Variability of the agronomic indicators of *Pennisetum purpureum* cv. Cuba CT-115 with the sampling distance

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An experiment was conducted during two years to establish the variability of the agronomic indicators of *Pennisetum purpureum* cv. Cuba CT-115. Samples were taken at different sampling distances (1, 2, 3, 4 and 5 m length). The data of an experiment with random block design and four replicates were used. The lowest variance, standard deviation and coefficient of variation were obtained with sampling distance of five meters for the height (4.3, 2.1 and 1.88, and 1.1, 1.0 and 0.99 for the rainy and dry season, respectively). Similar performance had the per cent of leaves and dry matter of the whole plant. The sampling distance of five meters propitiated lower yield variability (18.04 and 12.35 % in the rainy season and dry season, respectively). Similar performance had the number of bunches/m (8.34 and 12.27, in that same order). In all the indicators, the lowest width of the values range was obtained, in general, in the distance of five meters. When sampling the population, five bunches/m recorded the lowest variability compared with 11 bunches/m. It is concluded that for the best estimation of the agronomic indicators, the samplings should be conducted in five linear meters. No less than five bunches as sample units should be taken. Similar studies in grasslands with different growing habits are recommended.

Key words: *sample, yield, grass.*

One of the aspects demanding closer attention, higher rigor and precision in the assessment experiments of the agronomic indicators of meadow grasses is the sampling method, as the representation of the sampled population depends on it. This aspect is hard to obtain due to the inborn variability of the pastures population under grazing conditions and in experimental plots.

The studies conducted on this respect have allowed establishing a methodology to carry out the sampling and determine the morpho-physiological indicators of *Cynodon nlemfuensis* (Del Pozo *et al*. 1998). They have also made possible studying the biology of *Sporobolus indicus* (Sardiñas *et al*. 2008) and that of the growing indexes of *Pennisetum purpureum* cv. CT-115 (Fortes *et al*. 2007) under grazing conditions. Studies on experimental plots have been conducted in this last variety (Herrera *et al*. 2013). The referred researches stated, in each case, the number of samples needed to represent sampled population.

The objective of this study was to determine the variability of the agronomic indicators of *Pennisetum purpureum* cv. Cuba CT-115 when taking samples at different sampling distances.

Materials and Methods

The data reported by Herrera *et al*. (2013), from an experiment conducted for two years in the pastures station "Miguel Sistachs Naya", belonging to the Institute of Animal Science were taken. The soil on which the experiment was carried out is typical red ferralitic (Hernández *et al*. 1999). The pasture used was *Pennisetum purpureum* cv. Cuba CT-115.

Treatment and design. Five sampling distances (1, 2, 3, 4 and 5 m) were studied through a random block design with four replicates.

Procedure. The samplings were conducted every 90 d, in both experimental seasons, at 10 cm above the soil level, in the three main furrows of each plot. The two external ones were removed as border effect. The samples, corresponding to each sampling distance of each plot, were protected from sunshine and high temperatures. Later, they were taken to the lab as soon as possible. There was neither irrigation nor fertilization for two years.

Indicators. In each sample, the leaves and stems were manually separated. The DM was determined through drying in an air circulation oven at 65 °C until reaching constant weight. From here on, the percent of leaves and dry matter yield were calculated. Previous to the sampling, the plant height from the soil to the growing point was calculated. The number of bunches was counted after the sampling. All the indicators were taken in agreement with Herrera (2006).

Statistical analysis. The mean, variance, standard deviation, coefficient of variation and values range of the indicators were counted for each seasonal period (rainy and dry) of the two years of study. The number of bunches was transformed according to $\sqrt{n}$. The statistical software InfoStat (2002) was used.

Results and Discussion

The samplings corresponded with each trimester of the year and the results had similar performance. Therefore, the results were shown according to the seasonal period (rainy and dry), including the information of four trimesters of each period during the two experimental years.

In both seasonal periods, the lowest variance, standard deviation, coefficient of variation and values range of the plant height were obtained when the sampling distance was of five meters (table 1).

These results are logical considering the reduced number of plants in the lowest sampling distances. This determines the lower competition for light and nutrients and, as consequence, a better growth and development, expressed in the higher height reached in the rainy season, is probably achieved. However, in the dry season, when the stressing conditions due to the water supply limitation, lower temperatures and external nutrients predominate, the same does not occur. This has been referred by Herrera *et al*. (2012), when assessing Pennisetum clones obtained by *in vitro* tissue culture.

The previous statement is reaffirmed in the performance of the values range. The lowest sampling distances (one and two meters) had the highest values range in the rainy season (25 and 11 units, respectively), while it was lower in the dry season (13 and 10 units in that same order).

The table 2 shows the DM percent of the whole plant in respect to the sampling distance. It was similar to that obtained in the height in respect to the values, but the mean values did not have a uniform response pattern.

The response pattern of this indicator is not easy to explain, due to the complexity of the mechanism and hydric balance of the plant, where multiple factors that may alter it occur. Temperature is among them, varying constantly under field conditions and influencing on the water flow rate, its gradient and the transpiration stimulated as the environmental temperature increases. However, the lowest values range was always obtained with the highest sampling distance. Designing specific experiments to explain this performance would be appropriate, if considering that this indicator is the basis for calculating the crop yield.

The values for the leaves percent varied as the sampling distance increased and did not follow a defined pattern. Nevertheless, the best values were recorded at the distance of five meters (table 3). In spite the values did not follow a uniform response, the lowest variability expressed through the coefficient of variation was

Table 1. Statistics for the plant height

Distance, m	Mean, cm	Variance	SD	CV, %	Range	
					Minimum	Maximum
Rainy season						
1	116	46.5	6.8	5.88	104	129
2	108	12.3	3.5	3.22	103	114
3	108	11.4	3.4	3.14	103	114
4	104	4.2	2.0	1.96	100	108
5	110	4.3	2.1	1.88	105	113
Dry season						
1	99	18.6	4.3	4.34	90	103
2	93	8.6	2.9	3.13	88	98
3	107	5.6	2.4	2.21	103	112
4	105	2.9	1.7	1.63	101	108
5	105	1.1	1.0	0.99	105	109

Table 2. Statistics of the DM percent of the whole plant

Distance, m	Mean, %	Variance	SD	CV, %	Range	
					Minimum	Maximum
Rainy season						
1	19.21	0.74	0.86	4.48	17.4	20.7
2	19.75	0.45	0.67	3.41	18.7	20.8
3	20.30	0.31	0.53	2.72	19.4	21.1
4	20.00	0.27	0.52	2.58	19.3	20.9
5	19.90	0.13	0.36	1.80	19.1	20.5
Dry season						
1	21.35	1.05	1.02	4.79	19.9	22.8
2	21.22	0.08	0.94	4.42	20.1	22.8
3	20.80	0.15	0.89	1.88	20.1	21.8
4	21.61	0.13	0.36	1.69	21.0	22.0
5	22.78	0.11	0.33	1.46	22.7	23.8

obtained with the highest distance.

Fortes (2012) informed that as the population of this pasture increased, the number of dead leaves increased, especially in the vertical strata closest to the soil. As the sampling was conducted at 10 cm from the soil, this element was considered for not including the dead ones in the leaves percent.

This indicator is of great importance for assessing new plant materials, even in the study of different management systems. The photosynthesis and the synthesis of substances needed for the plant metabolism occur in the leaves. Besides, as feeding source, leaves have the highest amount of nutrients available for the animal.

The DM yield according to sampling distance is presented in table 4. The lowest coefficient of variation was obtained again at the distance of five meters, in spite the lowest variance and standard deviation were found at the lowest distances.

Like in the previous indicators, this is logical and closely related with the population existing in each sampling distance (table 5). Because at the lowest distances the number of bunches is also the lowest, the random sampling is not achieved rigorously. Maybe, the subjectivity of who conducts the sampling and introduces higher variability when taking is the most important aspect. This is determined by the growth and development degree bunches reach in respect to their vital space and competence among them.

This study showed that, when sampling one meter, the population varies between two and five bunches, so the sampling is controlled. In this case, the random principle does not predominate and the person conducting the sampling may prefer subjective elements or selecting those bunches with lower or higher development.

If considering these yields as basis, the estimation error obtained when calculating the yield per area is clearly proved when using the lowest sampling distances.

Table 3. Statistics for the percent of leaves

Distance, m	Mean, %	Variance	SD	CV, %	Range	
					Minimum	Maximum
Rainy season						
1	44.39	1.71	1.31	5.73	43.20	46.70
2	42.11	5.81	2.41	4.79	39.20	45.95
3	42.05	0.73	0.85	3.28	40.82	43.86
4	42.66	4.18	2.04	2.94	39.29	46.00
5	43.97	1.99	2.41	2.03	41.33	46.51
Dry season						
1	43.59	7.75	2.78	6.39	39.07	48.00
2	44.78	2.36	1.53	4.72	42.50	46.72
3	46.71	2.37	1.54	3.43	44.44	49.08
4	45.91	0.89	0.95	3.29	44.03	47.06
5	43.56	4.22	2.05	2.06	40.05	47.07

Table 4. Statistics for the dry matter yield

Distance, m	Mean, %	Variance	SD	CV, %	Range	
					Minimum	Maximum
Rainy season						
1	0.39	0.02	0.14	37.44	0.20	0.62
2	0.92	0.04	0.20	21.40	0.59	1.20
3	0.93	0.04	0.20	21.76	0.57	1.25
4	1.13	0.05	0.22	19.10	0.76	1.59
5	2.01	0.13	0.36	18.04	1.47	2.75
Dry season						
1	0.33	0.03	0.16	49.69	0.14	0.63
2	0.52	0.02	0.16	30.26	0.24	0.83
3	0.70	0.01	0.11	16.31	0.55	0.92
4	1.35	0.04	0.19	14.49	0.98	1.67
5	1.43	0.31	0.18	12.35	1.17	1.69

Table 5. Statistics for the number of bunch/m

Distance, m	Mean, %	Variance	SD	CV, %	Range	
					Minimum	Maximum
Rainy season						
1	2.62 (1.61)	0.32	0.57	21.68	2	3.5
2	3.87 (1.97)	0.63	0.79	20.49	3	5
3	5.17 (2.27)	0.88	0.94	18.14	4	6
4	7.94 (2.82)	1.59	1.26	16.64	6	9.5
5	9.33 (3.05)	0.61	0.78	8.34	8	11
Dry season						
1	2.80 (1.67)	0.64	0.80	28.69	2	5
2	4.80 (2.19)	0.69	0.83	17.29	4	7
3	5.10 (2.26)	0.64	0.86	15.58	4	6
4	7.90 (2.81)	1.35	1.16	14.72	6	10
5	9.70 (3.11)	1.42	1.19	12.27	8	11.5

( ) Values transformed according to $\sqrt{n}$.

In both experimental seasons, the difference between five and one meter was over 1 kg of DM. This may determine that the decision taken is not the most appropriate. Thus, it is important to know in detail the characteristics of the sampling used.

This previously exposed has been demonstrated when conducting a similar study, but with the number of bunches (table 6). When samples are taken in less than five bunches, the variability may increase up to 69 %, as the case of green yield (GM), and up to 65 % in the DM yield. However, this variability diminishes extraordinarily with five bunches and the sample is more precise and reliable.

The samples conducted in more than five bunches did not improve substantially neither the standard deviation nor the coefficient of variation. This could bring about the introduction of errors, due to the time of the sample processing, previously informed by del Pozo *et al*. (1998).

Another factor that may influence these results is that the characteristics of the bunch are not uniform. The observations conducted in the experimental field showed that the bunch size, its perimeter and the number of stems may vary from 11 to 30. This irregularity is responsible for the variability of the studied indicators.

In the internacional (Brown 1954 and Penatti *et al*. 2005) and national (Senra and Venereo 1986 and Herrera 2007) literature, the problem related with the rigor and precision of the sampling is referred. There is no a uniform methodology to establish the variability of the agronomic indicators due to the influence on the results of different aspects: environmental factors, pastures management, how and when taking the sample, preservation and transfer, time dedicated to processing, number and technical abilities of the persons conducted the sampling, among other aspects. This study contributes to respond some questions related to the sampling.

The results reaffirm the necessity of knowing how to conduct the sampling before starting any research, as well as the ideal number of samples and how to reduce at maximum the variability of the indicators to be measured. All this will have effect on the veracity, rigor and quality of the information.

The results of this study demonstrated that sampling distances below five meters should not be used, due to the variability of the agronomic indicators. Besides, considering that this study was conducted in an erect bunchy plant is precise, thus the results may not be extended to other plants with different architecture and growing habit. Therefore, further studies in function of the plant to be studied are needed.

Table 6. Coefficient of variation and standard deviation for several indicators

Number of bunches	GM, kg		DM, kg		Leaves, %	
	CV, %	SD	CV, %	SD	CV, %	SD
2	68.9	7.86	65.2	6.92	47.9	4.9
3	59.8	5.44	56.1	4.36	35.2	3.7
4	45.3	4.48	31.9	2.41	23.4	2.5
5	20.9	2.31	10.7	1.20	11.6	1.4
8	20.7	2.25	10.2	1.18	11.4	1.2
11	20.5	2.20	10.1	1.17	11.0	1.0

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