Influence of the sampling distance on the agronomical indicators of *Pennisetum purpureum* cv. Cuba CT-115

R.S. Herrera, M. García, Dayleni Fortes, Ana M. Cruz and Aida Romero

Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, Mayabeque, Cuba
Email: rherrera@ica.co.cu

The influence of sampling distance (1, 2, 3, 4 and 5 meters) on the agronomical indicators of *Pennisetum purpureum* cv. Cuba CT-115, cultivated in a typical red ferrallitic soil without irrigation or fertilization was studied using a random block design with four replications. The experiment was developed during two years and samplings were practiced every 90 d. In both seasonal periods, plant height differed ($P < 0.001$) between sampling distances, the same as the dry matter percentages of leaves, stems and the whole plant. Similar performance showed the leaf and stem contents. The highest ($P < 0.001$) DM yields were obtained in the highest sampling distances and varied between 0.39 – 2.01 and 0.13 – 1.48 kg for five and one meter, respectively. The number of sprouts/m showed the same performance ranging between 8.0 and 9.8 for the distance of five meters regarding to 2.25 – 2.59 for the distance of one meter. The best sampling distance was five meters, due to lower variability of the agronomical indicators and high representativeness. Similar studies with grasses of different growing habits as well as with legumes are recommended.

Key words: *sampling, grass, yield, population*

One of the main problems for the study of pastures is the absence of a fast, precise and simple method for the sampling devoted to learn the performance of the agronomical indicators of a pasture population be it under grazing, forage areas, experimental plots or under commercial production conditions. This restriction is undertaken in national (Lerch 1977, Senra and Venereo 1986 and Herrera 2007) and international literature (Brown 1954, Bryan *et al*. 1964 and Johnson 1978).

Facing this situation and in spite of its impact, there is not yet a uniform methodology to establish the variability of the agronomical indicators, due to the influence of diverse factors on the result found: environment, pasture management, way and hour of taking the sample, conservation and moving of the sample, time for its processing, number and technical skill of the persons realizing the sampling, among others.

This situation reaches more importance on evaluating new pasture varieties, since from the quality, rigor and precision of results obtained will depend the recommendation of introducing a new variety which surpasses that traditionally employed in a certain environment.

The objective of this study was to determine the influence of the sampling distance on the agronomical indicators of *Pennisetum purpureum* cv. Cuba CT-115.

Materials and Methods

Location. The experiment was developed in the pasture station "Miguel Sistachs Naya" of the Institute of Animal Science in a typical red ferrallitic soil (Hernández *et al*. 1999).

Treatment and design. Five sampling distances (1, 2, 3, 4 and 5 meters) were studied through a complete random design with four replications.

Procedure. There was a conventional soil preparation and plantation was carried out at the beginning of the rainy period with *Pennisetum purpureum* cv. Cuba CT-115 seeds of four months of age. Seed was planted in the bottom of the furrows which were one meter apart. Using a machete they were cut in fragments of five buds and covered with a mattock with an approximately l0 cm soil layer. It was assured that the same number of buds per furrow and per plot (measuring 25 m^2) was planted. At 150 d of plantation the establishment cut was practiced at 10 cm above soil level. From this moment samplings were carried out every 90 d in both seasonal periods and in the same date, at 10 cm above soil level. Samplings were conducted in the three central furrows of each plot and the two external were eliminated as border effect. Samples of each furrow per plot were protected from the sun and high temperatures and moving them to the laboratory as soon as possible. During the establishment and throughout the two experimental years there was no irrigation or fertilization.

Indicators: In each one of the samples taken the manual separation of leaves and stems was made. They were placed in an air circulating oven at 65ºC until attaining constant weight and dry matter began to be determined. From here, DM percentages of each fraction and of the whole plant were calculated. Also, leaf content and dry matter yield were quantified. Before sampling, plant height from soil level to the growth point in five random points was taken. The number of sprouts was quantified after sampling. All indicators were taken and calculated according to Herrera (2006).

Statistical analysis. An analysis of variance was carried out according to the experimental design, considering the four samplings realized in each seasonal period, according to InfoStat (2002). The number of sprouts was transformed by $\sqrt{n}$.

Results and Discussion

Since samplings were conducted in the same date in the two years, values showed equal performance on realizing the analysis in each quarterly sampling. Therefore, the decision was taken of reporting the values corresponding to each trimester of each seasonal period during the two years, and for each one of the indicators studied.

In both seasonal periods there were differences ($P < 0.05$) in plant height with the sampling distance. The highest values were registered when applied the sampling distance of five meters (table 1).

These values were logical, since at the highest distances the principle of random sampling is fulfilled with greater rigor, due to higher population. In this way the subjectivity that can be introduced by the person performing the sampling, is eliminated. Also, the possible competition established among plants for sunlight and nutrients must be considered.

Another interesting element was the tendency evidenced in the lowest values obtained in the second trimester of each seasonal period. This can be attributed to the fact that the experiment was conducted without irrigation or fertilization. Similar tendency reported Herrera and Padilla (2010) in various grass species, even with the use of fertilization and irrigation.

The lowest ($P < 0.05$) dry matter percentages of the leaf were only obtained with the highest sampling distance in the first and second trimester of the dry and rainy periods, respectively. In all trimesters, the lowest ($P < 0.05$) percentage of stem dry matter and of the whole plant was shown in the five meters distance (table 2).

The performance of the percentile dry matter values of the leaf, stem and whole plant are related to the mechanism complexities and water balance of the plant, in which multiple factors take part that can alter it. Among them are temperature and solar radiation. These factors vary constantly under field conditions and have an impact on the water transportation speed, its gradient and the transpiration that is stimulated as those are increased.

What was previously mentioned could be reasserted since in the highest sampling distances there is more shade between plants than with the shortest. This could have an effect on lower water loss by transpiration and, thus, in the dry matter decrease due to the increase of endogenous water. However, it would be appropriate to design specific experiments accounting for this performance, if taken into account the importance of these indicators in grassland management.

Excepting the second trimester of the rainy period, the percentage of leaves and stem varied ($P < 0.05$) with the sampling distance, and did not show a uniform response pattern (table 3), although there was a tendency not to differ between the highest distances.

This variability in the response pattern of these indicators is not easy to explain, since they maintained constant all the operations related to the sampling and processing of the sample. This rules out the possibility that one factor external to the experiment could influence on the result, since these indicators were analyzed by the same experienced technician and with adequate preparation.

However, although the same sample size was taken, probably, these were not similar, due to the unequal development attained by the sprouts due to the population present at each sampling distance. In this sense, it is known that as population increases, sprouts manifest different growth and development, including the number of individuals forming it, which was demonstrated by Gutiérrez *et al*. (2012) with this same pasture. Also, the fact that there were no differences between the distances of four and five meters could confirm this criterion.

The highest ($P < 0.001$) dry matter yields were obtained in the sampling distance of five meters throughout the whole experimental stage (table 4).

These results have logical performance and are closely related, the same as in the previous indicators, to the existing population at each sampling distance (table 5), since at lower distances the number of sprouts is also lower, the random sampling is not fulfilled with rigor and higher variability is introduced at the moment of taking

Table 1. Plant height (cm)with the sampling distance

Distance, m	Dry period		Rainy period	
	I trimester	II trimester	I trimester	II trimester
1	99.70[b]	29.08[b]	104.70[b]	121.87[b]
2	93.82[c]	29.08[b]	104.27[b]	123.25[b]
3	105.60[ab]	32.25[ab]	109.33[ab]	124.64[ab]
4	105.25[ab]	32.00[ab]	113.09[a]	128.07[a]
5	107.78[a]	33.50[a]	112.55[a]	128.64[a]
SE ±	1.96***	1.21*	2.05**	1.41**

[abc]Values with different letters by column differ at $P < 0.05$ (Duncan 1955)

*P < 0.05 **P < 0.01 ***P < 0.001

Table 2. Dry matter percentages of the leaf, stem and whole plant with the sampling distance

Distance, m	Dry period		Rainy period	
	I trimester	II trimester	I trimester	II trimester
Leaf				
1	27.84[a]	28.18	27.19	27.10[a]
2	27.20[a]	28.17	26.17	25.90[b]
3	25.63[b]	28.25	26.66	26.05[b]
4	27.05[ab]	28.27	26.79	26.07[ab]
5	23.36[c]	27.67	25.71	24.96[c]
SE ±	0.52**	0.27	0.68	0.33***
Stem				
1	21.84[a]	16.83[a]	17.10[a]	19.63[a]
2	18.39[b]	16.59[ab]	17.39[a]	19.55[a]
3	19.45[b]	15.58[bc]	17.31[a]	19.56[a]
4	19.58[b]	15.73[bc]	16.92[a]	18.59[b]
5	17.90[b]	15.21[c]	15.20[b]	18.68[b]
EE ±	0.59***	0.35**	0.33***	0.22***
Whole plant				
1	22.06[a]	23.77[a]	19.79[ab]	22.00[a]
2	22.69[a]	22.70b	19.90[a]	22.48[a]
3	21.38[ab]	22.73b	19.88[ab]	21.26b
4	21.75[ab]	22.31b	19.91[a]	22.04[a]
5	20.74[b]	21.21c	19.07b	20.95b
SE ±	0.42**	0.32***	0.27**	0.21***

[abc]Values with different letters by column differ at P < 0.05 (Duncan 1955)
**P< 0.01 ***P< 0.001

Table 3. Percentages of leaf and stem with the sampling distance

Distance, m	Dry period		Rainy period	
	I trimester	II trimester	I trimester	II trimester
Leaf, %				
1	43.59[a]	69.05[c]	44.40[b]	42.98
2	44.78[ab]	66.89[b]	42.11[a]	43.43
3	45.40[ab]	68.39[c]	43.11[ab]	42.94
4	46.96[b]	66.86[b]	42.66[ab]	43.22
5	45.47[ab]	62.98[a]	44.24[b]	42.72
SE ±	0.77*	0.52**	0.60*	0.26
Stem,%				
1	56.34[b]	30.93[a]	55.55[a]	56.96
2	55.18[ab]	33.11[c]	57.81[b]	56.57
3	54.57[ab]	31.46[b]	56.89[ab]	57.03
4	53.02[a]	33.04[c]	57.34[b]	56.72
5	54.49[ab]	37.01[d]	55.32[a]	57.28
SE ±	0.78*	0.52***	0.58**	0.66

[abc]Values with different letters by column differ at P < 0.05 (Duncan 1955)
**P< 0.01 ***P< 0.001

Table 4. Dry matter yield (kg) with the sampling distance

Distance, m	Dry period		Rainy period	
	I trimester	II trimester	I trimester	II trimester
1	0.33[a]	0.13[a]	0.39[a]	0.46[a]
2	0.52[b]	0.21[b]	0.92[b]	0.68[b]
3	0.70[c]	0.25[b]	0.93[b]	0.96[c]
4	1.43[d]	0.36[c]	1.28[c]	1.27[d]
5	1.48[d]	0.39[c]	2.01[d]	1.89[e]
SE ±	0.17***	0.01***	0.08***	0.07***

[abcde]Values with different letter by column differ at $P < 0.05$ (Duncan 1955)
***$P < 0.001$

Table 5. Population (sprouts/m) with the sampling distance

Distance, m	Dry period		Rainy period	
	I trimester	II trimester	I trimester	II trimester
1	1.60[a] (2.56)	1.55[a] (2.40)	1.61[a] (2.59)	1.50[a] (2.25)
2	2.09[b] (4.37)	1.96[b] (3.72)	1.95[b] (3.84)	2.08[b] (4.33)
3	2.32[b] (5.38)	2.35[c] (5.77)	2.26[c] (5.11)	2.32[c] (5.38)
4	2.75[c] (7.56)	2.71[d] (7.34)	2.67[d] (7.13)	2.74[d] (7.51)
5	3.04[d] (9.24)	3.13[e] (9.80)	3.05[e] (9.30)	2.96[e] (8.76)
SE ±	0.09***	0.08***	0.04***	0.08***

[abcde]Values with different letters by column differ at $P < 0.05$ (Duncan 1955)
( ) Original values
***$P < 0.001$

the sample. This is given by the degree of growth and development that sprouts attained regarding their vital space and competition established among them.

When one meter was sampled in this study, the population varied between two and three sprouts, therefore the sampling was directed. In this case there was no possibility of selecting at random the sprout, and the technician realizing the sampling could be oriented by the subjective characteristics or selecting, according to his criterion that with better characteristics. These aspects do not occur at five meter distance, where the population ranged between eight and nine sprouts. This propitiated the possible differences in the architecture and composition of the sprouts comprising the different sampling distances.

Taking into account these yields, the estimation mistake obtained was clearly observed on using the lowest sampling distances that could be higher than 1 kg DM/m. This would determine that on calculating yield per area, a serious mistake will be made bringing about that the decision taken would not be the most appropriate or the most correct. Therefore, the importance of learning in detail the characteristics of the sampling used.

In order to confirm the above mentioned a field observation was made to quantify the number of stems integrating the sprouts and it was found that it could range between 11 and 30 stems. Also, the coefficient of variation was calculated for yield and it was found that for the distance of one meter was of 37 and 49% in the rainy and dry periods, respectively. For five meters was of 18 and 12% for similar climatic stage. These elements contribute to account for the results presented for the studied indicators.

Different studies concerning the sampling have devoted special interest to the establishment of the number of samples necessary to be taken so as the result represents reliably the characteristics of the pasture population (Penatti *et al*. 2005, Ledo *et al*. 2008 and Leal *et al*. 2009). However, the distance that must be sampled has not been considered, since results will not only depend from the number but also of the combination of both factors (number of samples and sampling distance).

Results obtained in this experiment evidenced that before starting any research, be it in grazing, plots or under commercial production conditions, it is necessary to learn how to make the sampling. This includes the sampling distance and the number of samples that will be taken. These aspects will have a repercussion on the veracity, rigor and quality of the information obtained.

According to the conditions in which this study was developed, it is suggested that sampling distances lower than five meters must not be employed. It is necessary to consider that this study was developed in an erect plant, thus, their results cannot be extrapolated to other plants with different architecture and growth habit. New studies in function of the type of plant requiring investigation are suggested.

References

Brown, D. 1954. Methods of surveying and measuring vegetation. Bulletin 42. Commonwealth Agricultural Bureaux, England. p.18

Bryan, W.W., Shaw, N.H., Edge, L.A., Junes, R.J., t´Mannetje, R.T. & Yates, J.J. 1964. Some concepts and methods in subtropical pastures research. Bulletin 47. CSIRO. Australia. p.16

Duncan, D, B. 1955. Multiple range and multiple F test. Biometrics 11:1

Gutiérrez, E., Nava, J.J., Herrera, R.S., Bernal, H., Treviño, E & Olivares, E. 2012. Effect of sowing density and planting date on the establihment of *Pennisetum purpureum* cv. Cuba CT-115 in a semiarid region of Northen Mexico. UDSA-AMPA-ASAS-CSAS-WSASA. Joint Annual Meeting. Phoenix, Arizona, USA.

Hernández, A., Pérez, J.M. & Boch, D. 1999. Nueva versión de la clasificación genética de los suelos de Cuba. AGROINFIR-MINAG. Ciudad de La Habana, Cuba. p.64

Herrera, R.S. 2006. Fisiología, calidad y muestreos. In: Fisiología, producción de biomasa y sistemas silvopastoriles en pastos tropicales. Abono orgánico y biogás. Eds. Herrera, R.S., Rodríguez, I. y Febles, G. EDICA. Instituto de Ciencia Animal, La Habana, Cuba. p.89

Herrera, R.S. 2007. Collection and processing of the pasture sample. Their influence on morphological indicators and the chemical composition. Cuban J. Agric. Sci. 41:199

Herrera, R.S. & Padilla, C. 2010. Producción de biomasa. In: Producción de biomasa y semillas de pastos y forrajes. Curso pre-congreso. III Congreso de Producción Animal. La Habana, Cuba. CD-ROM

InfoStat 2002. InfoStat profesional. Versión 1.1. Universidad de Córdoba. Estadística y Diseño. F.C.A. Córdoba, Argentina

Johnson, A.D. 1978. Measurements of grassland vegetation and animal production. Bulletin 52, Ed. T´Mannetje, England. p. 8

Leal, B., Leão., de Andrade, M., Batista, J.C. & Ferreira, M. 2009. Repetibilidade e respostas de características morfofisiologicas e productivas de capim-elefante de porte baixo sob pastejo. Pesq. Agrop. Bras. 44:1731

Ledo, F.J., Pereira, A.V., de Souza, F., Avad, A.M., Jank, L & Oliveira, J.S. 2008. Estimativas de repetivilidade para caracteres forrafeiros en *Panicum máximum*. Pesq. Agrop. Bras. 32:1299

Lerch, G. 1977. La preparación de la experimentación científica. In: La experimentación en las ciencias biológicas y agrícolas. Ed. Científico-Técnica. La Habana, Cuba. p. 7

Penatti, M.A., Corsi, M., Gonçalves., Bueno, G & da Silva, C. 2005. Numero de amostras e relação dimensã: formato de moldura de amostragem para determinação de masa de forragen de gramíneas cespitosas. Rev. Bras. Zootec. 34:36

Senra, A. & Venereo, A. 1986. Métodos de muestreo. In: Los pastos en Cuba. Tomo I. Producción. Eds. M. Sistachs, G. Crespo, G. Febles, R.S. Herrera y T. Ruiz. Ed. Instituto de Ciencia Animal. La Habana, Cuba. p. 648

Received: October 8,l 2012