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Grazing Crop Residues with Beef Cattle

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Definition of terms:
ADG: Average Daily Gain
AFO: Animal Feeding Operation
AUM: Animal Unit Month
CP: Crude Protein
IVDMD: *In vitro* dry matter digestibility
DEQ: Department of Environmental Quality
TDN: Total digestible nutrients

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A major cost for beef cow-calf and backgrounding operations is feeding harvested forages that are stored and fed in the late fall and winter months. This is even more of an issue during drought conditions when feed resources are limited and often expensive. To lower feed costs, many producers attempt to extend the grazing season by using crop residues. Nebraska has an abundance of crop residue available for late fall and winter grazing.

Although corn crop residue grazing is effective in reducing feed costs, some producers are concerned that grazing and, therefore, residue removal and compaction will have a negative effect on subsequent grain yields. There are some corn residue fields that should not be grazed by livestock due to topography/landscape and/or corn grain yield, but there are very few of those fields in Nebraska. Another concern is animal performance from grazing residue that has been genetically enhanced. Residue grazing is an important management practice for many cattle operations as either a winter feed resource for maintaining the breeding herd or putting weight on cull cows. Spring-born calves weaned in the fall can also be wintered on corn residue if appropriate strategies for supplementation are used to achieve targeted gains.

Nutritional Content of Corn, Milo, and Soybean Residues

Crude protein (CP) and *in-vitro* dry matter digestibility (IVDMD) content of different residues are shown in *Table 1*. IVDMD, an estimate of digestibility of a feed or forage (the higher the digestibility, the greater the energy content of a feed), is closely related to total digestible nutrients (TDN). The terms IVDMD and TDN will be used interchangeably in this Extension Circular.

The corn cob and stalk are lowest in protein and palatability. The leaf and husk are intermediate in nutrient quality as indicated by the percent IVDMD, but high in palatability. The grain is highest in nutrient quality (*Table 1*). Nutrient quality of residue in a corn field varies between irrigated or rainfed (dryland) fields (*Table 2*). In rainfed corn fields, the grain, husk and leaf, cob, and stalk are generally equal to or greater in protein and energy content compared to residue components in irrigated corn fields. Although the proportions of husk and leaf and stalk differ between rainfed and irrigated corn fields, the overall nutrient content per ton of dryland corn residue is expected to be slightly greater. More total pounds of residue is left in an irrigated corn field after harvest. Research indicates about two times more residue is left in irrigated fields (over 9,000 lb/acre) compared to rainfed fields (5,000 lb/acre) because corn grain yield is typically greater in irrigated fields. The amount of residual grain left in the field after harvest varies depending on factors such as harvest date, lodging due to insects and disease, and harvest efficiency. Low amounts of ear drop in corn fields is more common today due to genetic advances that result in stronger stalks, and technical advances in combines that do a better job of harvesting the corn grain.

Many of the nutrient quality aspects described for corn also can be applied to grain sorghum stubble; however, there are at least two differences (*Table 1*):

- The grain sorghum leaf is generally higher in protein than a corn leaf.

Table 1. Average percentage composition of harvested crop residues — dry matter basis

	Percent crude protein			Percent IVDMD[a]	
	Percent dry matter	Range	Average	Range	Average
Corn					
Grain	73	9.5-11.2	10.2	88-95	90
Leaf	76	6.2-7.8	6.5	43-48	46
Husk	55	3.0-4.0	3.5	57-64	61
Cob	58	2.1-3.8	2.8	32-38	35
Stalk	31	3.4-4.9	4.1	43-50	45
Milo					
Grain	74	10.3-11.0	10.5	85-95	90
Leaf	66	6.0-11.0	8.0	51-59	56
Stalk	25	3.3-3.9	3.6	49-53	52
Soybean residue					
Leaf	87	11.0-13.1	12.0	50-56	53
Stem	88	3.6-4.5	4.0	33-36	35
Pod	88	4.5-9.0	6.1	45-51	48
Soybean	89	49.0-52.0	50.5	91-94	92

[a]IVDMD = *In vitro* dry matter digestibility. IVDMD is approximately equal to TDN (total digestible nutrients).

Table 2. Proportions and quality of residue in irrigated and dryland field corn residue

Item	Irrigated			Dryland (Rainfed)		
	Proportion percent	CP[a] percent	IVDMD[b] percent	Proportion percent	CP[a] percent	IVDMD[b] percent
Grain	4.0	9.6	91.4	4.0	12.8	90.8
Leaf and husk	45.0	3.7	51.6	51.0	6.4	49.7
Stalk	40.0	3.0	42.6	33.0	5.9	47.8
Cob	11.0	2.6	33.6	12.0	4.6	36.2

[a]CP = Percent crude protein
[b]IVDMD = *In vitro* dry matter digestibility

- Sorghum grain is not utilized as well as corn grain. The sorghum berry's hard outer coat makes it more difficult for the animal to digest. However, cattle can founder in grain sorghum fields that have excessive amounts of grain left after harvest, indicating there is some utilization even though the berry is not mechanically processed.

The TDN content of the soybean leaf, pod, and stalk are low (35-52 percent, *Table 1*). The low energy content for soybean residue is due to the high lignin content, especially in the stalk. Lignin is the indigestible cell wall component of the plant.

Research has shown that over time the nutrient content of crop residue fields does slightly decrease due to weathering. The greatest nutrient loss is energy content in the husk and leaves. Also, nutrient losses are greater in wet, humid conditions due to increased decomposition and weathering. Nutrient losses can result from trampling or cattle activity in wet, muddy field conditions.

Grazing Characteristics of Crop Residues

When grazing residue, cattle will select and eat the grain first, followed by the husk and leaf and finally the cob and stalk. Because of this selection process, the cornstalk residue diet consumed could be very high in energy content (70 percent TDN) at first when there are ears of corn in the field to select, then low (45 percent TDN) at the end of grazing. Also, as the stocking rate (number of cattle per acre) increases, the nutrient content of the residue remaining for consumption declines more rapidly since the grain, husk, and leaves are being removed or trampled at a faster rate.

Cows grazing corn residue or grain sorghum stubble will consume 25-50 percent of the available residue in 30-100 days (depending on stocking density/stocking rate), leaving enough material to prevent soil erosion. In the Midwest, weather records indicate the range in number of continuous grazing days for crop residue is between 65 and 111 days.

Weather can be the most important factor in successfully grazing crop residue. For example, snow and/or ice cover can reduce or eliminate access, and mud makes grazing difficult and results in decreased animal performance and forage waste. During years of heavy snow accumulation, grain sorghum stubble provides better grazing opportunities than cornstalks. The grain sorghum head is cut off near the top of the plant during harvest, leaving more standing forage in the form of leaves above the accumulated snow. However, delayed frost, unseasonably warm temperatures, and moisture allow grain sorghum plants to remain green or develop new growth after harvest. *This new green growth, commonly referred to as "suckers," is usually high in toxic compound called prussic acid.* If "sucker" growth occurs, cattle should not graze the stubble until at least seven days following a hard freeze.

Determining Stocking Rate of Crop Residues

Stocking rate influences the amount of grain, husk, and leaf available per animal. The amount of grain, husk, and leaf available affect diet quality because all are highly digestible. The rate of decline in the most digestible components of a corn residue field are affected by stocking rate, trampling, the amount of residue components available, and environmental factors (*Figure 1*). Comparisons have shown that gains increase as stocking rate decreases.

Residue (leaf and husk) remaining in the field after grain harvest is related to grain yield. There are some differences in the amount of residue depending on hybrids planted. *Table 3* illustrates the percentage of the corn plant that is each of its component parts. The stalk (top 1/3 + bottom 2/3) is about 45 percent of the total corn plant. Leaf, leaf sheath, husk, and shank are about 40 percent of the total corn plant. On a bushel of corn basis, the stalk is 15.3 lb/bu of corn, and husk and leaf components are 13.4 lb/bu of corn. In another study it was determined that the relationship for pounds of leaf and husk per acre on a dry matter basis = ([bu/acre corn yield x 38.2] + 429) x 0.39. For corn there will be

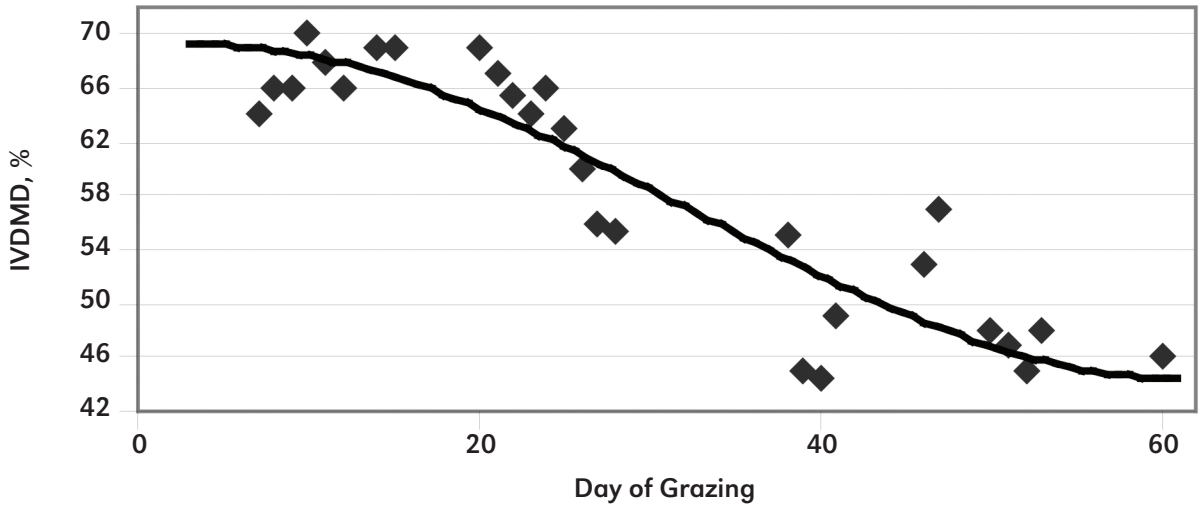

Figure 1. *In vitro* dry matter disappearance (IVDMD) of the roughage fraction of diets selected by esopohageally fistulated calves grazing cornstalks

between 13 lb and 16 lb leaf and husk, on a dry matter basis, per bushel of corn. Data from these two independent studies allow us to be confident about the pounds of husk and leaf, on a dry matter basis, per bushel of corn harvested. Using 16 lb of husk and leaf components per bushel of corn and using the estimate of 50 percent utilization of the leaf and husk and understanding that some residue disappears by trampling and other factors, grazing days/stocking rate can be determined. As an example, if corn yield is 180 bu/acre, this yield produces 2,880 lb (180 bu/acre x 16 lb of husk and leaf per bushel) of leaf and husk per acre on a dry matter basis and 1,440 lb (50 percent of the total 2,880 lb) of husk and leaf components on a dry matter basis available for cattle to consume. This is equivalent to about 2.0 AUM (1,440 lb of husk and leaf per acre at 50 percent use/702 lb of feed per AUM). One Animal Unit Month (AUM) is the amount of forage required to sustain a 1,000 lb cow or equivalent for one month, and it has been determined that a 1,000 lb cow will consume 702 lb of dry matter monthly. A 1,200 lb cow is 1.2 AU and would consume 842 lb (702 lb x 1.2 AU) of forage dry matter per month. If the corn yield was 180 bu/acre and produces 2,880 lb of husk and leaf per acre on a dry matter basis and 50 percent of the husk and leaf are consumed, this residue field would provide 1.7 AUM (1,440 lb of husk and leaf on a dry matter basis per acre/842 lb of forage per month for a 1,200 lb cow = 1.7 AUM) per acre for a 1,200 lb cow or 51 days of grazing (30 days per month x 1.7 AUM = 51 days of grazing). If one acre of corn that yielded 180 bu/acre supplies enough husk and leaf to feed a 1,200 lb cow for 51 days then this field would supply enough husk and leaves to feed a 600 lb calf for 102 days. Higher grain yields provide more AUMs and lower yields fewer AUMs. A cornstalk grazing calculator (Excel Spreadsheet and Cow-Q-Lations app) can be found at *http://beef.unl.edu* on the page titled "Learning Modules, Apps, and Webinars."

Table 3. Plant part IVDMD, % of total plant DM, and lb DM/bu grain

Plant part	IVDMD	% of Plant DM	lb/bu[1]
Top 1/3 stalk	37.57%	3.60%	1.21
Bottom 2/3 stalk	33.85%	41.83%	14.12
Leaf	45.70%	18.72%	6.30
Leaf sheath	38.56%	12.60%	4.23
Husk	59.03%	7.48%	2.51
Shank	49.75%	1.09%	.37
Cob	34.94%	14.68%	4.93

[1]15.5 percent moisture corn grain

Grazing Strategies

Do not force cattle to eat the cobs and stalks. Producers who graze livestock on crop residue should have an emergency feed supply, such as hay or silage, for use during severe weather. Snow cover up to 5 inches will probably not reduce grazing. Do not be in a hurry to provide supplemental feed during times of snow cover as cattle can become conditioned to supplemental feed and seem to have less interest in grazing. The concern about weather conditions is when freezing rain is followed by extended periods of cold temperatures that cause the residue to be coated with ice and remain stuck to the ground, making it difficult for cattle to eat the residue. If these conditions exist, cattle will need to be fed supplemental feeds or removed from the field and be fed.

Strip grazing (fencing off portions of a residue field) or moving cattle from field to field provides a more uniform nutrient intake. Daily gains of cattle are greater when fields are stripped grazed versus whole-field grazing. However, if residue fields are strip-grazed and there are extended periods of deep snow and icy conditions, some of the best feed may be left ungrazed.

Whole-field grazing is the most common grazing strategy. Whole-field grazing has the potential to allow cattle to consume the best feed (grain, leaf, and husk) prior to possible snowfall or muddy conditions. Whole-field grazing should allow cows to put on weight during the early phase, with weight being maintained in the latter part of the grazing season. To keep thin cows gaining weight while grazing crop residue and not supplementing protein and/or energy, move cows to a fresh field frequently, allowing them to consume "fresh" husk and leaf material.

If allowed access to both cornstalks and soybean stubble, cows will graze soybean stubble, consuming the pods or beans left on the ground. Again, because of the high lignin content of the soybean stem, there is little energy in this portion.

Supplementation Strategies for Cattle Grazing Corn Residues

As long as cattle have access to all components of a corn residue field, and stocking rates and grazing days are calculated as previously described, cattle will select a diet that is on average 5.5 percent crude protein and 55 percent TDN. Ordinarily, dry, gestating cows will maintain body weight and may gain .5-1 lb/head daily on corn and grain sorghum residue grazing programs when some grain, husks, and leaves are available. Mature cows that begin the corn residue grazing period in a body condition score of 5 (to learn more about body condition scoring see EC281 *Body Condition Scoring Beef Cows: A Tool for Managing the Nutrition Program for Beef Herds* or the NUBeef-BCS app found in the Apple App iStore and Google Play) or greater and grazing at our recommended stocking rate will at least maintain body condition. First-calf heifers in late gestation grazing corn residue that contains no grain will need protein supplementation and, as grazing days increase, will also need energy supplementation. Lactating beef females will need both protein and energy supplementation while grazing corn residue fields to maintain body condition. For calves grazing crop residues, energy and protein will need to be supplemented to achieve daily gains of more than 1 pound.

If a protein supplement is fed to breeding livestock, the supplement will need to contain degraded intake protein (DIP). This protein supplement could contain some non-protein nitrogen (NPN), but it is recommended that 10 percent or less of the protein in the supplement comes from an NPN source. When supplementing cattle, it is essential that all animals get their share. Feeding the protein source every other day or every third day means larger quantities are fed and, in theory, timid and young cows are more likely to get their share compared to daily feedings.

Salt, mineral, and vitamin A supplements are recommended for cattle grazing crop residues. The supplemental mineral profile will change depending on the type of supplement fed. For instance, cows grazing corn residue alone will need to have phosphorus supplemented but if distillers grain is used to provide protein and energy, no additional phosphorus maybe needed.

Gestating Spring Calving Cows: Nutrient (protein, energy, mineral, and vitamin) requirements for beef females increase as their stage of production proceeds from mid-gestation to calving. Spring-calving cows typically will have their calves weaned in October or November and will not be lactating while grazing crop residue. If mature cows are in body condition score of 5 or greater, and grazing days are calculated per the example previously described, cows will not need supplementation other than salt and a mineral/vitamin supplement.

If mature, gestating cows are thin at the time they begin grazing crop residues, they will respond to protein supplementation. Begin by supplementing 1 lb/head/day of a supplement that is 25-32 percent crude protein. Because corn milling byproducts are high in protein and energy, consider distillers-grains-based supplements if priced economically. The "eye of the manager" is critical when managing thin cows grazing crop residues, and supplementation strategies may need to be modified to get spring calving cows in a body condition score of at least 5 by calving.

Gestating, Spring Calving, First-Calf Heifers: For the first-calf-heifer, the pounds of crude protein and TDN needed on a daily basis increase from mid-gestation to late-gestation. If average weight of the heifers is 1,000 lb at their first calving, they will eat about 22 lb of feed daily on a dry matter basis of corn residue. Percent of the ration needing to be crude protein is 7.5 percent (1.7 lb daily) and 10.0 percent (2.2 lb daily) for first-calf heifers in mid- and late-gestation. Likewise, the percent of the ration that needs to be TDN is 52 percent (11.4 lb daily) and 61 percent (13.4 lb daily) in mid- and late-gestation. The reason for the higher percentage of nutrients required by first-calf heifers compared to cows is that first-calf heifers weigh less; therefore, the amount of feed consumed daily is less. In addition, first-calf heifers not only have a nutrient requirement for the growing fetus, they also have a nutrient requirement for their own growth. Diet quality and nutrient density of the diet is important because research data indicate that feed intake decreases by 17 percent in heifers as they approach their first calving and doesn't return to pre-calving intake until about three weeks post-calving. Rumen capacity is likely reduced because of the growing fetus.

Mid-gestating, first-calf heifers will need protein supplementation while grazing corn residue. Heifers at this stage of production will be about 0.5 lb of protein/head/day deficient. As an example, heifers would need to be fed 1.7 lb/head/day of a 32 percent protein supplement that was 90 percent dry matter ((0.5 lb /.32)/0.90 = 1.7 lb/head/day "as-fed"). Late gestating heifers will be 0.9 lb/head/day deficient in protein and 1.3 lb/head/day deficient in TDN (energy). As an example, heifers would need to be fed 3.1 lb/head/day "as-fed" of a feed that was 32 percent crude protein, 88 percent TDN, and 90 percent dry matter.

Fall Calving Cow: Fall-calving cows can use corn residue for fall-winter grazing. If the amount of ear drop is low, one management option may be to early wean fall calves at 90-120 days of age. Weaning calves would reduce nutrient needs of the cow, and high quality feeds could be fed to the calf directly. The cow can be maintained on crop residue without supplementation besides salt and a mineral/vitamin supplement.

Another option would be to supplement fall calving, lactating cows while grazing cornstalk residue. Fall calving cows with a suckling calf will lose weight and body condition while grazing corn residues unless supplemental protein and energy is provided. It is not recommended for cows to lose weight and body condition prior to or during the breeding season. Pay close attention to first-calf heifers as their nutrient needs are high and will lose the most weight if not supplemented. Corn byproducts are excellent supplements because they are high in protein, energy, and phosphorus, and lactating cows grazing corn residue are likely to be deficient in protein, energy, and phosphorus. A grazing strategy for fall calving, lactating cows is to allow them access to the highest quality diet while grazing corn residue by rotating them to a new stalk field every 40 to 50 days, depending on corn yield. However, even with this grazing strategy, lactating cows grazing corn residue will need to be supplemented with protein and energy.

Lactating, fall-calving cows with an average weight of 1,200 lb and producing 18-20 lb of milk daily would eat about 27 lb of dry matter and need a diet that is about 10 percent protein (2.7 lb/head/day) and 60 percent TDN (16.2 lb/head/day) for the first three months after calving. Using recommended stocking rate and grazing days based on corn grain yield at harvest, cows will select a diet that on average is 5.5 percent crude protein and 55 percent TDN. As an example, lactating cows that are one to three months after calving will need to be supplemented 4.5 lb/head/day "as-fed" of a supplement that is 30 percent crude protein, 90 percent TDN, and 90 percent dry matter. This amount of supplement should be fed daily. Four to six months after calving, this lactating cow will need a diet that is on the average 8.5 percent (2.3 lb/head/day) crude protein and 56.5 percent TDN (15.2 lb/head/day). These cows grazing corn residue will be 0.8 lb/head/day deficient in protein and 0.3 lb/head/day deficient in TDN. As an example, lactating cows that are four to six months post-calving will need to be supplemented 3.0 lb/head/day "as-fed" of a supplement that is 30 percent crude protein, 88 percent TDN, and 90 percent dry matter. In this scenario, consider feeding 6.0 lb/head every other day. When supplementing cows that are nursing a calf, as the calf gets older (2 to 3 months of age), they also will eat the supplement. The amount of supplement delivered may need to increase 0.5 to 1.0 lb/head/day to compensate for the supplement consumed by the calf. Grazing corn residue and supplementation strategies for fall calving, lactating cows will require intensive management.

Other management options for lactating cows grazing corn residue:

- Supplement protein and energy until the end of the breeding season and then not supplement and let cows lose weight and body condition, assuming cows will gain back body condition after the calf is weaned and while grazing high quality spring/summer grass, and be at a minimum of body condition of 5 by calving.
- Supplement lactating cows until the breeding season is over, then wean the calf and not supplement the cow and feed the weaned calf directly.
- Wean the calf at 90 days of age and feed the calf directly and not supplement the cow.

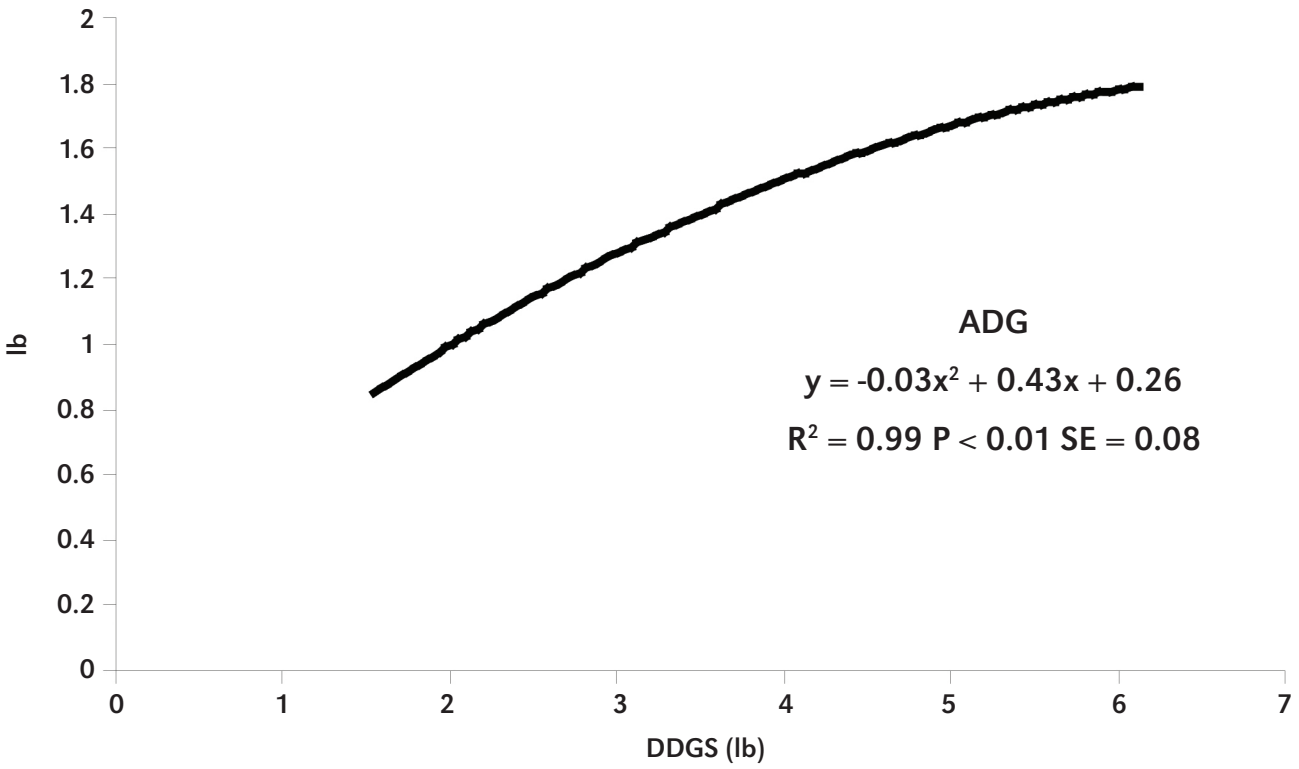

Figure 2. Average daily gain (lb) of calves supplemented dried distillers grains plus solubles while grazing cornstalk residue

Calves: Forage bulkiness of crop residues will cause lower performance for young cattle, as their rumen capacity per unit of body weight is less than that of mature cows. Supplementation is necessary for calves grazing cornstalks to gain 1.0 lb/day. This may be adequate if a producer is wintering calves for low rates of gain and plans to summer them on grass. Research indicates that greater rates of gain while grazing corn residue are more economical than supplementation while grazing summer grass. Supplementing the calf with energy and protein will support higher gains. Data indicate that the supplement should have at least 0.36 lb of escape protein (undegradable intake protein, UIP, or bypass protein) per head per day to get weight gains with calves. Total protein supplementation may need to be as high as 0.9 lb/day depending on the targeted ADG (Average Daily Gain) desired. *Figure 2* illustrates the effect of supplementation of calves grazing cornstalk residue. As supplementation of dry distillers grains increased, performance (ADG) increased. Calves gain about 1.5 lb/day when supplemented between 3-5 lb of dried distillers grains per head per day. Steers calves weaned in the fall supplemented with 5.0-6.0 lb/head/day of corn gluten feed while grazing cornstalks will gain between 1.5-1.9 lb/head/day. Using these data, calves grazing corn residue can be program fed to a targeted ADG.

Corn milling byproducts (i.e., corn gluten feed and distillers grains) can be used as the supplement or the basis of the supplement. Corn byproducts from the ethanol industry are excellent sources of protein (18-30 percent), phosphorus (0.8-1.0 percent), and energy (110-125 percent energy value of corn grain). Corn milling byproducts could be used as a protein and/or energy supplement for calves grazing crop residues. Distillers grains are also a good source of bypass protein (65 percent bypass or undegraded intake protein, UIP). If corn milling byproducts are used as a supplement, phosphorus supplementation is not necessary. Minerals and vitamins can be offered "free choice." If distillers grains or corn gluten feed are fed, calcium (i.e., limestone) will likely need to be supplemented because these feeds are high phosphorus, and calcium supplementation will reduce the likelihood of urinary calculi in male calves.

Milo Stubble Supplementation

On average, the energy and protein in the leaves of milo stubble appear adequate for cows in mid- to late gestation, but not for heifers in late gestation (*Table 1*). Monitor body condition of mature, gestating cows grazing milo stubble. If they appear to be losing condition, supplement protein. Based on book values, cows are about 0.45 lb deficient in protein and need to be supplemented similar to that described above. Remember, because of the milo berry's hard outer coat, it is not utilized as well as corn grain by the cow, but cows can

still experience acidosis (founder in milo fields that have excess milo heads left in the field after harvest).

Estimating Ear Drop

Estimating the amount of corn left in a field helps producers determine a grazing strategy. An 8-inch ear of corn contains about 0.50 lb of corn grain; therefore, 112 8-inch ears would equal 1 bushel (1 bushel = 56 pounds). By counting the number of ears, the amount of corn can be estimated. If corn is planted in 30-inch rows, count the number of ears in three different 100-foot furrow strips and divide by two to give an approximate number of bushels per acre. Small ears and broken ears should be counted as half ears, while very large ears could be counted as an ear and a half. Any amount beyond 8-10 bu/acre will require a well-planned grazing strategy to ensure that too much grain is not consumed.

Estimating Milo Head Drop

Because of the hard outer coat, the grain in a milo stubble field is not well digested by cattle, yet when there are large amounts of grain available, founder can occur. One milo head has about 0.12 lb of grain, and about 466 milo heads would equal 1 bushel of milo (1 bushel = 56 pounds). As fields approach 10 bushels left in the field, producers need to implement well-planned grazing strategies to avoid founder.

Grazing Strategies for Corn Residue Fields with Excess Grain

Excess grain (more than 8-12 bushels per acre) left in the field can cause both acidosis and founder in cattle. Founder, an abnormal hoof growth condition, results from excessive grain intake which causes an increase in rumen acid production. In severe cases of acidosis, the result is long toe or hoof growth and severe lameness. While hand-picking corn would be the most effective solution, it may not be realistic for producers.

Strategies for using high-grain corn residue fields include:

- graze yearling cattle or calves first, then follow with cows;
- graze cull cows destined for slaughter first, then follow with the main herd;
- short-term graze (only a few hours per day);
- increase the stocking rate to reduce grain intake per animal;
- divide the field into strips with power fence using polywire and fiberglass posts, forcing cows to consume some husks and leaves along with the ears of corn, thus reducing the potential of founder.

The experience level of the cattle grazing a corn residue field determines how efficiently they will glean a field for grain. Old cows with previous experience in corn residue fields can consume amazingly high amounts of corn, as can experienced yearling cattle, so inexperienced calves may have the least risk of founder or acidosis in high-grain corn residue fields because they must first learn how to find corn so their grain intake increases gradually. Finally, in corn residue fields that have excess ear drop, it may be beneficial to fill cows up with forage before allowing them access to the stalks. This will limit their corn intake and may help reduce founder or acidosis.

Grazing Crop Residue and Effect on Subsequent Grain Yield

Experiments have been designed to evaluate the effect of fall/winter grazing of crop residues on subsequent grain production. Data from experiments conducted in Nebraska indicate that fall and winter grazing has no effects on crop yields compared to ungrazed areas. Neither corn nor soybean yields were adversely affected following grazing. Residue cover after grazing is less compared to ungrazed plots. In no-till cropping systems, additional tillage was not required following fall and winter grazing. In a ridge-till system, grazing cornstalks did not adversely affect the integrity of the ridges, but soil bulk density in the top (0-3 inches) depth was increased in the inter-row following grazing under muddy conditions. Other measurements showed soil bulk density may increase in cattle paths following grazing. Spring grazing indicated a slight decrease in water infiltration rate compared to ungrazed areas. Spring grazing of stalks also showed a decrease in residue cover. However, in long-term experiments (*Table 4*: 16 years; *Table 5*: 10 years; *Table 6*: 5 years) analyzing the effect of residue removal by grazing, there was no negative effect on soybean or corn yields.

Time of Grazing and Crop Yield

Experiments were conducted during the fall and winter to evaluate performance of calves grazing corn residue on conventional and ridge-till fields. In these crop residue grazing experiments, calf stocking rate was 1.2 head/acre for a 60 day grazing period from December to February. To determine impact of grazing, subsequent grain yields were measured by machine harvest the following fall from grazed and ungrazed areas of each tillage method. The three-year yield averages for ridge-till and conventional systems show no difference between treatments.

Table 4. 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	*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 percent moisture for soybeans and 15.5 percent moisture for corn grain.
[2]Means with differing superscripts in a row are different ($P < 0.05$).

Table 5. Effect of grazing corn residue in the fall/winter or spring on corn and soybean 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	*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 percent moisture for soybeans and 15.5 percent moisture for corn grain.
[2]Means with differing superscripts in a row are different ($P < 0.05$).

Table 6. 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	Light fall grazing (1 AUM/ac)	Heavy fall grazing (2 AUM/ac)	Baled	SEM	*P*-value
Corn, bu/ac	148	152	155	147	6.7	0.16

[1]Yields are based on 15.5 percent moisture.

Because no differences were observed due to winter grazing, an additional spring grazing treatment was evaluated to determine the impact on subsequent crop yield (*Table 4*). Crop production was based on an annual corn-soybean rotation with one-half of the field planted to each crop. Tillage treatments included ridge-tilling during the summer, no-tillage, and fall tillage followed by conventional tillage (disk) in the spring, or spring conventional tillage alone. All tillage treatments were conducted during the corn rotation with no tillage following the soybean crop. The stocking rate was based on average stocking rates to optimize animal performance. Soybean yields showed no difference between grazed and ungrazed treatments. Spring and fall tillage treatments had no effect on soybean yield when compared to the no-till treatments. Corn yield, two years after the grazing treatment, showed no differences due to spring grazing or tillage treatments. Overall grazing improved soybean yields over ungrazed treatments and included significant improvement in yield in no-till grazed over no-till ungrazed treatments. Spring and fall tillage had no effect on soybean yield when compared to no-till treatments. There was no effect on corn yields the second year after grazing when compared to the ungrazed treatments.

Careful strategies should be considered when grazing crop residues in March and April due to the possibility of mud. In our research, no negative impacts were observed when grazing cattle on crop residues in "normal" spring conditions.

Grazing Genetically Modified Corn

Concerns with changes in animal performance due to genetically modified corn residues also have been evaluated. Steer calves grazing four different fields of corn residue (Bt corn rootworm protected, non-Bt, RR (Roundup Ready), and non-RR) stocked at equal stocking density (1.06 acre/steer/60 days) were used to evaluate genetic enhancement on animal performance. Steer performance was not different between Bt corn-rootworm protected or RR hybrids and their parental controls following the 60 day grazing period. The animal performance demonstrates feeding value of corn residue does not differ between genetically enhanced corn hybrids and their non-genetically enhanced parent hybrid. Similar research showed no difference in steer performance due to the incorporation of the Bt trait for corn borer protection. There also is no preference between Bt and non-Bt hybrids. During the

grazing period, 47.5 percent of the steers were observed grazing Bt residue, and 52.5 percent of the steers were observed grazing non-Bt residue.

To determine the effects of grazing crop residues for Bt-corn hybrids on performance of pregnant beef cows, one non-Bt corn hybrid and three Bt corn hybrids were compared. Rates of change in the concentrations of digestible dry matter and CP over winter were not significantly affected by 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 (3,199 vs 825 lb/DM/cow) but did not differ between corn hybrids.

The data from these experiments suggest genetic enhancement of corn has no effect on corn residue use by grazing beef cattle. Producers can take advantage of increased yields and reduced herbicide/pesticide use with Bt corn rootworm protected or RR hybrids without adverse effects on corn residue grazing performance.

What Are Crop Residues Worth?

There are several ways to assign a value to crop residue. The owner of the corn field can consider what is being sacrificed — the nutrients and organic matter removed from the field, the cost of waiting to begin post-harvest field operations and scattering weed seeds. On the other hand, pasturing cornstalks can reduce volunteer corn problems the next year and eliminate the need to shred stalks, and almost all nutrients are returned to the soil in the manure. The user of the cornstalk field may have feed savings and additional weight gains from utilizing the field, but may incur additional costs in moving the livestock and providing water and fencing.

Several of the advantages and disadvantages of pasturing crop residue are difficult to value. A crop owner may think that when cattle are grazing a cornstalk field that nutrients are being removed. If cows maintain weight while grazing a stalk field, by definition no nutrients are lost. Cows grazing a corn residue field eat about 20 percent of the residue and digest about half, so about 10-12 percent of the organic matter is potentially lost. There is some weathering and residue lost to wind. With this in mind it can be assumed that essentially little to no organic matter losses should be attributed to cows grazing the residue. This concept is supported by many years of corn residue grazing and measuring subsequent corn yield and finding no difference between grazed and ungrazed fields. If calves graze cornstalk residue and are supplemented, more nutrients may be added to the field than removed.

The feed value of crop residue can be estimated based on daily consumption and price of feed saved, which is usually the largest benefit of using crop residue. Corn and grain sorghum residue are comparable in nutritional value to grass hay (7 percent protein and 52-56 percent TDN). Additional savings may be realized in reduced wear and tear of drylot facilities, reduced equipment operating costs, labor reduction for feeding and manure removal, and compliance with the Department of Environmental Quality (DEQ) for feeding animals in confinement. Animal feeding operation (AFO) guidelines have been established in Nebraska in regard to "drylotting" animals. Livestock maintained in an area where vegetation cannot be maintained may be considered an AFO, which should trigger the producer to request an inspection from DEQ. There is a fee for the DEQ inspection. The smaller the number of cows that are fed in a drylot situation, the less likely a permit will be required. However, in some scenarios for livestock managers, it is either drylot and feed harvested forages during the winter or a portion of the winter, or have cows graze crop residue. These savings usually more than offset the additional costs of supplying water and fencing, moving cattle, and inspecting the grazing cattle.

An example for estimating crop residue value is presented in *Table 7*. The yield for the 160-acre field will support 1.6 AUM per acre, and a 1,200 lb cow is 1.2 AU. For 60 head of 1,200 lb cows, for 3.5 months there are about 252 AUMs needed and the 160 acres provides 256 AUMs. For illustration, additional weight gain is assumed to be zero and manure credit is ignored. The primary savings in manure may likely be the reduced cost in removing and spreading the manure from the drylot facilities.

The value of the crop residue can be estimated on an acre or head-per-day basis. Due to weather variability, the rental value of crop residue grazing on a per acre basis is uncertain. Renting crop residue on a per day basis can reduce renter's uncertainty since the rental period can be adjusted based on weather conditions. Livestock producers grazing their own crop residue would realize the benefit from both sides as estimated in *Table 7*. Livestock producers renting crop residue could consider the net cost of their next best alternative (for example, supplementation on dormant pasture or feeding in drylot) as the maximum rental value of the crop residue. Landlords could consider any livestock costs covered by the landlord, minus the net benefit to the crop enterprise, as the minimum rental value of the crop residue. Both the maximum rental value the cattle could realize ($26.97/acre, *Table 7*) and the minimum rental value the crop must cover ($6.25/acre, *Table 7*) should be adjusted based on factors discussed earlier. The remaining range in rental values provides a basis for negotiating a rental rate. This is an example and can be used as a guide to begin discussion on establishing a rental rate.

Table 7. Example budget estimating the value of grazing crop residue

60 Cows Grazing 160 Acres of Crop Residue for 105 Days		
Net benefit to livestock enterprise		
Feed savings[1]	60 head @ $1.20 per day for 105 days	$ 6,930.00
Drylot savings[2]		$ 2,272.00
Value of additional weight gain (loss)[3]		$0
Less crop residue grazing costs[4]		$ -4,887.00
Net livestock benefit		$ 4,315.00
per acre = $4,315/(160 acres) =		$ 26.97
per head day = $4,315 / (60 head x 105 days) =		$ .68
Net benefit to crop enterprise		
Saving shredding stalks 160 acres @ $6.25/acre[5]		$ 1,000.00
Manure credit less nutrient and organic matter consumed[6]		0
Net crop benefit		$ 1,000.00
Per acre		$ 6.25

[1]Example feed savings based on 105 days at 30 lb grass hay/head/day at $80 per ton. May need to be adjusted for supplemental feed needed while grazing crop residue.
[2]Electricity cost for pumping 25 gallons water/head/day at 5 cents/1,000 gallons. Depreciation and interest for water tank and tank heater of $32 per annum. Fuel cost for tank heater based on 1 gallon/day for 105 days. Lot cleaning and repairs of $500 per year. Labor for feeding and oversight; yardage $0.20/head/day. DEQ fees, maintenance of buffer strips, etc., $5.00 per cow.
[3]Add value of any additional weight gain expected from crop residue grazing (or subtract loss in value). Example assumed to be zero.
[4]Moving cattle five miles at 55 cents/mile equipment charge plus 12 hours labor. Water costs as described above plus hauling two miles at 55 cents/mile equipment charge and two hours of labor per day. A total of $450/year for depreciation and interest on fencing materials, battery charger, and labor for installation and tear down. Additional oversight costs of 10 pickup miles per day at 55 cents per mile, plus 30 minutes labor time per day.
[5]Fuel, repairs, and labor cost.
[6]The manure produced may contain more nutrients than the stalks removed, but nitrogen losses are possible, making it difficult to estimate a net manure credit.

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