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GROWTH RESPONSE OF HAIR SHEEP FED UREA-AMMONIATED GUINEAGRASS (*PANICUM MAXIMUM*) HAY

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ABSTRACT

Laboratory, digestion, and growth studies evaluated urea as a source of ammoniation for quality improvement in guineagrass (*Panicum maximum*) hay. Large round bales (320 kg) were reconstituted with water to yield a final moisture concentration of 25%, and treated with urea at 0, 4 or 6% of the forage DM. The urea solution was sprayed onto both flat surfaces of the bales. Each treatment was applied to three bales. Each bale was stored air-tight in individual 6-mil thickness plastic bags for 60 days. Crude protein concentration and in vitro organic matter digestion increased in a linear ($P < 0.01$) manner with increasing urea treatment level. Cell wall concentration decreased in a linear ($P < 0.05$) manner with increasing urea treatment level, although the absolute reduction was minimal.

In the digestion trial, six St. Croix White hair neutered male sheep (30 kg) were used in a replicated 3 X 3 Latin square design to evaluate the three urea treatment levels. In the growth trial, 30 sheep similar to those used in the digestion trial were allotted to six pens of five head each, with two pens assigned to the same three treatments. In the digestion and growth trials, hay intake increased in a quadratic ($P < 0.05$) manner with increasing urea treatment level. Apparent OM digestibility was not affected ($P > 0.10$), however apparent fiber digestibilities increased in a linear ($P < 0.05$) manner due to urea treatment. Linear improvements in daily gain ($P < 0.05$) and gain/feed ($P = 0.07$) were observed by urea treatment. Urea ammoniation offers potential for improving the feeding value of tropical forages, and provides an option for quality forage during the dry season.

INTRODUCTION

Efficiency of ruminant livestock production in the semi-arid tropics is severely hampered by seasonal deficiencies in the quantity and quality of available forage. Supplementation with concentrates is sometimes practiced to resolve feed deficiency during the dry season, however expense of importing grains and oilseeds which compete with human and nonruminant livestock consumption limits its widespread use. Forage conservation through hay or silage production also provides a viable option for many tropical areas, however advanced maturity of many stored forages and crop residues results in low feeding value (Ventura et al., 1975; Brown, 1988).

Chemical treatment to improve forage feeding value offers an opportunity to utilize large amounts of low quality grasses and crop residues available in tropical regions. Alkali treatment with NaOH or CaOH has increased forage digestibility, voluntary intake and animal performance (Klopfenstein, 1978; Jayasuriya, 1979). Increased forage nutritive value has also been obtained by anhydrous ammonia treatment (Gibb and Baker, 1989; Horton et al., 1991), however the response generally has not been as great as that by NaOH treatment (Garrett et al., 1979; Horton et al., 1982). An advantage of using a nitrogenous alkali compared to NaOH is that the increased microbial requirement for nitrogen when forage digestibility is increased by forage treatment is supplied by the chemical. However, limited availability and high cost of anhydrous ammonia, and increased regulation of its transportation limits its use in certain regions.

Urea is widely available in many areas, and has been used as a source of ammoniation to improve the feeding value of various grasses and crop residues (Oji and Mowat, 1977; Hadjipanayiotou, 1982; Fahmy and Klopfenstein, 1994). The objectives of the present research were to investigate the effectiveness of urea-ammoniation for improving the feeding value of guineagrass hay.

MATERIALS AND METHODS

Sheep growth and digestion trials reported here were part of a larger project evaluating urea-ammoniation of guineagrass hay (Adjei et al., 1994). Experiments were conducted at the Agricultural Experiment Station at the University of the Virgin Islands in St. Croix, U.S.V.I. Large round hay bales (approximately 320 kg) were used. Hay was purchased from the local Department of Agriculture, and was composed of approximately 90% guineagrass, with small quantities of leucaena (*Leucaena leucocephala*), johnsongrass (*Sorghum halepense*), casha (*Acacia* spp.) and hurricane grass (*Bothriochloa pertusa)*. Hay dry matter (DM) concentration averaged 87%.

Hay bales were reconstituted with water to 25% moisture and treated with urea at 0, 4 or 6% of the forage DM. The urea solution was applied by spraying onto both flat surfaces of the bales. Each treatment was applied to three bales, resulting in a total of nine bales used for the experiments. Each bale was stored air-tight in individual 6-mil thickness plastic bags for 60 days. After storage, each bale was sampled with a core sampler at approximately 20 sites. Samples were dried at 50°C, ground to pass a 1-mm screen and stored for quality analysis.

Samples were analyzed for dry matter (DM), organic matter (OM) and total N were determined according to AOAC (1984). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by the procedures of Goering and Van Soest (1970) and Golding et al. (1985). Cellulose (CELL) was calculated as the difference between ADF and ADL, and hemicellulose (HC) was calculated as the difference between NDF and ADF. In vitro OM digestion (IVOMD) was determined in duplicate tubes within duplicate runs by the modified Tilley and Terry (1963) procedure described by Moore and Mott (1974).

The round bales were ground through a 2.5-cm screen and stored under cover. In the growth trial, 30 St. Croix White hair neutered male sheep (30 kg) were randomly allotted to six pens, resulting in five head per pen. Two pens were assigned to each of the 0, 4 and 6% urea treatment levels. Dehydrated alfalfa (*Medicago sativa*) pellets were fed to sheep in all pens at the rate of 0.5% of body weight. A 50% (w/v) urea solution was applied at feeding time to the nontreated and 4% urea treated hays to equal the nitrogen concentration of the 6% urea treated hay. Prior to feeding, refusals of hay and alfalfa pellets from the previous day's offering were collected. Refusal of alfalfa pellets was minimal. The daily offering of hay was adjusted to approximately 120% of the previous day's intake. Daily samples of feed ingredients and feed refusal were collected and composited on a weekly basis. Sub-samples were dried in a forced-air oven at 50°C, ground to pass a 1-mm screen and analyzed for DM and OM (AOAC, 1984).

In the digestion trial, six neutered male sheep, similar to those used in the growth trial, were used in a replicated 3 X 3 Latin square design to study the same diets as those in the growth trial. Sheep were fitted with fecal collection bags and were housed in individual digestion crates (1.5 X 0.75 m). Each of the three periods consisted of a 10-d dietary adjustment phase followed by a 5-d collection phase. Sheep were fed once daily, with alfalfa pellets fed as described for the growth trial. Refusal of alfalfa pellets was minimal. Ad libitum feeding of the hays was as described for the growth trial. During the collection phase, daily samples of individual feed ingredients and feed refusals were obtained. A fecal sample representing approximately 10% of the daily fecal production was obtained. Daily samples of individual feed ingredients, feed refusal and feces were bulked over the 5-d collection period, thoroughly mixed and subsamples taken. Subsamples were dried in a forced-air oven at 50°C, ground to pass a 1-mm screen and analyzed for DM, OM, NDF and ADF as described above.

Data were analyzed by analysis of variance according to the GLM procedure of SAS (1985). Laboratory measures of forage quality were analyzed as a completely randomized design (Steel and

Torrie, 1980), with hay bale as the experimental unit. Model sums of squares were partitioned to test for the linear and quadratic effects of urea treatment level. Data from the digestion trial were analyzed as a replicated Latin square design (Steel and Torrie, 1980) with model sums of squares partitioned in square, animal, period and treatment effects. Contrast statements were prepared to test for the linear and quadratic effects of urea treatment level. Data from the growth trial were analyzed as a completely randomized design (Steel and Torrie, 1980) with model sums of squares partitioned to test for the linear and quadratic effects of urea treatment level. Pen was used as the experimental unit.

RESULTS AND DISCUSSION

Crude protein concentration of the guineagrass hay increased in a linear manner with increasing urea treatment level (Table 1). For both the 4 and 6% treatment levels, retention of added nitrogen from urea averaged 47%. Increased hay CP concentration was due to nitrogen contribution from added urea, and the degree of increased CP due to urea treatment was similar to that reported for urea treatment in other forages (Kiangi et al., 1981; Dias-da-Silva and Sundstol, 1986; Macdearmid et al., 1988) and for anhydrous ammonia treatment (Brown et al., 1987). Losses of nitrogen from added urea are volatile ammonia gas release from urea degradation (Tetlow, 1983; Williams et al., 1984a). Naturally occurring microbial urease activity in crop residues (Jayasuriya and Pearce, 1983; Williams et al., 1984b) and guineagrass (Adjei et al., 1994) has been shown to be adequate to degrade the added urea to ammonia.

Table 1. Influence of urea treatment level (% of the forage dry matter) on the chemical composition and in vitro digestion of guineagrass (*Panicum maximum*) hay.

	Urea treatment level				P value[2]	
Item[1]	0	4	6	SE	L	Q
Crude protein	5.3	7.8	10.5	.22	.01	.77
Neutral detergent fiber	74.6	74.0	72.6	.25	.03	.69
Acid detergent fiber	45.5	45.3	44.6	.34	.13	.81
Cellulose	37.3	37.5	36.4	.27	.04	.53
Hemicellulose	29.1	28.8	28.0	.25	.04	.59
Acid detergent lignin	8.1	7.8	8.2	.12	.34	.49
In vitro organic matter digestion	42.6	48.2	49.3	.58	.01	.22

[1] Crude protein (%, DM basis); Fiber values are expressed as % ash free, DM basis.
[2] Probability value for the linear (L) and quadratic (Q) effects of urea treatment level.

Cell wall (NDF) concentration was reduced by urea treatment (Table 1). Of the cell wall components, cellulose and hemicellulose were reduced by urea-ammoniation, but absolute reductions were small. In vitro OM digestion of the guineagrass hay was increased by urea treatment. In general, alkali treatment with NaOH or anhydrous ammonia has improved forage digestibility through reduced forage NDF concentration by solubilization of the HC and(or) ADL fractions (Klopfenstein, 1978; Gibb and Baker, 1989). Increased in vitro digestion and reduced NDF concentration have been reported due to urea treatment (Tetlow, 1983; Macdearmid et al., 1988). Neutral detergent fiber concentration of untreated hay in our experiments was 70 to 75%. Fahmy and Klopfenstein (1994) also found no effect on NDF concentration (74%) but an increase in IVOMD (44 to 55%) due to urea treatment of corn stalks. Similar results reported by Kiangi et al. (1981), Hadjipanayiotou (1984) and Williams et al. (1984b) for a range of cereal straws (70 to 75% NDF) suggest that in some cases, the urea treatment effect may not be adequately described by laboratory evaluation when initial NDF concentration of the untreated forage is relatively low.

In the digestion trial, hay intake increased in a quadratic manner with increasing urea treatment level (Table 2). Apparent OM digestibility was not affected by urea treatment, but due to increased hay intake, digestible OM intake increased in a quadratic manner with increasing urea treatment level. Apparent digestibilities of NDF, ADF and HC increased in a linear manner due to urea ammoniation.

Table 2. Influence of urea treatment level (% of the forage dry matter) on the digestibility by sheep fed guineagrass (*Panicum maximum*) hay.

	Urea treatment level				P value[2]	
Item[1]	0	4	6	SE	L	Q
Intake, g OM						
Hay	510.9	614.4	572.6	20.37	.25	.05
Pellets	166.3	153.5	157.7	4.54	.18	.40
Total	677.1	767.9	730.3	22.22	.29	.05
OM digestibility, %	62.8	64.9	65.3	1.16	.90	.85
Digestible OM intake, g	424.4	496.5	475.6	14.33	.40	.05
NDF digestibility, %	65.9	69.2	70.5	.12	.03	.37
ADF digestibility, %	62.5	66.7	67.1	1.25	.04	.21
HC digestibility, %	70.9	73.4	76.3	1.11	.01	.65

[1] OM = organic matter, NDF = neutral detergent fiber, ADF = acid detergent fiber, HC = hemicellulose.

[2] Probability for the linear (L) and quadratic (Q) effect of urea treatment level.

Hay intake also increased in a quadratic manner in the growth trial (Table 3). Statistical analysis indicated that daily gain and feed efficiency increased in a linear manner with increasing urea treatment level, however numerical differences between the 4 and 6% urea treatment levels were small.

Table 3. Influence of urea treatment level (% of the forage dry matter) on the growth performance by sheep fed guineagrass (*Panicum maximum*) hay.

	Urea treatment level				P value[2]	
Item[1]	0	4	6	SE	L	Q
Intake, g OM						
Hay	1025	1294	1156	50.2	.01	.009
Pellets	306	317	309	3.6	.61	.38
Total	1330	1610	1465	52.2	.01	.008
Daily gain, g	17.3	50.8	47.7	7.48	.04	.23
Gain/feed	.013	.032	.033	.0046	.07	.47

[1] OM = organic matter.
[2] Probability for the linear (L) and quadratic (Q) effect of urea treatment level.

In the digestion and growth trials, voluntary intake of the urea treated hays was greater than that of the control, with intake of the 6% urea treated hay being less than that of the 4% urea treated hay. Observations in the field did not suggest that hay treated at 6% had a stronger ammonia odor than hay treated at 4% urea. Increased forage intake due to urea treatment has been reported (Hadjipanayiotou, 1982; Fahmy and Klopfenstein, 1994). Linear increases in intake of cereal straws have been observed with urea treatment up to 7% (Macdearmid et al, 1988) and 8% (Jayasuriya and Perera, 1982) of the forage DM.

In our experiments, apparent OM digestibility was not affected, but cell wall digestibility was increased by urea treatment. Digestible OM intake was increased resulting in large increases in daily gain by sheep. Increased in vivo digestibility of urea treated straw has been reported, but in many experiments straw was chopped, mixed with a urea solution and ensiled (Williams et al., 1984b; Fahmy and Klopfenstein, 1994). Dias-de-Silva and Sundstol (1986) treated wheat straw with urea using two methods. In one method, chopped straw (8-cm screen) was mixed with a urea solution and stored in a silo, while in another method, the urea solution was sprayed onto rectangular bales (25 kg) and the bales stored under plastic in the conventional stack method. In their experiments, voluntary intake and in vivo digestibilities of OM and cell wall components were increased due to urea treatment, with greater improvements observed in straw which had been chopped and stored in a silo compared to hay treated in the stack method. They suggested that the urea solution was more completely mixed with, and was exposed to a greater surface area in the chopped compared to the baled straw, resulting in a more effective treatment.

Results indicate that urea-ammoniation can be an effective tool for improving the nutritive value of guineagrass hay. Effects of urea-ammoniation on cell wall composition were inconsistent; however, digestible OM intake was increased by urea treatment leading to large improvements in animal performance.

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