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The Value of Crop Residue

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Harvesting crop residues for feed, bedding or biomass can add value to a farming operation. However there are short and long term consequences to removing crop residues.

Nutrient Value

Calculating nutrient value of baled straw or stover is fairly straight-forward. However, nutrient concentration in stover/straw can vary widely depending on factors such as soils, management, fertility levels, weather and many other factors. For example, potassium can be leached from the residue if heavy rains occur before residue removal. The nutrient concentration values presented here represent three-year average concentrations from a long-term study near Brookings, SD (Table 1).

Estimating crop stover/straw produced per acre can be done by knowing grain yield. Multiply the grain yield by the conversion factor of 52.8, 57.9, or 57.9 for corn, soybean or wheat, respectively, to estimate stover or straw yield (10% moisture basis) per acre. This estimate convert's grain yield into stover yield by assuming stover weight produced/acre is equal to weight of grain produced/acre.

To estimate the fertilizer value of nutrients in one ton of corn residue, set up a spreadsheet as per Table 2. This table can be duplicated for soybean and wheat and the appropriate nutrient concentration values from Table 1 inserted into column b in Table 2.

To determine a nutrient removal value per acre, determine number of bales per field and divide by the acres in field and multiply this value times the value in last column of Table 3.

In many South Dakota soils, the plant available K is very high (> 160 ppm soil test). Response to K has been documented on corn grown on soils at 150 ppm K and lower. In cases where soils are substantially higher than this (>250 ppm), the producer may not wish to assign a full fertilizer value to potassium.

The above tables document average nutrient removals. This is a long-term recognition that continued removal of these nutrients will eventually deplete soil fertility if not replaced. However, it is not critical that the removed nutrients be applied immediately for the next year's crop. Nutrient recommendations should be based on soil tests, crop grown and yield goals.

Other essential plant nutrients are also removed with stover harvests. These include calcium (Ca) and magnesium (Mg). Removal of these basic cations along with K could eventually lead to increased liming needs on some soils. However, removal rates are typically very small in comparison to the soil's supply of these nutrients. In addition, micronutrient removal is very small and removal value would be minimal.

Value of Soil Organic Matter

Soil organic matter (SOM) levels are determined by relative rates of production and decomposition of both the above and below ground plant biomass material.

Soils with higher levels of soil organic matter have better soil tilth and higher nutrient and water holding capacity. These soils resist erosion because they have better soil aggregate stability which allows for increased aeration, water infiltration, and drainage. Soils with higher levels of organic matter also appear to be healthier in part because they support higher populations of soil microorganisms that are important for nutrient cycling in the soil. Removing crop residues or stover from fields reduces the amount of plant material available for conversion to organic matter and could also affect these beneficial characteristics in a soil.

The impact of residue removal on SOM is not well defined, however, a Nebraska study found an average decrease of 6% SOM over five years for continuous no-till corn when approximately 50% of the crop residue was removed each year (Varvel et al., 2008). In a six year South Dakota study, topsoil (0-6") SOM decreased an average of 0.23% when removing all stover compared to removing none over three no-till rotations (H. Woodard and A. Bly. 2007, personal communication). The nutrients removed can be replaced by using inorganic fertilizer, but the other functions of SOM are not so easily mitigated.

In a review of corn belt studies (Wilhelm et al., 2007) showed that in continuous corn with yields of 175 bu/ac or greater, two 1200 lb (dry weight) round bales/a of stover could be removed without negatively affecting soil organic carbon under conservation tillage systems. With lower residue corn-soybean rotations, corn yields of 225 bu/a were needed to sustain soil organic carbon with this level of stover removal. In both situations the system left 30% of the soil surface covered. The study noted that with a moldboard plow tillage system, much higher corn yields were needed to sustain SOM levels. This was probably due to higher erosion rates and higher SOM decomposition rates with the increased tillage.

The amount of crop residue needed to maintain SOM will vary with differing soils and management options. However, with high residue rotations utilizing conservation tillage systems, less crop residue is needed to maintain SOM. Crop residue removals in excess of SOM maintenance levels will ultimately result in the deterioration of the soil resource and lead to declining yields. Since SOM levels in cultivated fields are already much reduced from native levels, it may be wise to be cautious with residue removal until more long term data is available.

Value of Wind and Water Control

A crop residue cover has many positive effects on soil. Crop residue can protect the soil from the forces of wind and water. Soil erosion can be significantly reduced by the presence of plant residues. In addition, crop residue can conserve water by trapping snow and reducing evaporation.

Wind Erosion Control

Vegetative residues control wind erosion by reducing wind velocity at the soil surface and protecting the soil particles from its forces. Returning plant residues can eventually increase soil aggregation thereby requiring stronger winds to move these larger particles while adding soil quality. Higher standing, heavier residues prove to be the most effective at reducing wind speed at the soil surface. Height and quantity is usually determined by harvest and tillage methods. Removal of residues would decrease the protection and increase the loss of soil by wind erosion. Ground covers of 30 – 60% can reduce wind erosion by an estimated 70 – 90% (Wortmann et al., 2008).

In addition to the protection and conservation of the soil, plant residues can benefit crop seedling survival. Wind blown soil particles can cause considerable damage to new seedling tissues.

For additional information on the effects of crop residue coverage on wind erosion for specific soils and climatic conditions see the NRCS-WEPS web site at http://www.weru.ksu.edu/nrcs/wepsnrcs.html and your nearest SD NRCS field office.

Water Erosion

Soil losses due to water erosion are well documented. Water erosion results in soil and soil nutrient loss along with potential degradation of surface water resources. Such losses can also reduce yield potential. The effectiveness and benefits of crop residue for the control of water erosion are also well documented. Vegetative residue increases moisture retention and reduces surface sediment and water runoff (Edwards, 1995). In general, medium and highly erodible soils require higher amounts of residue for protection and little if any residue should be harvested. Soils with lower erodibility need 2 to 3 tons of residue per acre to limit erosion from exceeding 5 tons or less of soil per acre (Wortmann et al., 2008). More crop residue can be harvested under no-till compared with tilled conditions, and with terraces compared with no terraces. Cultural practices that lower the amount and quality of residue may eventually lower land productivity and value.

For further information on management practices that limit water erosion and the impact of residue cover as influenced by soil and climatic condition see the web site at http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm and your nearest SD NRCS field office.

Water Availability

Crop residues on the soil surface slow water runoff by acting as small dams, reduce surface crust formation, and enhance infiltration (Edwards, 1995). Combined with reduced water evaporation from the soil surface, the higher level of soil moisture can lead to higher crop yields (Conservation Technology Information Center, 1996). Water evaporation studies have shown that crop residues saved 3.5 inches of soil water (Klocke et al, 2008). Additional available soil water, in many situations, can result in considerable yield increases. Soil water loss may be the greatest cost of crop residue harvesting, especially in drought-prone areas. Under water limiting conditions, corn is expected to produce as much as 12 bushels per inch of available water after the 7 to 10 inches required prior to grain production. A Colorado study indicated each additional inch of stored soil moisture can increase wheat yields by 3 to 5 bushels per acre.

Additional water availability values can be associated with snow trapping effects of erect crop residues.

A soil moisture management tool is available for Western South Dakota and can be found at the SD NRCS website. The Excel spreadsheet gives probabilities of water availability for crop yields for different climatic and management scenarios.

References

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Table 1. Average grain yield, stover/straw yields, and nitrogen (N), phosphorus (P2O5), potassium (K2O), and sulfur (S) contents for stover/straw, Brookings, SD[1]

CROP	MEASURED GRAIN YIELD	MEASURED STOVER/ STRAW YIELD[2]	NUTRIENT CONTENT[2] OF STOVER/STRAW			
			N	P_2O_5	K_2O	S
	bu/a	lb/a	-------------------%			
Corn	155	8,412	0.54	0.18	1.10	0.07
Soybean	48	4,724	0.52	0.18	0.83	0.12
Wheat	62	4,173	0.51	0.16	1.56	0.11

[1] H. Woodard and A. Bly. 2007, personal communication, SDSU.
[2] Adjusted to 10% assumed moisture.
Includes most of the above ground portion of the plant stover/straw remaining directly after grain harvest.

Table 2. The fertilizer value of nutrients in one ton of corn residue.[1]

NUTRIENT	CONCENTRATION IN RESIDUE[2] %	POUNDS PER TON LB/TON	FERTILIZER NUTRIENT PRICE[3] $/LB	VALUE OF NUTRIENT IN RESIDUE $/TON	VALUE OF NUTRIENT IN 1200 LB BALE $/BALE
a	b	c = b/100 x 2000	d	e = c x d	f = e x 0.6
N	0.54	11	$0.66	$7.13	$4.28
P2O5	0.18	4	$0.56	$2.02	$1.21
K2O	1.10	22	$0.55	$12.10	$7.26
S	0.07	1	$0.32	$0.45	$0.27
Total value				$21.69	$13.02

[1] Based on Table from Wortmann et al., 2008.
[2] From Table 1
[3] Based on Sept. 2011 prices. Substitute current prices in column d to calculate $ values in columns e and f.

Table 3. Summary of crop stover/straw nutrient content and total fertilizer value of residue nutrients.

CROP	NUTRIENT CONTENT				TOTAL VALUE1 OF NUTRIENT IN RESIDUE PER TON	TOTAL VALUE1 OF NUTRIENT IN 1200 LB BALE
	N	P2O5	K2O	S		
	lb/ton				$/ton	$/bale
Corn	11	4	22	1	$21.69	$13.02
Soybean	10	4	17	2	$18.78	$11.27
Wheat	10	3	31	2	$26.39	$15.83

[1] Based on Sept. 2011 prices. Substitute current prices in column d to calculate $ values in columns e and f in Table 2 above.

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