, 20, 25, 30 and 35% of the mean, at sowing times

ACI95%	NT	NE	LE	FML	FMS	FME	FMP	DML	DMS	DME	DMP
Sowing time 1 (May 3, 2016)											
5%	>1000	>1000	492	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
10%	>1000	467	121	>1000	837	768	836	>1000	731	827	733
15%	523	210	55	595	368	339	368	520	339	371	324
20%	292	116	31	333	216	191	210	290	194	215	188
25%	188	77	20	220	137	126	131	187	121	136	119
30%	131	53	15	151	93	87	96	132	86	95	84
35%	97	37	10	107	70	63	70	98	64	70	61
Sowing time 2 (May 25, 2016)											
5%	>1000	>1000	340	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
10%	476	389	89	534	506	630	492	474	468	617	468
15%	210	177	39	246	227	284	229	215	215	271	207
20%	121	102	22	137	128	162	129	120	122	155	115
25%	75	63	15	86	82	105	82	76	77	101	74
30%	54	44	10	62	58	74	58	54	53	71	50
35%	40	33	8	45	42	55	43	39	39	51	39
Sowing time 3 (June 7, 2016)											
5%	>1000	884	194	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000

10%	681	222	51	484	355	461	345	463	433	602	423
15%	306	98	23	209	155	203	159	207	197	265	191
20%	171	57	13	120	91	117	87	116	110	151	108
25%	111	38	9	78	56	74	57	74	70	96	70
30%	76	27	6	53	41	52	40	51	51	68	48
35%	58	18	5	40	30	40	29	38	36	50	36
Sowing time 4 (June 22, 2016)											
5%	>1000	>1000	248	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
10%	565	261	62	504	375	512	384	446	436	567	425
15%	255	116	28	224	172	234	170	201	197	250	185
20%	145	65	16	129	94	133	94	112	110	143	109
25%	92	40	10	81	61	88	62	72	70	92	68
30%	64	29	8	58	43	61	44	48	49	64	49
35%	48	23	6	43	32	44	32	37	36	47	36
Sowing time 5 (July 4, 2016)											
5%	>1000	>1000	550	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
10%	>1000	466	140	751	629	809	622	598	638	747	607
15%	761	207	63	329	278	366	277	267	285	341	265
20%	425	117	36	187	159	209	157	149	161	190	152
25%	276	75	23	121	101	133	99	95	103	123	98
30%	189	53	16	83	70	96	72	67	71	86	67
35%	138	42	12	61	52	67	53	50	52	61	49

Variability among traits, as to the size of the sample, was observed by Cargnelutti Filho et al. (2014) in the culture of forage turnip, Toebe et al. (2014) in the culture of maize and Silva et al. (2015) in the sunflower culture. Cargnelutti Filho et al. (2009), besides verifying variability in sample size among the traits, found differences regarding the sample size among soybean genotypes. This can also be described in the present study, once that for the cultivar BRS Progresso, in general, the sample sizes were smaller than for cultivar Temprano.

Table 4. Sample size (number of plants) for the mean trait estimation, number of tillers (NT); number of ears (NE); length of ear (LE, in cm); fresh matter of leaf (FML, in g); fresh matter of stalk (FMS, in g); fresh matter of ear (FME, in g); fresh matter of plant (FMP = FML + FMS + FME, in g); dry matter of leaf (DML, in g); dry matter of stalk (DMS, in g); dry matter of ear (DME, in g); and dry matter of plant (DMP = DML + DMS + DME, in g) of the cultivar Temprano, for the amplitude of the confidence interval ($ACI_{95\%}$) of 5, 10, 15, 20, 25, 30 and 35% of the mean, at sowing times

ACI95%	NT	NE	LE	FML	FMS	FME	FMP	DML	DMS	DME	DMP
Sowing time 1 (May 3, 2016)											
5%	>1000	>1000	282	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
10%	>1000	489	70	>1000	510	564	510	>1000	512	667	510
15%	562	220	32	683	226	258	228	588	233	296	232
20%	320	120	18	385	130	148	127	337	129	168	133
25%	202	81	12	246	85	93	84	217	83	107	82
30%	138	56	9	171	60	65	59	150	60	75	60
35%	104	42	7	129	44	48	43	109	43	55	43
Sowing time 2 (May 25, 2016)											
5%	>1000	>1000	689	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
10%	>1000	>1000	172	>1000	669	948	683	>1000	801	>1000	762
15%	543	480	75	648	301	421	296	529	360	482	344
20%	307	275	44	371	170	240	170	299	201	275	193
25%	196	177	28	237	110	152	110	194	129	177	123
30%	134	123	20	160	78	107	74	130	89	123	86
35%	102	90	14	122	55	77	58	100	68	87	65

Sowing time 3 (June 7, 2016)											
5%	>1000	>1000	477	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
10%	756	548	119	895	543	857	538	732	632	989	582
15%	331	246	54	396	247	372	236	328	278	447	271
20%	190	143	31	228	139	212	132	185	158	250	151
25%	123	87	19	145	87	137	87	120	102	162	96
30%	87	63	14	100	63	96	62	83	72	113	67
35%	63	45	11	75	44	71	46	60	52	81	51
Sowing time 4 (June 22, 2016)											
5%	>1000	>1000	451	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
10%	>1000	443	116	>1000	642	688	619	935	606	777	590
15%	479	205	51	>1000	280	312	278	409	269	354	263
20%	265	115	28	642	164	173	159	232	152	198	147
25%	170	71	18	413	104	112	104	148	96	127	97
30%	114	53	13	285	73	80	71	107	69	91	66
35%	88	39	10	211	54	57	53	79	51	67	49
Sowing time 5 (July 4, 2016)											
5%	>1000	>1000	474	>1000	>1000	>1000	>1000	>1000	>1000	>1000	>1000
10%	>1000	436	122	>1000	371	656	364	865	380	877	368
15%	506	193	55	899	165	291	164	384	164	399	162
20%	278	111	32	519	92	165	93	220	96	218	95
25%	178	74	20	325	60	105	58	144	60	144	60
30%	128	48	14	226	42	75	41	98	42	99	42
35%	92	35	10	171	31	54	31	72	32	74	31

The sowing times influenced the sample size in both cultivars. In the BRS Progresso, the first and the last time of sowing had the largest sample size, which was not observed in the cultivar Temprano. In the culture of pigeonpea, Facco et al. (2015) found variability for the sample size among traits, between the period of evaluation of culture during its development and among crop years. This shows that before different environmental conditions each culture and cultivate respond in a way, that is why it is fundamental the presence of different scenarios to estimate the sample size.

The individual assessment of more than 1,000 plants in both cultivars in field experiments would be difficult to measure, because there are a large number of plants, requiring much labor and time of the researcher. To solve this problem, it is estimated sample sizes for $ACI_{95\%}$ of 10, 15, 20, 25, 30 and 35% of the mean (Tables 3 and 4). Upon defining the size of the sample, the trait and the level of precision required should be taken into account. In case the researcher opts for a sample size with $ACI_{95\%}$ of 20% of the mean for all traits and the sowing times, for the cultivar BRS Progresso, 189 plants would need to be assessed, and to cultivar Temprano, 285 plants. Thus, following indications of Cargnelutti Filho et al. (2015b), for an experiment carried out in a randomized block design with four replications, 48 and 72 plants of cultivars BRS Progresso and Temprano, respectively would have to be assessed, in each repetition.

4. Conclusions

There is variability in the sample size to estimate the mean among the traits, cultivars and sowing times in the rye crop.

The measurement of 425, 276, 189 and 138 plants in cultivar BRS Progresso and 642, 413, 285 and 211 plants in cultivar Temprano, are enough to estimate the mean amplitude of the confidence interval of 95% maximum of 20, 25, 30 and 35%, respectively, for all the traits and sowing times.

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