2015

Corn residue stocking rate affects cattle performance but not subsequent grain yield

L. A. Stalker
University of Nebraska-Lincoln, stalkera@byui.edu

H. Blanco-Canqui
University of Nebraska-Lincoln, hblanco2@unl.edu

Jennifer A. Gigax
University of Nebraska-Lincoln

A. L. McGee
University of Nebraska-Lincoln

T. M. Shaver
University of Nebraska-Lincoln, tshaver2@unl.edu

See next page for additional authors

Published October 9, 2015

Corn residue stocking rate affects cattle performance but not subsequent grain yield[1]

L. A. Stalker,*[2] H. Blanco-Canqui,† J. A. Gigax,* A. L. McGee,* T. M. Shaver,* and S. J. van Donk*

*University of Nebraska-Lincoln, West Central Research and Extension Center, North Platte 69101; and †Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln 68583

ABSTRACT: This study investigated effects of stocking rate on cattle performance, quality and quantity of corn residue, and impact of residue removal on grain yield for 5 yr at the University of Nebraska – Lincoln West Central Water Resources Field Laboratory near Brule, NE. Four removal treatments—1) no removal (control), 2) grazing at 2.5 animal unit month (AUM)/ha, 3) grazing at 5.0 AUM/ha, and 4) baling—were applied to a center pivot–irrigated corn field (53 ha). The field was divided into eight 6.6-ha paddocks to which replicated treatments were assigned. Samples of residue were collected in October and March (before and after residue removal) using ten 0.5-m^2 quadrats per treatment replication. Residue was separated into 5 plant parts—stem, cob, leaf, husk, and grain—and analyzed for nutrient content. Esophageally fistulated cattle were used to measure diet quality. Cattle assigned to the 2.5 AUM/ha stocking rate treatment gained more BW ($P < 0.01$) and BCS ($P < 0.01$) than cattle assigned to the 5.0 AUM/ha treatment. Leaf contained the most ($P < 0.01$) CP and husk had the greatest ($P < 0.01$) in vitro OM disappearance (IVOMD) but the CP and IVOMD of individual plant parts did not differ ($P > 0.69$) between sampling dates. Amount of total residue was reduced ($P < 0.05$) by baling and both grazing treatments between October and March but was not different ($P > 0.05$) in control paddocks between sampling dates. As a proportion of the total residue, stem increased ($P < 0.01$) and husk decreased ($P < 0.01$) between October and March. Diet CP content was similar ($P = 0.10$) between sampling dates for the 2 grazing treatments but IVOMD was greater after grazing in the 2.5 AUM/ha grazing treatment ($P = 0.04$). Subsequent grain yields were not different ($P = 0.16$) across all 4 residue removal treatments. At the proper stocking rate, corn residue grazing results in acceptable animal performance without negatively impacting subsequent corn grain production.

Key words: baling, beef cattle, corn residue utilization, grazing

J. Anim. Sci. 2015.93:4977–4983
doi:10.2527/jas2015-9259

INTRODUCTION

Both corn and beef production are major industries in Nebraska and the United States. About 34 million ha of corn was harvested in the United States in 2014 with yields of 10.7 Mg/ha (USDA-NASS, 2014), resulting in about 300 million t of residue. There were about 30 million beef cows in the United States in July 2014 (USDA-NASS et al., 2014), meaning there is more than 10 t of corn residue per beef cow. Although corn residue represents a vast potential feed source, little work has been done to address straightforward management questions. Different parts of the corn plant vary widely in nutrient content (Fernandez-Rivera and Klopfenstein, 1989a) and stocking rate is, therefore, expected to affect animal performance. With increased interest in corn residue as feed for beef cattle also come questions about how removal of corn residue impacts subsequent grain yield and soil properties. The impact of residue removal on grain yield is variable within the literature (Blanco-Canqui and Lal, 2009; Karlen et al., 2014). Most of the differences are attributed to the interaction of residue removal and tillage method, soil type, and climate (Wilhelm et al., 2004). However, almost all studies evaluating the impact of residue removal on subsequent

[1]A contribution of the University of Nebraska Agricultural Research Division, supported in part by funds provided through the Hatch Act.

[2]Corresponding author: aaron.stalker@unl.edu

Received April 30, 2015.
Accepted August 7, 2015.

crop production have been conducted by mechanically harvesting residue. Little work has evaluated the effects of residue removal by grazing, which differs substantially from mechanical harvest in that much of the nutrients consumed by cattle are not removed from the field. Conflicting results and the growing importance of corn residue use to the beef and other industries prompted the initiation of this study. It was hypothesized that grazing corn residue would not be detrimental to subsequent grain yield and that cattle performance would improve as stocking rate decreased. Objectives were to determine 1) the impact of corn residue removal on grain yield, 2) quality of residue over time, and 3) effects of stocking rate on cattle performance while grazing residue.

MATERIALS AND METHODS

Study Site and Animals

This 5-yr study was conducted at the West Central Water Resources Field Laboratory near Brule, NE, with the approval of the University of Nebraska Institutional Animal Care and Use Committee (project 921). Beginning in October 2008, a center pivot–irrigated corn field (53 ha) was divided into eight 6.6-ha paddocks to which treatments were applied. Paddocks were randomly assigned to 4 replicated treatments: 1) no removal (control), 2) grazing at 2.5 animal unit month (**AUM**)/ha, 3) grazing at 5.0 AUM/ha, and 4) baling. The field was in continuous-corn, no-till management and treatments were applied to the same paddocks each year for 5 yr. All agronomic practices, including fertilization and irrigation rates, planting and harvest dates, and pesticide application, were constant among treatments within year. Fertilization rate was designed to supply sufficient N, P, and K to achieve yields of 10.5 Mg/ha. Irrigation rate was managed to replace water lost to evapotranspiration such that yield was not limited by lack of water. Two dominant soil series are present in the field including Duroc loam (fine-silty, mixed, superactive, mesic Pachic Haplustolls) and a Satanta loam (fine-loamy, mixed, superactive, mesic Aridic Argiustolls). The field elevation above sea level is 1,056 m and it is classified as being in a semiarid region with a mean annual precipitation of 475 mm. Beef cows (three-fourths Red Angus and one-fourth Simmental) in late gestation with previous corn residue grazing experience grazed the paddocks from late November to early February. Cows were stratified by BW and randomly assigned to treatment each year. Cow BW and BCS (Wagner et al., 1988) were assessed before and after grazing. Cows were stocked at 2.5 AUM/ha in the light grazing paddocks and 5.0 AUM/ha in the heavy grazing paddocks. This field produces average corn grain yields for the state of Nebraska and the recommended stocking rate is 3.75 AUM/ha (Wilson et al., 2004). Stocking rates were selected to represent conservative and aggressive values for this field. Cows were introduced to and removed from all paddocks assigned to grazing treatments simultaneously each year and differences in stocking rate were achieved by introducing twice as many cattle to the 5.0 AUM/ha 5 kg/(cow·d^{-1}) of a 32% CP supplement delivered 3 d/wk. Supplement was in the form of 1.9-cm manufactured cubes fed on the ground. Residue in paddocks assigned to baling treatment was raked into windrows using a v-rake (H&S HDII-17; H&S Manufacturing Co., Marshfield, WI) and then baled using a round baler (Hesston 2856A; AGCO Manufacturing Co., Duluth, GA) after grain harvest. Residue in paddocks assigned to the control treatment remained undisturbed following grain harvest.

Corn Residue Sample Collection

In 2 yr (2008 and 2011), corn biomass samples were collected before (mid October, about 1 wk before grain harvest) and after (mid March) treatments were applied. Each paddock was sampled before and after treatment application at 10 random locations, the Global Positioning System coordinates of which were recorded. Postresidue removal sites were located immediately adjacent to the pretreatment application location, resulting in contiguous sampling sites. A 0.5-m^2 quadrat that was 76.2 by 65.6 cm was centered on the row (76.2 cm row spacing) and clipped to ground level. All residue on the ground within the quadrat was collected and sorted into 5 plant parts: stem, cob, leaf, husk, and grain.

Laboratory Analysis

After being sorted, plant parts were chopped to a 5-cm particle size and then allowed to air dry at ambient temperature indoors for 168 h. Then, samples of each plant part were weighed, dried in duplicate in a 60°C forced-air oven for 48 h, and immediately weighed back to determine DM. After determining DM, all samples, except grain, were composited by plant part within treatment replication from which a representative subsample was collected. For all plant parts except grain, the composited sample was ground to pass either a 2- or 1-mm screen using a Wiley Mill (Arthur Thomas, Philadelphia, PA). Corn grain was not analyzed for nutrient content because it was a very small portion of the posttreatment application residue and does not vary as widely in nutrient content as the other plant fractions. Samples ground to pass a 2-mm screen were analyzed for ash, N content (Leco FP-2000 nitrogen analyzer; Leco Corp., Henderson, NV), which was converted to

CP as N × 6.25; and NDF following procedure A described by Van Soest et al. (1991) without the inclusion of amylase or sodium sulfite. In vitro OM disappearance (**IVOMD**) was determined following exactly the procedure described by Stalker et al. (2013). In vitro DM disappearance was estimated using a modified version of the procedure described by Tilley and Terry (1963). The original procedure was modified by adding 1 g urea/L to McDougall's buffer and by using a 50:50 mixture of ruminal fluid and buffer (Weiss, 1994). About 2 L ruminal fluid were collected via the fistula from 2 ruminally cannulated steers (250 kg BW) fed a 100% smooth bromegrass hay (8.3% CP and 55% NDF) diet, offered once daily at 1.5%, about 2 h after feeding, mixed together in equal volumes, and strained through 3 layers of cheese cloth to serve as inoculum for the in vitro run. Inoculum was transported to the laboratory in insulated containers and kept at 39°C under constant purging with CO_2. For each in vitro run, 0.25 g of sample ground to pass a 1-mm screen was added to a 100-mL polypropylene tube. Twenty milliliters of ruminal fluid mixed with buffer in a 1:1 ratio (vol/vol) was added and each tube was flushed with CO_2, stoppered with a Bunsen valve, and incubated at 39°C for 48 h. At 12 h intervals, tubes were carefully swirled by hand. At the end of the 48 h incubation, 1 mL of 6 *N* HCl and 100 mg pepsin (P-7012; Sigma-Aldrich, St. Louis, MO) was added to each tube and incubation continued for an additional 24 h. After the pepsin digest, the contents of the tube were filtered through number 54 Whatman filter paper and placed in a 60°C forced-air oven for 24 h. Five blank tubes, containing only inoculum, were incubated, digested, filtered, and dried as described for tubes containing samples and used for correction. Ash content of filtered residue was determined and in vitro disappearance was converted to an OM basis. In addition, 5 forages of known in vivo digestibility were included in duplicate in the in vitro run and treated exactly as the corn plant parts. These standards were used to convert the raw IVOMD to true IVOMD as described by Stalker et al. (2013).

Diet Sample Collection

Diet samples were collected from each paddock assigned to a grazing treatment, using 3 mature, esophageally fistulated cows (635 kg BW) with previous corn residue grazing experience, both before and after residue removal treatments were applied. Esophageally fistulated cows were used only for diet sampling and not used in the continuous grazing of the experimental paddocks. Surgeries were performed at least 36 mo before initiation of the experiment. Before each diet sample collection, cows were withheld from feed, but not water, for 12 h. Fistulated cattle were transported to paddocks where diets samples were collected, fitted with solid bottom collection bags after removal of the esophageal plug and introduced to the paddock, and then allowed to graze for about 20 min. After collection, fistulated cows were removed from the paddocks. Diet samples were dried, ground, and analyzed for IVOMD and CP as described for plant parts.

Subsequent Corn Grain Yield

Impact of residue removal on subsequent year grain yields was determined by measuring grain yield using a grain yield monitor (Greenstar 2600 mass flow and moisture sensor; John Deere Des Moines Works, Ankeny, IA) integrated into the combine (JD9500; Deere & Company, Moline, IL) for 5 consecutive years after residue removal treatments were applied.

Statistical Analysis

All data were analyzed using the Mixed procedure of SAS (SAS Inst. Inc., Cary, NC). The animal performance model and the esophageal diet quality model included the independent variables of stocking rate as a fixed effect and year as a random effect. The residue nutrient content model included residue removal treatment, plant part, sampling date, and the interaction between plant part and sampling date as fixed effects and year as a random effect. The models analyzing amount and percent of total residue made up by each plant fraction included the effects of treatment, sampling date, and their interaction as fixed effects and year as a random effect. The model analyzing 5-yr average corn grain yield following treatment application included removal treatment as a fixed effect and year as a repeated measure. The data were fitted to multiple covariate structures and ultimately a variance components covariate structure was used in the final analysis as it was the best fit for the data based on the Akaike information criterion. Least squares means were separated using the LSD method when there was an overall significant ($P < 0.05$) effect of treatment. In all cases, paddock (treatment replication within year) was used as the experimental unit.

RESULTS AND DISCUSSION

Animal Performance

Cows in both the 2.5 and 5.0 AUM/ha stocking rate treatments gained BW (Table 1) while grazing corn residue; however, cows assigned to the 2.5 AUM/ha treatment gained more ($P < 0.01$). Cows in the 2.5 AUM/ha treatment gained BCS ($P < 0.01$) whereas

Table 1. Cow BW and BCS grazing corn residue at 2.5 or 5.0 animal unit months (AUM) per hectare

Item	2.5 AUM/ha	5.0 AUM/ha	SE	*P*-value
Start BW, kg	440	443	10	0.19
End BW, kg	470	457	17	<0.01
BW change, kg	30	14	10	<0.01
Start BCS[1]	5.2	5.2	0.1	0.60
End BCS	5.5	5.2	0.1	<0.01
BCS change	0.3	0.0	0.2	<0.01

[1]Scale of 1 (emaciated) to 9 (extremely obese); Wagner et al. (1988).

cows in the 5.0 AUM/ha treatment maintained BCS. These results are similar to those reported by Russell et al. (1993), who provided grazing allowances of 1.6, 3.2, and 6.4 AUM/ha to mature cows and found cattle maintained BW at stocking rates of 3.2 and 6.4 AUM/ha and gained BW at 1.6 AUM/ha, although plot size and cow numbers were both very small. Other reports of the effects of stocking rate while grazing corn residue on performance of mature beef cattle do not appear in refereed literature. However, previous work conducted using growing animals agrees with results of the current study. Irlbeck et al. (1991) measured the ADG of yearling steers when stocked at either 2.9 or 5.8 AUM/ha. Cattle stocked at 2.9 AUM/ha had the greatest ADG across 3 corn hybrids. Differing animal performance as a result of stocking rate is a function of the difference in nutrient content of corn plant parts and the relative abundance of individual plant parts.

Residue Quality

Different corn plant parts varied widely in their nutrient content; however, the nutrient content of individual plant parts did not change between sampling dates (Table 2). In all cases, ash, NDF, and IVOMD of a given plant part in March were similar ($P > 0.69$) to that value about 5 mo earlier in October. Crude protein was similar ($P > 0.05$) at both sampling dates for all plant parts except husk. Husk had greater CP content in March than October. Why CP content of husk would increase over time may be due to the more rapid decomposition of the carbohydrate fraction of husk relative to its CP fraction or, speculatively, a reflection of the high N content of microorganisms decomposing the sample. Nutritive values found in this study are comparable to those reported by Fernandez-Rivera and Klopfenstein (1989a), who found CP content of leaf and husk was 5.6% before grazing and 4.8% after grazing. However, they also found CP content of corn residue was not different before (4.7 and 4.9% CP) and after (5.1 and 4.7% CP) grazing under stocking rates of 2.47 and 4.69 animals/ha, respectively. Given the dramatic improvements in commercial corn hybrid genetic composition and yield potential, so much similarity between the present study and values reported by Fernandez-Rivera and Klopfenstein (1989a) is surprising. However, these similarities may be coincidental, as numerous factors, such as hybrid, relative maturity, and fertilization practices, likely affect nutrient quality of residue.

Leaf contained about twice as much ash as cobs, husks, and leaves, which did not differ ($P > 0.05$) in ash content from each other (Table 2). Leaf had the greatest ($P < 0.01$) CP content, whereas cob, husk, and stem contained low amounts of CP. In vitro OM disappearance was greatest ($P < 0.01$) for husk followed by leaf and then cob and stem in descending order.

Residue Quantity

Corn grain remaining in the field following grain harvest was primarily entire ears that were not picked up by the combine. Postresidue removal grain averaged 406 kg/ha (DM) and was not different ($P = 0.84$) among treatments. The lack of difference among treatments is likely due to the fact that the residue quantification methodology (ten 0.5-m^2 quadrats per treatment replication) was not well suited to accurate assessment of down ears because they were rare and heavy and created very large SE. Because corn grain was a minor component of the total residue, it was excluded from residue calculations.

When viewed as a proportion of total residue, cob, husk, leaf, and stem made up 15, 10, 35, and 40%, respectively, of the residue before treatment application

Table 2. Ash, CP, NDF, and in vitro OM disappearance (IVOMD) of corn plant parts collected before and after residue removal

	Cob		Husk		Leaf		Stem					
Item	October	March	October	March	October	March	October	March	SE	Part	Date	Part × date[1]
Ash, %	7.2^b	7.3^b	4.8^b	5.6^b	15.5^a	15.7^a	6.0^b	5.8^b	1.2	<0.01	0.74	0.97
CP, % OM	3.5^{cd}	3.3^d	3.5^d	4.5^b	6.7^a	6.5^a	4.2^{bc}	3.8^{cd}	0.4	<0.01	0.76	0.01
NDF, % OM	87.6^a	87.9^a	88.1^a	85.0^{ab}	80.3^c	80.0^c	81.9^{bc}	84.4^{ab}	1.7	<0.01	0.69	0.29
IVOMD, %	46.1^c	45.5^c	63.6^a	64.4^a	53.1^b	50.9^b	43.5^c	45.3^c	1.3	<0.01	0.93	0.38

[a–d]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

[1]Plant part × sampling date interaction.

Table 3. Amount of residue (DM basis) by plant part before and after residue removal

	Control		2.5 AUM[1]/ha		5.0 AUM/ha		Baled					
Plant part	October	March	October	March	October	March	October	March	SE	Treatment	Date	Treatment × date[2]
Cob, kg/ha	1,299[a]	926[ab]	1,279[a]	1,025[ab]	1,272[a]	1,199[ab]	1,254[a]	757[b]	277	0.41	<0.01	0.46
Husk, kg/ha	882[a]	501[b]	820[a]	350[b]	805[a]	141[c]	757[a]	51[c]	82	<0.01	<0.01	0.03
Leaf, kg/ha	2,967[a]	2,230[b]	2,944[a]	1,718[b]	3,002[a]	1,602[b]	2,938[a]	487[c]	229	<0.01	<0.01	0.01
Stem, kg/ha	3,422[a]	3,226[a]	3,320[a]	3,459[a]	3,624[a]	3,417[a]	3,386[a]	1,120[b]	399	<0.01	<0.01	<0.01
Total, kg/ha	8,571[a]	6,885[bc]	8,363[ab]	6,552[c]	8,702[a]	6,359[c]	8,334[ab]	2,416[d]	789	<0.01	<0.01	<0.01
Cob, %	15.0[bc]	13.4[c]	15.2[bc]	15.2[bc]	14.4[c]	18.6[b]	14.9[bc]	29.6[a]	2.4	<0.01	<0.01	<0.01
Husk, %	10.2[a]	7.7[b]	9.7[a]	5.3[c]	9.3[ab]	2.2[d]	9.1[ab]	1.7[d]	0.7	<0.01	<0.01	<0.01
Leaf, %	34.6[a]	32.0[ab]	35.7[a]	27.1[bc]	34.5[a]	25.4[c]	35.4[a]	19.9[d]	3.5	0.04	<0.01	0.02
Stem, %	40.1[d]	47.0[bc]	39.4[d]	52.3[ab]	41.8[cd]	53.8[a]	40.7[cd]	48.8[ab]	2.3	0.30	<0.01	0.48

[a–d]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

[1]AUM = animal unit month.

[2]Residue removal treatment × sampling date interaction.

(Table 3). In all cases, stem made up a greater ($P < 0.05$) proportion and husk made up a lesser ($P < 0.05$) proportion of the total residue in March than in October. For all treatments except control, the proportion of leaf was reduced ($P < 0.05$) in March compared with October. The proportion of cob after baling was greatly increased ($P < 0.05$). This is likely due to the physical shape and size of cob, which make it difficult to rake and bale.

Total amount of residue was similar among treatments in October (Table 3). In March, after application of residue removal treatments, the mass of total residue was lower ($P < 0.05$) for all treatments relative to the preremoval amount for all treatments, including the control, where residue was not removed. Decrease in residue mass in the control paddocks reflects losses due to wind and decomposition between October and March. In the control treatment, about 43% of the mass of husks disappeared over the course of the study, demonstrating the labile nature of husks. Leaves are also susceptible to natural loss and were reduced by about 35% between October and March in the control treatment. Cobs and stems are more stable, the mass of which were not different ($P > 0.05$) between October and March in the control treatment. Previous research (Fernandez-Rivera and Klopfenstein, 1989a; Gutierrez-Ornelas and Klopfenstein, 1991) has demonstrated that calves primarily consume husk and leaf. Data from the present study indicate mature cows likely exhibit similar preference. In the 2.5 AUM/ha treatment, the amount of husk and leaf were reduced by 57 and 42%, respectively. In the 5.0 AUM/ha grazing treatment, husks and leaves were reduced by 82 and 47%, respectively, after grazing. For both grazing treatments, the mass of cob and stem was similar ($P > 0.05$) before and after grazing, demonstrating that cattle avoid consuming cob and stem. Baling reduced ($P < 0.05$) the amount of all plant parts. In the baling treatment, only 7% of the husk present in October remained in March.

Diet Quality

Diet CP values were not affected ($P > 0.05$) by stocking rate or sampling date (Table 4). Diet IVOMD was reduced ($P = 0.04$) for the 5.0 AUM/ha stocking rate treatment compared with the 2.5 AUM/ha treatment. These values are comparable to values reported in previous work, even though genetic composition of corn hybrids changes rapidly. Fernandez-Rivera and Klopfenstein (1989b) measured the nutrient content of diet samples collected from calves grazing corn residue. These authors reported the DM digestibility of corn residue diets decline as day of grazing and stocking rate increase.

Difference in animal performance based on stocking rate observed in this experiment was a function of the relationship between the large difference in the nutrient content of the different parts of the corn plant (Table 2) and their relative abundance (Table 3). Because cows preferentially consume husk, which is the most digestible yet least abundant plant part, as stocking rate increases, the proportion of husk as a total of intake is reduced. Therefore, at higher stocking rates, cattle are forced to consume less digestible plant parts (Table 4), resulting in reduced performance. These data demonstrate that acceptable performance of mature, gestating cows can be achieved at stocking rates of up to 5.0 AUM/ha on corn fields that yield about 9.4 Mg/ha.

One concern with corn residue use is the removal of the nutrients from the field and the additional cost required to replace these nutrients for subsequent crop production. There are 2 important differences in nutrient removal levels between type of use (i.e., grazing and baling). First, cattle consume only a portion of the total residue, which varies depending on stocking rate. Second, the plant parts cattle readily consume range in digestibility from about 51 to 70%, meaning that 49 to 30% of the OM and, if nonlactating, mature cattle are used to graze the residue, essentially 100% of other nutrients, such as phosphorus and potassium, are re-

Table 4. Crude protein and in vitro OM disappearance (IVOMD) of diet samples collected from esophageally fistulated cattle before and after grazing

Item	2.5 AUM[1]/ha	5.0 AUM/ha	SEM	*P*-value
CP, % OM				
Before grazing	4.0	3.3	0.4	0.06
After grazing	3.2	3.9	0.4	0.10
IVOMD, % OM				
Before grazing	66.4	67.8	2.6	0.48
After grazing	63.4	55.3	4.9	0.04

[1]AUM = animal unit month.

Table 5. Average corn grain yield after residue removal treatment

Yield, Mg/ha	Treatment Control	2.5 AUM[1]/ha	5.0 AUM/ha	Baling	SE	*P*-value
2009	7.8	8.1	8.5	7.8	0.5	0.77
2010	9.7	10.2	10.3	10.2	0.2	0.16
2011	10.1	9.8	10.5	10.3	0.5	0.85
2012	9.7	10.2	9.8	9.2	0.3	0.36
2013	9.1	9.3	9.4	8.6	0.4	0.52
5-yr average	9.3	9.5	9.7	9.2	0.4	0.16

[1]AUM = animal unit month.

turned to the soil surface. In contrast, when residue is baled, a greater amount of the residue is removed and none of the OM and nutrients contained in the bale are returned to the soil surface.

Subsequent Grain Yield

Corn grain yields within any individual year or averaged across all 5 yr were not affected ($P > 0.15$) by treatment and averaged 9.4 Mg/ha (Table 5). These grain yields, collected for 5 yr, demonstrate that removing corn grain residue from a sprinkler-irrigated, no-till, continuous-corn field has no detrimental effect on subsequent grain yield. Previous research has measured the effects of corn residue grazing on subsequent yield. One study conducted in Illinois demonstrated an increase in corn grain yield subsequent to residue grazing despite an increase in soil penetration resistance under rain fed conditions (Tracy and Zhang, 2008). Grazing animals frequently cause soil compaction but adverse effects on subsequent crop production rarely occur because the compaction is shallow and usually ameliorated by natural soil or biological processes (e.g., wetting/drying and/or freeze/thaw cycles or plant root activity; Bell et al., 2011; Clark et al., 2004). On some high-producing corn fields, residue is so abundant it depresses subsequent grain yield; therefore, removal of a portion of the residue alleviates grain yield suppression (Karlen et al., 2014). The amount of residue produced likely explains in part why Tracy and Zhang (2008) observed an increase in corn grain yield after residue grazing but no increase was observed in the present study. In the present study, the amount of residue produced was not sufficient to impair the subsequent crop, but in the study reported by Tracy and Zhang (2008), yields were sufficiently high to produce enough residue to impair yield. Tracy and Zhang (2008) also included a cool-season annual mixture into their crop rotation, which also may have contributed to the increased yield in grazed treatments.

Because cattle preferentially select husk and leaf, the 2 most nutrient-dense parts of corn residue, stocking rate plays a major role in determining animal performance while grazing corn residue. As stocking rate decreases, BW and BCS would be expected to increase. Nutrient content of corn residue is stable during the winter, and corn residue could, therefore, be used at any time throughout the winter. However, husks are labile and might be used to a greater extent immediately after harvest of corn grain. Because cattle consume only a fraction of the total residue (depending on stocking rate) and retain only a fraction of what they consume, nutrient removal from the field caused by grazing is much less than nutrient removal caused by baling. At stocking rates and other conditions, including irrigation rates, similar to this experiment, corn residue can be grazed without negatively impacting subsequent corn grain production.

LITERATURE CITED

Bell, L. W., J. A. Kirkegaard, A. Swan, J. R. Hunt, N. I. Huth, and N. A. Fettell. 2011. Impacts of soil damage by grazing livestock on crop productivity. Soil Tillage Res. 113:19–29. doi:10.1016/j.still.2011.02.003.

Blanco-Canqui, H., and R. Lal. 2009. Crop residue removal impacts on soil productivity and environmental quality. Crit. Rev. Plant Sci. 28:139–163. doi:10.1080/073526809027765070

Clark, J. T., J. R. Russell, D. L. Karlen, P. L. Singleton, W. D. Busby, and B. C. Peterson. 2004. Soil surface property and soybean yield response to corn stover grazing. Agron. J. 96:1364–1371. doi:10.2134/agronj2004.13640

Fernandez-Rivera, S., and T. J. Klopfenstein. 1989a. Diet composition and daily gain of growing cattle grazing dryland and irrigated cornstalks at several stocking rates. J. Anim. Sci. 67:590–596.

Fernandez-Rivera, S., and T. J. Klopfenstein. 1989b. Yield and quality components of corn crop residues and utilization of these residues by grazing cattle. J. Anim. Sci. 67:597–605.

Gutierrez-Ornelas, E., and T. J. Klopfenstein. 1991. Changes in availability and nutritive value of different corn residue parts as affected by early and late grazing seasons. J. Anim. Sci. 69:1741–1750.

Irlbeck, N., T. J. Klopfenstein, M. Sindt, and R. Stock. 1991. Quality and quantity of corn residue on gain of grazing cattle. In: 1991 Nebraska Beef Cattle Report. Rep. No. MP 56. Univ. of Nebraska, Lincoln. p. 19–22.

Karlen, D. L., S. J. Birrell, J. M. F. Johnson, S. L. Osborne, T. E. Schumacher, G. E. Varvel, R. B. Ferguson, J. M. Novak, J. R. Fredrick, J. M. Baker, J. A. Lamb, P. R. Adler, G. R. Roth, and E. D. Nafziger. 2014. Multi-location corn stover harvest effects on crop yields and nutrient removal. BioEnergy Res. 7:528–539. doi:10.1007/s12155-014-9419-7.

Russell, J. R., M. R. Brasche, and A. M. Cowen. 1993. Effects of grazing allowance and system on the use of corn-crop residues by gestating beef cows. J. Anim. Sci. 71:1256–1265.

Stalker, L. A., B. G. Lorenz, N. A. Ahern, and T. J. Klopfenstein. 2013. Inclusion of forage standards with known in vivo digestibility in in vitro procedures. Livest. Sci. 151:198–202. doi:10.1016/j.livsci.2012.11.020.

Tilley, J. M. A., and R. A. Terry. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Br. Grassl. Soc. 18:104–111. doi:10.1111/j.1365-2494.1963.tb00335.x.

Tracy, B. F., and Y. Zhang. 2008. Soil compaction, corn yield response, and soil nutrient pool dynamics within an integrated crop–livestock system in Illinois. Crop Sci. 48:1211–1218. doi:10.2135/cropsci2007.07.0390.

USDA National Agricultural Statistics Service (USDA-NASS). 2014. Quick stats. http://www.nass.usda.gov/Quick_Stats/. (Accessed 15 April 2015.)

Van Soest, P. J., J. B. Robertson, and B. A. Lewis. 1991. Methods of dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583–3597.

Wagner, J. J., K. S. Lusby, J. W. Oltjen, J. Rakestraw, R. P. Wettemann, and L. E. Walters. 1988. Carcass composition in mature Hereford cows: Estimation and effect on daily metabolizable energy requirement during winter. J. Anim. Sci. 66:603–612.

Weiss, W. P. 1994. Estimation of digestibility of forages by laboratory methods. In: G. C. Fahey Jr., editor, Forage quality, evaluation, and utilization. Amer. Soc. Agron., Crop Sci. Soc. Amer., Soil Sci. Soc. Amer., Inc., Madison, WI. p. 644–681.

Wilhelm, W. W., J. M. F. Johnson, J. L. Hatfield, W. B. Voorhees, and D. R. Linden. 2004. Crop and soil productivity response to corn residue removal: A literature review. Agron. J. 96:1–17. doi:10.2134/agronj2004.0001.

Wilson, C. B., G. E. Erickson, T. J. Klopfenstein, R. J. Rasby, D. C. Adams, and I. G. Rush. 2004. A review of corn stalk grazing on animal performance and crop yield. In: 2004 Nebraska Beef Cattle Report. Rep. No. MP 80-A. Univ. of Nebraska, Lincoln. p. 13–15.