Northern NY Agricultural Development Program
2004 Project Report

Economic and Environmental Impacts Of Corn Silage Maturity Management

Project Leaders:
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Background:

Farmers often chop corn for silage before the proper stage of maturity. Harvesting prior to proper maturity can result in reduced dry matter yield and increased effluent production. Because of the very high biochemical oxygen demand (BOD), which is an estimate of pollution potential of silage effluent, this represents a potentially serious source of water pollution. It has been found that silage effluent has nearly 60 times the BOD of human sewage because of the nutrient density of the effluent.

In the U.S., owners of large livestock operations (Concentrated Animal Feeding Operations) have recently been required to collect and treat silage effluent. The objectives of this project in Northern New York are:

1. To evaluate yield and forage quality changes with increasing maturity for one corn hybrid.

2. To determine the effect of maturity on silage effluent production and effluent characteristics.

Methods:

One field of NK3030 (RM93d), planted in early June 2005 at Cha-Liz Farm in West Chazy, NY, was selected for this study. Harvest dates of September 17 (Mature 1), September 24 (Mature 2) and October 8 (Mature 3) were determined based on maturity of silage at the time of harvest.

At each harvest time, the corn forage was hand harvested at 12" chop height from 17'4" of row replicated 4 times for each stage of maturity. Harvested corn was weighed to estimate yield. Corn forage was manually harvested on September 17th and fed through a chopper head at 1.9 cm (3/4") theoretical length of cut and processed at 3 mm roller spacing. Corn harvested on September 24th and October 8th was mechanically harvested through the same chopper head and settings. Three levels of maturity were targeted for dry matters at: 25% (Mature 1), 30% (Mature 2), and 35% (Mature 3).

Midi Silos Used for Ensiling

Previously constructed midi silos were used for ensiling fresh chopped corn. These structures are three feet by four feet concrete culverts placed upright and buried ~two feet in the ground.

Midi silos were filled at a packing density of 12-14 lbs. DM/cubic foot for each of the three stages of maturity, with four replications. Silos were filled with ~1000 pounds of fresh weight corn forage.

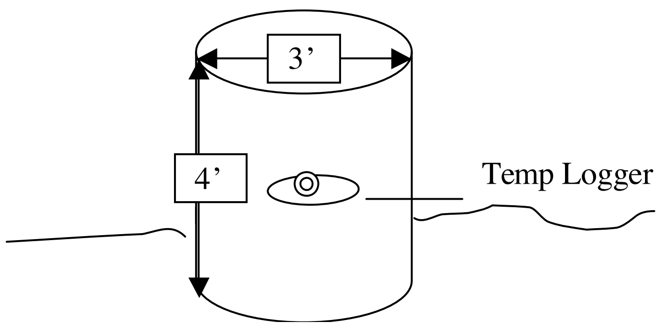

Figure 1. Buried concrete Midi-silo showing placement of temperature data logger.

At filling, sub-samples were taken randomly through filling for each silo and composited. Samples were analyzed for nutrient analysis at Dairy One Forage Laboratory (Ithaca, NY) for dry matter, crude protein, soluble protein, ADF, NDF, ash, lignin, starch, and sugar.

Figure 2. View of midi silos positioned on sloping hill to allow for external collection of effluent.

A "Tiny Talk" temperature data logger (Figure 1.) was placed in each silo at filling at a depth of approximately twenty-two inches from the bottom of the silo, and temperature data was recorded every two hours.

One "Tiny Talk" was placed outside of the silos to collect ambient temperature.

After filling, each silo was sealed using plastic sheeting, a tire for weight and a wooden board to prevent pooling of water on top of the packed surface.

Effluent was collected 1 week after silo filling. Volume was measured, and the effluent analyzed for BOD5 (5-day biochemical oxygen demand) and nutrient content including crude protein, sugar, and starch.

On December 14, 16 and 22nd, after 70-100 days of ensiling, silos were opened and emptied. Since the surface of the silos was frozen, spoiled silage was not easily discernible. Therefore, the top six inches of silage was removed from all silos, weighed and discarded. The remaining silage was removed in three twelve-inch sections identified as top, middle and bottom of silos. Material within these sections was composited and analyzed for nutrient content.

Silage was analyzed for particle size distribution, aerobic stability and nutrient analysis. Aerobic stability was analyzed by storing silage in Honig boxes for 48 hrs. in a controlled temperature room at 77°F and evaluating temperature change using a Tiny Talk temperature data logger.

Nutrient analyses included: dry matter, crude protein, soluble protein, ADF, NDF, ash, lignin, non-soluble carbohydrates, starch, sugar, pH, lactic acid, volatile fatty acids, ammonia, mold and yeast counts (Dairy One, Ithaca, NY). In Vitro dry matter disappearance (48hr) and NDF disappearance was analyzed at Miner Institute (Chazy, NY) using an Ankom Daisy II incubator and Ankom Fiber digester.

Data was analyzed as a one-way analysis of variance for a completely randomized design evaluating the effect of corn maturity on forage quality parameters after ensiling. In addition, effects of corn maturity on effluent production were also evaluated using this design.

Results:

Fresh forage DM and nutrient parameters are presented in Table 1. The harvested forage was less mature than anticipated with dry matters of 23%, 25% and 31% for the three levels of maturity. The crude protein and sugar content of the forage was higher for the less mature forages (Mature 1 and 2) while the total DM disappearance was highest for the more mature corn forage (Mature 3). The dry matter density of the silos increased with increasing maturity, indicating that bunk density may be improved when packing more mature corn forage.

Table 1. DM and nutrient parameters of fresh chopped corn forage prior to ensiling and packing density of silos.

	Mature 1		Mature 2		Mature 3		
Item	mean	sd	Mean	sd	Mean	sd	*P*-value
DM	23.27[c]	0.22	25.19[b]	0.56	31.17[a]	0.33	<0.001
CP (%DM)	7.95[a]	0.13	7.93[a]	0.61	6.15[b]	0.19	0.001
Lignin (%DM)	4.00	0.24	3.03	0.63	3.78	0.53	0.051
Sugar (%DM)	16.00[a]	0.48	14.03[ab]	2.48	9.28[b]	3.79	0.015
Starch (%DM)	20.93[b]	1.01	26.40[a]	0.61	27.65[a]	3.49	0.004
NDF (%DM)	51.48[a]	1.98	44.97[b]	0.83	44.12[b]	2.07	0.004
DMdt48 (%DM)	78.03[b]	1.73	79.75[ab]	0.91	81.10[a]	1.41	0.036
NDFd48 (%DM)	57.34	2.59	55.90	1.23	57.87	1.79	0.376
Wet Density*	44.30[a]	0.70	46.10[a]	0.84	42.21[b]	1.26	0.001
DM Density*	11.16[c]	0.18	12.60[b]	0.19	14.14[a]	0.58	<0.001

**lbs/cubic foot*

One week after ensiling, silos packed at 23%DM and 25%DM averaged 2.7 and 8.8 L of effluent, respectively (Table 2). No effluent was produced from silos packed at 31%DM. It is not clear why the 25% DM forage produced more effluent than the less mature forage (23%DM), however the higher wet density of the Mature 2 silage may have been a contributing factor. Crude protein, starch and BOD5 levels did not differ in the effluent produced by the less mature forages. Sugar content was highest in the effluent from the least mature forage.

Table 2. Effluent recovery and profile after ensiling.

	Mature 1		Mature 2		Mature 3		
Item	mean	sd	mean	sd	mean	sd	*P*-value
Effluent Volume (L)	2.68[b]	2.42	8.83[a]	0.50	0.00[b]	0.00	<0.001
Effl. CP (%DM)	9.43	0.62	8.98	1.20	-	-	0.531
Effl. Sugar (%DM)	44.65[a]	8.24	28.83[b]	9.29	-	-	0.044
Effl. Starch (%DM)	3.10	1.26	2.60	0.89	-	-	0.541
Effl. BOD5* (mg/L)	28,538	13,641	36,313	927	-	-	0.299

**BOD5=Biochemical Oxygen Demand=amount of oxygen required by bacteria to decompose organic material over 5 days under aerobic conditions.*

The dry matter of forage after ensiling was ~ 2% units lower than fresh forage (Table 3). There was no difference in DM loss based on stage of maturity of forage at harvest. Crude protein, soluble protein, sugar and NDF values were lowest for the forage harvested at the latest stage of maturity (Mature 3). Starch values, on the other hand, were highest for Mature 3, indicating higher levels of starch in the kernels. Total DM digestibility was lowest for the least mature forage, however there was no difference in digestibility of forage NDF. Using the Milk2000 spreadsheet, (University of Wisconsin, version 7.4) Milk/ton was lowest for the least mature corn.

Table 3. DM and nutrient parameters of ensiled forage harvested at differing stages of maturity.

	Mature 1		Mature 2		Mature 3		
Item	mean	sd	mean	sd	Mean	sd	P-value
DM	21.93[c]	0.77	23.54[b]	1.06	28.83[a]	0.75	<0.001
DM loss (%DM)	9.08	2.30	11.69	0.76	12.51	3.00	0.130
CP (%DM)	8.18[a]	0.37	8.60[a]	0.32	7.63[b]	0.57	0.001
SP (%CP)	54.00[a]	3.07	47.67[b]	3.23	41.92[c]	2.57	<0.001
Lignin (%DM)	3.61	0.34	3.23	0.59	3.39	0.49	0.174
Sugar (%DM)	1.93[a]	0.48	1.53[ab]	0.46	1.28[b]	0.66	0.022
Starch (%DM)	20.19[c]	1.63	30.43[b]	1.46	33.85[a]	2.72	<0.001
NDF (%DM)	49.77[a]	1.04	44.54[b]	0.90	42.51[c]	1.56	<0.001
True DM disapp. (%DM)	78.56[b]	0.77	80.82[a]	1.40	81.22[a]	1.34	<0.001
NDF disapp. (%NDF)	57.68	0.99	57.36	2.93	56.33	3.76	0.481
Milk/Ton (lbs./ton)*	3276[b]	116	3411[a]	128	3497[a]	133	<0.001

**Milk2000 (University of Wisconsin, version 7.4)*

The fermentation profile of the silages indicate that all stages of maturity had been preserved well. The most mature forage had the highest pH and the lowest total silage acids content, particularly lactic and acetic acid (Table 4).

Table 4. Fermentation profile and digestibility parameters of forages after ensiling.

	Mature 1		Mature 2		Mature 3		
Item	mean	sd	Mean	sd	mean	sd	P-value
pH	3.91[b]	0.09	3.99[ab]	0.14	4.07[a]	0.11	0.007
Ammonia (% DM)	0.38[a]	0.06	0.37[a]	0.09	0.27[b]	0.03	<0.001
Lactic Acid (% DM)	6.36[a]	0.86	5.76[ab]	1.18	4.88[b]	0.42	0.001
Acetic Acid (% DM)	3.34[a]	1.28	3.31[a]	1.44	1.97[b]	0.32	0.006
Lactic Acid/Acetic Acid	2.09	0.57	2.05	0.81	2.55	0.47	0.113
Propionic Acid (% DM)	0.02	0.02	0.02	0.02	0.05	0.08	0.257
Isobutyric Acid (% DM)	0.12	0.02	0.12	0.03	0.10	0.03	0.088
Butyric Acid (% DM)	0.01	0.05	0.07	0.08	0.05	0.08	0.126
Total Silage Acids (% DM)	9.86[a]	1.11	9.28[a]	1.05	6.99[b]	0.45	<0.001

For each silo, mold and yeast counts were evaluated on the top, middle and bottom section of the silo. The maturity treatments were replicated 4 times, resulting in 12 total samples. Mold and yeast counts were fairly low for all maturity levels regardless of silo section with the highest colony counts reaching 200/g (Table 5).

Table 5. Frequency table of mold and yeast counts for maturity levels of forages after ensiling (colonies/g).

Item	Mature 1	Mature 2	Mature 3	*P*-value
Mold Counts				0.140
≤ 100	11	12	9	
100-1000	1	0	3	
>1000	0	0	0	
Yeast Counts				0.358
≤ 100	11	12	12	
100-1000	1	0	0	
>1000	0	0	0	

The average temperatures recorded by the data loggers during the ensiling process are presented in Figure 3. Temperature patterns indicate similar fermentations for both the Maturity 2 and 3 silages. The least mature forages lacked the characteristic 10-degree increase in temperature during the first few days of ensiling.

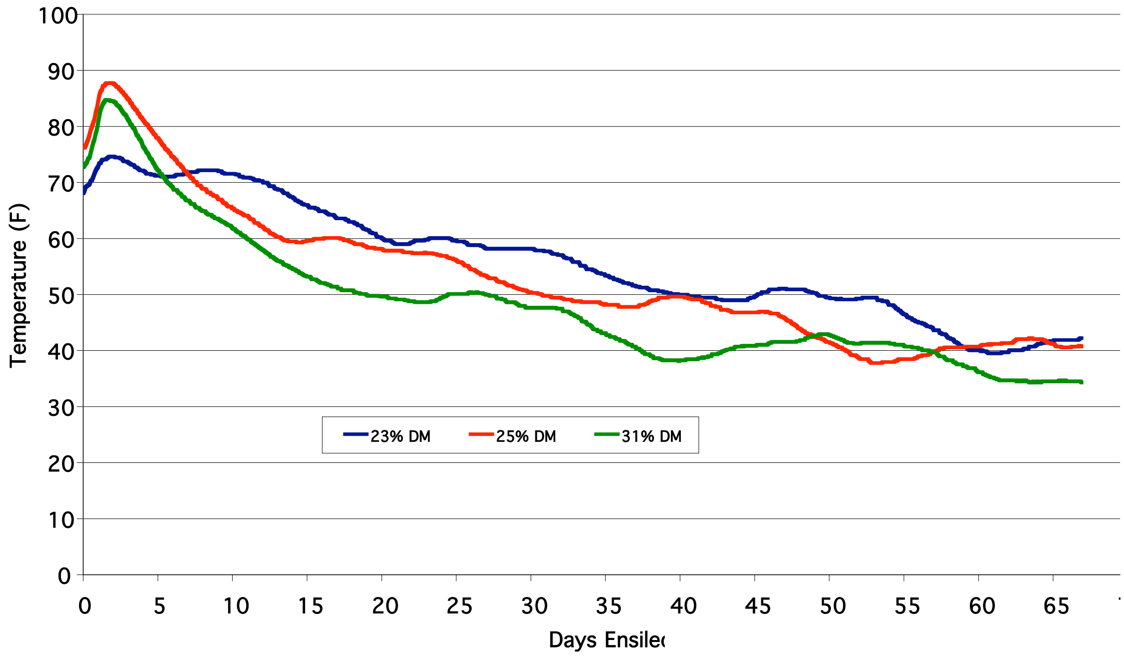

Figure 3. Midi silo temperature during ensiling process.

After ensiling, a subsample of silage removed from each silo section (top, middle and bottom) was placed into a Honig box and stored at 77°F to evaluate the stability of the forage over 48 hours. Silage and room temperature mean differences are illustrated by silage maturity for the top, middle and bottom of the silo in Figures 4, 5, and 6. All maturity levels showed similar patterns of heating regardless of section of the silo removed.

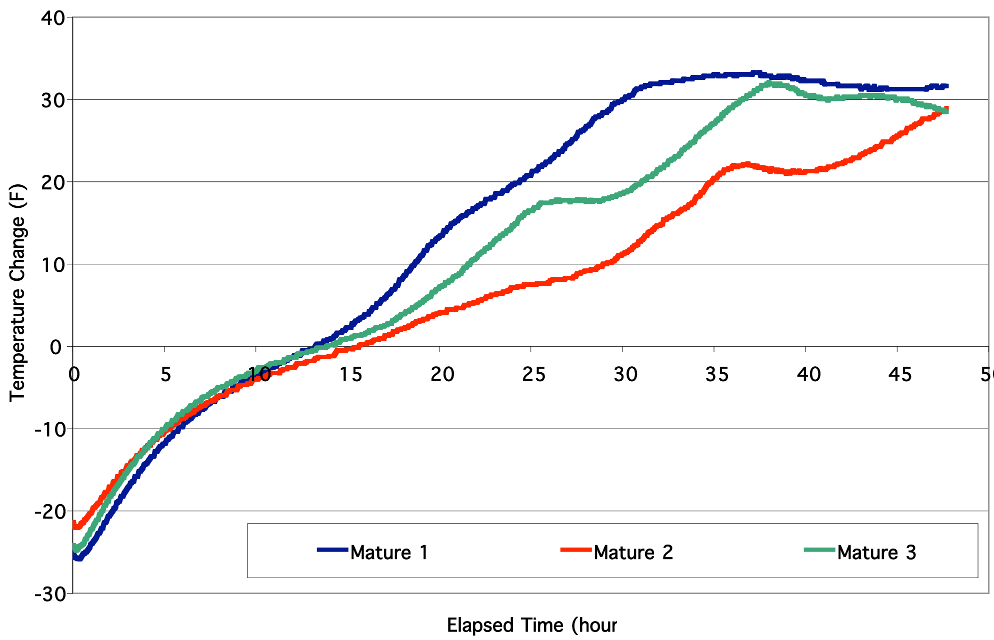

Figure 4. Silage-ambient temperature differences for silage removed from top third of silo by forage maturity.

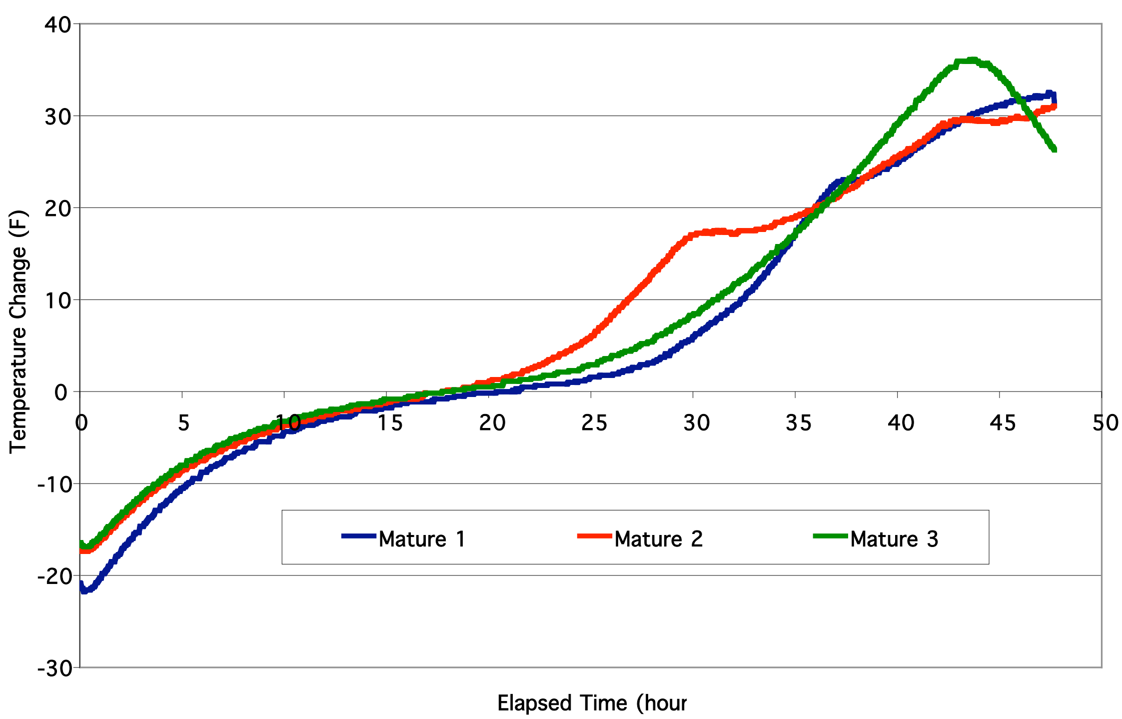

Figure 5. Silage ambient temperature differences for silage removed from middle third of silo by forage maturity.

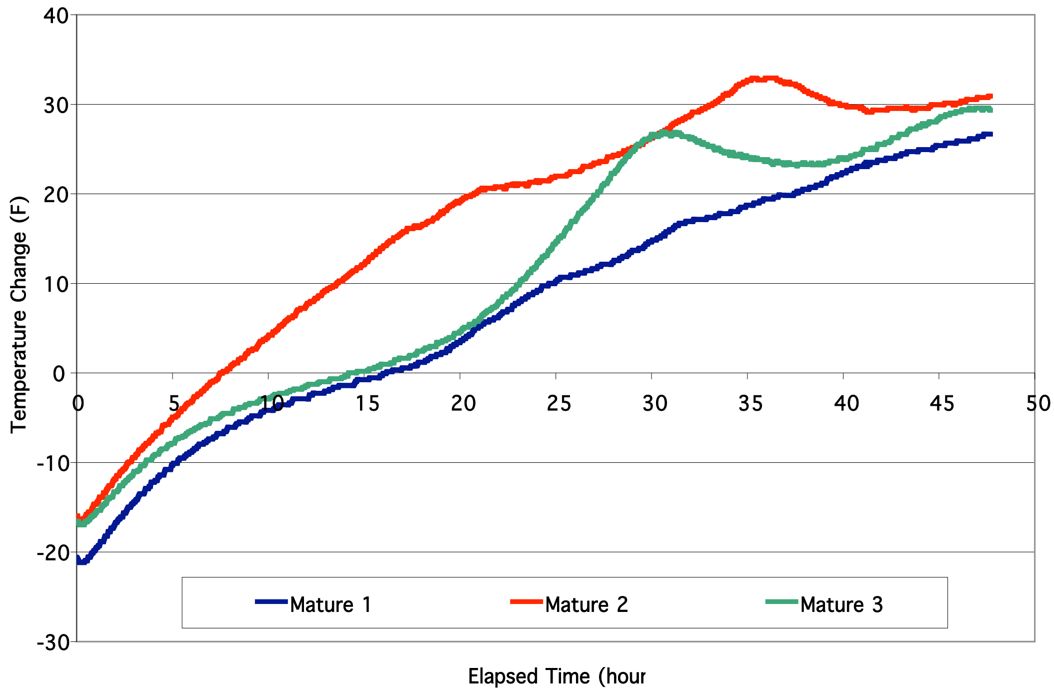

Figure 6. Silage-ambient temperature differences for silage removed from bottom third of silo by forage maturity.

Conclusions/Outcomes/Impacts:

Although the target dry matters were not met for this study, our findings indicate that immature corn forage harvested for silage (<25% DM) will have higher fiber with lower total DM digestibility. According to Milk2000 calculations, the least mature silage produced on this study would have resulted in 200 pounds less milk per ton of silage fed when compared to the mature corn forage harvested at 31% DM. Forage ensiled at less than 26% DM resulted in approximately 15 liters of effluent for every ton of forage ensiled. The biological impact of this nutrient dense pollutant is extremely alarming and should be avoided by ensiling only corn forage harvested at the proper maturity.

Outreach:

This information will be presented at the 2005 Corn Congress at Miner Institute on March 3, 2005. A brief summary of this report will be published in the Miner Institute Farm Report, which has a readership of over 11,000 farmers and agribusinesses throughout the U.S., Canada and Japan. This information will also be made available as a research report on the Miner Institute website (www.whminer.com).

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Northern New York Agricultural Development Program:

The Northern New York Agricultural Development Program provided funding for this agricultural environmental research project. The Northern New York Agricultural Development Program is a farmer-driven research and education program specific to New York state's six northernmost counties: Jefferson, Lewis, St. Lawrence, Franklin, Clinton and Essex. Thirty-three farmers serve on the Program board led by Co-Chairs Jon Greenwood of Canton (315-386-3231) and Joe Giroux of Plattsburgh (518) 563-7523. For more information, contact Jon, Joe or R. David Smith at 607-255-7286 or visit www.nnyagdev.org # # #