Effect of Cotton Stems Addition on the Chemical Composition and *In Sacco* Dry Matter Digestibility of Pearl Millet Silage

R. S. Grewal[1], S. Saijpaul* and S. Kaushal
Department of Animal Nutrition Punjab Agricultural University, Ludhiana. 141004, India

ABSTRACT : The possibility of using cotton stems as a roughage source in animal feeding was explored. Ground cotton stems (T2 and T3) or stems treated with 0.5% urea (T4 and T5) were ensiled with pearl millet green fodder in double lined plastic bags of 3 kg capacity for 50 days. Formic acid (0.4% v/v) was sprayed on T3 and T5 silages. The treatments were compared with pearl millet silage alone (T1) which constituted the control. All the bags were placed in the silo pit of pearl millet silage. Results indicated that urea treatment of cotton stems increased and formic acid application reduced dry matter loss of the silages. Inclusion of cotton stems in the silage significantly ($p<0.05$) increased CF, ADF, cellulose and ADL due to its higher cell wall content. The hemicellulose was significantly lower in T3 (16.7%) and T5 (22.52%) as compared to T2 (23.45%) and T4 (24.6%) due to formic acid application. Ammoniation significantly increased NH3-N content in T4 (0.202%) and formic acid controlled NH_3-N level in T5 (0.107%).The *in sacco* dry matter digestibility was significantly higher ($p<0.05$) in formic acid preserved silages T3 and T5 (47.73 and 47.93%) as compared to silages without formic acid (44.94 and 41.22 %) in T2 and T4 respectively, but lower than T1 (54.39%). It is concluded that cotton stems can be ensiled with pearl millet fodder in 1:4 ratio with or without urea treatment. Formic acid application further increases the silage quality. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 12 : 1722-1724)***

Key Words : Ammoniated Cotton Stems, Silage, Chemical Composition, Digestibility

INTRODUCTION

Approximately 0.12 million tonnes of cotton stems (*Gossypium hirsutum*) are available annually in the Punjab state of India. At present most of these stems are used as domestic fuel and the dried leaves and twigs are ploughed back into the fields. Cotton stems could become a source of roughage for ruminants under adverse conditions or an additional feed resource in meeting the requirements of livestock. It could also become a dry roughage source to reduce the cost of the ration.

High moisture fodder which are otherwise difficult to ensile can be effectively ensiled by mixing with wheat straw (Nandra and Chopra. 1985). Research also indicated that increasing the dry matter of roughage decreased NH3-N content of the silage (Kim et al., 2001). Formic acid restricts the growth of bacteria in silage (Bolsen et al., 1996). Addition of formic acid to forage during ensiling improved the dry matter recovery, animal intake and energy digestibility (Waldo. 1977). Fermentation data of lucerne (*Medicago sativa*) silage containing ozone treated cotton stems has given encouraging results (Ben-Ghedalia and Yosef. 1989). Hence this research was planned to explore the possibility of using cotton stems in pearl millet (*Pennisetum typhoides*) silage preparation.

* Corresponding Author: S. Saijpaul. E-mail: sksaijpaul@rediffmail.com
[1] Department of Animal Breeding and Genetics Punjab Agricultural University, Ludhiana 141004, India.
Received February 3, 2003; Accepted May 28, 2003

MATERIALS AND METHODS

Treatment of cotton stalks

Stems of American cotton (*Gossypium hirsutum*) were taken after last picking from the field. The cotton stems were chopped into 7.5 cm pieces, sun dried and ground coarsely to 2.5 mm size. Cotton stems were prepared by spraying with 50 ml of 0.5% urea solution/100 mg material and kept overnight for soaking. Cotton stems were ensiled with fresh pearl millet fodder harvested after 55 days from sowing, at pre boot stage with or without 0.4% formic acid (on fresh basis). The ratio of the cotton stem: pearl millet fodder was 20:80 on dry matter (DM) basis in order to maintain the roughage DM between 30-35% at the time of ensiling. The following silages were prepared: pearl millet (T1), pearl millet+cotton stems (T2), pearl millet+cotton stems+0.4% formic acid (T3), pearl millet+urea treated cotton stems (T4) and pearl millet+urea treated cotton stems+0.4% formic acid (T5). The cotton stems and green fodder were mixed thoroughly and densely packed into 3 kg capacity double lined polythene bags and tied. These bags were placed in a large silage pit of pearl millet silage to maintain the anaerobic environment and optimum temperature. The bags were taken out after 50 days and weighed to estimate dry matter loss.

Animal management and feeding

The experiment was conducted on two adult rumen fistulated buffaloes (*Bubalis bubalis*) averaging 350 kg body weight. During the experiment the animals were kept

Table 1. Chemical composition dry matter (DM) basis of pearl millet fodder, urea treated and untreated cotton stems.

Parameters	Pearl millet	Cotton stem	Urea treated cotton stem
Dry matter	23	90	40
Organic matter	91.3	95.82	95.80
Crude protein	7.65	6.10	7.44
Crude fiber	31.54	57.28	58.20
Ether extract	2.44	1.16	1.05
Ash	8.70	4.18	4.20
Nitrogen free extract	49.66	31.28	29.11
Cellulose	42.99	39.71	38.95
Neutral detergent fiber	72.10	78.42	79.26
Acid detergent fiber	47.80	63.12	65.85
Acid detergent lignin	4.84	16.57	18.66
Hemicellulose	24.30	15.30	13.41

T1: Pearl millet silage, T2: Pearl millet−cotton stems silage, T3: Pearl millet−cotton stems+0.4% formic acid silage, T4: Pearl millet−urea treated cotton stems, T5: Pearl millet−urea treated cotton stems−0.4% formic acid.

in well ventilated shed with individual feeding and watering arrangement. The animals were fed on wheat straw *ad libitum*, 5 kg oat fodder and 1.5 kg concentrate mixture containing 30% wheat grain, 30% de-oiled mustard cake, 32% de-oiled rice bran, 5% molasses, 1% common salt and 2% mineral mixture to meet digestible crude protein (DCP) requirements (Kearl, 1982). Clean, fresh drinking water was provided to the experimental animals twice daily at 10 am and 4 pm.

Processing of samples and incubation in the rumen of fistulated animals

The silage samples were oven dried at 50°C for 48 h and ground to 1 mm size. The *In sacco* degradability of DM was determined by the polyester bag (7×15 cm, pore size 50-55 μm) technique (Mehrez and Orskov, 1977) with 3 g of dried sample taken in quadruplicate and incubated in the rumen for 48 h .

Analytical techniques

The pH of the silage was determined with a digital pH meter after macerating a 10 g representative sample of silage in 90 ml of distilled water. The remaining silage extract was stored in a refrigerator and later analysed for ammonical nitrogen (NH_3-N) by the method given by Conway (1957). The dry matter was calculated by drying the sample at 70°C for 24 h in a hot air oven. The dried samples were ground and used for determination of proximate principles (AOAC, 1980) and cell wall components (Goering and Van Soest, 1970). All data were statistically analysed for mean and multiple range tests according to the methods of Snedecor and Cochran (1968) using STATG software.

RESULTS AND DISCUSSION

The average chemical composition of pearl millet green fodder, cotton stem and 0.5% urea treated cotton stem is given in Table 1. Pearl millet fodder had crude protein similar to ammoniated cotton stem, but the crude fibre, acid detergent fiber (ADF), neutral detergent fiber (NDF), cellulose, acid detergent lignin (ADL) and hemicellulose fractions were considerably less than cotton stem. Higher ether extract and nitrogen free extract indicated more soluble nutrients in pearl millet fodder compared with cotton stem. Ammoniation of cotton stem increased the crude protein due to urea treatment and acid detergent lignin content as a result of binding of nitrogen to the acid detergent fiber which exhibits lignin like properties as proposed by Moller (1986).

Formic acid application reduced significantly ($p>0.05$) the DM loss (T3 vs. T2 and T5 vs. T4) during ensiling (Table 2) as also reported by Kim et al. (2001). Formic acid treated silage having urea treated cotton stems gave significantly higher crude protein value than silage without

Table 2. Chemical composition and *in sacco* dry matter digestibility (DMD) of pearl millet alone and pearl millet and cotton stem silages

Parameters	T1	T2	T3	T4	T5
Organic matter	$89.91^{a}\pm0.08$	$90.75^{bc}\pm0.21$	$91.05^{c}\pm0.08$	$91.13^{c}\pm0.83$	$90.45^{ab}\pm0.09$
Total ash	$10.03^{c}\pm0.08$	$9.25^{ab}\pm0.21$	$8.95^{a}\pm0.08$	$8.86^{a}\pm0.83$	$9.55^{bc}\pm0.11$
Crude protein	$4.56^{a}\pm0.01$	$4.66^{ab}\pm0.02$	$4.91^{b}\pm0.33$	$4.65^{ab}\pm0.03$	$5.86^{c}\pm0.33$
Crude fiber	$38.52^{a}\pm0.52$	$41.51^{b}\pm0.08$	$42.77^{c}\pm0.68$	$43.5^{c}\pm0.78$	$43.29^{c}\pm0.83$
Ether extract	$2.06^{e}\pm0.03$	$1.51^{c}\pm0.03$	$1.36^{a}\pm0.01$	$1.59^{d}\pm0.01$	$1.41^{b}\pm0.03$
Neutral detergent fiber	$75.66^{b}\pm1.20$	$80.79^{d}\pm1.51$	$74.09^{a}\pm1.21$	$80.43^{d}\pm0.61$	$77.03^{c}\pm0.30$
Acid detergent fiber	$49.73^{a}\pm0.60$	$57.34^{d}\pm0.90$	$57.39^{d}\pm0.61$	$55.83^{c}\pm0.91$	$54.51^{b}\pm0.01$
Hemicellulose	$25.93^{e}\pm0.42$	$23.45^{c}\pm0.42$	$16.70^{a}\pm0.30$	$24.60^{d}\pm0.21$	$22.52^{b}\pm0.20$
Cellulose	$38.68^{a}\pm0.60$	$41.78^{c}\pm0.01$	$41.58^{c}\pm0.60$	$41.93^{c}\pm0.01$	$40.55^{b}\pm0.30$
Acid detergent lignin	$7.85^{a}\pm0.92$	$10.44^{b}\pm0.30$	$11.13^{b}\pm1.20$	$10.27^{b}\pm0.01$	$10.51^{b}\pm0.30$
Dry matter loss	$11.9^{b}\pm0.9$	$12.30^{b}\pm0.3$	$10.1^{a}\pm1.0$	$13.7^{c}\pm0.3$	$12.8^{b}\pm0.7$
In sacco dry matter digestibility	$54.39^{d}\pm1.59$	$44.94^{b}\pm0.33$	$47.73^{c}\pm0.94$	$41.22^{a}\pm1.92$	$47.93^{c}\pm1.34$

Values bearing different superscripts in the same row differ significantly ($p<0.05$). T1: Pearl millet silage. T2: Pearl millet−cotton stems silage. T3: Pearl millet−cotton stems+0.4% formic acid silage. T4: Pearl millet+urea treated cotton stems. T5: Pearl millet+urea treated cotton stems−0.4 % formic acid.

Table 3. Chemical characteristics of pearl millet silages

Parameters	T1	T2	T3	T4	T5
pH	$3.85^{a}\pm0.02$	$3.87^{a}\pm0.04$	$3.97^{a}\pm0.06$	$4.56^{c}\pm0.06$	$4.05^{b}\pm0.05$
Ammonical nitrogen (mg/100 g DM)	$57.52^{b}\pm6.6$	$57.0^{b}\pm1.0$	$36.35^{a}\pm0.1$	$206.09^{d}\pm93.06$	$100.70^{c}\pm16.93$
Total nitrogen (mg/100 g DM)	$787.12^{a}\pm9.5$	$802.60^{a}\pm2.2$	$822.48^{a}\pm37.5$	$950.60^{b}\pm7.32$	$1,038.83^{c}\pm50.46$
Ammonical nitrogen as % of total nitrogen	$7.31^{a}\pm0.74$	$7.10^{b}\pm0.14$	$4.42^{b}\pm1.75$	$21.68^{d}\pm0.55$	$9.69^{c}\pm1.24$

Values bearing different superscripts in the same row differ significantly ($p<0.05$). T1: Pearl millet silage. T2: Pearl millet−cotton stems silage. T3: Pearl millet−cotton stems+0.4% formic acid silage. T4: Pearl millet+urea treated cotton stems. T5: Pearl millet+urea treated cotton stems−0.4% formic acid.

formic acid indicating decreased microbial degradation of protein during ensiling (Charmley et al., 1990). Addition of cotton stems to the silage increased the crude fiber due to the higher lignified nature of cotton stems. Neutral detergent fiber fraction was less in T3 and T5 than T2 and T4 indicating some hemicellulose solubilizing effect of formic acid. This might be due to the breakdown of hemicellulose fraction in acidic condition as reported earlier (Morrison, 1979). Other fiber fractions like cellulose, ADF and ADL remained statistically similar in treatments T2 and T3 but was higher than control. *In sacco* dry matter digestibility (DMD) was highest in pearl millet silage (T1) and was lowest in pearl millet+urea treated cotton stem silage. Addition of formic acid significantly ($p<0.05$) improved the DMD of both untreated and urea treated cotton stem silages. Ammoniation of cotton stems significantly decreased ($p<0.05$) DMD of the silage (41.22%) as compared to untreated cotton stems indicating that urea treatment was ineffective in improving the silage digestibility.

Formic acid application reduced the pH of the silages (Table 3). The NH_3 released from ammoniated cotton stem containing silages depressed the acidic action of formic acid as apparent from the higher pH in T5 as compared to T3. Ammoniation increased the ammonical nitrogen in T4 and T5. The acidic conditions decreased the microbial degradation of protein which was reflected in lower NH_3-N in silages T3 and T5 as compared to T2 and T4. Similar results were obtained by Charmley et al. (1990). Total nitrogen did not vary much for treatments except T4 and T5 which was significantly higher due to urea treatment. The NH_3-N as percent of total nitrogen was significantly ($p<0.05$) lower in T3 and T5 silages since formic acid successfully preserved the protein fraction in these silages which could result in higher availability of crude protein to the animals. Similar findings have also been reported earlier (Rooke et al., 1988).

CONCLUSION

It may be concluded that cotton stems which otherwise are burnt as fuel, can be used for animal feeding through ensiling with pearl millet fodder in ratio of 20:80. Formic acid treatment at 0.4% of fresh weight further improved the quality of the silages. However, urea treatment before ensiling does not have any favourable effect on silage. Further research on animal performance with such silages is required to quantify their feeding value.

REFERENCES

AOAC. 1980. Official Methods of Analysis 13th ed Association of Official Analytical Chemists, Washington, DC.

Ben-Ghedalia, D. and E. Yosef. 1989. Ozonated cotton stalks as a silage additive: fermentation data on Lucerne with particular reference to protein degradation. J. Sci. Food and Agri. 46:279-287.

Bolsen, K. K., G. Ashbelt and Z. G. Weinberg. 1996. Silage fermentation and silage additives- Review. Asian-Aust. J. Anim. Sci. 9:483-493.

Charmley, E., M. Gil and C. Thomas. 1990. The effect of formic acid treatment and the duration of the wilting period on the digestion of silage by young steers. Anim. Prod. 51:497-504.

Conway, E. J. 1957. Microdiffusion Analysis and Volumetric Error. London: Crosby Lockwood.

Goering, H. K. and P. J. Van Soest. 1970. Forage fibre analysis (Apparatus, reagents, procedures and some applications). USDA Agricultural Handbook No. 379, Washington, DC. pp. 1-12.

Kearl, L. C. 1982. Nutrient Requirements of Ruminants in Developing countries. International feedstuffs institute. Utah Agricultural Experiment Station. Utah State Univ. Logan, Utah.

Kim, J. G., S. Chung Seo, J. S. Ham, W. S. Kang and D. A. Kim. 2001. Effects of maturity at harvest and wilting days on quality of round baled rye silage. Asian-Aust. J. Anim. Sci. 14:1233-1237.

Mehrez, A. Z. and E. R. Orskov. 1977. A study of the artificial fibre bag technique for determining the digestibility of feeds in the rumen. J. Agri. Sci. (Camb.) 88:645-650.

Moller, E., N. Wilt, H. Z. Thellesen and M. Hesselholt. 1986. Straw for fodder V Straw quality after addition of ammonia. Tidsskrift for planteavl 90:61-65.

Morrison, I. M. 1979. Changes in cell-wall components of laboratory silages and effect of various additives on these changes. J. Agric. Sci. (Camb.) 93:581-586.

Nandra, K. S. and A. K. Chopra. 1985. Effect of different treatments on the quality of berseem silage. J. Res. Punjab Agricultural Univ. 32:397-400.

Rooke, J. A., F. M. Maya, J. A. Arnould and D. G. Armstrong. 1988. The chemical composition and nutritive value of grass silages prepared with no additive or with the application of additives containing either Lactobacillus plantum or formic acid. Grass and Forage Sci. 43:87-95.

Snedecor, G. W. and W. G. Cochran. 1968. Statistical Methods (6th ed) Oxford and IBH Publishing Co. Calcutta.

Waldo, D. R. 1977. Potential of chemical preservation and improvement of forages. J. Dairy Sci. 60:306-326.