PRODUCTION

Hay Preservation Systems no. 0.705

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Quick Facts...

The way forage is harvested and stored determines how well the quality is preserved.

Hay preservatives and drying agents are used to reduce dry matter losses and improve nutrient preservation.

Organic acid-based preservatives appear to be the most promising for preserving high-moisture hay.

Carbonate-based drying agents reduce field-curing time by at least one day.

Curing

Growing a good forage crop is only the first step in producing quality hay. The way forage is harvested and stored determines how well the quality of the standing crop is preserved.

Large quantities of water must be passively removed from cut forage during field-curing of hay. For each ton of 12 percent moisture hay produced, approximately 1.7 and 2.2 tons of water is removed from the fresh herbage of grasses and legumes, respectively.

The time for field curing depends on weather conditions and mechanical handling at cutting. Low relative humidity, high air temperature and good air movement around the cut forage all accelerate the rate of drying. Because leaves of cut herbages lose water more rapidly than stems, mechanical conditioning (crushing or crimping) also can reduce the time required for curing. However, this effect generally is greater for legumes than grasses.

Reducing the curing time is of critical importance in haymaking. Dry matter losses due to respiration, ranging from 4 to 15 percent, continue until the plant moisture content is reduced to approximately 35 percent. Dry matter losses associated with leaf shattering during the curing process have been estimated to range from approximately 2 to 5 percent for grasses and 3 to 35 percent for legumes.

Prolonged periods of curing also increase the potential for losses due to rainfall. Leaching, leaf shattering and excessive biological decomposition are common consequences of rainfall during field curing. Rain also can indirectly contribute to losses during curing. Rain-soaked hay frequently requires additional raking, resulting in further leaf shattering.

All the various kinds of dry matter losses that occur during haymaking contribute to serious losses in nutritive value. This is because the most nutritious components of the plant are most susceptible to loss. Therefore, management practices that reduce these losses will result in hay quality improvement.

Chemical treatments can reduce dry matter losses during field curing. The two types of chemicals used are preservatives and drying agents. Hay preservatives are designed to reduce microbial activity and spoilage in high moisture hays. Drying agents accelerate curing rates.

Preservatives

The use of hay preservatives permits greater flexibility in haymaking operations. Hay can be baled at moisture levels of up to 35 percent, thereby reducing the time required for curing. This reduces the severe leaf shattering losses associated with handling dry forage. Because moisture content is difficult to determine accurately in curing windrows, preservatives can ensure proper preservation when hay is baled at moisture levels of between 20 to 35 percent.

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Anhydrous ammonia has fungicidal properties and has been used successfully in the preservation of high-moisture hays. Use of 1 percent anhydrous ammonia has been shown to reduce storage dry matter losses and prevent heating and mold development in hays containing up to 32 precent moisture. Increased crude protein content is an additional benefit of ammonia preservation. However, this method of chemical preservation has not received wide acceptance because of problems in supplying the ammonia to large amounts of hay.

Recent data suggest that dry urea could be used as an alternative to anhydrous ammonia in preserving high-moisture hays and increasing the crude protein content of poor-quality hays. However, application equipment has not yet been developed for this material. Therefore, use of this material is presently not recommended on a commercial basis.

Organic acids have been the most widely accepted hay preservatives. Materials such as propionic acid and ammonium isobutyrate act as fungicides to reduce mold development, heating and deterioration in hays baled at high moisture content. The most common commercial formulations consist of propionic acid and mixtures containing propionic acid and ammonium isobutyrate, acetic acid or formaldehyde. Flavoring ingredients also have been added to some of the commercial products.

Organic acid preservatives must be applied at an appropriate rate as the hay is fed into the baler. Applicators consisting of a corrosion-resistant tank, a 12-volt pump powered by the tractor's electrical system, spray nozzles and plastic tubing, which are commercially available, can be attached directly to most conventional balers.

Recommended application rates are based on the moisture content of the hay (see Table 1). These rates are appropriate for propionic acid alone, mixtures of propionic acid and acetic acid (80:20 percent) or formaldehyde (70:30 percent), and ammonium isobutyrate. Although hays containing moisture levels higher than 35 percent moisture can be effectively preserved with these materials, the practice is not recommended because of preservative costs and difficulty of handling wet bales.

Table 1: Recommended application rates for organic acid hay preservatives.

Hay moisture content % of fresh weight	% of D.W.	Application rate lb chemical/ ton of D.W.
20-25	0.5	10
25-30	1.0	20
30-35	1.5	30

Source: Clark, P., G.T. Lane and J.K. Evans.

Certain precautions should be observed in using organic acid-based preservatives. Use goggles and protective clothing when mixing or transferring the material. Have water available at all times to flush affected areas if an accident occurs. Thoroughly wash and flush equipment surfaces and applicator systems immediately after use to prevent excessive corrosion.

Store treated hay under protective cover because the preservatives on outer surfaces can be leached or diluted by rainfall. Keep preserved hay separate from conventional field-cured hay. The drier hay can absorb moisture, making mold development possible.

The cost effectiveness of organic acid preservatives is difficult to determine. Obviously, their cost is minimal compared to losing an entire hay crop because of inclement weather. Detailed assessments of less severe alternatives indicate that the cost of the preservatives is justified when the value of the treated hay is compared to that of rain-damaged or wet (greater than 25 percent moisture) hay. However, preservatives are not cost-effective when hay can be produced with minimal leaf loss under "ideal" curing conditions.

Other hay preservatives have been evaluated on a limited basis, but have not yet received widespread scrutiny. Several microbial additives have been shown to be effective in preventing heating and mold development in wet hays. However, their effectiveness appears to be limited to hay containing 20 to 25 percent moisture. Therefore, use of these materials is questionable considering the proven value of organic acids.

Drying Agents

Treatments designed to accelerate drying rates of forages reduce the potential for rain damage during field-curing. Mechanical conditioning has long been used to accomplish this purpose. Recently, chemical drying agents have been proposed as an additional means of reducing the duration of field-curing.

Preliminary studies conducted in Australia suggested that potassium carbonate solutions were effective in increasing drying rates of alfalfa. Subsequent research has confirmed these results and demonstrated increased effectiveness of using combinations of potassium carbonate and emulsions of fatty acid esters. Work at Colorado State by Iwan et al. (1993) showed that drying agents were effective in decreasing duration of curing hay by one-half to one-third under favorable curing conditions. They are least effective under cool, humid conditions. Available evidence suggests that drying agents are of limited effectiveness with grass hay.

Several carbonate-based commercial formulations are available and have generally produced similar results when used on alfalfa. The carbonate-based drying agents function by modifying the waxy cutin layer of the plants so it is more permeable to water. The formulations are most effective when applied to stems at cutting. Commercially available applicator kits include a holding tank and pump, hoses, nozzles and deflector bar mounted in front of the header about 8 to 10 inches above the cutting level. This device pushes plant tops over so the spray can be directed primarily at the stems.

Current projections using solutions containing potassium carbonate alone indicate that this treatment is cost effective for alfalfa except under cool, humid conditions. Because sodium carbonate is much cheaper, solutions of one-half potassium carbonate and one-half sodium carbonate may further improve the cost effectiveness of this treatment.

Summary

Hay preservatives and drying agents allow for increased flexibility in haymaking systems. Under certain conditions, they can greatly increase the efficiency of nutrient preservation. However, carefully assess the magnitude of problems in current hay-handling operations before making a decision.

Certain commercial formulators fail to indicate the composition of their products. This causes considerable confusion for hay producers because the nature of the product determines how it should be used and the anticipated benefits. If a preservative is justified, the organic acid-based formulations have proven most successful. Of the drying agents available, carbonate-based products, which also contain fatty acid esters, have proven to be most beneficial. Before making a final decision, know the general composition of the products to be evaluated.

For More Information

Clark, P., G.T. Lane and J.K Evans. Hay preservatives*. University of Kentucky Cooperative Extension Bulletin (ID 46).*

Proceeding of the Second Intermountain Meadow Symposium*. 1984. Colorado State University Experiment Station Special Series #34.*

Iwan, J.M., J.F. Shanahan, and D.H. Smith. 1993. "Impact of environmental and harvest management variables on alfalfa forage drying and quality." Agron. J. *85:216-220.*

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