RUMINAL SILAGE DEGRADABILITY AND PRODUCTIVITY OF FORAGE AND GRAIN-TYPE SORGHUM CULTIVARS

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ABSTRACT: Forages for feeding dairy cows should conciliate the potential for high dry matter yield per unit area, maximizing animal stocking rate, with high nutritive value, which enables decreasing the amount of concentrate feedstuffs per milk unit produced. Eighteen sorghum cultivars were cultivated 0.70 m apart and with 12 plants per linear meter. Plants harvested at the milk-to-dough stage were ensiled in the laboratory. Eleven agronomic and chemical traits were evaluated. Silage samples were incubated *in situ* and the effective ruminal dry matter degradation (DEF) was calculated assuming a fractional passage rate of -0.04 h^{-1}. Dry matter yield was 13.0 ± 2.3 (mean ± S.D.) t ha^{-1}. The neutral detergent fiber content was 50.3 ± 3.8 and the DEF was 48.8 ± 2.8% (dry matter basis). The average sorghum DEF was 84% of the DEF of a composite sample of 60 corn hybrids simultaneously cultivated, ensiled and ruminally incubated. The 12 forage-type cultivars were taller, more productive, had higher fiber content and lower DEF than the 6 grain and dual purpose-type cultivars. The acid detergent fiber content had the greatest correlation with DEF (r= -0.64). The linear model correlating DEF with productivity was: DEF=54.694 – 0.4449 x t of dry matter ha^{-1} (r^2=0.14). Although there are cultivars that show high productivity and digestibility, it seems to be difficult to conciliate the maximum nutritive value with the maximum productivity of the sorghum crop.
Key words: digestibility, fiber, rumen, *in situ*, corn silage

DEGRADABILIDADE RUMINAL DAS SILAGENS E PRODUTIVIDADE DE CULTIVARES DE SORGO DE TIPO FORRAGEIRO E GRANÍFERO

RESUMO: Forrageiras para alimentação de vacas leiteiras devem conciliar a alta produção de matéria seca por área, maximizando a taxa de lotação animal, com o alto valor nutritivo, capaz de reduzir a necessidade de alimentos concentrados por litro de leite produzido. Dezoito cultivares de sorgo foram cultivados com espaçamento de 0,70 m e 12 plantas por metro linear. As plantas colhidas ao atingirem o estádio leitoso-pastoso foram ensiladas em laboratório. Onze características agronômicas e químicas foram avaliadas. As silagens foram incubadas *in situ* e a degradabilidade efetiva da matéria seca no rúmen (DEF) foi calculada assumindo uma taxa de passagem de -0,04 h^{-1}. A produção de matéria seca foi 13,0 ± 2,3 (média ± D.P.) t ha^{-1}. O teor de fibra em detergente neutro foi 50,3 ± 3,8 e a DEF foi 48,8 ± 2,8 (% da matéria seca). A DEF média do sorgo foi 84% da DEF de uma amostra composta de 60 cultivares de milho simultaneamente cultivados, ensilados e incubados no rúmen. Os 12 cultivares do tipo forrageiro foram mais altos, produtivos e fibrosos e tiveram menor DEF que os 6 cultivares graníferos e de duplo propósito. O teor de fibra em detergente ácido foi a característica mais correlacionada à DEF (r=-0,64). O modelo linear correlacionando a DEF à produtividade foi: DEF=54,69 – 0,4449 x t de matéria seca ha^{-1} (r^2=0,14). Apesar de existirem cultivares com alta produtividade e digestibilidade, pode ser difícil conciliar o máximo valor nutritivo com a máxima produtividade na planta de sorgo.
Palavras-chave: digestibilidade, fibra, rúmen, *in situ*, silagem de milho

INTRODUCTION

Forages for feeding dairy cows should preferentially conciliate the potential for high dry matter yield per unit area, maximizing animal stocking rate, with a high nutritive value per unit of dry matter, which enables decreasing the need for concentrate feedstuffs per milk unit produced. The sorghum crop has a high productivity potential and a high content of nonfibrous carbohydrates, mainly starch, which are desirable attributes of dairy cattle forages. Agronomically, the sorghum may be superior to corn for planting towards the end of the rainy season or the “safrinha” (minicrop) planting (Escalada & Plucknett, 1975) and in regions with scarce water availability (Bennett & Tucker, 1986).

Commercial sorghum cultivars are constantly being developed, making the comparison between plant types an issue of continued interest. Morphologically, the sorghum plant has large variability (Fribourg, 1995). Plant height at maturity can range from 0.45 to 5 m. The panicle can be compact in grain-type cultivars and more open in forage-type cultivars. The number of seeds per kg ranges from 25,000 to 60,000 for grain sorghums, while in forage sorghums it ranges from 120,000 to 150,000. The percentage of tanin in the seed also varies and may determine protein and carbohydrate digestibility of the grain (Barry & Manley, 1984). Possible interactions between cultivars and the environment may also exist, making it necessary to select cultivars for the environment where they are going to be grown (Embrapa, 1982).

The objective of this work was to evaluate agronomic and chemical traits and silage ruminal degradability of whole sorghum plants. The possibility of conciliating productivity and nutritive value for ruminants in a plant population of great variation in morphology and agronomical aptitude, from the same experimental field located in the south of the State of Minas Gerais, was also evaluated.

MATERIAL AND METHODS

Eighteen sorghum cultivars were evaluated in an experiment organized as a completely randomized block design with three replicates, installed in Lavras, MG, Brazil (21°14’43”S, 44°59’59”W) on December 1, 1997. For statistical analysis purposes, cultivars were separated by plant type according to specifications given by seed producing companies into forage (Forrag), those specifically developed for use as animal feed in the form of whole plants, or dual purpose and grain sorghum (Gran + DP). The following forage-type sorghums were cultivated: ACA 726, AG 2002, AGX 202, AGX 213, BR 501, BR 601, BR 700, C 11, C 15, CEPX 9702, CMSXS 755 and P 54037. Dual purpose sorghum was: AG 2005. Grain sorghum cultivars were: C 51, DK 57, MASSA 03, P 8118 and XB 1502.

Plots consisted of four, 5-m long rows, 0.70 m apart. After thinning, 12 plants were maintained per linear meter. The soil was tilled in the conventional way, with one plowing and two harrowings. Fertilization at planting consisted of 350 kg ha^{-1} of 8-28-16 rate + 0.5 kg ha^{-1} Zn and a sidedressing with 70 kg ha^{-1} nitrogen in the form of urea, when plants had 5 to 7 leaves. All other cultural practices were those commonly adopted for sorghum cropping (Embrapa, 1982).

Plant evaluations were made in two central rows of each plot. Samples were harvested 10 cm from the soil surface when plants reached the milk-to-dough grain maturation stage, 100 to 120 days after emergence. The following agronomic characters were evaluated for each cultivar: Flowering (FL): defined as the number of days elapsed from seeding to the point when 50% of the plants in the plot had their panicles open and releasing polen; Plant height (PH): measured from the soil surface to the flag leaf node; Dry matter percentage (DMp): determined by drying in a 58°C forced air oven for 72 h and later drying in a 100°C oven for 24 h; Fresh matter yield (FMY): determined by weighing all plants from the usable area; Dry matter yield (DMY): determined by multiplying FMY by DMp.

Immediately after harvesting, plants were ground in a forage chopper and two 900 g sub-samples were obtained. The first sample was dried in a 58°C forced air oven for 72 h and ground with a Wiley mill (5 mm screen; Arthur H. Thomas, Philadelphia, EUA) to determine DMp. The second sample was ensiled in experimental PVC silos, with Bunsen type valves and sealed with masking tape. The silos were 50 cm tall with a 10 cm diameter.

A composite sample was formed per cultivar one hundred days after ensiling by mixing similar amounts of each ensiled plot. The composite sample per cultivar was dried in a 58°C forced air oven for 72 h. Half of these samples were ground with a Wiley mill (5 mm screen), remaining available for the determination of ruminal *in situ* degradability. The other half was ground with a 1 mm screen to be used for chemical analyses: Silage dry matter percentage (DMs): measured as previously described for DMp; Ash free neutral detergent fiber (NDF): NDF assay used 0.5 g of sodium sulfite and 200 μL of heat stable α-amylase, 100 μL added to 50 mL of NDF solution prior to boiling and the other 100 μL into the crucible filled with hot water during filtering (Van Soest et al., 1991); Ash free acid detergent fiber (ADF): determined non sequentially according to Van Soest et al. (1991); Crude protein (CP) and ether extract (EE): determined according to the Association of Official Analytical Chemists (1970); Ash: determined by combustion in a 550°C muffle for five hours; Nonfibrous carbohydrates (NFC): calculated by the formula 100-(CP+NDF+EE+Ash).

The *in situ* degradability of the silages was determined in eight non-lactating, rumen-cannulated cows. The animals were fed a diet consisting of sorghum silage *ad libitum* and 2 kg of a corn-soybean meal based concentrate for 18 days; incubations were performed during the last 3 days. Five gram samples were placed into 7 x 15 cm, 100% polyester bags. Laundry bags (20 x 35 cm) containing sets of 18 polyester bags were placed in reverse order in the ventral region of the rumen. Incubation times were: 12, 24 and 72 h. Laundry bags were attached to the rumen cannula plug with a nylon string and anchored in the rumen with lead balls. Upon removal from the rumen, bags were immediately soaked in ice water and washed in a washing machine for 20 minutes. The bags were then dried for 72 hours at 58°C for residual dry matter determination. The time zero bags, used to determine the instantaneously degradable A fraction (A), were not introduced into the rumen of the animals and were washed with the incubated bags in the same washing machine cycle.

The A fraction was assumed to be the mean value of 8 washed samples for each cultivar. The indigestible C fraction was assumed to be the residue of bags that were incubated for 72 hours. The slowly degradable B fraction was obtained by the expression 100-(A+C). The fractional degradation rate of the B fraction (kd) was determined by linear regression, over times 0, 12 and 24, of the natural logarithm of bag residues as a percentage of the initial bag content after subtracting fraction C from that number. The effective ruminal dry matter degradability (DEF) was calculated by the equation A+B[kd/(kd+kp)], with an assumed kp, the fractional passage rate, of –0.04 h^{-1}.

Statistical analyses

The analyses of variance were performed by the GLM procedure of SAS (1995). A model containing the block (1 to 3) and cultivar (1 to 18) effects was utilized for the agronomic traits (DMp, PH, FL, FMY, DMY). Another analysis was carried out comparing agronomic traits of forage cultivars (Forrag) (n=12) with those of grain and dual purpose cultivars (Gran+DP) (n=6). For this analysis a similar model was utilized, but the cultivar effect was replaced by the cultivar type effect (Forrag or Gran+DP). Chemical traits (DMs, NDF, ADF, CP, EE, Ash, NFC) of ensiled and composited samples were also analysed with a model containing the cultivar type effect, but without the block effect.

The *in situ* degradation parameters (DEF, B, C, kd) were analyzed with a model containing cow (1 to 8) and cultivar (1 to 18) effects. The A fraction was analyzed by the same model but without the cow effect, since the nylon bags to estimate degradation at time 0 were not methodologically inserted into the rumen of the animals. Another analysis was performed comparing rumen degradability of Forrag with Gran+DP. For this analysis a similar model was utilized, in which the cultivar effect was replaced by the cultivar type effect (Forrag or Gran+DP). The instaneously degradable A fraction of Forrag and Gran+DP were analyzed by the same model, but without the cow effect, for the same reasons presented before.

The least square means were generated for the chemical and agronomic traits and for the DEF of each cultivar to be used in the correlation and regression analyzes by the CORR procedure of SAS (1995). The model that best predicted DEF was estimated by *Stepwise*-type regression, with agronomic and chemical traits as independent variables. Since NDF and ADF were highly correlated (r=0.93), only the variable that was more correlated with DEF, i.e., ADF, was utilized in the regression. Only independent variables with significance smaller than 0.15 were included in the model.

RESULTS AND DISCUSSION

The cultivar effect was significant for all agronomic traits ($P < 0.01$), showing the large morphological variability among sorghum plants (Table 1). The DMp at harvest can be considered low when compared to values for corn plants at the hard-dough maturation stage (Fonseca, 2000). Sorghum plants have a smaller proportion of grain in the whole plant as compared to corn (Zago, 1997; Fancelli & Dourado Neto, 2000). Forage-type cultivars showed smaller DMp than grain and dual purpose cultivars (Table 2), as a reflex of the greater plant size and proportionality of leaves and stalks relative to panicle (Pedreira et al., 2001).

Table 1 - Agronomic traits, silage chemical traits and silage dry matter ruminal degradation parameters of 18 sorghum cultivars: Plant dry matter content (DMp), plant height (PH), flowering (FL), fresh matter yield (FMY), dry matter yield (DMY), silage dry matter content (DMs), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE), ash, non-fiber carbohydrates (NFC), effective ruminal dry matter degradability (DEF), instataneously degradable A fraction (A), slowly degradable B fraction (B), indigestible C fraction (C) and fractional degradation rate of the B fraction (kd).

Variable	Mean	Standard Deviation	Minimum	Maximum
DMp (% of fresh)	31.8	4.0	23.7	38.3
PH (m)	2.3	0.6	1.4	3.2
FL (days)	75	7.5	66	90
FMY (t ha^{-1})	41.9	10.2	25.2	65.3
DMY (t ha^{-1})	13.0	2.3	8.8	16.6
DMs (% of fresh)	28.7	4.0	21.6	35.6
CP (% of DM)	6.7	0.6	5.9	8.1
NDF (% of DM)	50.3	3.8	44.8	60.4
ADF (% of DM)	31.6	3.3	26.5	40.6
EE (% of DM)	4.0	0.6	3.0	5.0
Ash (% of DM)	5.1	0.4	3.8	5.8
NFC (% of DM)[1]	33.6	3.6	24.7	39.3
DEF (% of DM)[2]	48.8	2.8	44.0	54.0
A (% of DM)	27.1	2.7	21.3	31.2
B (% of DM)	44.1	3.7	34.9	47.9
C (% of DM)	28.4	3.7	23.3	36.6
kd (% h^{-1})	-3.8	0.3	-3.3	-4.3

[1]NFC = 100 - (CP + NDF + EE + ASH).
[2]DEF = A+B[kd/(kd+kp)]. kp = -4% h^{-1}.

The DMs of the silages (Table 1) was, on average, 10% lower than the DMp at harvest (Table 1). Since no loss of effluent was observed in the mini PVC silos, the difference in DM % could be the result of DM degradation during ensiling (McDonald et al., 1991) or water formation during the fermentation of carbohydrates to acetic acid (Gourley & Lusk, 1978). Another possibility would be the loss of volatile fatty acids during silage drying in the oven (Petit et al., 1997). However, the correlation between DMp and DMs among the 18 cultivars was 0.91, demonstrating that this trait was maintained after ensiling for each cultivar. The linear equation that correlated DMp with DMs was: DMs=5.7674 + 0.9073 DMp, r^2=0.84. The DM percentage determines the fermentative profile of the silage (McDonald et al., 1991), the calculation of dry matter yield per hectare and the as fed proportion of each in diets for dairy cows. DM determination in harvested plants seems to be adequate and saves time and work as compared to making the determination after ensiling.

The forage cultivars were taller and more productive than the grain cultivars (Table 2), a consensus in the literature (Zago, 1991). Corn hybrids cultivated simultaneously in areas adjacent to this experiment yielded, on average, 16.0 t of DM per hectare, ranging from 9.3 to 21.3 (Fonseca et al., 2002). Even though some sorghum cultivars may attain higher yields than corn hybrids, the mean yield of the 12 forage cultivars (Table 2) was lower than the mean value of 60 corn hybrids (Fonseca et al., 2002). Assuming that both corn and sorghum cultivated at the beginning of the rainy season would be ensiled when the soil has higher moisture content and higher propensity to compaction, and both would need soil decompaction after being mechanically harvested with a silage harvester, using sorghum rattoon is not an option when the objective is an adequate management of the soil (Pereira, 2000). In this case, the comparison of yield per unit area between corn and sorghum should be made based on one annual cut; in this case, corn shows higher yield. In late cultivation or in minicropping, which explore the potential for lower sensitivity to photoperiod and water deficiency by the sorghum plant relative to corn (Escalada & Plucknett, 1975), the crop can be superior to corn in yield or even become a second crop after corn has been cultivated in the area. In areas to be utilized for corn silage, sorghum may provide a second forage cropping season, when ensiling would take place in the dry season, with a reduced propensity to soil compaction, enabling the rattoon to be maintained for a new harvest or to be used as straw for no-till corn cropping.

Table 2 - Agronomic traits of 12 forage sorghum cultivars (Forrag) and 6 grain and dual purpose cultivars (Gran+DP): Plant dry matter content (DMp), plant height (PH), flowering (FL), fresh matter yield (FMY) and dry matter yield (DMY).

	Forrag	Gran+DP	SEM[1]	*P* for cultivar type effect
DMp (% of fresh)	30.6	34.8	0.88	<0.01
PH (m)	2.55	1.67	0.08	<0.001
FL (days)	75.6	73.3	2.67	0.54
FMY (t ha^{-1})	46.8	31.8	1.80	<0.001
DMY (t ha^{-1})	14.1	11.0	0.53	<0.001

Each cultivar was planted in triplicate and harvested at 10 cm from the soil surface at the milk-to-dough stage of maturity.
[1]SEM = Standard error of the mean.

The proportional difference between the smallest and the greatest value for silages chemical traits ranged from 35%, for NDF, to 67%, for EE (Table 1). The coefficient of variation for traits CP and NDF was around 10%, twice as high as the value observed for a population of 60 corn hybrids (Fonseca et al., 2002), demonstrating the high variability that exists among sorghum plants. Carbohydrate digestibility probably has a high impact on the nutritional value of sorghum plants, since the sum of NDF and NFC totaled 84% of the plant.

Grain cultivars were richer in protein and less fibrous than forage cultivars (Table 3). The mean content of NDF in the sorghum cultivars (Table 1) was approximately 8% lower than the mean for corn hybrids cropped under the same environment conditions (54.5 % of DM) (Fonseca et al., 2002). However, the minimum value of 44.8 is similar to the minimum observed in Brazilian commercial corn hybrids (Fonseca et al., 2002) and close to the mean for United States corn hybrids (Allen et al., 1991). The utilization of grain-type sorghum enables obtaining plants with low fiber content and high nonfibrous carbohydrate content.

Table 3 - Silage chemical traits of 12 forage sorghum cultivars (Forrag) and 6 grain and dual purpose cultivars (Gran+DP): Silage dry matter content (DMs), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE), ash and non-fiber carbohydrates (NFC). Values are expressed as % of dry matter, except DMs, which is % of fresh material.

	Forrag	Gran+DP	SEM[1]	*P* for cultivar type effect
DMs	27.6	30.9	1.35	0.11
CP	6.4	7.4	0.16	<0.001
EE	4.0	4.3	0.22	0.35
Ash	5.1	5.3	0.17	0.47
NDF	52.0	47.1	1.08	<0.01
ADF	33.3	28.5	0.89	<0.01
NFC[2]	32.6	36.0	1.17	0.06

Each cultivar was planted in triplicate and harvested at 10 cm from the soil surface at the milk-to-dough stage of maturity and ensiled for 100 days in mini PVC silos.
[1]SEM = Standard error of the mean.
[2]NFC = 100-(CP+NDF+EE+Ash)

The lower fiber content and the greater NFC content of Gran+DP cultivars explain the greater DEF found as compared to Forrag cultivars (Table 4). Fibrous carbohydrates have slow degradability in the rumen when compared to nonfibrous carbohydrates which, for the most part, consist of starch in the sorghum plant (Van Soest, 1994). The variability of chemical and agronomic traits among cultivars (Tables 1 and 3) was greater than the variability in rumen degradability (Table 1). The coefficient of variation of trait PH was 24.7%, while the same value for DEF was 5.7%. Possible differences in the digestibility of the chemical components, especially NDF and starch, could be responsible for the proportionally smaller variability of DEF. It is possible that cultivars which are high in fiber and low in starch may show higher fiber digestibility and less digestible starch than low-fiber and high-starch cultivars, for instance (Silva, 1997).

Even though the mean fiber content (Table 1) was lower than for corn hybrids (Fonseca et al., 2002), DM sorghum degradability (Table 1) was lower than corn DM degradability. The DEF of sorghum silages was about 90% of the value found for corn hybrids evaluated by Fonseca et al. (2002) (54.3% of DM). Since comparisons of rumen degradability values between experiments are subject to variations in techniques and rumen environment, a direct comparison between corn and sorghum was carried out in this work. A composite sample from the 60 hybrids studied by Fonseca et al. (2002) was formed by adding identical amounts of pre-dried and ground material. The composite corn sample was ruminally incubated simultaneously with the 18 sorghum cultivars. The NDF content in the composite sample was 48.6% of the DM and the DEF was 57.9% of the DM. The mean DEF for the 18 sorghum cultivars (Table 1) was 84% of the DEF in the composite corn sample. Lloveras (1990), in Spain, also observed that the *in vitro* digestibility of sorghum silage was 84.2% of the corn silage digestibility, and Azevedo (1973) observed that sorghum digestibility was 79.7% of that verified for corn. Differences in fiber quality or in ruminal nonfibrous carbohydrate degradability between corn and sorghum could explain this fact. The endosperm in sorghum grain is more vitreous than in corn, possibly limiting starch degradation in the rumen (Rooney & Pflugfelder, 1986; Theurer, 1986; Theurer et al., 1999).

Table 4 - Silage dry matter ruminal degradation parameters of 12 forage sorghum (Forrag) and 6 grain and dual purpose (Gran+DP) cultivars: Effective ruminal dry matter degradability (DEF), instantaneously degradable A fraction (A), slowly degradable B fraction (B), indigestible C fraction (C) and fractional degradation rate of the B fraction (kd). Values are expressed as % of dry matter, except kd, which is % h^{-1}.

	Forrag	Gran+DP	SEM[1]	*P* for cultivar type effect
DEF[2]	47.7	51.3	0.35	<0.001
A	26.8	29.2	0.59	<0.01
B	43.6	45.5	0.63	0.03
C	29.8	25.7	0.60	<0.001
kd	-3.83	-3.97	0.11	0.35

Each cultivar was planted in triplicate and harvested at 10 cm from the soil surface at the milk-to-dough stage of maturity and ensiled for 100 days in mini PVC silos.

[1] SEM = Standard error of the mean.

[2] DEF = A+B[kd/(kd+kp)]. kp = -4% h^{-1}.

The correlation between ADF and DEF was 0.03 lower than the correlation between NDF and DEF (Table 5). The correlation between ADF and digestibility is known to be greater than the correlation between NDF and digestibility (Van Soest, 1994). Among all agronomic and chemical traits, except for NDF which was not included in the procedure to avoid colinearity problems (Chatterjee & Price, 1991), only ADF was utilized as an independent variable in the regression for predicting DEF, when the selection of variables utilized *stepwise*-type methodology (Figure 1). The use of ADF to select cultivars of high ruminal digestibility seems to be indicated. Notwithstanding, since NDF represents the entire fiber fraction, it is better correlated to rumination, ruminal fill passage of digesta and dry matter consumption, and therefore has greater practical applicability in ration balancing (formulation) (Van Soest, 1994). In the field, the NDF analysis seems to conciliate the applicability of the information for ration balancing with the possibility of estimating forage sorghum digestibility, without a significant loss in digestibility prediction relative to ADF. The equation that correlated NDF with DEF was: DEF=71.671 – 0.4524 NDF, r^2=0.38.

Since tall and productive forage-type cultivars also have greater fiber content (Table 3), the correlation between DEF and yield per unit area was negative (Table

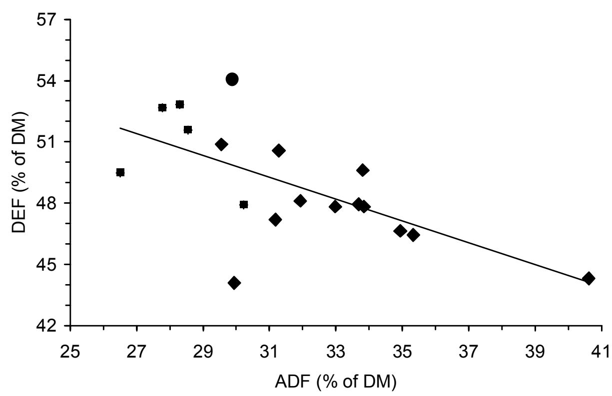

Figure 1 - Correlation between ADF and effective ruminal dry matter degradability (DEF). DEF = 65.851 - 0.5354 ADF, r^2 = 0.42. Cultivar type according to seed company: (◆) forage, (■) grain, (●) dual purpose.

Table 5 - Correlation among agronomic traits, silage chemical traits and effective ruminal dry matter degradability (DEF) of 18 sorghum cultivars.

	CP	NDF	ADF	EE	Ash	PH	FL	FMY	DMY	DEF[5]
DMs	0.40[3]	-0.39[4]	-0.48[2]	-0.25	-0.51[2]	-0.42[3]	0.20	-0.51[2]	0.03	0.40[3]
CP		-0.59[1]	-0.62[1]	-0.19	0.26	-0.89[1]	-0.01	-0.69[1]	-0.51[2]	0.41[3]
NDF			0.94[1]	-0.01	0.06	0.65[1]	-0.45[3]	0.61[1]	0.47[2]	-0.62[1]
ADF				0.06	0.07	0.73[1]	-0.47[2]	0.61[1]	0.45[3]	-0.65[1]
EE					0.35[4]	0.09	-0.12	0.23	-0.01	0.14
Ash						-0.11	-0.05	0.21	-0.12	0.12
PH							0.04	0.74[1]	0.57[1]	-0.37[4]
FL								0.24	0.32	0.35[4]
FMY									0.81[1]	-0.43[3]
DMY										-0.37[4]

CP=Crude protein; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; EE=Ether extract; PH=Plant height; FL=Flowering; FMY=Fresh matter yield; DMY=Dry matter yield; DMs= silage dry matter content.
[1]$P \le 0.01$, [2]$P \le 0.05$, [3]$P \le 0.10$, [4]$P \le 0.15$. [5]DEF = A+B[kd/(kd+kp)]. kp = -4%/h.

5). For the corn hybrids studied by Fonseca et al. (2002), the correlation between DM yield per hectare and DM ruminal degradability was -0.06, indicating that it is not necessary to penalize productivity when choosing high nutritional value corn hybrids. On the other hand conciliating high productivity and high nutritional value of the sorghum plant seems to be more difficult.

Even though there are cultivars that conciliate good productivity and digestibility, selecting for high rumen degradability may result in cultivars with short size and low yield per unit area (Figure 2). When choosing sorghum cultivars for silage production it is necessary to define whether the objective is high productivity or high nutritive value. Some variables to be used in defining the seed purchasing strategy would be the number of animals to be fed, the nutritional requirement per animal, the price of other feedstuffs and the price of milk. For sorghum plants, it seems to be harder to conciliate a high animal stocking rate with low utilization of concentrate feedstuffs per milk unit produced than for corn plants.

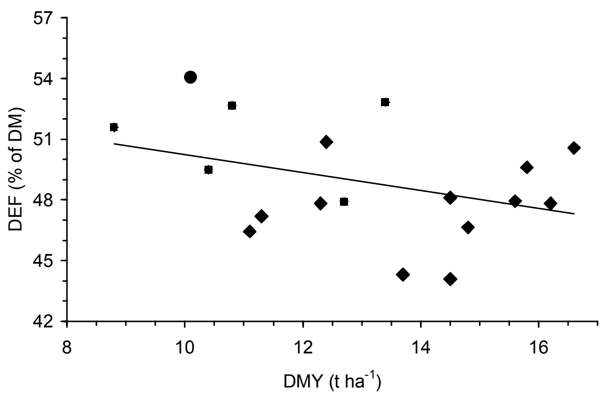

Figure 2 - Correlation between dry matter yield per hectare (DMY) and effective ruminal dry matter degradability (DEF). DEF = 54.694 - 0.4449 DMY, r^2 = 0.14. Cultivar type according to seed company: (◆) forage, (■) grain, (●) dual purpose.

CONCLUSIONS

The variability of chemical and agronomic traits of sorghum cultivars was higher than the variability of kinetic parameters describing dry matter degradation in the rumen. Forage cultivars were taller, more productive and fibrous than grain and dual purpose cultivars, but showed lower DEF. The selection of high nutritional value cultivars should aim to reduce plant fiber content. It may be difficult to conciliate the maximum degradability of dry matter in the rumen with the maximum yield per unit area of the sorghum crop.

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