

# RATE AND EXTENT OF TOP SPOILAGE LOSSES OF ALFALFA SILAGE STORED IN HORIZONTAL SILOS<sup>1</sup>

*J. T. Dickerson, Y. Niwa<sup>2</sup>, K. K. Bolsen,  
B. E. Brent, C. Lin, and J. E. Bradford*

## Summary

Effects of covering, time, and depth from the surface on the rate and extent of top spoilage losses in alfalfa silages stored in horizontal silos were studied under pilot- and farm-scale conditions. Covering silages increased silage DM and nutrient recoveries, regardless of time or depth from the original surface, when compared to uncovered counterparts. Treatment  $\times$  location  $\times$  time interactions ( $P < .001$ ) were observed for pH, lactic acid, and DM recovery in uncovered silages. By week 2 post-ensiling, significant deterioration had occurred in the top foot of uncovered silages, as evidenced by higher pH (7.36) and lower lactic acid (2.1% of the silage DM) and DM recoveries (85.6% of the DM ensiled). After week 4 post-ensiling, significant deterioration had occurred in the second foot from the surface, and it continued into the third foot after week 7. These data indicate that protecting the silage stored in the top 3 ft of horizontal silos immediately after filling should greatly increase storage efficiency.

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

## Introduction

Horizontal (bunker and trench) silos are economically attractive for storing large amounts of ensiled feeds, but by design, they allow large percentages of the silage mass to be exposed to the environment. Because these structures are relatively shallow, over 20% of

the original ensiled volume can be within the top 3 ft. Past research with corn has shown dry matter (DM) losses of up to 40% in the top 20 inches of silage. To date, controlled experiments under simulated farm-scale conditions have not adequately characterized the rate and extent of DM losses occurring in this top layer. Such data are necessary to assess the economic feasibility of covering silage in horizontal silos.

Our objectives were to determine the extent of losses in the top 3 ft of farm-scale horizontal silos and to develop a laboratory model to study the rate and extent of those losses.

## Experimental Procedures

**Pilot-scale silos.** First-cutting alfalfa (10% bloom) was packed to equal densities (15 lb of DM/ft<sup>3</sup>) into 16, 55-gallon drums. Each drum was divided horizontally with plastic netting into thirds to partition the fresh material at 12 and 24 inches below the original surface. A perforated 1.0 in. PVC pipe was placed at the bottom of each drum and connected through an air-lock to drain off percolated water. Drums were either covered with .4 mm plastic sheeting or left uncovered. Pilot silos were stored outside and opened at 2, 4, 7, and 12 weeks post-ensiling (two silos/treatment/opening time). Samples were analyzed for pH, lactic acid, acetic acid, and DM content. The data were analyzed as a split-plot design with duplicate drums and time periods being whole-plot factors, and location (depth) within drums denoting the sub-plot units.

---

<sup>1</sup>Financial assistance was provided by Kemin Industries Inc., Des Moines, Iowa and Mr. Richard Porter, Reading, Kansas.

<sup>2</sup>Visiting researcher from Nihon University, Fujisawa City, Japan.

**Farm-scale silos.** Second-cutting alfalfa (10% bloom) was swathed, wilted, chopped, and packed in two, 16 ft long × 13.5 ft wide × 4 ft deep, bunker silos. During filling, nylon net bags, each containing 6.5 lb of fresh material, were placed 10, 20, and 30 inches from the top of the original silage mass. Thermocouples were placed at each location, and temperatures were recorded daily for the first 30 days. The silos contained similar amounts of fresh material and were packed by a tractor to densities that were similar to those in the pilot-scale silos. Treatments were the same as in the pilot-scale trial. Bunkers were emptied at 12 weeks post-ensiling. Nylon bags were recovered, and silage was weighed, mixed, sampled, and analyzed as above.

## Results and Discussion

Silages stored in covered pilot-scale silos were well preserved and of high quality, whereas uncovered silages were of poor quality and deteriorated steadily during storage. Treatment × location × time interactions ( $P < .001$ ) were observed for pH, lactic acid content, and DM recovery. Figure 1 shows the effects of covering and time post-ensiling on silage pH at the three depths from the original surface. The silage pH in covered drums was below 5.0 at all four opening times, regardless of location. In contrast, in the top 12 inches, uncovered silages exhibited a dramatically higher pH (7.36) by week 2 post-ensiling. Deterioration progressed as deep as 24 inches in uncovered silages by week 7, and by week 12, pH of silage was similar below 24 inches and at 12 to 24 inches (6.15 and 6.14).

Illustrated in Figure 2 are the effects of covering and time post-ensiling on silage lactic acid content at the three depths from the original surface. Lactic acid content of silage stored in covered drums was not affected by time or location; 7.3, 8.2, and 8.3% of the silage DM at the 0 to 12, 12 to 24, and 24 to 36 inch depths, respectively, at week 12 post-ensiling. Lactic acid content of a silage represents a balance between lactic acid production and utilization. There was insufficient lactic acid to preserve

silage in the top 12 inches of uncovered silages at all of the opening periods. Initially in the uncovered silages, adequate amounts of lactic acid were present below 12 inches. However, by week 12, silage lactic acid content had markedly declined, whereas acetic acid had increased (9.9, 10.6, and 10.0% of the silage DM at the 0 to 12, 12 to 24, and 24 to 36 inch depths, respectively). Silage acetic acid and ammonia-nitrogen contents were higher ( $P < .05$ ) when silage was stored in uncovered silos, regardless of location or storage period. Silage made in uncovered silos possessed characteristics commonly observed in poorly preserved material.

Shown in Figure 3 are the effects of covering and time post-ensiling on silage DM recovery at the three depths from the original surface. Silages stored in covered drums exhibited high DM recoveries, regardless of time or location, averaging 92.3, 91.3, and 91.3% of the DM ensiled at the three depths at week 12. As expected, DM recoveries were compromised in uncovered silages, regardless of depth. Silage DM recovery decreased linearly at each opening date for silage above 12 inches and at week 4 in silage stored 12 to 24 inches from the original surface. The DM recoveries of silage stored in uncovered silos at week 12 were 33.9, 59.2, and 64.2% of the DM ensiled at the 0 to 12, 12 to 24, and 24 to 36 inch depths, respectively.

Shown in Table 1 are the effects of covering and depth from the surface on silage DM recovery, pH, lactic acid, acetic acid, and temperature in the farm-scale silos. The covered silage was of excellent quality and similar to silage made in the covered pilot-scale silos. Silage from the uncovered farm-scale silo exhibited low DM recovery (22.2% of the DM ensiled), high pH (9.59), and low lactic acid content (0.1% of the silage DM) 10 inches from the surface at 12 weeks post-ensiling. Below 20 inches from the surface, silage DM recovery and pH approached the levels in covered silage. Silage temperature at 30 days post-ensiling was significantly higher at all depths in the

uncovered farm-scale silo when compared to silage that was covered.

Pilot-scale silos successfully replicated most conditions in the farm-scale silos. However,

temperatures in the farm-scale silos were higher, probably representing greater heat dissipation from the smaller, less insulated, pilot-scale silos.

**Table 1. Effects of Covering Treatment and Depth from the Surface on DM Recovery, pH, Lactic Acid, Acetic Acid, and Temperature of Alfalfa Silage Stored in Farm-scale Horizontal Silos at 12 Weeks Post-ensiling**

Treatment	Depth from surface, inches	DM recovery <sup>1</sup>	pH	Lactic acid <sup>2</sup>	Acetic acid <sup>2</sup>	Lactic: acetic	Temp, <sup>3</sup> °F
Uncovered	10	22.2	9.58	.1	---	---	97 (120)
	20	76.6	5.35	3.1	2.0	1.6	127 (122)
	30	85.4	4.55	2.6	2.2	1.2	82 (106)
Covered	10	92.8	4.88	2.4	1.3	1.8	72 (75)
	20	98.4	4.49	7.5	3.6	2.1	77 (82)
	30	94.3	4.50	8.0	4.8	1.7	72 (86)

<sup>1</sup>Expressed as a % of the DM ensiled.

<sup>2</sup>Expressed as a % of the silage dry matter.

<sup>3</sup>Temperature at 30 days post-ensiling and maximum temperature from 0 to 30 days in parenthesis.

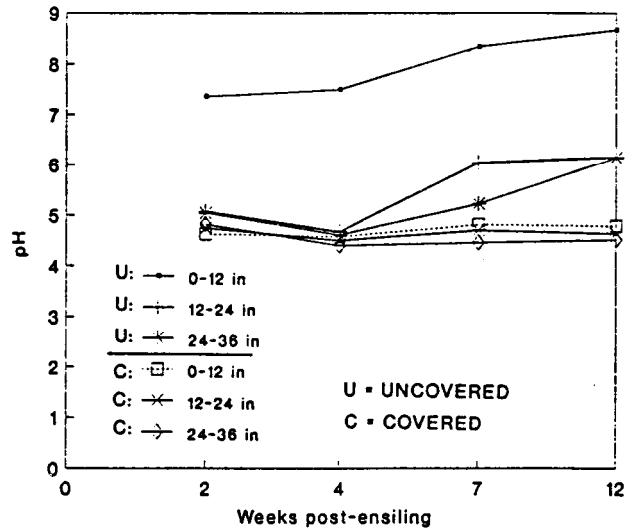


Figure 1. Effects of Covering and Time Post-ensiling on Silage pH at the Three Depths from the Original Surface in Pilot-scale Silos

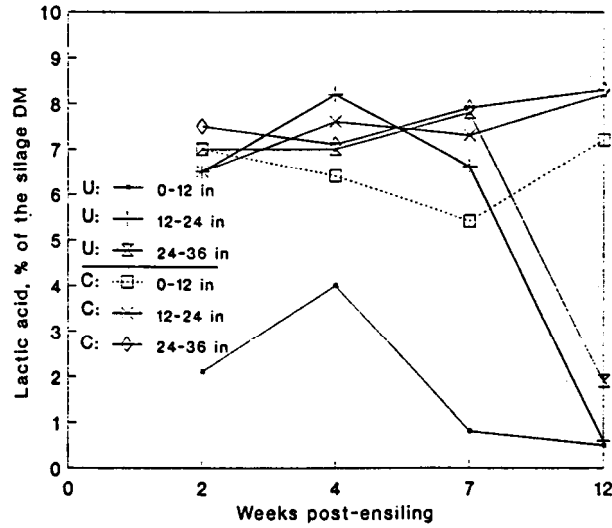


Figure 2. Effects of Covering and Time Post-ensiling on Silage Lactic Acid Content at the Three Depths from the Original Surface in Pilot-scale Silos

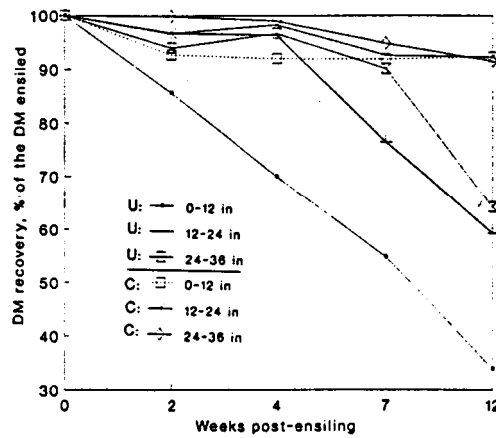


Figure 3. Effects of Covering and Time Post-ensiling on Silage DM Recovery at the Three Depths from the Original Surface in Pilot-scale Silos