SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter: 24

Short- and Long-term Consequences of Corn Stover Harvesting

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Over the past 20 years the amount of corn residue produced has increased with grain yields. High yields require that these materials be carefully managed. In some situations, corn-residue harvesting can increase the yield of the following corn crop (reducing disease pressure and carbon accumulations). However, yield gains as a result of stover harvesting maybe short-lived. Stover harvesting reduces soil residue cover, which increases the risk of wind and water erosion, and, in the long term, may reduce organic matter, and soil health. In addition, a failure to account for harvesting costs and nutrient removal can further decrease short- and long-term monetary gains. This chapter discusses the short- and long-term consequences of corn stover harvesting.

Stover Harvesting Introduction

Stover Harvesting Ethanol and Livestock Feed

In the United States, there is an increased use of corn stover to provide livestock feed and bedding and to produce cellulosic ethanol (US Department of Energy estimates, 2010). The use of corn stover for bedding is definitely not new. The use of corn stover as a feed, which is protein deficient (5.4% on a dry matter basis) (Table 24.1), was not practical without the availability of an inexpensive high-protein source (distillers grain) from the ethanol industry. Details on creating distillers grain-enhanced diets are provided in Garcia and Kalscheur (2006). and Carlson et al. (2010). They suggested that stover harvesting, when combined with the application of livestock manure to the residue-harvested land, has many benefits.

Table 24.1 Nutrient content of various feed components. *(Modified from Garcia and Kalscheur, 2006)* In this table, CP is crude protein, ADF is acid detergent fiber, NDF is neutral detergent fiber, TDN is total digestible nutrients, Ca is calcium, P is phosphorus, and S is sulfur.

Feed component	CP	ADF	NDF	Fat	TDN	Ca	P	S
				% Dry matter				
Distillers grain	29.7	19.7	38.8	10	78.5	0.22	0.83	0.44
Soy hulls	13.9	44.6	60.3	2.7	67.3	0.63	0.17	0.12
Beet pulp	10	23.1	45.8	1.1	69.1	0.91	0.09	0.3
Corn silage	8.8	28.1	45	3.2	68.8	0.28	0.26	0.14
Corn stalks	5.4	46.5	77	1.1	54.1	0.35	1.16	0.1
Oat straw	4.4	47	70	2.2	50	0.24	0.06	0.23
Wheat straw	4.8	49.4	73	1.6	47.5	0.31	0.1	0.11

Maintaining Soil Organic Matter

The harvesting of cornstalks for off-farm sale reduces the amount of plant material available to maintain soil organic matter (Clay et al., 2012, 2014, 2015). The amount of corn stover that can be sustainably removed is dependent on many factors, including rotations, the amount of organic matter in the soil, the amount of crop residue returned to the soil, slope, climate, and tillage (Clay et al., 2015). Tillage generally increases soil organic C mineralization and the associated soil organic C maintenance requirement. Research suggests that: 1) in a rotation that includes both corn and soybean, removing corn stover most likely will contribute to a gradual decrease in soil organic matter; 2) soil carbon loss is linked to the tillage intensity; and 3) from 1985 to 2010, South Dakota soil carbon contents in the surface 6 inches increased 24% (Clay et al., 2012, 2014). The increase in soil organic carbon was attributed to increasing corn yields, reduced tillage intensity, and improved corn genetics. Clay (2014) reported that 22%, 63%, and 36% of the yield increases in corn, soybean, and wheat, respectively, from 1974 to 2012 could be linked to improved soil health, providing a $1.1 billion impact on the South Dakota economy in 2012.

Fertilizer Recommendations and Residue Harvesting

South Dakota fertilizer recommendations do not account for corn-residue harvesting. A 200 bu/acre corn crop produces about 4.75 tons of stover per acre (Arora et al., 2011). The amount of N, P_2O_5, and K_2O contained in the grain of a 200 bu/acre corn crop is approximately 180, 76, and 54 lbs, respectively (Table 24.2). In contrast, N and P_2O_5 in residue is 16 and 5.8 lbs/ton, whereas, K_2O in residue is about 40 lbs/ton. This suggests that about 190 lbs of K_2O could be removed annually, if all corn residue is harvested. Over time, this removal can lead to K deficiencies.

Stover Harvesting and Corn Pathogens

Although several corn pathogens are residue borne, it is not recommended in South Dakota to harvest corn stover specifically for disease management. In South Dakota, rotations, tillage, hybrid selection, scouting, and foliar fungicides applied at V6 or tasseling, if warranted, are the recommended practices for disease management in corn.

Table 24.2 The amount of nutrients (pounds/ton) contained in the grain and straw of plants routinely grown in South Dakota. The nitrogen (N), phosphorus (P_2O_5), potassium (K_2O), magnesium (Mg), and sulfur (S) removal rates for corn residue were based on a 0.5 harvest index (grain/(grain + residue)) and dry corn weighing 47.32 lbs/bu. ***(Modified from Clay et al., 2011)***

Plant	N	P_2O_5	K_2O	Mg	S
lbs/ton					
Alfalfa	51	12	49	5.4	5.4
Barley straw	13	5.1	39	3	3
Corn residue	16	5.8	40	5	3
Oat straw	12	6.3	37	4	4.5
Soybean residue	40	8.8	37	8.1	6.2
Wheat straw	14	3.3	2.4	2	2.8
lbs/bu					
Barley grain	0.99	0.04	0.32	0.06	0.09
Corn grain	0.9	0.38	0.27	0.09	0.08
oat grain	0.77	0.28	0.19	0.04	0.07
soybean grain	3.8	0.84	1.3	0.21	0.18
wheat grain	1.5	0.6	0.34	0.15	0.1
lbs/acre (200 bu/corn crop)					
Corn grain	180	76	54	18	16
corn residue	76	27	189	24	14

6-Year Budget with Residue Harvesting

When harvesting stover in a continuous corn rotation, there are at least two extreme scenarios that can be envisioned. The first strategy is where stover is used as livestock bedding or feed and the manure is returned to the field. This management system represents a "closed loop," with at least some nutrients and organic matter returned via manure application. The closed-loop question is considered in Carlson et al. (2010). The second system is where the stover is sold and leaves the farm with no returning nutrients or residue. This chapter addresses the second scenario.

Credits

Harvesting corn residue in continuous corn rotations may reduce yield losses often observed as corn is planted after corn (i.e. yield drag). This question was investigated in an experiment where 60% of the corn stover was harvested annually for 5 years (Table 24.3). This experiment showed that in a continuous corn rotation, residue harvesting can produce short-term yield increases (≤2 years) and (inconsistently) long-term yield losses (≥4 years). Based on this experiment, there was on average a 14 bu/acre yield gain for the first two years following stover harvesting, and based on a corn selling price of \$3.50/bu, this represent a \$49/(a×year) credit. However, in years 4 and 5, there was an 8 bu/acre decrease, which represents a \$28/(a×year) loss. The second credit is the amount of money received for the residue. In this budget, it was estimated that 2.4 tons stover/acre was sold annually at a price of \$44.87/ton (Edwards, 2014), or a gain of \$107.

The value of the nutrients contained within the stover was \$26.12/ton (Table 24.4). Others have reported slightly different values. For example, the USDA-NRCS estimated that the nutrient value of a ton of corn residue was \$46.17/ton, whereas Mayer (2012) estimated that the nutrient value was \$16.25. Edwards (2014) had slightly different values and reported that the nutrient value of stover was \$49.62/ton. In Michigan, Pennington (2013) estimated that the nutrient content of stover was \$31.25/ton. Differences between the studies are the result of different estimates of stover nutrient concentration and fertilizer selling price (Table 24.4). In this analysis, it was estimated that 2.4 tons of stover was harvested annually, and that the value of the nutrients in each ton was \$26.12/ton.

Table 24.3 The impact on corn yields of removing 60% of corn residue annually. This experiment was conducted at Aurora, SD, from 2008–2012. Tillage used at the site was chisel plow and 150 lbs N/acre was broadcast-applied in the spring following seeding. Each treatment had eight replicates. A p-value < 0.05 means that the two values are significantly different.

Residue removed	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	2008	2009	2010	2011	2012
Grain yield (bu/acre)					
60%	207	200	176	175	164
0%	196	183	172	183	172
p	ns	< 0.05	ns	< 0.05	ns

Table 24.4 The value of a ton of stover based on current (top ½ of table) or future (bottom ½ of table) fertilizer cost and upon the amount of N, P_2O_5, and K_2O removed in 1 ton of harvested stover. The table also shows how different values of the N contained in the stover would impact the estimated value.

	Retail Price	Estimated lbs/ton	Value/ ton
	\$/lb		*\$/ton*
N	0.48	16	7.68
P_2O_5	0.42	5.8	2.44
K_2O	0.40	40	16
total			26.12
	Cost of N		
	\$/lb		*\$/ton*
	0.5		30.9
	0.6		37.1
	0.8		49.4

Stover harvesting costs were based on reports from Iowa and Indiana. In Iowa, Edwards (2014) estimated that non-nutrient harvesting costs were \$31.22/ton, whereas in Indiana, Thompson and Tyner (2011) had slightly lower values and estimated that the harvesting costs were \$17.56/ton. They also estimated additional costs (\$42.72) for transport, unloading, and storage. To provide a conservative estimate of harvesting costs, we used \$17.56/ton. If the costs are higher, profitability will be reduced.

The five-year budget was based on annual loss of soil nutrients ($26.12/ton, Table 24.4), non-nutrient harvesting costs ($17.56/ton), changes in the yield, and a stover selling price of $44.87/ton. During the first two years, there was a net increase in return, and thereafter, there was a net loss. This analysis suggests that there is a short-term opportunity when the residues are sold off-farm. However, these returns may be short-lived.

Table 24.5 A net budget of residue harvesting on the economic returns over a 6-year period.

Investments Nutrient $/acre	Years 1-5 Harvest $/acre	Total $/acre	Year 6 Nutrient $/acre	Harvest $/acre	Total $/acre
310.18	208.53	518.71	62.04	41.71	103.75
Credits					
Yield	***Selling***		***Yield***	***Selling***	
84	532.85	616.85	-28	106.57	78.57
Net change		98.14			-25.1795
Annual profit		19.63			-25.1795

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