Research Update 673

Round Bale Storage Techniques

(Funded by: Agri-Food Agreement and ERDA)*

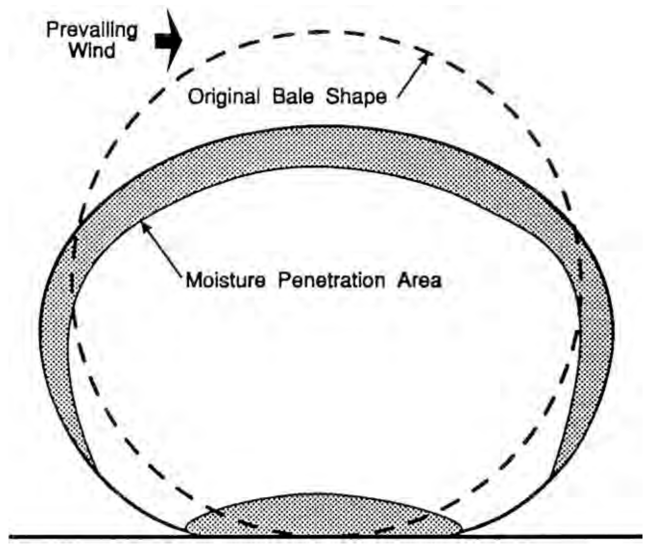
INTRODUCTION

Traditionally, farmers have stored round bales outside with little protection from the weather. Limited research has been conducted (under Canadian Prairie conditions) on the round bale's ability to shed rainfall and retain food quality.

Recently, equipment has been developed to improve round bale storage. Round bale wrappers wrap the circumference with plastic. This is intended to protect and preserve the hay during storage. Also, round bale silage baggers have been developed to allow farmers to make silage using high moisture hay bales sealed in plastic tubes.

In 1988, PAMI initiated a research project to widen the industry's knowledge of round bale preservation systems. This project was supported by Agriculture Canada under the Agri-Food Agreement, a subsidiary agreement of the Canada-Manitoba Economic & Regional Development Agreement (ERDA).

The objectives of the project were: a) to measure change of quantity and quality of round bales stored using wrapped storage systems and traditional storage systems, and b) to evaluate the functional performance of two bale wrappers and one silage bagger.



IN BRIEF

- In 1988, the Praide Agricultural Machinery Institute (PAMI) in co-operation with Manitoba Agriculture, conducted a research project to study the functional and economic aspects of round bale preservation systems.
- A round bale storage study compared plastic wrapped bales with traditional storage methods. The Vermeer and Unverferth wrapping machines were compared against: single row unprotected (Rowed), two-bale vertical unprotected (Mushroom), and enclosed building (Inside) bales.
- The hay used for the research was 60% alfalfa and 40% Brome/ Timothy grass, 75 to 100% in bloom at 10 to 15% moisture content. The bales used in the study were stored for 16 months in Manitoba receiving 17 in (425 mm) of rain. The long-term average for the test site is 24 in (600 mm) of rain.
- The Inside bales had 0% Total Feed Loss (0% spoilage and 0% dry matter loss).
- The Rowed bales had 6.4% Total Feed Loss (5.6% spoilage and 0.8% dry matter loss). Some of the spoiled hay, in areas other than the bottom of the bale, could still be consumed by cattle.
- The plastic wrapped bales had a 7.5% Total Feed Loss (3.8% spoilage and 3.7% dry matter loss). Spoilage primarily occurred at the bottom of these bales. This spoiled hay was determined to be unfit for cattle consumption.
- The Mushroom method had the bottom bale on its end and the top bale on its side. Total Feed Loss for this method was 10.6% (9.1% spoilage and 1.5% dry matter loss). Most of the spoilage (80%) occurred in the bottom placed bale.
- Plastic wrapped bales retained considerable moisture in the bottom of the bale which led to high dry matter and spoilage losses. Also, prior to feeding, this high moisture may make it difficult to remove the plastic due to freezing. Deterioration of the plastic wrap had occurred after one year of storage.
- Under the conditions during the test, no economic advantage was realized in wrapping round bales with plastic.
- If different conditions were experienced, an economic advantage for wrapped bales may exist. Additional research, encompassing a variety of weather conditions, forage types, forage maturities, and test sites, would be required before a general conclusion could be drawn.
- PAMI published Evaluation Reports on: the Vermeer Bale Wrapper, the Unverferth Bale Wrapper, and the Rampak Silage Bagger.
- Both the Vermeer and the Unverferth machines functioned well when wrapping round bales with plastic. There was no statistical difference between the total loss of the two types of bale wrappers. The Rampak round bale silage bagger functioned well for inserting round bales into plastic tubes.

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WHAT WERE THE RESULTS

MOISTURE CONTENT: Excluding the bottom of the bales, the moisture content ranged from 9.3% to 11.8% for all bales under test.

The moisture content was greater in the bottoms of the plastic wrapped bales than in the bottoms of both unprotected systems (Wrapped avg. 62%; Rowed avg. 34%; and Mushroom avg. 42%).

With the wrapped bales, moisture that entered the bales collected in the bottoms because the plastic did not permit the water to escape. Water was also able to enter the ends of the bales because the bales were not placed tightly together. Also, moisture was able to enter through holes in the plastic wrap. During the wrapping process, some stalks punctured the plastic wrap. Also, the plastic wrap deteriorated, developing large holes during the 16 month storage period.

The high moisture content in the bottoms of the wrapped bales could be a problem during winter feeding. The plastic wrap and twine could freeze to the bales.

DRY MATTER LOSS: There was no significant difference in dry matter loss for the three traditional storage treatments (Inside 1.1% gain; Rowed 0.8% loss; and Mushroom 1.5% loss). SEE FIGURE 1.

The Vermeer (Wrap #1) and Unverferth (Wrap #2) wrapped bales had significantly greater dry matter losses (3.8% and 3.6% loss, respectively).

SPOILAGE LOSS: The average spoilage losses of the Inside, Rowed, and Mushroom storage treatments were 0%, 5.6%, and 9.1%, respectively. SEE FIGURE 2.

The spoilage of the Rowed bales occurred at the bottom of the bale and around the outer shell which was exposed to the weather.

For the Mushroom storage system, the average spoilage losses for the top and bottom bales were 4.2 and 14.0%, respectively. The higher spoilage to the bottom bale was primarily due to water run ning off the top bale and into the bottom bale. Also, the top twine of the bottom bale often came loose, allowing more water to enter.

The spoilage loss measured for the Vermeer and Unverferth wrapped bales were 3.9% to 3.6%, respectively. The spoilage loss of the wrapped bales was significantly less than the two outside storage treatments. Wrapped bale spoilage occurred almost entirely at the bottom of the bales.

Surface spoilage (as seen with outside treatments) was still consumable, even though the nutrient value was reduced. Bottom spoilage (as seen with wrapped bales) was considered unconsumable.

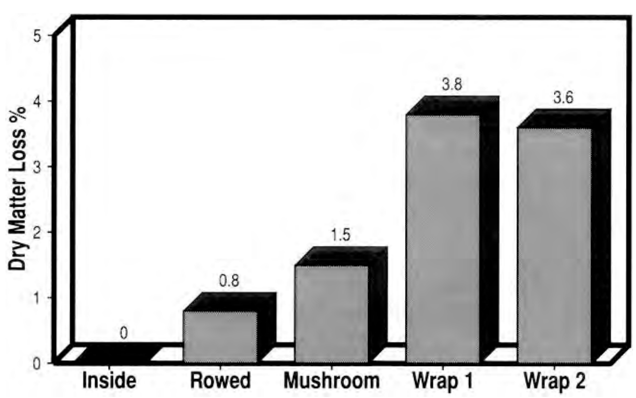

FIGURE 1. Dry Matter Losses for Different Storage Treatments.

TOTAL FIELD LOSS: The total feed loss is the addition of the dry matter loss and the spoilage loss.

The Inside treatment had 0% Total Feed Loss (0% dry matter loss and 0% spoilage). The Rowed bales had 6.4% Total Feed Loss (0.8% dry matter loss and 5.6% spoilage loss). SEE FIGURE 3.

The plastic wrapped bales had a 7.5% Total Feed Loss (3.7% dry matter loss and 3.8% spoilage). There was no significant difference between the Vermeer and Unverferth machines.

The Mushroom method had a Total Feed Loss of 10.6% (1.5% dry matter loss and 9.1% spoilage).

In this study, wrapped bales statistically provided no better protection from deterioration than the unprotected horizontal storage treatment.

NUTRIENT CHANGES: No change in protein levels was observed during the study. A slight drop in total digestible nutrients was observed for all the test treatments.

ECONOMICS

Under the conditions tested in the study, the total feed losses associated with the wrapped bales were not significantly different from either of the unprotected storage treatments. Further, there was no difference in feed quality between storage treatments. This would indicate that there were no economic advantages to wrapping round bales with plastic under the conditions tested.

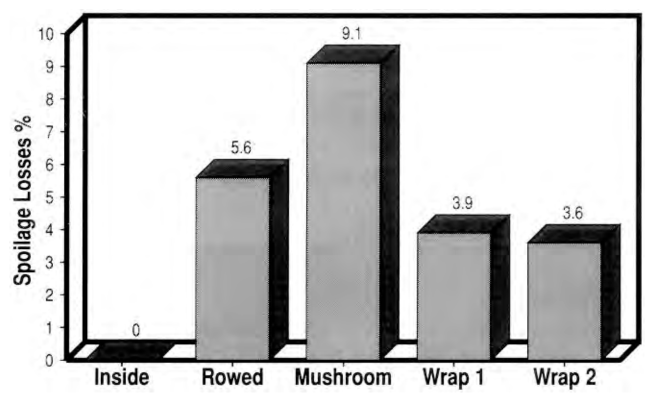

FIGURE 2. Spoilage Losses for Different Storage Treatments.

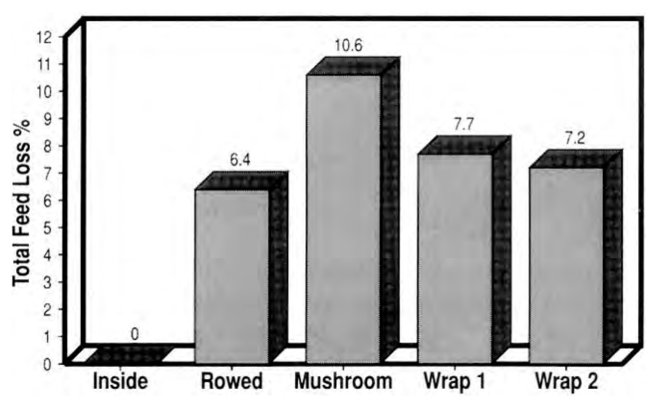

FIGURE 3. Total Feed Losses for Different Storage Treatments.

WHAT IF?

These results are for one specific set of test conditions and should be treated accordingly. Otherconditions could give different results. PAMI recommends further study to answer the following questions:

- Weather conditions on the Canadian Prairies are both extremeand locally variable, leading to discrepancies in test results. As an example, if the rainfall were greater, what would be the relative total losses between the different storage treatments?
- If the test site was not as well drained, what would be the effect on the spoilage losses of the different treatments?
- How does the plastic deteriorate over time? How quickly does spoilage accompany plastic deterioration?
- What effect does the ratio of the alfalfa/grass mix haveonthe rateof spoilage?
- Mature hay was used in this study. What effect would hay maturity have on the overall results?
- Measurements were taken after 16 months. What effects would be seen if the test periods were changed?
- Under the different conditions, would the economics be different?

HOW THEY WERE TESTED

The purpose of the project was to study the comparison of hay losses between wrapped bale storage systems and conventional storage systems.

The wrapped storage systems used bales wrapped by both the Vermeer and Unverferth bale wrappers. In both cases, the bales were wrapped with a double layer of plastic. The bales were placed end to end, in rows, with a 4 to 6 in (100 to 150 mm) space between bales to allow forventilation.

The conventional storage systems consisted of three methods:

bales stored horizontally end to end (Rowed).

bales stored vertically (two bales high with the bottom bale on its end and the top bale on its side- Mushroom).

bales protected from the weather in an enclosed building (Inside).

Because the Rampak Silage Bagger was intended for round bale SILAGE and not for preservation, it was not included in the comparison studies.

The hay selected for this project was approximately 60% alfalfa and 40% Brome/Timothy mix. At cutting, the alfalfa was 75 to 100% in bloom. In this study, poor weather forced the use of mature hay.

The hay was cut with a mower conditioner and baled four days later with an expanding chamber round baler. The baler produced hard core bales with an average density of 11.9 lb/ft^3 (191 kg/m^3) at 10 to 15% M.C.

On the fifth day, six bales were chosen for each of the five storage treatments. Core samples were sent for nutrient analysis.

The outside storage area was located in a well drained area that was considered ideal. The total rainfall for 16 months was 16.7 in (424 mm). Average rainfall for this area is usually 23.8 in (604 mm) for the 16 month period.

After 16 months of storage, the bales were measured, weighed, and cored. Three nutrient core samples were combined to give one representative sample of each bale.

Next, the dry matter loss and the spoilage loss were calculated to determine the total feed loss over the total storage period.

All feed rations are sold on a dry matter basis to compensate for variable moisture contents. Dry matter loss is the normal change that hay undergoes while in storage. This change is brought about by several factors (i.e. oxidation, environment, weathering, chemical changes, etc.). Calculations for dry matter loss are adjusted to reflect zero moisture content.

Spoilage was identified as hay that:

1) was appreciably discoloured (brown to black),

2) contained visible mold, or

3) had deteriorated to a "manure like" material.

The first two types occurred mainly in the outer bale shell and much of the material was considered fit for cattle consumption. The third type of spoilage occurred at the bottom of the bales and was unfit for cattle consumption.

WHICH EQUIPMENT WAS TESTED

Part of this study was the comparison of mechanical preservation systems against traditional storage methods. Machine evaluation determines its functional performance under the following conditions: quality of work, rate of work, power requirements, ease of operation and adjustment, operator safety, operator's manual, and machine mechanical history.

VERMEER BALE WRAPPER: This machine was a hydraulically driven, round bale wrapping system mounted on atwo-wheel trailer. The 5.4 ft (1.65 m) wide plastic was wrapped around the bales to prevent penetration of moisture into the circumference of the bale. One 5000 ft (1520 m) roll will wrap about 130 bales at a cost of about $300.00 per roll.

The complete test results can be obtained by asking for PAMI Evaluation Report #625, "Vermeer Bale Wrapper".

UNVERFERTH BALE WRAPPER: This machine is a hydraulically driven round bale wrapping system which mounted onto a three-point tractor hitch and can wrap a wide range of bale shapes and sizes. The 20 in (508 mm) wide plastic wrap was used to prevent moisture penetration into the circumference of the bale. One 6000 ft (1830 m) roll will wrap about 35 bales (with a double layer of plastic) at a cost of about $83.00 per roll.

The complete test results can be obtained by asking for PAMI Evaluation Report #627, "Unverferth RA220 Bale Wrapper".

HURST RAMPAK SILAGE BAGGER: This is a hydraulically driven, round bale bagging system mounted on a two-wheel trailer. Immediately after baling, round bales were inserted into a 100 ft (30.5 m) long plastic tube. The tube was sealed to prevent spoilage. Each bag could hold 18 large bales or 23 small bales.

The complete test results can be obtained by asking for PAMI Evaluation Report #601, "Rampak Silage Bagger".

FURTHER INFORMATION

For further information, contact PAMI at 1-800-567-PAMI and ask for Report #DP4688, "Evaluation of Round Bale Storage Techniques", (Cost: $5.00).

To discuss specific results, contact the authors: Ryan Schott, Project Engineer, or Ken Maloff, Information Services at PAMI.

SUMMARY CHART

VERMEER BALE WRAPPER - PAMI Evaluation Report #626

RETAIL PRICE	$4,575.00 (f.o.b. Portage la Prairie, MB, March, 1990), plastic roll - $300/5000 ft (1520 m) roll, sufficient to wrap about 130 bales
RATE OF WORK	20 to 24 bales/hour for two operators
QUALITY OF WORK	
Plastic Wrap	**Very Good;** generally depended on bale form
Storability	**Very Good;** bales spaced 4 to 6 in (100 to 150 mm) apart to permit ventilation
EASE OF OPERATION	
Hitching	**Very Good**; several hitch positions to suit tractor drawbar height
Plastic Wrap Installation	**Very Good**; easily installed by one person
Wrapping	**Very Good;** depended on bate condition
Plastic Wrap Tension	**Fair;** the brake was difficult tooperate, however, the operator could alternatively use his hand
Knife	**Very Good;** easy to operate
Loading and Unloading	**Good;** the wrapper was difficult to maneuver
Maneuverability	**Fair;** wrapper was difficult to align
Removal of Plastic	**Very Good;** cut along one side of bale and plastic can be removed in one sheet
Lubrication	**Very Good;** Seven grease fittings required lubrication every 8 hours
Adjustments	No adjustments were necessary
POWER REQUIREMENTS	
Tractor	40 hp (30 kW) was sufficient
OPERATOR SAFETY	Safe to operate if normal precautions were observed
OPERATOR'S MANUAL	**Very Good;** was clear and concise
MECHANICAL HISTORY	No mechanical problems during test

UNVERFERTH RA220 BALE WRAPPER - PAMI Evaluation Report #627

RETAIL PRICE	$2,295.00 (f.o.b. Portage la Prairie, MB, March, 1990), plastic roll - $83/6000 ft (1830 m), sufficient to double wrap about 35 bales.
RATE OF WORK	10 to 12 bales/hour
QUALITY OF WORK	
Plastic Wrap	**Very Good;** well suited to bate shape variations
Storability	**Very Good;** bales spaced 4 to 6 in (100 to 150 mm) apart to permit ventilation
EASE OF OPERATION	
Hitching	**Very Good;** Stands provide easy hitching to a three-point hitch
Plastic Wrap Installation	**Very Good;** easy to install
Wrapping	**Good;** easy to operate with well formed bales, problems with winch assembly
Loading and Unloading	**Good;** easy with a well formed bale
Maneuverability	**Good;** easy to place bales
Removal of Plastic	**Very Good;** cut along one side of bale and plastic can be removed in one sheet
EASE OF ADJUSTMENT	
Plastic Wrap Tension	**Fair;** had difficulty maintaining desired tension
Plastic Wrap Overlap	**Very Good;** wide range of overlap settings
Lubrication	**Good;** graphite easily applied to centre spike and carrier pole as required, difficult to grease drive wheel
POWER REQUIREMENTS	Most 65 hp (50 kW) tractors have adequate weight to maintain stability
OPERATOR SAFETY	Operation required special safety precautions
OPERATOR'S MANUAL	**Poor;** provided limited information
MECHANICAL HISTORY	Drive gear failed, winch plate distorted, drive wheel marked frame

RAMPAK SILAGE BAGGER - PAMI Evaluation Report #601

RETAIL PRICE	$4,903.00 (f.o.b. Portage la Prairie, MB, July, 1989), poly tubing - $126/roll or $143/folded; sufficient to do 18 - 5 ft (1.5 m) or 23 - 4 ft (1.2 m) bales
RATE OF WORK	30 minutes to fill 100 ft (30 m) bag
QUALITY OF WORK	
Plastic Wrap	**Very Good;** generally depended on bale form
EASE OF OPERATION	
Hitching	**Very Good;** remote control feature interferes with jack **operation**
Poly Tubing installation	
- roll	**Fair;** roll was difficult to place onto supports
- folded bags	**Very Good**; bar had to be made to hang the tubing
Loading	**Very Good;** ramp was provided when using forks while grapples were convenient for setting bales directly onto carriage
Shear Bolts	**Fair;** poly tubing occasionally ripped when repositioning the drum
Transporting	**Very Good;** easy to transport
Adjustments and Servicing	**Excellent;** only two lubrication points; no adjustments were necessary
POWER REQUIREMENTS	
Tractor Size	30 to 50 hp (22 to 37 kW) was sufficient
OPERATOR SAFETY	**Very Good;** if normal safety precautions were observed
OPERATOR'S MANUAL	**Good;** was clear and concise, information was lacking on lubrication and shear bolt replacement
MECHANICAL HISTORY	Drop extension rail stops failed

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