Effects of Grazing Crop Residues of bt-Corn Hybrids on Performance of Pregnant Beef Cows

A.S. Leaflet R1745

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Summary

To determine the effects of grazing crop residues from bt-corn hybrids on performance of pregnant beef cows, one non bt-corn hybrid (Pioneer 3489) and three bt-corn hybrids (Pioneer 34RO7 and Novartis NX6236 with the Yieldgard event and Novartis N64Z4 with the Knockout event) were planted in duplicate 7.1-acre fields in 1998 and 1999. Thirty Angus x Charolais x Simmental cows in midgestation were allotted amongst two drylots or the eight crop residue fields to strip-graze for 126 days. Cow body condition scores were visually estimated biweekly and alfalfa-grass hay was supplemented to maintain a mean body condition score of 5 on a 9-point scale. Corn stalks and ear shanks from Pioneer 3489 corn had a higher (P<.05) infestation of corn borers than did any of the bt-corn hybrids. Mean yields of harvested grain, dropped ears or grain, or crop residue dry matter (DM) or organic matter (OM) over the two years were not significantly affected by corn hybrid, but values for bt-corn hybrids were not equivalent to the non bt-corn hybrid. At grazing initiation, crop residues from Novartis NX6236 and N64Z4 had higher (P<.05) concentrations of in vitro digestible organic matter (IVOMD) and lower (P<.05) concentrations of acid detergent fiber (ADF) and acid detergent lignin (ADL) than Pioneer 3489 or Pioneer 34RO7. Rates of change in the concentrations of IVOMD, neutral detergent fiber (NDF), ADF, ADL and crude protein (CP) over winter were not significantly affected by corn hybrid, but rates for bt-corn hybrids were not equivalent to non bt-corn hybrids. Forage selected during feeding by fistulated steers did not differ in IVOMD concentrations between winter feeding systems or NDF, ADF, CP or acid detergent insoluble nitrogen (ADIN) concentrations between corn hybrids. Intakes of forage digestible DM, NDF and ADF did not differ between winter feeding systems, but were not equivalent to the non bt-corn hybrid. Mean amounts of hay required to maintain body condition score of cows maintained in a drylot were greater than cows grazing crop residues (3199 vs 825 lb DM/cow), but did not differ between corn hybrids.

Introduction

The ISU Beef Cow Business Records have shown that grazing of corn crop residues is the primary factor affecting the profitability of beef cow-calf production in Iowa. However, beginning in 1997, observations by some producers indicated that performance was impaired in cows grazing corn crop residues from bt-corn hybrids that were genetically engineered for European core borer resistance. Although it was not known whether this effect actually occurred, it was hypothesized that it could have been caused by a direct reduction in digestibility, a rapid reduction in forage quality resulting from a higher moisture concentration, or a reduced number of ears dropped on the ground in bt-hybrids. Because approximately 25 to 33% of the total corn acreage in Iowa is planted with bt-hybrids, a significant reduction in corn crop residue forage quality could have large effects on the profitability of cow-calf production in Iowa. Therefore, an experiment was conducted over the winter to compare the chemical composition and in vitro digestibility of grazed and ungrazed corn crop residues from different bt- and non bt-corn hybrids and to determine the amounts of hay required to maintain a body condition score of 5 in pregnant beef cows grazing different bt- and non bt-corn hybrids.

Materials and Methods

In May of 1998 and 1999, one non bt-corn hybrid and three bt-corn 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 Yieldgard event (the near isogenic bt-hybrid to Pioneer 3489), Novartis NX6236 with the Yieldgard event, and Novartis N64-Z4 with the Knockout event.

On September 4, 1998, and September 10, 1999, 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, 1998, and October 24, 1999, 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 two 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. On two consecutive days after 14 days of grazing, forage selected during two 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 Cr after a pulse-dose of 30 gm of Cr-mordanted fiber containing approximately 2% Cr.

Data were analyzed by Analysis of Variance with differences between means of variables with significant effects tested by t-tests. In order to test for type II error (saying that two treatments were equal when they actually weren't) data were also analyzed as equivalence tests by determining whether confidence intervals of $\pm$ 10% for each bt-hybrid or the drylot treatments were within an equivalence range of $\pm$ 20% from the mean of the non bt-hybrid.

Table 1. Corn borer infestation of different non bt- and bt-corn hybrids.

		bt-hybrids		
	Non bt-hybrid	YieldGard Event		Knockout event
	3489	34R07	NX6236	N6424
	Corn borer infected, %			
First generation				
Upper stalk				
Year 1	23.0^{ax}	0^{by}	0^{by}	0^{by}
Year 2	13.0^{ax}	1.0^{by}	0^{by}	0^{by}
Mean	18.0^{ax}	$.5^{by}$	0^{by}	0^{by}
Lower stalk				
Year 1	20.0^{x}	0^{y}	1.5^{y}	0^{y}
Year 2	5.0^{ax}	0^{by}	0^{by}	0^{by}
Mean	12.5^{x}	0^{y}	$.8^{y}$	0^{y}
Second generation				
Upper stalk				
Year 1	10.0^{x}	0^{y}	0^{y}	1.0^{y}
Year 2	10.0^{ax}	0^{by}	0^{by}	0^{by}
Mean	10.8^{ax}	0^{by}	0^{by}	$.5^{by}$
Lower stalk				
Year 1	4.0^{ax}	0^{by}	0^{by}	0^{by}
Year 2	0^{x}	0^{y}	0^{y}	0^{y}
Mean	2.0^{ax}	0^{by}	0^{by}	0^{by}
Shank				
Year 1	21.0^{ax}	0^{by}	0^{by}	1.0^{by}
Year 2	5.0^{ax}	0^{by}	0^{by}	0^{by}
Mean	13.0^{ax}	0^{by}	0^{by}	$.5^{by}$

^{abcd}In this and other tables, differences between means with different superscripts are significant, P<.05.
^{xy}In this and other tables, means with the same superscripts are equivalent to the non bt-hybrid assuming a confidence interval of $\pm$ 10% for each treatment within an equivalence region of $\pm$ 20% of the mean of the non bt-hybrid.

Results and Discussion

Although corn residues from the non bt-corn hybrid 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 (Table 1), corn hybrid did not significantly ($P > .05$) affect average grain or crop residue dry matter yields, dropped ears and grain or post-grazing residue cover over the two years (Table 2). However, equivalence testing showed that the grain and crop residue dry matter yields and amounts of dropped ears and grain from bt-corn hybrids were not equal to those of the non bt-corn hybrid. This implies that greater replication is needed to make definite inferences on the effects of hybrid on these variables. Under the dry conditions experienced late in the growing season of 1999, the non bt-hybrid had lower ($P < .05$) grain yields than those of the bt-hybrids. 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 3) nor the rates of loss of corn crop residue DM, OM or IVOMD during the grazing season (Table 4). However, equivalence testing also showed that means of these variables for the bt-corn hybrids were not equivalent to the non-bt hybrid. Losses of crop residue 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 27.4 and 58.1% of the OM and IVOMD losses from the crop residues over the winter grazing season.

Crop residues from the NX6236 and N64-Z4 hybrids had higher ($P < .05$) concentrations of digestible organic matter (IVOMD) than the 3489 and 34RO7 hybrids at the initiation of grazing (Table 3). This higher 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 lower ($P < .05$) 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 or neutral detergent fiber (NDF). Crude protein (CP) and acid detergent insoluble nitrogen (ADIN) concentrations at the initiation of grazing did not differ between corn hybrids. However, the concentration of CP in crop residues from Novartis N6236 and the concentrations of ADIN in both Novartis hybrids at the initiation of grazing were not equivalent to those of the non bt-corn hybrid.

Corn hybrid did not significantly affect the mean rates of change in neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), or crude protein (CP) concentrations in grazed and ungrazed crop residues over winter (Table 4). However, these values were not equivalent to those of the non bt-hybrid. In contrast, the proportion of nitrogen bound as acid detergent insoluble nitrogen (ADIN) increased more rapidly in bt-hybrids than the non-bt-hybrid, implying that the digestibility of protein in the bt-hybrids was decreasing more rapidly than the non bt-hybrid. Rates of change in concentrations of dry matter (DM), organic matter (OM), digestible organic matter (IVOMD), and neutral detergent fiber (NDF) did not differ between grazed and ungrazed field areas over winter. However, the rates of increase in the concentrations of acid detergent fiber (ADF) and crude protein (CP) were greater ($P < .05$) in grazed than ungrazed areas of the field, indicating more selective grazing against these components.

Over the two years of the experiment, the concentration of digestible organic matter (IVOMD) selected by cattle grazing corn crop residues or fed hay in a drylot after two weeks of grazing did not differ (Table 5). Furthermore, the IVOMD concentrations of forages selected by steers grazing crop residues from the bt-corn hybrids were equal to those grazing the non bt-corn hybrid. In order to select a diet with equal digestibility, selectivity of forage by cattle grazing corn crop residues was greater ($P < .05$) than steers fed hay. Cattle grazing corn crop residues consumed forage with higher ($P < .05$) concentrations of neutral detergent fiber (NDF) and acid detergent fiber (ADF) and lower ($P < .05$) concentrations of crude protein (CP) than steers fed hay. There was no difference in the selectivity of neutral detergent fiber (NDF) or acid detergent fiber over the two years (Table 6). However, the selectivity for intake of crude protein (CP) was greater ($P < .05$) in cattle grazing corn crop residues than cows fed hay and was greater ($P < .05$) in cattle grazing corn crop residues from the non bt-hybrid than in those grazing crop residues from bt-corn. Although cattle grazing corn crop residues selected forages with a higher proportion of nitrogen bound as acid detergent insoluble nitrogen (ADIN) in yr 1 than cattle fed hay in a drylot, this effect was not observed either in yr 2 nor in the average of both years. Similarly, the selectivity against consumption of acid detergent insoluble nitrogen (ADIN) did not differ across treatments in the two years.

Over the two years, there was no difference in the in vivo digestibility or the amount of forage dry matter consumed by cows between treatments after 14 days of grazing (Table 7). As a result, there was no difference in the intake of digestible dry matter (Table 8). However, because of variation in the dry matter and digestible dry matter intakes, values of these variables for cows fed hay or grazing bt-corn crop residues were not equivalent to cows grazing non bt-corn crop residues. Similarly, intakes of neutral detergent fiber (NDF) or acid detergent fiber (ADF) by cows fed hay or grazing bt-corn crop residues were not equivalent to cows grazing non bt-corn crop residues. However, cows fed a mixed alfalfa-grass hay in the drylot consumed more ($P < .05$) crude protein than cows grazing corn crop residues.

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 9). However, the condition score changes of cows grazing crop residues from hybrids containing Yieldgard or fed hay in a drylot were not equivalent to cows grazing the non bt-corn hybrid. Cows grazing corn crop residues required 2374 lb/cow less ($P < .05$) hay dry matter than cows fed hay in a drylot over 126 days in two years. In contrast, there was no difference in the amounts of hay needed to maintain equivalent body condition between hybrids. But the amounts of hay fed to cows grazing the bt-corn crop residues were not equivalent to those of cows grazing non bt-corn crop residues.

Implications

These results imply that although the presence of bt- events in corn does decrease the infestation of corn borers in corn stalks and shanks, increases grain yields, and reduces dropped ears and grain, it does not largely affect the nutritive value of corn crop residues or the performance on animals consuming them. However, the differences in acid detergent lignin concentrations between hybrids that were unrelated to the presence of the bt- events implies that there may be enough variation in the composition of corn stalks of normal hybrids to affect the performance of animals grazing them if the quantity of available forage limited grazing selection.

Acknowledgments

This project was funded, in part, by the Leopold Center for Sustainable Agriculture, Iowa State University, Ames. The authors gratefully acknowledge Pioneer Hybrids International, Johnston, IA, and Novartis Seeds, Minneapolis, MN, for supplying corn seed, and Rod Berryman, research center superintendent, and the animal caretakers at the Iowa State University Beef Nutrition Research Center for their assistance in conducting this experiment.

Table 2. Yields of harvested grain and residue, amounts of dropped ears and grain, and post-grazing ground cover from fields containing different non bt- and bt-corn hybrids.

		bt-hybrids		
	Non bt-hybrid	YieldGard Event		Knockout Event
	3489	34R07	NX6236	N64Z4
Yields, lb DM/acre				
Grain				
Year 1	8047^{x}	8562^{x}	8708^{x}	8943^{x}
Year 2	5168^{ax}	7712^{by}	6341^{cy}	6136^{acy}
Mean	6608^{x}	8119^{y}	7524^{y}	7540^{y}
Crop Residue				
Year 1	7062^{x}	7738^{y}	7652^{y}	6863^{y}
Year 2	4116^{x}	4264^{x}	3321^{y}	3719^{y}
Mean	5588^{x}	6001^{y}	5487^{x}	5291^{y}
Dropped				
Ear /acre				
Year 1	885^{x}	791^{y}	253^{y}	791^{y}
Year 2	411^{x}	63^{y}	63^{y}	300^{y}
Mean	648^{x}	395^{y}	158^{y}	545^{y}
Grain, lb DM/acre				
Year 1	227^{x}	192^{y}	52^{y}	50^{y}
Year 2	118^{ax}	17^{by}	13^{by}	62^{aby}
Mean	172^{x}	104^{y}	33^{y}	56^{y}
Post-grazing residue cover, %				
Year 1	85.4^{x}	86.9^{x}	84.6^{x}	82.0^{x}
Year 2	40.9^{x}	52.4^{y}	36.9^{y}	38.6^{y}
Mean	63.2^{x}	69.7^{x}	60.7^{x}	60.3^{x}

Table 3. Yields and compositions of corn crop residues from different non bt- and bt-corn hybrids at initiation of grazing.

	Hybrid				Significance		
		bt-hybrids					
	Non bt-hybrid	YieldGard event		Knockout event	Hybrid	Yr	HxYr
	3489	34R07	NX6236	N64Z4			
Yield, lb/acre							
OM							
Year 1	6230^{x}	6569^{y}	6906^{y}	5796^{y}	.89	<.01	.81
Year 2	3825	3969	3101	3440			
IVDOM							
Year 1	2745^{x}	2836^{y}	3537^{y}	2937^{y}	.89	<.01	.59
Year 2	1670	1813	1498	1684			
DM %							
Year 1	71.9^{x}	68.7^{x}	56.6^{y}	58.4^{x}	.32	<.01	.71
Year 2	84.8	85.8	80.7	81.6			
% of DM							
OM							
Year 1	88.5^{x}	84.8^{x}	90.8^{x}	84.0^{x}	.12	<.01	.19
Year 2	93.3	93.2	93.4	92.9			
% of OM							
IVOMD							
Year 1	44.6^{x}	43.20^{x}	51.3^{x}	51.2^{x}	.01	.36	.45
Year 2	42.7	45.6	48.3	48.9			
NDF							
Year 1	77.5^{x}	78.1^{x}	74.2^{x}	73.2^{x}	.19	<.01	.39
Year 2	79.3	82.2	80.0	80.2			
ADF							
Year 1	46.9^{x}	49.5^{x}	45.6^{x}	45.6^{x}	.02	.04	.58
Year 2	48.3	50.0	48.5	46.9			
ADL							
Year 1	6.6^{x}	7.4^{x}	5.4^{y}	5.7^{y}	.02	<.01	.36
Year 2	5.5	5.4	4.9	4.4			
CP							
Year 1	4.4^{x}	4.7^{x}	4.8^{y}	5.1^{x}	.91	.05	.76
Year 2	4.1	4.0	4.3	3.7			
% of NDF							
ADL							
Year 1	8.5^{x}	9.4^{x}	7.3^{y}	7.8^{y}	.04	<.01	.32
Year 2	6.9	6.6	6.1	5.2			
% of N							
ADIN							
Year 1	25.8^{x}	25.6^{x}	17.0^{y}	21.4^{y}	.12	<.01	.44
Year 2	14.4	13.6	12.1	13.2			

Table 4. Daily changes in yields and compositions of crop residues from grazed and ungrazed non bt- and bt-corn hybrids.

	Hybrids				Significance		
		bt-hybrids					
	Non bt-hybrid	YieldGard event		Knockout event	Hybrid	Graze	HxG
	3489	34R07	NX6236	N64Z4			
Yield, lb/acre							
OM							
Grazed	-10.1^{x}	-11.2^{y}	-12.5^{y}	-11.4^{y}	.89	.07	.91
Ungrazed	-5.1	.4	-6.3	-1.3			
IVOMD							
Grazed	-7.7^{x}	-7.3^{y}	-10.1^{y}	-9.0^{y}	.61	.09	.89
Ungrazed	-6.3	-2.4	-6.8	-4.3			
DM %							
Grazed	$-.27^{x}$	$-.30^{x}$	$-.22^{y}$	$-.26^{y}$	.08	NS	<.56
Ungrazed	-.34	-.31	-.23	-.24			
OM, % of DM							
Grazed	$-.04^{x}$	$-.12^{y}$	$-.12^{y}$	$-.10^{y}$	.04	NS	<.01
Ungrazed	-.12	-.12	-.08	-.07			
% of OM							
IVOMD							
Grazed	$-.07^{x}$	$-.06^{y}$	$-.10^{y}$	$-.10^{y}$	.33	.22	.91
Ungrazed	-.07	-.03	-.07	-.07			
NDF							
Grazed	$.05^{x}$	$.01^{y}$	$.02^{y}$	$.04^{x}$	.25	.16	.83
Ungrazed	.01	-.02	.01	.02			
ADF							
Grazed	$.06^{x}$	$.07^{y}$	$.07^{y}$	$.07^{x}$	.42	.02	.48
Ungrazed	.05	.02	.05	.05			
ADL							
Grazed	$.06^{x}$	$.08^{y}$	$.05^{x}$	$.05^{y}$	.84	.24	.57
Ungrazed	.05	.04	.05	.04			
CP							
Grazed	0^{x}	0^{y}	0^{y}	0^{y}	.54	.01	.44
Ungrazed	.01	.01	0	.01			
% of NDF							
ADL							
Grazed	$.06^{x}$	$.09^{y}$	$.07^{y}$	$.06^{y}$	.76	.35	.70
Ungrazed	.06	.05	.06	.05			
% of N							
ADIN							
Grazed	$.06^{x}$	$.09^{y}$	$.10^{y}$	$.10^{y}$	.03	.28	.31
Ungrazed	.06	.10	.09	.06			

Table 5. Composition of corn crop residue forage selected during grazing of different non bt- and bt-corn hybrids and hay fed in a drylot.

	Winter feeding system				
	Crop residue grazing				
		bt-hybrid			
	Non bt-hybrid	YieldGard event		Knockout event	Drylot
	3489	34R07	NX6236	N64Z4	
OM, % of DM					
Year 1	85.0^{x}	87.5^{x}	87.6^{x}	87.9^{x}	89.5^{x}
Year 2	86.6^{x}	87.9^{x}	89.1^{x}	86.9^{x}	89.2^{x}
Mean	85.8^{x}	87.7^{x}	88.4^{x}	87.4^{x}	89.3^{x}
% of OM					
IVOMD					
Year 1	47.7^{x}	43.7^{x}	47.5^{x}	50.6^{x}	48.1^{x}
Year 2	54.9^{ax}	59.2^{ax}	56.4^{ax}	54.0^{abx}	48.1^{bx}
Mean	51.3^{x}	51.5^{x}	51.9^{x}	52.3^{x}	48.1^{x}
NDF					
Year 1	69.2^{ax}	72.4^{ax}	73.2^{ax}	73.4^{ax}	53.4^{by}
Year 2	63.1^{x}	65.8^{x}	67.0^{x}	65.6^{x}	57.9^{x}
Mean	66.1^{ax}	69.1^{ax}	70.1^{ax}	69.5^{ax}	55.7^{by}
ADF					
Year 1	48.4^{ax}	42.8^{bx}	42.4^{bx}	40.8^{ax}	44.6^{cx}
Year 2	36.6^{x}	36.7^{x}	38.4^{x}	39.7^{y}	48.8^{y}
Mean	38.4^{ax}	39.8^{ax}	40.4^{ax}	40.2^{ax}	46.7^{by}
CP					
Year 1	8.9^{ax}	7.5^{aby}	7.1^{aby}	5.7^{by}	18.4^{by}
Year 2	8.2^{aby}	6.9^{ay}	6.5^{ay}	7.2^{ay}	12.0^{by}
Mean	8.5^{ax}	7.2^{ay}	6.8^{ay}	6.5^{ay}	15.2^{by}
% of N					
ADIN					
Year 1	15.2^{ax}	18.2^{by}	14.7^{ax}	17.1^{cx}	9.6^{ay}
Year 2	11.1^{x}	10.9^{y}	10.7^{y}	11.6^{y}	14.5^{y}
Mean	13.1^{x}	14.5^{y}	12.7^{x}	14.3^{x}	12.0^{x}

Table 6. Selectivity of cows during grazing of different non bt- and bt-corn hybrids or during hay feeding in a drylot.

	Winter feeding system				
	Crop residue grazing				
		bt-hybrid			
	Non bt-hybrid	YieldGard event		Knockout event	Drylot
	3489	34R07	NX6236	N64Z4	
	(Selected forage:Available forage)				
OM					
Year 1	.93^{x}	1.02^{x}	1.00^{x}	.98^{x}	.96^{x}
Year 2	.91^{x}	.92^{x}	.93^{x}	.91^{x}	.93^{x}
Mean	.92^{x}	.97^{x}	.97^{x}	.95^{x}	.95^{x}
IVDOM					
Year 1	1.19^{x}	1.27^{y}	1.27^{y}	1.22^{x}	.90^{y}
Year 2	1.20^{abx}	1.36^{ay}	1.22^{abx}	1.13^{bx}	1.03^{by}
Mean	1.20^{ax}	1.32^{ax}	1.24^{ax}	1.17^{ax}	.97^{by}
NDF					
Year 1	.87^{x}	.89^{x}	.92^{x}	.93^{x}	.96^{x}
Year 2	.80^{x}	.84^{x}	.87^{y}	.88^{y}	.87^{y}
Mean	.83^{x}	.87^{x}	.89^{x}	.90^{x}	.91^{x}
ADF					
Year 1	.75^{ax}	.76^{ax}	.79^{ax}	.77^{ax}	.93^{by}
Year 2	.75^{x}	.74^{x}	.81^{y}	.86^{y}	.88^{y}
Mean	.75^{x}	.75^{x}	.80^{x}	.82^{x}	.90^{x}
CP					
Year 1	2.04^{ax}	1.57^{by}	1.57^{by}	1.40^{by}	1.11^{cy}
Year 2	2.17^{x}	1.94^{y}	1.65^{y}	1.78^{y}	1.17^{y}
Mean	2.11^{ax}	1.76^{aby}	1.61^{by}	1.59^{by}	1.14^{cy}
ADIN					
Year 1	.54^{ax}	.66^{ay}	.56^{ax}	.70^{ay}	.87^{by}
Year 2	.69^{x}	.63^{y}	.62^{y}	.80^{y}	.93^{y}
Mean	.61^{x}	.64^{y}	.59^{y}	.75^{y}	.90^{y}

Table 7. Digestibility and amount of forage consumed by cows grazing different non bt- and bt-corn hybrids or fed hay in a drylot.

	Winter feeding system				
	Crop residue grazing				
		bt-hybrid			
	Non bt-hybrid	YieldGard event		Knockout event	Drylot
	34	34R07	NX6236	N64Z4	
Selected forage digestibility, %					
Year 1	56.8^{x}	54.5^{x}	46.7^{y}	56.2^{x}	66.2^{y}
Year 2	41.9^{x}	49.5^{y}	49.0^{y}	42.8^{x}	37.4^{y}
Mean	49.4^{x}	52.0^{x}	47.8^{x}	49.1^{x}	51.8^{x}
Dry matter intake,					
lb/day					
Year 1	31.7^{ax}	32.6^{ax}	20.0^{by}	29.3^{aby}	34.8^{ay}
Year 2	31.0^{x}	35.4^{y}	31.2^{y}	27.7^{y}	29.7^{y}
Mean	31.4^{x}	34.1^{y}	25.5^{y}	28.4^{y}	32.1^{y}
% BW					
Year 1	2.27^{ax}	2.46^{ay}	1.48^{by}	2.21^{aby}	2.49^{ay}
Year 2	2.20^{x}	2.51^{y}	2.29^{x}	2.07^{y}	2.31^{x}
Mean	2.23^{x}	2.48^{y}	1.88^{y}	2.14^{x}	2.40^{y}

Table 8. Amounts of OM and its components in forage consumed by cows grazing different non bt- and bt-corn hybrids or fed hay in a drylot.

	Winter feeding system				
	Crop residue grazing				
		bt-hybrid			
	Non bt-hybrid	YieldGard event		Knockout event	Drylot
	3489	34R07	NX6236	N64Z4	
	% of BW				
OM					
Year 1	1.93^{x}	2.15^{y}	1.29^{y}	1.94^{y}	2.22^{y}
Year 2	1.90^{x}	2.19^{y}	2.04^{y}	1.80^{y}	2.05^{y}
Mean	1.91^{x}	2.17^{y}	1.66^{y}	1.87^{x}	2.14^{y}
DDM					
Year 1	1.28^{ax}	1.35^{ay}	.70^{by}	1.25^{ay}	1.63^{ay}
Year 2	.92^{x}	1.24^{y}	1.11^{y}	.86^{y}	.87^{y}
Mean	1.10^{x}	1.30^{y}	.90^{y}	1.05^{y}	1.24^{y}
NDF					
Year 1	1.34^{x}	1.56^{y}	.95^{y}	1.46^{y}	1.20^{y}
Year 2	1.20^{x}	1.44^{y}	1.37^{y}	1.18^{x}	1.18^{x}
Mean	1.27^{x}	1.50^{y}	1.17^{y}	1.32^{y}	1.19^{y}
ADF					
Year 1	.79^{x}	.93^{y}	.55^{y}	.81^{x}	1.00^{y}
Year 2	.69^{x}	.80^{y}	.78^{y}	.71^{y}	1.00^{y}
Mean	.74^{x}	.86^{y}	.67^{y}	.76^{x}	1.00^{y}
CP					
Year 1	.17^{ax}	.16^{acx}	.09^{by}	.11^{bcy}	.40^{dy}
Year 2	.15^{x}	.15^{y}	.13^{y}	.13^{y}	.25^{y}
Mean	.16^{ax}	.16^{ax}	.11^{ay}	.12^{ay}	.32^{by}

Table 9. 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 maintained in a drylot.

	Winter feeding system				
	Crop residue grazing				
		bt-hybrid			
	Non bt-hybrid	YieldGard event		Knockout event	Drylot
	3489	34R07	NX6236	N64Z4	
Cow BW, lb					
Initial					
Year 1	1400^{x}	1362^{x}	1405^{x}	1373^{x}	1393^{x}
Year 2	1391^{x}	1374^{x}	1344^{x}	1315^{x}	1311^{x}
Mean	1396^{x}	1368^{x}	1374^{x}	1345^{x}	1352^{x}
Seasonal change					
Year 1	67.5^{x}	93.5^{y}	70.5^{y}	80.5^{y}	67.5^{y}
Year 2	107.0^{x}	76.0^{y}	66.5^{y}	117.5^{y}	115.0^{y}
Mean	87.2^{x}	84.8^{y}	68.5^{y}	99.0^{y}	91.3^{y}
Cow condition score					
Initial					
Year 1	5.0^{x}	5.0^{x}	5.0^{x}	5.1^{x}	5.0^{x}
Year 2	5.2^{x}	5.2^{x}	5.1^{x}	5.1^{x}	5.1^{x}
Mean	5.1^{x}	5.1^{x}	5.1^{x}	5.1^{x}	5.1^{x}
Seasonal change					
Year 1	.09^{x}	-.25^{y}	-.33^{y}	0^{y}	-.09^{y}
Year 2	-.11^{x}	-.23^{y}	-.39^{y}	-.06^{y}	-.17^{y}
Mean	-.01^{x}	-.24^{y}	-.36^{y}	-.03^{x}	-.13^{y}
Hay fed, lb DM/cow					
Year 1	1431^{ax}	1380^{ax}	1375^{ax}	1191^{ay}	3183^{by}
Year 2	321^{ax}	263^{ay}	278^{ay}	362^{ay}	3217^{by}
Mean	875^{ax}	821^{ax}	826^{ax}	776^{ay}	3200^{by}