IN SITU DEGRADABILITY OF CORN STOVER AND ELEPHANT-GRASS HARVESTED AT FOUR STAGES OF MATURITY

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ABSTRACT: Among tropical forages, corn silage is largely used by farmers trying to explore the maximum genetic potential from the animals. However, other tropical forages, such as elephant-grass (*Pennisetum purpureum*), are more productive and therefore cheaper to use than corn silage. Our objective was to compare the in situ degradability of elephant-grass with that from corn hybrids, all harvested at four stages of maturity. The experimental design followed a randomized block design with nested subplots. Two corn hybrids: AG5011, ZN8392 were harvested with 25, 30, 35, and 40% dry matter (DM) in the whole plant, and separated in stem + leaf sheath + leaf blade (stover), and cobs. Elephant-grass was harvested with 30, 40, 50 and 60 days after a leveling cut. Dried and ground samples were incubated in nylon bags inside the rumen for 0, 6, 12, 24, 48 and 72 h to estimate the kinetics of ruminal DM and neutral detergent fiber (NDF) degradation. The advance of maturity increased the NDF and acid detergent fiber (ADF) content in elephant-grass, and reduced its DM degradability. However, maturity had little or no effect on fiber content and DM degradability of corn stover. Elephant-grass had a higher NDF degradability than corn stover, and there was no effect of maturity on NDF degradability of either elephant-grass or corn stover. Fiber degradability of elephant-grass was not worse than that of corn stover, and therefore the choice of forage should be made on economical analysis rather than assuming an intrinsic low production potential for elephant-grass based diets.
Key words: *Pennisetum purpureum*, corn silage, digestibility, rumen, tropical grass

DEGRADABILIDADE *IN SITU* DE HÍBRIDOS DE MILHO E DE CAPIM-ELEFANTE COLHIDOS EM QUATRO ESTÁDIOS DE MATURIDADE

RESUMO: Dentre as forragens, a silagem de milho é amplamente utilizada pelos fazendeiros que visam explorar o máximo do potencial genético dos animais. No entanto, outros volumosos tropicais como o capim-elefante (*Pennisetum purpureum*) são mais produtivos e, portanto, mais baratos do que a silagem de milho. Nosso objetivo foi comparar a degradabilidade *in situ* do capim-elefante com a degradabilidade de híbridos de milho, colhidos em quatro estágios de maturidade. O experimento seguiu um delineamento de blocos ao acaso com sub-parcelas. Dois híbridos de milho: AG5011 e ZN8392 foram colhidos com 25, 30, 35 e 40% matéria seca (MS) na planta toda e separados na fração colmo + bainha + folhas e espigas. Capim elefante foi colhido 30, 40, 50 e 60 dias após o corte de nivelamento. As amostras secas e trituradas foram incubadas no rúmen por 0, 6, 12, 24, 48 e 72 h para cálculo da cinética da degradação ruminal da MS e da fibra em detergente neutro (FDN). O avanço da maturidade aumentou os teores de FDN e fibra em detergente ácido (FDA) do capim elefante e reduziu a degradabilidade da MS. Entretanto, a maturidade teve pouco efeito sobre os teores de fibra e a degradabilidade da MS da fração planta dos híbridos de milho. O capim elefante apresentou maior degradabilidade da FDN do que híbridos de milho, e não houve efeito da maturidade sobre a degradabilidade da FDN das duas espécies. A degradabilidade da fibra de capim-elefante não é pior do que a de híbridos de milho e, portanto a escolha da forragem deve ser feita com base em análises econômicas ao invés de assumir um menor potencial de produção em dietas a base de capim elefante.
Palavras-chave: *Pennisetum purpureum*, digestibilidade, gramínea tropical, rúmen, silagem-de-milho

INTRODUCTION

Forages are the basis for ruminant nutrition and cell-wall digestibility is a major limiting factor of forages nutritive value (Wattiaux et al., 1991). Among available tropical forages corn silage is widely used on dairy farms with high production per cow and is frequently taken as the one with the highest nutritive value (Nussio et al., 2003). The higher nutritive value of corn silage is dependent on the percentage of grain in the total mass (Schmid et al., 1976; Lauer et al., 2001). However, Deinum & Bakker (1981) and Coors & Lauer (2000) have demonstrated that as grain percentage increases, stover digestibility decreases, so that there is no strong relationship between grain percentage and total forage dry matter digestibility. Even more important for the definition of corn silage quality is the observation that milk production in intensified system is usually limited by fiber digestibility, due to the fill effect in the digestive tract (Mertens, 1983). Corn silage with higher fiber digestibility has a higher potential for feed intake and energy concentration, allowing better animal production (Allen, 1996).

Another advantage of corn silage is that it maintains the nutritive value for long period of time (Bal et al., 1997). This occurs because the percentage of grain in the total mass increases to counteract the decline in stover nutritional quality (Silva et al., 2000; Nussio et al., 2001). When plant dry matter (DM) concentration increased from 32% to 40% DM digestibility of the whole plant was unchanged, but the stover digestibility decreased from 62% to 54% (Daynard & Hunter, 1975).

Other tropical grasses, such as elephant-grass (*Pennisetum purpureum*), have a greater yield potential in comparison to corn silage, but their nutritional value declines rapidly with advance of maturity (Deschamps, 1999). Since fiber degradability is usually the most important limitation for animal performance in the tropics (Wattiaux et al., 1991), it potentially could be used as an indicator of nutritive value when selecting forages. Therefore, it was our objective to compare the DM and neutral detergent fiber (NDF) *in situ* degradability of corn stover and elephant-grass, harvested at four stages of maturity.

MATERIAL AND METHODS

Forage production and harvest

Corn **-** On September 8th, 1997, 2 corn hybrids: AG 5011 (Agroceres, SP, Brazil) and ZN 8392 (Zeneca, SP, Brazil) were sown in a commercial field in Assis-SP-Brazil (22º38'S, 50º27'W). The row spacing was 0.9 m and the calculated final sowing density was 6 seeds per linear meter. Fertilizer was applied at 105 kg ha^{-1} N, 70 kg ha^{-1} P_2O_5 and 110 kg ha^{-1} K_2O. Inside each corn field, three experimental blocks were arranged with six rows of corn by 10 m in length. Within each block, areas were assigned randomly to four sampling times, based on plant dry matter concentration. Field DM was monitored twice a week by collecting plant samples and drying them for 4 h at 105ºC in a forced ventilation oven. Twelve corn plants were sampled at random from each block when the field had reached DM concentration of 25, 30, 35 and 40%. The corncobs with the husks were removed from the rest of the plant (stover) and the two fractions were weighed, chopped and frozen in plastic bags at -20ºC.

Elephant-grass - An elephant-grass (*Pennisetum purpureum* cv. Napier*)* production field located at São Pedro, SP, Brazil (22º60'S, 47º88'W) was chosen. After a first leveling cut at approximately 10 cm from the ground, 100 kg ha^{-1} N was applied and three blocks of 6 m × 10 m were arranged. Within each block areas were assigned randomly to four sampling times: 30, 40, 50 and 60 days after the first cut. Approximately 10 kg of fresh material was collected at each sampling time by clipping the plants 10 cm above the soil level. The plants were chopped and the samples frozen in plastic bags at -20ºC.

Chemical analyses

The samples were dried in a forced ventilation oven for 72 h at 60ºC or until constant weight. Forage samples were analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin according to Goering & Soest (1970). Total N and mineral matter (MM) were determined according to AOAC (1990).

Ruminal degradability

A mature ruminally cannulated Holstein dry dairy cow was used to determine *in situ* degradation characteristics. The animal was kept in a free stall and received a corn silage based total mixed ration (TMR) *ad libitum* 14 days before and during the *in situ* incubation, and had free access to water and trace mineralized salt. The TMR contained 67% DM, 35.4% NDF, 21.6% ADF and 17% crude protein (CP) and the animal was fed twice daily. Dacron bags (13 cm × 7 cm; 50 mm pore size) were filled with 3 g of dried ground sample giving a sample:surface area ratio of 16.5 mg cm^{-2}. Forage samples from each block were incubated separately in the rumen. The samples from all two corn hybrids and elephant-grass were incubated simultaneously in the rumen.

All bags were soaked in warm water for 10 minutes to remove water-soluble components and hasten microbial colonization. Triplicates bags for each roughage and stage of maturity for each time, excepted 0, were suspended in the rumen attached to a lead weight, just prior to feeding (07h30 a.m.), and incubated for 6, 12, 24, 48 or 72 h. Two empty bags and two bags containing a standard oat hay sample were included as controls. After the incubation period the bags were immediately placed in ice water to stop the fermentation process. The bags were washed in a washing machine with constant water flux for approximately 15 min until the point of clear water. The bags were dried for 48 h at 60ºC in a forced-air oven. After drying the bags were weighed and analyzed for residual NDF.

Calculations of kinetics of ruminal DM and NDF degradation were obtained with McDonald's equation (1981): $D = A + [B \times (1\text{-}e^{-kd \times T})]$ when $T >$ Lag or $D = A$ when $T \leq$ Lag; where D = degradability at time T, A = soluble fraction (%, wash value at 0h), B = insoluble potentially digestible fraction (%), kd = fractional rate of degradation (% h^{-1}), T = time of incubation and Lag = discrete lag time. The procedure NLIN of SAS® (2000) was used to fit the model to the data using the Marquardt Method. Initial estimates of the model parameters were based on data set visual appraisal.

Statistical analyses

This experiment followed a randomized block design with sub-sampling. Analysis was done using the GLM procedure of SAS® (2000) considering the fixed effects of grass specie (corn or elephant-grass), block within specie, maturity and the interaction species ´ maturity. When a significant species × maturity interaction was apparent, the option SLICE was used to test for maturity effect within each grass species.

Data from *in situ* degradability was analyzed as a split-plot design, where the experimental periods were the blocks, the incubation times were the plots and the grass species were the sub-plots.

RESULTS AND DISCUSSION

Chemical composition

The chemical composition of corn stover and elephant grass was different for all variables analyzed (Table 1). On average, elephant-grass had lower DM content, and higher NDF, ADF and lignin content (Table 1). There was a significant maturity × grass effect for CP, NDF and ADF content ($p < 0.05$, Table 1). Maturity had no effect on the CP, NDF and ADF content of corn stover, but reduced CP, and increased NDF and ADF content in elephant-grass (Table 2).

The NDF content of forages increases with advance in maturity (Soest, 1994). However, in corn silage, the NDF content usually decreases with advanced maturity, mainly because of increased starch accumulation in the grain fraction (Filya, 2004). In our study, the lack of increase in NDF content of corn stover with advanced maturity was unexpected. Working in Mexico, Estrada-Flores et al. (2006) observed an increase from 58% to 64% in the NDF content of corn stem when harvested at three stages of maturity. Darby & Lauer (2002) also reported a linear increase in the NDF content of corn stover harvested at six stages of maturity.

One explanation for these contrasting results is the range of maturity that the hybrids were harvested. In our study, the DM content of corn stover increased from 16.5 to 25%, while in the Estrada-Flores et al. (2006) study, the plants were harvested with a DM content of the stems varying from 22% to 66%. In the Darby & Lauer (2002) study, there was no difference in the NDF or ADF content of corn stover for the first three stages of maturity, both increasing linearly after the fourth harvest date. Zeoula et al. (2003) reported a cubic effect of maturity on NDF content of corn stems. It would be advantageous to the farmer to use corn hybrids with a slow increase in fiber content of corn stover with advanced maturity, which would permit a larger flexibility on the harvest date.

Table 1 - Average chemical composition of corn stover and elephant-grass harvested at four stages of maturity.

Grass species	DM[1]	CP[2]	NDF[3]	ADF[4]	LIG[5]	LIG/NDF[6]
	%					
Corn	20.4	7.7	63.8	41.8	6.0	9.5
Elephant-grass	14.8	9.1	72.8	45.1	9.5	13.1
	P-value					
Species	<0.001	0.001	<0.001	0.002	0.008	0.05
Maturity	<0.001	<0.001	0.05	0.09	0.52	0.43
Maturity × Species	<0.001	0.04	<0.001	0.025	0.94	0.66

[1]DM = dry matter; [2]CP = crude protein; [3]NDF = neutral detergent fiber; [4]ADF = acid detergent fiber; [5]LIG = lignin; [6]LIG/NDF = lignin/neutral detergent fiber

Table 2 - Chemical composition of corn stover and elephant-grass harvested at four stages of maturity.

Corn stover						
DM at harvest	DM[1]	CP[2]	NDF[3]	ADF[4]	LIG[5]	LIG/NDF[6]
%			%			
25	16.5	8.3	65.5	42.5	5.4	8.3
30	19.0	8.0	64.4	41.2	5.3	8.2
35	25.1	7.6	63.2	42.5	7.5	12.1
40	21.2	6.9	62.0	40.9	6.2	10.0
SEM	0.2	0.2	0.7	0.6	0.7	1.0
P-value for maturity effect	<0.001	0.19	0.31	0.63	0.67	0.51
Elephant-grass						
Age at harvest	DM[1]	CP[2]	NDF[3]	ADF[4]	LIG[5]	LIG/NDF[6]
day			%			
40	12.2	11.8	65.3	40.5	10.1	15.4
47	13.1	8.9	75.7	45.2	8.3	11.0
54	15.9	8.5	73.5	47.6	10.8	14.6
61	17.8	7.2	76.8	47.0	8.9	11.5
SEM	0.3	0.3	1.0	0.8	0.9	1.4
P-value for maturity effect	<0.001	<0.001	0.001	0.01	0.75	0.56

[1]DM = dry matter; [2]CP = crude protein; [3]NDF = neutral detergent fiber; [4]ADF = acid detergent fiber; [5]LIG = lignin; [6]LIG/NDF = lignin/neutral detergent fiber

Table 3 - Average *in situ* dry matter degradability of corn stover and elephant-grass harvested at four stages of maturity.

Grass species	Incubation time, h					
	0	6	12	24	48	72
Corn	34.2	38.0	41.3	48.4	55.7	59.5
Elephant-grass	28.3	35.3	38.9	47.3	58.6	62.0
P-value						
Maturity	0.70	0.92	0.55	0.007	0.003	0.03
Species	<0.001	0.026	0.007	0.26	0.006	0.05
Maturity × Species	0.002	0.004	<0.001	0.013	0.008	0.004

Dry matter degradability

There was effect of maturity on *in situ* DM degradability at 24, 48 and 72 h of rumen incubation in both grass species (Table 3), and there was also a difference in DM degradability between grass species at most time points (Table 3). Corn stover had higher DM degradability in the shorter incubation points (0, 6 and 12 h), while elephant-grass had higher DM degradability after 48 and 72 h of rumen incubation (Table 3). The maturity × species interaction was significant for all time points (Table 3).

Advanced maturity reduced DM degradability of elephant-grass after 12, 24, 48 and 72 h of rumen incubation (Table 4) while maturity did reduce DM degradability of corn stover, and in fact, DM degradability of corn stover was increased with advanced maturity after 0, 6 and 12 h of rumen incubation (Table 4).

Maturity has a dramatic effect on DM degradability of elephant-grass (Brito et al., 1999 and Soares et al., 2004). The reduction in DM degradability with advanced maturity has been appointed as the main factor restricting elephant-grass utilization in diets of high producing animals (Salerno et al., 1990).

After calculating the parameters for the kinetics of rumen DM degradability no difference was observed in the rate of DM degradability between elephant-grass and corn stover (Table 5). Corn stover had higher soluble fraction (A) and lower potentially degradable fraction (B) than elephant-grass ($p < 0.05$, Table 5). There was no significant maturity × species interaction. The higher A fraction of corn stover reflects the higher DM degradability after short rumen incubation, and the lower B fraction reflects the lower DM degradability with longer rumen incubations (Table 3).

Table 4 - *In situ* dry matter degradability of corn stover and elephant-grass harvested at four stages of maturity.

Corn stover						
DM at harvest, %	Incubation time, h					
	0	6	12	24	48	72
25	31.7	35.3	39.5	49.2	57.0	59.2
30	31.9	35.7	39.0	46.3	54.3	58.5
35	35.8	40.7	44.1	48.9	56.1	61.2
40	37.3	40.3	42.6	49.4	55.5	59.3
SEM	1.3	1.3	0.9	1.1	1.1	1.4
P-value for maturity effect	0.004	0.01	0.002	0.22	0.37	0.54
Elephant-grass						
Age at harvest, d	Incubation time, h					
	0	6	12	24	48	72
40	31.3	38.8	43.3	52.7	63.6	68.9
47	28.8	36.6	40.5	46.9	60.6	58.5
54	26.6	32.2	34.8	42.9	55.2	61.2
61	26.4	33.7	36.9	46.6	54.8	59.3
SEM	1.5	1.8	1.3	1.6	1.5	1.9
P-value for maturity effect	0.09	0.08	<0.001	0.002	<0.001	0.002

Table 5 - Average kinetics parameters of *in situ* dry matter degradability of corn stover and elephant-grass harvested at four stages of maturity.

Grass species	A[1]	B[2]	Kd[3]	LAG[4]	U[5]
Corn	33.1	30.2	3.0	2.2	36.6
Elephant- grass	28.4	39.2	2.9	0.4	32.5
			P-value		
Maturity	0.22	0.76	0.39	0.69	0.39
Species	0.01	0.004	0.86	0.26	0.11
Maturity × Species	0.18	0.19	0.33	0.45	0.17

[1]A = soluble fraction (%), [2]B = insoluble potentially degradable fraction (%), [3]kd = rate of degradation (% h^{-1}), [4]Lag = discrete lag time (h), [5]U = indigestible fraction

The highest A fraction of corn stover could be explained by the lower NDF content across maturities. The highest B fraction for elephant-grass could be an indicator of higher potentially degradable fiber, which is usually negatively correlated with lignin/NDF (Traxler et al., 1998). However, in this study, the lignin/NDF content of elephant-grass was higher than in corn stover (Table 1). Although elephant-grass had higher lignin/NDF content than corn stover, the NDF degradability of elephant-grass was higher than the NDF degradability of corn stover in all time points, except 0 h of rumen incubation (Table 7) this agrees with the higher B fraction observed for the kinetics of DM degradability.

The advance in maturity did not alter the kinetics parameters of *in situ* DM degradability for both grasses (Table 6). When working with tropical forages Paciullo et al. (2002) did not also find any difference in the rate of DM digestion for the stem of young or old plants. In contrast a decrease in DM degradability of corn stover has been demonstrated by others (Darby & Lauer, 2002; Lewis et al., 2004). Lewis et al. (2004) reported a significant maturity × hybrid interaction for stover DM degradability when working with three corn hybrids.

Neutral detergent fiber degradability

A grass effect for NDF degradability was observed (Table 7). Elephant-grass had higher *in situ* NDF degradability than corn stover (Table 7). The maturity × grass interaction was not significant (Table 7). Overall, maturity had little effect on NDF degradability on both grass species. With advance in maturity there was an increase in NDF degradability of corn stover only after 6 h of rumen incubation, while in elephant-grass there was a tendency for lower NDF degradability after 72 h of rumen incubation (Table 8).

Table 6 - Kinetics parameters for *in situ* dry matter degradability of corn stover and elephant-grass harvested at four stages of maturity.

Corn stover					
DM at harvest, %	A[1]	B[2]	Kd[3]	LAG[4]	U[5]
25	34.0	27.2	4.6	5.4	38.7
30	30.7	31.8	2.7	2.7	37.4
35	36.3	31.0	2.2	0.0	32.7
40	31.5	30.7	2.3	0.8	37.7
SEM	1.3	1.7	0.5	1.6	2.4
P-value for maturity effect	0.11	0.38	0.11	0.23	0.40
Elephant-grass					
Age at harvest, d	A[1]	B[2]	Kd[3]	LAG[4]	U[5]
40	31.5	43.2	2.8	0.0	25.1
47	29.0	39.0	2.7	0.0	31.1
54	26.6	38.6	2.6	1.5	34.9
61	26.4	43.1	2.4	0.0	30
SEM	1.8	2.5	0.8	2.3	3.4
P-value for maturity effect	0.29	0.34	0.93	0.95	0.20

[1]A = soluble fraction (%), [2]B = insoluble potentially degradable fraction (%), [3]kd = rate of degradation (% h^{-1}), [4]Lag = discrete lag time (h), [5]U=indigestible fraction

Table 7 - Average *in situ* NDF degradability of corn stover and elephant-grass harvested at four stages of maturity.

Grass species	Incubation time, h					
	0	6	12	24	48	72
Corn	4.8	5.1	16.4	28.4	36.3	42.1
Elephant-grass	2.9	11.5	20.2	33.3	45.3	50.6
P-value						
Maturity	0.47	0.34	0.99	0.22	0.13	0.21
Species	0.42	0.003	0.02	0.004	<0.001	<0.001
Maturity × Species	0.14	0.10	0.08	0.16	0.28	0.18

When looking at the kinetics parameters there was a significant grass effect for the B fraction lag-time and a tendency for a difference in the U fraction (Table 9). Elephant-grass had a higher potentially degradable NDF fraction, shorter lag-time and smaller indigestible NDF fraction (Table 9). The rate of NDF degradability was the same (Table 9). Advance in maturity had no effect on the kinetics of NDF degradability for either corn-stover or elephant-grass (Table 10). In contrast to our results, Estrada-Flores et al. (2006), Browne et al. (2005) have reported a marked decrease in NDF degradability of corn hybrids with advance in maturity.

When evaluating five corn hybrids in Brazil, Zeoula et al. (2003) also did not observe a clear effect of maturity on *in vitro* DM and NDF degradability of corn stem. There was a great variability among the five hybrids, and the authors attributed this behavior to the process of nutrient translocation between the stem and the grains, that can be greatly altered by environmental conditions (Zeoula et al., 2003).

The observation that the NDF of elephant-grass had a greater degradability than the NDF from corn stover was unexpected. Elephant-grass is a tropical forage capable of annual DM yield about 3 to 4 times higher than the DM yields obtained with corn silage (Minson et al. 1993). However, although in the tropics corn for silage has a much lower productivity than elephant-grass, it is usually considered the best quality forage available for ruminants, and is allocated to the higher performing animals in a property (Nussio et al., 2003).

Although corn silage has a higher energy value than elephant-grass it also has lower stover NDF degradability. This lower NDF degradability can limit productivity, especially in high producing dairy cows,

Table 8 - *In situ* NDF degradability of corn stover and elephant-grass harvested at four stages of maturity.

	Corn stover					
DM at harvest, %	Incubation time, h					
	0	6	12	24	48	72
25	5.7	2.9	15.8	30.3	40.0	42.5
30	0.2	0.6	13.0	25.5	34.2	41.4
35	2.7	7.8	19.0	28.4	36.3	43.3
40	10.5	9.3	17.6	29.3	34.8	41.1
SEM	3.1	2.1	1.8	1.8	2.0	2.2
P-value for maturity effect	0.07	0.03	0.12	0.29	0.19	0.89
	Elephant-grass					
Age at harvest, d	Incubation time, h					
	0	6	12	24	48	72
40	0.0	9.5	20.6	35.9	47.9	56.7
47	4.3	14.8	23.1	35.7	49.0	52.4
54	6.0	8.9	17.6	28.2	42.2	45.7
61	2.7	12.6	19.7	33.2	42.0	47.6
SEM	3.5	2.9	2.4	2.6	2.8	3.2
P-value for maturity effect	0.52	0.48	0.49	0.14	0.18	0.09

Table 9 - Average kinetics parameters of *in situ* NDF degradability of corn stover and elephant-grass harvested at four stages of maturity.

Grass species	A[1]	B[2]	Kd[3]	LAG[4]	U[5]
Corn	5.8	37.2	5.0	5.5	56.9
Elephant-grass	3.3	50.3	4.0	1.7	46.5
			P-value		
Maturity	0.82	0.19	0.49	0.82	0.89
Species	0.48	0.006	0.19	0.009	0.10
Maturity × Species	0.71	0.20	0.41	0.07	0.82

[1]A = soluble fraction (%), [2]B = insoluble potentially degradable fraction (%), [3]kd = rate of degradation (%/h), [4]Lag = discrete lag time (h), [5]U = indigestible fraction

Table 10 - Kinetics parameters for *in situ* NDF degradability of corn stover and elephant-grass harvested at four stages of maturity.

	Corn stover				
DM at harvest, %	A[1]	B[2]	Kd[3]	LAG[4]	U[5]
25	4.5	38.0	6.9	7.1	57.4
30	4.8	37.9	4.4	6.8	57.2
35	3.4	40.6	4.4	2.5	55.9
40	10.4	32.3	4.2	5.7	57.2
SEM	3.7	2.8	0.7	0.9	5.7
P-value for maturity effect	0.60	0.34	0.14	0.07	0.99
	Elephant-grass				
Age at harvest, d	A[1]	B[2]	Kd[3]	LAG[4]	U[5]
40	0.0	59.6	3.9	1.2	40.4
47	4.3	51.3	4.1	0.7	44.4
54	6.0	43.5	3.8	4.1	50.5
61	2.8	46.7	4.2	0.7	50.6
SEM	5.3	4.0	1.0	1.3	8.0
P-value for maturity effect	0.87	0.15	0.99	0.33	0.77

[1]A = soluble fraction (%), [2]B = insoluble potentially degradable fraction (%), [3]kd = rate of degradation (% h^{-1}), [4]Lag = discrete lag time (h), [5]U = indigestible fraction

where intake is usually limited by the fill effect of forages (Oba & Allen, 1999). Digestibility of the cell-wall has been appointed as the major limiting factor of the nutritive value of forages (Wattiaux et al., 1991). Based on this concept, temperate countries have used cell-wall digestibility as the target in corn breeding programs aiming silage production (Dolstra et al., 1993; Argillier et al., 2000). There is great variability in cell-wall degradability of corn stover grown in Brazil (Silva et al., 1999), and given its lower NDF degradability as compared to elephant-grass, it would be important to incorporate this parameter into corn breeding programs.

In conclusion, maturity decreased DM degradability of elephant-grass more dramatically than in corn stover. However, NDF degradability was greater for elephant-grass than corn stover. The choice of forage should be made on economical analysis rather than assuming an intrinsic low production potential for elephant-grass based diets.

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