LOSSES FROM TOP SPOILAGE IN CORN AND FORAGE SORGHUM SILAGES IN HORIZONTAL SILOS[1]

J. T. Dickerson[2], K. K. Bolsen, B. E. Brent, and C. Lin[3]

Summary

Corn and forage sorghum silages were stored in small (simulated), farm-scale, bunker silos for 180 days, and dry matter (DM) and organic matter (OM) losses; fermentation characteristics; and temperatures were measured at 10, 20, and 30 inches from the original silage surface. Sealing the exposed surface significantly increased DM and OM recoveries in both crops, regardless of depth. Immediate sealing preserved more DM and OM than delayed sealing, particularly at the 10-in. depth.

The unsealed silages from both crops maintained dramatically higher temperatures within the top 3 ft. than sealed silages. As expected, the unsealed silages deteriorated completely at 10- and 20-in. depths, and the delayed-seal, forage sorghum silage showed considerable deterioration at the 10-in. depth. The immediately sealed corn silages had better fermentation profiles than their forage sorghum counterparts. A mold inhibitor, Top Savor®, increased OM recovery by about 2 percent in the forage sorghum silage, but had no effect on corn silage.

These results indicate that sealing (covering) silos immediately after filling greatly improves storage efficiency and silage quality in the top 3 ft.

(Key Words: Silage, Top Spoilage, Corn, Sorghum.)

Introduction

Bunkers, trenches, or stacks appear to be economical for storing large amounts of ensiled feeds, but their design allows large percentages of the ensiled material to be exposed to the weather. In addition, silage in horizontal silos is affected by other influences such as crop DM, permeability of the silo walls, surface area exposure during filling, length of storage, and rate of removal, all of which result in a wide range of preservation losses throughout the silage mass.

Results presented last year (KAES Report of Progress 623) showed that over 50% of the DM was lost in the top 2 ft. of unsealed alfalfa silage after 12 wks of storage. To date, controlled experiments under farm-scale conditions have not adequately characterized DM losses in the top layer for corn and sorghum silages. Such data are necessary to assess the economic feasibility of sealing (covering) silage in horizontal silos.

Our objectives were to determine the extent of losses in the top 3 ft. of horizontal silos and to develop research techniques that simulate farm-scale conditions.

[1]Financial assistance was provided by Kemin Industries Inc., Des Moines, Iowa and Mr. Richard Porter, Porter Farms, Reading, Kansas.

[2]Former graduate student. Current address: Biotal, Inc., Ft. Dodge, Iowa.

[3]Former graduate student. Current address: Agri-King, Inc., Fulton, Illinois.

Experimental Procedures

Experiment 1: whole-plant corn. On August 28 and 29, 1990, whole-plant corn (2/3 milk line maturity and 35.4% DM) was chopped and packed into four, 16 ft. long × 13.5 ft. wide × 4 ft. deep, bunker silos. During filling, nylon net bags, each containing 4.5 lb of fresh material, were placed 10, 20, and 30 inches from the top of the original ensiled mass (3 bags/depth/silo). Thermocouples were placed at each bag location, and temperatures were recorded for the first 42 days. The silos contained similar amounts of fresh material and were packed with tractors to densities that were similar to farm-scale conditions. Treatments were 1) left unsealed; 2) sealed with .4 mm polyethylene sheeting; 3) sealed with .4 mm polyethylene sheeting after a topical application of a commercial mold inhibitor, Top Savor®, at 1.0 lb/10 sq. ft. (provided by Kemin Industries, Inc., Des Moines, Iowa); and 4) left unsealed for 7 days post-filling, then sealed as described for treatment 3. The sheeting was weighted with tires. Bunkers were emptied at 180 days after filling. The nylon net bags were recovered, and the silage was weighed, mixed, sampled, and frozen for future analyses.

Experiment 2: forage sorghum. On September 27 and 28, 1990, whole-plant, Pioneer 947 forage sorghum (late-dough maturity and 30.8% DM) was chopped and packed into four bunker silos and treated the same as in Experiment 1 (above).

Chemical analysis of the samples. The DM content of pre-ensiled material and silages was determined by drying for 72 h at 55 C in a forced-draft oven, with no correction for volatile losses. The dried samples were then ground in a Wiley mill (1-mm screen), and analyzed for total ash content by combustion. Parallel samples were analyzed fresh for pH, lactic acid, volatile fatty acids, ethanol (ETOH), and ammonia-nitrogen.

Results and Discussion

Experiment 1: whole-plant corn. Results are presented in Table 1. The DM content was lower at the 10- and 30-in. depths and higher at the 20-in. depth in the unsealed silage than in sealed silages. The unsealed silage retained less DM and OM at each depth than the sealed silages, and fermentation characteristics at the 10- and 20-in. depths were significantly improved by all three sealing treatments. Silages that were sealed immediately (TRT 2 and 3) had higher DM and OM recoveries at the 10-in. depth than the delayed-seal silage (TRT 4).

Few fermentation differences were observed among the sealed silages, although the delayed-seal silage had a numerically lower lactic:acetic acid ratio at the 30-in. depth. Unsealed silage had the highest maximum temperatures at the 10- and 20-in. depths. Both silages that were sealed immediately (TRT 2 and 3) had similar temperature profiles. As expected, the unsealed and delayed-seal silages had similar temperatures at all three depths until day 7 post-filling, when the TRT 4 silage was sealed.

Experiment 2: forage sorghum. Results are presented in Table 2. The unsealed silage had lower DM at the 10-in. depth and higher DM content at the 20-in. depth compared to silages that were sealed immediately. Similar to the corn silages, unsealed forage sorghum silage had dramatically lower DM and OM recoveries at the 10- and 20-in. depths and numerically lower values at 30 in. compared to the sealed silages. The delayed-seal silage (TRT 4) tended to have lower DM and OM recoveries, regardless of depth, compared to the silages that were sealed immediately (TRT 2 and 3). At 10 in., silage sealed immediately with Top-Savor (TRT 3) had higher DM and OM recoveries than silage without Top-Savor (TRT 2). Estimated OM recovery values were generally higher than actual values, regardless of sealing treatment or storage depth.

The unsealed silage had deteriorated completely at the 10- and 20-in. depths, as evidenced by high pH values and lack of sufficient fermentation end-products. The delayed-seal forage sorghum silage at the 10-in. depth underwent more deterioration than its delayed-seal corn silage counterpart. Silages that were sealed immediately (TRT 2 and 3) had higher pH values and less fermentation acids at 10 in. than at the 20- and 30-in. depths. Similar to the corn silages, unsealed forage sorghum silage reached and maintained the highest temperatures, regardless of depth, and the maximum temperature at 20 in. was higher in the delayed-seal silage than in silages that were sealed immediately. The maximum temperature of the unsealed silage was reached on day 20 post-filling at all three depths. In contrast, temperatures in the delayed-seal silage reached their highest values at the 10-, 20-, and 30-in. depths by 6, 8, and 5 days post-filling, respectively. The two silages that were sealed immediately (TRT 2 and 3) both reached their maximum values at the 10-,20-, and 30-in. depths by 5, 7, and 5 days post-filling, respectively.

Conclusions. These results indicate that the mechanisms of silage losses from top spoilage are complex and probably not determined by a single factor. Actual spoilage loss appears to be due to an interaction of various chemical, physical, and microbiological processes. The partial verification of a rapid and accurate method to estimate these losses using silage ash content (see page 128 of this report), along with the small, farm-scale, research silos used in these experiments, should facilitate future studies on mechanisms of top spoilage loss and lead to the development of new, effective, protection methods.

Table 1. Effects of Sealing Treatment and Depth from the Original Surface (Depth) on the DM Content, DM and OM Recoveries (Rec.), Fermentation Characteristics, and Temperature (Temp.) of Corn Silages from Buried Bags Stored in the Farm-scale Silos in Experiment 1

Sealing treatment[1]	Depth, inches	DM, %	Actual DM rec.[2]	Actual OM rec.[2]	Est. OM rec.[3]	pH	Lactic acid	Acetic acid	ETOH	NH_3-N	Lactic: acetic	Temp.[4], °F
							----- % of the silage DM -----					
TRT 1	10	23.0	19.6	15.5	25.2	6.69	.15	.42	.20	.03	.36	131 (135)
	20	34.4	70.6	70.1	74.5	5.10	.52	1.00	.27	.02	.52	129 (131)
	30	30.3	80.8	78.0	90.8	3.78	3.51	3.43	1.64	.14	1.02	99 (100)
TRT 2	10	29.5	77.5	77.1	82.1	4.46	1.31	2.19	.37	.11	.60	84 (108)
	20	32.9	90.9	90.2	86.5	3.84	3.38	1.74	1.51	.11	1.94	93 (106)
	30	31.9	87.7	87.2	88.1	3.86	3.26	1.62	1.52	.10	2.01	91 (100)
TRT 3	10	29.3	75.3	74.0	74.2	5.54	.33	.57	.38	.10	.58	86 (109)
	20	32.3	85.3	84.7	83.6	3.89	1.41	1.34	1.89	.17	1.05	95 (109)
	30	32.1	85.3	84.3	81.5	3.81	3.01	1.65	1.16	.13	1.82	91 (97)
TRT 4	10	30.3	67.6	66.9	86.0	4.71	.83	1.23	1.09	.09	.67	90 (120)
	20	32.3	84.5	84.4	99.0	3.93	1.88	1.20	1.29	.07	1.57	91 (113)
	30	32.0	87.6	87.0	92.0	3.81	3.03	2.03	1.63	.10	1.49	91 (93)

[1]Treatment (TRT) 1 = unsealed; TRT 2 = sealed immediately; TRT 3 = sealed immediately plus Top Savor®; and TRT 4 = sealed 7 days post-filling plus Top Savor®.

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

[3]Estimated (est.) OM recovery calculated from equation on page 128 of this report.

[4]Temperature at 30 days post-filling (maximum temperature from 0 to 42 days post-filling in parentheses).

Table 2. Effects of Sealing Treatment and Depth from the Original Surface (Depth) on the DM Content, DM and OM Recoveries (Rec.), Fermentation Characteristics, and Temperature (Temp.) of Forage Sorghum Silages from Buried Bags Stored in the Farm-scale Silos in Experiment 2

Sealing treat-ment[1]	Depth, inches	DM, %	Actual DM rec.[2]	Actual OM rec.[2]	Est. OM rec.[3]	pH	Lactic acid	Acetic acid	ETOH	NH_3-N	Lactic: acetic	Temp.[4], °F
							----- % of the silage DM ------					
TRT 1	10	27.7	23.0	19.1	23.9	8.77	ND[5]	.23	ND	.03	---	137 (137)
	20	36.9	46.8	44.0	51.9	9.12	.09	.10	ND	.04	.90	117 (117)
	30	27.7	79.8	75.8	74.5	3.90	5.75	6.61	1.04	.09	.87	97 (97)
TRT 2	10	31.5	78.7	75.2	79.1	4.43	.35	2.67	1.33	.09	.52	75 (108)
	20	29.4	93.3	90.0	101.7	3.81	5.18	2.77	.87	.07	1.87	81 (104)
	30	27.6	93.3	91.5	98.1	3.70	6.17	2.30	.70	.07	2.68	84 (91)
TRT 3	10	31.2	82.0	79.9	88.0	4.00	.45	1.42	.93	.04	.32	68 (109)
	20	29.7	93.4	91.3	95.3	3.80	3.82	2.46	.90	.08	1.55	82 (102)
	30	27.2	93.0	90.6	94.3	3.75	7.31	3.14	.76	.08	2.33	81 (95)
TRT 4	10	26.1	72.8	69.3	72.1	7.36	.17	.19	.62	.05	.89	77 (113)
	20	30.0	90.0	88.3	93.2	3.80	6.93	2.90	.83	.08	2.39	88 (109)
	30	28.2	87.1	84.2	91.6	3.82	7.33	4.23	1.16	.08	1.73	84 (95)

[1]Treatment (TRT) 1 = unsealed; TRT 2 = sealed immediately; TRT 3 = sealed immediately plus Top Savor®; and TRT 4 = sealed 7 days post-filling plus Top Savor®.
[2]Expressed as a % of the DM or OM ensiled.
[3]Estimated (est.) OM recovery calculated from equation on page 128 of this report.
[4]Temperature at 30 days post-filling (maximum temperature from 0 to 42 days post-filling in parentheses).
[5]ND = not detected.