Mechanical and Chemical Conditioning Effect on Field Drying Rate and Quality of Grass Hay

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ABSTRACT : A field experiment was carried out to determine the effects of mechanical and chemical conditioning at mowing on field drying rate and quality of grass hay in 1996. Mower conditioner and/or chemical drying agent (K_2CO_3) were used at different harvest stages (late boot, heading and bloom stages) for hastening hay-making. After field drying, square bales were made by hay baler, and the visual estimation and nutritive value of hay were evaluated after storing two months. In mower conditioning, the duration of field drying was shortened by 0.5 to 1 day compared with drying agent, and by 1 to 2 days compared with control. The drying matter loss of hay was reduced by late harvest and mechanical conditioning. The visual score (leafiness, green color, odor and softness), and acid detergent fiber (ADF), neutral detergent fiber (NDF), *in vitro* dry matter digestibllity (IVDMD), and relative feed value (RFV) of hay were improved with mechanical conditioning, but chemical alone had little effect on quality. The quality of hay harvested at bloom stage was much lower than that of hay harvested at late boot and heading stage. In conclusion, mower conditioning can enhance the field drying rate of grass hay, however the drying efficiency of chemical drying agent is very low. Also the effects of chemical/mechanical combined conditioning are very similar compared with mechanical conditioning alone. Harvesting at late boot to heading stage is recommended for the production of high quality hay. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 8 : 1109-1112*)

Key Words : Mower Conditioner, Drying Agent, Drying Rate, Hay Quality, Grass Hay

INTRODUCTION

Hay-making should to remove moisture quickly so that nutrient losses from weathering and microbial degradation are minimized. The degree of moisture removal in the field and plant growth stage at mowing are the most important factors for making high quality hay (Verma et al., 1986; Baylor, 1991; Pitt, 1991). The rate of drying in the field is highly dependent on environmental and forage conditions: i.e., solar radiation, temperature, humidity, moisture content of the soil, and the density and thickness of the swath (Bolsen et al., 1991; Itokawa et al., 1996).

Prolonged drying periods result in increased dry matter losses from continued plant respiration, microbiological attack, leaching by rain and shattering of over-dried leaves. Also delayed harvest of forages causes poor quality of hay.

Mechanical and chemical conditioning are processes which speed the field drying of forages (Rotz and Davies, 1986). Mechanical methods of conditioning by crushing, breaking and abrading the forage material are widely used to help speed the field drying process by forage producers. Chemical drying agents are also effective in moisture reduction of forages on the field. Potassium carbonate (K_2CO_3) has been widely used for hastening hay making, especially alfalfa (Tullberg and Angus, 1978; Tullberg and Minson, 1978; Meredith and Warboys, 1996; Seo et al., 1998).

The objectives of the study were to evaluate the effectiveness of mechanical and chemical conditioning for hastening the drying rate of grasses, and to determine the optimum harvest stage for high quality hay production.

MATERIALS AND METHODS

This study was carried out at the experimental farm of National Livestock Research Institute, Suwon in 1996. The mixed species in this experiment consisted of about 40% orchardgrass (*Dactylis glomerata* L.), 30% tall fescue (*Festuca arundinacea* Schreb.), 15% Kentucky bluegrass (*Poa pratensis* L.), 10% ladino clover (*Trifolium repens* L.) and 5% perennial ryegrass (*Lolium perenne* L.). The size of the experimental plot was about 1.0 ha.

For the experiment, a split plot design with four replications was arranged with different harvest stage as the main plot, and mechanical / chemical conditioning as the sub plot. Grasses were harvested at the late boot (8 May), heading (14 May) and bloom (27 May) stages. The mechanical and/or chemical conditionings used in this study were 1) mower-conditioner (roll-type) with 2.8 m of mower width, 2) 2% potassium carbonate (K_2CO_3) solution, 3) mechanical and chemical combined treatment, and 4) no mechanical or chemical conditioning (control).

The chemical drying agent was sprayed with a large sprayer on the plant just before mowing, and the mower-conditioner was pulled behind the tractor. After

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Table 1. Meteorological data during five days after harvest of grasses, 1996

Harvest stage	Investigation (5 days)	Mean temp. (℃)	Precipitation (mm)	Relative humidity (%)	Sunshine (%)	Sunlight intensity (MJ/㎡)	Wind speed (m/s)
Late boot	8~12 May	14.9	0.0	72	76	17.54	2.0
Heading	14~18 May	19.0	0.0	68	59	13.85	1.0
Bloom	27~31 May	21.5	0.0	70	46	12.70	1.0

* Suwon meteorological station.

Table 2. Plant height, dry matter (DM) percentage, forage yield, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), *in vitro* dry matter digestibility (IVDMD), and relative feed value (RFV) of grasses at mowing as affected by harvest stage

Harvest stage	Plant height (cm)	DM (%)	DM yield (kg/ha)	CP (%)	ADF (%)	NDF (%)	IVDMD (%)	RFV
Late boot	58	14.7	2,778	21.0	27.8	45.9	67.2	136
Heading	72	16.6	4,570	16.0	31.6	51.2	64.3	117
Bloom	88	26.3	4,938	13.5	36.6	57.7	60.4	97
LSD (0.05)	12.8	4.1	484	2.4	1.2	0.8	1.0	2.7

mowing, the hay was tedded at 12:00 each day during the field drying period. The moisture content of the hay was determined at 12:00 and 16:00 for five days after mowing. The hay was baled by square hay baler at about 18 to 20% moisture. Dimensions and weight of bales were about 40 cm width×30 cm height×50 cm length, and 8~10 kg.

Dry matter loss was measured as difference of bale weight between baling and after storing two months. Hay quality was evaluated by both visual estimation (Burns and Lacefield, 1991) and NIR analysis (NIR systems Inc., 1990, ISI program). The crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and *in vitro* dry matter digestibility (IVDMD) of forages were determined at mowing and after storing two months. Relative feed value (RFV) was calculated by the equation of Holland and Kezar (1990).

The meteorological conditions during five days after harvest of pasture plants are shown in table 1. The mean air temperature during five days after mowing were 14.9℃ at late boot, 19.0℃ at heading, and 21.5℃ at bloom stage, and the weather conditions were very sunny, regardless of harvest time.

RESULTS AND DISCUSSION

Forage yield and nutritive value at mowing as affected by harvest stage

The plant height, dry matter(DM) percentage, DM yield, CP, ADF, NDF, IVDMD, and RFV of grasses at mowing as affected by harvest stage are shown in table 2.

Plant height increased with growth advance of grasses, and DM percentage was higher at bloom stage than those of late boot and heading stages.

The forage yield was significantly increased with delayed harvest ($p<0.05$). The yields were 2,778 kg at late boot, 4,570 kg at heading, and 4,938 kg/ha at bloom stage. However, the nutritive value of grasses decreased rapidly as the harvest stage was delayed. The CP, IVDMD and RFV were decreased remarkably from 21.0%, 67.2% and 136 at late stage to 13.5%, 60.4%, and 97 at bloom stage, respectively.

Drying rate and nutritive value of grass hay as affected by mechanical/chemical conditioning

Drying rate and nutritive value of grass hay as affected by mechanical/chemical conditionings are shown in table 3. Mechanical conditioning increased the drying rate of grasses, but drying speed by chemical was of little effectiveness compared to mechanical conditioning. To produce high quality hay, forages should by baled about 18 to 20% moisture (Pitt, 1991). The length of time between mowing and baling was 4, 3~4, 2~2.5 and 2~2.5 days for control, chemical K_2CO_3 conditioning, mower-conditioning, and K_2CO_3+mower-conditioning, respectively. With mower conditioning, field drying was shortened by 1.5 to 2 days compared with control.

DM loss of hay was greatly reduced by mechanical conditioning. Visual score for leafiness, green color, odor and softness after storage was high in mechanical conditioning. The scores of mower-conditioning and K_2CO_3+mower-conditioning were all 82 (good), but those of control and K_2CO_3 alone were 77 (fair) and 78 (fair), respectively. Nutritive components, such as CP, ADF, NDF, IVDMD and RFV were improved by mechanical conditioning, but were little altered by chemical alone. Han and Kim

Table 3. Field drying rate and hay quality of grasses as affected by harvest stage and chemical/mechanical conditioning after storing two months

Harvest stage	Chemical/ mechanical conditioning	Days for field drying	DM loss (%)	Visual score*	CP (%)	ADF (%)	NDF (%)	IVDMD (%)	RFV
Late boot	Control	5~6	16.9	83	20.1	33.5	56.1	62.9	104
	K_2CO_3	4~5	10.7	84	19.3	32.7	55.1	63.5	107
	Mechanical	3	5.6	89	20.2	29.8	53.5	65.7	114
	K_2CO_3+Mecha.	3	2.8	89	19.8	29.6	52.9	65.8	115
Heading	Control	4	9.9	77	15.6	33.6	57.6	62.7	101
	K_2CO_3	3~4	7.5	78	15.8	33.9	55.3	62.5	105
	Mechanical	2~3	3.4	82	16.1	32.1	54.3	63.9	109
	K_2CO_3+Mecha.	2~3	3.2	82	16.3	32.9	55.8	63.3	105
Bloom	Control	3	+	61	12.8	37.4	60.2	59.8	92
	K_2CO_3	3	+	63	12.3	36.9	59.6	60.2	94
	Mechanical	1~2	+	65	12.9	36.9	59.8	60.2	94
	K_2CO_3+Mecha.	1~2	+	65	13.3	36.3	58.1	60.7	98

Mecha. means mechanical, + : trace.
The samples within four replications were mixed.
* Estimation of score : excellent (90 and above), good (80~89), fair (65~79), poor (below 65).

Table 4. Drying rate and quality of grass hay as affected by harvest stage after storing two months

Harvest stage	Days for field drying	DM loss (%)	Visual score*	CP (%)	ADF (%)	NDF (%)	IVDMD (%)	RFV
Late boot	4	9.0	86	19.9	31.4	54.4	64.5	110
Heading	3	6.0	80	15.9	33.3	55.8	63.1	105
Bloom	2	+	63	12.8	36.9	59.4	60.2	94
LSD (0.05)	0.5	-	-	1.3	1.6	1.5	1.1	4.3

+: trace.
* Estimation of score: excellent (90 and above), good (80~89), fair (65~79), poor (below 65).

(1996) also reported that there was no effect of chemical conditioning on nutritive value of spring oats.

In this study, chemical conditioning did not affect drying efficiency and hay quality as much as mechanical conditioning. However, many researchers reported that chemical conditioning was effective on drying of alfalfa hay (Wieghart et al., 1980; Rotz and Davis, 1986; Rotz and Thomas, 1988; Akkharath el al., 1996; Meredith and Warboys, 1996; Seo et al., 1998). Rotz and Davis (1986) reported that chemical conditioning was less effective at the drying time of alfalfa because of the greater forage yield. Higher yields cause heavier swaths for drying. Chemical conditioning is less effective in a heavy swath because the swath restricts drying, particularly in grasses.

The effect of chemical/mechanical combined conditioning was very similar compared with mechanical conditioning alone in this experiment. Verma et al. (1986) also reported similar results that drying rate of mechanical conditioning was almost doubled in ryegrass, and combination of chemical and mechanical conditioning was not more effective than mechanical conditioning only. In alfalfa, however, the chemical/mechanical combined conditioning improved drying efficiency in the USA (Rotz et al., 1982), and in the UK (Meredith and Warboys, 1996).

Drying rate and nutritive value of grass hay as affected by harvest stage after storing two months

Table 4 shows the days for field drying of grasses were shortened by delayed harvest. But the visual score, CP, ADF, NDF, IVDMD and RFV were remarkably decreased when harvested at bloom stage. The visual score, IVDMD and RFV were 86 (good), 64.5 and 110 at late boot, 80 (good), 63.1 and 105 at heading, and 63 (poor), 60.2 and 94 at bloom stage, respectively.

In conclusion, mechanical conditioning can enhance

the field drying rate and hay quality of grasses. However, the effectiveness of the chemical drying agent is very low. Also the effects of chemical/mechanical combined conditioning are very similar compared with mechanical alone. Harvest at late boot to heading stage is recommended for production of high quality hay.

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