OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
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Hay Storage Considerations

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There are a variety of ways in hay can be stored after baling. and many factors to consider when making decisions on how to maximize the return on investment of hay storage. Factors including available labor, value of hay, loss of quality, loss of dry matter, and cost of the storage investment should all be considered.

The Value of Hay

Understanding the value of hay produced is key to being able to calculate the value of any hay storage option. There are a couple of ways to determine the value of a hay crop. Locally one can follow hay auctions prices to develop an estimation of hay value, however a forage analysis is the best tool to use to determine the value of your forage. Contact your local Extension office for more information regarding hay sampling and interpreting forage analysis results.

Estimating Hay Storage Losses

Dry matter losses during hay storage can be attributed to multiple factors, including density of the bales, climate (temperature and rainfall), and storage method. Research conducted over the last 40 years in various regions of the country investigating hay storage losses are shown in Table 1.

Bale Size Effects on Loss

When it comes to estimating dry matter and storage losses, the size of the bale matters. In the case of a round bale the smaller the bale, the greatest proportion of forage is in the outer 4 to 6 inches where most of the dry matter and nutrient loss will take place.

Table 1. Estimated percent dry-matter losses after 6 months of dry hay storage. Summarized by Edwards, 2017.

Source	Year	On Bare Ground	On Gravel or Pallets		On Ground, Covered			Stored inside a building
		No Cover	No Cover	Covered	Tarped	Wrapped	Under Roof	
Anderson et al.	1981	14%						3%
Verma and Nelson	1983	28-40%			12%	11%		2-9%
Atwal et al.	1984	40%	40%		30%			9%
Belyea et al.	1985	15%			6%			2%
Baxter	1986	33-35%	33-35%					3-7%
Penn St. Univ.	1992	15-40%						4%
Michigan St. Univ.	1993	35%	30%		15%	23%		12%
U. of Georgia	1993	50%	35%	14%	10%			4%
West Virginia U. - Rayburn	1995	7-61%	28-39%	5-10%				
Iowa St. U.	1996	10-25%	11%					5%
U. of Wisconsin - Holmes	2004	9.5%	8%	4%				2%
U. of Wisconsin - Saxe	2007	5-61%	3-46%	2-17%		4-8%	2-10%	
Oklahoma St. - Hunke	2017	5-20%	3-15%	2-4%	5-10%		2-5%	2%
Average		27%	22%	8%	13	13%	6%	5%

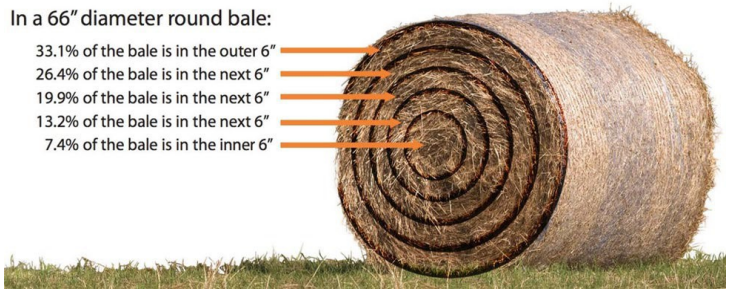


Figure 1. Volume of hay in a 66" round bale example. Wells, 2011.

Figure 1 shows the amount of hay in each six inch layer of a five and a half foot bale, which contains 33.1% of its dry matter inthe outer 6 inches of the bale. The amount of dry matter of different bale diameters from four to six feet can be found in Table 2. A four-foot bale contains 41% of its dry matter in the outer six inches compared to a six foot bale which only contains 31% of its dry matter in the outer six inches.

Most round balers can tie bales with either twine, plastic net wrap, or both. While either option may be suitable for your operation, research from Michigan State University (MSU) and the University of Wisconsin (UW) have shown conflicting results with regards to the effect of net wrap on dry matter loss.

In three different studies of varying lengths of time, MSU researchers reported there were no significant differences in dry matter loss whencomparing net wrapped or twine tied bales that were stored on outdoors, uncovered, and on pallets (Harrigan and Rotz, 1994). Conversely, in UW trials, net wrap reduced dry matter losses by 4%. Dry matter losses were 11.3% and 7.3% for net wrap and plastic twine respectively (Shinners et al., 2002). Both studies showed significant differences when comparing hay stored outside compared to bales stored indoors.

Table 2. Effect of bale dimensions on estimating hay losses. FromCollins el al. 1997

Bale Dimensions (feet)		Depth of Weathered Hay Layer (inches)			
Diameter	Width	2	4	6	8
		% of bale affected			
4′	4′	16	31	44	56
5′	4′	13	25	36	46
6′	5′	11	21	31	40

Storge Options

On the Ground, an Improved Pad, or Pallets

When storing hay on the ground, it should be in an area thatis well drained with a slight slope to allow surface water to escape. Store bales in an area away from a tree line to promote air flow and proper drying after a rain fall event. With most dry matter losses occurring on the bottom of bale when stored outdoors. Dry matter losses can be reduced by stacking bales on pallets or a stone storage pad to improve drainage.

Round bales can be stored either in a row, placed tightly end to end, or in a pyramid shaped stack, depending on how much ground space is available. When stacked in a pyramid shape, the bales that are off the ground experience less forage loss. However, the upper layer also sheds rainfall down to the bottom layer of bales which then has the potential to increase storage losses when bales remain uncovered.

If storing hay outdoors bales may be covered with individual bale covers or with a large tarp in the case of stacked bales. For round bales stacked in a pyramid, having the bales covered will help minimize foragelosses, especially within the lowest tier of the stack.

Properly tarping the stack will influence the effectiveness of the tarp. The tarp should cover the widest span of the bottom tier of bales. Depending on the size of the tarp it may take two to three individuals to secure the tarp properly. The tarp should be secured tightly and continuously tightened as the stack of hay settles.

Left: Round bales twine tied, uncovered, stored outside. Right: Inline wrapped, dry hay

Wrapping Hay

Wrapping hay can reduce storage losses when compared to other methods of outdoor storage. Producers will have to determine if the cost to have bales custom wrapped or the cost of purchasing a wrapper can be justified.

There are two types of hay wrappers available today, individual bale and inline type wrappers. Regardless of which type of wrapper is used, bale handling equipment.

including a loader will be needed Each type of wrapper has both advantage and disadvantages in how they operate, Table 3. Additional information regarding the wrapping of hay can be found in the Factsheet: Making Quality Baleage.

Stored Inside

If in the hay is stored for an extended period of time, a hay storage facility may offer the great return on investment. Square bales, both large and small are well suited for indoor storage due to uniform shape and size. Round bales can also be stored inside, however the size of the storage facility needed is partially determined by how the bales are stacked in the barn.

Table 3. Comparing Single Bale vs. Inline Wrapping

Single Bale Wrapper		Inline Bale Wrapper	
Advantage	Disadvantage	Advantage	Disadvantage
Can stack bales, requires less ground space	Uses more plastic per bales	Uses less plastic per bale	Requires larger space/ pad to operate, place bales
Allows for slower feed out rates	Requires hydraulic bale moving attachment	Faster wrapping process	Feed out rate should be faster
Cheaper to purchase	Takes longer to wrap per bale		Cost significantly more to purchase wrapper

Return on Storage Investment

The return on investment for hay storage is dependent on several factors. Total cost of the hay storage system, depreciation, interest, repairs, taxes, and insurance should all be calculated into the cost of hay storage. The University of Wisconsin has a spreadsheet based decision tool to estimate annual hay storage costs at: :https://fyi.extension.wisc.edu/forage/files/2014/01/BaleStora ge5-7-04.xls.

Round bales stored inside, on pallets.

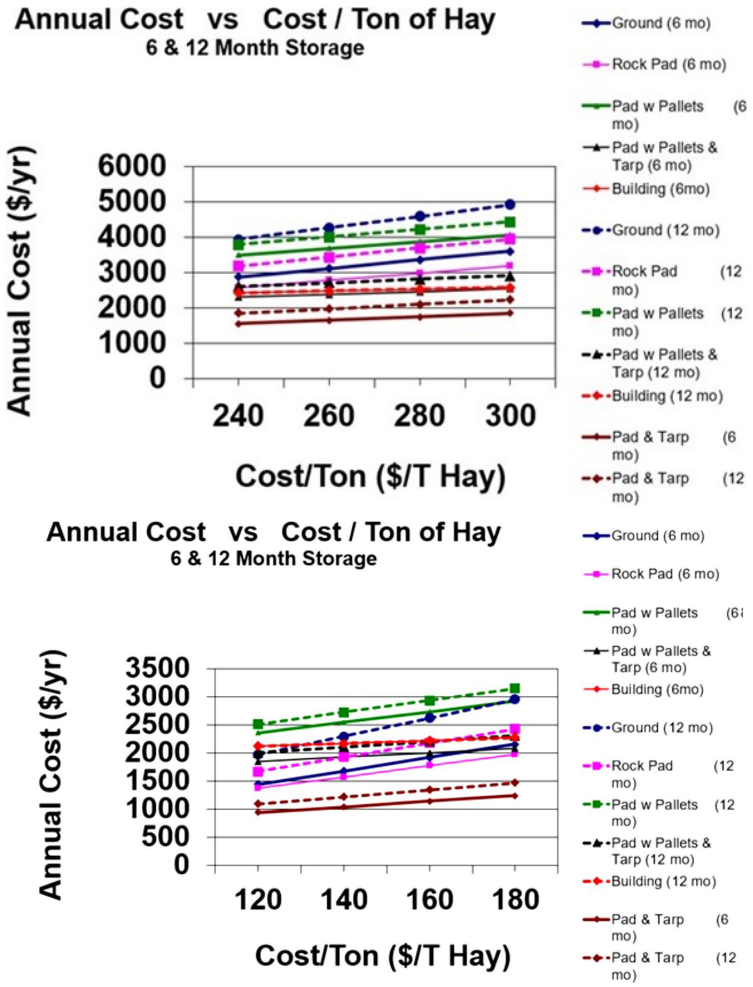
As demonstrated in Figure 2, the UW decision tool estimates the annual costs of storing hay of values at both 6 and 12 months of storage. The tool considers climate, the value of the forage, size and number of bales to be stored.

The example in Figure 2 estimates storage cost for 250, 5x5 round bales weighing 1200 pounds each, or total storage costs for 126 tons of dry matter.

Storage options aside from uncovered ground storage included a 40' by 60' pole barn ($6/ft^2), a 3,125 ft^2 improved gravel pad ($0.30/ft^2) with the stack either on pallets ($0.26/ft^2) or covered with a tarp ($0.06/ft^2).

Keep in mind the results of this analysis depend on the assumptions used in the worksheet.

Figure 2. Estimated annual cost of storing 250 round bales (126 tons of dry matter) for 6 and 12 months using decision tool by Holmes, 2004.



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