Effects of Cutting Height and Maturity on the Nutritive Value of Corn Silage for Lactating Cows^{1,2}

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ABSTRACT

We studied the effect of increasing the cutting height of whole-plant corn at the time of harvest from 12.7 (NC) to 45.7 (HC) cm on yield and nutritive value of silage for dairy cows. Three leafy corn silage hybrids were harvested at NC and HC at about 34% dry matter (E) and 41% DM (L) and ensiled in laboratory silos. Increasing the height of cutting lowered yields of harvested DM/ha. In addition, the concentrations of DM and starch were higher but the concentrations of lactic acid, crude protein, neutral detergent fiber (NDF), and acid detergent fiber were lower in HC than in NC. The concentration of acid detergent lignin was also lower in HC, but only in corn harvested at E. In vitro digestion (30 h) of NDF was greater in HC (50.7%) than NC (48.3%). Calculated yield of milk per tonne of forage DM was greater for HC than for NC at E but not at L. In a lactation experiment, increasing the height of cutting of another leafy corn silage hybrid, TMF29400, in general also resulted in similar changes in nutrient composition as just described. When fed to lactating dairy cows, HC corn silage resulted in tendencies for greater NDF digestion in the total tract, higher milk production and improved feed efficiency, but there were no differences in 3.5% fat corrected milk between treatments. Results of this study suggest that increasing the cutting height of whole plant corn at harvest can improve the nutritive value of corn silage for lactating dairy cows.

(Key words: corn silage, height of cutting, silage maturity)

Abbreviation key: ADL = acid detergent lignin, E = corn silage harvest between $\frac{1}{3}$ and $\frac{2}{3}$ milkline, HC =

corn silage cut to leave 45.7 cm of stalk on the field, L = corn silage harvested at black layer, NC = corn silage cut to leave 12.7 cm of stalk on the field.

INTRODUCTION

Corn silage is one the most popular forages fed to dairy cows because it has good agronomic characteristics, yields high concentrations of nutrients, ensiles well, and incorporates easily into TMR. In the past, much emphasis was placed on the total yield of DM and the amount of grain produced from corn hybrids. However these measurements, alone, are poor indicators of nutritive value (Cox and Cherney, 2001). More recent criteria utilized for hybrid selection include categories for high fiber and starch digestibility in order to maximize milk production per hectare or milk production per tonne of silage (Hunt et al., 1993; Barriere et al., 1995). For example, leafy corn hybrids have been developed to have good DM yields and also have more leaves above the ears, which should lead to improved digestibility and better animal performance (Tolera and Sundstøl, 1999; Cox and Cherney, 2001).

Methods of harvest management can also affect the nutritive value of corn grown for silage. Specifically, harvesting too early can be detrimental because of excessive losses of nutrients from silo runoff and because the concentration of energy may be low because of poor starch development in the kernel. In contrast, mature corn silage harvested in the black layer stage of maturity is low in nutritive value because of poor starch and fiber digestion (Wiersma et al., 1993). Recently, preliminary studies have suggested that increasing the height of cutting, which results in leaving a larger proportion of less digestible stalk in the field, may improve the nutritive value of corn silage for lactating dairy cows (Curran and Posch, 2000; Pitzen 2000). However, more data is needed to evaluate the potential of this management practice. Thus, the objective of this study was to evaluate the effect of cut height on the nutritive value of corn silage. Secondly, we determined the inter-

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action between cut height with harvest maturity on the nutritive value corn silage.

MATERIALS AND METHODS

Cutting Experiment

Corn was planted at the University of Delaware Dairy in a single field of silt loam soil at a theoretical planting density of 72,500 seeds per hectare (29,000 seeds per acre) in 0.76 m (30 in.) rows. The site had been managed as corn-alfalfa rotation every 4 yr for at least 12 yr. In the last year of each alfalfa rotation, alfalfa was harvested in the spring then followed by no-till planting of corn using Round-Up (Monsanto Co., St. Louis, MO) or Gramoxone (Syngenta Crop Protection, Inc., Greensboro, NC). Small grain planting (typically barley or wheat) followed in the fall of each year. Management strategies included application of sheep, beef and horse manure, and tandem disk harrow-cultivation followed by a field finisher applied with rolling basket and tines. Dry fertilizer starter (10-20-20, N-P₂O₅-K₂O; Milford Fertilizer, Milford, DE) was applied at a rate of 112 kg/ha, as was Broad Strike-Dual herbicide (Dow Elanco, Indianapolis, IN) and a 30% urea ammonium nitrate solution (UAN, CF Industries, Inc., Long Grove, IL). Average low daily temperature during the growing season of June through mid-September was 16.8°C and the average high daily temperature during this time was 28.0°C. Accumulated growing degree days (base 50) for the planted forages was approximately 2593. Total rainfall was 47 cm for this period.

At harvest, shears were used to cut four random rows of plants, measuring 5.33 m in length, from four plots for each of three leafy hybrids (Mycogen Seeds, Egan, MN) of corn: TMF100 (98- to 101-d relative maturity), TMF108 (104- to 108-d relative maturity), and TMF2404 (94- to 99-d relative maturity). Corn was harvested early (**E**; average of 34% DM and ½ to ⅔ milk line, 109 d after planting) and late (**L**; average of 41% DM and black layer, 125 d after planting). The cutting height was also altered to either leave 12.7 cm (**NC**) or 45.7 cm (**HC**) of stalk in the field. The number of plants and total weight from each row were recorded after cutting. Total yield of DM per hectare was calculated by multiplying the weight of harvested plants from each row by 1000. For each hybrid, maturity, and height of cutting, individual rows of plants were fed into a self-propelled forage harvester (New Holland FP230, New Holland, PA) equipped with a mechanical processor with rollers positioned to have a clearance of 3 mm resulting in >90% of kernels being cracked. The theoretical cut length was set at 0.95 cm. A representative sample of chopped forage from each row was packed in laboratory silos (27 cm width × 36 cm height) to achieve

an average DM density of 230 ± 5 kg/m³. Silos were stored at ambient temperature (20 to 27°C) in an enclosed barn.

After 50 d of ensiling, representative portions of wet silage from each silo were homogenized for 1 min in sterile ¼-strength Ringers solution (Oxoid BR52, Unipath, Basingstoke, UK) and the pH of the water extract was determined. A portion of the water extract was filtered through Whatman 54 filter paper (Whatman, Clifton, NJ), acidified with 50% H₂SO₄, and frozen prior to analysis of lactic acid and VFA. An enzymatic kit was used (kit 826 - UV, Sigma-Aldrich, St. Louis, MO) for the analysis of D- and L- lactic acids. For analysis of D-lactic acid, L-lactic dehydrogenase was replaced with a similar amount of D-lactic dehydrogenase (Sigma L-9636). L-Lactic acid (Sigma L-2250) and D-lactic acid (Sigma L-1000) were used as standards for their respective assays. Lactic acid was reported as the sum of L- and D-lactic acid. Water extracts were acidified with 25% m-phosphoric acid (5:1 vol/vol) and analyzed for VFA using a Hewlett Packard 5890 gas chromatograph (Hewlett Packard, Avondale, PA) with a 530-μm Carbowax 20M column and flame ionization detector. The chromatograph was set to the following program: 70°C for 1 min, then a 5°C increase/min until it reached 100°C, then increasing at a rate of 45°C/min until the temperature reached 170°C, and maintained a final holding period of 5 min.

Silage samples were also dried in a forced-draft oven (60°C, 48 h) for the determination of DM. Dried samples were ground to pass through a 1-mm screen using a Cyclone Sample Mill (UDY Corp., Fort Collins, Colorado). Residual DM was determined on all ground samples at 100°C for 24 h. Neutral detergent fiber was analyzed using sulfite and amylase (Van Soest et al., 1991) and ADF was analyzed (Robertson and Van Soest, 1981) using an Ankom²⁰⁰ Fiber Analyzer (Ankom Technology, Fairport, NY). Acid detergent lignin was determined following ADF analysis using 72% H₂SO₄. Total N was determined on dried samples after complete combustion (Leco CNS 2000 Analyzer, St. Joseph, MI) and multiplied by 6.25 to obtain CP. The concentration of starch was determined on all samples (Dairy One Forage Lab, Ithaca, NY). Thirty-hour in vitro NDF digestibility was determined using 0.25 g of sample in F57 bags (acetone washed) in a Daisy^{II} Incubator (Ankom Technology, Fairport, NY) following the general procedure of Goering and Van Soest (1970). The Milk 2000 University of Wisconsin Corn Silage Evaluation System (Schwab et al., 2001) was used to estimate NE_L, milk production per hectare and milk production per tonne of corn silage. The original program requires values from 48-h in vitro NDF digestion but the program was adjusted to use data from a 30-h in vitro digestion.

Lactation Experiment

A leafy hybrid of corn (TMF29400, 95-d relative maturity, Mycogen Seeds, Egan, MN) was planted in 0.76 m rows at a density of 72,500 seeds per hectare. Agronomic management was as previously described. Whole plant corn was harvested and mechanically processed (as previously described) at $\frac{1}{2}$ kernel milkline and 38% DM. Treatments were harvested at a normal cut height (NC; leaving 12.7 cm of stalk in the field) and at a higher cut height (HC; leaving 45.7 cm of plant in the field). Estimates of DM yield were made as previously described. Chopped forage (about 40 t of each) was packed and stored in a silo bag (Ag/Bag International, Ltd., Warrenton, OR) for use during the lactation trial.

Forage was ensiled for 150 d prior to feeding in a lactation trial. Both ends of the bag silo were opened simultaneously for feed out. Twenty multiparous Holstein cows (averaging 83 ± 22 DIM and > 45 kg of milk per d) were trained to use Calan gates (American Calan, Northwood, NH). During a 10-d pretreatment period, cows were offered a TMR consisting of 40% (DM basis) corn silage (comprised of a mixture of both the HC and NC corn silages), 10% alfalfa haylage, 8% alfalfa hay and 42% concentrate (Table 1). The TMR was offered to achieve a 5% daily refusal. Cows had access to fresh water at all times. At the end of the pretreatment period, cows were randomly assigned to one of two treatment diets based on parity, stage of lactation, and milk production. The treatments differed only in their source of corn silage, either HC or NC (Table 2). Cows were fed their respective diets for a 4-wk treatment period. Throughout the study, milk production was recorded twice daily and averaged on a weekly basis. Milk samples were collected weekly from two consecutive milkings (a.m. and p.m.) during the pretreatment and treatment periods. The milk was analyzed for percent fat, CP, and lactose by infrared analyses (Mid-East Milk Lab Services, Inc., Hagerstown, MD). Body weights were recorded at the start and end of the treatment period.

During the treatment period, samples of silages, concentrate, and TMR were collected three times each week and pooled prior to weekly analyses. Silages were analyzed as previously described. The TMR was analyzed for DM, ADF, NDF, and starch as previously described. The distribution of feed particles from corn silages and their respective TMR were measured (Lammers et al., 1996) using a particle size separator (Nasco, Fort Atkinson, WI).

To measure in vivo digestibility of the TMR, fecal grab samples were taken during wk 4 of the treatment period. All cows were sampled every 8- to 10-h over a 4-d period to represent each 3-h increment in a 36-h

Table 1. Composition (% DM) of concentrate mixed into the TMR during the lactation experiment.

Ingredient	%
Corn meal fine	20.4
Soybean meal, 47.5%	17.6
Distillers dried grains	12.3
Gluten feed	12.3
Soybean hulls	7.13
Soybean roasted	5.75
Corn gluten, 60% CP	5.02
Wheat midds	3.97
Fat blend ¹	3.06
Soybean meal, extruded	2.81
Limestone, 37%	2.54
Molasses blend ²	2.04
Sesquicarbonate	2.05
Salt	1.06
Protein blend ³	0.66
Dicalcium phosphate ⁴	0.50
Urea	0.41
Magnesium oxide	0.21
Selenium, 0.06%	0.11
Trace minerals ⁵	0.04
Vitamins ⁶	0.04

¹Feed grade combination of tallow, poultry, and porcine fats.

²Contained (DM basis) 0.5% Ca, 0.03 g of Cu/kg, 5.0% crude fat, 3.0 % CP, 0.50 g of I/kg, 0.40% Mg, 0.68 mcal/lb NE_L, 45.5% NSC, 3.2% K, 0.70% S, 63% TDN, 0.50% P, 0.01g of Zn/kg, 0.94 UIP.

³Dried blood meal, hydrolyzed poultry feathers, fishmeal, calcium carbonate, and ethoxyquin.

⁴Contained (DM basis) 27% Ca and 20% P.

⁵2.1% Ca, 1.6g of Co/kg, 40 g of Cu/kg, 4.0 g of I/kg, 6.0 g of Fe/kg, 150 g of Mn/kg, 13.0% S, 160 g of Zn/kg.

⁶Contained (DM basis) 26,400 KIU of vitamin A/kg, 8800 KIU/kg of vitamin D, and 165,000 IU of vitamin E/kg.

span. Three hundred grams of feces from each individual sample was mixed together to form a single composite sample of feces for each cow. Representative portions of these samples were dried in a forced-air oven (60°C, 48 h) for the determination of DM. The dried samples were ground through a 1-mm screen and were also analyzed for laboratory DM, CP, NDF, ADF (as described), and indigestible NDF. Indigestible NDF was determined on NDF residue after 120 h of in vitro fermentation in the Daisy^{II} Incubator and used as a marker for total tract digestibility (Oba and Allen, 1999). Indigestible NDF for each TMR, and each component of the TMR was determined using samples collected during the period of fecal collection.

Statistics

All data are presented on a DM basis. The silage data were analyzed by analysis of variance using the General Linear Models procedure of SAS (SAS, 1989). The experimental design was a 2×2 factorial arrangement of treatments. The effects of height of cutting, maturity and their interactions were tested. Differences among

Table 2. Ingredients, chemical composition and particle size distribution of TMR fed during the lactation experiment.

Item	NC ¹ -TMR	HC ² -TMR
Ingredient (DM basis)		
Corn silage—NC, %	40	
Corn silage—HC, %		40
Alfalfa silage, %	10	10
Alfalfa hay, %	8	8
Concentrate, %	42	42
Chemical composition (DM basis)		
DM, %	62.7	63.1
CP, %	17.6	17.7
NDF, %	34.2	33.5
ADF, %	20.6	19.9
Starch, %	24.9	25.8
Minerals ³		
Ca, %	0.89	0.89
P, %	0.38	0.39
K, %	1.59	1.67
Mg, %	0.31	0.30
TMR particle size ⁴		
Large (> 1.91 cm)	11	10
Medium (0.79 to 1.91 cm)	45	45
Small (< 0.79 cm)	44	45

¹Corn silage that had been harvested to leave 12.7 cm of stalk in the field.

²Corn silage that had been harvested to leave 45.7 cm of stalk in the field.

³Analyzed from a single composite sample of each TMR.

⁴Particle size distribution of the fresh TMR prior to feeding using a Penn State forage particle separator.

main effects were compared using Tukey's test (Snedecor and Cochran, 1980). Effects were considered significant at $P < 0.05$ and tendencies were noted at $P < 0.10$.

The production data from the lactation trial and composition of NC and HC corn silages were analyzed as a completed randomized design with weekly observations as repeated measurements and subjected to analysis of variance by the General Linear Models procedure of SAS (SAS, 1989). Significance was declared at $P < 0.05$ and trends were noted at $P < 0.12$.

RESULTS

Cutting Experiment

The nutrient compositions of three silage hybrids cut at 12.7 cm or 45.7 cm and harvested at ½ milklane or black layer are shown in Table 3. Silage pH averaged 3.71 across all treatments and there was maturity × cut interaction. Increasing the height of cutting and maturity raised ($P < 0.05$) the concentration of DM in the harvested plants (average of 38.6% for HC vs. 36.6 for NC) but decreased ($P < 0.05$) the concentration of CP (average of 8.43% for NC vs. 8.30% for HC). The concentration of NDF tended to be lower ($P < 0.10$) when height of cutting was increased in HC (average

of 41.3%) vs. NC (42.9%). Height of cutting decreased the concentration ($P < 0.05$) of ADF in HC (average of 23.4%) when compared to NC (25.3%). Harvesting at high cut caused a reduction in the concentration of ADL (3.27 vs. 2.42%) at the earlier but not later stage of maturity (cut × maturity interaction, $P < 0.05$). The concentration of starch increased ($P < 0.05$) with advancing stage of maturity and increasing height of cut. Concentrations of lactic and acetic acids were not affected by height of cutting but were lower in silage cut late. In vitro NDF digestibility after 30 h of incubation was affected only by height of cutting and was greater in HC (50.7%) than in NC (48.3%).

Yield of DM and calculations from Milk2000 are shown in Table 4. Increasing the height of cutting tended to decrease ($P < 0.10$) the DM yield (average of 16.6 t/ha for NC vs. 15.8 t/ha for HC) at harvest. Yield of DM was also greater for silage harvested late, than for silage harvested early (17.1 vs. 15.3 t/ha, respectively). There was a cut × maturity interaction ($P < 0.05$) for NE_L as increasing height of cutting improved the estimate for NE_L when silage was harvested at L but not when it was harvested at E. Increased height of cutting ($P < 0.05$) improved milk production per tonne of forage in corn silage harvested early (1625 vs. 1723), but not when it was harvested late (1682 vs. 1685). Kilograms of milk produced per hectare were greatest ($P < 0.05$) for L when compared to E (28,284 vs. 25,811 kg/ha) but was not affected by height of cut.

Lactation Experiment

The yield of DM and nutrient composition of corn silage harvested at different heights of cut are presented in Table 5. Yield tended to decrease by approximately 10% when the cut height was raised from 12.7 (16.8 t/ha) to 45.7 cm (15.3 t/ha). There were no differences between NC and HC for pH or concentrations of DM, CP, NDF, or fermentation acids. However, the concentrations of ADF and ADL were lower in HC when compared to NC. In contrast, the concentration of starch was higher in HC (37.4) than in NC (35.2%). Digestibility of NDF after 30 h of in vitro digestion was not different between treatments (average of 41.9%). The distribution of feed particles from a particle size separator was not different between treatments.

Results from the lactation experiment are shown in Table 6. Harvesting corn plants higher tended to increase milk production by 1.5 kg/d but had no effect on 3.5% FCM. The composition and yield of milk fat and protein were also not affected by treatment. Body weight change was not different for cows on either diet. Feed efficiency (kg of milk produced/kg of DM consumed) also tended to increase from 1.67 to 1.72. Diges-

Table 3. Effect of cut height¹ and maturity² on the chemical composition of corn silage.

	NC		HC		SE	Effect ³
	E	L	E	L		
DM, %	33.0	40.3	34.7	42.6	0.4	C, M
pH	3.68	3.73	3.67	3.77	0.01	M, M*C
CP, %	8.59	8.27	8.51	8.09	0.05	C, M
NDF, %	43.4	42.4	41.0	41.5	0.8	
ADF, %	25.4	25.2	23.6	23.1	0.5	C
ADL, %	3.27	2.80	2.42	2.67	0.18	C, C*M
Starch, %	30.9	34.1	32.8	36.0	0.7	C, M
Lactic acid, %	7.56	5.69	7.40	5.31	0.14	M
Acetic acid, %	2.15	1.56	1.94	1.62	0.10	M
NDFD ⁴ , %	48.7	48.0	51.5	49.9	1.0	C

¹NC = corn silage cut to leave 12.7 cm in the field, HC = corn cut to leave 45.7 cm in the field.

²E = corn harvested at 34% DM, L = corn harvested at 41% DM.

³Effect of C = Cut or M = Maturity, $P < 0.05$.

⁴NDF digestibility after 30 h in vitro fermentation.

tion of nutrients in the total tract was unaffected by height of cutting with the exception of a tendency for improved digestion of NDF (Table 7).

DISCUSSION

Increasing the cutting height of corn silage at harvest could be a method to improve its nutritive value. In the current study, increasing height of cutting of whole-plant corn at harvest from 12.7 cm or 45.7 cm numerically decreased DM yield by about 5% in three leafy corn silage hybrids. In our lactation trial, DM yield was decreased by about 10% when height of cutting was increased. Pitzen (2000) and Kruczynska et al. (2001) each compared DM yields at cut heights that were similar to those used by us and reported similar decreases in DM yield. Curran and Posch (2000) reported about a 12% decline in DM yield between cut heights that left 10.2 vs. 50 cm but only a 7% decline comparing cut heights of 20.4 vs. 50 cm. Overall, it appears that increasing the cutting height of corn silage from 12.7 to

45.7 cm will result in a decrease in DM yield of about 5 to 10%.

Increasing the cutting height of whole-plant corn at harvest also improved its nutritive value for dairy cattle by reducing the concentrations of NDF, ADF, and ADL but increasing the concentrations of starch and in vitro NDF-D. Kruczynska et al. (2001) also observed a reduction in crude fiber and ADF, and greater effective degradability of silage that was cut at 50 vs. 10 cm. Dominguez et al. (2002) reported that increasing the cut height from 23 to 71 cm increased whole-plant DM and reduced the concentration of NDF. Most changes that we, and others, have observed due to increased height of cut have been consistent with the fact that more fibrous and highly lignified stems (Tolera and Sundstøl, 1999) are left in the field. In addition, highly digestible leaves and kernels (representing 40 to 50% of plant weight) (Verbic et al., 1995) represent a larger proportion of the total DM in the high cut silage. Specifically, we observed a 13% and 26% decrease in ADL but only a 2% and 5% increase in NDF-D when silage was cut

Table 4. Effect of cut height¹ and maturity² on the yield of DM, NE_L, and calculated milk production.

	NC		HC		SE	Effect ³
	E	L	E	L		
DM, t/ha	15.6	17.6	15.0	16.5	0.5	M
NE _L ⁴ , Mcal/kg	0.69	0.71	0.72	0.71	0.01	C*M
Milk yield ⁵						
kg/t	1625	1682	1723	1685	26	C
kg/ha	25,412	28,997	26,210	27,572	864	M

¹NC = corn silage cut to leave 12.7 cm in the field, HC = corn cut to leave 45.7 cm in the field.

²E = corn harvested at 34% DM, L = corn harvested at 41% DM.

³Effect of C = Cut or M = Maturity, $P < 0.05$.

⁴Net energy for lactation, Mcal/kg.

⁵Milk yield adapted from Milk2000 (Schwab et al., 2001) using 30 h NDF digestion.

Table 5. Yield and composition of corn and alfalfa silages fed to cows consuming a diet comprised of either normal or high cut corn silage.

Item	Corn Silage		Alfalfa Silage
	NC ¹	HC ²	
DM, t/ha	16.8	15.3	...
pH	3.71	3.73	...
Chemical Composition			
DM, %	37.2	38.3	38.1
CP, %	6.66	6.76	18.2
NDF, %	39.9	38.1	45.7
ADF, %	24.2	22.3	35.2
ADL, %	2.16	1.87	7.28
Starch, %	35.2	37.4	5.48
Lactic acid, %	5.57	4.81	...
Acetic acid, %	1.56	1.67	...
Propionic acid, %	0.24	0.17	...
NDF-D ³ , %	42.3	41.6	...
Particle size distribution ⁴ , %			
Large (> 1.91 cm)	8	9	...
Medium (0.79 to 1.91 cm)	62	64	...
Small (< 0.79 cm)	30	27	...

¹Corn silage cut to leave 12.7 cm in the field.²Corn silage cut to leave 45.7 cm in the field.³Digestibility of NDF after 30 h in vitro fermentation.⁴Calculated from silage remaining on top, middle and bottom screens of the Pennsylvania State forage particle separator.

high in the lactation and hybrid trials, respectively. Curran and Posch (2000) reported a 1.5% improvement in digestible fiber when corn silage was harvested at 16 vs. 51 cm of cutting height.

Few interactions were found between cutting height and maturity, possibly because the difference in maturity between E and L was relatively small and because of this, maturity had no effect on in vitro NDF digestion. Harvesting at L caused a decline in the concentration of CP but an increase in the concentration of starch.

Table 6. Comparison of animal performance from cows fed a diet comprised of either normal or high cut corn silage.

Item	NC-TMR ¹	HC-TMR ²	SE
Milk, kg/d	45.2 ^b	46.7 ^a	0.8
Milk fat, kg/d	1.47	1.42	0.06
Milk protein, kg/d	1.29	1.34	0.03
3.5% FCM, kg/d	43.4	43.2	1.2
Milk composition, %			
Fat	3.26	3.03	0.13
CP	2.84	2.89	0.03
BW, kg	621	628	17
BW change, kg/d	1.70	2.08	0.60
DMI, kg	25.4	25.6	0.3
Feed efficiency ³	1.67 ^b	1.72 ^a	0.04

^{a,b}Means in columns with unlike superscript differ ($P < 0.12$).¹Corn silage used in the TMR was cut to leave 12.7 cm in the field.²Corn silage used in the TMR was cut to leave 45.7 cm in the field.³kg of milk produced/kg of feed consumed.**Table 7.** Apparent nutrient digestibility from cows fed a diet comprised of either normal or high-cut corn silage.

Item	NC-TMR ¹	HC-TMR ²	SE
	% of DM		
OM	65.3	64.0	0.7
DM	62.8	61.5	0.6
CP	64.9	62.9	1.0
NDF	31.8 ^b	34.3 ^a	1.1
ADF	30.2	30.9	1.9
Starch	98.3	98.4	0.1

^{a,b}Means in columns with unlike superscript differ ($P < 0.11$).¹Corn silage used in the TMR was cut to leave 12.7 cm in the field.²Corn silage used in the TMR was cut to leave 45.7 cm in the field.

As found in some studies with corn silage, the concentrations of ADF and NDF in our study were not different due to maturity at harvest. The concentrations of lactic and acetic acids were reduced in more mature corn silage and is most likely due to a combination of lower water soluble carbohydrates (not measured) and a reduction in growth of lactic acid bacteria because of a lowered water activity in the drier, more mature crop.

When entered into the Milk 2000 program, height of cutting in our study had no effect on kilograms of milk produced per hectare but late cut silage produced more milk per hectare. High cutting silage resulted in an increase (6%) in kilograms of milk produced per tonne of forage in E but not in L corn silage. Curran and Posch (2000) reported a decrease in kilograms of milk produced per hectare, but a 7.9% increase in kilograms of milk produced per tonne of forage when the cutting height of corn silage was increased from 10.2 to 51 cm.

In our lactation experiment, we fed the same proportions of low and high cut silages. Increasing the cutting height of corn silage did not affect the composition of milk or yield of milk components but milk fat percentage was numerically lower in HC vs. NC silage. Domniguez et al. (2002), fed cows a higher proportion of high cut corn silage but less high moisture corn than cows fed low cut silage. They concluded that cows could be fed diets with a higher forage content when diets were formulated for an equal amount of NDF using high cut corn silage without a change in milk production or composition but cows produced only 30 to 35 kg/d in that experiment.

Total digestion of nutrients in the digestive tract from cows in our study were similar to those reported by Oba and Allen (1999) who used cows that consumed similar amounts of DM and produced similar amounts of milk as those used in the current study. Although the digestion of most nutrients in the total tract were unaffected by treatment, NDF digestion was improved by 2.5 units and may partially explain the tendency for an increase

in milk production (+1.5 kg of milk/d) and improved feed efficiency. However, the numerical decrease in milk fat content could have been due to a reduction in effective fiber content of the diet.

CONCLUSIONS

In a trial utilizing several leafy corn silage hybrids harvested at two maturities, increasing the cutting height of corn silage from 12.7 to 45.7 cm improved its nutritive value by decreasing the concentrations of ADF, NDF, and ADL but increasing the concentration of starch. In vitro NDF digestion was only marginally increased in silage cut higher. A general trend for lower DM yield was observed with increased cut height. Height of cutting had few interactions with plant maturity. In a lactation trial, increasing height of cutting of a leafy corn silage hybrid resulted in changes similar to that just described with the exception that no differences were found between treatments in in vitro NDF digestion. However, when these silages were fed to lactating cows, total tract NDF digestion tended to be greater and cows tended to be more efficient in converting DM to milk. Although there was a tendency to produce more milk, 3.5% FCM was not different between treatments.

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