

FLOODED CORN SILAGE STUDY RESULTS – A PRELIMINARY REPORT

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INTRODUCTION

Preliminary results of analysis of from corn silage samples impacted by Hurricane Irene in 2011 are reported in this paper. Statistical analyses have not been completed on some of the data and additional chemical analysis is in process.

Hurricane Irene caused severe damage to crops in the Northeastern part of the United States. This insult occurred approximately one month prior to harvest for corn silage, which is the predominant forage crop that is fed to lactating dairy cows. High winds and rain resulted in various degrees of lodging to corn plants. In some fields, lodging was so severe that harvesting was impossible. In other fields, lodging was only to a moderate extent and the crops were harvested, but the health of the plants was in question because the normal flow of nutrients between the roots and the plant was most likely compromised. Flooding from over flowing rivers also resulted in plants being submerged under water for various lengths of time. Plants under stress from flooding usually respond by reduced photosynthesis and are thus more prone to root, ear, and stalk rot (Nielsen, 2003, 2011). If submerged for more than 48 to 72 h, plant death can occur because of a lack of oxygen in the soil (Thomison, 1995; Yordanova and Popova, 2007). In many instances, the flooding that occurred due to Hurricane Irene was above the ears of corn. When floodwaters receded, high quantities of silt remained on the ears and lower stalks of the plants.

After the hurricane, the FDA advised producers to avoid harvesting crops for animal feed that had the potential for contamination from sewage, heavy metals, pathogens, and industrial chemicals (USDA, Office of Communications, 2011). However, allowances were made based on a farm-to-farm basis with recommendations for segregation and monitoring of contaminated feed. In addition to the possible contaminants listed above, there was concern over high ash and microbial laden plants causing abnormal silage fermentations that might compromise the nutritive value of the crops. For example, the high buffering capacity from soil might increase the probability of a clostridial fermentation. Depending on the types of microorganisms present, there could have been effects on silage fermentation and (or) there could be direct threats to animal health (because of pathogenic organisms) during feed out (Driehuis and Oude Elferink, 2000). Potential for increased loads of mycotoxins in harvested plants was also a concern because of physical damage to the plants allowing for fungal growth (Teller et al., 2005).

JOINT REGIONAL STUDY

A joint regional study was initiated to collect samples in order to evaluate the effects of the hurricane on the nutritive value of corn silages. The objectives were to:

- a) Determine the degree of soil and heavy metal contamination
- b) Determine if the compromised crops ensiled normally by analyzing for normal fermentation profiles and volatile organic compounds
- c) Determine the occurrence and quantify concentrations of mycotoxins
- d) Qualitatively assess the degree of contamination from major microbial pathogens
- e) Examine the nutritive value of impacted silage.

STUDY PROTOCOL

Extension and industry personnel collaborated to identify farms whose corn silage was compromised due to lodging and/or flooding as a result of Hurricane Irene. A total of 30 damaged and 8 undamaged silages were collected. All silages had been ensiled for more than 60 days.

Samples were analyzed by Cumberland Valley Analytical for the following analyses:

- a) Standard wet chem: DM, CP, SP, ADF (ADFom*), ADL, NDF (NDFom*), starch, sugar, ash, Ca, P, Mg, Na, Fe, Mn, Zn, Cu
- b) In vitro NDF-D (NDF-Dom*), 30 h
- c) Yeast and molds
- d) Silage fermentation analyses: lactic acid, VFA, titratable acidity, CP equivalent from ammonia, and ammonia N as a percentage of total N
- e) Heavy metals: aluminum, antimony, arsenic, barium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, phosphorus, potassium, selenium, sodium, sulfur, thallium, zinc
- f) Mycotoxin panel: Aflatoxin B1, B2, G1, G2, Deoxynivalenol (DON), Zearalenone, 15 Acetyl-DON, 3 Acetyl-DON and T-2 Toxin
- g) Qualitative analysis for *Escherichia coli* O 157, *Listeria* spp., and *Salmonella* spp. using a lateral flow technique (Strategic Diagnostics Inc., Newark, DE). (These analyses are in progress.)
- h) Volatile organic compounds: Analysis is under development.

RESULTS AND DISCUSSION

Of the 30 samples considered to be damaged by the hurricane, 18 were exposed to flooding for ≥ 24 h. Seventeen of thirty samples were categorized as having moderate to high silt levels at harvest. Fifty percent of the damaged samples had abnormal appearances and 33% had abnormal smells at harvest.

The general nutrient composition of corn silages is in Table 1. In general the nutritive composition of the flooded corn silages was similar to that of control silages. However flooded corn silages had slightly lower NDF-D and higher ash content than control silages. Of particular note is the range in ash values for flooded samples (2.30 to 28.2%). We visited the farm that had the highest ash content of our samples prior to attempted harvest. Corn plants were so extremely silt laden in that particular field that the majority of the field was never harvested because it interfered with normal operation of the chopper. The normal content of ash in corn silages usually ranges between 3.5 to 4.5% (NRC, 2001; Dairy One Laboratories, 2011).

Table 1. Dry matter, pH, and chemical composition of control and flooded corn silage

Item	Control corn, n=8			Flooded corn, n=30		
	Mean	Min	Max	Mean	Min	Max
DM, %	35.16	28.60	42.20	37.90	27.30	51.70
CP, %	7.36	6.30	8.00	7.56	5.20	9.70
SP, ¹ % of CP	54.14	47.40	62.30	52.17	32.70	66.20
NE _L , mcal/kg	1.67	1.58	1.78	1.52	0.86	1.74
ADFom*, %	24.66	20.70	29.40	23.83	19.00	31.60
ADL, ² %	2.94	1.77	3.47	3.47	2.49	6.93
NDFom*, %	40.59	35.70	46.10	39.51	33.40	52.40
NDF-D om*, ³ % of NDF	60.25	55.20	65.40	52.40	31.50	63.20
Sugar, %	1.18	0.60	2.10	1.26	0.60	3.00
Starch, %	32.80	28.00	39.50	30.15	7.30	42.00
NFC, ⁴ %	45.66	39.80	51.60	41.82	16.40	54.10
Ash, %	3.85	2.60	7.70	8.93	2.30	28.20

¹SP = Soluble protein.

²ADL = Acid detergent lignin.

³NDF-D = 30 h In vitro neutral detergent fiber digestibility.

⁴NFC = Non-fiber carbohydrate.

*Organic matter basis.

The macro and trace mineral content of silages is in Table 2. Most minerals were not severely affected by flooding except for Fe. Flooded samples had almost ten times the concentration of Fe as did control silages with the highest sample containing 12,534 ppm of Fe. The high Fe content of flooded corn silages was likely a combination of the soil itself as well as a result of soil wearing on the chopping blades of the harvester. Although a high percentage of the Fe was probably in the ferric form (Fe³⁺) form and insoluble, there would be potential for reduction to the ferrous form (Fe²⁺) by acidic conditions in silage (Hansen and Spears, 2009) and the abomasum of a cow leading to excessive amounts of available Fe (Beede, 2009). (We did not test for the form of Fe in our analysis.) High levels of soluble Fe have been documented to interfere with normal Zn and Cu status in ruminants (Phillippo et al, 1987; Prabowo et al., 1988). High Fe has also been reported to depress DM digestion and reduce VFA production in batch

The pH and organic acid content of silages is in Table 4. The pH of flooded samples was slightly greater than that of control silages and was probably due to an increase in buffering content of the forages due to contamination of soil. Control and flooded corn silage samples generally ensiled well although flooded silages had slightly lower concentrations of lactic acid but higher butyric acid than control silages. Butyric acid was detected in only 1 of 8 and 2 of 30 control and flooded corn samples, respectively. Because corn has such a low buffering capacity to begin with, it appears that even the addition of large amounts of soil had generally small effects on silage fermentation.

Table 4. The pH and volatile fatty acid content of control and flooded corn silage

Item	Control corn, n=8			Flooded corn, n=30		
	Mean	Min	Max	Mean	Min	Max
pH	3.87	3.72	4.06	4.03	3.67	5.51
Lactic acid, %	5.00	2.40	8.10	4.23	1.10	7.50
Acetic acid, %	2.88	1.61	5.95	2.60	0.21	5.72
Propionic acid, %	0.28	0.03	0.69	0.24	0.01	1.04
Butyric acid, %	0.20	0.20	0.20	0.47	0.03	0.91
Total VFA, %	8.14	6.44	10.12	7.07	1.27	13.63
Lactic:acetic ratio	2.20	0.45	4.18	2.15	0.32	5.24

The microbial composition and mycotoxin content of samples is in Table 5. Flooded silages had more yeasts than control silages but all silages had low numbers of molds. Deoxynivalenol was the prevalent mycotoxin detected in corn silages. This mycotoxin was detected in 75% (6 out 8) and 90% (27 out 30) of control and flooded corn samples, respectively. Zearalenone was detected in 1 out 8 (12.5%) control sample whereas 7 out of 30 (23.3%) flooded corn sample contained this mycotoxin. 15-Acetyl DON was not detected in control corn samples and this mycotoxin was detected in only 1 flooded corn sample. Although there was a higher incidence of zearalenone in flooded samples, this incidence and concentrations were probably lower than anticipated.

Table 5. Yeasts, molds, and mycotoxin content of control and flooded corn silage

Item	Control corn			Flooded corn		
	Mean	Min	Max	Mean	Min	Max
Yeasts, log cfu/g ¹	4.9	3.0	5.6	7.3	3.0	8.6
Molds, log cfu/g ¹	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
Deoxynivalenol, ppm ²	2.2	0.8	5.0	3.4	0.5	15.5
15 Acetyl DON, ppm ²	ND ³	ND	ND	0.8	0.8	0.8
Zearalenone, ppm ²	2.1	2.1	2.1	1.5	0.6	3.1

¹wet weight basis.

²DM basis.

³ND = Not detected.

In a questionnaire completed by producers submitting samples, 23/30 fed the flooded corn to their herd animals. A total of 9/23 reported issues with feeding the compromised silage that included reduced DM intake, reduced milk production, high SCC, scouring, lowered milk fat test and repeat breeding.

SUMMARY

Corn silage compromised by flooding and lodging from Hurricane Irene appeared to ensile to a normal degree although concentrations of ash were high in many samples. The high ash resulted in high concentrations of Fe and Al whereas most other minerals and heavy metals were only moderately affected. While the incidence of mycotoxins in was greater in damaged than undamaged corn, it was less than may have been anticipated by some. A relatively high number of farms that fed the compromised silage complained of animal issue associated with feeding of the compromised silages. However, these claims have not been substantiated. Analyses on volatile compounds and identification of microbial pathogens are in progress.

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