Should a Hay Preservative Be Used?

*by Dwain Meyer, North Dakota State University*Questions concerning the use of hay preservatives often arise during the first harvest when trying to make hay between rainstorms is common in late May and early June. Nothing is more frustrating than having 40+ acres of hay almost dry with a short-term forecast of significant rain, which is when high-moisture hay preservatives have real potential.

There are basically three types of hay preservatives marketed: organic acids, bacterial inoculants, and anhydrous ammonia. Anhydrous ammonia has been shown to be an effective preservative of high-moisture hay, but it should be used only with low-quality grass hays. When kept in the bale with covering, anhydrous ammonia will help prevent molding and increase the crude protein and digestibility of the hay, but it should never be used on high-quality hay like alfalfa. Bacterial inoculants are used at less than 25% moisture and attempt to prevent molding and heating of bales by increasing the level of micro-organisms naturally found on the hay. Results have been somewhat inconsistent, especially for the anaerobic inoculants commonly marketed. There is an advantage of the bacterial inoculants in that some producers feel that they help maintain hay's green color.

Organic acids have been the most consistent high-moisture hay preservative for high-quality alfalfa hay. Propionic acid (propionate), the most common organic acid used and most effective when used at the correct rates, acts as a fungicide inhibiting growth of aerobic microorganisms that are responsible for the heating and molding of high-moisture hay. Some commercial products use a small amount of acetic acid or add additional compounds like inorganic acids, formaldehyde, or flavoring ingredients.

The primary advantages of using propionic acid as a high-moisture preservative include reducing mold, reducing drying time in the field, reducing potential rain damage, reducing leaf loss from harvesting at a greater moisture content, and providing more baling flexibility. Baling can be initiated earlier in the day and can continue later into the evening allowing greater acreage to be harvested.

Research at several universities has evaluated the effectiveness of organic acids on reducing heating, mold formation, dry matter loss, and digestibility. For example, Knapp et al. at Purdue University evaluated storage losses and composition of alfalfa hay baled at 32% moisture and treated with propionic acid. Untreated hay reached a maximum storage temperature of 124ºF, lost 15.1% of its dry weight, and had 3.4% total carbohydrates and 60.5% digestibility. Hay treated with 1% propionic acid had a maximum temperature of only 84ºF (similar to the air temperature), lost 7.6% of its dry weight, and had 6.5% total carbohydrates and 65.0% digestibility. High-moisture hay treated with 0.2 and 0.5% propionic acid were only partially effective, indicating the importance of having the correct rate applied.

Jorgensen et al. at the University of Wisconsin evaluated 1% propionic acid-treated hay compared with untreated hay as feed for lactating dairy cows. Dry matter intake was higher for the dry hay than treated hay probably due to the lower moisture content at feeding (85.9% vs. 89.9%). Milk production, however, was slightly higher from the acid-treated hay and no significant difference in milk fat content was noted.

The primary disadvantage of using propionic acid as a high-moisture hay preservative has been the loss of hay's green color. As a result, acid-treated hay frequently will not demand the same price as untreated hay at auction. Another disadvantage in the past was that the organic acid would corrode the balers, decreasing the effective life of the equipment, but use of buffered propionic acid (ammonium propionate) has reduced this problem. Still it's a good idea to wash the baler after use.

Effective use of propionic acid requires applying an adequate rate depending on the moisture content of the hay and the size of bale. Dry hay can be stored without molding if the moisture content is 15-18% for small square bales, 14-16% for soft-core large round bales, and 12-15% for large square and hard-core large round bales. Above these moisture levels, propionic acid should be applied to ensure adequate preservation.

Recommended rates for applying preservative to hay are 0.5% acid for 20-25% moisture hay, 1.0% acid for 25-30% moisture hay, and 1.5% acid for 30-35% moisture hay. For the large square and hard-core bales, applying a slightly higher rate might be appropriate. Applying a preservative to hay with greater than 35% moisture is not recommended because of the preservative cost and difficulty in handling wet bales.

Preservatives generally are applied with nozzles located on the baler shoot. Adequate nozzles are needed to get a uniform application to all of the hay. Mixing the preservative with water (1:1) permits more thorough coverage of the hay, but the rate of acid application must be maintained. Application equipment (tank, pumps, nozzles, etc.) costs about $1,000 for a minimum setup with the cost increasing for more elaborate setups. The cost can be recovered quickly, however, if a high-value hay crop can be put up rather than rain-damaged.

Determining the moisture content of the hay to be baled can be a challenge since it is constantly changing as the hay dries or takes on moisture. Hand-held probe-type moisture tests can be purchased, but frequent sampling is necessary to evaluate the changing moisture content. Some systems allow on-the-go evaluation of moisture content so the rate applied can be adjusted automatically or manually as the moisture content changes. Even then, wet bunches of hay can cause problems and result in molding and heating. In addition, there is always a learning curve for each producer on what is effective for their individual situation.

Propionic acid-treated hay should ideally be stored inside or under cover. Never store treated hay with untreated hay since moisture can move from the higher-moisture bales to the dry hay during curing and thereby initiate deterioration of the dry hay. When piling acid-treated hay, stack the bales loosely so they can "sweat" and cure. Tightly packed stacks may prevent curing and lead to deterioration of the hay.

Does a hay preservative pay? Holt and Lectenberg at Purdue University presented four scenarios attempting to answer this question (Table 1). The four scenarios were:

- hay baled at less than 25% moisture with no rain,
- hay rained on before it dried,
- hay baled at 32% moisture to avoid the rain,
- hay baled at 32% moisture but propionic acid (PA) used.

Harvest losses were decreased at higher moisture contents, but storage losses were doubled or more. Total digestible nutrients (TDN) were highest in the dry hay followed by the propionic acid-treated hay. Based on the value per acre of each scenario, the propionic acid-treated hay was superior to the rain-damaged hay, but not the field-dried hay without rain. Using propionic acid treatment costing $10/ton (low for today's cost) and $2.50 for corn (also low for today), the preservative treatment paid for itself compared to rain-damaged or high-moisture hay without a preservative. Compare the economics based on the going price of propionic acid, TDN value, and cost of corn.

In summary, use of organic acids as high-moisture hay preservatives has its best potential in the prevention of rain damaged hay and not as a normal harvesting procedure. Their use to increase the harvesting window is also valuable for covering large acerage.

Table 1. Economic comparison of four alternative haying situations

Component Evaluated	Baled Dry		Baled Wet	
	No Rain	1" Rain	Untreated	1% PA
Respiration Loss in Field (%)	5	10	5	5
Harvest Loss	10	15	5	5
Harvested Yield (lb/ac)	1700	1500	1800	1800
Storage Loss	5	5	18	10
Final Yield (lb/ac)	1600	1500	1440	1600
TDN (%)	66	61	59	64
TDN Yield (lb/ac)	1056	854	850	1024
% TDN Lost After Cut	25	39	39	27
Value/ac ($)	58.08	46.97	46.75	56.32

TDN valued at $0.55/lb (shelled corn at $2.50/bu)