2013

Brown Mid-Rib Corn Variety Trial

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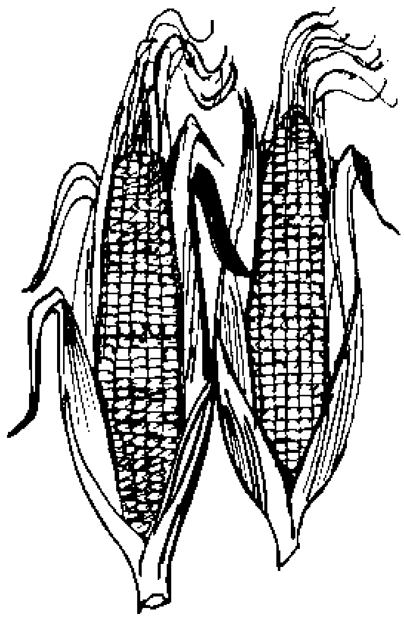

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2013 Brown Mid-Rib Corn Variety Trial

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Brown mid-rib (BMR) corn has a lower lignin content than other silage corn varieties, which makes it more digestible to dairy cows, potentially increasing milk production. Growers interested in BMR corn look for high-yielding varieties with favorable chemical composition and quality. Since 2010, the University of Vermont Extension Northwest Crops & Soils program has conducted research trials to evaluate BMR corn silage varieties. In 2013, the trial included 10 varieties from three different seed companies. While the information presented can begin to describe the yield and quality performance of these BMR corn varieties in this region, it is important to note that the data represent results from only one season and one location. Compare other hybrid performance data before making varietal selections.

MATERIALS AND METHODS

A trial was conducted at Borderview Research Farm in Alburgh, Vermont in 2013 in order to evaluate ten BMR corn varieties. The experimental design was a randomized block of 5'x50' plots (two 30" rows of corn) with three replications (Table 1). The soil was a Benson rocky silt loam, and the area was previously planted with soybeans. The seedbed was prepared with spring disking and finished with a spike tooth harrow. The corn was planted on 14-May at a rate of 34,000 seeds per acre with a John Deere 1750 four-row corn planter.

Corn was planted and a 10-20-20 starter fertilizer was applied at 200 lbs per acre on 14-May. On 6-Jun, Syngenta's selective herbicide Lumax® (Mesotrione, S-Metolachlor, and triazine) was applied at a rate of 3 quarts per acre with Dupont Accent® (Nicosulfuron) at a rate of 0.33 ounces per acre. An additional topdress fertilizer (urea (46-0-0)) was applied on 20-Jun at a rate of 200lbs per acre. Plots were harvested on 2-Nov with a John Deere two-row chopper, and whole-plant silage was collected and weighed in a forage wagon.

Table 1. Agronomic information for the 2013 BMR corn variety trial at Borderview Research Farm.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Soybeans
Tillage operations	Fall chisel plow, spring disk, spike tooth harrow
Plot size (ft.)	5 x 50
Replicates	3
Seeding rate	34,000 seeds ac^{-1}
Row width (in.)	30
Planting date	14-May
Starter fertilizer	200 lbs ac^{-1} of 10-20-20
Additional fertilizer (topdress)	200 lbs ac^{-1} urea (46-0-0), 20-Jun
Herbicide	3 qt ac^{-1} Lumax®, 0.33 oz ac^{-1} Accent®, 6-Jun
Harvest date	2-Nov

Treatments were 10 publicly-available corn varieties (Table 2). The seed for this trial was donated by three participating seed companies, Mycogen, Pioneer, and Seedway, LLC, whose contact information is listed below. Varieties ranged from 88-114 days in relative maturity. Relative Maturity (RM) and seed trait information was provided by the seed companies.

Mycogen	Pioneer	Seedway
Claude Fortin Highgate, Vermont (802) 363-2803	Bourdeau Bros. Sheldon, VT (802) 933-2277	Ed Schillawski Shoreham, Vermont (802) 897-2281

Table 2. Relative maturities and listed traits of ten evaluated BMR varieties.

Variety	Company	Relative maturity	Traits
SW3937	Seedway	94-96	BMR
F2F298	Mycogen	88	BMR, HXI, LL, RR2
F2F343	Mycogen	92	BMR, RR2
F2F387	Mycogen	95	BMR, HXT, LL, RR2
F2F488	Mycogen	99	BMR, HXT, LL, RR2
F2F569	Mycogen	104	BMR, HXT, LL, RR2
F2F626	Mycogen	109	BMR, SSX, LL, RR2
F2F665	Mycogen	109	BMR, HXT, LL, RR2
P1376XR	Pioneer	113	BMR, HXX, LL, RR2
P1449XR	Pioneer	114	BMR, HXX, LL, RR2

BMR = Brown mid-rib, a naturally-occurring gene
HXI = Herculex® I Insect Protection, glyphosate (Roundup®, Touchdown®) and glufosinate (Ignite®) herbicide tolerance
HXT = Herculex Xtra®, provides season-long control of a variety of pests, including European corn borer, western bean cutworm, corn rootworm
HXX = Herculex XTRA® (HXX) combines Herculex I and Herculex RW traits to provide consistent, season-long control of corn rootworms, allows protection in-plant and above-and below-ground
LL = Glufosinate-ammonium (LibertyLink®) herbicide tolerance
RR2 = Roundup Ready corn, glyphosate (Roundup®, Touchdown®) herbicide tolerance
SSX = Genuity® SmartStax™, provides control of a variety of pests, including European corn borer, western bean cutworm, corn rootworm, provides herbicide flexibility and makes possible a 5% refuge requirement

Chopped silage was dried and ground with a Wiley laboratory mill. A subsample was retained for analysis. The subsamples of the harvested material were collected, dried, ground, and then analyzed at the University of Vermont's Testing Laboratory, Burlington, VT, for quality analysis. Dry matter yields were calculated and then adjusted to 35% dry matter.

Silage quality was analyzed using the FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer. Dried and coarsely-ground plot samples were brought to the lab where they were reground using a cyclone sample mill (1mm screen) from the UDY Corporation. The samples were then analyzed using the FOSS NIRS DS2500 for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), 30-hour digestible NDF (NDFD), starch, non-fiber components (NFC), nonstructural components (NSC), and total digestible nutrients (TDN).

Mixtures of true proteins, composed of amino acids, and non-protein nitrogen make up the CP content of forages. The CP content of forages is determined by measuring the amount of nitrogen and multiplying by

6.25. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of plants are contained in the fiber fraction. The detergent fiber analysis system separates forages into two parts: cell contents, which include sugars, starches, proteins, non-protein nitrogen, fats and other highly digestible compounds; and the less digestible components found in the fiber fraction. The total fiber content of forage is contained in the neutral detergent fiber (NDF). Chemically, this fraction includes cellulose, hemicellulose, and lignin. Because of these chemical components and their association with the bulkiness of feeds, NDF is closely related to feed intake and rumen fill in cows. Recently, forage testing laboratories have begun to evaluate forages for NDF digestibility (NDFD). Evaluation of forages and other feedstuffs for NDFD is being conducted to aid prediction of feed energy content and animal performance. Research has demonstrated that lactating dairy cows will eat more dry matter and produce more milk when fed forages with optimum NDFD. Forages with increased NDFD will result in higher energy values and, perhaps more importantly, increased forage intakes. Forage NDFD can range from 20 – 80% NDF.

Net energy for lactation (NE_L) is calculated based on concentrations of NDF and ADF. NE_L can be used as a tool to determine the quality of a ration, but should not be considered the sole indicator of the quality of a feed, as NE_L is affected by the quantity of a cow's dry matter intake, the speed at which her ration is consumed, the contents of the ration, feeding practices, the level of her production, and many other factors. Most labs calculate NE_L at an intake of three times maintenance. Starch can also have an effect on NE_L, where the greater the starch content, the higher the NE_L (measured in Mcal per pound of silage), up to a certain point. High grain corn silage can have average starch values exceeding 40%, although levels greater than 30% are not considered to affect energy content, and might in fact have a negative impact on digestion. Starch levels vary from field to field, depending on growing conditions and variety.

The silage performance indices of milk per acre and milk per ton were calculated using a model derived from the spreadsheet entitled "MILK2006," developed by researchers at the University of Wisconsin. Milk per ton measures the pounds of milk that could be produced from a ton of silage. This value is generated by approximating a balanced ration meeting animal energy, protein, and fiber needs based on silage quality. The value is based on a standard cow weight and level of milk production. Milk per acre is calculated by multiplying the milk per ton value by silage dry matter yield. Therefore, milk per ton is an overall indicator of forage quality and milk per acre an indicator of forage yield and quality. Milk per ton and milk per acre calculations provide relative rankings of forage samples, but should not be considered as predictive of actual milk responses in specific situations for the following reasons:

1) Equations and calculations are simplified to reduce inputs for ease of use,
2) Farm to farm differences exist,
3) Genetic, dietary, and environmental differences affecting feed utilization are not considered.

Yield data and stand characteristics were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and hybrids were treated as fixed. Hybrid mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among hybrids is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown. Where the difference between two hybrids within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that for 9 out of 10 times, there is a real difference between the two hybrids. Hybrids that were not significantly lower in performance than the highest hybrid in a particular column are indicated with an asterisk. In the example below, hybrid C is significantly different from hybrid A but not from hybrid B. The difference between C and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these hybrids did not differ in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

Hybrid	Yield
A	6.0
B	7.5*
C	**9.0***
LSD (0.10)	2.0

RESULTS

Using data from a Davis Instruments Vantage Pro2 weather station at Borderview Research Farm in Alburgh, VT, weather data was summarized for the 2013 growing season (Table 3). Although the spring season started out very wet, with higher precipitation in May and June than normal (based on 1981-2010 data) the rest of the summer and into fall remained drier than usual. May had 4.79 inches more precipitation and June had 9.23 inches more precipitation than the 30-year average. The wet spring resulted in a delay in planting for many growers. Temperatures throughout the growing season were very similar to the historical average. However, above-average temperatures in October allowed for rapid growth and plant maturation at the end of the season. There were an accumulated 2,401 Growing Degree Days (GDDs) at a base temperature of 50°F. This was 189 more than the historical 30-year average for May-October.

Table 3. Summarized weather data for 2013 – Alburgh, VT.

Alburgh, VT	May	June	July	August	September	October
Average temperature (°F)	59.1	64	71.7	67.7	59.3	51.1
Departure from normal	2.7	-1.8	1.1	-1.1	-1.3	2.9
Precipitation (inches)	4.79	9.23 *	1.89	2.41	2.20	2.39 ◊
Departure from normal	1.34	5.54	-2.26	-1.50	-1.44	-1.21
Growing Degree Days (base 50°F)	312	427	677	554	289	142
Departure from normal	113	-47	37	-27	-29	142

Based on weather data from a Davis Instruments Vantage Pro2 with Weatherlink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.
* June 2013 precipitation data based on National Weather Service data from cooperative stations in South Hero, VT.
◊ October 2013 precipitation data based on National Weather Service data from cooperative stations in Burlington, VT.

Dry matter content of the corn silage at harvest ranged from 44.3% (SW3937) to 30.6% (F2F665). A range in dry matters is to be expected as the varieties were harvested on the same day but differed in RM. The variety with the highest yield after being adjusted to 35% dry matter was 'P1449XR' (Table 4). However, yields adjusted to 35% dry matter did not vary significantly by variety in this trial. The mean yield for the BMR variety trial was 23.5 tons.

Table 4. Yield and dry matter content of ten BMR varieties, Alburgh, VT, 2013.

Variety	Relative Maturity	Yield at 35% DM tons ac^{-1}	Harvest DM %
SW3937	94-96	19.7	**44.3**
F2F298	88	20.3	39.0
F2F343	92	20.2	38.3
F2F387	95	21.7	40.2
F2F488	99	21.8	32.8
F2F569	104	29.4	43.4
F2F626	109	22.8	32.9
F2F665	109	20.9	30.6
P1376XR	113	26.1	29.8
P1449XR	114	**31.9**	34.2
LSD (0.10)		NS	NS
Trial mean		23.5	36.5

Treatments indicated in **bold** had the top observed performance.
NS – No significant difference was determined between treatments.

The majority of forage quality characteristics analyzed varied significantly by BMR corn variety (Table 5). The variety with the highest concentration of crude protein (CP) was 'P1376XR' with 8.82%. This value is significantly different from all the other varieties except SW3937, which was 8.39%. The variety with the highest percent of starch was 'F2F343' with 34.8%, which is statistically similar to SW3937, 'F2F298', 'F2F387', 'F2F569', P1376XR, and P1449XR, and was 2.6% higher than the trial mean.

The content of nonstructural carbohydrates (NSC) was highest in the variety F2F387 (36.7%). This value is significantly different from the NSC content of the varieties 'F2F488', F2F569, 'F2F626', and 'F2F665'. The variety F2F387 had the highest percent of total digestible nutrients (TDN) and the highest calculation of net energy for lactation (NE_L). This variety was statistically similar to the varieties SW3937, F2F298, F2F343, F2F569, P1376XR, and P1449XR for TDN and NE_L.

Lower lignin content means that the corn is more digestible to dairy cows. Thus, a lower percentage of lignin can potentially increase milk production. The variety with the lowest percent lignin was F2F387 at 2.20%. However, this was not statistically different from any of the other varieties. The trial average of percent lignin was 2.43%.

Table 5. Forage quality of ten evaluated BMR corn varieties, Alburgh, VT, 2013.

Variety	Forage quality characteristics									Milk	
	CP	ADF	NDF	NDFD	Starch	NSC	TDN	Lignin	NE_L	ton^{-1}	ac^{-1}
	% of DM	% of DM	% of DM	% of DM	% of DM	% of DM	% of DM	% of DM	Mcal lb^{-1}	lbs	lbs
SW3937	8.39*	22.2*	42.1*	65.5	34.1*	35.4*	72.3*	2.39	0.75*	2803	19284
F2F298	7.58	22.9*	41.2*	**68.9**	32.9*	35.5*	72.9*	2.44	0.76*	2863	20302
F2F343	7.36	23.2*	41.5*	65.3	**34.8***	35.4*	73.2*	2.26	0.76*	2913*	20710
F2F387	7.37	21.9*	40.8*	66.8	34.2*	**36.7***	**73.8***	**2.20**	**0.77***	2874	21805
F2F488	8.08	24.2	44.2	66.7	30.8	32.4	71.4	2.54	0.74	2868	21933
F2F569	7.41	24.7	44.5	65.3	31.4*	33.0	72.1*	2.63	0.75*	2854	29396
F2F626	7.02	25.5	46.3	63.9	29.6	32.6	71.7	2.57	0.74	2764	22168
F2F665	7.73	26.6	46.7	66.5	27.8	30.4	70.1	2.56	0.73	2796	20436
P1376XR	**8.82***	22.6*	40.7*	67.3	32.2*	34.7*	72.8*	2.50	0.76*	2968*	27075
P1449XR	8.25	**21.7***	**39.9***	67.1	33.9*	35.6*	73.7*	2.24	0.77*	**2991***	**33183**
LSD (0.10)	0.46	1.9	3.2	NS	3.4	2.6	1.9	NS	0.02	114	NS
Trial mean	7.80	23.5	42.8	66.3	32.2	34.2	72.4	2.43	0.75	2869	23629

Treatments indicated in **bold** had the top observed performance.
* Treatments indicated with an asterisk did not perform significantly worse than the top-performing treatment in a particular column.
NS – No significant difference was determined between treatments.

Acid detergent fiber (ADF), a measure of difficult-to-digest fiber content, and neutral detergent fiber (NDF), which is related to dairy cow feed intake, were both lowest in the variety P1449XR (21.7% and 39.9% respectively). The ADF and NDF concentrations of P1449XR are statistically similar to the varieties P1376XR, F2F387, F2F343, F2F298, and SW3937 (Figure 1). The percentage of NDF that is digestible in 30 hours (NDFD) did not differ statistically by variety.

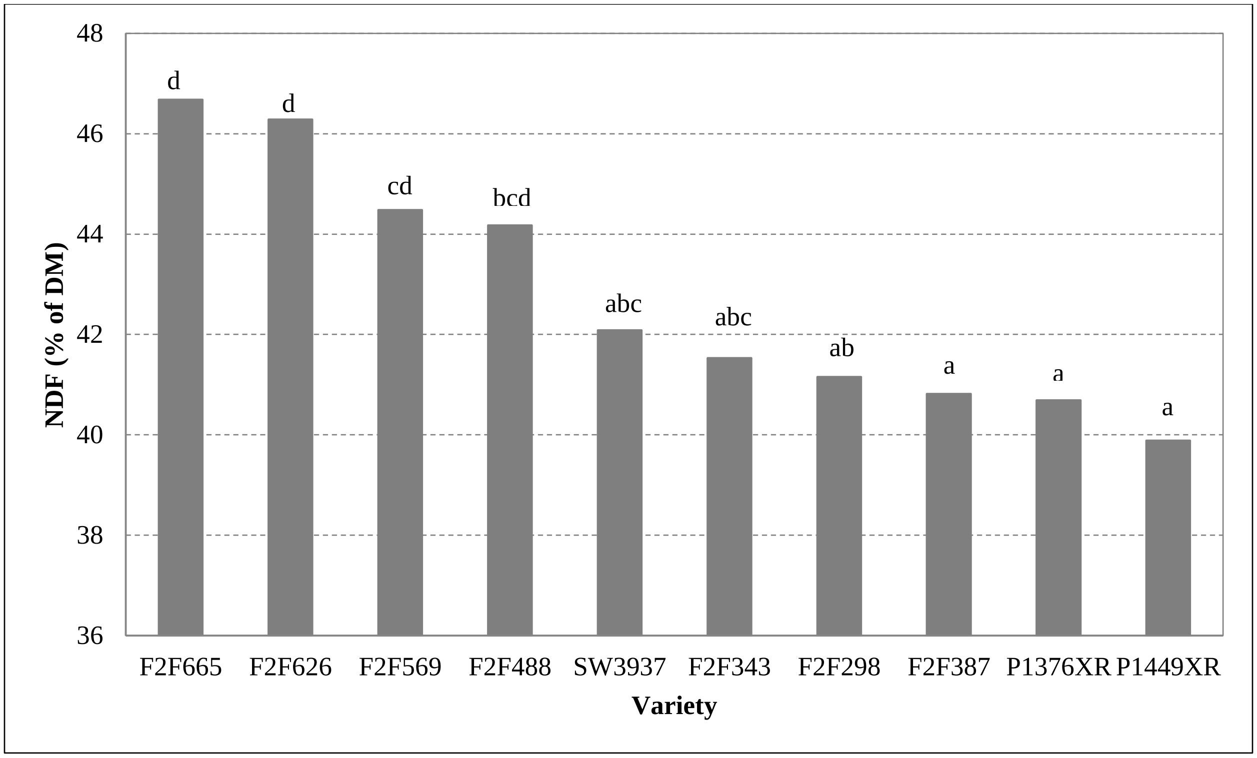

Figure 1. Percent neutral detergent fiber (NDF) of ten BMR corn silage varieties, Alburgh, VT, 2013. Treatments with the same letter did not differ significantly (p=0.10).

The amount of milk per ton of feed was calculated to be highest in P1449XR (2991 lbs per ton). This is statistically higher than all other varieties except P1376XR and F2F343, with 2968 lbs and 2913 lbs respectively (Figure 2). Milk per acre, an indicator of both yield and quality, was also highest in P1449XR, but this value did not differ significantly from other varieties. Figure 2 demonstrates the relationship between milk per ton and milk per acre, and includes dotted lines to represent the trial averages. Varieties that fall above or to the right of the lines performed better than the trial average, and varieties in the upper right quadrant of the figure were above average in both milk per ton and milk per acre.

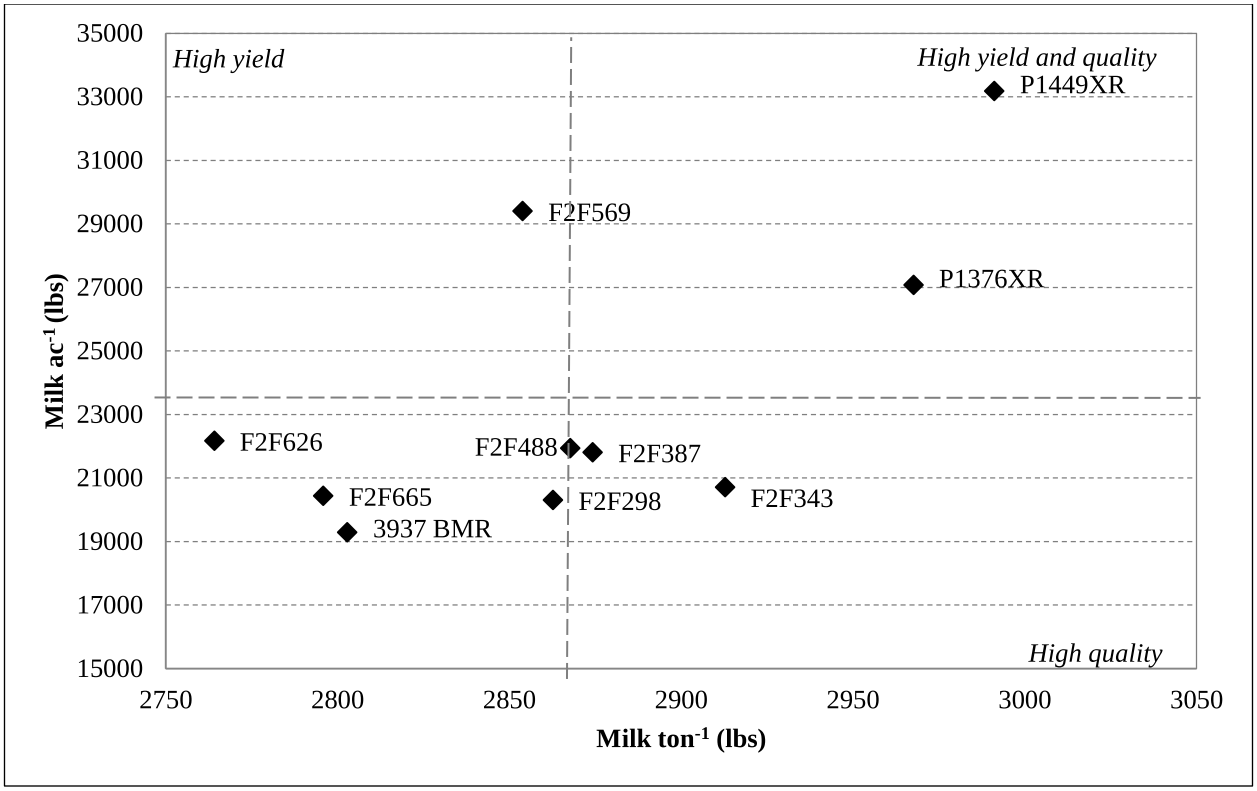

Figure 2. Milk production of ten BMR corn silage varieties, Alburgh, VT, 2013, showing relationship between milk per ton and milk per acre. Dotted lines represent the mean milk per ton and milk per acre for the location.

DISCUSSION

The average yield for this BMR corn trial was 23.5 tons per acre at 35% dry matter content. This is higher than the trial average in 2012 (19.8 tons per acre) and 2011 (18.6 tons per acre). In spite of the very wet spring and planting season, the summer temperatures were close to average and only slightly drier than the historical average. Thus, the comparatively high yields may be due in part to the favorable growing season.

While BMR corn can have a yield drag when compared to conventional silage corn varieties in a given year, its higher NDF digestibility (NDFD) often makes it a viable choice for growers looking to maximize milk production. As expected, NDFD was high (66.3%) and did not differ by variety. Interestingly, the BMR Corn trial yield average in 2013 (23.5 tons per acre) exceeded the Long Season Corn trial yield average by one ton per acre (22.4 tons per acre).

Although yields did not vary significantly between varieties, almost all forage quality characteristics did vary. Only milk per acre, NDFD, and lignin were statistically the same for all varieties.

Milk per ton, an indicator of overall forage quality, was highest in the varieties P1449XR, P1376XR, and F2F343.

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