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Influence of Corn Variety and Cutting Height on Nutritive Value of Silage Fed to Lactating Dairy Cows

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ABSTRACT

Two corn varieties predicted to differ in digestibility were harvested at 2 cutting heights (10.2 or 30.5 cm) to determine effects on the nutrient content of the resulting silage, nutrient intake, nutrient digestibility, and production of lactating cows fed such corn silage originally harvested at two-thirds milk line. Acid detergent fiber (ADF) concentration was higher and in vitro true dry matter (DM) digestibility (IVTDMD) was lower for the variety predicted to have average digestibility. An interaction was observed between variety and cutting height because of decreased ADF and increased IVTDMD for the average digestibility variety cut at 30.5 vs. 10.2 cm; no differences were observed for the higher digestibility variety at each cutting height. When silages were fed to 32 Holstein cows in a 5-wk randomized design trial, DM intake, milk yield, and milk composition were similar. There was an interaction between variety and cutting height for DM intake and total tract apparent digestibility of DM, crude protein, and neutral detergent fiber because of lower intake and digestibility for the diets containing either the high cut, average quality variety or low cut, higher quality variety. These results suggest that increasing the cutting height to 30.5 cm does not improve silage quality or improve milk yield of cows. Although the 2 varieties selected for this trial were predicted to differ in digestibility, these differences were not great enough to influence milk yield or composition of lactating cows.
(**Key words:** corn silage, milk yield, nutrient digestibility)

Abbreviation key: ECM = energy-corrected milk, **IVTDMD** = in vitro true dry matter digestibility.

INTRODUCTION

Corn varieties differ in nutrient content and digestibility (Johnson et al., 1985; Coors, 1996; Allen, 1998). Barrière et al. (1995) observed a 1- to 2-kg/d nonsignificant increase in milk yield and greater BW gain when lactating Holstein × Friesian cows were fed corn silage produced from varieties with higher concentrations of digestible OM. Hunt et al. (1993) reported improved average daily gain and feed efficiency for growing steers fed diets based on a corn variety that was more digestible as measured by in vitro true DM digestibility (**IVTDMD**) compared with another variety with similar yield characteristics but was lower in IVTDMD. Differences between varieties evaluated in the Wisconsin variety test trials range from 1.9 to 2.1 U for IVTDMD and 2.1 to 3.8 U for NDF (Coors, 1996). Oba and Allen (1999) reported a 0.17-kg increase in DMI and a 0.25-kg increase in 4% FCM yield for each 1-U increase in NDF digestibility. These results suggest that corn hybrid varieties that have higher digestibility should support higher milk yield.

In the Southeastern US, the combination of high ambient temperature and humidity coupled with a more constant photoperiod reduces forage quality. Buxton (1996) reported that forage digestibility decreased 0.3 to 0.7 percentage units for each 1°C increase in temperature above normal. The depression is attributed primarily to higher concentrations of NDF that is less digestible. These environmental factors could further diminish differences among corn varieties. The lower portion of the corn plant is considered to be less digestible (Tolera and Sundstl, 1999), so increasing the cutting height of corn silage at harvest could increase forage digestibility and improve animal performance. Lauer (1998) reported a 15% decrease in the yield of corn silage when the cutter bar was raised from 15.2 to 45.7 cm; however, potential milk yield increased based on the Milk2000 model (Undersander et al., 1993). Many dairy producers with limited land resources are not able to sacrifice 15% of their silage yield and still produce adequate supplies of corn silage, but might consider increasing cutting height to 30.5 cm if silage quality and milk yield were improved. The objective of this trial was to determine the effect of corn hybrid variety and cutting height on the feeding value of silage to lactating dairy cows.

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MATERIALS AND METHODS

Silage Production

Two corn hybrid varieties (Pioneer 31G20 and 32K61; Pioneer Hi-Bred International, Des Moines, IA) that had similar ratings for yield and nutrient content but differed in predicted digestibility, based on company ratings, were planted on March 22, 1999 in a Tifton sandy loam soil at a seeding rate of approximately 69,135 plants/ha. A commercial fertilizer was applied at the rate of 65 kg N, 65 kg P, and 126 kg K/ha immediately before planting. An additional 108 kg/ha N was applied when the corn was approximately 60 cm in height. Irrigation was provided as needed to supplement natural rainfall. Corn was chopped at approximately two-thirds milk line on July 8 and 9, 1999 using a conventional pull-type chopper with a theoretical chop length of 1.3 cm. Approximately one-half of each variety was cut at a height of 10.2 cm (normal), and the remaining proportion was cut at a height of 30.5 cm (high). The chopped corn was immediately packed into a 2.4-m plastic bag, where it was allowed to ferment and was stored until the lactation trial was conducted.

Table 1. Ingredient composition of experimental diets.

Ingredient	
	(% of DM)
Corn silage	40.64
Alfalfa hay	5.82
Cottonseed	5.82
Steam-flaked corn	15.56
Ground corn	2.60
Soybean hulls	10.84
Megalac[1]	0.87
Urea	0.59
Soybean meal, 49% CP	11.53
Prolak[2]	2.62
Potassium carbonate	0.57
Salt	0.28
Magnesium oxide	0.22
Dicalcium phosphate	0.24
Sodium bicarbonate	0.81
Limestone	0.87
Trace mineral-vitamin premix[3]	0.11

[1]Calcium salts of long-chain fatty acids (Church & Dwight Co., Inc., Princeton, NJ).

[2]Animal-marine protein blend (H. J. Baker & Bro., Inc. Stamford, CT).

[3]Premix contained (DM basis) 16.51% Ca, 0.05% K, 1.00% Na, 0.01% Cl, 2.11% S, 179 mg/kg Co, 11,970 mg/kg Cu, 1830 mg/kg Fe, 1050 mg/kg I, 35,830 mg/kg Mn, 260 mg/kg Se, 34,740 mg/kg Zn, 2,400,000 IU/kg vitamin A, 959,000 IU/kg vitamin D, and 12,000 IU/kg vitamin E.

Lactation Trial

Thirty-two Holstein cows (171 ± 95 DIM, 26.5 ± 3.5 kg DMI, 36.0 ± 6.3 kg/d milk, 4.1 ± 0.5% fat, 3.1 ± 0.3% protein, and 604 ± 63 kg BW) were used in a 5-wk randomized block design study with a 2 × 2 factorial arrangement of treatments. Treatments consisted of 2 corn hybrid varieties (31G20 and 32K61) cut at 2 heights (average or normal). Cows were fed a corn silage and alfalfa hay-based ration during the 2-wk pretrial period. At the end of the pretrial period, cows were blocked by energy-corrected milk (**ECM**) yield and assigned randomly to 1 of 4 experimental diets. All protocols for this trial were approved by The University of Georgia Institute of Animal Care and Use Committee.

Experimental diets (Table 1) were offered individually once daily at 110% of the previous day's intake consumption behind Calan doors (American Calan Inc., Northwood, NH). Diets contained 40.6% of the total DM as corn silage (Table 1). The amount of TMR offered and orts were recorded daily. Samples of ingredients, diets, and orts were collected 4 d each week, and DM content was determined by drying in a forced-air oven at 55°C for 48 h. Milk yield was recorded electronically at each milking (Alfa Laval Agri., Inc., Kansas City, MO). Milk samples were collected from 2 consecutive milkings each week and shipped to the Southeast Milk (Belleview, FL) for analysis of fat and protein concentrations using a Foss 4000 equipped with an A filter (Foss North America, Eden Prairie, MN). Cows were weighed on 2 consecutive d at the end of the preliminary period and at wk 5 of the experimental period.

Ingredient, diet, and ort samples were composited by week and ground to pass through a 1-mm screen using a Wiley mill (Arthur H. Thomas, Philadelphia, PA). Composite samples were analyzed for DM, CP, ash, (AOAC, 1990) ADF, and NDF (Van Soest et al., 1991), and indigestible ADF (Cochran et al., 1986). The IVTDMD of the forages was determined according to methods of Goering and Van Soest (1970).

Fecal grab samples were collected from 4 cows on each treatment the last 3 d of wk 5 at 12-h intervals. Sampling time was advanced by 4 h each day. Samples were dried in a forced-air oven at 55°C, ground to pass through a 1-mm screen, and composited by cow. Fecal samples were analyzed for DM, ash, CP, ADF, NDF and indigestible ADF. Indigestible ADF was used as an internal marker to determine apparent digestibility of nutrients (Cochran et al., 1986). Intake data from wk 5 were used to calculate digestibility coefficients.

Statistical Analysis

Production data were subjected to ANOVA using PROC MIXED procedures of SAS (1989). Sums of squares were partitioned to covariant, hybrid, cutting height, week, and the appropriate interactions. Pretrial variables were used as a covariant in each of the respec-

Table 2. Chemical composition of corn silage hybrids cut at 2 heights (in cm).

	Pioneer 31G20[1]		Pioneer 32K61[1]			*P*		
	10.2 cm	30.5 cm	10.2 cm	30.5 cm	SE	Hybrid (H)	Cut (C)	H × C
	(%)							
DM	35.8	35.2	35.6	36.7				
	(% of DM)							
Ash	2.87	3.19	2.61	2.52	0.25	0.08	0.66	0.42
CP	7.82	8.24	8.27	7.94	0.19	0.72	0.83	0.08
ADF	27.24	25.79	25.50	24.15	0.50	0.01	0.02	0.92
NDF	46.73	45.48	45.21	44.25	0.81	0.12	0.20	0.86
IVTDMD[2]	66.53	68.42	69.53	68.80	0.51	0.01	0.28	0.03
NE_L, Mcal/kg	1.26	1.28	1.31	1.29				
Milk yield[3]								
kg/metric tonne	2107	2177	2310	2203				
kg/ha	18,878	17,557	20,700	17,767				

[1]Pioneer Hi-Bred International, Des Moines, IA.

[2]IVTDMD = In vitro true DM digestibility.

[3]Values calculated using Milk2000 corn silage variety evaluation program (Schwab et al., 2001). Silage DM yield was estimated at 17.92 and 16.13 tonne/ha based on plot samples.

tive models. Cow within treatment was included as a random variable, and week was considered a repeated measure. Analyses of variance for chemical content of corn silage, nutrient intake, apparent digestibility coefficients, and change in BW data were conducted using GLM procedures of SAS (1989). Sums of squares were partitioned to hybrid and cutting height.

RESULTS AND DISCUSSION

The corn silage produced from 32K61 tended to have lower concentrations of NDF ($P < 0.12$) and ADF ($P < 0.01$) and higher IVTDMD ($P < 0.01$) compared with 31G20 (Table 2). Corn silage harvested at 30.5 cm had lower concentrations of ADF ($P < 0.01$) compared with that harvested at 10.2 cm, but no differences were observed in concentration of NDF or IVTDMD. There was an interaction ($P < 0.05$) of cutting height and variety because of increased IVTDMD for 31G20 harvested at 30.5 cm compared with that harvested at 10.2 cm; no differences were observed between the 2 cutting heights for 32K61. A similar tendency for an interaction ($P < 0.08$) of cutting height and variety was observed for CP concentrations.

Table 3. Chemical composition of experimental diets based on 2 corn silage hybrids cut at 2 heights (in cm).

	Pioneer 31G20[1]		Pioneer 32K61[1]	
	10.2 cm	30.5 cm	10.2 cm	30.5 cm
DM, %	55.77	55.86	54.89	56.22
Ash, % of DM	5.95	5.90	5.90	5.85
CP, % of DM	16.77	17.10	16.76	17.09
RDP,[2] % of CP	62.29	62.16	62.16	62.30
RUP,[2] % of CP	37.71	37.84	37.84	37.71
ADF, % of DM	22.01	21.68	21.87	21.78
NDF, % of DM	41.61	41.82	39.59	40.4
NE_L,[2] Mcal/kg	1.59	1.59	1.59	1.59

[1]Pioneer Hi-Bred International, Des Moines, IA.

[2]Calculated using NRC (2001) values.

The lower portion of the corn plant is generally considered to contain more fiber and lignin that would be less digestible (Tolera and Sundstl, 1999). The results of our trial suggest that the composition of the lower proportion of the corn plant differs among varieties and that the lower proportion of the more digestible varieties may be more similar in composition and digestibility to the upper portion of the plant than varieties with lower digestibility. This would imply that the potential animal response to increasing cutting height might not be consistent among all varieties.

The net energy of lactation concentration and potential milk yield was predicted using the Milk 2000 corn silage variety evaluation program (Schwab et al., 2000). The DM yield was approximately 10% lower when the cutting height was increased based on plot data (not reported) resulting in an estimated yield of 17.92 and 16.13 metric ton/ha for normal and high cut corn silage for each variety. The NE_L concentration and predicted milk yield were numerically higher for 32K61 than for 31G20 (Table 2). Milk yield (kg/ha) was numerically higher for silage cut at the normal cutting height compared with that for silage cut at 30.5 cm, reflecting the lower DM yield. Predicted milk yield (kg/metric ton) was not greatly different because of variety or cutting height, which is in contrast with previous reports that indicate a positive response to increasing the cutting height at harvest (Lauer, 1998).

The composition of experimental diets is outlined in Table 3. All diets contained similar concentrations of

Table 4. Performance of lactating cows fed diets based on 2 corn silage hybrids cut at 2 heights (in cm).

	Pioneer 31G20[1]		Pioneer 32K61[1]			P		
	10.2 cm	30.5 cm	10.2 cm	30.5 cm	SE	Hybrid (H)	Cut (C)	H × C
DMI, kg/d	25.8	24.6	24.4	25.6	0.4	0.64	0.97	0.006
Milk, kg/d	36.7	37.2	36.6	38.2	1.2	0.70	0.40	0.64
Fat, %	4.02	4.06	3.73	3.95	0.15	0.19	0.39	0.57
Fat, kg/d	1.48	1.51	1.37	1.51	0.07	0.25	0.16	0.45
Protein, %	3.15	3.12	3.15	3.24	0.04	0.15	0.52	0.14
Protein, kg/d	1.16	1.16	1.15	1.24	0.04	0.57	0.46	0.30
ECM,[2] kg/d	39.1	39.7	37.6	40.5	1.34	0.63	0.19	0.41
Efficiency, DMI/ECM	1.51	1.62	1.52	1.57	0.04	0.72	0.08	0.55
Final BW, kg	608.6	631.0	612.5	605.8	23.7	0.65	0.74	0.55
BW gain, kg	9.6	9.8	14.2	9.8	7.2	0.75	0.76	0.75

[1]Pioneer Hi-Bred International, Des Moines, IA.

[2]ECM = Energy-corrected milk yield adjusted to 3.5% fat and 3.2% protein.

nutrients based on chemical analysis and results ration evaluation based on actual DMI, milk yield, and milk composition (NRC, 2001).

The DMI of cows fed diets containing silage produced from 31G20 normal and 32K61 high was higher ($P < 0.006$) than that observed for the other treatments (Table 4). No differences ($P > 0.10$) in milk yield, milk concentration, yield of milk fat and protein, or ECM were observed among varieties or cutting heights. Efficiency of converting DM into ECM tended to be higher ($P < 0.08$) for silage harvested at 30.5 cm compared with that observed for silage harvested at 10.2 cm, but no differences were observed between varieties. Final BW and BW gain over the 5-wk trial were not different ($P > 0.10$) among treatments.

Except for CP intake, which was higher ($P < 0.01$) for the higher cut silage, and ADF intake, which tended to be higher ($P < 0.08$) for 32K61 compared with 31G20, no differences in nutrient intake were observed among treatments during wk 5 of the trial (Table 5). Apparent digestibility of DM ($P < 0.01$), CP ($P < 0.04$), ADF ($P < 0.07$), and NDF ($P < 0.01$) exhibited an interaction because of higher coefficients for 31G20 normal and 32K61 high compared with 31G20 high and 32K61 normal. These observations are in contrast to IVTDMD of the individual silages. The reason for these differences is not readily apparent.

Neylon and Kung (2003) reported a trend for increased milk yield, NDF digestibility, and feed efficiency for cows fed diets containing corn silage harvested at a cutting height of 45.7 cm compared with that cut at 12.7 cm. However, yield of 3.5% FCM was not different because of numerically lower concentrations of milk fat for the diets containing corn silage harvested at 45.7 cm. Oba and Allen (1999) summarized literature comparing forages differing in digestibility and reported an average increase in 4% FCM of 0.25 kg for each 1-U increase in NDF digestibility.

Based on the IVTDMD values measured in our trial (Table 2), NDF digestibility would not have been significantly increased, supporting the lack of any improvement in milk yield. One possible factor for the lack of improvement associated with increased cutting height may be the environment. The growing conditions

Table 5. Nutrient intake and digestibility of lactating cows fed diets based on 2 corn silage hybrids cut at 2 heights (in cm).

	Pioneer 31G20[1]		Pioneer 32K61[1]			P		
	10.2 cm	30.5 cm	10.2 cm	30.5 cm	SE	Hybrid (H)	Cut (C)	H × C
Intake, kg/d								
DM	24.17	26.37	26.13	27.01	1.19	0.29	0.22	0.59
CP	3.86	4.49	4.17	4.73	0.20	0.19	0.01	0.86
ADF	5.07	5.52	6.01	5.57	0.26	0.08	0.99	0.11
NDF	9.75	9.95	9.91	9.72	0.44	0.94	0.99	0.67
Apparent digestibility, %								
DM	62.97	56.93	59.87	65.18	1.71	0.16	0.83	0.01
CP	64.78	60.98	62.94	70.90	2.49	0.13	0.42	0.04
ADF	40.77	31.22	42.43	44.31	2.90	0.03	0.21	0.07
NDF	51.95	39.31	43.45	49.21	2.41	0.78	0.18	0.01

[1]Pioneer Hi-Bred International, Des Moines, IA.

in the Southeast US are characterized by periods of high temperature and humidity along with a more constant day length. These characteristics have been reported to decrease digestibility because of increased concentrations of lignin and fiber (Buxton, 1996). These potential changes might have partially offset any potential improvement in nutrient digestibility related to hybrid or cutting height.

The results of the current trial do not support increasing the cutting height of corn as a means of improving nutrient digestibility or milk yield of cows in midlactation. The difference in predicted nutrient digestibility between the hybrids used in the current trial was not adequate to support improved performance. Because the magnitude of difference in predicted digestibility between varieties is not typically published, it is not clear how the predicted differences may affect animal performance. Based on previous reports, selection of varieties that have higher digestibility rating would be expected to support high animal performance. However, the potential negative effect of environmental conditions common to the Southeastern US may reduce the potential differences observed in other areas.

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