Removing Crop Residue Removes Nutrients from the Field

There has been a lot of discussion about the value of crop residue since the U.S. Department of Energy's Office of Biomass Program announced plans to increase the use of crop residue as a source of biomass for renewable fuel production. Crop residue can be fermented, burned, charred, or gasified to produce energy. However the residue is used, one thing is certain: it needs to be taken out of the field. As farmers start to harvest corn fields this season, many are wondering whether it is a good idea to remove some of the crop residue.

Many questions are being asked about the amount of stover that can be removed without adverse consequences to the soil's level of organic matter or physical and chemical properties and to successive crop yields. These questions are not easily answered, because typically the effect of residue removal is not apparent in the short term, and multiple variables can impact the results. Tillage, crop rotation, and yield level are some of the most important factors dictating how much crop residue can be harvested and still ensure sustainability of the system. A study by Johnson and collaborators showed the effect of crop rotation, tillage, and yield level on the amount of corn residue that can be removed in Corn Belt fields without negatively affecting organic carbon in the soil (assuming no additional carbon in the form of manure, cover crops, etc.) and protecting soils from erosion. In their study, summarized in Table 1, corn grain yield was adjusted to 15.5% moisture, and stover yield was calculated on a 1,200-lb dry-weight round bale basis. The conservation tillage system left at least 30% of the soil surface covered with residue after planting.

Table 1. Maximum corn residue removal to maintain soil organic carbon levels and protect against erosion as affected by crop rotation, tillage, and corn yield.

Corn yield		*Bales/A that can be removed*			
		Continuous corn		*Corn-soybean*	
Grain (bushels/A)	*Stover (bales/A)*	*Moldboard plow*	*Conservation tillage*	*Moldboard plow*	*Conservation tillage*
125	4.4	0.0	0.5	0.0	0.0
150	5.3	0.0	1.3	0.0	0.0
175	6.2	0.4	2.2	0.0	0.2
200	7.0	1.3	3.1	0.0	1.1
225	7.9	2.2	4.0	0.0	2.0
250	8.8	3.0	4.8	0.0	2.8

Adapted from J.M.F. Johnson, D.C. Reicosky, R.R. Allmeras, D. Archer, and W.W. Wilhelm. 2006. "A Matter of Balance: Conservation and Renewable Energy." *Journal of Soil and Water Conservation* 61:120-125A.

We are all familiar with the fact that removing grain also means removing nutrients from the soil. Since significant amounts of nutrients are not translocated to the grain but remain in above-ground crop tissues, removing residue from the field likewise means removing soil nutrients. The export of plant nutrients from a field when crop residue is being removed is also an important point to consider. While there are many factors that can influence the amount of nutrient removal when crop residue is baled, the way to calculate actual removal is straightforward. Following are a few simple steps that can be used to calculate nutrient removal and value when corn stover is taken out of the field. (In this discussion, stover refers to all above-ground corn plant material except grain--leaves, stalks, shank, husks, and cobs.)

1. How much stover is produced in a corn field?

The first step in determining total nutrient removal in stover is to calculate how much stover is produced. This is typically estimated from a harvest index (also known as residue-to-corn grain ratio). The ratio in Table 1 is actually 0.9:1, but the most widely used dry weight ratio is 1:1 residue:grain.

Using this 1:1 ratio to calculate the pounds of dry residue produced, the grain yield (in bushels per acre) is multiplied by 47.3. (A 56-pound bushel of corn at 15.5% moisture contains 8.7 pounds of water). The value can then be divided by 2,000 to obtain the number of dry tons produced. Of course, this is just an estimate; this calculation will tend to overestimate stover quantity in high-yield fields (>180 bushels per acre) and tend to underestimate stover quantity in low-yield fields (<100 bushels per acre).

2. How much stover is actually being removed?

The second step is to determine how much of the total stover is being removed from the field. The most reliable method is to directly measure the weight and water content of the residue being removed. Doing this would eliminate the first step and give the most accurate information. Since this approach is not always feasible, approximate removal amounts need to be determined in relation to the harvest method. Data from Iowa State University showed that with shredding and raking stover, 80% of the total will be removed; raking alone will remove 65%, and collecting stover from the combine windrow will remove 50%. The cutting height at the time of harvest also will influence how much stover can be removed. The higher the cutting height, the lower the amount of stover that can be removed. To estimate the total amount of stover removed, multiply the estimated total stover produced (step 1) by the percent removed by the method of harvest used.

3. What is the nutrient content of stover?

The third step in calculating how much nutrient is removed in stover is to determine the stover's nutrient content. Again, the most accurate method is to collect representative samples from the already collected stover (bales or stacks) and analyze them for nutrients. If this is not feasible, ballpark values can be used. However, the actual amount of nutrients present in the stover can vary significantly from a standard value dependent on several factors, including growing season conditions, hybrid, general fertility of the soil, and the time elapsed and amount and frequency of precipitation since the crop reached maturity and the time the stover was removed from the field. While phosphorus (P) in stover has low mobility because it is present in organic forms, potassium (K) is present in a highly soluble inorganic form. Leaching from stover with rainfall is thus more pronounced for K than for P. At plant maturity, corn stover on average contains 7 lb of P_2O_5 per ton and 30 lb of K_2O per ton. Due to the factors I have noted, there can be large variability in the actual amounts of P and especially K in the stover. P content typically varies between 5 and 8 lb of P_2O_5 per ton, and K content can vary between 5 and 40 lb of K_2O per ton.

4. What is the estimated value of stover?

Finally, to calculate an estimated stover value, multiply the amount of nutrients removed in stover (step 3) by the current price of the corresponding nutrient. It is important to recognize that only P and K have been discussed in this article because their removal directly impacts requirements of corn nutrients that need to be included in fertilization plans for the following crop. Stover also includes other nutrients, including nitrogen (N), calcium (Ca), magnesium (Mg), sulfur (S), and micronutrients, as well as organic carbon. The impact of increased removal of these nutrients and organic carbon through removing stover is not as obvious in the short term as for P and K, but it will definitely carry consequences in the long term. While Ca, Mg, S, and micronutrients are not typically provided through fertilization in Illinois, greater removal can accelerate soil deficiencies. Removal of basic cations (such as K, Ca, and Mg) can lead to an increase in the need to lime soils to maintain adequate pH levels. Nitrogen reserves, as well as organic matter depletions, can lead to less crop availability of N through the process of mineralization (conversion of organic N to inorganic). Diminishing organic carbon contents will also result in negative impacts on soil physical, chemical, and biological properties. All factors, including nutrient removal and soil resources, should be carefully considered when estimating the actual cost of stover removal.

5. What about removing just the corncobs?

The popularity of corncobs as a bioenergy feedstock is increasing. Since they represent only about 20% of the total residue produced in a corn field, removal of cobs alone could be viewed as a way to

minimize the long-term effect of residue removal on soil productivity. Additional reasons why corncobs are becoming a preferred material include the fact that they are more consistent than other parts of the crop residue in terms of density and moisture; they can be collected in one operation during grain harvest without additional trips over the field, as would be required for baling residue; and the outdoor storage for corncobs is far easier than for stalks and leaves since cobs are less susceptible to decomposition. Finally, the amount of P and K present in cobs is far less than that in stalks and leaves, so removal of cobs would represent less removal of nutrients from the field. A ton of cobs contains approximately 1.8 lb of P_2O_5 and 20 lb of K_2O.--*Fabián Fernández*

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