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Effects of Harvesting Different Sorghum-Sudan Grass Varieties as Hay or Silage on Chemical Composition and Digestible Dry Matter Yield

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Abstract: The objective of this study was to evaluate the harvesting different sorghum-sudan grass varieties as hay or silage on chemical composition, digestible dry matter and crude protein yields under eastern Anatolia conditions. The sorghum-sudan grass hybrids were harvested by hand, weighed and air-dried to conserve as hay when they were approximately 150 cm tall. After air-drying, approximately 100 g of sub-sample were taken for determinations of dry matter, chemical composition and *in vitro* DM digestibility of hays. To conserve as silage, the sorghum-sudan grass hybrids were harvested by a one-row forage harvester at dough stages of kernel maturity and were ensiled in mini-silos (1L in volume) in triplicate for each variety. Packing was accomplished by hand-power. After 60 d of incubation, silages were opened and analyzed for DM, Organic Matter (OM), Crude Protein (CP), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), pH, lactic acid, acetic acid, propionic acid, butyric acid concentrations and *in vitro* DM Digestibility (IVDMD). The concentrations of DM, OM and NDF were higher, but CP concentration was lower in silages compared with hays ($P<0.05$). All silage pH were around recommended optimal pH value of 3.8-4.2, ranging from 4.09 to 4.20. Silage organic acid contents were generally in a desirable range (low in acetic and butyric acid and high in lactic acid content) and correlated with pH values. While IVDMD concentrations were higher ($P<0.05$), IVDMD yields were less ($P<0.05$) in hays compared with silages. However, CP yields were similar between two conservation methods. In conclusion, silage-making seemed to be the best conservation method for these sorghum-sudan grass varieties for eastern Anatolia conditions and hay making seemed to have great potential to yield more nutrient in places where it can be harvested more than 3 times, based on digestible DM yields and CP yields.

Key words: Sorghum-sudan grass, Conservation method, *In vitro* Digestibility, Digestible dry matter yield

Introduction

Forage sorghum has increasingly become an important silage crop for beef and dairy producers (Young *et al.*, 1993) in areas where corn production is limited because of lack or not well distribution of rainfall throughout a year. Thus, sorghum's importance as a feed grain and silage crop has increased steadily during last 25 years (Dickerson *et al.*, 1995).

Sorghum harvested at the soft dough stage of development and stored as silage may contain 52 to 65% dry matter digestibility, 8 to 10% CP, 60 to 75% NDF and 34 to 40% ADF (Undersander *et al.*, 1990). In general, forage sorghum silage has 80 to 90 percent of energy value of corn silage per unit of DM due to a lower percentage of grain-to-forage, a lower percentage of grain digestibility and a stalk of lower digestibility compared with corn silage (Grant and Stock, 1996). Sorghum-sudan grass has typically been used as summer pasture or hay crop. However, if ensiled properly, sorghum-sudan grass can make excellent quality silage. Total yield will be less than from sorghum, but if harvested early, it contains 1.5-2 times the amount of protein, reducing the need for supplemental protein in the ration. Sorghum-sudan grass has also fast re-growth and a second or third crop generally can be harvested. However, plants should be a minimum of 50-60 cm high before harvest to avoid possible prussic acid poisoning (Holland and Kezar, 1995).

Sorghum are best suited to warm, fertile soils and tolerates drought relatively well (Undersander *et al.*, 1990). Therefore, it typically produces less dry matter yield per hectare under irrigation, but produces more dry matter and energy yields per hectare than corn on dryland (Grant and Stock, 1996), indicating that sorghum may be preferred over corn for silage in areas where climate is not well suited for corn production. Besides, improved sorghum hybrids often give DM yields comparable to corn with lower production cost today, but there are often large variations among sorghum hybrids (Dickerson *et al.*, 1995).

The objective of this study was to evaluate the harvesting different sorghum-sudan grass varieties as hay or silage on chemical composition, digestible dry matter and crude protein yields under eastern Anatolia conditions.

Materials and Methods

Three forage sorghum-sudan grass hybrids (Grass II, Grazer and P-988) with different characteristics were selected. All were grown under irrigation system. The forage sorghum plots were planted on June 10 and each hybrid was randomly assigned to three replications. The sorghum-sudan grass fields were watered every 10 d and were fertilized with 100 kg nitrogen and 80 kg phosphorus per ha. Rows were 5 m long and with a 40 cm spacing and plots were thinned to uniform stands of 100 plants per m^2.

The sorghum-sudan grass hybrids were harvested by hand, weighed and air-dried to conserve as hay when they were approximately 150 cm tall. After air-drying, approximately 100 g of sub-sample were taken for determinations of dry matter, chemical composition and *in vitro* DM digestibility of hays. To conserve as silage, the sorghum-sudan grass hybrids were harvested by a one-row forage harvester at dough stages of kernel maturity. Chopped forage from each plot weighed, sampled for DM and collected for silage-making. Silage was made from each plot (triplicate) in a 1L capacity mini-silo. Ensiling were performed by stamping as much of chopped plant material into the mini-silo as possible. By this action most of the air was excluded. After ensiling, each mini-silo was sealed off tightly with a screw lid. The lids were poked with a pin to get rid of gas pressure that build up during the initial phase of ensiling and then, the holes were sealed with a tape after first week of ensiling. The mini-silos were then stored 60 d in a dark room with a temperature ranging between 20 to 25^{o}C. After 60 d ensiling, sampling was accomplished by complete emptying of silo, after discarding upper part of silage, into a container. From this material, sub-samples were taken for determinations of dry matter, pH, organic acids, chemical composition and *in vitro* DM digestibility of silages.

The pH of each sample was determined in triplicate using approximately 25 g wet ensilage added to 100 ml of distelled water. After hydration for 10 min by a blender, the pH was determined using a digital pH meter (Polan *et al.*, 1998). The filtrate were filtered through filter paper and centrifuged and stored for organic acid analysis. Organic acid analysis were accomplished by using a gas chromatograph (Shimadzu, GC-14B) as described by Leventini *et al.* (1990).

Dry Matter (DM) of silages were determined by oven drying of triplicate sub-samples at 65^{o}C for 72-h.

Dried samples of silage and hays were ground to pass through a 1 mm screen before analysis. Ash concentrations of samples were determined in a muffle furnace at 550^{o}C for 8 h. Wet silage and dried hay samples were analyzed for CP by Kjeldahl procedure (1980). Samples were analyzed for neutral detergent fiber NDF (1979) and acid detergent fiber ADF (1970). *In vitro* Dry Matter Digestibility (IVDMD) according to procedure of Tilley and Terry (1963), as modified by Marten and Barnes (1980). Ruminal ingesta from an alfalfa-fed ruminally fistulated ram was hand-collected and strained through four layers of cheesecloth to provide the innocula for IVDMD determination. DM, digestible DM and CP yields kg/ hectare (ha) were, then, calculated.

Statistical analysis

All data were subjected to analysis of variance for completely randomized design using the GLM procedure of SAS (1985) and means of fermentation parameters were separated by Duncan's t-test (1980).

Results

Dry matter content of P-988 and Grass II varieties conserved as silage had significantly (P<0.05) higher compared with that of Grazer, whereas dry matter content of all sorgum-sudan grass varieties conserved as hay were similar (Table 1). However DM content of sorgum-sudan grasses were significantly lower in those conserved as hay compared with those of silage at harvesting (P<0.05). In contrast, OM concentrations of silages were significantly less in sorgum-sudan grasses conserved as hay (P<0.05). While CP concentrations did not differ among different sorgum-sudan grass conserved as or hay (P>0.05), hays had significantly greater CP concentrations compared with silages. NDF concentrations were significantly higher in silages than hays (P<0.05), concentrations of ADF did not differ between two conservation method (P>0.05). The highest ADF concentration was observed with Grass II conserved as silage (P<0.05).

Table 1: Chemical compositions of different sorghum-sudan grass varieties conserved as silage or hay (% of DM)

	Conservation method									
	Silage			Hay			Significance[a]			
Items	P-988	Grass-II	Grazer	P-988	Grass-II	Grazer	Con	Var	V x C	SEM
KM	31.80	32.40	27.40	17.82	17.04	16.35	0.01	0.01	0.01	0.78
Ash	5.95	7.18	7.00	9.52	9.34	10.20	0.01	0.11	0.21	0.45
OM	94.05	92.82	93.00	90.48	90.66	89.80	0.01	0.27	0.18	0.46
CP	8.15	7.60	7.95	15.51	14.75	16.47	0.01	0.27	0.52	0.72

NDF	68.61	71.53	68.45	66.13	65.91	66.20	0.01	0.16	0.08	0.91
ADF	38.70	43.69	38.48	38.91	39.66	39.91	0.38	0.03	0.05	1.27

[a]Con= Conservation method, Var=Variety, V x C= Variety x conservation interaction

Table 2: The effects of different sorghum-sudan grass varieties on the fermentation properties of silage

Items	P-988	Grass-II	Grazer	Significance	SEM
PH	4.09	4.11	4.20	0.56	0.09
Lactic acid, % DM	4.09^{ab}	4.25^{a}	3.82^{c}	0.05	0.10
Acetic acid, % DM	0.46^{b}	0.89^{a}	0.49^{b}	0.02	0.03
Butyric acid, % DM	0.11^{a}	0.06^{b}	0.13^{a}	0.01	0.01

ab...values with different superscripts in the same row differ significantly (P<0.05)

Table 3: *In vitro* DM digestibility, DM, IVDMD and CP yields of different sorghum- sudan grass vaieties conserved as silage or hay, kg/ha

	Conservation method									
	Silage			Hay			Significance			
Items	P-988	Grass-II	Grazer	P-988	Grass-II	Grazer	Con	Var	VxC	SEM
IVDMD, %DM	55.59	53.62	54.96	61.25	62.46	61.02	0.01	0.91	0.31	1.26
DM yield	22.242	22.677	18.543	11.905	10.619	11.095	0.01	0.01	0.01	844
IVDMD yield	12.354	12.144	10.208	7.334	6.617	6.715	0.01	0.01	0.03	474
CP yield	1.810	1.722	1.471	1.848	1.543	1.810	0.45	0.05	0.45	93

[a]Con= Conservation method, Var=Variety, V x C= Variety x conservation interaction

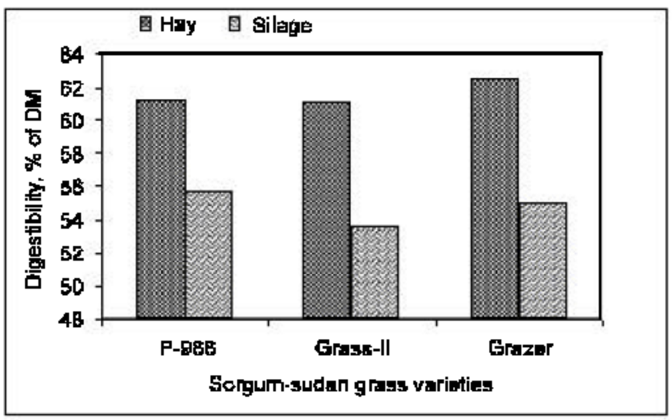

Fig. 1: *In vitro* dry matter digestibility of different sorghum-sudan grass varieties conserved as silage or hay (% of DM). SEM=1.27

The effects of variety on some fermentation-related properties of sorghum-sudan grass silage is shown in Table 2. Silage pHs were similar among varieties (P>0.05). The lowest lactic acid concentrations were observed with Grazer (P<0.05). The concentrations of acetic acid were significantly lower, but butyric acid concentrations were significantly higher in P-988 and Grazer silages compared with Grass II silage (P<0.05).

In vitro dry matter digestibilities were similar among varieties conserved as silage or hay (P>0.05; Table 3 and Fig. 1). However, *in vitro* dry matter digestibility of hays were significantly higher than that of silages (P<0.05).

Both DM and IVDMD yields were significantly higher (P<0.05) in all sorghum varieties conserved as silage compared with those of hays (Table 4). The highest IVDMD yields were observed with P-988 variety harvested as silage or hay (12.354 and 7.384 kg/ha, respectively; (P<0.05). Either conservation method or variety did not affect CP yields (P>0.05).

Discussion

The main aim of this study was evaluate the harvesting different sorghum-sudan grass varieties as hay or silage on chemical composition and digestible dry matter under eastern Anatolia conditions, in which climate is not well suited for corn production due to lack of rainfall.

The concentrations of DM and OM increased with increasing maturity because sorghum-sudan grassess were less mature when harvested to be preserved as hay compared with silage. It is well known that as plant matures, DM concentrations of plant increase (Sonon *et al.*, 1991) which is in agreement with the results of the current study. The DM concentrations of silages in variety were in the range of DM known to be optimal for silage-making.

The effect of conservation method on CP content was significant for all varieties. Crude protein concentrations of silages ranged from 7.60 to 8.15 % whereas concentrations of hays ranged from 14.75 to 16.47 %. A significant decrease in CP content of sorghum with maturity has been reported by Snyman and Joubert (1996) which supports the results of this study. The concentrations of NDF in silages were significantly greater than those of hays. The predominant feature of increasing physiological maturity of most forages is a tremendous reduction in the leaf to stem ratio (Albrecth *et al.*, 1987), resulting in an increase in cell wall and lignin contents (Jung and Vogel, 1992).

Silage pH ranged from 4.09 to 4.20, which were optimal for well preserved silage. Lactic acid contents of silages ranged form 3.82 to 4.25 % DM. The concentration of acetic acid were less than 1% of DM in this study, suggesting rapid decrease of silage pH. Butyric acid contents were at negligible levels. Enterobacteria and lactic acid bacteria normally dominate all of the other microorganisms within the first 1 to 3 d after sealing. However, once pH has dropped to 5, the enterobacteria decline rapidly, leaving the lactic acid bacteria the principle microorganism in the silage (Muck, 1991). Both groups of the bacteria ferment sugars primarily, but the enterobacteria largely produce acetic acid whereas the lactic acid bacteria mainly produce lactic acid (McDonald, 1981). The lactic acid bacteria can grow actively 1 to 4 wk lowering the pH usually between 3.8 to 5.0 (Muck, 1991). The amount of sugars converted by the lactic acid bacteria to fermentation products is dependent on the sugar content, moister level and buffering capacity of the crop (Rotz and Muck, 1994). While corn plant can contain 20 to 30 % soluble carbohydrate at milk stage, it decreases to 10% at dough stage (Johnson *et al.*, 1996), resulting in a decrease in organic acid content of silage when ensiled. The decreases in lactic acid content of silages with maturity can be explained with decreases in soluble carbohydrate content of forage sorghum with maturity. The buffering capacity of crop determines approximately the amount of fermentation acid necessary to reach a given pH (Melvin, 1965). In general, the buffering capacities are lowest for corn, intermediate for grasses and highest for legumes, indicating that the lowest fermentation products would be seen in corn. This may explain the low organic acid content of sorghum silage. The third principle anaerobic bacteria, clostridia, have much more detrimental effect on silage quality if pH is not sufficiently low (Rotz and Muck, 1994). These bacteria ferments sugar, lactic acid and amino acids producing butyric acids and amines. Percentage of butyric acid concentrations in the current study were at negligible levels, indicating a good conservation of silages.

In vitro DM digestibilities of all sorghum-sudan grass variety decreased when conserved as silage. It is also well documented that forage digestibility declines with increasing lignin concentrations (Van Soest, 1992). Among grass, both leaf and stem increase in cell wall and lignin contents with advancing maturity (Jung and Vogel, 1992), resulting in a decrease in dry matter digestibilities of both stem and leaf of grasses with increasing forage maturity because of increased lignification with maturity (Akin and Chesson, 1989), which support the results of the current study.

While *in vitro* DM yields were 6.617 - 7.334 kg/ha for hays, they were 10.208 – 12.354 for silages. Even though the highest *in vitro* DM digestibilities were observed with hays, *in vitro* digestible DM yields were greater in silages for all sorghum-sudan grass varieties compared with those of hays because of increases in DM yields of sorghum-sudan grass varieties with maturity. P-988 variety produced the highest in vitro digestible DM yields in both conservation methods (7.334 and 12.354 kg/ha, respectively) among three sorghum-sudan grass varieties. *In vitro* digestible DM yields observed in the current study were in the range of the study reported by Kaiser and Havilah (1989). However, CP yields were similar between two conservation methods because almost 2 fold higher CP concentrations in hays compensated the differences in DM yields, resulting in similar amount of CP yield per ha.

In conclusion, silage-making seemed to be the best conservation method for these sorghum-sudan grass varieties for eastern Anatolia conditions and hay making seemed to have great potential to yield more nutrient in places where it can be harvested more than 3 times, based on digestible DM yields and CP yields.

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