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Chemical Composition Indicators in Sugar Cane Based on the Re-Shooting Age, Plant Variety, and Plant Fraction

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ABSTRACT

The general goal of this paper was to assess the behavior of chemical composition indicators (dry matter, ash, gross protein, phosphorous, and potassium) of two new sugar cane varieties, according to plant fraction and re-shooting age. Several plant fractions (whole, nodes, stem) were analyzed chemically at different re-shooting ages (six, eight, and eleven months). Forage variety My5514 was used as control. Multivariate analysis of variance was also made. The results demonstrated that the chemical composition indicators of ash, gross protein, phosphorous, and potassium in sugar cane, depended on the age of re-shooting, variety, and plant fraction. Dry matter depended on the re-shoot age and plant fraction.

Key words: *sugar cane, chemical composition, re-shooting age, variety, plant fraction*

INTRODUCTION

The fast-growing world population lacking productive support to palliate the current food crisis must be seriously considered due to severe limitations faced by developing countries to feed thousands of humans. It increases poverty, malnutrition, hunger, environmental destruction, and diseases that affect a major part of the planet (Martínez *et al*., 2008).

This reality compels individuals and organizations to find new and more convenient alternatives that promote sustainable development, to meet today´s needs without compromising the satisfaction of the needs of future generations. Accordingly, diversification and good use of resources are important and effective instruments to meet that goal.

In Cuba, productive diversification in agriculture may contribute significantly to total or partial replacement of imports, especially of raw materials, a pressing need that must be addressed (Fernández *et al*., 2014).

In this context, diversification as a strategy for development in livestock raising, mainly bovines, calls for utilization of sugar cane (*Saccharum* spp.) as feed and energy supplements during the dry season in Cuba (November-April), with little availability of sufficient quality pastures in the major livestock areas.

The use of sugar cane in the diet of ruminants has become an important practice under Cuban conditions; pasture and forage yields scarcely go over 15 t of DM/ha, in dry lands. In addition to it, the best conditions for sugar cane harvest coincides with the longest period of feedstuff shortages, suggesting that the plant is an alternative to complement the deficit of grass and forages during the dry season in tropical regions (Rodríguez *et al*., 2009).

Considering advances made in ruminant nutrition, knowledge of the nutritional value of forages becomes fundamental. They are a very important component in bovine diets, as well as an inexpensive, feasible and sustainable choice (León *et al*., 2012). Hence, the aim of this paper was to assess the behavior of chemical composition indicators of two new sugar cane varieties chosen as forage sources by the Plant Breeding Department at the

Mideastern Regional Station for Sugar Cane Research, in the province of Camagüey, Cuba, based on evaluation of plant fraction and re-shooting age.

MATERIALS AND METHODS

The experiment was made at the Mideastern Regional Station for Sugar Cane Research (ETICA), in Camagüey, Cuba, situated 57.08 m above sea level, on 21º 31´north latitude, and 78º 04´west longitude (Agro-weather Station, Florida, Camagüey, 2011). This study was developed on a brown soil with carbonates (Hernández, Ascanio and Morales, 1999).

The prevailing climatic conditions during the study are shown in Table 1.

RESULTS AND DISCUSSION

The chemical composition of sugar cane is one key element that reveals its nutritional value. The study of all its indicators, and the variations originated by several factors are pivotal to make an efficient use of the plant during the dry season, when animal nutrition is more complex.

Table 2 shows the results of multivariate analysis of variance for dry matter (DM), according to the re-shooting age, plant variety, and plant fraction. No significant differences were observed during the interaction of the three factors studied. However, there were significant differences in re-shooting age and plant fraction interaction. The accumulation of DM from this crop was dependent on the interaction of both factors.

The results corroborated the reports by Pate, Álvarez, Phillips and Eiland (2002) in a comparison study of the nutritional value of 66 commercial varieties of sugar cane in south Florida, and other reports made by Valladares *et al*. (2009) in Cuba, while establishing mathematical models to describe the growth speed while accumulating dry matter of three varieties of sugar cane with different maturation dynamics.

The behavior of this indicator may be related to an increase in the cell wall of the plant as it ages. Though it may have been influenced by other causes (water availability, root system development, and season, etc.), plants are also known to undergo morphological changes as they grow, like a decrease in foliar sheets, and an increase of vascular bundles (Mari, Nussio and Schmidt, 2004), which can cause variations of the indicator in forage.

These results corroborated the importance of the bromatological composition for animal nutrition. The DM contents in food are directly proportional to the amount of nutrients per surface unit, allowing animal breeding systems to be more productive and efficient.

It is also important to know the value of ash, the portion that indicates the content of minerals in foods, which is important during many metabolic processes. Moreover, a lot of minerals are essential to the organism, since they are part of certain important organic substances (hormones, enzymes, and other active proteins. So they belong to the group of factors indispensable for nutrition (García *et al*., 2006).

Table 2 shows the results of multivariate analysis of variance for ashes, according to the re-shooting age, plant variety, and plant fraction. Significant differences were observed in the interaction of the three factors studied. Hence, the ash contents in sugar cane depended on the re-shooting age, plant variety, and plant fraction.

Similar behaviors were published by Pate, Álvarez, Phillips and Eiland (2002) in south Florida, the US; and byAnjos, Silva and Campana (2008) in a study of Brazilian sugar cane cultivars.

These results can be explained thanks to the plant's need to use every photoassimilate produced throughout its vegetative stages, which eventually became deficient, especially during growth and maturation. These processes did not occur simultaneously in all the plant varieties; the genetic traits of each individual were translocated to a greater or lesser extent into the buds, where the main physiological changes of the plant take place (Wiley, 2014).

Crude protein (CP) is a bromatological composition indicator that depends on the capacity of the plant to assimilate the largest amount of nitrogen from the soil, with a great effect on the chemical properties.

Table 4 shows the results of multivariate analysis of variance for CP, according to the re-shooting age, plant variety, and plant fraction. Significant differences were observed as to the interaction of the three factors studied.

These results evidenced that the CP contents in the plant depended on the re-shooting age, the cultivar, and plant fraction. Similar behaviors were published by Delgado (2002); Pate, Álvarez, Phillips and Eiland (2002); Preston (2003); Martín (2004); Rincón (2005); Chaves (2007); Vassallo (2007); Anjos, Silva and Campana (2008); Rodríguez *et al*. (2009) and Aguirre *et al*. (2010).

Table 5 shows the results of multivariate analysis of variance for phosphorous (P), according to the re-shooting age, plant variety, and plant fraction. There were significant differences in the interaction of the three factors studied. Hence, the P contents in sugar cane depended on the re-shooting age, plant variety, and plant fraction.

This behavior corroborated the reports by Barrera (2010); García (2011) and Villegas, León, García and Arcia (2013), on the translocation of this element in the plant. They supported the general argument that P contents depend on the plant variety, and decerease with age. Accordingly, high concentrations of the mineral are generally found in young growing organs, though it is lower in older leaves and stems.

Table 6 shows the results of multivariate analysis of variance for potassium (K), according to the re-shooting age, plant variety, and plant fraction. Significant differences were observed in the interaction of the three factors studied.

These results evidenced that the K contents in the plant were dependent on the re-shooting age, cultivar, and plant fraction. Similar behaviors were published by Delgado (2002); Pate, Álvarez, Phillips and Eiland (2002); Preston (2003); Martín (2004); Rincón (2005); Chaves (2007); Vassallo (2007); Anjos, Silva and Campana (2008); Rodríguez et al. *(2009) and Aguirre et al. (2010).*

CONCLUSIONS

The sugarcane chemical composition indicators ash, crude protein, phosphorous, and potassium depended on the re-shooting age, plant variety, and plant fraction. Dry matter was dependent on the re-shooting age and plant fraction.

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Table 1. Climatic variables

Month	Year	Sugar cane stump			Month	Year	Ratan cane		
		Tmp (^{0}C)	RH (%)	Prec. (mm)			Tmp (^{0}C)	RH (%)	Prec. (mm)
November	2009	24.8	77.2	22.7	November	2010	23.5	79.4	27.4
December	2009	24.8	76.8	36.2	December	2010	19.1	75.1	2.9
January	2010	21.9	71.6	0.1	January	2011	22.3	78.2	6.2
February	2010	22.0	73.4	108.0	February	2011	23.6	71.0	0.3
March	2010	22.6	70.6	13.3	March	2011	24.2	66.8	11.9
April	2010	25.2	70.7	91.4	April	2011	26.1	65.6	10.0
May	2010	27.3	73.2	60.2	May	2011	26.1	68.2	82.9
June	2010	28.1	75.0	160.4	June	2011	26.8	81.0	273.6
July	2010	27.4	80.1	186.8	July	2011	27.1	80.2	163.1
August	2010	27.5	80.7	244.1	August	2011	27.3	82.2	288.4
September	2010	26.6	83.5	363.5	September	2011	26.5	83.0	194.8
October	2010	25.8	85.4	182.4					

Agro-Weather Station, Florida, Camagüey, Cuba (2011)

Table 2. Multivariate analysis of variance of dry matter (Tukey P < 0.05)

Source	SC	gl	CM	F	P < 0.05
Main effects					
A:Re-shooting age	288.996	2	144.498	193.54	0.0000
B:Cultivar	15.8726	2	7.9363	10.63	0.0001
C:Fraction	894.709	2	447.355	599.19	0.0000
Interactions					
AB	0.905556	4	0.226389	0.30	0.8746
AC	81.592	4	20.398	27.32	0.0000
BC	0.51177	4	0.127943	0.17	0.9521
ABC	1.40523	8	0.175654	0.24	0.9825
Error	40.3164	54	0.7466		
Total	1324.31	80			

Table 3. Multivariate analysis of ashes (Tukey P < 0.05)

Source	SC	gl	CM	F	P < 0.05
Main effects					
A:Re-shooting age	41.7489	2	20.8744	4014.31	0.0000
B:Cultivar	7.15087	2	3.57543	687.58	0.0000
C:Fraction	125.722	2	62.8608	12088.62	0.0000
Interactions					
AB	7.48967	4	1.87242	360.08	0.0000
AC	135.445	4	33.8613	6511.78	0.0000
BC	5.89067	4	1.47267	283.21	0.0000
ABC	5.0924	8	0.63655	122.41	0.0000
Error	0.2808	54	0.0052		
Total	328.82	80			

Table 4. Multivariate analysis of crude protein (Tukey P < 0.05)

Source	SC	gl	CM	F	P < 0.05
Main effects					
A:Re-shooting age	1.23015	2	0.615075	7.60	0.0012
B:Cultivar	3.99541	2	1.9977	24.67	0.0000
C:Fraction	16.0566	2	8.02831	99.15	0.0000
Interactions					
AB	1.24229	4	0.310572	3.84	0.0081
AC	28.7521	4	7.18803	88.77	0.0000
BC	0.38139	4	0.0953475	1.18	0.3310
ABC	3.65207	8	0.456509	5.64	0.0000
Error	4.37233	54	0.0809691		
Total	59.6824	80			

Table 5. Multivariate analysis of variance of phosphorous (Tukey P <0.05)

Source	SC	gl	CM	F	P < 0.05
Main effects					
A:Re-shooting age	0.00675556	2	0.00337778	6.76	0.0024
B:Cultivar	0.000422222	2	0.000211111	0.42	0.6577
C:Fraction	0.0108222	2	0.00541111	10.82	0.0001
Interactions					
AB	0.00337778	4	0.000844444	1.69	0.1660
AC	0.0455778	4	0.0113944	22.79	0.0000
BC	0.00271111	4	0.000677778	1.36	0.2616
ABC	0.0160889	8	0.00201111	4.02	0.0008
Error	0.027	54	0.0005		
Total	0.112756	80			

Table 6 Multivariate analysis of variance of potassium (Tukey P <0.05)

Source	SC	gl	CM	F	P < 0.05
Main effects					
A:Re-shooting age	5.50442	2	2.75221	581.45	0.0000
B:Cultivar	3.77636	2	1.88818	398.91	0.0000
C:Fraction	0.107356	2	0.0536778	11.34	0.0001
Interactions					
AB	1.38571	4	0.346428	73.19	0.0000
AC	14.1955	4	3.54888	749.76	0.0000
BC	0.208778	4	0.0521944	11.03	0.0000
ABC	3.13636	8	0.392044	82.83	0.0000
Error	0.2556	54	0.00473333		
Total	28.5701	80			