Preserving the Value of Dry Stored Hay

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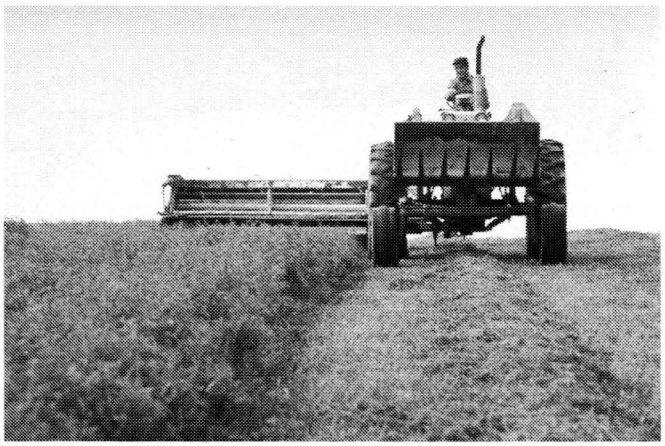
Production of baled hay uses a large amount of resources (land, labor, seed, fuel, fertilizer, equipment). The way you store that hay after baling can have a big effect on losses in hay quantity and quality, so it is worth investing additional resources (money, labor, equipment) in hay storage to preserve the value of the hay and to ensure a good return on your initial investment.

This publication discusses principles of hay storage and the results of hay storage research conducted at several different locations. The information is designed to help you determine the best practices for preserving the value of your baled hay.



Losses are Affected by Moisture, Temperature, and Time

Most of the dry matter and quality losses that occur during storage are due to molds and bacteria that consume nutrients contained in the hay. These microorganisms generate heat that causes chemical reactions and additional nutrient loss. In extreme cases, the heat generated by molds and bacteria can result in fires, destroying the hay and the surrounding structures. Molds and bacteria grow and reproduce faster if the hay is warm and moist, and, of course, the more time they have to work, the more damage they can do.

In general, microorganism-caused losses are lower at lower temperature and moisture, and are lower for shorter storage periods. Since most hay is stored outdoors or in structures that are not heated or cooled, storage temperature follows outdoor temperature and is beyond your control. Hay harvested late in the season and consumed during the winter months is stored for a relatively short time at relatively low temperatures and should have minimal losses. Hay harvested early in the season and stored into winter will be subject to some warm temperatures before winter arrives and is likely to have greater losses. The greatest losses can be expected for hay that is stored through winter into the following spring and summer. Oklahoma State University publication #1716, *Round Bale Storage*, indicates you can expect losses after 12 to 18 months of storage to be twice as great as losses after nine months of storage.

Since we have little control over hay storage temperature, and since livestock feeders and hay processors usually need to store hay for year-round use, controlling moisture is probably your best strategy for limiting storage losses. You need to bale at a moisture that is low enough to prevent mold activity (less than 20%, wet basis) and then use storage methods that protect the hay from being rewet by precipitation or soil moisture.

Bale at the Proper Moisture

Timing of baling is critical for maximizing the value of hay. Optimum moisture for baling is in the range of 15% to 20% moisture (wet basis).

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Table 1. Dry matter and quality loss (% of initial crop yield) at different hay storage moisture values (US Dairy Forage Research Center, Madison, WI).

Storage Moisture	Dry Matter Loss	Digestible Dry Matter Loss	Crude Protein Loss
11 to 20%	4.5%	6.2%	6.0%
20 to 25%	7.9	11.8	8.8
25 to 34%	10.9	13.5	7.5

Baling at lower than 15% moisture will result in greater harvesting losses, especially for alfalfa, because leaf loss increases as moisture decreases.

Storing hay at greater than 20% moisture will result in some molding and heating, greater dry matter and nutrient loss during storage, and some discoloration. A study of small rectangular bales stored in a barn at the US Dairy Forage Research Center, Madison, Wisconsin, showed that loss of dry matter increased with storage moisture (Table 1). Loss of quality was also greater in the wetter bales.

Large hay packages, especially large rectangular bales, do not lose much moisture after baling. Therefore it is important to bale at the proper moisture, instead of baling at a higher moisture and counting on some natural drying in storage. If you must bale at higher moisture, here are some options:

- Bale at a slightly higher moisture (20% to 30%) and apply a preservative that inhibits mold growth in storage.
- Bale at a higher moisture (20% to 35%) and dry the bales artificially.
- Bale at a much higher moisture (50% to 65%) and ensile the bales by storing them sealed in plastic.

This publication discusses only storage of dry hay. For more information on these high-moisture options contact an extension office, experiment station, forage council, or forage-related agribusiness.

Protecting Bales from Soil Moisture and Precipitation

If you store dry hay outside, it is worth finding ways to prevent direct contact between the ground and the bottom layer of bales, because the bales resting on the ground will absorb enough moisture to grow mold. Research studies and farmer experience show that placing hay bales on layers of coarse gravel, old tires, or wood pallets is an effective way to prevent rewetting the hay by soil moisture. Studies in other states indicate that storage losses are about 5 percentage points less for hay stored on gravel, tires, or pallets compared to hay stored directly on the ground.

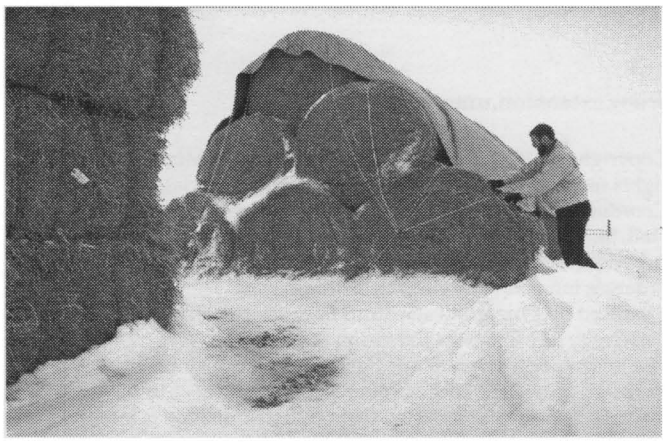
A hay storage study was conducted at the University of Minnesota West Central Experiment Station at Morris, Minnesota to determine losses that can be expected for different storage methods under Minnesota conditions. The study was supported by several agencies [1]. Hay for the study was third cutting alfalfa baled at about 18% moisture in September 1996. Half of the hay was baled as 5-ft. diameter by 6-ft. long large round bales and the other half was baled as 3-ft. by 4-ft. by 8-ft. large rectangular bales. Bales were stored in four ways:

1. Uncovered, directly on the ground (on pasture, or sod).
2. Uncovered, on gravel.

3. Covered with a tarp, on gravel.
4. In a shed that had an earthen floor and an enclosed north side.

Round bales were stored on their sides, pyramid style, in piles of twelve bales. The bottom layer was three bales wide by two bales long, the middle layer was two by two, and the top layer was one bale wide by two bales long. The rectangular bales were stored in piles of eleven bales, all oriented the same direction, and resting on their four-foot wide sides. Nine of the rectangular bales were stacked three wide and three high, and the two bales on top were placed over the cracks between bales in the lower layers. Bales were stored until mid-June 1997 (about eight months) and then reweighed, resampled, and sold.

In the Morris study, we found that for both round bales and rectangular bales, the bottom bales stored uncovered on sod were rewet. Their moisture content went from 18% to about 32%, high enough to cause significant spoilage by mid-June. Spoilage would have been even worse if bales had been left in place through the summer. The percentage of the total volume of bottom bales that appeared to be spoiled was about the same (22% to 23%) for both round and rectangular bales. This compared to a volume of 1% to 8% of bottom bales spoiled in the treatments stored on gravel or in the barn.



It is important to make sure that stones don't adhere to the bottom layer of bales, if hay stored on gravel will be processed in a hammer mill or other processor that could be damaged by foreign objects. Problems with stones can be reduced by using larger-sized gravel or crushed rock for the base, or by using pallets or tires instead of gravel.

Water from rain and melted snow can also rewet hay to moistures that are high enough to support mold growth. Studies at other universities have shown that covering hay can result in up to 10 percentage units less dry matter loss. In our study at Morris, covering bales reduced dry matter loss by about 6 percentage units; average dry matter loss for bales stored covered on gravel was 4.8%, compared to 10.9% for bales stored uncovered on gravel.

When bales were stored uncovered on sod at Morris, the upper layers of round bales did not show any increase in moisture, and the upper layers of rectangular bales were rewet slightly to an average of about 22% moisture. Even though the average moisture absorption in the upper layers was relatively small, the "water-shed" locations (points where water ran off an upper bale onto a lower one) showed greater moisture increase and very obvious mold development, particularly in the large rectangular bales.

Dry matter losses caused by the combination of soil moisture and precipitation can be fairly large. For example, in Oklahoma, researchers found 13.1% dry matter loss for uncovered storage on the ground versus 2% loss for covered storage on pallets. Wisconsin researchers found 10.9% loss for uncovered storage on the ground versus 4.6% in a barn. In the Morris study, average dry matter losses in the uncovered piles on sod were 11.2% versus 2.3% in the barn. It appears that for eight to nine months of storage, you can expect a 6 to 11 percentage unit advantage by keeping bales off wet ground and under cover.

Besides losing dry matter, uncovered hay also loses quality as determined by nutritional analysis and by appearance. The loss in dry matter reduces weight available for sale and the loss in quality can have a large impact on animal performance and on hay value. For example, in our study at Morris, the internal parts of bales stored in the shed had a relative feed value (RFV) of 133 and the bottom six inches of the bales at the bottom of the pile had an RFV of 106. The internal parts of bales stored uncovered, outside on sod had an RFV of 114 and the external parts of the bales had RFVs ranging from 55 to 107. In just eight months, the differences in hay weight, quality, and price resulted in hay stored in the shed being worth about $3350 more per 100 tons harvested than hay stored outside on sod. These numbers indicate that it is worth considering an investment in tarps and gravel, or even hay storage sheds.

Should I Use Round Bales or Rectangular Bales?

These studies do not show a clear advantage for one bale type over the other. Advantages of large round bales include greater availability of balers and handling equipment (at this time), lower price for balers, and greater ability to shed water if bales are stored uncovered. Disadvantages include less efficient use of space in hauling and storing bales, and a tendency for bales to lose their shape during storage. Advantages of large rectangular bales include more efficient use of space in transport and storage, and better shape retention during storage. Disadvantages include greater cost and lower availability (at this time) of balers, and greater moisture absorption by bales stored without cover.

In spite of the tendency for uncovered large rectangular bales to absorb more moisture than large round bales, our study at Morris indicated no significant difference in average dry matter loss for the two bale types over an eight-month storage period.

Summary

To get the greatest value from dry baled hay:

- Bale hay at 15% to 20% moisture (wet basis).
- If hay is stored uncovered, use bales harvested early in the season first, and try to sell or feed all bales before the following spring.
- If bales are stored outside, place them on gravel, old tires, or pallets rather than directly on the ground to protect them from losses caused by soil moisture.
- Consider investing in tarps or in storage buildings to protect bales from losses caused by precipitation.

[1] *The Minnesota Valley Alfalfa Producers and the University of Minnesota conducted a comprehensive cost-shared research and development program in support of the Minnesota Agri-Power project. The Minnesota Agri-Power project was supported by Minnesota Valley Alfalfa Producers, Minnesota farmers, US Departments of Energy and Agriculture, University of Minnesota, Oak Ridge National Laboratory, National Renewable Energy Laboratory, Minnesota Department of Agriculture, Legislative Commission on Minnesota Resources, Agricultural Utilization Research Institute, Minnesota Forage and Grassland Council and others.*

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Produced by Communication and Educational Technology Services, University of Minnesota Extension Service.

FO-7404-B
1999