Large Round Bale Hay Storage

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Large round balers are one of the most economical hay production systems because of low labor requirements. One person can potentially handle the entire haying operation with the large round bale hay production system. A Kansas Cooperative Extension survey of south central Kansas farmers found that 72 percent used large round bales as their primary hay package while another 18 percent used round bales and small square bales.

Large round bales do have drawbacks. Because of their shape, they are not well suited for barn storage. A hay barn simply will not hold as much hay in round bales as in square. The survey revealed that almost 60 percent of respondents store all hay in large round bales outside unprotected and 25 percent store a portion of their hay outside unprotected. Though large round bales shed some rain, significant water penetration can occur if storage conditions are less than ideal.

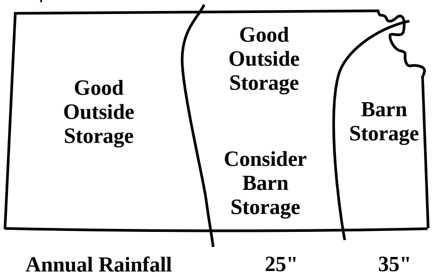
Storage losses occur even under the best (barn) storage conditions with any type of hay. However, losses are greatest for large round bales stored unprotected outside. Some storage loss is natural, either from dry matter loss or reductions in palatability and digestibility.

Dry matter loss is simply a reduction in weight of the bale due to decomposition and handling as well as losses to rodents. It does not include any reduction in moisture content due to additional drying.

Reduced palatability and digestibility are usually caused by weather exposure, but can be caused by high moisture content at baling. Weathered hay may not be as appealing to livestock, so feeding losses increase with the amount of hay refused. Furthermore, consumption of weathered hay doesn't mean livestock are getting feed value from it. If digestibility is lower, rate of gain also may be lower. Feed value loss in weathered hay is usually a greater source of loss than that from total dry matter loss. When both are calculated, total feed loss during storage can easily surpass 50 percent.

Weathering losses are generally limited to the outer 4 to 8 inches for hay stored outside. However, in a 5-foot-diameter bale, approximately one-third of the bale's volume is in the outer 4 inches, and more than half of the volume is in the outer 8 inches. For a 6-foot-diameter bale, one-third of the hay is in the outer 6 inches and one-half is in the outer 12 inches. Though weathering losses reaching a depth of 12 inches are uncommon, they are possible. However, weathering losses as deep as 4 inches in bales stored outside unprotected are commonly found. This means 20 to 50

Figure 1. Outside storage depends on annual rainfall.



percent of a bale can be affected by weather under poor storage conditions.

Hay type also affects the severity of losses due to weather exposure. Stemmy hays such as alfalfa, sudan and mature small grains generally don't form a good thatch and deteriorate faster than grass hay. This is important, since the thatched layer is responsible for shedding rainfall. Bales receiving low amounts of rainfall naturally weather less than bales receiving high amounts. Producers should consider annual precipitation amounts when determining a suitable storage method.

Storage method and length of storage have a strong impact on weathering losses. Barn-stored hay suffers significantly less weathering loss than unprotected hay stored outside. Dry matter losses for barn-stored hay generally range from 2 to 8 percent. Covering outside stored hay can also reduce weathering. Hay stored outside will continue to deteriorate, but most spoilage occurs early in the storage period. Hay stored in barns for long periods also will continue to deteriorate, but at a much slower rate.

A well-formed, dense bale will minimize storage losses through improved handling ability and weather resistance. Moisture content at baling also plays an important role. If hay is too wet, quality could decrease due to heating. However, baling too dry could cause baler losses to increase dramatically. While round bales can be baled at moisture contents ranging from 15 to 20 percent (depending on conditions), the ideal moisture content is approximately 18 percent.

Storage losses for large round bales stored outside in Kansas with no protection can easily exceed 25 percent, but losses can be minimized through good management. Figure 1 shows storage recommendations for large round bales. If outside storage is the chosen method, attention to storage site and stacking method can minimize losses in feed value.

Storage Site

Deterioration at the bottom of bales stored on damp soil can be substantial. A well-drained site will help minimize moisture absorption and thus deterioration. If possible, elevate bales by stacking on old tires, shipping pallets or railroad ties. Adding a base layer of 3 to 4 inches of crushed rock to the storage site will help minimize losses at the bottom of bales. Storing bales on the ridge of a hill instead of near the bottom will also help reduce bottom deterioration. Weeds or tall grass at the storage site will increase deterioration of the bottom of the bale.

Round bales stored outside need air circulation and sunlight to help dry the outer layer after a rain. Storing the bales under trees blocks wind circulation and sunlight, which enhances bale drying. Any rain protection trees might offer is more than offset by damage from shading.

Stacking Method

There are a variety of methods for stacking large round bales. This publication will discuss the methods in three categories.

Individual Bales: Bales are sometimes stored individually for ease of handling with equipment that grabs the bale from both ends. If bales are stored individually, a space of at least 18 inches between bales is needed for air circulation. Storing bales with the rounded sides touching is not recommended because this creates a trap for rain and snow. The bales may be easier to handle with some truck-mounted equipment, but losses will be higher.

End to End: Tightly stacking bales end to end makes better use of the storage area and protects the ends from weathering. If bales are not stacked tightly against each other, rain could penetrate the ends and increase damage.

North-south bale rows allow an equal amount of sunlight on both sides of the bale row, which results in more uniform drying. Leaving at least 3 feet between rows allows air circulation and sunlight to reach bales and reduces the chance of snow accumulation on the bales. If snow accumulation is a possibility, stack rows farther apart to allow sunlight to melt the snow.

The table below shows dry matter losses associated with weathering for different stacking methods for alfalfa and brome hay storage in Kansas. Although this study found no significant differences between north-south versus east-west rows, the former is preferred because of uniform drying. Quality losses on the north side of the east-west row exceeded those on the south side of the row. The bales used in the study were fairly dense and well formed, which confirms that minimizing hay storage losses begins at baling. This study also emphasizes that site selection is more important than row orientation.

Stacks: In the past, stacking bales in pyramids has been a popular way to minimize storage space requirements. However, if bales are not covered, weathering losses can be devastating. A South Dakota study reported dry

Table 1. Average dry matter losses for storage sites and stacking methods for alfalfa and brome hay.

Stacking Method	Rooks County (alfalfa)	Wabaunsee County (brome)
E-W Rows	9.8%	11.0%
N-S Rows	10.1%	14.1%
Stacked	7.9%	11.6%

matter losses in prairie hay stacked in pyramids at more than 10 percent for one year of storage. Dry matter losses were 4 percent for bales stacked individually and less than 1 percent for bales stacked end to end.

Another method becoming popular in Kansas is to turn one bale on end and then stack another on top of it, as shown in the photo on page 1. This has been referred to as the "Canadian" method, though the source of the name is unknown. A Kansas State University study indicates that this could be a feasible stacking method (see table). Dry matter and quality losses were similar to those of bales stored end to end in north-south and east-west rows. Hay spoilage at the bottom of the bale was higher for this method, but less hay is exposed to the ground. High-density, well-formed bales tied with plastic twine or net are necessary for bottom bales in these stacks. Sisal twine is not recommended since it can rot and let bales fall apart.

Bale Wrapping

Net or mesh wrapping has become a popular alternative to twine for tying large round bales because of its perceived advantage of improved protection from weather. Kansas State University studies found the storage characteristics of net-wrapped bales were similar to twine-wrapped bales. Though rainfall during the trials was below normal, studies at other universities have reported no advantages for net wrapping during storage. Some research indicates that net could be a superior wrapping material on low-density bales, but this type of bale is not preferred.

Solid plastic is also available for wrapping large round bales. It can be applied by the baler or as a separate operation. While the plastic will shed rain, it can also trap moisture in the bale. Bales wrapped with plastic should be stored individually if the moisture content at baling exceeds 18 percent. This allows moisture to escape from the ends of bales. Researchers in Canada and Louisiana reported finding moisture accumulating in the bottom of plastic-wrapped bales stored end-to-end.

Covering Bales

Covering bales offers some promise for reducing weather-related losses for bales stored outside. However, it does have drawbacks. First, if a low quality cover is used, it may be subject to wind damage. Any tears in plastic tarps must be repaired immediately to hold the cover in place. Covers also need to be anchored to the ground or stack to keep them in place. Reinforced plastic sheeting is more expensive, but will require less maintenance and last longer.

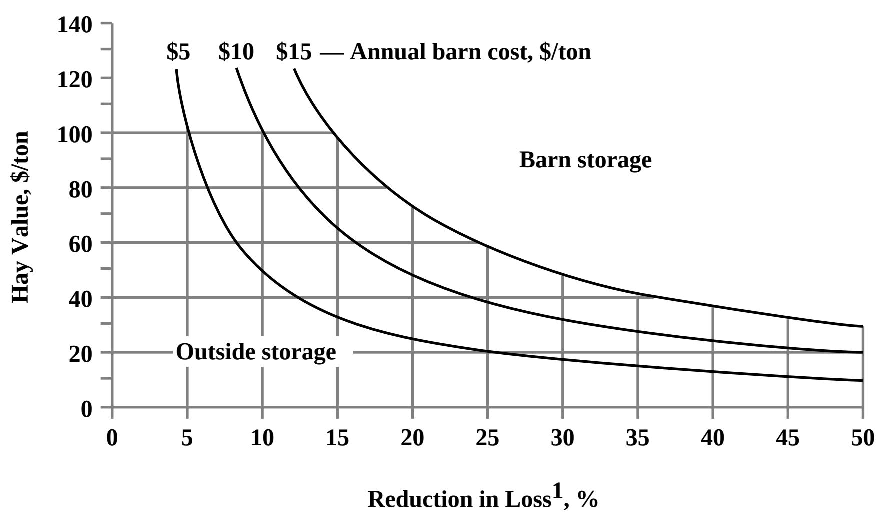
Covering bales with plastic also will trap moisture. If high-moisture hay (over 18 percent) is sealed under plastic, quality losses can result from excessive heating and mold development. Moisture condensation at the top of the stack could also cause spoilage in high moisture hay. Costs for covering bales can be minimized by stacking bales in pyramids. This allows more hay to be covered by the tarp.

Barn Storage

Barn storage is the best method for preserving hay quality, but it can be expensive if a structure needs to be built. A typical pole barn with 16 to 18 feet of clearance requires 12 to 15 square feet of floor space per ton of hay stored depending on bale size, density, and stacking method. Initial construction cost will depend on whether the barn is open-sided or fully enclosed. Based on an initial construction cost of $4.20 per square foot for an open-sided barn and $5.50 per square foot for a fully enclosed barn, the building construction cost is between $54.60 and $71.50 per ton of hay storage.

The annual costs of storage will depend on years for depreciation, interest rate, taxes, insurance, and maintenance. Table 1 lists the annual cost per ton of hay for A) barns without sides and B) fully enclosed barns. To determine if barn storage is economical, the annual cost of storage per ton needs to be compared to the benefit (income) of barn storage. The benefit or income due to barn storage will be the reduction of dry matter loss and feed value loss compared to outside storage. This benefit is calculated by multiplying the value of hay times the reduction in loss. For example, if hay is worth $50 per ton and barn storage reduces hay losses by 20 percent, the benefit of storage would be $10 per ton ($50 × .20 = $10).

Figure 2. Break-even between outside and barn storage.



[1]Reduction in dry matter and/or feed value loss due to barn storage

Figure 2 shows the break-even points of barn storage and outside storage at various hay values and reduction in loss amounts at different annual barn costs. The reduction in storage losses and annual barn cost will depend on the type of barn constructed (open sided vs. fully enclosed) as well as the geographical location.

In western Kansas where the reduction in hay loss would be fairly low, barn storage is not economical unless hay is sold at premium prices. However, in eastern Kansas building a barn for large round bale storage appears to be economical even for relatively low-value hay. For example, if barn storage reduces losses by 25 percent, barn storage would be economical for hay valued at $40 per ton or higher based on an annual barn cost of $10 per ton.

The average cost of constructing a hay barn will be fairly constant across the state. However, the benefit of barn storage, in terms of reducing dry matter and feed value loss, will vary considerably across the state.

The economics of barn storage will also vary considerably from area to area. Because of this, it is important for producers to carefully analyze the economics of barn storage for their operation. In addition to estimating the economics of barn storage, producers need to consider some of the intangible benefits of barn storage as well. For example, hay stored in a barn is often easier to feed during the winter because there is no ice on the bales. Also, hay barns are a very flexible-use structure allowing them to be utilized for multiple purposes (hay storage, machinery storage, etc.).

This method of comparing costs and benefits of barn storage could be used to evaluate the economics of other types of hay storage improvements as well (rock, covering bales, wrapping, etc.).

Table 2. Annual cost per ton of hay (based on 13 ft^2/ton of storage space).

Storage space required (sq ft/ton)	13.0
Construction costs/sq ft — no sides	$4.20
Construction costs/sq ft — fully enclosed	$5.50
A. Total investment/ton — no sides	$54.60
B. Total investment/ton — fully enclosed	$71.50
Depreciation (20 years)	5.00%
Interest rate (charged on 1/2 of investment)	12.00%
Taxes and insurance	1.75%
Maintenance	1.25%
Total annual cost	14.00%
A. Annual cost/ton of hay — no sides	$7.64
B. Annual cost/ton of hay — fully enclosed	$10.01

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