Corn Residue Removal by Grazing and Effects on Grain Yield

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Introduction

It may seem odd that this is a topic discussed at a grazing conference. However, our group at the University of Nebraska believes, based on research, that corn residue is an excellent forage resource that can be economically included in a cow-calf system as a component that can be grazed. It has been estimated that only about 25% of the corn residue is grazed in Nebraska, and use declines as you move from west to east. The amount of corn residue in the Midwest increased with the increased corn production over the years. Opportunities exist to remove the corn residue from the field for grazing with beef cattle. There continues to be questions as to whether residue removal affects corn grain yields in subsequent years. Removing the residue from the soil means that nutrients associated with residues are lost and then must be replaced with fertilization. Because yields are the most important profit indicator for a grain producer, it becomes necessary to evaluate the possible change in grain yield with residue removed either by baling or grazing. With corn residue removal, it is important to determine the amount of nutrients removed per acre from the field that may impact fertilizer rates that may need to be supplied by the next planting. Changes in land use present both challenges and opportunities for the beef industry. While increasing corn production is related to the decline in traditional forage acres, residue from corn production represents a forage resource becoming more abundant. The nutritional quality of corn residue is influenced by the proportion of plant parts consumed. Grazing cornstalks during fall/winter presents an opportunity for intensified cow-calf systems to capitalize on an economical forage resource. Designing intensified cow-calf systems that are

integrated with crop production is an opportunity for the beef industry in areas of crop production.

Effect of Grazing on Grain Yield

The University of Nebraska has research on the effect of corn residue removal by grazing on subsequent grain yield. The research locations are near Mead in eastern Nebraska and Brule in western Nebraska. There was no interaction between tillage and spring grazing observed for either soybean or corn yield over a nine-year period (1997-2006), suggesting that spring grazing had the same effect regardless of whether no-till, ridge till, or spring till was used. Across all tillage treatments, spring grazing of corn residue increased soybean yields (58.5 vs. 57.0 bu/ac for spring grazed and ungrazed, respectively) and had no effect on corn yields (210 vs. 210 bu/ac for spring grazed and ungrazed, respectively). Similarly, over a 16-year period (1997-2013), spring grazing of strips managed under no-till increased soybean yields and had no effect on corn yields (Table 1). Over a 10-year period (2003-2013), fall grazing improved soybean yields over both spring grazing and no grazing (Table 2), whereas spring grazing tended to increase soybean yields when compared to no grazing. No effects of grazing in either season were observed on corn yields.

Removal of residue did not affect corn grain yields over a five-year period (2009-2013) in continuous corn rotation (Table 3). However, it is interesting to note corn grain yields in grazing treatments were numerically increased by 4-7 bu/ac compared to ungrazed treatment. In summary, in long-term studies (16 years) at Mead, NE, grazing corn residue in fall or spring resulted in an improvement in subsequent-year soybean yields, and had no effect on corn yields

when an annual corn-soybean rotation was used. In a study (five years) at Brule, NE, continuous corn rotation or fall grazing of corn residue had no effect on corn yields.

Many crop producers have concerns about cattle trampling adversely affecting soil physical properties and subsequent crop productivity. Soil physical properties influence the ability of a plant to acquire water, nutrients, and oxygen. Although some studies have shown that cattle grazing cropland in winter/early spring can compact soils, effects of grazing are usually short-lived due to amelioration through natural processes such as wetting/drying or freezing/thawing cycles and biological action of roots or soil biota that create pores and break down compacted layers. In current studies, grazing did not cause negative impacts on crop yield, suggesting any compaction caused by cattle did not negatively impact crop growth, even when fields were managed under no-till. With high corn yield, excessive amount of residue can be produced and can have negative impacts on the subsequent crop by impeding seed placement and insulating soil such that it remains excessively cold and wet in the spring, causing poor germination and slow emergence. Grazing of corn residue can be used to manage residue levels without tillage and its resulting loss of soil structure and soil organic matter (resulting from oxidation by soil bacteria when exposed to air).

Implications

These data suggest that the grazing of corn residue at UNL-recommended stocking rates in the fall or in the spring will have no negative impact on subsequent soybean or corn yields. Thus, grazing of corn residue can be an economical source for cattle producers as well as provide extra source of income for corn producers. Further, grazing corn residue offers an alternative to tillage to manage residue levels on fields.

SARE Survey of Crop Consultants and Row Crop Producers

While crop yields, soil properties, and animal impacts due to grazing have been assessed in research studies, perceptions of consultants and producers and factors influencing producer decisions to graze or not graze corn residue are still unclear. It is estimated 25% of Nebraska's corn residue acres are currently grazed. It can only be postulated that concerns of degrading soil and associated impacts on subsequent grain yield or the limited number of cows in the area to graze the residue are reasons for the low percentage of corn residue being grazed. Even though corn residue is a potential forage source for grazing cattle, how residue is used or managed post-harvest is determined by the land owner. Therefore, our survey was developed to better understand factors influencing perceptions and behaviors of crop consultants and producers in Nebraska regarding grazing corn residue.

Crop consultants (n=234) and crop producers (n=130) in Nebraska were surveyed. The survey had 16 questions for consultants and 14 for producers. There were some similar questions across surveys to allow for comparison between responses of consultants and producers. Online-survey software was used to create, distribute, and store data for both surveys. Surveys were distributed using an electronic mailing list of crop consultants and producers developed by University of Nebraska Extension educators.

The survey return rate was 24.9% (234/940) for the consultant survey. Seventy-six percent of consultants influenced 4000+ acres, with the remaining 24% influencing less than 4,000 acres. The majority of influenced acres was either sprinkler irrigated or rain-fed, with about 50% under

no-till management. Eighty-two percent of consultants reported that they recommend clients graze corn residue with livestock.

The producer survey had a return rate of 23.9% (130/545). Forty percent of producers farmed 200-999 acres, 30.7% farmed 1000-3999 acres, and 20.2% farmed 1-199 acres, and 3.5% farmed 4000+ acres. The majority of their land was either sprinkler irrigated or rain-fed. About 80% of producers reported utilizing a no-till farming practice. About 50% reported that corn residue was grazed by their own cattle or rented for grazing, while about 40% indicated corn residue was not grazed, and 10% reported they did a combination of both grazed and not grazed (Figure 1). The response regarding grazing was also broken down into 36.9% that owned the livestock grazing their corn residue and 11.7% rented their stalks to other cattle producers for grazing.

Comparisons and frequencies were analyzed between responses indicating the perception of participants of grazing impact on yield and if they recommended or allowed grazing (Table 4). Consultants that recommended grazing corn residue and producers that allowed grazing had similar perceptions that grazing had a neutral to positive impact on subsequent grain yields. Producers that did not allow grazing were more likely to reply that grazing corn residue had no impact to a slight decrease on the subsequent corn yield (bushels per acre), while producers that allowed grazing replied that grazing corn residue had no impact or resulted in a slight increase on the subsequent corn yield (bushels per acre) (Figure 2). This difference was also present for producers' perception regarding subsequent soybean yields (Figure 3) after grazing corn residue. Research suggests that grazing has no impact or may even slightly increase corn and soybean yields. Based on the results from this survey, a portion of crop consultants and producers

perceives or observes decreased subsequent grain yields – even though the few published studies on corn residue grazing report grazing has neutral to positive impacts on subsequent grain yields.

Producers were also asked to address their practices related to corn residue rental rates (Table 5). Of the producers that currently allow grazing, about half reported not charging a rental fee, about 40% had a rental fee rate ranging from $1 to $15 per acre, and about 12% charged $16 to $25 per acre. Forty-two percent of producers that did not allow corn residue grazing indicated they would allow cattle to graze corn residue if offered $15 per acre or less, 18% would allow cattle to graze corn residue for $16 to $35 plus per acre, and the remaining 40% would not allow grazing regardless of the rental fee rate charged.

Producers' reasons for not grazing corn residue were compared between those that would allow grazing for a rental fee with those that would not allow grazing regardless of the rental fee (Table 6). The majority of respondents that would not allow grazing regardless of rental fee indicated that they felt grazing caused compaction (65%) on their field or had a negative impact on their farming practices (tillage or planting, 55%). Sixty percent of the producers that would allow grazing for a rental fee selected "other," and based on their comments, approximately 70-75% of those respondents indicated they did not have access to livestock for grazing. Three important reasons deemed by consultants for not recommending grazing included: grazing had a negative impact on farming practices, grazing reduces subsequent grain yields, and livestock producers would not pay for the worth of corn residue.

Fifty-six percent of consultants indicated they based client recommendations regarding grazing corn residue on their "own observation," while 31.6% indicated they received information from the University of Nebraska Extension (Figure 4). Producer responses to this question were similar to consultants, with 43.8% basing their decisions regarding grazing corn residue on their "own observation," followed by 22.3% basing decisions on information received from University of Nebraska Extension. For both consultants and producers, their own observation and the University of Nebraska Extension remained the first and second choice regardless of whether they recommended/allowed grazing or did not recommend/allow grazing.

Implications

The purpose of the survey conducted in this study was to gain better understanding of factors influencing perceptions, attitudes, and behaviors of crop consultants and producers on grazing corn residue. The results indicated the majority of consultants and producers had a neutral perception toward grazing impact on subsequent crop yields, and that a large portion of consultants recommended grazing. The results also indicated that producers did not allow grazing mostly because of concerns related to soil compaction, inconvenience (lack of water, fencing, and land/equipment damage) and lack of access to livestock. To our knowledge, this survey was the first to investigate factors influencing corn residue grazing recommendations of crop consultants and practices of producers in Nebraska.

SARE Corn Residue Removal on Corn Yield and Soil Attributes

Because there are many different soil types and farming practices in Nebraska and data generated from University studies are from just two locations: Mead and Brule, a USDA SARE (Sustainable Agriculture Research and Education) grant was secured to collect data at cooperator

sites across Nebraska. Study locations included Ainsworth, Norfolk, Odessa, Scottsbluff, Nebraska City, and Clay Center. At each location, there were three treatments: grazed, baled, and control (no grazing or baling). Each field was in a continuous corn rotation, except for the Nebraska City site that was in a corn-soybean rotation, and the Scottsbluff that was in a corn-soybean-beet rotation. The Nebraska City location was rain-fed, Odessa had sub-surface drip irrigation, and the other three sites were pivot irrigated. All locations were in no-till, except for the Ainsworth site, which was disked. Data for collection at continuous corn sites included hand-harvest yields of corn grain and stover. Hand-harvest was done once corn reached black layer stage of maturity.

The corn grazed areas were fenced off, and cows were stocked based on corn yield and targeted to remove 50% husk and leaf components of the corn residue. The stocking rate was determined using the University of Nebraska's corn stalk grazing calculator. The baled replications were baled following corn grain harvest by the cooperator. The bales from each replication were counted and weighed. The bales were sampled by taking a core from each bale, and core samples were composited into a bag for each replication. Residue samples were sent to Ward Laboratories for infrared spectrometry nutrient analysis.

Corn hand-harvest dates in year 1 were mid-October. Nebraska City had two fields that rotated between corn and soybeans, and soybeans were hand-harvested in 2014 and 2015 following corn residue grazing the previous year. Once soybeans reached about 13% moisture, soybeans were harvested late September.

Nutrient analysis for potassium, Ca, P, and K from Ward Laboratories analysis was used to determine pounds of N, $CaCO_3$, P_2O_5, and K_2O removed per acre. Nutrient concentration determined in corn residue sample analysis multiplied by a conversion factor (2.5 for $CaCO_3$, 1.2

for P_2O_5, and 2.29 for K_2O) provided the amount of nutrients removed from the field when baling corn residue.

There were no interactions between location and treatment for all yield and harvest index analyses, but location was significant, as expected. Despite the differences in management and weather at each location, treatment did not differ in their effects. The weather patterns and topographic and soil characteristics among locations across eastern Nebraska made each location unique. No differences were observed among treatments for corn grain yield (Table 7). Because most locations were irrigated, the effects of residue cover on soil moisture might be reduced, but the two years of collection were both wetter than previous years. The percentage ground cover by corn residue was measured in the spring following the first year. There was a difference among treatments, with grazed having 77.5% cover, baled having 45.8% cover, and control having 88.7% cover. The baled treatments had numerically higher corn grain yields than control plots, and this may be due to less nitrogen being tied up and available ground cover that enabled the ground to warm up earlier. It takes nitrogen to degrade carbon, and with less residue being recycled, a short-term bump in yields may be recorded. These data suggest there is no evidence grazing or leaving residue alone will change the grain yield. Across locations in the present study, grain yields ranged from 152 to 286 bu per acre. In addition, there was no difference in stover yield among treatments (Table 7). Stover yields ranged from 5,236 to 10,656 lb dry mass per acre across locations. Corn stover amounts were similar across treatments. There was no difference in harvest index among treatments (62.3, 61.3 and 61.0 ± 0.62% for baled, grazed, and control, respectively) reported in Table 7. The harvest index is a measure of the percentage of grain produced in a corn plant. The proportion is roughly two-thirds of the plant above-ground biomass produced. Harvest index ranged from 55.1 to 69.0% across locations.

There was no interaction between the two fields at Nebraska City and treatment applied. Soybean grain yield did not differ for baled, grazed, and control; grain yields were 59.1, 61.3, and 62.0 bushels per acre, respectively. The soybean stover produced did not differ among treatments (3,335, 3,807, and 3,452 lb dry mass per acre, respectively).

Nutrient removal by the process of baling means that nutrients will need to be replaced with fertilizer later. Nitrogen, P, K, and Ca are four major nutrients that plants need for growth. The amount of N removed by baling varied across locations, as lb of nitrogen removed per acre ranged from 10.9 to 84.1 lb. Nebraska City and Ainsworth had similar nutrient removal in 2013 and 2015, while 2014 was different for N removal.

Calcium removal, reported as $CaCO_3$, removed per acre ranged from 10.6 lb/acre in Odessa to 60.1 lb/acre in Norfolk. Norfolk, Clay Center, and Scottsbluff showed no difference between years in $CaCO_3$ removal, while Odessa had more nutrients removed (31.3 and 27.0 lb/acre) in the first two years. At the Nebraska City, more nutrients were removed in the first and third years (44.3 and 34.0 lb/acre, respectively).

Phosphorus removal, calculated as lb of P_2O_5, varied by location; amount of phosphorus removed equated to 0.75 to 8.77 lb/acre across the cooperators. All locations, except for Nebraska City, showed no difference between years in terms of the level of P removed each year. Nebraska City P_2O_5 removal was different ($P \leq 0.05$) across all three years, ranging from 0.75 to 2.93 lb removed per acre from baling.

Lastly, K_2O removal ranged among locations from 21 to 285 lb/acre. There was no difference between years at the Norfolk, Clay Center, and Scottsbluff locations ($P > 0.29$, $P > 0.31$, and $P >$

0.10, respectively). Ainsworth and Nebraska City had different amounts ($P < 0.01$) of K_2O removed across years (22.0 - 71.6 and 70.1 - 204 lbs, respectively).

The amount of nutrient removed is a function of the amount of residue removed by baling. Depending on the location of the site, management, weather and soil type, the amount of nutrients removed differed. Among the six cooperator sites over the three years of baling, the average amount of corn residue removed per acre by baling ranged from 2,845 to 5,333 pounds. This range displays how the amount of nutrients removed per acre from the field varies based on the lb of residue removed.

Nutrient removal by baling varies across the state depending on location in Nebraska. The removal of nutrients such as N, P, and K by baling leads to additional fertilizer application in the future. These nutrients will need to be replaced with inorganic or organic fertilizers for the next crop, which may lead to higher fertilizer costs. In 2014, the state received a lot of rainfall, so there is a possibility that the uptake of nutrients could be linked to rainfall amount, meaning more nutrients may be present in the corn residue due to uptake. These data demonstrate that it is important to sample bales to receive accurate nutrient analysis of corn residue bales. The results show that corn production varies with location. Overall, there was no effect of baling and grazing on grain yields, but the question becomes whether there would be yield effects in the long term, which warrants further monitoring.

Implications

A two-year study evaluating the effect of corn residue baling or grazing on subsequent yields, as well as nutrient removal by baling was conducted at five locations in Nebraska. Three treatments were applied to each field: baled, grazed, and control (no baling or no grazing). Grain and stover

yields at each field were measured by hand harvest at maturity. No differences were observed among treatments for corn yield, with baled having yields of 237 bu grain/acre, grazed with 233 bu grain/acre, and control with 220 bu grain/acre. There was no difference in stover yield among treatments (8,108, 8,252, and 7,903 lb stover/acre dry mass for baled, grazed, and control, respectively). Mean harvest index was 61.6 and did not differ among treatments. Nutrient removal by baling varied with location. Results indicate that grazing corn residue provides a potential feed resource with no negative impact on grain yield.

Table 1. Effect of grazing corn residue in the spring over a 16-year period (1997-2013) on corn and soybean yields[1] from a field managed in an annual corn-soybean rotation at Mead, Neb.

	Ungrazed	Spring Grazed	SEM[1]	P-value[2]
Corn, bu/ac	214	214	2.6	0.96
Soybean, bu/ac	57.8[b]	59.3[a]	0.54	0.03

[1]Yields are based on 13% moisture for soybeans and 15.5% moisture for corn grain.
[2]Means with differing superscripts in a row are different (P<0.05)

Table 2. Effect of grazing corn residue in the fall/winter or spring on corn and soybeans yields[1] over a 10-year period (2003-2013) from a field managed in an annual corn-soybean rotation at Mead, Neb.

	Ungrazed	Spring Grazed	Fall Grazed	SEM[1]	P-value[2]
Corn, bu/ac	207	209	211	3.9	0.55
Soybean, bu/ac	62.1[b]	63.5[b]	65.5[a]	0.54	< 0.01

[1]Yields are based on 13% moisture for soybeans and 15.5% moisture for corn grain.
[2]Means with differing superscripts in a row are different (P<0.05).

Table 3. Effect of corn residue removal on corn grain yield[1] over a five-year period *(2009-2013) from a field used for continuous corn production at Brule, Neb.

	Ungrazed	Fall Grazing 1 AUM/ac	Spring Grazing 2 AUM/ac	Baled	SEM[1]	P-value
Corn, bu/ac	148	152	155	147	6.7	0.16

[1]Yields are based on 15.5% moisture.

Figure 1. Percent of farmers grazing corn residue with their own livestock, renting corn residue to others or not grazing corn residue.

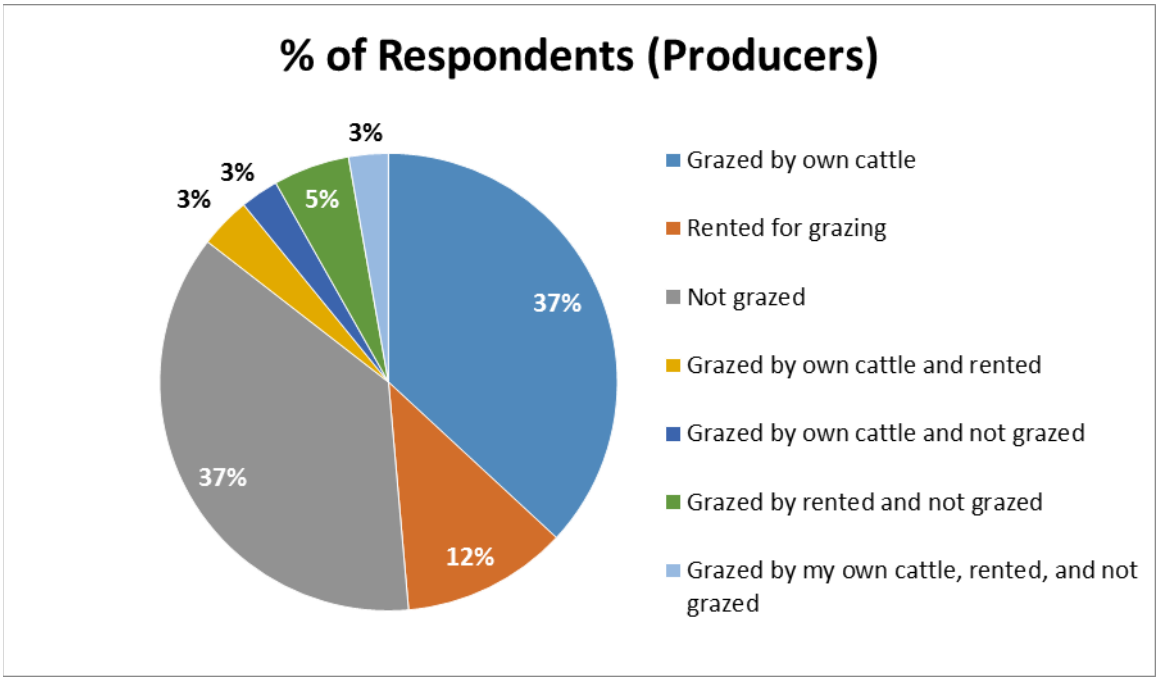

Table 4. Producers' and consultants' thoughts on how grazing corn residue impacts the yield of next year's corn and soybean crops.

How large of an impact does grazing cornstalks have on the yield of next year's corn crop?	Producer	Consultant
Decrease yield	17 (18.5%)	38 (20.7%)
No impact	46 (50.0%)	75 (40.8%)
Increase yield	29 (31.5%)	71 (38.6%)
How large of an impact does grazing cornstalks have on the yield of next year's soybean crop?	Producer	Consultant
Decrease yield	17 (19.1%)	28 (15.1%)
No impact	43 (48.3%)	89 (48.1%)
Increase yield	29 (32.6%)	68 (36.8%)

Table 5. Comparisons between producers that currently allow grazing and currently do not allow grazing and their perceptions on grazing rental rates.

Grazing Rental Fee[1]	Currently Allow (n=43), %	Currently Do Not Allow (n-50), %
Free	48.8	14.0
$1 to $15 per acre	39.5	28.0
$16 to $25 per acre	11.7	8.8
$26 to $35 per acre	0.0	4.0
> $35 per acre	0.0	6.0
Would not allow grazing regardless the rental fee	--	40.0

[1]What rental fee do you charge (currently allow) vs. what rental fee would you need (do not allow) for cattle to graze corn residue.

Figure 2. Producers that allowed grazing versus producers that didn't allow grazing and their thoughts on how grazing corn residue impacts the following year's corn crop yield (bu/acre).

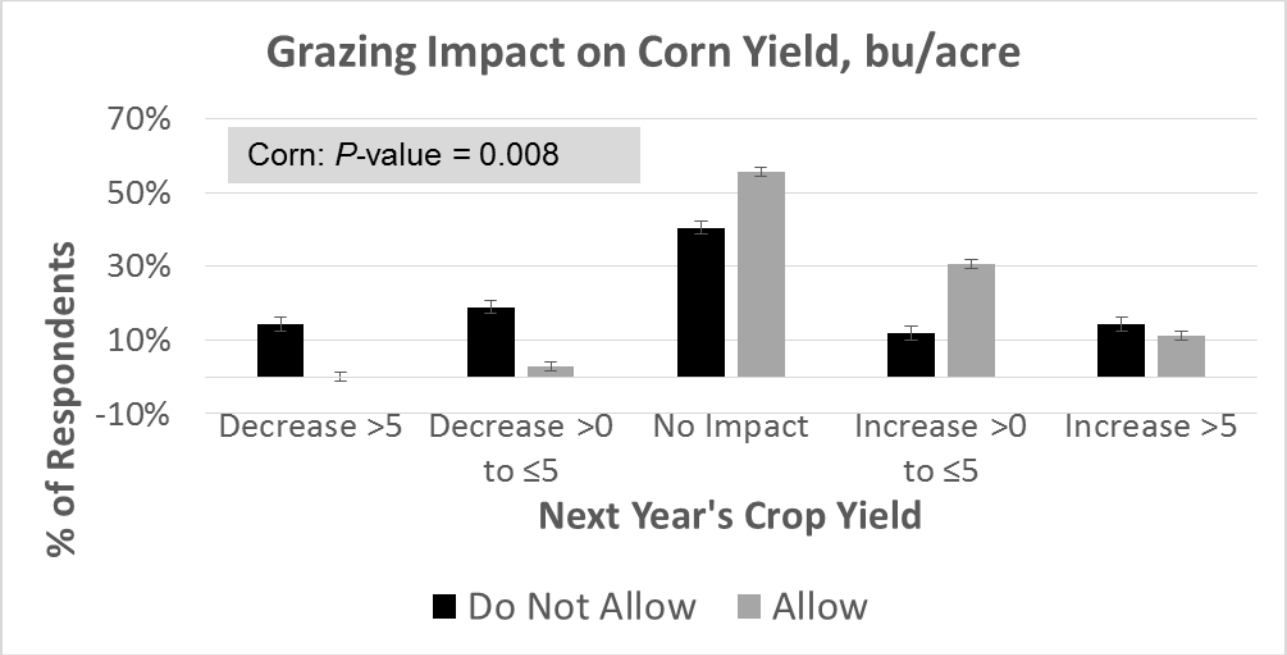

Figure 3. Producers that allowed grazing versus producers that didn't allow grazing and their thoughts on how grazing corn residue impacts the following year's soybean crop yield (bu/acre).

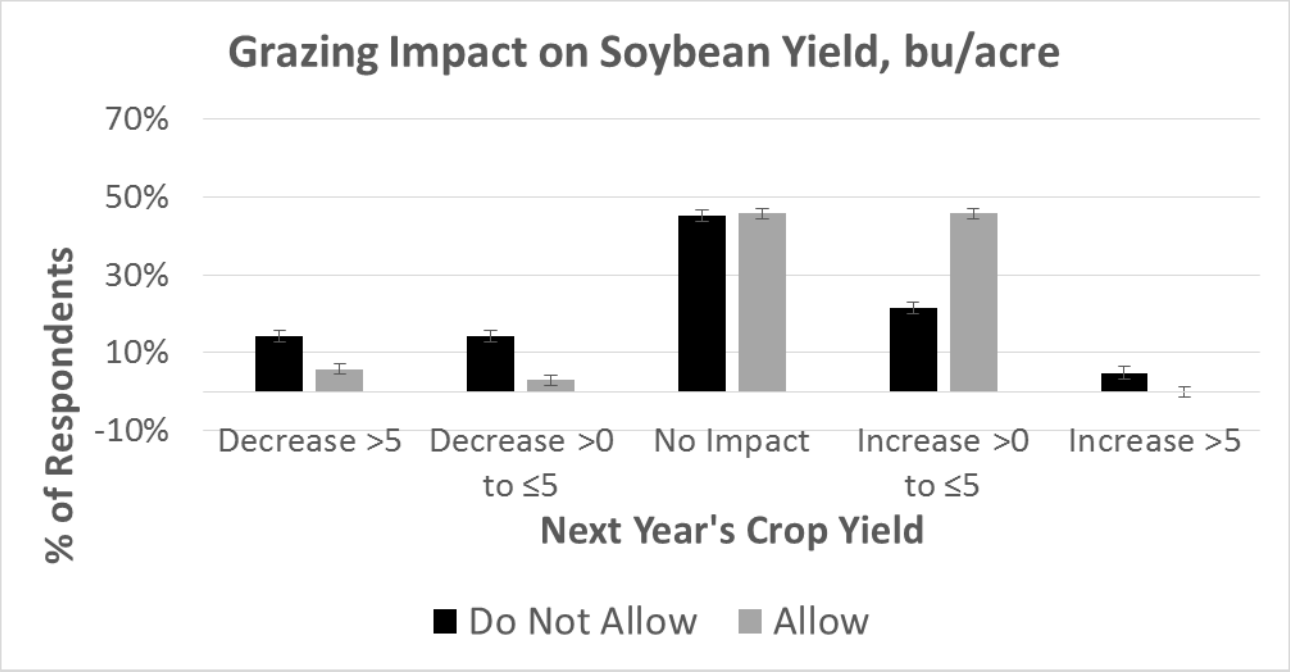

Table 6. Comparisons between producers who currently do not graze but would consider grazing for a fee and those that would not consider grazing regardless of the rental fee.

What are the reasons your corn residue is not grazed?[1]	Do not Allow, but would Rent for a Fee (n=30), %	Do not Allow Regardless of Rental Fee (n=20), %
Reduces subsequent year's crop yields	0.0	10.0
Negative impact on farming practice	10.0	55.0
Lack of water for livestock	26.7	40.0
Lack of fencing	10.0	30.0
Livestock producers will not pay for worth of stalks	30.0	25.0
Interferes with fall field work	23.3	25.0
Causes compaction	20.0	65.0
Other	60.0	30.0

[1]The question was a "select all that apply," so percentages will be over 100%.

Table 7. Two years of corn yield and harvest index data from four locations across eastern Nebraska.

	Treatment[1]				
Item	Grazed	Baled	Control	SEM[1]	*P*-value
Corn grain yield, bu/acre[2]	239	234	223	5.09	0.18
Corn stover yield, lbs DM/acre[2]	8,135	8,326	7,945	218	0.59
Harvest Index, %[3]	62.3	61.3	61.0	0.62	0.44
Soybean grain yield, bu/acre[4]	59.1	61.3	62.0	3.46	0.83

[1]SEM = Pooled standard error mean for response variable
[2]Corn grain and stover yield are measures from 4 cooperator sites: Ainsworth, Clay Center, Norfolk, Odessa
[3]Harvest index is the measure of the percentage of corn grain to total biomass (grain + stover).

Figure 4. Where Survey Respondents Received Information.