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CORN SILAGE: HYBRID X PLANT POPULATION STUDY

by

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INTRODUCTION

Seed companies have recently developed corn hybrids with speciality or value-added traits. Although many of the specialty hybrids (high-oil, high-lysine, waxy corn, etc.) have been targeted for the grain market, seed companies have also released speciality corn silage hybrids. For example, Cargill has released brown midrib hybrids and Mycogen has released TMF or leafy hybrids. Both the brown midrib and leafy hybrids, which have been bred for stover quality characteristics, have been developed exclusively for corn silage production. Transgenic hybrids, such as Bt or herbicide resistant hybrids, may also improve corn silage production. Understandably, the price of specialty or transgenic hybrids exceeds the cost of normal hybrids, often significantly. New York dairy producers require more information on the yield and quality of speciality and transgenic hybrids compared with normal hybrids. With the seed cost and potential silage quality differences between speciality and transgenic vs. normal hybrids, corn hybrid selection for dairy producers has increased in importance.

We initiated a 2-yr study at the Aurora Research Farm in 1998 to examine the silage yield and quality of some speciality silage hybrids and transgenic hybrids vs. normal commercial hybrids. We examined the hybrids under two harvest plant populations (27000 and 34000 plants/acre) because the seed companies recommended harvest populations for the brown midrib and leafy hybrids of only 26000 plants/acre, much less than our recommendations for silage production. Again, because of the greater seed costs, determination of optimum seeding rates for speciality and transgenic hybrids is of great importance.

MATERIALS AND METHODS

Nineteen hybrids in 1998 and 30 hybrids in 1999 (relative maturities of 97 to 113 days) were planted at 30000 and 37000 plants/acre in late April on a Honeoye silt loam soil at the Aurora Research Farm in central New York. The experimental site, which had a soil pH value of 7.7, has been in a corn-soybean rotation since 1990. The experimental area received a broadcast application of about 60 lbs K/acre in April of 1999. We used a liquid starter fertilizer of N and P to apply about 30 lbs/acre of N and P at planting in both years. Immediately after planting, we applied Bladex and Dual for weed control. At the V4 stage, we injected a liquid urea-ammonium N source to apply 140 lbs N/acre in both years. At the V5 stage, we thinned a few plants from each subplot to attain final harvest populations of about 27000 and 34000 plants/acre for each hybrid in both years. Because dry conditions resulted in premature senescence in both years, individual hybrids were harvested by hand at the denting stage to ½ milk line over a 15-day period from late August to early September, about 15 days earlier than normal.

Five plants from each plot were selected at harvest, divided into grain and stover, dried, and weighed to estimate whole plant moisture and grain content of the plant. Stover and grain were then reassembled into a whole plant sample and ground sequentially through a hammer mill, wiley mill, and cyclone mill. Samples (0.5 g) were analyzed by wet chemistry for whole plant neutral detergent fiber (NDF), in vitro true digestibility (IVTD), NDF digestibility, and N (x

6.25 = crude protein).

Experimental design was a split-block with four replications. Hybrids represented whole plots (120' by 20') and harvest populations represented subplots (24' by 20'). All data were analyzed with analysis of variance procedures (ANOVA) using the SAS Statistical Software Package. Because a different number of hybrids were evaluated in 1998 and 1999, we used a separate analysis for each year.

RESULTS AND DISCUSSION

The 1998 growing season at the Aurora Research Farm can be characterized as exceptionally warm and somewhat dry in May, exceptionally wet in June, and exceptionally dry and warm in August (Table 1). Most hybrids silked from July 15 to July 20, about 10 days earlier than normal. Because of the dry and warm August conditions, most hybrids, which suffered from some water stress during the grain-filling period, had premature leaf senescence. Consequently, the stover was very dry at harvest time, despite harvesting at the ½ milk line stage of development.

The 1999 growing season at the Aurora Research Farm can be characterized as exceptionally warm and dry, especially from May through July when only 4.7 in. of precipitation were recorded (Table 1). Most hybrids silked from July 10 to July 20 during very warm and dry conditions. Some hybrids, especially the TMF hybrids, delayed silk emergence after tassel initiation, which resulted in very poor pollination. Most hybrids attained 65% dry matter (DM) in late August or early September at the denting stage about 25 days earlier than normal. Consequently, we harvested the silage at the denting stage this year rather than the usual 1/2 milk line stage of development.

The brown midrib hybrids (F657 and XB867), 110 to 113 days in relative maturity, yielded about 15% less than comparable hybrids of the same maturity (Table 2). The brown midrib hybrids and TMF hybrids (TMF99, TMF106, and T286602), responded positively to the higher plant population, despite the recommendations by the seed companies not to exceed harvest populations of 26000 plants/acre. The TMF hybrids yielded about the same as the other hybrids of comparable maturity. Also, the Bt hybrids vs. the non-Bt counterparts (37M81 vs. 37R71, 3523 vs. 35N05, DK580 vs. DK580Bt, DK493 vs. DK493Bt) yielded the same in 1998. Overall, the speciality silage hybrids and transgenic hybrids examined in this study either provided no silage yield benefit (TMF and Bt hybrids) or decreased yield by 15% (brown midribs) in 1998.

When averaged across hybrids, corn silage yields were 5.5% greater at harvest populations of 34000 plants/acre (25.1 tons/acre) compared with 27000 plants/acre (23.5 tons/acre). Despite very dry conditions during grain-filling, plant populations did not affect the percent grain in the silage with about 50% grain in the silage at both populations (Table 3). Hybrids had a significant effect on percent grain in the silage with most of the specialty silage hybrids (TMF106, TMF99, T286602, XB867) having relatively low grain concentrations.

Plant populations had minimal effect on corn silage quality characteristics in 1998 (data not shown). When averaged across populations, brown midrib hybrids had the greatest IVTD concentrations among hybrids in 1998 (Table 4). Likewise the brown midrib hybrids were among the hybrids with the greatest crude protein (CP) concentrations (Table 4). The brown midrib hybrids also had the greatest NDF digestibility among hybrids, despite the relatively high NDF concentration for XB867 (Table 5). In contrast to the brown midrib hybrids, the TMF hybrids had only average IVTD and CP concentrations as well as relatively high NDF concentrations. The TMF hybrids, however, did have relatively high NDF digestibility. Some of the Bt hybrids when compared with their normal counterparts had greater NDF and IVTD digestibilities. The Bt hybrids, however, did not show a consistent enough improvement to state categorically that the use of Bt hybrids improved silage quality in 1998.

Silage yields ranged from only 8.1 to 11.9 tons/acre (35% DM) in 1999 because of the very dry and warm conditions from May through July (Table 6). The percent grain in the silage at harvest ranged from 11 to 48% among the hybrids (Table 7). Generally, the 97 to 100-d hybrids had more grain in the silage at harvest because of somewhat cooler weather conditions around pollination time. The TMF hybrids (TMF 106, 2720, TMF 99, TMF 100, and TMF 108) generally had the least grain in the silage among hybrids (11 to 30%), especially at 34000 plants/acre because of poor pollination. The brown midrib hybrids (F657, XB667, and F687) also had relatively low grain in the silage at harvest (21 to 31%). Although plant densities did not affect the percent grain in the silage, there was a significant hybrid x plant density interaction because of the significant decrease in percent grain for the leafy hybrids (TMF hybrids, NK 4687, and N58-D1) at 34000 plants/acre.

Despite the low grain content for TMF 108, 2720, TMF 100, NK 4687, and TMF 106, those hybrids yielded as well as the highest-yielding hybrids in 1999. The TMF and NK hybrids did, however, show a consistent yield decrease at the higher plant densities. Although the longer-season hybrids (105-113-d) experienced hotter and drier conditions around the silking period, the longer-season hybrids generally yielded the greatest. The 110 to 113-d brown midrib hybrids yielded 17% (F657 and F867) to 25% less (XB667) compared with 33V08, the hybrid with the highest numerical yield in 1999. The yield penalty, associated with the use of brown midrib hybrids, thus exceeded the expected 10 to 15% decrease, presumably because of the stressful conditions. As in 1998, the Bt hybrids vs. the non-Bt counterparts yielded the same.

Plant densities did not affect silage yields in 1999, despite the extremely dry conditions. Although there was no significant hybrid x plant density interaction (p=0.10), the leafy hybrids obviously do not yield as well at 34,000 vs. 27,000 plants/acre at harvest under dry conditions. In contrast, the Pioneer, Dekalb, and Cargill (brown midrib) hybrids did not suffer a yield decrease at the higher plant densities in 1999.

Hybrids affected IVTD, crude protein (CP), NDF, and NDF digestibility in 1999 (Tables

8 and 9). As in 1998, the brown midrib hybrids had the greatest IVTD concentrations (89.4 to 91.4%) among hybrids because of very high fiber digestibility (68 to 79%). Although the TMF hybrids generally had the least grain in the silage at harvest, the TMF hybrids had the same IVTD concentrations compared with most other hybrids. The TMF hybrids again had relatively high fiber digestibility (65 to 69%), which apparently compensated for the low grain concentrations and resulted in relatively high IVTD concentrations. In fact, IVTD concentrations were exceedingly high in 1999, presumably because of high NDF digestibility of the stover, associated with the lack of cell elongation (thus less cell wall) under dry conditions, which resulted in very short corn plants (< 6 ft). The IVTD concentration had a significant positive correlation (r=0.79, n=30) with NDF digestibility in 1999.

Plant density affected IVTD and NDF, but not NDF digestibility and CP in 1999 (data not shown). When averaged across hybrids, IVTD averaged 85.3% at 27,000 plants/acre and 84.7% at 34,000 plants/acre at harvest. The NDF concentrations averaged 41.9% at 27,000 plants/acre and 42.9% at 34,000 plants/acre at harvest. Previous studies have also indicated that silage quality usually decreases as plant densities increase.

SUMMARY

The brown midrib hybrids examined in this study affected both yield and quality of corn silage, whereas the TMF and transgenic hybrids affected yield and quality minimally. For example, the brown midrib hybrids yielded 15 to 20% less than hybrids of comparable maturity, but the brown midrib hybrids averaged about 5 to 10 percentage units more in IVTD concentrations and about 10 to 20 percentage units more in NDF digestibility compared with the other hybrids in this experiment. In contrast, the TMF hybrids had similar yields as other hybrids of comparable maturity. Likewise, the TMF hybrids, despite low grain concentrations especially in the dry year, had about the same IVTD compared with most other hybrids except for the brown midribs, presumably because of somewhat greater NDF digestibility. The Bt hybrids had no effect on silage yield and limited effect on silage quality. Consequently, we do not recommend the use of Bt hybrids in New York unless a field has a history of corn borer infestation.

Both the brown midrib and TMF hybrids had low grain concentrations in the silage in both years of the study. Consequently, we do not recommend these hybrids for dual purpose (grain or silage) use. The brown midrib hybrids examined in this study yielded 1.6 tons/acre or 8% more at harvest populations of 34000 vs. 27000 plants/acre in 1998. In 1999, the brown midrib hybrids yielded the same at both populations, despite excessively dry and warm conditions. Consequently, the silage producer can plant the brown midrib hybrids at populations as high as 35000 plants/acre without fear of a yield penalty, although the current cost of the seed negates the economic advantage for planting at these populations. In contrast, the TMF hybrids in this study yielded 1.5 tons/acre or 7% more in 1998, but 0.8 tons/acre or 8% less in 1999. Because of the potential for a yield penalty at harvest populations above 30,000 plants/acre in dry years, we recommend that silage producers follow the planting rate recommendations by Mycogen for their TMF hybrids.

Table 1. Weather conditions at the Aurora Research Farm during the 1998 and 1999 growing seasons.

	PRECIPITATION (IN.)			GDD		
Month	1998	1999	Mean	1998	1999	Mean
May	2.73	1.12	3.20	452	350	296
June	6.02	1.59	4.02	500	541	495
July	3.62	2.02	3.11	622	666	628
August	1.61	2.73	3.58	653	526	581
September	-	-	-	446	430	390
	13.98	7.44	13.91	2673	2513	2390

Table 2. Corn silage yields of 19 hybrids at two plant densities at the Aurora Research Farm in central New York in 1998.

Hybrid	27000 plants/acre	34000 plants/acre	Mean
P33V08	25.7	27.7	26.7
P35N05	24.8	28.4	26.1
P3563	25.8	26.7	26.1
P3523	26.5	25.7	26.1
DK580	24.0	27.3	25.7
TMF106	23.5	26.9	25.2
TMF108	25.3	25.1	25.2
DK580Bt	25.0	24.8	24.9
P34G81	24.6	24.8	24.7
WR 2108L	23.5	25.7	24.6
TMF99	23.7	24.4	24.1
T286602	22.4	24.7	23.5
P37M81	23.0	23.6	23.3
P37R71	23.1	23.1	23.1
DK493	22.2	23.8	23.0
DK493RR	22.7	23.3	23.0
DK493Bt	23.2	22.7	23.0
XB867	21.3	23.7	22.5
F657	21.3	22.1	21.7
	23.8	25.1	
LSD 0.05	0.5		2.0

Table 3. Percent grain of 19 hybrids at two plant densities at the Aurora Research Farm in central New York in 1998.

Hybrid	27000 Plants/acre	34000 Plants/acre	Mean
P33V08	47.4	45.9	46.7
P35N05	50.2	50.9	51.6
P3563	49.7	48.6	49.1
P3523	47.5	47.3	47.4
DK580	51.9	53.8	52.9
TMF106	45.7	46.2	45.9
TMF108	51.1	49.7	50.4
DK580Bt	49.8	50.3	50.0
P34G81	51.7	52.7	52.2
WR 2108L	46.5	49.7	48.1
TMF99	46.6	46.8	46.7
T286602	46.2	46.0	46.1
P37M81	54.3	56.4	55.4
P37R71	50.7	53.9	52.3
DK493	53.6	52.9	53.2
DK493RR	55.4	51.3	53.3
DK493Bt	52.6	50.0	51.4
XB867	40.8	40.0	40.4
F657	51.0	51.8	51.4
	49.7	50.0	
LSD 0.05	NS		2.8

Table 4. In vitro true digestibility (IVTD) and crude protein (CP) percentages of nineteen hybrids, averaged across two plant densities, at the Aurora Research Farm in central New York 1998.

Hybrid	IVTD (%)	% CP
XB867	84.3	7.7
F657	82.0	7.4
DK493Bt	79.9	6.9
P35N05	79.7	6.8
DK493RR	79.5	6.9
DK580Bt	79.0	7.4
DK493	78.2	7.2
TMF99	77.1	7.2
P33V08	77.0	7.2
TMF106	77.0	6.9
DK580	76.6	7.2
TMF108	76.6	6.4
P37R71	76.0	7.3
WR2108L	75.9	6.6
P37M81	75.6	7.4
P3523	75.6	6.9
P34G81	75.1	7.3
T286602	74.6	7.0
P3563	74.2	6.9
LSD 0.05	2.0	0.5

Table 5. Neutral detergent fiber (NDF) and NDF digestibility percentages of nineteen hybrids, averaged across two plant densities, at the Aurora Research Farm in central New York.

Hybrid	NDF(%)	NDF DIGESTIBILITY (%)
F657	38.2	59.1
DK493RR	38.9	47.3
DK493	39.2	44.1
DK493Bt	40.2	49.9
P35N05	40.2	49.6
WR2108L	40.9	41.1
P33V08	41.0	43.6
P37R71	41.2	39.0
DK580	41.2	43.4
P34G81	41.5	39.0
DK580Bt	41.7	49.6
P37M81	42.2	39.8
TMF108	43.3	45.9
XB867	44.1	59.2
TMF106	44.6	48.3
TMF99	44.9	49.0
P3523	45.0	40.1
T286602	46.1	44.8
P3563	46.2	38.0
LSD 0.05	2.2	4.4

Table 6. Silage yield of 30 hybrids at two plant densities in central New York in 1999.

Hybrid	27000 plants/acre	34000 plants/acre	Mean
		tons/acre (35% DM)	
33V08	11.8	11.9	11.9
34B82	11.4	11.6	11.5
3523	11.2	11.4	11.3
TMF108	11.8	10.7	11.3
2720	11.6	10.9	11.3
N58-D1	12.4	10.2	11.3
34G82	11.3	11.2	11.3
TMF100	11.8	10.6	11.2
Asgrow 601	11.7	10.7	11.2
NK4687(Bt)	11.4	11.0	11.2
34G81	11.1	10.9	11.0
DK580(Bt)	10.8	11.2	11.0
TMF106	11.4	10.6	11.0
3563	11.6	10.3	11.0
35N05	11.0	10.8	10.9
DK580RR	10.7	10.5	10.6
DK580	10.5	10.4	10.5
TMF99	10.5	10.3	10.4
Asgrow 502	10.6	10.2	10.4
F657	9.8	9.8	9.8
F867	9.5	10.0	9.8
Asgrow 505Bt	10.1	9.2	9.7
37R71	10.1	9.9	9.7
DK493RR	9.4	9.4	9.4
DK493Bt	9.3	9.5	9.4
DK493	9.0	9.4	9.2
D493GR	9.2	9.2	9.2
37M81	8.6	9.3	8.9
XB667	8.6	9.1	8.8
397	8.3	7.9	8.1
LSD 0.05			1.5

Table 7. Percent grain in the silage at harvest for 30 hybrids at two plant densities in central New York in 1999.

Hybrid	27000 plants/acre	34000 plants/acre	Mean
37M81	47	48	48
397	47	43	45
37R71	45	45	45
Asgrow 502	47	43	45
DK493	42	42	42
DK493RR	40	40	40
DK580	40	40	40
Asgrow 601	41	38	40
DK493Bt	40	39	40
34G82	38	40	39
DK493GR	40	37	38
DK580Bt	38	38	38
DK580RR	36	38	37
N58-D1(Bt)	41	33	37
34G81	36	34	35
3523	32	33	33
35N05	34	31	33
33V08	33	32	33
34B82	34	28	31
F657	34	28	31
TMF108	33	26	30
Asgrow 505Bt	31	26	29
3563	31	26	29
XB667	26	26	26
TMF100	32	13	23
F867	19	23	21
TMF99	16	18	17
NK4687(Bt)	18	11	17
2720	14	9	12
TMF106	15	6	11
LSD 0.05			5

Table 8. In vitro true digestibility (IVTD) and crude protein (CP) of 30 hybrids averaged across two plant densities in central New York in 1999.

Hybrid	IVTD (%)	% CP
F657	91.4	7.1
F867	89.6	7.5
XB667	89.4	7.8
397	87.7	7.6
DK580RR	85.6	7.2
DK580Bt	85.3	6.9
Asgrow 502	85.2	7.3
TMF99	85.0	7.4
37M81	84.9	7.9
TMF108	84.8	6.3
TMF100	84.8	7.0
DK493RR	84.7	7.3
NK4687(Bt)	84.6	6.3
3523	84.6	6.9
33V08	84.6	6.7
NK58-D1(Bt)	84.5	7.2
35N05	84.5	7.2
TMF106	84.3	6.9
3563	84.3	7.0
DK580	84.1	6.8
D493GR	84.1	7.4
37R71	84.1	7.9
Asgrow 505Bt	84.0	7.2
DK493	83.9	7.2
34G82	83.9	7.6
Asgrow601	83.9	7.0
34G81	83.8	7.5
DK493Bt	83.4	7.5
34B23	83.3	6.8
2720	81.7	6.6
LSD 0.05	1.9	0.4

Table 9. Neutral detergent fiber (NDF) and NDF digestibility averaged across two plant densities in central New York in 1999.

Hybrid	NDF(%)	NDF DIGESTIBILITY (%)
F657	40.4	78.6
F867	45.8	77.2
XB667	42.3	75.0
397	38.8	69.3
NK4687(Bt)	50.1	69.3
TMF99	48.9	69.3
TMF106	49.8	68.6
TMF100	38.8	67.1
3563	46.9	66.2
TMF108	46.6	65.7
33V08	44.4	65.1
35N05	44.2	65.1
2720	44.4	64.7
3523	42.7	64.4
DK580RR	39.7	63.6
DK580Bt	39.7	62.7
NK58-D1(Bt)	41.4	62.6
Asgrow 505Bt	42.6	62.3
DK493RR	40.5	62.0
34G81	40.5	59.9
DK493	39.6	59.5
DK580	38.8	59.0
34G82	39.1	58.8
DK493Bt	40.0	58.4
37M81	36.4	58.3
37R71	37.3	57.4
Asgrow 601	37.7	57.4
LSD 0.05	1.7	5.0