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TRANSGENIC MAIZE HYBRID CROP RESIDUES: NUTRITIVE VALUE AND THEIR EFFECTS ON PERFORMANCE OF GRAZING BEEF COWS

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Abstract

Several maize (*Zea mays*) hybrids, including three transgenic hybrids containing *Bacillus thuringiensis* (Bt) enzymes *(*Bt-maize hybrids), were planted in a field study. Mature, mid-gestation, beef cows (*Bos tarus*) strip-grazed post-harvest residues as paddocks over 126 days. Body condition-scores and weights were monitored. Forage yield, weathering losses and forage composition were monitored on grazed and ungrazed areas. Forage selection and intake were estimated. Grain yields, dropped grain, initial crop residue concentrations of dry matter (DM), organic matter (OM) and in vitro digestible organic matter (IVDOM) yields were similar among hybrids. Hybrids varied in infestation of maize borers, initial amounts of residue DM, acid detergent fiber (ADF) and acid detergent lignin (ADL) and IVDOM. Mean rates of change in forage and concentration of IVDOM selected by steers was similar between hybrids. Cows grazing residues required 50% less supplemental hay to retain the same body condition as cows consuming hay in drylot.

Keywords: Transgenic plants, cattle, grazing, maize, animal performance, nutritive quality

Introduction

Maize producers in the United States can use hybrids containing transgenic inclusion of Bt bacterial enzymes to manage the European maize borer. Maize plants containing these proteins (Bt-maize) interact with maize borer in the same manner, as does Bt insecticide. Bt maize hybrids do affected milk production in dairy cows fed fresh maize , Faust and Miller (1997). The Bt proteins are denatured during ensiling, Fearing (1997). Little research has evaluated the effects of these transgenic plant residues on the nutritional value of the crop residues or the performance of cattle grazing them. Therefore, an experiment was undertaken comparing the nutritional value of Bt- and non Bt-maize hybrid residues.

Material and Methods

One non Bt-maize hybrid and three Bt-maize hybrids were planted in 1998 near Ames, Iowa, U.S. at 57,200 to 61,600 plants/ha on 2.9-ha plots, in a replicated complete block design with two replicates. Hybrids included a non Bt-maize hybrid 'Pioneer 3489, a near-isogenic Bt-containing hybrid 'Pioneer 34R07', and two additional Bt-maize hybrids, 'Novartis NX6236' and 'Novartis N64-Z4'. The three Bt-containing hybrids were developed from separate transgenic events. Maize borer damage was evaluated before grain harvest. Grain yields were determined at harvest, and dropped maize ears and associated grain was determined in eight 4-m^2 locations per field. Fields were divided into four paddocks with electric fence. Three mature, mid-gestation, crossbred beef cows were allotted to each field or to replicated drylots. Cows grazed maize crop residues for 126 days with a new strip offered monthly. Cows grazing crop residues or maintained in a drylot were offered alfalfa (*Medicago sativa*)-grass (*Bromus inermis*) at a level to maintain a body condition score of 5 (9-point scale). A mineral and vitamin mixture supplement was offered free choice. Available forage samples were collected monthly from two or more 4-m^2

location per grazed or ungrazed pasture, and from four 4-m^2 exclosures at the termination of grazing. Dried samples were analyzed for OM, IVDOM, CP, ADIN, NDF, ADF, and ADL. Cows were weighed with body fill at the initiation, monthly during, and at the end of the experiment. Two individuals assessed visual cow body condition score biweekly. Forage selected during 2 hours of grazing was evacuated from one ruminally fistulated steer per field on the 14th day of the first grazing period. Freeze-dried subsamples were analyzed for OM, IVDOM, CP, ADIN, NDF, ADF, and acid detergent lignin (ADL). Forage selectivity of steers grazing different hybrids or consuming hay were determined by comparing the concentrations of the various constituents consumed with those in the available forage. Simultaneously fecal output in two cows per field was determined from the passage kinetics of Chromium (Cr) after a pulse-dose of Cr-mordanted fiber.

Results and Discussion

Evaluation of maize plants for European maize borer damage revealed minimal damage, but more evidence of stalk and ear-shank feeding in the non Bt-maize hybrid. Grain yields, dropped ears and grain, or post-grazing residue cover did not differ among hybrids. Maize hybrid neither affected the yields of maize crop residue DM, OM, and IVOMD at harvest nor the rates of loss of maize crop residue DM, OM or IVOMD during the grazing season. Moisture content of residue at the initiation of grazing varied among hybrids. 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 accounted for 14.7 and 62.7% of the OM and IVOMD losses from the crop residues over the winter grazing season.

Hybrids NX6236 and N64-Z4 had higher initial IVOMD concentration (Table 1). This greater digestibility was associated with a lower ($P < .05$) concentration of ADF and lower concentrations of ADL. Crude protein and ADIN concentrations did not differ among maize hybrids.

Mean rates of change in DM, OM, IVOMD, NDF, ADF, ADL, CP and ADIN concentrations were similar in grazed and ungrazed crop residues across hybrids throughout the grazing period. Soil contamination of residues led to decreased OM concentration in grazed areas of the field. ADL and ADIN concentrations increased more rapidly in grazed areas than in ungrazed areas, implying grazing selection for plant components with lower concentrations of these constituents.

The concentration of IVOMD selected by fistulated steers grazing maize crop residues or fed hay in a drylot after 2 weeks of grazing did not differ (Table 2). Because of variation in composition among plant parts in maize crop residue, selectivity of maize residue grazed by steers tended to be greater ($P<.15$) than steers fed hay. Steers grazing maize residues consumed forage with higher ($P < .05$) concentrations of NDF, ADF and ADIN and lower ($P < .O5$) concentrations of CP than steers fed hay. Steers grazing maize residues were more selective against ($P < .O5$) ADF and ADIN and for ($P < .O5$) CP. Diet selection varied between hybrids. If stocking rates allow for diet selection, 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.

Hay was fed to maintain equal body score condition across all treatments. Cows grazing maize crop residues required 836 kg/cow less hay dry matter than cows fed hay in a drylot over 126 days ($P < .10$). Only minor differences ($P < .10$) were found in the amount of hay fed to cows grazing crop residues of the different hybrids.

Mean calving rate in the spring of 1999 was 100% across all treatments. Similarly, mean pregnancy rates of 73% and estimated calving intervals of 359 days did not differ across treatments. As expected, cows grazing maize crop residues from all maize 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 maize 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 maize 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 maize crop residues unrelated to the presence of the Bt-genes may be sufficient to cause some differences in the performance of cows grazing the maize crop residues. In a year with greater maize borer pressure and ear droppage, greater differences in residue nutritive value and animal performance might be observed between non-Bt- and Bt-maize hybrids.

References

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Table 1 - Composition of corn crop residues from different bt- and non bt-corn hybrids at initiation of grazing.

	Maize hybrids			
	non bt-hybrid	bt-hybrids		
Item	3489	34R07	NX6236	N64-Z4
DM, g/kg	720	687	566	584
OM, % of DM	885	848	908	840
g/kg of OM				
IVOMD	446 [a]	432 [a]	513 [a]	512 [b]
NDF	775	781	742	732
ADF	469 [a]	496 [b]	456 [a]	456 [b]
ADL	66	74	54	57
CP	44	47	48	51
ADIN, g/kg of N	258	256	170	214

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

Table 2 - Composition of maize crop residue forage selected during grazing of different Bt- and non bt-maize hybrids.

	Maize hybrids				
	non bt-hybrid	bt-hybrids			
Item	3489	34R07	NX6236	N64-Z4	Drylot hay
	Selected forage				
OM, g/kg of DM	850	876	877	879	895
g/kg of OM					
IVOMD	477	437	475	506	481
NDF	692 [a]	724 [a]	732 [a]	734 [a]	534 [b]
ADF	404 [a]	428 [b]	424 [b]	408 [b]	446 [c]
CP	89 [a]	75 [ab]	71 [ab]	58 [b]	184 [c]
ADIN, g/kg of N	152 [a]	182 [b]	147 [b]	171 [c]	96 [d]
	Selected forage:Available forage				
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.