Effect Of Hybrid On Corn Silage Yield, Nutrient Composition, In Vitro Digestion, Intake By Holstein Heifers, Intake And Milk Production By Lactating Holstein Cows

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ABSTRACT

The effect of hybrid on DM yield, plant population, nutrient composition, intake by Holstein heifers and performance of mid-lactation Holstein cows was investigated in a Plot Trial, an Intake Trial and a Lactation Trial. In the Plot Trial three corn hybrids, Mycogen® TMF94 (**Mycogen**), Cargill® F337 (**Cargill**) and Pioneer® 3861 (**Pioneer**) were planted at Miner Institute farm in three replicated plots. When compared with Pioneer, Mycogen and Cargill had lower yields of DM, higher concentrations of NDF and cellulose, and higher in vitro true DM disappearance. There were no differences in in vitro NDF disappearance and digestible DM yield for Mycogen and Cargill, when compared with Pioneer. Mycogen had higher yield of DM despite having a lower plant population, and also had fewer smut-infected ears than Cargill. However, Cargill had a higher in vitro true DM disappearance than Mycogen (P = 0.07). In the Intake Trial, six individually penned bred-heifers at Miner Institute were blocked by body weight, age and estimated calving date and randomly assigned to one of three diets in a replicated 3 × 3 Latin Square with three 21-d periods. The three test diets contained 79% on DM basis of Mycogen, Cargill and Pioneer corn silages. The Pioneer silage diet had lower DMI (P = 0.005) by Holstein heifers when compared with Mycogen and Cargill silage diets. No differences were observed in DMI or NDF intake between Mycogen silage diet and Cargill silage diet. In the Lactation Trial seventy-five mid-lactation Holstein cows on a commercial dairy farm were blocked by parity, days in milk, current milk production and 305 ME and randomly assigned to one of the three TMRs containing Mycogen, Cargill and Pioneer corn silages used in the Intake Trial. Milk production was highest for cows fed Cargill based TMR. It is concluded from this study that Mycogen was higher yielding but less digestible and resulted in lower milk production by lactating cows than Cargill. In addition Mycogen had higher IVTDMD, and similar DM yield and milk yield by lactating dairy cows when compared with Pioneer.

(**Key words:** Corn silage, hybrid, yield, in vitro digestion, intake, milk production)

Abbreviation key: **Mycogen** = Mycogen® TMF94, **Cargill** = Cargill® F337, **Pioneer** = Pioneer® 3861, **NSC** = non structural carbohydrates.

INTRODUCTION

In recent years there has been increasing interest in the development of corn hybrids specifically intended for silage production (Johnson et al., 1997). While grain:stalk ratio and whole plant dry matter yields are still important determinants of the adaptability of a hybrid to silage production, of greater importance is digestible DM yield per hectare and milk production per hectare or per tonne of forage. Mycogen® Seeds' TMF® corn silage hybrids feature tall leafy plants, and stalks with thinner rinds. The grain has softer starch, potentially resulting in better digestibility. Because of the robust plant morphology, recommended seeding rates of TMF® hybrids are somewhat less than with other hybrids. Cargill® Hybrid Seeds has been conducting intensive silage adaptability testing of their standard corn hybrids for several years, and in 1997 released the brown midrib (**BMR**) corn hybrids. The lignin of BMR corn hybrids is lower in concentration and its composition has been altered through several mutations of the BMR gene

(Dado, 1997). It has been reported from several studies that lactating dairy cows fed BMR corn silage had higher DMI, higher body weight gain and produced more milk than cows fed regular corn silage (Dado, 1997). However, BMR corn has been shown to have substantially lower grain and silage yields and are susceptibile to lodging (Dado, 1997). The seed price of BMR corn hybrids is about three times that of most corn hybrids. Pioneer Hi-Bred International has also evaluated several corn hybrids for silage adaptability, but to date has not released any corn hybrids solely for silage production.

The objective of this study was to use three corn hybrids, Mycogen® TMF94 (**Mycogen**), Cargill® F337 (**Cargill**) and Pioneer® 3861 (**Pioneer**) to determine hybrid effects on 1) agronomic characteristics, yield of DM and digestible DM, in vitro true DM disappearance (**IVTDMD**), in vitro NDF disappearance (**IVNDFD**) and nutrient composition; 2) ensiling characteristics and end products of fermentation of whole plant corn silages; 3) intake of DM and NDF by Holstein heifers fed diets consisting primarily of the whole corn plant corn silage; and 4) intake of DM, milk production and composition by mid-lactation multiparous Holstein cows fed the whole plant corn silage based TMRs. In this study Pioneer, a dual-purpose hybrid with good silage quality (Pioneer Hi-Bred International seed catalog, Eastern Area, 1998) was used as a basis of comparison against Mycogen and Cargill. Mycogen and Cargill were bred specifically for silage production, while Pioneer was bred for dual purpose with grain yield as the main criterion.

MATERIALS AND METHODS

Plot Trial

Planting and establishment. Three corn hybrids, Mycogen, Cargill and Pioneer were planted on a Hogansburg loam soil at the Miner Institute farm on May 13, 1997 and harvested on September 22, 1997. The seeding rates were 66,690 kernels/ha for Mycogen and 81,510 kernels/ha for Cargill and Pioneer. A field was divided into three blocks and each block subdivided into three plots which were then randomly assigned to one of the three corn hybrids. Planting was done in 76 cm rows. The field received dairy manure in October 1996, and 145 kg/ha of potassium (K_2O) was plowed down in November, 1996. Additional fertilizer was applied at a rate of 40-36-50 kg/ha (N-P_2O_5-K_2O) during planting.

Harvesting, sampling and ensiling. Forage yields were determined by harvesting four rows averaging 385 m length from each plot. At harvest the final plant population was determined by counting plants in one 4 × 4 m quadrant per plot, and expressing infected ears, barren ears and lodged plants as a percentage of counts made on 200 plants. Forage samples were collected from each plot for chemical analyses. Dry matter was also determined by drying forage samples in a forced air oven at 60°C to a constant weight. The remaining forages from each plot were chopped with a forage chopper, and ensiled in a total of nine minisilos for 15 d for silage characterization, resulting in three replications per treatment. The minisilos were made out of polyvinyl chloride material and were 0.102 m in diameter and 0.457 m long. The particle sizes of the chopped forages were also characterized at ensiling using the Penn State forage particle separator (University of Pennsylvania, College Park, PA.) into small (< 0.79 cm), medium (0.79 - 1.9 cm) and large (> 1.9 cm).

Intake Trial

Forages and Diets. Mycogen and Cargill grown on a commercial dairy farm in Chazy located 10 kilometers from Miner Institute and Pioneer grown at Miner Institute were tested in this trial. Hybrids were planted at the same rates used in the Plot Trial. After harvest, Pioneer was chopped and trucked to the commercial dairy farm where it was ensiled into a silage bag for 5 months. Mycogen and Cargill were also ensiled in silage bags for 5 months at the farm. The same equipment was used to harvest all forages. The test diets formulated using the CPM® Dairy Software (Cornell-Penn-Miner, Cornell University, Ithaca, NY) were primarily composed of corn silage from Mycogen, Cargill and Pioneer corn hybrids which also served as the treatments. The corn silages were trucked from the commercial dairy farm to Miner Institute daily. The composition of the diets on a DM basis was 79.33% corn silage, 10.55% soybean meal, 9.00% Heifer Focus® pellet, 0.16% Magox® mineral mix, 0.79% Hi-calcium® mineral mix and 0.16% Sel Plus® mineral mix. The Heifer Focus® pellet supplied protein, minerals and vitamins, the Magox® supplied magnesium, and Sel Plus® supplied selenium and vitamin E. During the data collection period, DMI was measured by recording feed offered and feed refused for 5 consecutive days.

Animals, feeding and sampling. Six bred heifers (average age = 18 months and initial body weight = 548.9 kg) housed individually in box stalls at the Miner Institute, were blocked by body weight, age and estimated calving date and randomly assigned to one of three diets in a 3 × 3 Latin Square with three 21-d periods with 2 replications. During each period, the heifers were offered their test diets for ad libitum intake for a 2-wk adjustment period followed by a 1-wk data collection period. During the data collection period feed offered and refused by the animals was recorded daily for determination of DMI. Samples of feed offered were also collected for chemical analyses. Silages were sampled at the beginning of each Latin Square period, dried and composited for each feedstuff for chemical analyses. The amount of feed offered and refused by each heifer was recorded daily.

Lactation Trial

Forages and Diets. Three TMRs were formulated using the CPM® Dairy Software (Cornell-Penn-Miner, Cornell University, Ithaca, NY) with Mycogen, Cargill and Pioneer corn silages used in the Heifer Trial as the treatment variables (Table 7). Diets were isocaloric and contained the same amount of ADF and NDF. Forages were analyzed prior to the study and when any changes in forages were noted.

Animals, feeding and sampling. Seventy-five mid-lactation multiparous Holstein cows at the commercial dairy farm where the silages used in the Intake Trial were stored were used in the Lactation Trial. The cows were blocked by parity, days in milk, current milk production and 305 ME and randomly assigned to one of the three dietary treatments. Cows were penned by treatment, fed as a group for ad libitum intake and had free access to clean water. Before the cows were fed their test diets they were fed the farm's Medium Group TMR which did not contain any corn silage from the three test corn hybrids during a 1-wk adjustment period. During the adjustment period, milk yield was measured daily and a weekly average calculated to be used as a covariate in statistcal analysis of milk yield data collected during the test period. Milk

samples were also collected for compositional analysis from the last two consecutive milkings of the adjustment period. The test period during which the experimental TMRs were fed lasted for four weeks. Samples of silages were collected at the beginning of the test period and samples of feed offered to the animals were collected twice during the test period. After determining the DM content, samples were then composited for each feedstuff for chemical analyses. The amount of feed offered and refused by each pen of cows was recorded daily. Milk yield by each cow was recorded daily and then averaged by week. Milk samples were collected from each cow during wk 4 of the test period for compositional analyses.

Chemical Analyses

Fresh corn forage, silage and TMR samples were dried at 60^{o}C, ground to pass through a 1 mm screen using a Wiley mill (Model 3; Arthur T. Thomas Co., Philadelphia, PA) and analyzed for DM (100°C), ash (500°C), and CP (AOAC, 1995); NDF and ADF (without sodium sulfite; Van Soest et al., 1991); ADL (Van Soest and Wine, 1968); and non structural carbohydrates (**NSC**). Analyses for fresh corn forage and silage samples collected during the Plot Trial were done by Cumberland Valley Analytical Services (Maugansville, MD), and that of feed and silage samples collected from the Intake and Lactation Trials done by the Northeast DHI Forage Lab (Ithaca, NY). Hemicellulose was determined as the difference between NDF and ADF, and cellulose as the difference between ADF and ADL. In addition, fresh corn forage and silage samples were also analyzed for sugars and starch using the enzymatic digestion procedure of Smith (1981). In vitro true DM disappearance and IVNDFD were determined using the Ankom® Daisy II® in vitro fermenter (Ankom Technology Corporation, NY) using the method outlined by Goering and Van Soest (1970). Approximately 0.5 grams of sample DM were weighed into 4.5 × 5 cm Ankom® dacron bags which were heat sealed and exposed to in vitro digestion for 30 h in medium containing buffer (Goering and Van Soest, 1970) and ruminal fluid mixed in 4:1 ratio. Ruminal fluid was collected from a non-pregnant dry cow fed a corn and grass silage-based TMR for ad libitum intake and strained through four layers of cheesecloth prior to mixing with buffer. Bags were made from nitrogen-free white polyester monofilament fabric with 25 micron pore size. At the end of incubation bags were placed in an Ankom fiber analyzer and digesta samples exposed to NDF extraction. The NDF residue was either expressed as a fraction of initial sample DM to determine DM disappearance and as a fraction of initial sample NDF to determine NDF disappearance. Fresh corn forage and silage samples were analyzed for free ammonia nitrogen using a Wescan® Ammonia Analyzer, pH determined using a digital pH meter, and processed according to Fenner (1984) for the determination of volatile fatty acids (VFA) and lactic acid using gas chromatography (Supelco, Inc., 1975).

Milk samples were analyzed for total protein, fat composition, lactose and somatic cell counts by the Northeast DHI Dairy Lab (Ithaca, NY).

Statistical Analysis

Data collected from the Plot Trial was analyzed as a randomized block design using the following model.

$$Y_{ijl} = \mu + \tau_i + \gamma_j + \tau\gamma_{ij} + e_{ijl}$$

where,

μ is overall mean;

τ_i is the effect of the i^{th} treatment;

γ_j is the effect of the j^{th} plot or block;

$\tau\gamma_{ij}$ is the treatment by plot interaction; and

e_{ijl} is residual error.

Data were analyzed using the JMP statistical program (SAS, 1993) and least square means and standard error reported. If treatment differences were significant, orthogonal contrasts were performed for corn hybrids developed for silage production (Mycogen and Cargill) either between themselves or versus the corn hybrid developed for dual purpose with grain production as the main criteria (Pioneer). If interaction and (or) plot were not significant, they were removed from the full model and the reduced model reanalyzed.

Data collected from the Intake Trial was analyzed as a replicated 3×3 Latin Square using the general linear model procedure of the SAS (1993) and hybrid differences were determined by orthogonal contrasts when treatment effects were significant. The following model was used.

$$Y_{ijkl} = \mu + \alpha_i + \tau_j + \beta_k + r_l + e_{ijkl}$$

where,

μ is overall mean;

α_i is the effect of the i^{th} heifer;

τ_j is the effect of the j^{th} treatment;

β_k is the effect of the k^{th} period;

r_l is the effect of the l^{th} block (or replication); and

e_{ijkl} is residual error.

Data collected from the Lactation Trial were examined for normality, tested for homogeneity of variance and analyzed using the general linear model procedures of SAS (1993) using the following model.

$$Y_{ijk} = \mu + \tau_i + \gamma_j + \beta(x_{ijk} - \bar{x}..) + e_{ijk}$$

where,

μ is overall mean;

τ_i is the effect of the i^{th} treatment;

γ_j is the effect of the j^{th} block;

β is a linear regression coefficient indicating the dependency of Y_{ijk} and $x_{ij\,k}$;

$x_{ij\,k}$ is the ijk^{th} observation on the covariate; and

e_{ijk} is residual error.

The effects of diet on milk and milk component production were analyzed using the first week's production data as a covariate for the analysis of the randomized block design. If treatment differences were significant, hybrid effects were determined using orthogonal contrasts.

RESULTS AND DISCUSSION

Plot Trials

DM yield, in vitro digestion, plant population and nutrient composition. Mycogen and Cargill corn forages had lower DM content at harvest (P = 0.004), DM yield (P = 0.0012), and a higher IVTDMD (P = 0.07) than Pioneer (Table 1). Although not statistically significant, IVDDM yield also followed a similar trend to that shown by DM yield and IVNDFD followed a similar trend to that shown by IVTDMD. Mycogen had lower IVTDMD (P = 0.07) and higher DM yield (P = 0.0053) than Cargill. There were no differences in plant population, infected ears, barren ears or lodged plants when Pioneer was compared with Mycogen and Cargill. Mycogen had fewer plants (P = 0.0068) and fewer smut-infected ears (P = 0.09) than Cargill. Cargill did not lodge as has been reported to occasionally be a problem with BMR corn. From field observations Pioneer had larger cobs relative to the non-grain part of the plant when compared with Mycogen and Cargill, and Mycogen had large leafy plants.

TABLE 1. Dry matter content at harvest, in vitro true DM disappearance (IVTDMD), in vitro NDF Disappearance (IVNDFD), and yields of DM and in vitro digestible DM (IVDDM) of fresh Mycogen TMF94 (Mycogen), Cargill F337 (Cargill) and Pioneer 3861 (Pioneer) corn hybrid forages

	Treatment means				Contrasts	
Item	Mycogen (M)	Cargill (C)	Pioneer (P)	SE	P v M+C	M v C
DM, %	27.8	27.3	33.7	0.40	0.0004	NS
IVTDMD[1], %	75.1	79.2	73.7	1.64	0.07	0.07
IVNDFD, %	44.7	48.9	43.5	3.29	NS	NS
Yield-30%DM, t/ha	50.2	46.3	52.8	0.65	0.0012	0.0053
DM yield, t/ha	15.1	13.9	15.8	0.20	0.0012	0.0053
IVDDM yield, t/ha	11.3	11.0	11.7	0.33	NS	NS
Plant population						
Plants/ha	66278.3	82333.3	76570.0	2812.2	NS	0.0068
Infected, %	0.17	2.17	0.00	0.701	NS	0.0901
Barren ears, %	1.00	0.33	0.83	0.397	NS	NS
Lodged, %	0.17	0.17	0.00	0.136	NS	NS

[1]In vitro true DM disappearance is determined by expressing NDF residue after in vitro digestion as a fraction of initial sample DM.

When compared with Pioneer, Mycogen and Cargill had higher concentration of ash (% of DM; P = 0.020), NDF (% of DM; P = 0.030), cellulose (% of DM; P = 0.031), calcium (% of DM; P = 0.006), potassium (% of DM; P = 0.10), magnesium (% of DM; P = 0.009) and copper (ppm; P = 0.010) [Table 2]. Although not statistically significant, the concentration of ADF (% of DM) was numerically lower for Pioneer when compared with Mycogen and Cargill.

TABLE 2. Nutrient composition of fresh Mycogen TMF94 (Mycogen), Cargill F337 (Cargill) and Pioneer 3861 (Pioneer) corn hybrid forages

	Treatment means				Contrasts	
Item	Mycogen (M)	Cargill (C)	Pioneer (P)	SE	P v M+C	M v C
	(% of DM)					
Ash	5.2	5.2	4.7	0.12	0.020	NS
CP	6.6	6.7	6.8	0.14	NS	NS
Soluble protein	1.5	1.7	1.0	0.24	NS	NS
ADF	26.0	24.3	23.2	0.50	NS	0.080
NDF	45.6	44.9	40.8	1.15	0.030	NS
Hemicellulose	19.6	20.6	17.6	1.14	NS	NS
Cellulose	23.0	22.0	20.7	0.52	0.031	NS
ADL	3.0	2.3	2.5	0.10	NS	0.002
NSC[1]	41.4	41.7	39.9	1.56	NS	NS
Sugars	8.6	8.2	8.4	1.12	NS	NS
Starch	32.7	33.5	31.5	2.50	NS	NS
Calcium	0.20	0.22	0.14	0.011	0.006	NS
Phosphorus	0.19	0.22	0.20	0.022	NS	NS
Potassium	1.33	1.15	1.10	0.028	0.010	0.008
Magnesium	0.13	0.14	0.10	0.007	0.009	NS
	(% of NDF)					
ADF	57.0	54.1	57.0	1.77	NS	NS
Hemicellulose	43.0	45.9	43.0	1.77	NS	NS
Cellulose	50.4	49.0	50.9	1.73	NS	NS
ADL	6.6	5.0	6.1	0.24	NS	0.019
	(ppm)					
Iron	66.3	50.3	61.3	8.73	NS	NS
Manganese	17.0	19.0	13.7	1.31	NS	NS
Zinc	20.7	25.0	18.3	2.57	NS	NS
Copper	5.3	5.3	3.7	0.33	0.01	NS

[1]Analyses for sugars and starch were done using the enzymatic digestion procedure of Smith (1981).

Mycogen had higher concentrations of ADF (% of DM; P = 0.080), ADL (% of DM; P = 0.002 and % of NDF; P = 0.019) and potassium (% of DM; P = 0.008) than Cargill. The three hybrids had similar concentrations of CP, soluble protein, sugars, starch, NSC, phosphorus, iron, manganese and zinc (Table 2). There were no differences among hybrids for particle size distribution at ensiling (Table 3).

TABLE 3. Particle size distribution at ensiling of fresh Mycogen TMF94 (Mycogen), Cargill F337 (Cargill) and Pioneer 3861 (Pioneer) corn hybrid Forages

	Treatment means[1]			
Particle size	Mycogen	Cargill	Pioneer	SE
	(% of DM)			
Small (< 0.79 cm)	7.3	7.1	6.6	2.07
Medium (0.79 – 1.90 cm)	65.5	64.0	64.8	1.57
Large (> 1.90 cm)	27.2	28.8	28.6	1.32

[1]There were no differences among treatment means ($P > 0.10$)

It was expected that Mycogen would have the lowest plant population because of the lower seeding rate used compared with the other hybrids. Because Mycogen has a robust plant morphology, produces large girthy ears and has two to four extra leaves above the ear when compared with dual-purpose corn hybrids, it had higher yield of DM than Cargill despite having a lower plant population. The higher DM and NDF digestibilities of the Cargill may be explained by the low ADL concentration of this hybrid. Brown midrib corn hybrids generally have lower lignin concentrations than other corn hybrids (Dado, 1997). Lignin has long been recognized as the primary impedement to forage digestibility (Jung and Allen, 1995). Mycogen was more digestible than Pioneer despite similar ADL content of the two corn hybrids. The higher concentration of minerals in Mycogen and Cargill explains their higher ash content when compared with Pioneer.

Nutrient composition of corn silages fermented in mini-silos. When compared with Pioneer, Mycogen and Cargill had lower DM content (P = 0.006) and numerically higher IVNDFD and concentration of NDF (Table 4). Concentrations of sugars, starch, NSC, VFAs and lactate were similar among the silages of the three corn hybrids. Although not statistically significant, Cargill had numerically higher IVTDMD and IVNDFD, and lower NDF concentration than Mycogen. The higher digestibility of the Cargill hybrid is partially explained by its lower ADL concentration.

TABLE 4. Dry matter content, in vitro true DM disappearance (IVTDMD), in vitro NDF Disappearance (IVNDFD) and nutrient composition of Mycogen TMF94 (Mycogen), Cargill F337 (Cargill) and Pioneer 3861 (Pioneer) silages fermented in mini-silos

	Treatment means				Contrasts	
Item[1]	Mycogen (M)	Cargill (C)	Pioneer (P)	SE	P v M+C	M v C
DM, %	26.4	25.9	32.7	0.44	0.0006	NS
IVTDMD, %	73.8	77.5	73.9	1.74	NS	NS
IVNDFD, %	44.3	51.7	40.8	3.49	NS	NS
		(% of DM)				
NDF	48.3	46.7	44.2	1.28	0.036	NS
NSC[2]	29.50	30.53	31.31	1.80	NS	NS
Sugars	1.00	1.23	1.31	0.136	NS	NS
Starch	28.5	29.3	30.0	1.87	NS	NS
Acetate	0.95	1.06	0.88	0.149	NS	NS
Propionate[3]	ND	ND	0.35	0.349	NS	NS
Lactate	4.97	5.82	4.16	0.481	NS	NS

[1]Valerate was not detected.
[2]Analyses for sugars and starch were done using the enzymatic digestion procedure of Smith (1981).
[3]ND denotes not detected.

Intake Trial

Table 5 displays the nutrient composition of feeds utilized in the Intake and Lactation Trials. Mycogen silage had the highest concentration of total VFA, acetate, and lactate. These favorable ensiling characteristics may be attributed to the relatively higher sugar content of Mycogen (Table 2). The Pioneer silage diet had lower DMI (P = 0.005) by Holstein heifers when compared with Mycogen and Cargill silage diets (Table 6). The lower digestibility of the Pioneer silage may have contributed to the reduced intake by heifers fed the diet based on this silage. No differences were observed in DMI between the Mycogen and Cargill silage diets, even though the Cargill hybrid appeared to have a higher digestibility during in vitro digestion.

TABLE 5. Chemical composition of Mycogen TMF94 (Mycogen), Cargill F337 (Cargill) and Pioneer 3861 (Pioneer) corn silages, alfalfa silage, grass hay, sugar beet pulp (SBP), high moisture corn (HMSC), whole cottonseed, soybean meal and protein mix used in diets fed to Holstein heifers or lactating Holstein cows

Composition	Mycogen Corn silage	Cargill corn silage	Pioneer corn silage	Alfalfa silage	Grass hay[3]	SBP	HMSC	Whole cottonseed	Soybean meal	Protein mix
PH	3.75	3.78	3.76	---	---	---	---	---	---	---
DM, %	26.6	25.7	29.0	47.1	89.0	90.0	66.2	92.0	93.0	91.7
IVTDMD, %	69.07	74.84	68.73	---	---	---	---	---	---	---
IVNDFD, %	28.23	45.70	32.05	---	---	---	---	---	---	---
						(% of DM)				
Ash	3.71	4.27	3.38	1.47	6.00	5.30	---	3.90	5.50	22.20
CP	7.4	8.7	7.1	19.2	7.0	9.8	8.1	20.5	42.8	50.7
ADF-CP	0.5	0.4	0.6	2.0	5.0	5.0	0.2	0.2	5.0	---
NDF-CP	0.9	1.0	0.9	3.1	---	---	---	---	---	---
Soluble protein	45.5	48.0	40.5	50.5	25.0	27.0	38.0	28.0	10.0	28.6
ADF	25.8	25.3	26.0	35.3	42.0	33.0	4.0	45.0	10.0	6.6
NDF	42.2	41.7	41.5	43.6	72.0	54.0	10.7	64.0	15.0	12.3
Hemicellulose	16.4	16.4	15.5	8.3	30.0	21.0	6.7	19.0	5.0	5.7
Cellulose	23.2	23.3	22.9	25.8	---	---	---	---	---	---
ADL	2.6	2.0	3.1	9.5	---	---	---	---	---	---
NSC[1]	30.12	30.95	32.10	25.2	10.0	31.0	76.1	1.1	17.7	9.1
Sugars	2.15	2.12	2.08	---	---	---	---	---	---	---
Starch	27.97	28.83	30.02	---	---	---	---	---	---	---
Fat	3.4	2.8	3.2	4.1	2.6	0.6	3.5	18.1	19.0	6.3
Volatile fatty acids										
Acetate	1.027	0.812	0.529	---	---	---	---	---	---	---
Propionate[2]	ND	ND	0.016	---	---	---	---	---	---	---
Butyrate[2]	ND	ND	0.018	---	---	---	---	---	---	---
Isovalerate[2]	ND	ND	0.018	---	---	---	---	---	---	---
Valerate[2]	ND	ND	0.039	---	---	---	---	---	---	---
Lactic acid	7.429	5.171	2.835	---	---	---	---	---	---	---

Table 7 cont.

						(% of NDF)				
ADF	61.1	60.7	62.7	81.0	58.3	61.1	37.4	70.3	66.7	53.7
Hemicellulose	38.9	39.3	37.3	19.0	41.7	38.9	62.6	29.7	33.3	46.3
Cellulose	55.0	55.9	55.2	59.2	---	---	---	---	---	---
ADL	6.2	4.8	7.5	21.8	---	---	---	---	---	---
Minerals										
						(% of DM)				
Calcium	0.22	0.29	0.21	1.49	0.31	0.68	0.05	0.13	0.27	1.20
Phosphorus	0.24	0.23	0.22	0.36	0.14	0.10	0.31	0.57	0.65	0.67
Sulfur	0.08	0.11	0.06	0.25	---	0.22	0.09	0.21	0.24	0.52
Magnesium	0.16	0.20	0.12	0.27	0.09	0.28	0.11	0.36	0.25	0.65
Potassium	1.04	0.93	1.06	2.67	2.00	0.22	0.44	1.22	1.80	1.11
Sodium	0.018	0.017	0.003	0.031	0.020	0.200	---	0.020	0.020	0.120
						(ppm)				
Iron	130.0	147.0	63.0	170.0	---	293.0	41.0	151.0	0.8	324.0
Zinc	22.0	23.0	17.0	30.0	---	1.0	17.0	---	62.0	47.0
Copper	5.0	7.0	4.0	10.0	---	14.0	1.0	54.0	20.0	13.0
Manganese	19.0	23.0	15.0	19.0	---	38.0	5.0	---	39.0	26.0
Molybdenum	1.0	0.8	0.8	2.0	---	---	---	---	---	---

[1]Analyses for sugars and starch for corn silages were done using the enzymatic digestion procedure of Smith (1981).
[2]ND denotes not detected.
[3]Predominantly Timothy hay.

TABLE 6. Intake of DM and NDF by Holstein heifers individually fed diets consisting of 79% (DM basis) Mycogen TMF94 (Mycogen), Cargill F337 (Cargill) or Pioneer 3861 (Pioneer) silage

	Treatment means				Contrasts	
Item	Mycogen (M)	Cargill (C)	Pioneer (P)	SE	P v M+C	M v C
Final body weight, kg	560.75	570.62	566.50	---	---	---
Body condition score	3.67	3.67	3.79	---	---	---
DM intake						
kg/d	12.00	12.04	11.33	0.34	0.005	NS
% of Body weight	2.14	2.11	2.00	0.05	0.003	NS

Lactation Trial

Nutrient composition of TMRs, corn silages and selected feed ingredients. Apart from differences in corn hybrid for the corn silages, the ingredients used to formulate the TMRs were similar (Table 7). Chemical analyses revealed that TMRs had similar concentrations of CP, ADF, NDF, calcium and potassium (Table 7). Mycogen silage-based TMR tended to have slightly higher hemicellulose concentration while Pioneer silage-based TMR tended to have lower concentrations of DM, phosphorus, sodium, iron, zinc, copper, manganese and molybdenum (Table 7). The composition of the corn silages is shown in Table 5 and has been discussed above under the Heifer Trial. The composition of sugar beet pulp, high moisture corn, whole cotton seed and protein concentrate included in the TMRs is also shown in Table 5.

DMI, milk yield, and milk composition. Since cows were group fed, no statistical analysis were conducted on DMI data. The mean DMI by cows fed Cargill-based TMR tended to be higher than that of cows fed Mycogen silage-based TMR and Pioneer silage-based TMR (Table 8). Interestingly, DMI by cows in the Lactation Trial where corn silage formed 31% (DM basis) of the diet, did not reflect the results of the Intake Trial where corn silage formed 79% (DM basis) of the diet and no differences were observed between the corn silage treatments (Table 6). Milk yield reflected the trends observed in DMI (Table 8). Milk yield was lower for cows fed Pioneer silage-based TMR when compared with cows fed Mycogen and Cargill silage-based TMRs (P = 0.06). Milk yield and 3.5% fat-corrected milk (**FCM**) yield were also lower for cows fed Mycogen silage-based TMR when compared with those fed Cargill silage-based TMR (P = 0.001). Although a direct comparison between Mycogen and Pioneer was not tested statistically, there appears to be no difference in milk yield and 3.5% FCM yield between cows fed the Mycogen and Pioneer-based TMRs. As anticipated, milk yield declined from week 1 to 4 of the experiment because the cows were approaching the end of their lactation period (Figure 1). Cows fed Pioneer silage-based TMR had similar milk fat, milk protein and milk lactose with cows fed Mycogen and Cargill silage-based TMRs (Table 8). Cows fed Mycogen silage-based TMR produced milk with higher protein content than cows fed Cargill silage-based TMR (P = 0.07). In agreement with what was observed in this study, Dado (1997) reported that it had been found in several studies that lactating dairy cows fed BMR corn silage had higher DMI and produced more milk than cows fed non BMR corn silage.

TABLE 7. Composition of Mycogen TMF94 (Mycogen), Cargill F337 (Cargill) and Pioneer 3861 (Pioneer) corn silage based TMRs fed to lactating Holstein cows

	TMR		
Composition	Mycogen	Cargill	Pioneer
		(% of DM)	
Ingredient			
Alfalfa silage	17.3	17.3	17.3
High moisture corn	20.24	20.24	20.24
Sugar beet pulp	7.79	7.79	7.79
Energy booster[1]	0.61	0.61	0.61
Whole cotton seed	2.25	2.25	2.25
Protein mix[2]	12.46	12.46	12.46
Grass hay[3]	1.73	1.73	1.73
Sodium bicarbonate	0.43	0.43	0.43
Roasted soybean	6.06	6.06	6.06
Mycogen corn silage	31.14	0.00	0.00
BMR corn silage	0.00	31.14	0.00
Pioneer corn silage	0.00	0.00	31.14
Chemical			
DM, %	46.9	46.2	45.0
		(% of DM)	
CP	17.0	17.3	17.7
Soluble protein	36.0	38.0	37.0
ADF-CP	1.3	1.3	1.1
ADF	22.7	23.4	23.9
NDF	35.3	34.7	35.1
Hemicellulose	12.6	11.3	11.2
Calcium	0.97	0.85	0.82
Phosphurus	0.42	0.41	0.34
Sulfur	0.19	0.18	0.17
Magnesium	0.29	0.30	0.25
Potassium	1.19	1.21	1.21
Sodium	0.88	0.76	0.52
		(ppm)	
Iron	265.0	296.0	210.0
Zinc	94.0	89.0	76.0
Copper	22.0	21.0	17.0
Manganese	49.0	49.0	41.0
Molybdenum	1.7	1.8	1.5

[1]Protein mix contained soybean hulls, soybean meal, fish meal, urea, canola meal, salt, blood meal, corn gluten, animal fat, niacin and vitamin E.
[1]Energy booster contained animal fat and calcium.
[2]Predominantly Timothy hay containing 7% CP and 72% NDF on DM basis.

TABLE 8. DMI, milk yield and milk composition of lactating Holstein cows group-fed TMRs based on Mycogen TMF94 (Mycogen), Cargill brown midrib (Cargill) and Pioneer 3861 (Pioneer) silages

	Treatment means				Contrasts	
Item	Mycogen (M)	Cargill (C)	Pioneer (P)	SE	P v M+C	M v C
DMI, kg/d	20.2	23.4	20.5	---	---	---
Milk yield, kg/d	31.1	33.4	31.2	0.46	0.06	0.001
3.5% Fat corrected milk yield, kg/d	33.46	35.78	33.27	0.78	NS	0.04
Milk fat, %	4.27	4.13	4.20	0.08	NS	NS
Milk true protein, %	3.11	3.04	3.04	0.02	NS	0.07
Crude protein, %	3.26	3.20	3.21	0.02	NS	0.07
Milk lactose, %	4.82	4.81	4.78	0.02	NS	NS
Linear somatic cell count (ln)	4.83	4.62	4.79	0.16	NS	NS

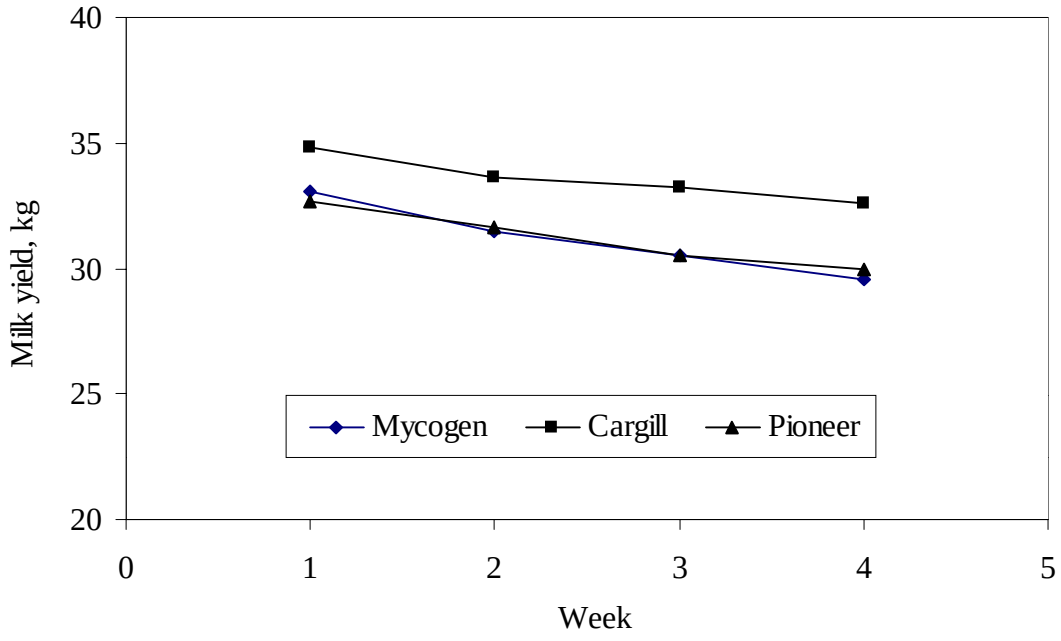

Figure 1. Average daily milk yield (kg/day) by lactating Holstein cows

CONCLUSIONS

Although Mycogen and Cargill had lower yields of DM and higher concentrations of NDF and cellulose when compared with Pioneer, they had higher IVTDMD. Mycogen when compared with Cargill, had higher yield of DM despite having a lower plant population, and also had fewer infected ears. Dry matter intake by Holstein heifers was also higher for Mycogen and Cargill based TMRs when compared with the Pioneer based TMR. There were no differences in DMI between Cargill and Mycogen silages fed as 79% (DM basis) of the heifer's diet. Cows fed the Cargill-based TMR yielded nearly 2 kg/d more milk than cows fed either Mycogen or Pioneer-based TMR. However, cows fed Mycogen-based TMR tended to have higher levels of milk fat and protein compared with cows fed the other corn silage treatments. Mycogen had higher DM yield, lower IVTDMD, and resulted in lower milk production by lactating cows when compared with Cargill. Mycogen hybrid had higher IVTDMD and DMI by heifers but had similar yields of DM, and promoted similar milk production by lactating cows when compared with Pioneer.

REFERENCES

AOAC. 1995. Official Methods of Analysis (16th Ed.). Association of Official Analytical Chemists, Arlington, VA.

Dado, R. G. 1997. Nutritional value of different corn hybrids. Pages 183-203 *in* Proc. Tri-State Dairy Nutr. Conf.

Fenner, H. 1984. Methods for determining fermentation products in acid preserved feeds and forages. Massachusetts Agric. Exp. Sta. Res. Bullet. 691., Univ. Massachusetts at Amherst, MA.

Goering, H. K., and P. J. Van Soest. 1970. Forage fiber analyses. Apparatus, reagents, procedures, and some applications. Agriculture Handbook N0. 379. USDA-ARS, Washington, DC.

Jung, H. G., and M. S. Allen. 1995. Characteristics of plant cell walls affecting intake and digestibility of forages by ruminants. J. Anim. Sci. 73:2774-2790.

Johnson, J. C., Jr., R. N. Gates, G. L. Newton, J. P. Wilson, L. D. Chandler, and P. R. Utley. 1997. Yield, composition, and in vitro digestibility of temperate and tropical corn hybrids grown as silage crops planted in summer. J. Dairy Sci. 80:550-557.

SAS. SAS/STAT® User's Guide: Statistics, Version 6, Fourth Edition., 1993. SAS Inst., Inc., Cary, NC.

Smith, D. 1981. Removing and analyzing total nonstructural carbohydrates from plant tissue. Report R207, College of Agric. Life Sci., University of Wisconsin, Madison,WI.

Supelco, Inc., 1975. GC Separation of of VFA. C2 - C5, Bull. 7498. Supelco, Inc., Bellefonte, PA.

Van Soest, P. J., J. B. Robertson, and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal production. J. Dairy Sci. 74:3583-3597.

Van Soest, P. J., and R. H. Wine. 1968. Determination of lignin and cellulose in acid-detergent fiber with permanganate. J. Assoc. Off. Anal. Chem. 51:780-785.

APPENDIX

Economic Analysis

The following economic analysis of the three hybrids being fed in a dairy ration are based on the following assumptions:

- 1997 seed cost – Mycogen TMF94 and Pioneer 3861 - $80/80,000 seeds
  Cargill F337 - $280/80,000 seeds
- Corn silage production cost = $741/Ha + seed cost
- Seed Corn Planting Rate – Mycogen – 66,700 plants/Ha
  Pioneer and Cargill – 81,500 plants/Ha
- TMR Cost - $3.63/cow/day
- Milk Price - $13.30 per cwt with $0.14 fat differential (paid per point over 3.5% butterfat)

Corn Silage Cost/kg

Corn silage production cost/Ha + seed cost/Ha ÷ DM yield = $/T ÷1000 = corn silage cost/kg

Mycogen: $741 + 66.7 = $807.7/Ha ÷ 15.1 T/Ha = $53.49/T ÷ 1000 = $0.0535/kg
Pioneer: $741 + 81.5 = $822.5/Ha ÷ 15.8 T/Ha = $52.06/T ÷ 1000 = $0.0521/kg
Cargill: $741 + 285 = $1026.0/Ha ÷ 13.9 T/Ha = $73.81/T ÷ 1000 = $0.0738/kg

Corn Silage Cost/cow/day

Dry Matter Intake x % corn silage in ration = kg corn silage consumed/day x corn silage cost/kg = cost/cow/day for corn silage

Mycogen: 20.2 kg/d x 31.13% cs in ration = 6.29kg x $0.0535/kg = $0.333/c/d
Pioneer: 20.5 kg/d x 31.14% cs in ration = 6.38kg x $0.0521/kg = $0.332/c/d
Cargill: 23.4 kg/d x 31.14% cs in ration = 7.29kg x $0.0738/kg = $0.538/c/d

Additional Cost Due to Hybrid/cow/day

The lowest corn silage cost/cow/day was subtracted from each hybrid

Mycogen: $0.333 – 0.332 = $0.001/c/d
Pioneer: $0.332 – 0.332 = $0.0 /c/d
Cargill: $0.538 - 0.332 = $0.206/c/d

TMR cost/cow/day

The TMR cost assumption will be used for the hybrid resulting in the lowest DMI and further calculations are based on this cost:
DMI (20.2 kg/d) = $3.63 + additional ration cost due to hybrid

Mycogen: $3.63 + $0.001 = $3.631/c/d
Pioneer: If 20.2 kg/d = $3.63, then 20.5 kg/d = $3.68 + $0.0 = $3.68/c/d

Cargill: If 20.2 kg/d = $3.63, then 23.4 kg/d = $4.21 + $0.206 = $4.416/c/d

Income Over Feed Cost

(Average #/c/d @ $13.30 per cwt + $0.14 fat differential) – TMR cost/cow/day = Income over Feed Cost/cow/day

Mycogen: $14.38/cwt x .686 = $9.86 - $3.631 = $6.229 income/c/d
Pioneer: $14.28/cwt x .688 = $9.82 - $3.68 = $6.14 income/c/d
Cargill: $14.18/cwt x .736 = $10.44 - $4.416 = $6.024 income/c/d

It should be emphasized that this economic analysis assumes no change in ration due to differences in corn silage quality. Cargill Seeds states in a technical reference that feeding BMR silage "may require certain adjustments in ration formulation". Adjusting the ration to account for higher corn silage dry matter intake would be expected to reduce the proportion of grain in the ration, thus reducing ration cost. This analysis illustrates the importance of segregating corn silage that is substantially different than "normal" corn silage, and reformulating rations to account for these differences. Feeding these silages will require more precise inventory management and perhaps investment in additional storage structures.