Northern NY Agricultural Development Program
2008-2009 Project Report

Project Title: Influence of maturity at harvest and ensiling time on protein solubility, starch degradability, and fiber digestibility of corn hybrids harvested for silage

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Collaborator(s): This project involved staff from Miner Institute only.

Cooperating Producers: This research took place on Miner Institute's farm

Background: Recently, some dairy consultants have recommended delaying corn silage harvest until whole plant dry matter content (DM) approaches 40%. The reasoning behind this recommendation is the high price of grain corn and the desire for higher potential energy due to an increase in starch content with maturity. However, digestibility tends to decrease as dry matter increases beyond the optimal DM. There is therefore a potential trade-off between increased energy and decreased whole plant digestibility. A critical question is whether an increase in energy from delayed harvest results in more milk/ton of corn silage. Research has also indicated that the length of fermentation time in the silo can affect both starch and protein degradability, which can influence cow performance. The increase in starch degradability over time in the silo could lead to rations being fed to cows with excessive degradable starch, which some research has shown can increase the risk of subacute ruminal acidosis. Since corn maturity at harvest may influence starch, protein, and fiber digestibility, delaying harvest could have impacts on both rumen health and milk production.

The objective of this study was to determine the influence of delaying corn harvest on starch content, starch degradability, and overall silage quality. The influence of delayed harvest was evaluated by differences in silage quality and predicted milk per ton between an initial harvest at typical whole-plant dry matter and a second harvest at a higher dry matter content (e.g., >40% DM). Differences in starch degradability, protein solubility, and fiber digestibility between fresh chopped and fermented (120 d) samples was also evaluated.

Methods: A preliminary study was conducted in fall 2008 using two hybrids. An initial harvest was taken on 9/15/08 and a second one on 9/25/08. Samples of freshly chopped corn were taken from three different locations in each of two fields. Initial samples were analyzed for DM, crude protein, soluble protein, degradable protein, starch, degradable starch, neutral detergent fiber (NDF), digestible NDF (NDFD), acid detergent fiber, pH, and lignin. Sub-samples were then vacuum-sealed in 11 in. by 11 in. polyurethane bags using the FoodSaver V2440 and allowed to ferment for 120 days. Fermented samples were analyzed for the quality parameters mentioned above, and for ethanol content and volatile fatty acids. Fresh and ensiled forage was dried, ground to 1 mm (Wiley Mill) and analyzed for crude protein, soluble protein, starch, and starch degradability. In 2009, the study was repeated with three different hybrids and will be analyzed in the same manner. Paired t-tests were used to analyze differences between the initial and delayed forage quality characteristics, and differences between fresh chopped and fermented

corn silage quality characteristics. The Milk 2006 model developed by the University of Wisconsin was used to estimate milk potential per ton of dry matter based on the corn silage quality of the initial and delayed harvests for fermented samples.

Results: Results showed that delaying harvest significantly increased ($P \leq .03$) the DM content of the fermented samples for both fields (Table 1, Appendix). For field R40, the delayed harvest had a greater starch content ($P = 0.01$) and a lower starch degradability ($P = 0.10$) compared to the initial harvest. In addition, the delayed harvest resulted in a 9% decrease in protein solubility ($P = 0.05$) compared to the initial harvest (Table 1). Neutral detergent fiber (NDF), digestible neutral detergent fiber (NDFD), acid detergent fiber (ADF), lignin, and pH showed only small changes between the initial and delayed harvests for both fields. Field S34 showed trends that were similar to field R40 for starch, starch degradability and soluble protein, but differences were not significant (Table 2). Average values of each field were used as inputs in the Milk 2006 model that predicts milk potential based on DM, crude protein, NDFD, starch, degradable starch, ash and fat content. Milk 2006 predicted that the delayed harvest would result in a 240 lb milk potential decrease per ton of dry matter for field R40 (Fig. 1). Assuming $15/cwt milk, this equates to a difference of about $50 per ton of dry matter between the initial and delayed harvest. Field S34 showed a similar drop in milk potential (data not shown).

Preliminary results also indicate that fermentation affected NDFD, starch, degradable starch and soluble protein content of the corn silage. For the initial harvest of field R40, NDFD and starch decreased ($P \leq 0.11$), and degradable starch increased ($P = 0.02$). Soluble protein content doubled ($P = 0.001$) after 120 days of fermentation. Trends were similar for the delayed harvest but differences were not as distinct (Table 3), with the exception of soluble protein, which approximately doubled after 120 days of fermentation. The initial and delayed harvest of S34 showed similar trends to R40 (Table 4.). Results indicate that fermentation increased starch degradability by about 9% for the initial harvest of both fields. Fermentation appeared to have less of an impact on starch degradability for the delayed harvest with increases due to fermentation ranging from about 3 to 6 % (Table 4).

Conclusions/Outcomes/Impacts: Preliminary results from the project indicate that delaying harvest and the associated increase in DM content had significant effects on corn silage quality and milk production potential. Delaying harvest increased the starch content of corn silage, but decreased starch degradability, soluble protein, and digestible neutral detergent fiber. Results indicate that there is a tradeoff between increased starch content and overall corn silage quality when considering a delayed harvest. Preliminary results from this study indicate that delaying harvest would not be beneficial from a forage quality and milk production standpoint. Results also showed that fermentation influenced starch, starch degradability, and soluble protein content of chopped corn. The increase in degradable starch could have implications for dairy ration formulation and needs to be further studied to determine the extent of increase as fermentation time increases. Results highlight the importance of timely harvest of corn to maximize digestible nutrients and thus milk production potential of the silage.

Outreach: Results from this project will be published in the Miner Institute Farm Report and presented at national and local meetings. An abstract will be submitted to the 2011 American

Dairy Science Association meeting. After the second year of the study a manuscript will be prepared for possible publication.

Ongoing Research: In 2009, the study was repeated with three different hybrids and will be analyzed in 2010. The main effect of delayed harvest will be evaluated using analysis of variance. Predicted milk per ton will be evaluated for each hybrid for the initial and delayed harvest. Correlations among dry matter content, starch content, starch degradability, protein solubility and other silage characteristics will also be performed to determine the relationship between dry matter content and overall silage quality.

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Reports/articles in which the results of this project have already been published:
No results from this research have been published yet.

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Appendix

Table 1. Dry matter, crude protein, soluble protein, starch, degradable starch, NDF, NDFD, ADF, and lignin content of 120 day fermented corn silage for field R40

Harvest †	120 day corn silage quality characteristics for field R40	Mean	SEM‡	*P*-value‡‡
1	Dry matter (%)	35.4	2.6	
2	Dry matter (%)	47.8	4.7	0.030
1	Crude protein (%)	8.2	0.6	
2	Crude protein (%)	7.6	0.4	0.160
1	Soluble protein (% of crude protein)	64.4	1.0	
2	Soluble protein (% of crude protein)	55.4	1.0	0.050
1	Starch (%)	36.3	2.5	
2	Starch (%)	39.7	2.2	0.010
1	Degradable starch (%)	89.9	0.3	
2	Degradable starch (%)	82.7	2.1	0.100
1	Neutral detergent fiber (% of DM)	37.8	0.5	
2	Neutral detergent fiber (% of DM)	36.1	2.5	0.620
1	Digestible neutral detergent fiber (% of NDF)	29.9	0.9	
2	Digestible neutral detergent fiber (% of NDF)	28.6	2.0	0.330
1	Acid detergent fiber (%)	22.4	0.4	
2	Acid detergent fiber (%)	20.9	1.5	0.430
1	Lignin (%)	3.3	0.2	
2	Lignin (%)	3.0	0.4	0.360

† Harvest 1 = initial harvest, Harvest 2 = harvest ten days after initial harvest

‡ Standard error of the mean (*n*=3)

‡‡ P-value from paired t-test comparing harvest 1 and harvest 2

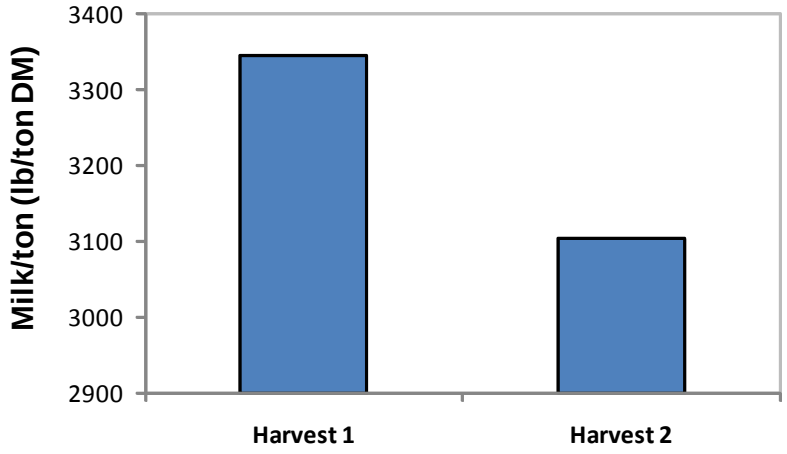

Figure 1. Predicted milk potential of corn silage for the initial and delayed harvest of field R40. Average values of input variables were used.

Table 2. Dry matter, crude protein, soluble protein, starch, degradable starch, NDF, NDFD, ADF, and lignin content of 120 day fermented corn silage for field S34

Table 3. NDFD, starch, degradable starch, and soluble protein content of fresh chopped

Harvest †	120 day corn silage quality characteristics for field S34	Mean	SEM‡	*P*-value‡‡
1	Dry matter (%)	35.7	1.1	
2	Dry matter (%)	41.9	1.4	0.020
1	Crude protein (%)	7.7	0.3	
2	Crude protein (%)	7.0	0.2	0.130
1	Soluble protein (%)	61.9	2.0	
2	Soluble protein (%)	57.9	2.2	0.390
1	Starch (%)	39.7	3.3	
2	Starch (%)	40.0	2.9	0.930
1	Degradable starch (%)	89.6	1.0	
2	Degradable starch (%)	83.8	4.9	0.280
1	Neutral detergent fiber (% of DM)	36.5	1.1	
2	Neutral detergent fiber (% of DM)	35.9	1.0	0.790
1	Digestible neutral detergent fiber (% of NDF)	33.3	0.6	
2	Digestible neutral detergent fiber (% of NDF)	32.4	0.2	0.360
1	Acid detergent fiber (%)	20.7	0.9	
2	Acid detergent fiber (%)	20.8	0.5	0.900
1	Lignin (%)	3.2	0.3	
2	Lignin (%)	3.6	0.5	0.580

† Harvest 1 = initial harvest, Harvest 2 = harvest ten days after initial harvest

‡ Standard error of the mean (*n*=3)

‡‡ P-value from paired t-test comparing harvest 1 and harvest 2

and 120 d fermented silage for the initial and delayed harvest of field R40

Fermentation stage	Initial harvest	Mean	SEM†	*P*-value‡‡
Fresh chopped	Digestible neutral detergent fiber (% of NDF)	38.1	2.8	
Fermented	Digestible neutral detergent fiber (% of NDF)	29.9	0.9	0.082
Fresh chopped	Starch (%)	43.6	1.9	
Fermented	Starch (%)	36.3	2.5	0.109
Fresh chopped	Degradable starch (%)	81.2	1.0	
Fermented	Degradable starch (%)	89.9	0.3	0.021
Fresh chopped	Soluble protein (%)	31.9	0.4	
Fermented	Soluble protein (%)	64.4	1.0	0.001
	Delayed harvest			
Fresh chopped	Digestible neutral detergent fiber (% of NDF)	36.7	1.6	
Fermented	Digestible neutral detergent fiber (% of NDF)	28.6	2.0	0.126
Fresh chopped	Starch (%)	40.8	1.2	
Fermented	Starch (%)	39.7	2.2	0.571
Fresh chopped	Degradable starch (%)	76.8	1.6	
Fermented	Degradable starch (%)	82.7	2.1	0.238
Fresh chopped	Soluble protein (%)	29.0	0.9	
Fermented	Soluble protein (%)	55.4	1.0	0.002

† Standard error of the mean (*n*=3)

‡‡ P-value from paired t-test comparing fresh chopped versus fermented corn silage

Table 4. NDFD, starch, degradable starch, and soluble protein content of fresh chopped and 120 d fermented silage for the initial and delayed harvest of field S34

Fermentation stage	Initial harvest	Mean	SEM†	*P*-value‡‡
Fresh chopped	Digestible neutral detergent fiber (% of NDF)	41.5	0.5	
Fermented	Digestible neutral detergent fiber (% of NDF)	33.3	0.6	0.018
Fresh chopped	Starch (%)	43.3	3.2	
Fermented	Starch (%)	39.7	3.3	0.192
Fresh chopped	Degradable starch (%)	80.7	2.1	
Fermented	Degradable starch (%)	89.6	1.0	0.079
Fresh chopped	Soluble protein (%)	27.7	2.8	
Fermented	Soluble protein (%)	61.9	2.0	0.019
	Delayed harvest			
Fresh chopped	Digestible neutral detergent fiber (% of NDF)	38.0	0.8	
Fermented	Digestible neutral detergent fiber (% of NDF)	32.4	0.2	0.025
Fresh chopped	Starch (%)	47.0	1.4	
Fermented	Starch (%)	40.0	2.9	0.159
Fresh chopped	Degradable starch (%)	80.7	2.3	
Fermented	Degradable starch (%)	83.8	4.9	0.697
Fresh chopped	Soluble protein (%)	25.1	2.4	
Fermented	Soluble protein (%)	57.9	2.2	0.001

† Standard error of the mean (n=3)
‡‡ P-value from paired t-test comparison