RATE AND EXTENT OF LOSSES FROM TOP SPOILAGE IN ALFALFA SILAGES STORED IN BUNKER SILOS

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Summary

Alfalfa silages were made in pilot- and farm-scale silos, and five sealing treatments were compared. After 90 days, sealing dramatically reduced dry matter (DM) losses at the 5 and 10 inch depths in the farm silos and at the 0 to 12, 12 to 24, and 24 to 36 inch depths in the pilot silos. Extending the storage period to 180 days in pilot silos had no effect on DM losses for sealed or delay-sealed silages, but DM losses for unsealed silages continued to increase at all three depths. Placing a roof over the unsealed, farm-scale silo increased the silage DM content at all three depths, increased storage temperatures at the 10 and 20 inch depths, and reduced DM loss at the 10 inch depth compared to the unsealed silo without a roof. Rainfall was much above normal (16.8 inches during the first 90 days of storage; 11.2 inches the second 90 days) and contributed to huge increases in the moisture content of silage at the lower depths in the unsealed, no roof, pilot- and farm-scale silos. Sealing also increased the nutritive value of the silages at the 5 and 10 inch depths.

(Key Words: Silage, Alfalfa, Top Spoilage, Bunker Silos.)

Introduction

Large horizontal silos (i.e., bunkers, trenches, and stacks) are economical for storing large quantities of ensiled feeds, but by design, much of the silage is exposed to the environment. In a silo with about 1,000 tons capacity (100 ft long × 40 ft wide × 12 ft deep), up to 25% of the original silage mass is within the top 3 feet. In an earlier study with alfalfa, we found that DM losses in an unsealed bunker exceeded 72 and 32% in the top 0 to 12 and 12 to 24 inches, respectively, after 12 wk of storage (KAES Report of Progress 623, page 74). However, sealing with polyethylene sheeting reduced the DM losses to less than 8% at each depth.

Our objectives were: 1) to measure the rate and extent of top spoilage losses in unsealed and sealed alfalfa silages and 2) to determine the effects of delaying sealing and of placing a roof over the silage mass on preservation efficiency and nutritive value. To our knowledge, the feasibility of using a roof to protect an unsealed silage mass from rain and snowfall has not been studied in controlled experiments.

Procedures

Farm-scale silos. On June 25 and 26, 1992, second cutting alfalfa was chopped and packed into four, 16 ft long × 13.5 ft wide × 4 ft deep, bunker silos. Alternate loads were used to fill the bottom half of each silo on the first day and the top half of each silo on the second day. All alfalfa was cut with a mower-conditioner and allowed to wilt for 24 hr before chopping. While the silos were being filled, nylon net bags, each containing 4.4 lb of fresh material, were placed at depths of 5, 10, and 20 inches from the surface of the initial ensiled mass (3 bags/ depth/silo). Thermocouples were placed at each bag location, and temperatures were recorded daily for the first 30 days, then twice weekly thereafter. The silos contained similar amounts of fresh material and were packed with tractors to densities that were similar to farm-scale conditions.

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Treatments were: 1) silo left unsealed, without a roof; 2) sealed, without a roof; 3) left unsealed, with a roof; and 4) sealed, with a roof. Both sealed silos were covered with a single sheet of .4 mm polyethylene, weighted with tires. A galvanized, tin roof was used for treatments 3 and 4. Bunkers were emptied at 90 days postfilling. The nylon net bags were recovered after the settling depths had been recorded, and the silage was weighed; mixed; sampled; and analyzed for dry matter (DM), pH, and in-situ DM digestibility. Depth settled was not recorded at the 10 inch depth.

Pilot-scale silos. The same chopped alfalfa that was used to fill the farm-scale silos was packed to equal densities into 33, polyethylene-lined, 55-gal drum, pilot-scale silos. Each drum was divided horizontally into thirds with nylon netting to partition the fresh material at 12 and 24 inches below the initial surface. A perforated, 1-inch, PVC pipe was placed at the bottom of the drums and connected through an air lock to drain percolated water. The first four treatments were the same as those described for the farm-scale silos, plus a fifth treatment in which sealing was delayed 7 days. All sealed silos were covered with a single .4 mm sheet of polyethylene; silos designated as "unroofed" were stored outside; silos designated as "roofed" were stored in an open-sided, metal building.

The "unroofed" pilot-scale silos were opened at 7, 90, and 180 days postfilling; the "roofed" silos were opened at 90 and 180 days; and delay-sealed silos were opened at 180 days. Three silos per treatment were opened at each time; the silage at each depth was weighed, mixed, and sampled; and the samples were analyzed for DM and pH.

Data collected from the pilot-scale silos were analyzed by analysis of variance of a split-plot design with sealing treatments and time after filling being whole-plot factors and location (depth from the initial surface) within drums denoting the subplot units. When significant sealing treatment by storage time by depth interactions occurred, the depths were analyzed separately. Comparisons were then made within days postfilling across sealing treatment.

Results and Discussion

The effects of sealing treatment, depth from the initial surface, and days postfilling on the preservation efficiency and nutritive value traits measured are shown in Table 1 (farm-scale silos) and Table 2 (pilot-scale silos).

In the farm-scale silos, sealing (with or without a roof) dramatically reduced silage DM losses and storage temperatures at the 5 and 10 inch depths. The silages in the two sealed silos were well preserved at all three depths, but only the silage at the 20 inch depth in the two unsealed silos was of acceptable quality. Silage DM losses at the 20 inch depth ranged from 6.3 to 12.8% in the four silos. Temperatures in the two sealed silos peaked within the first 3 days postfilling; temperatures in the unsealed, no-roof silo peaked within the first 3 to 4 wk; but temperatures in the unsealed, roof silo remained high for the longest time, particularly at the 20 inch depth. The unusually high rainfall during the 90-day storage (16.8 inches) produced a large amount of percolated water through the unsealed, no-roof silage; and the silages at the 10 and 20 inch depths were 10.1 and 15.3 percentage units wetter than the pre-ensiled forage. In contrast, the silages at the 10 and 20 inch depths in the unsealed, roof silo were actually 22.3 and 2.3 percentage units drier than the pre-ensiled forage, because considerable dehydration/evaporation took place in the absence of a seal. Placing a roof over the unsealed silage did not affect DM losses at the 5 and 20 inch depths compared to the unsealed, no-roof silage, but it reduced DM loss from 52.4 to 23.4% at the 10 inch depth. In-situ DM digestibilities of the unsealed silages at the 5 and 10 inch depths were 10 to 15 percentage units lower than those of the sealed silages.

In the pilot-scale silos, sealing (with or without a roof) produced similar preservation traits (i.e., DM content, DM recovery, and pH) as the farm-scale silos after 90 days of storage; and little, if any, additional deterioration occurred after 180 days. In general, the pilot-scale, unsealed, roofed silos had similar silage preservation traits to the farm-scale silo; however, silages in the pilot-scale, unsealed, no-roof silos at 90 days were much more deteriorated than their farm-scale counterpart. This is explained, in part, by a greater influence of the side wall in the 2.1 ft diameter pilot silos vs. the 13.5 ft wide farm silos. Delayed sealing (7 days) resulted in a dramatic improvement in preservation efficiency in the top 36 inches of silage compared to no seal, which is consistent with our previous studies with corn and forage sorghum silages (KAES Report of Progress 651:135).

These data document that sealing alfalfa silage in bunker silos greatly increases preservation efficiency and nutritive value in the initial top 2 to 3 ft of ensiled material.

Table 1. Effects of Sealing Treatment and Depth from the Initial Surface on the Settling Distance, Dry Matter (DM) Content, DM Recovery (Rec.), pH, In-situ Digestibility (Dig.), and Maximum Temperature (Temp.) of the Alfalfa Silages Stored in Farm-scale Bunker Silos

Sealing treatment	Initial depth	Distance settled[1]	Initial DM	90-day silage DM	90-day silage DM rec.[2]	90-day silage pH	In-situ DM dig.	Maximum temp.[3]
	--- inches ---		%	%	%	units	%	
Unsealed/ No roof	5	3.0	55.3	65.4	66.4	8.21	64.3	148.3 (16)
	10		55.3	45.2	47.6	8.68	64.9	147.3 (17)
	20	4.6	50.8	35.5	90.6	4.85	74.9	125.9 (24)
Sealed/ No roof	5	1.5	54.9	52.9	90.7	5.23	74.7	107.1 (1)
	10		54.9	52.7	91.1	5.28	76.8	110.0 (1)
	20	2.2	50.4	47.2	89.5	5.20	75.4	113.6 (1)
Unsealed/ Roof	5	<1.0	53.4	72.0	64.2	8.10	59.4	142.5 (17)
	10		53.4	75.7	76.6	7.57	59.4	148.8 (35)
	20	<1.0	47.2	49.5	87.2	4.63	71.4	134.7 (82)
Sealed/ Roof	5	<1.0	56.8	57.8	91.5	5.41	74.5	111.0 (2)
	10		56.8	57.7	89.9	5.41	74.7	112.7 (3)
	20	<1.0	50.3	53.8	93.7	5.20	68.7	108.9 (1)

[1]Distance settled during the 90-day storage period was not recorded for the 10 inch depth.
[2]Expressed as a % of the DM ensiled.
[3]The day postfilling when the maximum temperature occurred is shown in parentheses.

Table 2. Effects of Days Postfilling, Depth from the Initial Surface, and Sealing Treatment on the Dry Matter (DM) Content, DM Recovery, and pH of the Alfalfa Silages Stored in the Pilot-scale Silos

Days after filling	Initial depth	Sealing treatment[1]	DM	DM recovery[2]	pH
	inches		%	%	units
7	0 to 12	1	54.3	96.9	6.72
		2	52.9	94.5	5.80
		SE[3]	2.71	2.11	.15
	12 to 24	1	52.8	96.8	5.53
		2	53.5	97.0	5.58
		SE	3.53	2.79	.49
	24 to 36	1	54.5	98.1	5.56
		2	53.9	97.3	5.62
		SE	3.00	1.54	.15
90	0 to 12	1	23.6[a]	37.7[a]	7.71[b]
		2	49.1[b]	92.0[c]	5.08[a]
		3	48.3[b]	73.9[b]	8.94[c]
		5	49.4[b]	87.3[c]	5.53[a]
		SE	3.51	2.00	.09
	12 to 24	1	22.6[a]	66.8[a]	5.03[a]
		2	50.3[c]	94.4[c]	5.16[a]
		3	42.5[b]	84.1b	6.81[b]
		5	51.4[c]	93.4[c]	5.16[a]
		SE	2.46	2.17	.38
	24 to 36	1	23.5[a]	77.9[a]	4.90
		2	54.5[b]	97.0[b]	5.10
		3	54.5[b]	97.0[b]	5.26
		5	49.9[b]	94.7[b]	5.12
		SE	2.79	1.87	.11
180	0 to 12	1	26.8[a]	34.4[a]	8.28[b]
		2	46.8[b]	98.4[cd]	5.00[a]
		3	47.9[b]	57.4[b]	8.96[c]
		4	50.4[b]	92.5[d]	5.50[a]
		5	52.8[b]	84.3[c]	5.36[a]
		SE	2.71	2.11	.15
	12 to 24	1	21.3[a]	59.3[a]	5.74[b]
		2	47.8[b]	94.5[c]	5.07[a]
		3	45.1[b]	82.5[b]	6.62[b]
		4	51.3[b]	93.0[c]	5.06[a]
		5	54.2[b]	92.4[c]	5.13[a]
		SE	3.48	3.07	.55
	24 to 36	1	18.3[a]	65.9[a]	5.11
		2	48.9[b]	93.1[b]	5.07
		3	49.9[b]	90.4[b]	5.10
		4	50.9[b]	91.5[b]	5.02
		5	51.9[b]	90.5[b]	5.10
		SE	2.63	1.68	.16

[1]Treatment (TRT) 1 = unsealed, no roof; TRT 2 = sealed, no roof; TRT 3 = unsealed, roof; TRT 4 = sealed, roof; and TRT 5 = delay sealed, no roof.

[2]Expressed as a % of the DM ensiled.

[3]SE = standard error.

[a,b,c,d]Means across sealing treatment at each day postfilling and depth in the same column with different superscripts differ (P<.05).