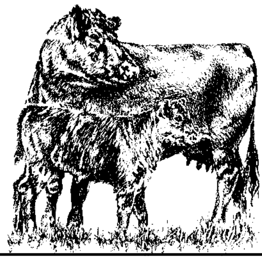

Alfalfa Hay Management

Each year in the United States approximately 140 million tons of hay are produced and stored in various forms. The amount of harvest and storage losses in making hay is estimated to be more than from any other crop grown. These losses can be reduced dramatically by harvesting at the proper stage of maturity, avoiding weather damage and minimizing harvest and storage losses.

Plant material losses when making hay range from 20 to 40 percent, but can exceed 70 percent if harvested in less than ideal weather conditions. The number one loss is from leaf shattering during mechanical handling, such as raking and baling when hay is too dry. Nutrients leached by rain and plant respiration during storage are other contributing factors in hay making losses.

Baling hay at higher than the optimum moisture content of 15 to 18 percent will minimize mechanical leaf loss and reduce the risk of rain damage because of the shortened wilting and drying period. However, baling at moisture levels above 20 percent generally increases storage losses from excessive heating and molding of the hay.

The use of drying agents, at the time of cutting, hastens the drying process. Preservatives applied while baling do not shorten drying time, but prevent heating and mold growth in hay baled at higher than recommended moisture levels.

Cutting at the "Best" Stage of Maturity

Alfalfa growth is very rapid in the spring and after each harvest through the onset of flowering. At these vegetative growth stages the proportion of leaves, by dry weight, is usually greater than that of the stems. At flower initiation stems increase in fiber and lignin and the ratio begins to reverse with a greater proportion of stems being present. Higher yield from mature alfalfa is due to the heavier and thicker stems that have increased quantities of undigestible cellulose and lignin.

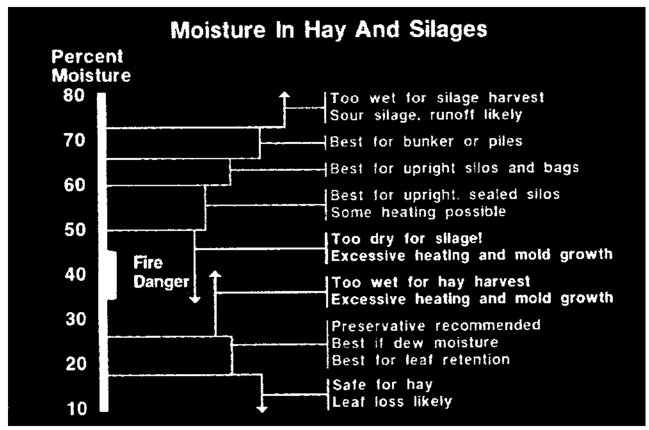

Fig. 1. Moisture management guide for preserving forages as silage or hay.

To harvest top quality alfalfa it should be cut at the growth stage where leaves are present in the greatest quantity and before stems develop heavy cell wall deposits. An example of how alfalfa matures is shown in Table 1.

Table 1. Percent change in cellulose and lignin content of alfalfa as it matures.

Harvest date	Leaf Cellulose	Leaf Lignin	Stem Cellulose	Stem Lignin
	(%)			
April 22	7.1	2.43	11.0	1.80
28	7.0	2.51	10.2	2.10
May 5	6.9	2.83	15.2	3.76
13	7.1	2.37	16.6	4.73
22	7.1	2.85	22.5	6.77
June 4	7.6	2.82	23.5	8.79

Source: Bittner 1988.

Reprinted with permission from Pioneer Forage Manual, A Nutritional Guide, 1990, Pioneer Hi-Bred International, Inc., Des Moines, Iowa.

Table 2. Cutting schedules for alfalfa in the northern U.S.

Stage of maturity	Cuts	DM	CP[1]	ADF[2]	NDF[3]	Milk[4]	Milk
		(tons/A)				(lb/T)	(lb/A)
Early mid-bud (4X + Fall)	5	3.8	27	26	36	2,152	8,178
Mid-bud (4X by 8/25)	4	4.2	26	28	37	2,091	8,782
First flower (3X + Fall)	4	4.6	19	31	41	1,851	8,515
First flower	3	4.5	18	32	42	1,718	7,731

Source: Alfalfa for Dairy Animals, Certified Alfalfa Seed Council.

[1]CP=crude protein

[2]ADF=acid detergent fiber

[3]NDF=neutral detergent fiber

[4]Milk yield estimated from a balanced ration for a 1350 pound cow producing 90 pounds of four percent fat-corrected milk per day.

Note that the leaves change very little as the alfalfa matures and that the cellulose and lignin content of the stems increases dramatically.

Harvesting alfalfa at the mid-to-late bud stage optimizes the production of qualiiy forage and, if well fertilized, is not detrimental to maintaining the stand. Animal productivity is the key measurement in determining the best harvest stage for alfalfa, as shown in Table 2.

Weather Losses

The uncertainty of good weather conditions often makes hay harvesting difficult. In Wisconsin it has been shown that normally 30 hours of sunshine (3 days) is needed to field dry unconditioned hay for safe storage. However, the U.S. Weather Bureau report shows that the probability of receiving three consecutive drying days in southern Wisconsin is less than 30 percent in June, less than 40 percent in July, and less than 50 percent in August. This means the chances are that more than half the hay will receive some rain damage. This situation is not unique to Wisconsin as many other areas receive similar amounts of precipitation.

Rain reduces the level of available carbohydrates, or energy, by increasing leaching and the amount of crude protein by leaf shattering. The extent of leaching loss is influenced by several factors, such as stage of maturity, moisture content at the time of rainfall, amount of rainfall, frequency of rains, and mowing and conditioning treatments. The influence of the stage of maturity and amount of rain on dry matter losses in alfalfa and red clover is shown in Table 3.

Table 3. The influence of stage of maturity and rain on dry matter losses in alfalfa and red clover as a percent of initial dry matter = % loss.

Loss	Stage of maturity	No rain	1.0 inch 1st 24 hr	1.65 inches	2.5 inches
Leaf loss	Bud	7.6	13.6	16.6	17.5
	Full bloom	6.3	9.1	16.7	19.8
Leaching and respiration	Bud	2.0	6.6	30.1	36.9
	Full bloom	2.7	4.7	23.5	31.8
Total	Bud	9.6	20.2	46.6	54.4
	Full bloom	9.0	13.7	40.2	51.5

Source: Rohweder 1983.

Note that leaching losses increase from a low of 2 percent with no rain to nearly 37 percent after 2.5 inches of rain and that alfalfa harvested in the bud stage undergoes more extensive leaching loss than hay harvested at full bloom. This would be expected because the amount of soluble nutrients decreases in alfalfa as the plant matures.

Leaf loss also is greater with increasing amounts of rainfall. One research study showed leaf loss increases from 7 percent with no rain to almost 18 percent after 2.5 inches. The combined losses from leaching, increased respiration, and leaf loss, increased from less than 10 percent for hay that received no rain, to more than 50 percent for hay that received 2.5 inches.

Little can be done about changing the weather, but the practice of baling hay in the 20 to 30 percent moisture range, which is higher than normally recommended, appears to be a feasible alternative in reducing field losses, providing storage losses can be minimized. Field drying time that is reduced by one third, or even cut in half, would greatly reduce the exposure of hay to the chance of rain damage.

Respiration Losses

The cells in plants continue to respire after cutting and until the plant moisture content falls below 40 percent. Under good drying conditions respiration accounts for 2 to 8 percent loss in dry matter, and under poor drying conditions this may increase to 16 percent. Respiration losses generally go unnoticed and cannot be avoided entirely, but there are several management practices that may minimize their effect.

Mowing hay as early in the day as possible allows for the maximum amount of solar drying. Newly cut hay normally dries to 25 to 30 percent moisture within the

Table 4. Effect of rain on dry matter loss in alfalfa.

	No rain	Rain (inches) 1.0	1.5	2.5
Dry matter % loss	9.6	10.2	46.6	54.4

Source: University of Wisconsin.

same day during good drying weather. If hay is cut late in the afternoon drying will be delayed and respiration extended.

The use of mechanical or chemical conditioners, which disrupt the plant's cuticle layer (waxy coat), will aid in moisture release and reduce drying times. Practices that reduce drying time will generally minimize respiration.

Mechanical Losses

The two most important factors contributing to mechanical field losses are moisture content of the alfalfa and type of baler. Losses from conventional, small rectangular balers range from 3 to 8 percent, while on the same hay large round-baler losses can be as high as 15 percent. Raking losses in alfalfa can range from 15 to 25 percent, and management practices that reduce the need for raking will conserve leaves and improve quality.

Nearly all mechanical losses are due to leaf shattering. Alfalfa leaves dry down three to five times faster than stems and as the plant moisture content decreases below 30 percent the leaves become extremely brittle. Leaf loss in alfalfa is critical since leaves make up about 50 percent of the plant weight but contain more than 70 percent of the protein, 90 percent of the carotene or vitamins, and more than 65 percent of the digestible energy. Research trials have determined that the leaf-to-stem ratio of alfalfa hay changes from 58:42 to 42:58 when the moisture content at baling decreases from 25 to 15 percent. Other research in Wisconsin confirmed that leaf loss increases with reduced moisture in the hay. Leaf loss increased by nearly 20 percent as the bale moisture decreased from 33 to 14 percent. This indicates that baling t a higher moisture content will reduce leaf loss.

Heat Damage

Hay at less than 20 percent moisture and stored under cover will still have a normal dry matter loss ranging up to 10 percent, which is largely due to handling. Baling hay above 20 percent moisture greatly increases the risk of spoilage by microorganisms. Storage losses are directly related to microbial growth and the heating that results. Excessive heating during storage causes a browning reaction, which reduces the nutritive value of the hay from soluble carbohydrate loss and lower protein digestibility. The extent of heating depends largely on the moisture content of the hay as well as the density and size of the bale, the air temperature and humidity, and the existing microbial population on the hay.

Aerobic fungi are the microbes primarily responsible for the breakdown of complex carbohydrates and generation of heat. Heat resistant fungi are known to be active when the temperature is between 113° and 150°F. Heating above 175°F results in the death of all microbes, which is often followed by heat-producing chemical reactions that increase temperatures further. Oxidation of reactive compounds may ultimately cause the temperature to rise to an ignition point of 448° to 527°F. If enough oxygen is present under these conditions spontaneous combustion will occur, resulting in fire.

Storage Losses

Weathering contributes significantly to storage losses when hay is stored outside. Most of the deterioration is on the outer layer of the bale and particularly where it rests on the soil. Large round bales stored outside have shown a dry matter loss of 17 percent compared to 6 percent of those kept under cover. The outer 3 inches of a round bale, 5 feet wide and 5 feet in diameter, make up almost 21 percent of the bale. It is common to have spoilage deeper than 3 inches in bales not stored under cover. These losses are dependent on the amount of rainfall, length of storage, and ability of the bale to shed water. Research information suggests that losses with large bales stored outside on the ground are about three times greater than with bales stored inside.

Table 5 shows a summary of the potential dry matter losses associated with harvesting and storing hay at recommended low moisture levels. The combination of poor harvesting management, bad weather, and exposed storage conditions may result in enormous losses.

Nutritional Losses

Leaf Loss

The primary nutritional losses that occur during the harvesting of hay are protein, due to leaf drop and shattering, and soluble carbohydrate and carotene losses due to leaching by rain. In most hay crops leaves contain approximately twice the available nutrients as do the stems. This means that leaf loss will reduce the nutritional value of hay approximately twice that of the dry matter loss.

Molding and Heat Damage

The main nutritional losses that occur during storage are due to mold growth and subsequent heating. Excessive heat will reduce protein and energy digestibility of the hay. Heat-damaged protein is measured by determining

Table 5. Dry matter losses of hay harvested and stored at recommended moisture levels.

		% DM Loss
Harvest losses		
Respiration		2 to 16
Mechanical		8 to 45
Weather (2.5 inches of rain)		40 to 50
Storage losses		
Inside		5 to 10
Outside on ground	1 year	8 to 29
	2 years	13 to 32

Source: University of Wisconsin

the nitrogen content of the fiber such as acid detergent fiber insoluble nitrogen (ADIN). Under normal conditions less than 7 percent of the total nitrogen should be present in the fiber. Excessive heat damage has occurred when this value reaches 15 percent or greater.

Research studies have shown that protein digestion is reduced by 11 digestion units for every 5 percent increase in ADIN, expressed as a percent of total N. Another study found that when the moisture content in large round bales of alfalfa increased from 15 to 27 percent, the ADIN as a percent of total N increased from 7 to 15 percent and protein digestibility was decreased from 71 to 53 percent. Dry matter digestibility also was reduced by five digestion percentage units, indicating that losses in digestible energy occurred.

WBRC

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, by the Cooperative Extension Systems at the University of Arizona, University of California, Colorado State University, University of Hawaii, University of Idaho, Montana State University, University of Nevada/Reno, New Mexico State University, Oregon State University, Utah State University, Washington State University and University of Wyoming, and the U.S. Department of Agriculture cooperating. The Cooperative Extension System provides equal opportunity in education and employment on the basis of race, color, religion, national origin, gender, age, disability, or status as a Vietnam-era veteran, as required by state and federal laws.

Fourth edition; December 2016 Reprint