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Evaluation of the nutritional value of forages in a silvopastoral system

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Abstract

The objective of the study was to evaluate the effect of season on the forage production and nutritional value, in an association of *Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs with *Leucaena leucocephala* (Lam.) de Wit. The herbaceous component and tree stratum were sampled; and the availability and chemical composition in the grass, twining legume and tree were estimated. The grass availability was high in both seasons, but higher ($p < 0{,}001$) in the rainy season (RS) with regards to the dry season (DS), with values of 5 895,2 and 3 763,1 kg DM/ha/rotation, respectively. The availability of *L. leucocephala* foliage was similar for both seasons (85,7 and 72,1 kg DM/ha/rotation for the RS and DS, respectively). The $IVDMD_{96}$ in *M. maximus* was adequate (≈ 650 g/kg DM) and similar for both seasons. The ME showed higher values ($p < 0{,}001$) in the RS (7,8 *vs* 7,0 MJ/kg DM). The CP was higher ($p = 0{,}004$) in the DS (13,8 *vs* 11,4 %), while the NDF and ADF did not differ between seasons. In *L. leucocephala* the $IVDMD_{96}$ ($p = 0{,}003$), ME ($p = 0{,}009$) and CP ($p = 0{,}003$) were higher in the DS compared with the RS (601,5 *vs* 545,1 g/kg DM; 7,3 *vs* 6,8 MJ/kg DM; 27,9 *vs* 24,8 %, respectively). In *Neonotonia wightii* (Wight & Arn.) J.A. Lackey all the indicators were similar for both seasons, with an excellent $IVDMD_{96}$ (641,4-667,2 g/kg DM) and CP (18,1-20,6 %) and adequate ME (7,4-7,7 MJ/kg DM). The association of cultivated grasses with *L. leucocephala*, under production conditions, showed high availability of total biomass and CP per hectare; which although higher in the rainy season, showed the potential of these systems to guarantee adequate food production throughout the year.

Keywords: chemical composition, nutrient availability, *Leucaena leucocephala, Megathyrsus maximus*

Introduction

Pastures and forages are the main food source for ruminants and represent the largest volume of the diet, because they are cheaper, have high production capacity and grow easily (Lee *et al*., 2017). On the other hand, nutrient intake is one of the main factors that restrict animal production in the tropic and can only be controlled if the nutritional value of the forages does not constitute a limiting factor (Olafadehan and Okunade, 2018).

Animal husbandry depends, to a large extent, on climate and meteorological factors; for such reason, the annual transition of climate conditions, mainly regarding temperature, relative humidity and rainfall, generates the corresponding variability in forage production and nutritional value. In that sense, tropical animal husbandry based on monocrop grass grazing faces great challenges, especially in the dry season, during which forage availability and quality decrease drastically (Cuartas-Cardona *et al*., 2014).

On the other hand, the determination of the current production capacity of pastures, along with the pressure regarding land use for animal husbandry, has become one of the main challenges to develop integrated planning and decision-making in tropical grazing systems (Crestani *et al*., 2013).

This explains the need to adopt sustainable animal husbandry systems that utilize the advantages of integrated management in the biophysical context of the neotropic, where natural landscapes and mixed forests are incorrectly used as extensive grazing systems. Thus, the environmental conversion based on silvopastoral systems constitutes a promising alternative to face these problems (Murgueitio *et al*., 2011), because systems with trees are capable of preserving biodiversity (Schindler *et al*., 2017), contributing environmental services to ecosystems (Martínez-Pastur *et al*., 2017), increasing qualitatively as well as quantitatively the forage offer for cattle (Carvalho *et al*., 2017), and minimizing the unbalance in feed production that characterizes the systems without trees (Murgueitio *et al*., 2016).

The chemical composition and morphology of forages determine the palatability and nutritional value for cattle, for which they influence the quantity of consumed feed, rumination efficiency, weight gain rate, volume and quality of the produced milk, and reproductive success (Herrero *et al*., 2015). Hence the objective of the study was to evaluate the effect of season on forage production and nutritional value, in an association of *Megathyrsus maximus* with *Leucaena leucocephala*.

Materials and Methods

Location of the experimental area. The research was developed during five years under production conditions, in the grazing area of the dairy farm 66, belonging to the Animal Husbandry Enterprise of Matanzas –Cuba–, which is geographically located at 22º 58′ 39″ North latitude and 81º 29′ 55,66″ West longitude, at 100 m.a.s.l. (Academia de Ciencias de Cuba, 1989).

Edaphoclimatic characteristics. The soil is classified as Brown with Carbonates (Hernández *et al*., 2015), with undulated relief. The climate is tropical warm (Centro del Clima-Instituto de Meteorología, 2018). The values of the climate variables in the experimental stage are shown in table 1.

Table 1. Performance of the climate variables in the experimental period.

Variable	RS	DS
Temperature (ºC)		
Maximum	32,6	28,8
Average	26,5	22,4
Minimum	17,8	15,2
Relative humidity (%)		
Maximum	96,2	95,0
Average	79,6	73,5
Minimum	51,1	43,4
Rainfall (mm)		
Accumulated rainfall	1 338,8	222,4
Evaporation (mm)		
Day	153,6	138,3
Night	50,2	47,9
24 hours	198,1	186,2
Wind (km/h)		
Maximum	64,3	55,5
Average	6,3	8,2
Cloudiness (eighths)		
Average	3,3	2,4

RS: rainy season, DS: dry season.

Grazing area and management description. The grazing area (42 ha) was divided into 36 paddocks of approximately 1,2 ha each. As cultivated grass, *M. maximus* cv. Likoni prevailed; while the tree legume of the system was *L. leucocephala* cv. Cunningham, which had been established for 10 years and was planted at a distance between rows of 5 m, with average density of 553 plants/hectare. For the management of the animals, the grazing surface was fractioned into three areas of 12 paddocks each; the occupation time was 3,0-3,5 days in the RS and 4,5-5,0 days in the DS, which allowed to guarantee resting times to the pasture of 33-39 days and 50-55 days for the RS and DS, respectively. The average stocking rate used was 2,0 LAU/ha.

The *L. leucocephala* plants were pruned in the February-April period, at 1,7 m of height, in an approximate quantity of 15 trees per occupation day in each rotation comprised in the pruning period.

Measurements in the plant community

Floristic composition. It was carried out with a six-month frequency in May and November, through the step method described by EEPFIH (1980).

Plant density of L. leucocephala. It was estimated with a six-month frequency (May and November). For such purpose, the quantity of *L. leucocephala* plants was counted in three characteristic rows of each paddock, the average among them was found, the result was multiplied by the quantity of rows in the paddock and this value was divided between the area.

Estimation of the availability for browsing in L. leucocephala. With a monthly frequency, the leaves and edible fresh stems (up to approximately 3 mm of diameter) were manually collected in 10 of the trees established in each paddock, simulating the browsing performed by the animals up to an approximate height of 2 m.

Pasture availability. It was monthly done, through the alternative method proposed by Martínez *et al*. (1990) upon the entrance and departure of the animals from the paddock; and as average 80 observations were made per hectare.

Proximal chemical analysis of the feedstuffs. With monthly frequency, a homogeneous sample of 300 g de *L. leucocephala* foliage, 300 g of the edible biomass of *M. maximus* y 300 g of *Neonotonia wightii* forage, harvested according to the methodology proposed by Herrera (2006), was sent to the laboratory. The following indicators were measured: dry matter (DM), ash, organic matter (OM), crude protein (CP) and ethereal extract (EE), according to the techniques described by the AOAC (1990). The fibrous fractions –neutral detergent fiber (NDF), acid detergent fiber (ADF)– and lignin were analyzed through the procedure referred by Van Soest *et al*. (1991), without ash correction, using ANKOM^{200} filter bags (ANKOM Technology Corporation, Fairport, NY, USA). The hemicellulose and cellulose were calculated through the difference between NDF, ADF and lignin. The NDF-bound nitrogen (N-NDF) was estimated according to the procedures proposed by Licitra *et al*. (1996).

In vitro DM degradability of the feedstuffs. It was estimated at 96 h of fermentation, through the *in vitro* gas production (GP) technique proposed by Theodorou *et al*. (1994).

Estimation of metabolizable energy (ME). The ME (MJ/kg DM) was estimated according to Menke and Steingass (1988):

$$ME\ (MJ/kg\ DM) = 2{,}20 + 0{,}136^{*}\ GP_{24}\ (mL/200\ mg\ DM) + 0{,}057^{*}CP$$

Where**:**

GP_{24}: gas volume at 24 h

CP (% DM): crude protein content of the feedstuff.

Statistical procedure. For the variables corresponding to the floristic composition the fulfillment of the theoretical assumptions of the variance analysis was tested, through the Statistica program: variance homogeneity by Levene's test (1960) and error normality, by Shapiro-Wilk test (1965). When it was proven that these assumptions were not fulfilled, the Arcsin √% transformation was applied, which did not allowed their fulfillment either.

For such reason, with the statistical program InfoStat (Di Rienzo *et al*., 2012) a non-parametric analysis (Kruskal-Wallis) was carried out, and Conover (1999) test was used for the comparison of the mean ranges. For the variables of the DM and CP availability of the grass and *L. leucocephala*, as well as for the data corresponding to the nutritional value of the diet feedstuffs, variance analysis was made according to general linear model. In the model the effect of season was taken into consideration, and LSD-Fisher test was applied for $p < 0{,}05$.

Results and Discussion

Table 2 shows the results of the floristic composition of the pastureland per season. It was observed that, in both seasons, approximately 70 % of the area was covered by cultivated pastures [*M. maximus*, *Cynodon nlemfuensis* Vanderyst and *Urochloa mutica* (Forssk.) T.Q.Nguyen], which were in turn represented in more than 70 % by the species *M. maximus*; while natural pastures occupied between 14,0 and 17,8 % of the grazing area, without differences between the seasons, and the main species

Table 2. Floristic composition of the pastureland per season*.

Indicator	RS	DS	P-value
Cultivated pastures	20,5 ± 18,88 (69,9)	25,8 ± 22,56 (70,7)	0,213
Natural pastures	20,6 ± 20,57 (14,0)	25,8 ± 23,36 (17,8)	0,218
Twining legumes	31,3 ± 5,63 (9,7)	20,3 ± 4,15 (5,4)	0,009
Weeds	25,3 ± 4,37 (6,4)	23,3 ± 4,85 (5,6)	0,645
CP + TL	25,1 ± 22,16 (79,6)	23,4 ± 25,16 (76,1)	0,694
W + Depopulated zones	24,5 ± 4,33 (6,4)	23,7 ± 4,56 (6,1)	0,857

* Mean range ± standard deviation (arithmetic mean expressed in %), RS: rainy season, DS: dry season, CP: cultivated pastures, W: weeds, TL: twining legumes.

were represented by the *Dichanthium annulatum* (Forssk.) Stapf - *Dichanthium caricosum* (L.) A. Camus, *Paspalum notatum* Alain ex Flüggé, *Cynodon dactylon* (L.) Pers., *Hyparrhenia rufa* (Nees) Stapf, *Sporobolus indicus* (L.) R. Br. and *Phylla strigillosa*.

The twining legumes, among which *N. wightii* represented more than 80 %, emerged naturally in the system and had a significantly higher presence (p = 0,009) in the RS with regards to the DS. In addition, the values were found to be slightly higher than those reported by Lamela *et al.* (2009) in a silvopastoral system (association of de *L. leucocephala* with *C. nlemfuensis*), in which the twining legumes equally emerged spontaneously (3,0-4,0 %).

Weeds (*Acacia farnesiana* (L.) Willd., *Dichrostachys cinerea* (L.) Wight & Arn., *Mimosa pudica* L. and *Ricinus communis* L., among others) had a relatively low presence in the system, with similar values for both seasons (6,4 and 5,6 % for the RS and DS, respectively); likewise, the depopulated zones were scarce (0,01-0,49 %) and did not show differences regarding the representation in the area between seasons.

The cultivated pastures plus twining legumes, which constitute the highest fraction of the diet and show the best nutritional value with regards to the other feedstuffs consumed by grazing animals, represented as a whole between 76,1 and 79,6 % from the total pasture area; while the surface occupied by weeds plus depopulated zones, which constitutes the area that does not produce feed directly for the animals, were between 6,1 and 6,4 % of the pastureland area.

Grass availability (table 3) was high in both seasons, although it showed significant differences (p < 0,001) in favor of the RS. On the contrary, the foliage availability in *L. leucocephala* was relatively low, but similar in the two seasons (85,7 and 72,1 kg DM/ha/rotation for the RS and DS, respectively). Nevertheless, these values are higher than the one reported by Sánchez-Santana *et al.* (2016) for an association of *M. maximus* and *L. leucocephala*, where the forage availability of the woody plant, with density of 236-364 plants/ha, was only 13,3 kg DM/ha/rotation.

On the other hand, the total biomass availability of the system was high in both seasons; however, it showed the same performance as the grass availability, with significant differences (p < 0,001) in favor of the RS.

It is necessary to emphasize that, although the rainfall during the DS represented only 14,3 % of the annual total, the DM availability in this season signified approximately 31 % of the annual availability, for which the system contributed to achieve a better balance in feed production between both seasons when being compared with the systems without trees, where the available biomass in the DS could represent less than 20 % with regards to the annual DM availability. These results prove the importance of associating cultivated grasses with trees, mainly legumes (*L. leucocephala*), because they allow not only to increase the edible biomass production of the system, but also to guarantee higher productive stability between the seasons (Sánchez *et al*., 2018).

The CP availability of the grass was high in both seasons, but significantly higher (p < 0,001) in the RS due to the higher DM availability shown by the pasture in that season. Yet, the CP availability of *L. leucocephala* was low and similar for both seasons. This determined that the total crude protein availability followed the same trend as the CP availability of the grass, with significant differences (p < 0,001) favorable for the RS.

Table 3. Availability of DM (kg DM/ha/rotation) and CP (kg CP/ha/rotation) of the SPS forages.

Availability		$\overline{X} \pm SE$		P-value
		RS	DS	
Dry matter	Grass	5 895,2 ± 309,64	3 763,1 ± 336,71	<0,001
	Leucaena	85,7 ± 9,84	72,1 ± 10,70	0,351
	Total	5 980,9 ±3 09,99	3 835,1 ± 337,09	<0,001
Crude protein	Grass	471,4 ± 25,28	331,5 ± 27,49	<0,001
	Leucaena	23,9 ± 2,74	20,1 ± 2,98	0,350
	Total	495,3 ± 25,48	351,6 ± 27,71	<0,001

RS: rainy season, DS: dry season.

The CP availability values of the system in both seasons propitiated that 3 501,6 kg CP/ha/year were reached, satisfactory result for the production conditions of Cuba, although lower (4 100,0 kg) than the one reported by Bacab *et al.* (2013) in an intensive silvopastoral system constituted by an association of *L. leucocephala* (10 000 plants/ha) and *Cynodon plectostachyus*.

The indicators of the nutritional value of *M. maximus* per season are shown in table 4. The OM content was optimum and showed higher values ($p = 0{,}044$) in the RS. The IVDMD at 96 h was high and had the same performance in both seasons, with average values of 655,1 and 649,5 g/kg DM for the RS and DS, respectively, which are within the range recommended by Arango *et al.* (2016) for this species (600-700 g/kg DM). In addition, such values are similar to the one reported by Santiago-Hernández *et al.* (2016) in a system of *M. maximus* cvs. Mombaza and Tanzania (657,0 g/kg DM) associated with *Melia azedarach* L., planted with a density of 1 000 plants per hectare. However, they are slightly higher than the ones obtained by Frota *et al.* (2017) in *M. maximus* cv. Mombaza in association with *Attalea speciosa* Mart. (629,9 and 609,8 g/kg DM for the RS and DS, respectively).

The ME in the *M. maximus* forage was relatively high in the two seasons and showed a higher value ($p < 0{,}001$) in the RS, similar to the one reported by Heuzé and Tran (2015), estimated through the *in vitro* gas production technique (7,9 MJ/kg DM). The CP was significantly higher ($p = 0{,}004$) in the DS with regards to the RS, which could have been associated to the decrease in the sunlight intensity in that season and to the capacity of *M. maximus* to tolerate limiting light conditions. According to Santiago-Hernández *et al.* (2016), under such conditions this species changes its physiology, thus decreasing biomass production, but improving its nutritional quality.

The CP content in the edible biomass of *M. maximus* in both seasons was higher than the one described for tropical grasses in monocrop (Gaviria *et al.*, 2015), which is due to the association of *M. maximus* with the trees (Silva-Parra *et al.*, 2018), in this case *L. leucocephala*, legume capable of fixing atmospheric nitrogen to the soil (Conrad *et al.*, 2018) and thus contribute to improve the nutritional quality of the pastures that are associated to it. The values for the RS (11,5 %) were similar to the ones reported for this grass, in a SPS with equal *L. leucocephala* density and equivalent rainfall regime (Sánchez-Santana *et al.*, 2016), as well as in another one with high density of this woody plant and a bimodal rainfall regime (Molina *et al.*, 2015).

In the case of N-NDF values of 43,7-45,6 % were found, similar to the ones reported by Montalvão-Lima *et al.* (2018) for the edible biomass of *M. maximus* (45,0 %) in monocrop, with fertilization (20 kg of P_2O_5/ha, 60 kg of K_2O/ha, and 70 kg of N/ha), on a soil classified as Oxisol, and an altitude of 1 014 m.a.s.l.

Table 4. Indicators of the nutritional value of *M. maximus*.

Indicator	$\overline{X} \pm SE$		P-value
	RS	DS	
Dry matter, %	31,2 ± 1,15	31,0 ± 1,08	0,840
OM, %	87,8 ± 1,22	86,6 ± 1,39	0,044
$IVDMD_{96}$, g /kg DM	655,1 ± 46,97	649,5 ± 62,17	0,831
ME, MJ/kg DM	7,81 ± 1,14	7,00 ± 0,64	<0,001
EE, %	1,31 ± 0,22	1,36 ± 0,26	0,137
CP, %	11,4 ± 1,69	13,8 ± 1,94	0,004
N-NDF, %	45,6 ± 5,03	43,7 ± 4,96	0,612
NDF, %	68,7 ± 2,54	68,0 ± 1,93	0,665
ADF, %	35,2 ± 1,69	34,4 ± 2,65	0,416
Cellulose, %	29,8 ± 2,37	28,1 ± 1,27	0,087
Hemicellulose, %	33,8 ± 3,14	34,9 ± 2,02	0,467
Lignin, %	5,4 ± 2,07	4,9 ± 0,92	0,553

RS: rainy season, DS: dry season.

The NDF and ADF content in the edible biomass of *M. maximus* did not differ between the seasons, implying that the phenological age of the plants was analogous even when the chronological age was different (33-39 and 55-60 days for the RS and DS, respectively). These values are lower than those reported by Rodríguez and Lara (2018) in *M. maximus* cv. Tanzania (74,9-80,7 and 41,9-57,6 % for NDF and ADF, respectively) in an intensive silvopastoral system constituted by an association of *L. leucocephala* (34 000 plants/ha) and *M. maximus*.

The hemicellulose content was similar to the one reported by Patiño-Pardo *et al*. (2018) for the forage of *M. maximus* cv. Tanzania, harvested between 35 and 45 days in the sub-region of Sabana in the Sucre Department –Colombia.

Regarding *L. leucocephala* (table 5), the OM content was adequate and with similar values in the two seasons. On the other hand, the $IVDMD_{96}$ showed a higher value ($p = 0{,}003$) in the DS, which could have been due to the lower lignin content in the foliage during that season. This indicator was within the range reported for the foliage of this plant by Pal *et al*. (2015) and Rivera-Herrera *et al*. (2017); however, it was higher than the one obtained by Hernández-Morales *et al*. (2018) *L. leucocephala* leaves (489,7 g/kg DM) in Mexico, as well as by Vivas-Arturo *et al*. (2017) in the edible biomass of this plant (412,0 g/kg DM) in Colombia. In the latter, the low digestibility value could be associated to the low proportion of leaves with regards to the stems in the total edible biomass.

The ME value was higher (p = 0,009) in the DS with regards to the RS. These data exceed the value reported by Rodríguez *et al*. (2014) in the meal of *L. leucocephala* foliage (6,3 MJ/kg DM); nevertheless, they are lower than the 8,4 MJ/kg DM reported by Heuzé and Tran (2015) for the edible biomass of this plant, in both cases estimated through *in vitro* gas production.

The CP content in the *L. leucocephala* foliage was higher ($p = 0{,}003$) in the DS with regards to the RS; however, such indicator showed adequate values in both seasons (24,8 and 27,9 % for the RS and DS, respectively), which are similar to the ones reported by Singh *et al*. (2014) and Cuartas-Cardona *et al*. (2015). These results prove the importance of *L. leucocephala* to increase the CP content of the diet supplied to grazing animals, because under such conditions legumes contribute more protein than grasses (Carvalho *et al*., 2017).

On the other hand, the foliage of tree legumes (such as *L. leucocephala*) is important not only due to the direct CP contribution, but also because of the presence of condensed tannins; they bind with the diet protein to form a tannin-protein complex which can insolubilize proteins and thus avoid their degradation in the rumen, which increases protein bypass towards the lower gastrointestinal tract. This causes a high content of proteins in the small

Table 5. Indicators of the nutritional value of *L. leucocephala*.

Indicator	$\overline{X} \pm SE$		P-value
	RS	DS	
Dry matter, %	30,2 ± 1,86	30,5 ± 1,93	0,807
OM, %	90,8 ± 1,08	90,2 ± 1,34	0,188
$IVDMD_{96}$, g/kg DM	545,1 ± 84,68	601,5 ± 59,97	0,003
ME, MJ/kg DM	6,75 ± 0,56	7,33 ± 0,66	0,009
EE, %	2,54 ± 0,45	2,61 ± 0,48	0,308
CP, %	24,8 ± 1,54	27,9 ± 1,40	0,003
N in NDF, %	51,0 ± 5,68	47,9 ± 5,59	0,485
NDF, %	50,3 ± 3,99	48,9 ± 4,62	0,309
ADF, %	29,9 ± 4,91	29,6 ± 4,12	0,966
Cellulose, %	14,9 ± 4,76	19,8 ± 4,09	0,268
Hemicellulose, %	21,4 ± 3,16	23,7 ± 2,35	0,337
Lignin, %	12,9 ± 2,61	10,0 ± 2,37	0,038

RS: rainy season, DS: dry season.

intestine, which, when digested increase amino acid absorption (Wanapat *et al*., 2015).

The NDF and ADF content in the *L. leucocephala* foliage was similar in both seasons, and the values were lower than the ones reported by Piñeiro-Vázquez *et al*. (2017) for the edible biomass of this plant in Yucatan, Mexico (58,1 and 42,0 % for the NDF and ADF, respectively). Nevertheless, the NDF content was higher than the one reported by Worknesh and Getachew (2018) in the edible biomass of *L. leucocephala* (34 %), harvested with a cutting frequency of 45 days, in Ethiopia.

The lignin content in the edible biomass of *L. leucocephala* was higher (p = 0,038) in the RS, maybe as a consequence of higher regrowth age, due to lower intake by the animals during the season in which the foliage shows the lowest nutritional value. The lignin content in the *L. leucocephala* foliage in the RS was similar to the one reported by Carvalho *et al*. (2017) in the edible biomass of this tree legume cultivated on a yellowish red latosolic soil , during the RS, in a system of association with cultivated pastures for goat feeding, in the Piauí State –Brazil.

On the contrary, the lignin content shown by the foliage of this plant in the DS was similar to the one reported by Worknesh and Getachew (2018) in *L. leucocephala* plants, harvested every 45 days, in Ethiopia (10,6 %).

The analysis of the nutritional value indicators of *N. wightii* forage (table 6) showed that in all the cases there was a statistically similar performance in the two seasons.

The IVDMD at 96 h was high, with higher values than 640 g/kg DM in the two seasons; this is similar to the report by Valarini and Possenti (2006) for the edible biomass of *N. wightii* (640 g/kg DM), harvested in Brazil in a system with annual rainfall of 1 185 mm.

The CP content (18,1-20,6 %) and NDF concentration (48,8-50,1 %) were similar to the values reported by Carter *et al*. (2015) for the forage of *N. wightii* (19,3 and 49,7 %, respectively) in Uganda. However, the ME for ruminants (7,40-7,67 MJ/kg DM) –calculated through the *in vitro* gas production technique– was lower than the one reported by Heuzé *et al*. (2015) for the *N. wightii* forage (8,10 MJ/kg DM), estimated through equations.

The NDF, ADF and lignin values were similar to the ones reported by Verdecia *et al*. (2017) in the *N. wightii* forage, harvested with a frequency between 30 and 45 days in the RS (49,7-52,9; 27,5-29,4 and 5,8-7,2 %, respectively), in a monocrop system on Brown soil with Carbonates, in Granma province –Cuba.

Conclusions

The association of cultivated grasses with *L. leucocephala*, under production conditions, showed high availability of total biomass and CP per hectare; which, even when it was higher in the rainy season, proved the potential of these systems to

Table 6. Indicators of the nutritional value of *N. wightii*.

Indicator	$\overline{X} \pm$ SE		P-Value
	RS	DS	
Dry matter, %	28,0 ± 1,98	28,3 ± 2,01	0,707
OM, %	88,4 ± 2,56	87,1 ± 2,03	0,501
$IVDMD_{96}$, g/kg DM	641,4 ± 73,64	667,2 ± 78,41	0,570
ME, MJ/kg DM	7,67 ± 1,92	7,40 ± 1,98	0,694
EE, %	1,76 ± 0,030	1,85 ± 0,028	0,341
CP, %	18,1 ± 3,18	20,6 ± 3,42	0,394
N in NDF, %	35,6 ± 4,6	32,8 ± 4,08	0,530
NDF, %	48,8 ± 3,58	50,1 ± 3,29	0,576
ADF, %	31,1 ± 3,62	30,3 ± 3,51	0,858
Cellulose, %	19,5 ± 3,06	22,0 ± 3,15	0,396
Hemicellulose, %	21,8 ± 2,78	24,6 ± 2,90	0,192
Lignin, %	7,5 ± 0,82	5,9 ± 0,74	0,430

RS: rainy season, EPLL: dry season.

guarantee adequate feed production throughout the year.

In addition, the edible biomass of *M. maximus* showed, in the two seasons, an adequate nutritional value, with higher concentration of ME in the RS and a higher CP content in the DS. Nevertheless, the *L. leucocephala* foliage had the best nutritional value in the DS, mainly regarding ME and $IVDMD_{96}$; while the *N. wightii* forage showed excellent nutritional value indicators throughout the year, for which the edible biomass of both legumes contributes to complement appropriately the potential diet represented by pasture in both seasons.

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