Effects of Corn Stover Removal on Nutrient Management

KEY POINTS Harvested corn stover can be used for:

- Livestock bedding.
- Livestock forage.
- Cellulosic ethanol.
- As a windbreak when bales are stacked.
- Reducing residue levels in corn-on-corn rotations.
- Other uses may include energy generation and fiber for use in building materials.

Introduction

The harvesting of cornstalk residue (corn stover) after grain harvest has long been used for bedding, cellulosic ethanol, and as an additional forage source for livestock, especially in years when forage production has been short due to drought. Removing stover to reduce residue levels is emerging as another reason after continuous, high yielding corn production situations. The amount of corn stover produced is greatly proportional to the amount of grain produced. For every 40 bu/acre of corn produced, one ton of residue is produced. For example, a 240 bu/acre field produces about six tons of residue while an 80 bu/acre field produces about two tons of residue.[1]

Figure 1. Corn Stover Bale. Photo courtesy of Jennifer Rees, Extension Educator, University of Nebraska.

The percentage of stover harvested depends on several factors including the amount of grain harvested, soil organic matter, climate, soil type, slope of the field, crop rotation, and the tillage used before the next crop in planted. When comparing stover to silage harvesting, there are several differences. Stover removal is often much less than the 90 to 95% of the above ground plant harvested for silage, depending on silage cutting height. The nutrients removed with silage harvest is well documented, while understanding the nutrients removed with harvesting stover is more complicated due to a later harvest and the amount of biomass removed. However, in many silage production operations, manure from the livestock operation can be applied to the harvested fields. This can allow for the replacement of nutrients lost from the corn crop harvested as silage. When comparing grain harvest plus some stover harvest to a silage harvest system, less biomass carbon (C) and less total plant nutrients are removed.[2]

One of the most important issues associated with stover used for cellulosic ethanol production is that it must have low soil contamination. This is why energy companies often recommend a partial stover harvest of 20 to 60 percent.[2]

The removal of corn stover is also being considered as a viable and sustainable management option in high yield, minimum or no till, continuous corn environments. This is a situation that is more likely to occur in irrigated western corn growing regions where high corn yields can occur year after year. These are production systems where high grain yields produce high levels of residue and are in environments where residue breakdown by biological processing is slow due to low levels of moisture in the winter and spring. This high level of residue production and build up is multiplied when there is no or very limited tillage to help with residue breakdown. The major problems caused by high levels of corn residue, still on the soil surface at planting time, are plugged planters, emergence issues due to poor soil to seed contact, and lower soil temperatures. These situations have shown an increased yield response to stover removal but do not require all the stover to be removed every year. 50 to 60 percent stover removal each year is often enough to greatly reduce the issues at planting time while helping to prevent most wind and water erosion concerns on fields with limited slope of no more than two to three percent along with maintaining good soil tilth.

Stover Nutrient Content

When considering the impact of nutrients removed in harvested stover, it is important to know how the interactions of crop rotations, corn yield levels, and the amount of plant matter removed can impact long-term soil health. The removal of nutrients directly affects the recycling of nutrients which affects the amount of fertilizer needed to grow the following crops. Determining the amount of nutrients in corn stover is complicated because nutrients, especially potassium (K), can be leached out of plant tissue from maturity through grain harvest, and continue until the stover is harvested and removed from the field. This means that nutrient concentrations per ton of stover removed, can vary considerably depending on the rainfall amount and pattern from plant maturity through time of grain harvest and until the stover is harvested.

There are numerous resources to help estimate the nutrient removal associated with stover harvest. One good resource is the Corn Nutrient Composition at Plant Maturity by Plant Part (Table 1). These averages help a farmer understand the differences and similarities of the nutrient composition by plant part at maturity, which is important when comparing removal by harvest type. The vegetative plant parts column which includes stalks, leaves, tassels, ear shanks, and husks and when combined with the cobs estimates the pounds of nutrients removed per ton of harvested stover on a dry matter basis.

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Carbon (C) will be removed with a grain harvest, but when returned to the soil is important to maintain soil organic matter. Carbon levels are nearly the same when comparing nutrients removed by each plant part on a pounds per ton /dry matter basis. However, the total amount of C removed by grain harvesting is about the same amount as the vegetative and cob amount combined (100% stover harvest). Yearly C removal levels do not include C in the root system which is not affected by any type of corn harvest.

Nitrogen (N) is the next nutrient to be considered when stover is removed. Since most of the N is removed with the grain harvest, the N in the vegetative tissue and cob need to be considered with a different approach. Much of the N is tied up in high C:N ratio tissues that need to be broken down by soil organisms before it becomes available for the next crop. In the short term, this nutrient tie-up can result in N being unavailable for the next crop, especially in high yield corn production environments. In recent years, there has been an increased focus placed on C and N removal because of their influence on the sustainability of the soil resource and water quality in all types of production systems.[2]

The last nutrient of importance is potassium (K). Potassium can have a high nutrient per ton concentration in the vegetative tissues that are removed with a stover harvest. Potassium is soluble in mature plant parts; therefore, in environments with high rainfall after plant maturity and before the stover is harvested, much of the K can potentially leach out before stover harvest. This is why there can be a high level of variation in the amount of K removed when stover is harvested. This depends greatly on the timing and the amount of rainfall after plant maturity and should be managed accordingly.

Finally, phosphorus (P), calcium (Ca), magnesium (Mg), sulfur (S) and micronutrients (zinc (Zn), manganese (Mn), copper (Cu), boron (B), iron (Fe)) are in low levels and are often not a concern when considering a stover harvest option.[2]

Table 1. Corn nutrient composition at plant maturity by plant part.*

Nutrient	Grain	Vegetation	Cob
	lb/ton (DM)		
C	795	840	797
N	24	12	10
P (P_2O_5)	12	3	--
K (K_2O)	8	22	--
Ca	2	9	--
Mg	2	6	--
S	2	1	--
Zn	0.030	0.031	--
Mn	0.006	0.069	--
Cu	0.004	0.015	--
B	0.009	0.015	--
Fe	0.047	0.281	--

**Corn nutrient composition at plant maturity by plant part. Sawyer, J.W. and Mallarino, A.*

Change in Nutrient Content with Time

Concentrations of P and K contained in corn stover decrease after maturity. Most of this decrease occurs after black layer formation through maturity.[2]

After grain harvest, K declines consistently in stover left in the field overwinter; however, the loss can be accelerated by rainfall anytime from maturity until the next crop is planted in the spring. Concentrations of P in the stover stay about the same in the fall and then decreases only slightly during the winter.

The potential for large change in stover K concentration from harvest until early spring makes estimates of K removal with stover harvest complicated.

Corn N, P, and K Fertilization after Stover Harvest

Knowing how much P and K is removed with any type of corn harvest is important to help maintain desirable soil-test values and is included in P and K fertilizer recommendations for corn grain production. Although N removed with corn grain production is not used to determine the N fertilizer rate for the next crop, it is reflected in traditional Corn Belt N rate recommendations. In many western corn production areas, fertility recommendations for the following corn crop are made using a winter soil fertility test along with yield goals. Corn nutrient removal estimates are not used for the recommendations. This type of fertility recommendation reflects less nutrient recycling due to less organic matter in the soil.

Most N response trials have not included harvested stover in the trials; therefore, studies with and without stover should be reviewed to help determine the short and long-term effects of stover removal on maximum economic corn yield potential. One study from Iowa, looked at two sites where continuous corn rotations were evaluated for the long-term effect of both partial stover removal and full stover removal on the fertility recommendation needed to reach maximum economic yield in the next-year corn crop.[2]
This study determined that the economic optimum N rate for partial removal (about 30 to 40% stover harvest) was 20 lb N/acre less than when all the corn residue was returned to the soil. This same study determined that economic optimum N rate for full stover removal (about 90% stover harvest) was 40 lb N/acre less than when all the corn residue was returned to the soil.[2]

These numbers seem backward as more N is being removed with the higher levels of stover harvest so it would be expected more applied N would be needed to grow the next corn crop. This type of response can be expected when high levels of high C:N ratio plant matter is added back to a soil. This response is caused by the inability of soil microbes (bacteria, fungi, protozoa and actinomycetes) to process (recycle) residue back into plant nutrients fast enough to meet the nutrient needs of that crop during the next growing season. Along with the fact that these same organisms are tying up soil N is why a higher N application is needed to maximize corn yield potential when stover is added back into the soil.[2]

Another source shows estimates for the average nutrient concentrations being removed per dry ton of corn stover removal:[1]

- 17 lb N/Ton
- 4 lb P_2O_5/Ton
- 34 lb K_2O/Ton
- 3 lb S/Ton

Nutrient amount (lbs/ton) x fertilizer price ($/lb) = Value of Nutrients in Stover ($/ton) [1]

Using the values above, this equation can be used to calculate the value of each nutrient lost in lbs/ton of stover harvested by using the current fertilizer price for each nutrient.

Conclusions

When considering if harvesting corn stover is right for your production system, several factors that influence soil quality should be considered. This decision may be a field-by-field decision due to the amount of stover produced, field slope, soil type, organic matter, tillage type, and crop rotation. These factors can affect the potential for wind and water erosion along with the nutrient recycling capacity of each field. Corn stover left on the soil surface can help reduce the potential for wind and water erosion by creating a protecting layer. This is a factor that is affected by the amount and type of tillage used after harvest that can decrease the protective stover layer by incorporating it into the soil. No-till or limited till production systems allow for more stover to be harvested as it conserves the stover left on the soil surface. Cover crops can be used with a stover harvest system to help protect the soil surface.

Soil organic matter (O.M.) and nutrient recycling are important soil quality considerations that need to be addressed before deciding if stover harvest is an option for your operation. While soil O.M. is very important for productive soils, it is in a constant state of flux. By harvesting the corn stover there is less C available for the soil to convert back into new O.M. However, it appears that new O.M., that is created over time by many forms of decomposing dead plant matter is driven by living and decomposing roots.[3] The C source associated with the roots, which is needed to sustain soil O.M., is not affected by stover harvest. By using minimum tillage along with limiting the amount of stover harvested to around 30 to 50% can often keep the C levels in most soil high enough to help sustain the O.M. needed for healthy soils. Higher corn grain producing fields produce higher stover amounts which can allow for higher stover removal levels while keeping enough to help protect the soil from erosion. When it comes to nutrient recycling, it is difficult for soils to recycle large amounts of high C:N ratio stover, especially in corn-on-corn rotations, rapidly enough for use by the following corn crop. This can cause a reduction in corn yield due to N that is tied up in the decomposing stover and not available for the next corn crop.

In many situations it comes down to economics, which varies annually by field depending on the many variables used to determine stover removal feasibility and value. Can the return from a stover crop create enough income to cover harvest costs, including the cost to deliver the stover to the end user, and storage along with replacing the nutrients lost by stover harvest. Most costs, which need to be included in a stover harvest economic analysis, are variable year to year, include fuel, equipment, labor, and fertilizer costs. While the value of stover used as a forage feed source, more in times of drought conditions, may be a very valuable resource for cattle feed on or off the farm.

Many corn production operations can successfully harvest stover when balanced with frequent soil testing and a good fertility program to monitor the affects to the soil over time. Like most production systems there are advantages and disadvantages for each system. Only when a farmer understands these limits and variables can an educated decision be made to decide if stover harvest is right for their operation.

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Source:

[1]Rees, J., Schmer, M., and Wortmann, C. 2017. Corn stover removal: nutrient value of stover and impacts on soil properties. CROPWATCH. University of Nebraska-Lincoln. Institute of Agriculture and Natural Resources. https://cropwatch.unl.edu/2017/corn-stover-removal-nutrient-value-stover-and-impacts-soil-properties

[2]Sawyer, J. E., and Mallarino, A. P. 2014. Nutrient considerations with corn stover harvest. PM 3052C. Iowa State University Extension and Outreach. https://store.extension.iastate.edu/Product/Nutrient-Considerations-with-Corn-Stover-Harvest

[3]Ertl, D. 2013. Sustainable corn stover harvest. Corn Stover research. Iowa Corn Promotion Board. https://www.iowacorn.org/corn-production/research-and-patents/corn-stover

Legal Statements:

Performance may vary, from location to location and from year to year, as local growing, soil and environmental conditions may vary. Growers should evaluate data from multiple locations and years whenever possible and should consider the impacts of these conditions on their growing environment.

The recommendations in this material are based upon trial observations and feedback received from a limited number of growers and growing environments. These recommendations should be considered as one reference point and should not be substituted for the professional opinion of agronomists, entomologists or other relevant experts evaluating specific conditions.