Nutritive Value of the Crop Residues from bt-Corn Hybrids and Their Effects on Performance of Grazing Beef Cows

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Summary

One non bt-corn hybrid (Pioneer 3489) and three bt-corn hyrids (Pioneer 34RO7, Novartis NX6236, and Novartis N64-Z4) were planted in replicated 7.1-acre fields. After grain harvest, fields were stocked with 3 mature cows in midgestation to be strip-grazed as four paddocks over 126 days. Six similar cows were allotted to replicated drylots. All cows were fed hay as necessary to maintain a condition score of 5 on a 9-point scale. Cows were condition-scored biweekly and weighed monthly. Forage yield and weathering losses were determined by sampling one 4-m^2 location per grazed or ungrazed paddock in each field with a minimum total of 2 locations of grazed or ungrazed forage per field. To measure forage selection during grazing, samples of grazed forage were collected from the rumen of one fistulated steer that grazed for 2 hours after ruminal evacuation. Non-bt-corn hybrids had greater (P<.05) infestation of corn borers in the upper stalk, lower stalk and ear shank than bt-corn hybrids. However, there were no differences in grain yields or dropped grain between hybrids. Crop residue dry matter, organic matter and in vitro digestible dry matter yields at the initiation of grazing did not differ between corn hybrids. Dry matter, organic matter and in vitro digestible dry matter losses tended (P<.10) to be greater from the NX6236 and N64-Z4 hybrids than from the 3489 and 34RO7 hybrids and were greater (P<.05) from grazed than non-grazed areas of the fields. At the initiation of grazing, dry matter concentrations of the crop residues from the NX6236 and N64-Z4 hybrids tended to be lower than those from the 3489 and 34RO7 hybrids. Crop residues from the NX6236 and N64-74 hybrids had lower concentrations of acid detergent fiber (P<.05) and acid detergent lignin (P=.07) and higher concentrations of in vitro digestible organic matter than the 3489 and 34RO7 hybrids. Over the grazing season, corn hybrid did not affect mean rates of change in forage composition. The concentration of in vitro digestible organic matter in forage selected by steers after two weeks of grazing did not differ. However, steers grazing corn crop residues consumed forage with higher (P<.05) concentrations of neutral detergent fiber, acid detergent fiber, and acid detergent insoluble nitrogen than steers fed hay. The acid detergent fiber concentration of forage selected by steers grazing the 3489 and N64-Z4 hybrids was lower (P < .05) than concentrations from the 34RO7 and NX6236 hybrids. In order to maintain similar body condition score changes, cows grazing crop residues from the 3489, 34RO7, NX6236, and N64-Z4 hybrids required 650, 628, 625, and 541 kg hay DM/cow compared with a hay requirement of 1447 kg hay DM/cow for cows maintained in a drylot.

Introduction

In order to control the adverse effects of damage from the eastern corn borer without spraying pesticides, seed corn companies have developed hybrids that are genetically modified by placing a crystal protein from the bacteria Bacillus thuringiensis into the stalks and leaves of the corn plants. When this protein is consumed, it interacts with the enzymes within the gut of corn borers and becomes a pesticide, thus killing the insect. Although this corn has been compared with non-bt-corn hybrids in yield tests, little research has evaluated the effects of this genetic alteration on the nutritional value of the crop residues from these hybrids or the performance of cattle grazing them.

Therefore, an experiment was conducted to compare the nutritional value of non-bt and bt-corn hybrids.

Materials and Methods

On May 12, 1998, one non-bt-corn hybrid and three bt-hybrids were seeded at a rate of 26,000 to 28,000 plants/acre into replicated 7.1-acre fields arranged in two blocks. The non-bt-corn hybrid was Pioneer 3489. The bt-corn hybrids included Pioneer 34RO7 with the Yield Guard event (the isogenic bt-hybrid to Pioneer 3489), Novartis NX6236 with the Yield Guard event, and Novartis N64-Z4 with the Knockout event.

On September 4, 1998, the ear shank and the upper and lower halves of the stalks were examined for first and second generation corn borer damage. At grain harvest on October 22, grain yields of each field were determined by weighing wagons. After grain harvest, corn ears were counted in eight 4-m^2 locations in each field. In the laboratory, grain from dropped ears was removed, weighed and dried. Fields were separated and divided into four paddocks with electric fence for strip-grazing. Three mature crossbred cows in midgestation were allotted to each field or to replicated drylots. Cows grazed the corn crop residues for 126 days with a new strip offered monthly. Cows

grazing crop residues or maintained in a drylot were offered alfalfa-grass hay in small square bales at an ad libitum level as necessary to maintain a body condition score of 5 on a 9-point scale. A mineral and vitamin mixture containing 60% dicalcium phosphate, 30% salt, 3% trace mineral salt and 7% vitamin A premix was offered free choice.

Available forage samples were collected monthly from a minimum of one 4-m^2 location per grazed or ungrazed paddock for a minimum of 2 locations/total sample. In addition, samples were collected from four 4-m^2 exclosures at the termination of grazing. Samples were weighed, ground, subsampled, dried and analyzed for organic matter, digestible organic matter, crude protein, acid detergent insoluble nitrogen, neutral detergent fiber, acid detergent fiber, and acid detergent lignin.

Cows were weighed after a minimum of three days of hay feeding to adjust gut fill at the initiation and end of the experiment. Cows were also weighed monthly during the experiment. Cow body condition score was visually measured on a 9-point scale biweekly by two individuals. After 14 days of grazing, forage selected during 2 hours of grazing after ruminal evacuation of one ruminally fistulated steer per field was collected, subsampled, freeze-dried, and analyzed for organic matter, digestible organic matter, crude protein, acid detergent insoluble nitrogen, neutral detergent fiber and acid detergent fiber. To determine the feeding selectivity of steers grazing corn crop residues from the different hybrids or consuming hay, the concentrations of the various constituents were compared with those in the available forage. Simultaneous to determination of grazing selectivity, fecal output in two cows per field was determined from the passage kinetics of Chromium (Cr) after a pulse-dose of 30 gm of Cr-mordanted fiber containing approximately 2% Cr.

Results and Discussion

Although stalks from non-bt-corn hybrids had higher proportions of stalks with first generation corn borers in the upper stalk, second generation corn borers in the lower stalk, and shanks infested with corn borers, corn hybrid did not significantly ($P > .05$) affect grain yields, dropped ears and grain or post-grazing residue cover (Table 1). Part of this lack of differences may have been caused by the light damage caused by corn borers in 1998. Furthermore, early season flooding in one of the fields may have resulted in large block effects. Similar to grain yields, corn hybrid neither affected the yields of corn crop residue dry matter (DM), OM (organic matter) or IVOMD (in vitro digestible organic matter) at harvest (Table 2) nor the rates of loss of corn crop residue DM, OM or IVOMD during the grazing season (Table 3). However, DM, OM and IVOMD losses tended to be greater from the NX6236 and N64-Z4 hybrids than from the 3489 and 34RO7 hybrids apparently because of the higher moisture concentration of the former hybrids at the initiation of grazing (Table 4). Losses of crop residue DM, OM and IVOMD were greater ($P < .05$) from grazed than non-grazed areas of the fields implying that forage losses by grazing were greater than those from weathering. Weathering losses accounted for averages of 14.7 and 62.7% of the OM and IVOMD losses from the crop residues over the winter grazing season.

As discussed above, the crop residues from the NX6236 and N64-Z4 hybrids tended to have lower DM concentrations at the initiation of grazing than the 3489 and 34RO7 hybrids (Table 4). Crop residues from the NX6236 and N64-Z4 hybrids had higher ($P < .05$) concentrations of IVOMD than the 3489 and 34RO7 hybrids at the initiation of grazing. This greater digestibility was associated with a lower ($P < .05$) concentration of acid detergent fiber (ADF) in the NX6236 and N64-Z4 hybrids than the 34RO7 hybrid and tendencies for lower concentrations of acid detergent lignin (ADL) in the NX6236 and N64-Z4 hybrids than the 3489 and 34RO7 hybrids, expressed either as a percentage of OM ($P = .07$) or neutral detergent fiber (NDF, $P = .10$). Crude protein (CP) and acid detergent insoluble nitrogen (ADIN) concentrations did not differ between corn hybrids.

Corn hybrid did not significantly affect the mean rates of change in DM, OM, IVOMD, NDF, ADF, ADL, CP and ADIN concentrations in grazed and ungrazed crop residues over winter (Table 5). Similarly, the rates of change in concentrations of DM, IVOMD, NDF, ADF, and CP did not differ between grazed and ungrazed field areas over winter. However, the decrease in OM concentration was greater ($P = .09$) in grazed than ungrazed areas of the field, indicating greater soil contamination in grazed areas. This effect was

Table 1. Corn borer infestation, grain and stalk yields, dropped ears and grain pre-grazing, and residue cover post-grazing from different non-bt- and bt-corn hybrids.

	Corn hybrids			
	Non-bt-hybrids	bt-hybrids		
		Yield guard event		Knockout event
Item	3489	34RO7	NX6236	N64-Z4
Corn borer infestation,				
1st generation upper stalk	23[a]	0[b]	0[b]	0[b]
2nd generation upper stalk	10	0	0	1
1st generation lower stalk	20	0	1.5	0
2nd generation lower stalk	4[a]	0[b]	0[b]	0[b]
Shank	21[a]	0[b]	0[b]	1[b]
Grain,				
DM%	80.9	79.4	80.7	82
Yield,				
Bu DM/ac	143.7	152.3	155.5	159.7
Kg DM/ha	9034	9573	9778	10040
Dropped ears, /ha	2187	1952	624	1952
Dropped grain, kg DM/ha	254	215	59	56
Post-grazing residue cover, %	85.4	86.9	84.6	81.9

[ab]Differences between means with different superscripts are significant, P<.05.

Table 2. Dry matter, OM, and IVOMD yields of corn crop residues from different non-bt- and bt-corn hybrids at initiation of grazing.

	Corn hybrids			
	Non-bt-hybrids	bt-hybrids		
		Yield guard event		Knockout event
Item	3489	34RO7	NX6236	N64-Z4
DM, kg/ha	7919	8679	8580	7696
OM, kg/ha	7000	7380	7760	6512
IVOMD, kg/ha	3083	3166	3974	3323

Table 3. Changes in DM, OM, and IVOMD yields of corn crop residues from grazed and ungrazed non-bt- and bt-corn hybrids.

	Corn hybrids (g)				Significance		
	Non-bt-hybrids	bt-hybrids					
		Yield guard event		Knockout event			
Item	3489	34RO7	NX6236	N64-Z4	h	g	hxg
	kg/ha/d						
DM,							
Grazed	-6.7	-11.7	-18.3	-15.0	NS	.03	NS
Ungrazed	9.4	20.8	-8.2	-5.0			
OM,							
Grazed	-7.2	-15.3	-25.5	-20.1	NS	.01	NS
Ungrazed	.4	7.6	-10.0	-8.0			
IVOMD,							
Grazed	-9.9	-10.8	-18.6	-16.5	NS	.02	NS
Ungrazed	-8.6	-1.7	-13.2	-11.4			

greater in fields with the NX6236 and N64-Z4 hybrids than in those with the 3489 and 34RO7 hybrids (h x g, P = .06). The concentrations of ADL (P = .05) and ADIN (P = .08) also increased more rapidly in grazed areas of the fields than in ungrazed areas implying grazing selection for plant components with lower concentrations of these constituents. The increase in ADL concentration primarily resulted from differences in the 3489 and 34RO7 hybrids (hxg, P = .08), which tended to have higher initial ADL values.

The concentration of IVOMD selected by steers grazing corn crop residues or fed hay in a drylot after 2 weeks of grazing did not differ (Table 6). In order to select a diet with equal digestibility, selectivity of forage by steers grazing corn crop residues tended to be greater (P = .15) than steers fed hay. Steers grazing corn crop residues consumed forage with higher (P < .05) concentrations of NDF, ADF and ADIN and lower (P < .05) concentrations of CP than steers fed hay although steers grazing corn crop residues were more selective against (P < .05) ADF and ADIN and for (P < .05) CP. The ADF concentration of forage selected by steers grazing the 3489 and N64-Z4 hybrids was lower (P < .05) than for those grazing the 34RO7 and NX6236 hybrids. However, because of greater (P < .05) selectivity, steers grazing the 3489 hybrid consumed forage with a higher (P < .05) concentration of CP and a lower (P < .05) concentration of ADIN than those consuming the N64-Z4 hybrid. Crude protein concentrations of forage selected by steers grazing the 34RO7 and NX6236 hybrids were intermediate between those of the 3489 and N64-Z4 hybrids. Because of the selectivity of CP, the CP concentrations of forage selected by cows grazing all hybrids except the N64-Z4 should be adequate to meet the CP requirements of beef cows in midgestation.

As designed, there were no differences in the initial body weights and condition scores or condition score changes of cows grazing the different corn hybrids or fed hay in a drylot (Table 7). In order to obtain no difference in body condition score, cows grazing corn crop residues required 836 kg/cow less (P < .05) hay dry matter than cows fed hay in a drylot over 126 days. Between grain hybrids, cows grazing crop residues from the 3489 hybrid tended (P < .10) to require more hay than cows grazing crop residues from the N64-Z4 hybrid to maintain equal body condition.

Mean calving rate in the spring of 1999 was 100% across all treatments. Similarly, mean pregnancy rates of 73% and calving intervals of 359 days, estimated by rectal palpation in October of 1999, did not differ across treatments.

Table 4. Composition of corn crop residues from different non-bt- and bt-corn hybrids at initiation of grazing.

	Corn hybrids			
	Non-bt-hybrids	bt-hybrids		
		Yield guard event		Knockout event
Item	3489	34RO7	NX6236	N64-Z4
DM, %	72.0	68.7	56.6	58.4
OM, % of DM	88.5	84.8	90.8	84.0
% of OM,				
IVOMD	44.6[a]	43.2[a]	51.3[b]	51.2[b]
NDF	77.5	78.1	74.2	73.2
ADF	46.9[a]	49.6[b]	45.6[a]	45.6[a]
ADL	6.6	7.4	5.4	5.7
CP	4.4	4.7	4.8	5.1
ADIN, % of N	25.8	25.6	17	21.4

[ab]Differences between means with different superscripts are significant, P<.05.

Implications

As expected, cows grazing corn crop residues from all corn hybrids required significantly less hay to maintain body condition equal to cows fed hay in drylots. Preliminary results imply that in a year with little corn borer pressure, there were few differences in the composition of crop residues resulting from the presence of bt- genes and, as a result, there was little difference in the amounts of hay required to maintain comparable body condition in cows grazing residues from the different corn crops. However, significant differences in the ADF and ADL concentrations between hybrids from the two different parental lines implies that the differences in the nutritive value of corn crop residues unrelated to the presence of the bt-genes may be sufficient to cause some differences in the performance of cows grazing the corn crop residues. Furthermore, in a year where greater difference in corn borer pressure caused greater differences in ear droppage, greater differences in the nutritive value of crop residues from non-bt- and bt-corn hybrids and, therefore, in the performance of the cows might be observed.

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Table 5. Changes in the composition of corn crop residues from grazed and ungrazed non-bt- and bt-corn hybrids.

	Corn hybrids (g)						
	non-bt-hybrids	bt-hybrids			Significance		
		Yield guard event		Knockout event			
Item	3489	34RO7	NX6236	N64-Z4	h	g	hxg
	% unit/d						
DM,							
Grazed	-.31	-.33	-.22	-.26	NS	NS	NS
Ungrazed	-.35	-.36	-.22	-.25			
OM,							
Grazed	-.03	-.08	-.17	-.12	NS	.09	.06
Ungrazed	-.08	-.10	-.03	-.04			
IVOMD,							
Grazed	-.12	-.08	-.12	-.16	NS	NS	NS
Ungrazed	-.13	-.06	-.13	-.13			
NDF,							
Grazed	.04	.02	.01	.04	NS	NS	NS
Ungrazed	.03	-.01	.05	.04			
ADF,							
Grazed	.07	.04	.06	.06	NS	NS	NS
Ungrazed	.06	0	.07	.07			
ADL,							
Grazed	.10	.12	.08	.07	NS	.05	.08
Ungrazed	.08	.06	.08	.07			
CP,							
Grazed	0	0	.01	.01	NS	NS	.08
Ungrazed	0	.01	0	0			
ADIN,							
Grazed	.05	.07	.08	.09	NS	.08	NS
Ungrazed	.05	.06	.05	.07			

Table 6. Composition of corn crop residue forage selected during grazing of different non-bt- and bt-corn hybrids.

	Winter system				
	Corn hybrids				
	Non-bt-hybrids	bt-hybrids			
		Yield guard event		Knockout event	
	3489	34RO7	NX6236	N64-Z4	Drylot hay
	Selected forage				
OM, % of DM	85.0	87.6	87.6	87.9	89.5
% of OM,					
IVDOM	47.7	43.7	47.5	50.6	48.1
NDF	69.2[a]	72.4[a]	73.2[a]	73.4[a]	53.4[b]
ADF	40.4[a]	42.8[b]	42.4[b]	40.8[a]	44.6[c]
CP	8.9[a]	7.5[ab]	7.1[ab]	5.8[b]	18.4[c]
ADIN, % of N	15.2[a]	18.2[b]	14.7[a]	17.1[c]	9.6[d]
	Selected forage:Available forage ratio				
OM	.93	1.02	1.00	.98	.96
IVDOM	1.19	1.27	1.27	1.22	.90
NDF	.87	.89	.92	.93	.96
ADF	.75[a]	.76[a]	.79[a]	.77[a]	.93[b]
CP	2.04[a]	1.57[b]	1.57[b]	1.40[b]	1.11[c]
ADIN	.54[a]	.66[ab]	.56[ab]	.70[b]	.87[c]

[abcd]Differences between means with different superscripts are significant, P<.05.

Table 7. Weight and condition score changes and amounts of hay required to maintain body condition of cows grazing crop residues of different non-bt- and bt-corn hybrids, or of cows maintained in a drylot.

	Winter system				
	Corn hybrids				
	Non-bt-hybrids	bt-hybrids			
		Yield guard event		Knockout event	
	3489	34RO7	NX6236	N64-Z4	Drylot hay
Initial,					
Body weight, kg	637	619	639	624	633
Condition score	5.0	5.0	5.0	5.1	5.0
Seasonal change,					
Body weight, kg	31	43	32	37	31
Condition score	.1	-.2	-.3	0	-.1
Total hay fed, kg DM/cow	650[a]	628[a]	625[a]	541[a]	1447[b]

[ab]Differences between means with different superscripts are significant, P<.05.