Effects of Adding Urea and Molasses on Napiergrass Silage Quality

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ABSTRACT : To standardize proper formulation of urea and molasses, the former to increase crude protein content of tropical grass and the latter for improving its silage quality, we examined the fermentation quality of silage of fresh and wilted napiergrass (*Pennisetum purpureum* Schumach) with different levels of urea and molasses with or without lactic acid bacteria (LAB). Silage was made of napiergrass with conditions of fresh young (Exp. 1),young wilted for half day (Exp. 2) and fresh mature (Exp. 3). Chopped plant materials of about 1cm length were ensiled into a laboratory silo and incubated for one month at 25℃. The treatments were the combination of 0, 0.2 and 0.6% of urea and 0, 2 and 5% of molasses (fresh material basis) with or without LAB inoculation. After opening the silo, pH, organic acids, volatile basic nitrogen (VBN) and total nitrogen (TN) were determined. Addition of molasses significantly ($p<0.01$) lowered pH values in three experiments. Though molasses addition increased lactic acid production even at a higher level of urea, pH values at 0 and 2% molasses were significantly increased by urea in fresh and wilted young silages, but in fresh mature silage it occurred only when molasses was not added. VBN/TN at 0.6% urea were decreased significantly by the highest molasses in three experiments. Significant increases in TN by the increasing of urea addition were observed at all levels of molasses in wilted young and fresh mature silages. In conclusion, a combination of 5% molasses and 0.6% urea could improve the nutritive and fermentation qualities of napiergrass silage under young, wilting and mature conditions. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 11 : 1542-1547*)

Key Words : Lactic Acid Bacteria, Molasses, Napiergrass, Silage Quality, Urea, Wilting

INTRODUCTION

Napiergrass (*Pennisetum purpureum* Schumach) is widely planted in the tropical and subtropical regions of the world (William and Hanna, 1975). Its low digestibility, low protein content and low herbage production in the dry season, limit animal production off napiergrass, as with many tropical grasses.

Silage making is another way of increasing animal production in the tropical region because animals can be fed when forage supplies are inadequate. Although napiergrass is one of the most common tropical grasses that is ensiled, its fermentation quality, intake and digestibility are generally low (Catchpoole and Henzell, 1971). As good quality silage requires production of lactic acid to rapidly reduce pH, another basic requirement for bacterial fermentation is that the plant material contains sufficient fermentable carbohydrates (McDonald et al., 1995). Low water soluble carbohydrate content may be the main cause of low napiergrass silage quality (Imura et al., 1999). Molasses is often added to silage as a sugar additive and is well known to increase fermentation and feeding quality (Bolsen et al., 1996; Humphreys, 1991; Yokota et al., 1992).

Low nutritive value (low protein content) of napiergrass silage is another problem. Urea addition is a common and cheap method of increasing nitrogen (N) supply to ruminants fed silage. Although urea addition raised total nitrogen content, it decreased the fermentation quality of silage by increasing pH with the release of ammonia (Pancholy et al., 1994). We considered that the addition of different combinations of urea and molasses may improve both the protein content and fermentation quality of the silage.

We ensiled fresh or wilted young and fresh mature napiergrass with different levels of urea and molasses and with or without inoculation of lactic acid bacteria (LAB), in three separate experiments, to test this hypothesis.

MATERIALS AND METHODS

Napiergrass was field grown at Kyushu University, Hakozaki, Fukuoka, Japan. The initial growth of napiergrass was harvested at about 15 cm above the ground using a sickle in July 1996 for Experiment 1, and the regrowth was cut and discarded in December before the stubble overwintering. In 1997 the initial growth from the stubble was harvested likewise in July for Experiment 2, and the regrowth was harvested likewise in November for Experiment 3. The plants were immediately chopped into about 1 cm length using an electric chopper. The plant material for ensiling in Experiment 1 was young napiergrass that was fresh chopped: 15.4% dry matter content (DM), 2.7% total nitrogen content (TN), 4.4% water soluble carbohydrate content (WSC). That in Experiment 2

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was young material that had been wilted for 12 h after chopping (20.10% DM, 2.5% TN, 4.9% WSC), and that in Experiment 3 was mature material that was fresh chopped (25.4% DM, 1.2% TN, 3.9% WSC).

Before ensiling, the plant materials were mixed with molasses, urea and LAB according to the treatments. The treatments were additions (fresh weight basis) of: no molasses or urea (control), no molasses and 0.2% or 0.6% urea, 2% molasses and 0%, 0.2% or 0.6% urea, 5% molasses and 0%, 0.2% or 0.6% urea. All treatments were made with or without LAB (*Lactobacillus plantarum*, inoculant) at the rate of 2×10^4 cfu/g to the napiergrass before ensiling. There were three replicates of each treatment. The grass, 650 g, was ensiled, using a stick to crush the material, in a 1 litre polyethylene container) for one month at room temperature (25℃).

After opening the silo, DM of the silage was determined by drying in an oven at 60℃ for at least 48 h (AOAC, 1984). Sixty grams of silage sample were soaked in 120 ml of water and stored at 5℃ for 1 day. The filtrates (silage extracts) were used for determining pH, volatile basic nitrogen (VBN), lactic acid and volatile fatty acids. The pH was measured with a glass electrode pH meter (Horiba). TN was analyzed by the Kjeldahl method (AOAC, 1984), volatile basic nitrogen (VBN) by the steam distillation method (AOAC, 1984), and lactic acid by the method of Barker and Summerson (1941). Volatile fatty acids were analyzed by gas chromatography (Shimadzu GC-17A with 12 m . capillary column, condition: column temperature 100℃ with injection temperature 250℃ and detection temperature 250℃).

The data were analyzed statistically by three-way analysis of variance (ANOVA) using a commercially available package (SAS, 1985)

RESULTS

Experiment 1

The pH and chemical composition of fresh young napiergrass silage and the results of ANOVA are shown in table 1.

Molasses addition showed an increasing effect on DM percentage. The TN decreased significantly with the addition of molasses. A significant interaction between urea and molasses levels in TN implied that the increasing effect on TN by urea addition disappeared as molasses level increased. LAB addition increased TN at 0% molasses.

At all urea levels, pH decreased significantly with increasing molasses addition. Urea additions of 0.2% or more at 0% molasses, and at 0.6% with 2% molasses increased pH significantly compared with NIL urea, but did not show a significant effect at 5% molasses. At all levels of molasses, urea addition increased VBN/TN significantly. In contrast, molasses addition decreased this parameter, and at 0% urea, molasses addition of 2% and more had significant lowering effects; molasses additions of 2% and 5% were needed to lower VBN/TN significantly at 0.2% and 0.6% urea, respectively. In lactic acid a significant interaction between molasses and urea was observed. Lactic acid increased significantly as the molasses level increased, but when urea levels increased this parameter tended to decrease, resulting in extremely low values in the urea treatment without molasses. LAB inoculation significantly increased lactic acid production. Acetic acid tended to decrease by molasses addition and to increase by urea addition. At all levels of molasses, butyric acid generally showed a large increase by 0.6% urea addition.

Expereiment 2

The pH and chemical composition of wilted young napiergrass silage and the results of ANOVA are shown in table 2.

Molasses increased DM percentage significantly. TN was increased significantly by the urea addition, but the higher the molasses level the smaller the enhancement of TN by urea addition. The value for TN was generally lowered by an increase in molasses.

The value of pH increased at 0 and 2% of molasses by urea addition, but did not increase at the highest level of molasses. Molasses decreased pH significantly at all levels of urea. The effect of LAB on pH was not consistent. The VBN/TN generally increased when urea level increased, but it was significantly decreased by molasses addition. LAB generally decreased VBN/TN. Lactic acid production was increased by molasses addition, but decreased by urea addition when molasses was not added. In general, LAB tended to enhance lactic acid production with 0% and 0.2% urea. Acetic acid production increased with the increase in urea at 0% molasses, but decreased by molasses addition. Urea addition without molasses increased butyric acid significantly, but the combination of urea and molasses showed a significant reduction of this parameter.

Experiment 3

The pH and chemical composition of fresh mature napiergrass silage and the results of ANOVA are shown in table 3.

The DM of silage generally increased with the increase in molasses level. LAB generally increased DM of silage until 2% addition of molasses. TN was significantly increased with the increase in urea level at all levels of molasses addition.

Without molasses, pH value increased with increasing urea levels, but at 2% molasses addition pH

Table 1. Effects of additions of molasses and urea on the composition of fresh young napiergrass silage (Experiment 1)

Treatment			DM (%) (SD)	pH (SD)	Chemical composition (%DM)				
Molasses (%)	Urea (%)	LAB			VBN/TN (SD)	TN (SD)	LA (SD)	AA (SD)	BA (SD)
0	0	-	11.30 (0.80)	4.82 (0.07)	17.49 (2.07)	2.17 (0.09)	1.81 (0.54)	0.45 (0.11)	0.00 (0.00)
		+	10.04 (0.19)	5.44 (0.81)	19.04 (0.44)	2.65 (0.10)	3.94 (0.69)	0.36 (0.12)	0.00 (0.00)
	0.2	-	9.68 (0.50)	5.95 (0.21)	32.04 (5.65)	2.55 (0.05)	0.06 (0.02)	0.59 (0.20)	0.06 (0.02)
		+	9.30 (0.66)	6.17 (0.28)	23.13 (1.71)	2.98 (0.26)	0.09 (0.02)	0.57 (0.14)	0.16 (0.11)
	0.6	-	10.04 (0.17)	5.81 (0.20)	18.92 (1.81)	2.56 (0.06)	0.05 (0.01)	0.28 (0.12)	0.43 (0.24)
		+	10.27 (0.84)	5.54 (0.16)	27.92 (1.34)	2.92 (0.18)	0.06 (0.01)	0.55 (0.10)	0.53 (0.04)
2	0	-	11.48 (0.16)	4.21 (0.41)	4.52 (0.46)	2.69 (0.32)	12.78 (0.24)	0.23 (0.09)	0.02 (0.01)
		+	12.63 (0.55)	4.18 (0.50)	4.26 (0.75)	2.19 (0.12)	14.13 (0.96)	0.18 (0.06)	0.03 (0.01)
	0.2	-	13.11 (0.37)	4.34 (0.11)	9.70 (1.45)	2.19 (0.15)	8.07 (0.77)	0.37 (0.13)	0.00 (0.00)
		+	12.43 (0.35)	4.35 (0.06)	10.15 (1.04)	2.32 (0.09)	11.94 (2.33)	0.33 (0.13)	0.00 (0.00)
	0.6	-	11.72 (0.83)	5.99 (0.54)	34.41 (2.92)	2.34 (0.19)	6.63 (0.70)	0.48 (0.10)	0.02 (0.01)
		+	11.78 (0.65)	5.19 (0.22)	23.58 (2.74)	2.33 (0.06)	7.97 (0.45)	0.61 (0.06)	0.45 (0.03)
5	0	-	13.57 (0.55)	3.62 (0.07)	4.57 (0.07)	1.96 (0.11)	13.82 (1.26)	0.13 (0.02)	0.01 (0.00)
		+	12.67 (0.22)	3.59 (0.03)	1.98 (0.16)	2.09 (0.07)	16.04 (0.44)	0.12 (0.02)	0.02 (0.01)
	0.2	-	13.56 (0.53)	3.64 (0.29)	6.01 (0.46)	1.92 (0.09)	11.54 (1.70)	0.15 (0.01)	0.00 (0.00)
		+	12.89 (0.47)	3.60 (0.02)	2.59 (0.21)	1.87 (0.11)	13.55 (1.82)	0.11 (0.03)	0.02 (0.01)
	0.6	-	12.39 (0.64)	4.05 (0.05)	10.54 (0.67)	2.37 (0.10)	15.30 (1.32)	0.44 (0.09)	0.29 (0.20)
		+	13.67 (0.61)	3.86 (0.05)	12.64 (4.13)	2.09 (0.15)	17.45 (0.10)	0.34 (0.10)	0.00 (0.00)
Statistical significance									
Main effects									
Molasses level			**	**	**	**	**	**	NS
Urea level			NS	**	**	NS	**	**	**
LAB addition			NS	NS	NS	NS	**	NS	NS
Interactions									
Molasses × Urea			NS	**	**	*	**	*	NS
Molasses × LAB			NS	NS	NS	**	NS	NS	NS
Urea × LAB			NS	NS	NS	NS	NS	NS	NS
Molasses × Urea × LAB			NS	NS	**	NS	NS	NS	NS

LAB: Lactic acid bacteria, DM: Dry matter, TN: Total nitrogen, VBN: Volatile basic nitrogen, LA: Lactic acid, AA: Acetic acid, BA: Butyric acid.

*,** Significantly different at $p<0.05$ and $p<0.01$, respectively. NS: Not significant, SD: Standard deviation.

Chemical composition determined on dry matter basis.

was only affected by 0.6% urea, and at 5% molasses urea did not affect this parameter. The inoculation of LAB generally decreased pH value. The VBN/TN was generally increased according to the increasing level of urea addition, but this parameter significantly decreased with increasing level of molasses addition. Without molasses LAB significantly increased VBN/TN at all urea levels, but when molasses was added VBN/TN tended to decrease with LAB inoculation. In lactic acid production, significant interaction effects between molasses and urea and those between urea and LAB were observed. Lactic acid was increased by LAB inoculation and 5% addition of molasses, but showed inconsistent tendencies when urea level was increased. Interaction effects between molasses and urea were detected for acetic acid and butyric acid production. Acetic acid generally increased as increasing level of urea addition, but generally decreased with increasing level of molasses addition. Butyric acid that increased by 0.6% addition of urea was reduced by 5% addition of molasses.

DISCUSSION

According to Catchpoole and Henzell (1971) quality silage has a pH value 4.2 or below, a butyric acid concentration of less than 0.2%, lactic acid between 3 and 13% of DM, and VBN/TN less than 11%. According to their standard, the results presented in tables 1 and 2 (Experiments 1 and 2) show that the silage fermentation quality of control (0% molasses and 0% urea) was low from the viewpoints of pH and

Table 2. Effects of additions of molasses and urea on the composition of wilted young napiergrass silage (Experiment 2)

Treatment			DM (%) (SD)	pH (SD)	Chemical composition (%DM)				
Molasses (%)	Urea (%)	LAB			VBN/TN (SD)	TN (SD)	LA (SD)	AA (SD)	BA (SD)
0	0	-	16.23 (1.03)	4.61 (0.11)	21.88 (1.27)	2.28 (0.08)	9.44 (0.93)	0.88 (0.42)	0.13 (0.13)
		+	15.83 (0.91)	4.62 (0.04)	15.85 (0.71)	2.44 (0.10)	12.19 (1.92)	0.99 (0.16)	0.00 (0.00)
	0.2	-	15.30 (0.85)	5.45 (0.29)	24.87 (0.39)	3.19 (0.14)	1.50 (1.21)	1.99 (0.74)	0.13 (0.56)
		+	15.17 (0.08)	6.10 (0.24)	18.61 (1.07)	2.92 (0.08)	2.46 (1.17)	3.52 (0.70)	0.99 (0.35)
	0.6	-	14.57 (0.57)	7.53 (0.22)	50.05 (4.26)	4.27 (0.14)	1.09 (0.29)	6.83 (0.29)	1.95 (0.37)
		+	15.25 (0.52)	7.55 (0.26)	42.22 (2.37)	4.07 (0.04)	1.39 (0.16)	4.74 (0.61)	0.79 (0.36)
2	0	-	18.51 (0.51)	4.18 (0.02)	2.04 (0.32)	2.33 (0.06)	10.03 (1.27)	0.19 (0.03)	0.00 (0.00)
		+	17.86 (0.15)	4.25 (0.15)	1.30 (0.22)	2.29 (0.02)	14.10 (1.72)	0.50 (0.04)	0.00 (0.00)
	0.2	-	17.89 (0.29)	4.35 (0.05)	17.80 (0.87)	2.57 (0.15)	12.76 (3.59)	0.54 (0.14)	0.01 (0.01)
		+	17.58 (0.51)	4.47 (0.06)	15.91 (0.23)	2.71 (0.08)	13.54 (0.35)	1.46 (0.69)	0.11 (0.01)
	0.6	-	16.86 (0.20)	5.62 (0.08)	34.49 (1.29)	3.65 (0.08)	15.66 (1.67)	1.74 (0.19)	0.02 (0.00)
		+	17.18 (0.36)	5.02 (0.08)	23.28 (1.15)	3.70 (0.14)	11.93 (2.22)	1.07 (0.19)	0.02 (0.00)
5	0	-	19.43 (0.15)	4.03 (0.02)	1.34 (0.17)	2.01 (0.04)	10.98 (1.43)	0.51 (0.19)	0.01 (0.00)
		+	19.35 (0.27)	3.97 (0.02)	1.71 (0.23)	1.96 (0.04)	14.23 (2.26)	0.45 (0.09)	0.01 (0.00)
	0.2	-	18.42 (0.97)	4.14 (0.01)	12.25 (1.56)	2.61 (0.10)	11.06 (3.33)	1.16 (0.11)	0.00 (0.00)
		+	19.25 (0.55)	4.06 (0.02)	11.05 (0.58)	2.50 (0.04)	14.93 (1.60)	0.73 (0.39)	0.00 (0.00)
	0.6	-	18.54 (0.52)	4.17 (0.03)	16.30 (0.74)	3.39 (0.33)	11.96 (2.86)	0.57 (0.16)	0.01 (0.00)
		+	18.92 (0.57)	4.12 (0.03)	10.17 (0.23)	3.35 (0.13)	10.44 (1.86)	0.63 (0.16)	0.00 (0.00)
Statistical significance									
Main effects									
Molasses level			**	**	**	**	**	**	**
Urea level			*	**	**	**	*	**	**
LAB addition			NS	NS	**	NS	NS	NS	NS
Interactions									
Molasses × Urea			NS	**	**	**	**	*	**
Molasses × LAB			NS	NS	*	NS	NS	NS	NS
Urea × LAB			NS	*	**	NS	*	**	NS
Molasses × Urea × LAB			NS	NS	NS	*	NS	*	NS

LAB: Lactic acid bacteria, DM: Dry matter, TN: Total nitrogen, VBN: Volatile basic nitrogen, LA: lactic acid, AA: Acetic acid, BA: Butyric acid.

*,** Significantly different at $p<0.05$ and $p<0.01$, respectively. NS: Not significant, SD: Standard deviation.

Chemical composition determined on dry matter basis.

VBN/TN. Nevertheless, we could not conclude the fermentation qualities of napiergrass silages were low, considering butyric acid contents were less than 0.2%. From the composition of organic acids, we can classify napiergrass silage as lactate dominant type. Acetate type silages are frequently reported in tropical grass silages. This may be related to the low sugar and high fiber contents of tropical grasses, but the process of acetate dominant fermentation is not yet fully understood.

Napiergrass is known to have a high moisture content, so wilting is recognized to be an effective procedure in silage making. McDonald et al. (1991) and Henderson (1993) reported that unless plant material had a high sugar content and a low buffering capacity, wet forage was difficult to ensile, because high moisture content generally promotes the development of clostridial fermentation and also dilutes plant sugar concentrations and slows the decline in silage pH. On the other hand, McDonald et al. (1995) suggested that wilting depressed plant protein degradation and activity of *clostridia* which is an ammonia producer.

In our present experiment, wilting was an efficient treatment in young napiergrass to lower pH value compared with fresh young napiergrass silage. Yokota et al. (1992) also found that pH value of direct cut silage of napiergrass was 5.09, while wilted silage had pH of 4.72. Mature napiergrass with higher DM also resulted in good silage quality (Experiment 3), though

Table 3. Effects of additions of molasses and urea on the composition of fresh mature napiergrass silage (Experiment 3)

Treatment			DM (%) (SD)	pH (SD)	Chemical composition (%DM)				
Molasses (%)	Urea (%)	LAB			VBN/TN (SD)	TN (SD)	LA (SD)	AA (SD)	BA (SD)
0	0	-	23.00 (0.59)	3.80 (0.00)	3.33 (0.86)	1.25 (0.11)	3.61 (0.25)	0.08 (0.03)	0.00 (0.00)
		+	25.36 (0.63)	3.64 (0.04)	4.58 (0.15)	1.27 (0.05)	7.08 (0.16)	0.13 (0.01)	0.00 (0.00)
	0.2	-	22.69 (0.61)	4.06 (0.08)	4.34 (1.00)	1.78 (0.07)	4.65 (0.41)	0.31 (0.12)	0.00 (0.00)
		+	22.08 (0.14)	4.08 (0.16)	5.36 (1.44)	1.61 (0.02)	5.74 (0.51)	0.52 (0.16)	0.02 (0.00)
	0.6	-	21.20 (0.30)	5.68 (0.03)	5.80 (0.72)	2.42 (0.06)	0.51 (0.09)	0.73 (0.14)	0.69 (0.19)
		+	22.46 (0.43)	5.43 (0.11)	9.23 (0.32)	2.40 (0.18)	0.62 (0.16)	0.66 (0.02)	0.46 (0.10)
2	0	-	22.93 (0.15)	4.23 (0.06)	2.09 (0.18)	1.51 (0.09)	3.73 (0.64)	0.19 (0.00)	0.01 (0.00)
		+	26.05 (0.49)	3.64 (0.03)	1.34 (0.07)	1.59 (0.05)	6.74 (0.73)	0.16 (0.02)	0.02 (0.01)
	0.2	-	23.05 (0.41)	3.97 (0.03)	3.52 (0.03)	1.65 (0.09)	2.95 (0.27)	0.27 (0.11)	0.00 (0.00)
		+	24.66 (0.49)	3.64 (0.03)	3.83 (0.21)	1.79 (0.07)	4.85 (1.13)	0.11 (0.04)	0.04 (0.03)
	0.6	-	22.55 (0.51)	4.92 (0.50)	4.41 (0.64)	2.39 (0.07)	4.31 (0.97)	0.49 (0.10)	0.23 (0.22)
		+	24.00 (0.22)	4.02 (0.03)	3.65 (0.19)	2.48 (0.10)	5.02 (0.86)	0.34 (0.08)	0.01 (0.00)
5	0	-	25.53 (0.20)	3.76 (0.05)	1.70 (0.20)	1.44 (0.06)	4.34 (0.17)	0.19 (0.02)	0.01 (0.00)
		+	24.73 (0.29)	3.50 (0.01)	0.97 (0.11)	1.35 (0.09)	7.46 (1.46)	0.12 (0.03)	0.00 (0.00)
	0.2	-	26.08 (0.33)	3.84 (0.04)	1.36 (0.25)	1.79 (0.08)	5.72 (0.22)	0.19 (0.02)	0.01 (0.00)
		+	24.95 (0.85)	3.62 (0.04)	1.13 (0.15)	1.79 (0.06)	6.28 (0.39)	0.16 (0.03)	0.02 (0.01)
	0.6	-	24.47 (0.28)	3.89 (0.03)	2.71 (0.14)	2.28 (0.07)	7.68 (0.18)	0.40 (0.15)	0.00 (0.00)
		+	24.80 (0.42)	3.81 (0.08)	1.49 (0.02)	2.32 (0.09)	7.88 (0.69)	0.28 (0.13)	0.01 (0.01)
Statistical significance									
Main effects									
Molasses level			**	**	**	NS	**	**	**
Urea level			**	**	**	**	*	**	**
LAB addition			**	**	NS	NS	**	NS	NS
Interactions									
Molasses × Urea			*	**	**	NS	**	*	**
Molasses × LAB			**	**	**	NS	NS	NS	NS
Urea × LAB			*	NS	NS	NS	**	NS	NS
Molasses × Urea × LAB			NS	NS	NS	NS	NS	NS	NS

LAB: Lactic acid bacteria, DM: Dry matter, TN: Total nitrogen, VBN: Volatile basic nitrogen, LA: lactic acid, AA: Acetic acid, BA: Butyric acid.

*,** Significantly different at $p<0.05$ and $p<0.01$,respectively. NS: Not significant, SD: Standard deviation.
Chemical composition determined on dry matter basis.

it may have a high fiber content and consequently a low digestibility. Thus, in the future a digestibility experiment is required.

Plant sugars are the substrates for the fermentation process, so that their concentration in the parent forage has a major influence on the extent and type of fermentation in silage. It appears that high water solubie carbohydrate concentration in fresh forages gives a high probability of lactate type silage and of the silage being well preserved (Wilkinson, 1983). Addition of soluble carbohydrate may be expected to improve the quality of silage and some additives are used in practice to overcome low content of sugars in tropical grasses.

Molasses is frequently used in silage making. Molasses addition on clover-grass silage was found to produce more lactate and less acetate and ammonia-N than untreated controls (McDonald et al., 1991). Yokota et al. (1992) reported that 4% molasses as a sugar additive in wilted napiergrass silage decreased the pH value from 4.72 to 3.99 and the fermentation type was not acetate but lactate dominant.

In our experiments molasses addition led to improvement of fermentation quality by decreasing pH value, VBN and butyric acid and by increasing lactic acid. Two percent molasses addition in the three experiments was shown to be almost sufficient to lower pH value to 4.2 which is thought to be the critical pH to depress *Clostridia* (McDonald et al., 1991; Scudamore and Livesey, 1998).

Urea addition to 0% molasses increased VBN/TN, resulting in higher pH and therefore increased butyric acid production. The deleterious effect of urea addition was more pronounced in young napiergrass than mature napiergrass. With 0.2% urea, 2% molasses decreased pH below 4.2 in mature grass silage, while in young grass silage it did not. Addition of 5% molasses in the three experiments resulted in good quality silages even at 0.6% urea addition, owing to the enhanced lactic acid fermentation or to the inhibition of clostridial bacteria growth by the supplement of higher soluble carbohydrates with molasses (Davies et al., 1997; McDonald et al., 1991).

Added urea in silage is easily decomposed to ammonia by plant and microbial enzymes and urease activity, during the initial phase of ensilage while pH is near neutral. Stephanie and Simon (1992) also found that the pH optimum in Jack bean (*Cana valia ensiformis*) urease activity was between 7 and 8, and activity inhibition occurred at pH 4.6. This enzymatic decomposition of urea might be depressed by a lowering of pH from a lactic acid production enhanced by higher molasses addition. This was implied by our present results; production of lactic acid with 2% molasses did not decrease pH to the level sufficient for inhibition of urease activity, and 5% molasses addition was necessary. The differences in the effect of the combination level of urea and molasses among the conditions of plant material may be mainly related to the differences in water content, because the urease activity may be lower and *Clostridia* activity to produce NH_3 may be depressed in materials with high dry matter. According to Weinberg and Muck (1996), if forage with too high moisture content is ensiled, *Clostridia* fermenting lactic acid to butyric acid and amino acids to ammonia might became active, resulting in an increase in pH value and a large loss of silage dry matter.

Ensiling of forages with LAB inoculation could restrict the development of yeasts, increase lactic acid content and lower the pH quickly (McDonald et al., 1991). In our experiment LAB inoculation increased lactic acid production in fresh young and mature napiergrass silages, but its effect on pH reduction was observed with the mature grass only.

The improving effect on nitrogen content in silage by the addition of urea was not large in fresh young napiergrass silage but was effective in wilted young and mature napiergrass silages. It is concluded from our experiments that in making silage with napiergrass, wilting and 5% molasses addition are important treatments when adding a high amount of urea (0.6%) intended to increase nitrogen in silage.

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