STORAGE LOSSES IN LARGE ROUND BALES USING VARIOUS STORAGE METHODS FOR SIX AND EIGHTEEN MONTHS

R. C. Reeder[1], D.H. Samples[2], H. M. Bartholomew[3], and S.L. Boyles[4]
[1]Department of Food, Agricultural, and Biological Engineering, Ohio State University, Columbus, Ohio, USA, 43210-1057
[2]Department of Extension, Ohio State University, Jackson, Ohio, USA, 45640
[3]Department of Extension, Ohio State University, Logan, Ohio, USA, 43138
[4]Department of Animal Sciences, Ohio State University, Columbus, Ohio, USA, 43210

ABSTRACT
Grass hay was baled with a variety of balers and tying materials in June, 1994 and 1995, at Jackson, Ohio. The bales were prepared and stored several ways. Waste hay accounted for less than ten percent of the dry matter after storage for six and eighteen months in all cases except one (a plastic wrap system intended for use with haylage). Bales stored inside had no waste. The best outdoor storage system, with less than one percent waste, used a 'bale bonnet' (top half covered with a plastic sheet) with the bale on a slatted pallet. One group of bales stored on the ground for 18 months had 8 percent waste; the others had 4.2 to 6.7 percent. Nutritive values (CP and NDF) did not change between 6 and 18 months of storage, and there was no difference among storage treatments. Each 2% reduction in waste was worth about a dollar per bale.

KEYWORDS
Hay, orchardgrass, tall fescue, round bales, storage, waste, nutrients

INTRODUCTION
As large round bales become a more common hay harvest method, losses from bales stored outside without protection are an economic concern. Bales kept more than a year often appear to have unacceptable losses in quality and amount of damaged hay.

Dry hay baled and stored properly has insignificant loss of dry matter during storage. Collins et al. (1995) found dry matter loss of about 5% for inside storage. However they and other researchers (Harrigan and Rotz, 1994; Rodriguez et al, 1994) have measured losses of 15 to 20 percent dry matter for unprotected storage and varying effects on nutritive value.

Most losses occur when the bottom or other part of the bale gets wet and stays wet. The purpose of this research was to evaluate various storage systems for six and eighteen months to determine their relative value in preventing waste.

METHODS AND MATERIALS
The experiment was conducted at the Jackson Branch of Ohio State University's Ohio Agriculture and Development Research Center, near Jackson, Ohio. The forage used for the experiment was grass hay composed primarily of tall fescue (*Festuca arundinacea*) and orchardgrass (*Dactylis glomerata*). Two round balers were used in 1994: a John Deere 535 (belt), and a New Holland 885 (chain). For comparison we baled eighteen square bales with a John Deere 24T.

Hay was baled on June 7, 1994. The 72 round bales were left in place for a week, weighed and randomly assigned a storage treatment with three bales per treatment. The bales were then placed in the storage area (either on solid pallets or the ground) and the storage treatment applied (bale sleeve, bale bonnet or no cover). Bales were stored end to end with at least 25 cm between them. The six 'Hay Wrap' bales were weighed, mechanically wrapped with plastic, and placed tightly end to end according to instructions from Hay Wrap Inc. Six round bales were stored in a shed on solid pallets. The square bales were stored inside, removed for weighing, and returned. Half of the bales were stored for six months, the other half for 18 months. There were thirteen treatments each for the 6- and 18-month bales (Table 1).

On Dec. 19 and 20, 1994, the six-month bales were weighed, the weather-damaged portions were removed by hand, and the bales were reweighed. Core samples of the remaining hay in each bale were oven-dried to determine dry matter content. Waste hay was not sampled. These 36 bales were not sampled in June either, so these bales are not included in Table 1 nor in the discussion below. However, observations and analysis of gross weights in 1994, show agreement with the results for 1995. Those observations resulted in the addition of a storage system for 1995, one which gave the best outdoor results.

Because we did not get moisture samples at the time of baling, we calculated the losses based on the amount of waste.

The 18-month bales were analyzed on Dec. 21, 1995. Weights of the remaining good hay and the waste hay were corrected for moisture content. Samples were analyzed for crude protein (CP), neutral detergent fiber (NDF), and mineral content at the OSU R.E.A.L. Lab at Wooster.

In June, 1995, 18 round bales were added to the experiment for a six month storage period (Table 1, lines 14-19). A Gehl 1875 baler (with belts) replaced the New Holland baler. We changed the pallets by removing about two-thirds of the boards from the solid 'floor'. These bales were also analyzed on December 21, 1995.

Precipitation received was 365mm (14.4"), 29% below normal, for the first six months of bale storage, and 1305mm (51.4"), 17% below normal, for the 18 month period. Precipitation on the hay baled in 1995 totaled 445 mm (17.5"), 10% below normal.

RESULTS AND DISCUSSION
Dry Matter Loss. Storage losses were less than expected. Bales stored inside had no waste and therefore no dry matter loss. In December, 1994, it was obvious that keeping the bottom of the bale dry was more important than covering the top. The bonnet, which covers the top half, but not the ends, protected the top almost as well as being under roof. The bale sleeve, which covers the entire bale except the ends, protected the top and sides, but caused water to collect at the bottom resulting in substantial waste. Using a pallet with a solid 'floor' caused the bottom of bales to stay wet resulting in almost as much waste as for those on the ground. Bonnets cost $8 each and should last for 3-4 years, sleeves cost $0.50 and should last 2-3 years, and the used pallets were free.

For 1995 the added treatment (Table 1, lines 16 and 19) resulted in less than 1% waste. Most other treatments had waste between 4.2 and 6.7%. Treatment #12, had 8.0%. Only the "Hay Wrap" had more waste with 18%. While that system may work for haylage, it did not work with our dry hay.

There did not appear to be any difference among the three round balers used. Sisal and plastic twine both failed after several months, but we had no problem handling those bales. Net wrap gave a tighter bale which seemed to hold its shape better, but had no advantage in reducing waste. We did not test net wrap bales on pallets.

Bale Quality. There was no significant change in NDF and CP for 18-month storage compared to 6-month storage, nor any difference among treatments.

Conclusions and Recommendations. Effective long term outdoor storage of round bales in humid areas requires that the hay be placed on a surface with good aeration. Covering the top half of the bale, with the ends open, gives excellent protection. Bales should not touch each other. If hay is worth $90/t (about $50 per bale) each 2% reduction in waste saves $1 per bale assuming the nutritive value of the good hay does not change, as was our experience.

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Table 1

Hay dry matter and quality values for several combinations of large round balers, tying or covering materials, length of storage and storage location.

Baler Wrap Location	Gross Initial Weight kg/bale	Dry Matter Dec '95 Good Hay	Dry Matter Dec '95 Waste,% **(Std. Err)	Moisture Content Dec '95 Final good % **(Std. Err)	Moisture Content Dec '95 Final %	Nutritive Value Crude Protein %	Nutritive Value NDF, %
1. Square, inside	21	20	0a	*	———	0	*
2. JD, pl. tw., inside	505	483	0a	9.3a (1.0)	———	12.3	70.9
3. JD, pl. tw., pallet	545	449	5.2bc (0.2)	9.9a (1.2)	62.7	11.9	73.8
4. JD, si. tw., pallet	500	392	6.4cd (0.8)	11.4ab (0.7)	53.2	*	0
5. NH, pl. tw., pallet	540	458	4.9bc (1.4)	10.0a (0.3)	54..0	12.3	66.7
6. JD, pl.tw., ground	525	425	6.7cd (0.5)	18.6cde (0.6)	55.0	12.0	70.7
7. JD, net, ground	490	390	5.7bc (0.4)	13.7abc (1.7)	67.4	*	*
8. JD, bigger, net, grnd	590	531	5.5bc (0.9)	8.2a (1.0)	55.1	9.8	75.0
9. JD, si.tw, ground	495	382	6.5cd (0.4)	15.6cd (0.4)	59.2	*	0
10. JD, sleeve, ground	515	431	5.4bc (0.2)	19.3cde (0.9)	68.6	11.0	68.2
11. NH, bonnet, grnd.	545	477	5.0bc (1.1)	16.2cd (1.6)	55.2	10.4	67.9
12. NH, pl. tw., grnd.	510	414	8.0d (1.9)	21.3e (6.3)	60.0	9.0	77.6
13. NH, "Hay Wrap"	525	369	18.0e (0.9)	19.0cde (0.4)	60.2	10.1	73.0
14. JD, pl.tw., ground	655	535	4.2b (0.3)	20.0de (1.1)	66.1	12.0	70.9
15. JD, net, ground	600	485	4.3b (0.2)	17.5cde (0.5)	57.7	11.2	71.0
16. JD, bonnet, slatted pallet	655	544	0.8a (0.3)	16.0cd (0.7)	26.5	12.0	71.0
17. Gehl, pl. tw., grnd.	570	456	6.5cd (0.8)	18.1cde (1.6)	64.5	11.7	73.8
18. Gehl, net, ground	670	423	5.8bcd (0.4)	17.7cde (0.4)	53.9	11.6	69.4
19. Gehl, bonnet, slatted pallet	625	509	0.5a (0.1)	15.5bcd (0.2)	20.4	12.6	70.6

Treatments 1- 13 were started in June, 1994; 14 - 19 were started in June, 1995.

Abbreviations: JD - John Deere; NH - New Holland; pl. tw. - plastic twine; si. tw. - sisal twine; net - net mesh; NDF - neutral detergent fiber

* = no test

** = Standard Error of the means

Values followed by the same letter (from "a" to "e") in the column are not significantly different at P<0.05 using LSD multiple range test. The nutritive values were not significantly different at P<0.05.