SDSU Extension

forage

JUNE 2020

SOUTH DAKOTA STATE UNIVERSITY®
AGRONOMY, HORTICULTURE & PLANT SCIENCE DEPARTMENT

Round Bale Storage Conservation

Sara Bauder | SDSU Extension Agronomy Field Specialist
Tracey Erickson | SDSU Extension Dairy Field Specialist
Kevin Shinners | Professor, University of Wisconsin-Madison

South Dakota has been one of the top producing forage states in the nation for many years. One of the most common methods of hay packaging and storage is large round bales stored outdoors. However, proper storage of a high quality product is vital to maintaining value and often overlooked. Quality losses that typically occur during storage are frequently a result of water that has entered the bale, which becomes entrapped and unable to evaporate, resulting in spoilage.

Round bales have characteristics that help limit storage losses. The round shape allows for a dense, well-made bale in which the outer thatch will help to shed precipitation, minimizing water penetration and spoilage loss. The water shedding capability of the forage leaf blade is also important to note. Grass has a broad, flat leaf and makes excellent thatch. Alfalfa has much smaller leaf area that does not form as nice of thatch as grass leaves. Most modern balers are capable of making bales that can conserve value if good storage practices are followed.

A 2019 bale stacking demonstration by SDSU Extension was undertaken to demonstrate some of the common bale stacking methods, and the positive and negative attributes about each.

Methods

On February 1, 2019, 44 net wrapped alfalfa round bales weighing an average of 1,479 lb. were delivered to the Southeast Research Farm near Beresford, SD. All bales came from the same lot; each were weighed and stacked outdoors on a slightly sloped, well-drained area. Seven bale stacks were formed and are detailed in Figures A-F. Each stack was core sampled at the time of initial stacking for nutrient analysis. Bales were left untouched for the remainder of the winter and most of the summer until stacks were core sampled, moisture probed with a Delmhorst moisture sensor (sampling 50 locations per bale, 8 inches deep from both flat faces of the bale), and weighed again on July 25th. The 2019 cropping season was unseasonably wet, with about 20 in. of rain falling at the Southeast Research Farm from Feb. 1-July 31 (climate.sdstate.edu); however, just 0.06 inches of rain fell the week before the bales were sampled.

Results and Conclusions

- The 'control' bales in Figure A (stored indoors on a dirt floor) picked up some moisture via wicking, but were otherwise dry and similar to their initial storage weight (Table 1). The majority of the indoor bales (98%) tested at less than 20% moisture. However, bales stored indoors can still be subject to loss, and should be carefully monitored and stored in a managed environment in order to conserve their value.

Table 1. 2019 Bale Stacking Demonstration- Bale Weight. Beresford, SD

Pile[1]	Initial Weight (Avg.) 1-Feb	Final Weight (Avg.) 25-Jul	Weight Loss (Avg.)
	lbs.	lbs.	lbs.
A	1474	1368	106
B	1438	1332	106
C	1492	1364	128
D	1480	1315	165
E	1476	1327	148
F	1437	1356	82

[1]See 'Figure' descriptions below which, match pile labels.

- Figure B depicts bales stored outdoors with no other bales directly in contact, similar to rowed bales with a large gap between rows and between bales within rows. With no restricting air movement, drying occurred within bales and only approximately 15% of the sampled area was greater than 22% moisture.

- Rowing bales that are pushed tightly together (Figure C) resulted in storage losses due to water movement between the flat faces of the bales. With no air movement or sunlight on the wet surfaces, about 66% of the sampling area of these bales was greater than 22% moisture. This may entice producers to leave more space between bales; however, snowfall can pack in these spaces and may cause similar issues, especially after late spring snowfalls when thawing occurs soon afterwards. Note that moisture is lower on the west side of the sampled bales because of increased temperatures that occur in the afternoon from sunlight.

- When little to no space is left between rows of bales (Figure D), water tends to run down into the "gutter" formed between the touching bales. Figure D depicts how moisture can be quite high where bales touch between rows. Note that sunlight was not able to reach the bottom quarter of these bales and therefore, more than 20% of the sampled area of the bale on the right was greater than 30% moisture; this raises the chance for spoilage in that area. This moisture trapping scenario is why it is strongly suggested to leave 3 to 4 feet of space between rows of bales.

- "Mushroom stacking" (Figure E) has been observed in South Dakota, as it creates a smaller storage area and is often used as a wind break. Unless bales are covered and the bottom bales are placed on a well-drained, porous surface, this stacking orientation tends to lead to very poorly conserved hay in the bottom bales. In Figure E, the top bale was open to airflow on all sides, and was quite dry throughout, with about 90% of the bale being less than 22% moisture. However, the moisture shed from the top bale drained down into the bottom bale, resulting in a different story for the bottom bale. With the bottom bale placed on end, water could easily flow between layers of thatch. In this case, over 45% of the bale was greater than 35% moisture, causing extensive spoilage and visible mold growth. When these bales were removed from storage they exhibited extensive spoilage and would likely have been subject to considerable rejection by foraging animals. Storing bales placed on end utilizing the "mushroom stacking" method outdoors contradicts all storage advantages of making round bales.

- Pyramid stacking bales is another common storage practice across the Midwest. Figure F shows that although pyramid stacking is space efficient, it also results in significant water infiltration in many of the bales. When stacked in this manner, water tends to shed from the upper bales and flow to the bales below; since lower bales have limited air movement and exposure to the sun, water that drains into them cannot easily evaporate. Over 35% of the sampled area was greater than 30% moisture in the two bottom bales on the east side of the pyramid. The bottom bales also squatted, creating more contact with the soil underneath, resulting in more moisture wicking. In any stacking scenario, lower bales tend to lose integrity due to spoilage.

Best Management Practices

The best bale conservation always comes from protecting bales from the elements – storing under a tarp or inside a building. Wrapping bales in plastic or breathable film (B-wrap) will also help conserve value; however, bales stored outdoors and uncovered can still be well-conserved if these simple practices are followed:

- Take care not to place bales where they will be shaded. This practice allows the sun to naturally dry bales after they have been exposed to rain or snow.

- Place bales in rows that are oriented north to south with about 3 to 4 feet between the rows.

    - These practices help sunlight dry bales after precipitation. There are pros and cons to how the bale rows are made. Butting bales tightly together (face to face) helps keep rain and snow away from the bale face and takes less storage space. On the other hand, rowing the bales with a gap of 12 to 18 in. between faces allows the bale face to dry if they become wet. There is no consensus for a standard recommendation on the distance between bale faces within rows.

- Bales should be on a slight, south facing slope to help water drain away. Placing bales on a well-drained soil or surface like a rock pad helps to drain water and reduce wicking.
- Net wrapping bales helps to promote a good leaf thatch and thus shed water well and hold shape integrity better than sisal twine wrapped bales.
- If bales must be stacked outdoors in a manner that reduces storage space, the best practice is to cover the pile.

Dry matter loss of hay is generally a function of moisture, temperature, and time. Table 2 depicts commonly accepted storage losses based upon various research trials. As one can see, there is great variability in losses depending upon storage methods which can adversely affect final hay value. To further evaluate the storage cost of round bales on your operation see the University of Wisconsin's "Comparing Round Bale Storage Costs" spreadsheet at https://fyi.extension.wisc.edu/forage/files/2014/01/BaleStorage5-7-04.xls. For a full report on this bale demonstration project, see the 2019 Southeast Research Farm annual report in print or online at https://openprairie.sdstate.edu/agexperimentsta_rsp/280/.

Table 2. Average Effect of Hay Storage Method on Storage Losses

Storage	Range of Dry Matter Loss (%)
Under Roof	2 - 10
Plastic wrap, on ground	4 - 7
Bale Sleeve, on ground	4 - 8
Covered, rock pad or elevated	2 - 17
Uncovered, rock pad or elevated	3 - 46
Uncovered, on ground, net wrap	6 - 25
Covered, on ground	4 - 46
Uncovered, on ground	5 - 61

https://fyi.extension.wisc.edu/forage/big-bale-storage-losses-how-different-options-stack-up/

Moisture Maps[1]

[1]Moisture maps created by Dr. Kevin Shinners, University of Wisconsin.

The areas shaded light-blue to dark-blue indicate regions of higher moisture where spoilage will be likely. Light-green regions represent moisture levels where spoilage may occur if the moisture cannot soon leave the bale by evaporation. Yellow or red regions represent areas where spoilage is not likely to occur. These images represent a "snapshot" of moisture at one instant in time. Bale moisture will change with time as storage and weather conditions change – either allowing moisture to leave the bale by evaporation or subjecting the bale to additional precipitation.

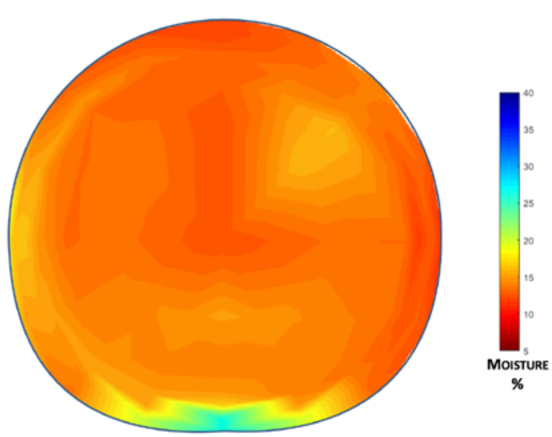

Figure A. Spatial moisture distribution at 8 inch depth from the vertical faces of a round alfalfa bale stored under roof in an open front hay shed. Note the wicking of moisture in the bottom portion of the bale.

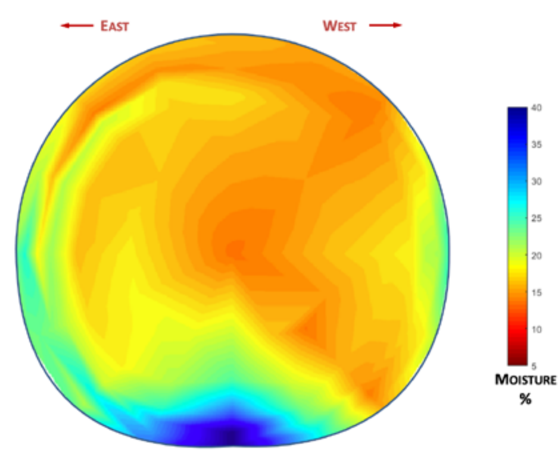

Figure B. Spatial moisture distribution at 8 inch depth from the vertical face of a round alfalfa bale set outdoors with no other bales around it. Note slight moisture wicking from the soil.

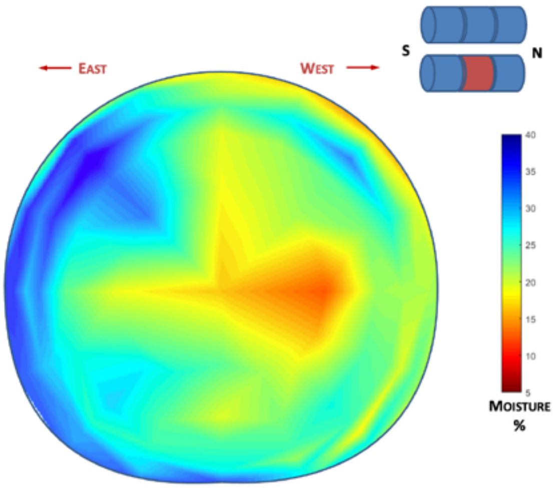

Figure C. Spatial moisture distribution of round alfalfa bales stored outdoors in a row running north to south with bales butted tightly together; approximately 3 feet was left between parallel rows. Note how limited air movement and sunlight on the bales in the middle of the row affect moisture 8 inches from the vertical faces of the bale. The probed bale is indicated in red.

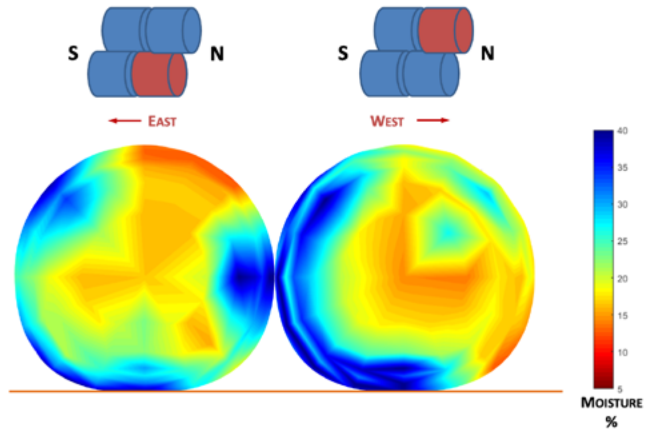

Figure D. Spatial moisture distribution at 8 inch depth from the vertical faces of round alfalfa bales stored outdoors in a row running north to south with bales butted tightly together and no space between the rows. Note how water penetrated into the "gutter" formed by the touching bales resulting in very high moisture where the bales touched. Bales probed are indicated in red.

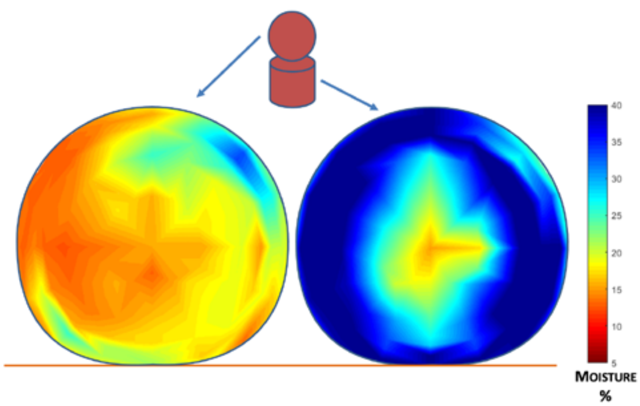

Figure E. Spatial moisture distribution at 8 inch depth from the vertical faces of round alfalfa bales stored outdoors with bottom bale (right) stacked on end and the top bale (left) stacked on top in its normal orientation. About 3 feet was left between stacks. Note that water shed from the top bale drained down to the bottom bale where water easily flowed between its layers. Bales probed are indicated by arrows.

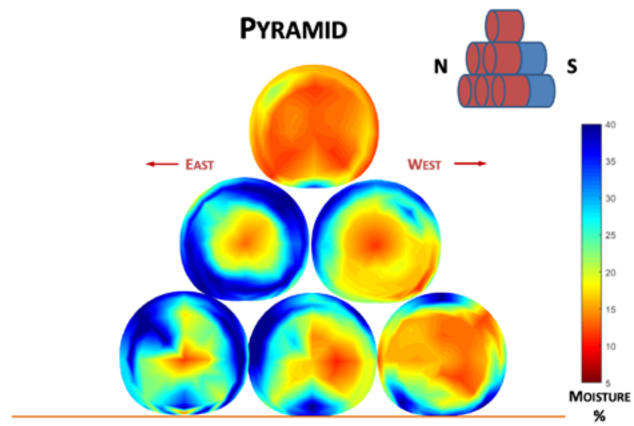

Figure F. Spatial moisture distribution at 8 inch depth from the vertical faces of round alfalfa bales stored outdoors in a pyramid shape. Note that water shed from the upper bales flows down to the bales below. Limited air movement and sun exposure makes it difficult for this water to be removed by evaporation. 11 bales were placed in a pyramid (6 on bottom, 4 on second layer, 1 on top) facing north/south outdoors. All bales butted together tight. All bales on the south side of the pile were probed (indicated in red).

Aknowledgement

Thank you to all staff and technicians with SDSU Extension, the Southeast South Dakota Research Farm and University of Wisconsin-Madison who helped make this project possible.