CORN STOVER HARVEST

IOWA STATE UNIVERSITY
Extension and Outreach

Nutrient Considerations with Corn Stover Harvest

Introduction

Harvested cornstalk residue (corn stover) after grain harvest has traditional uses as bedding and co-feed for livestock. Interest is increasing for other uses, especially for energy production such as cellulosic ethanol. While corn silage harvest has been practiced for many years, and nutrient removal with silage is well known, corn stover harvest and related nutrient removal is different due to the later timing of harvest and the separate grain harvest.

Stover harvest being promoted for ethanol production must have low soil contamination, and frequent total stover removal will not be desirable for soil sustainability reasons. Therefore, stover harvest for bioenergy will typically be less than the total of corn residue remaining after grain harvest. For use in ethanol production, company suggestions are for only partial stover harvest, 20 to 60 percent, which is much less than the 90 to 95 percent usually removed when silage is harvested. Therefore, grain plus some stover harvest will remove lesser amounts of biomass carbon (C) and plant nutrients compared to silage harvest. The amount and frequency of stover harvested in a specific rotation will determine the long-term impact on nutrient removal and recycling to soil.

Phosphorus (P) and potassium (K) have been the main nutrients of interest with silage harvest due to large removal amounts, but not nitrogen (N) or other nutrients. This is changing as more focus is being placed on C and N due to effects of their removal on the sustainability of the soil resource and water quality.

Corn Stover Nutrient Content

Determining corn stover nutrient content is complicated because nutrients, especially K, can be leached out of plant tissue from maturity to grain harvest, and from the stover after grain harvest. This means that nutrient concentrations of stover can be quite different depending on the rainfall pattern from plant maturity to time of harvest.

Nutrient content at plant maturity

Table 1 gives the average nutrient analysis of corn at maturity for grain, vegetative components (stalk, leaves, tassel, ear shank, and husk), and cob from several Iowa fields in recent years. Grain dry matter (DM) is approximately one-half of the aboveground vegetation plus cob. Since the C concentration in corn is similar for all plant components (DM basis), grain C is also approximately one-half of the vegetation plus cob components. The N concentration of cobs is lower than for vegetative plant parts, and for the data in Table 1 only cob C and N were measured. There is more N and P in grain than in the vegetative component, and more K in the vegetative component than in grain. This difference in relative P and K content of vegetative tissues compared to grain is why nutrient removal has to be calculated differently for grain, silage, and stover harvest. As is typically found, the concentration and amount of micronutrients is low in both corn grain and vegetative components. There is some additional Ca and Mg removed with stover harvest, but the additional amount removed is easily corrected by normal liming in most soils and is not an issue in soils with neutral pH or with free lime (calcareous).

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

Nutrient	Grain	Vegetation	Cob
	pounds/ton (DM)		
C	795	840	787
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	--

From 14 site years in 2006-2007; DM, dry matter; J.E. Sawyer and D.W. Barker.

Nutrient content at grain harvest

A better estimate of corn stover nutrient concentration is from data collected at grain harvest (Table 2). The concentrations in Table 2 are for stover that includes the cob,

with the stover collected where there would be little or no soil contamination. The P concentration is similar to the data in Table 1 (collected from whole standing plants at maturity), but the K concentration is lower. This is explained by leaching of K from the vegetative plant parts after maturity and until grain harvest. As for the data presented in Table 1, the concentration of micronutrients in corn stover is very low. Of note is the large range in nutrient concentrations across the study sites. This range is greater than found for grain nutrient concentrations, and makes estimation of actual stover nutrient removal from specific fields difficult. However, the actual amount of stover harvested would have the greatest impact on nutrient removal. One could sample stover bales and have samples analyzed if a more precise estimate of concentrations is needed, but sampling stover bales can be difficult. That method may also reflect soil contained in the baled stover, and concentrations including soil would overestimate the nutrient amount originating from the stover, but not total nutrient removal from the field. Also, nutrients in stover bales originating from soil contamination could have less agronomic value compared to stover due to different crop availability. That is, the amount of nutrients in the soil component would be a total amount, not a reflection of just plant available nutrient.

Table 2. Corn stover nutrient concentration at the time of grain harvest.

Nutrient	Average	Range
	lb/ton (DM)	
P (P_2O_5)	3	10
K (K_2O)	19	44
Ca	8	8
Mg	4	7
S	1	1
Zn	0.033	0.052
Mn	0.096	0.167
Cu	0.013	0.024
B	0.010	0.011
Fe	0.148	0.171

From 29 site years, 2008-2011; Little or no soil contamination; DM, dry matter; R.R. Oltmans and A.P. Mallarino.

Nutrient content in baled stover

Data presented in Figure 1 for P and K show results of sampling many corn stover bales in central Iowa. The baled stover includes any contamination with soil resulting from the normal baling process. These data show a wide range of observed concentrations and averages that are not far from data presented in Table 2. With concentrations skewed toward very high values, the median may be a better value to represent stover P and K concentrations.

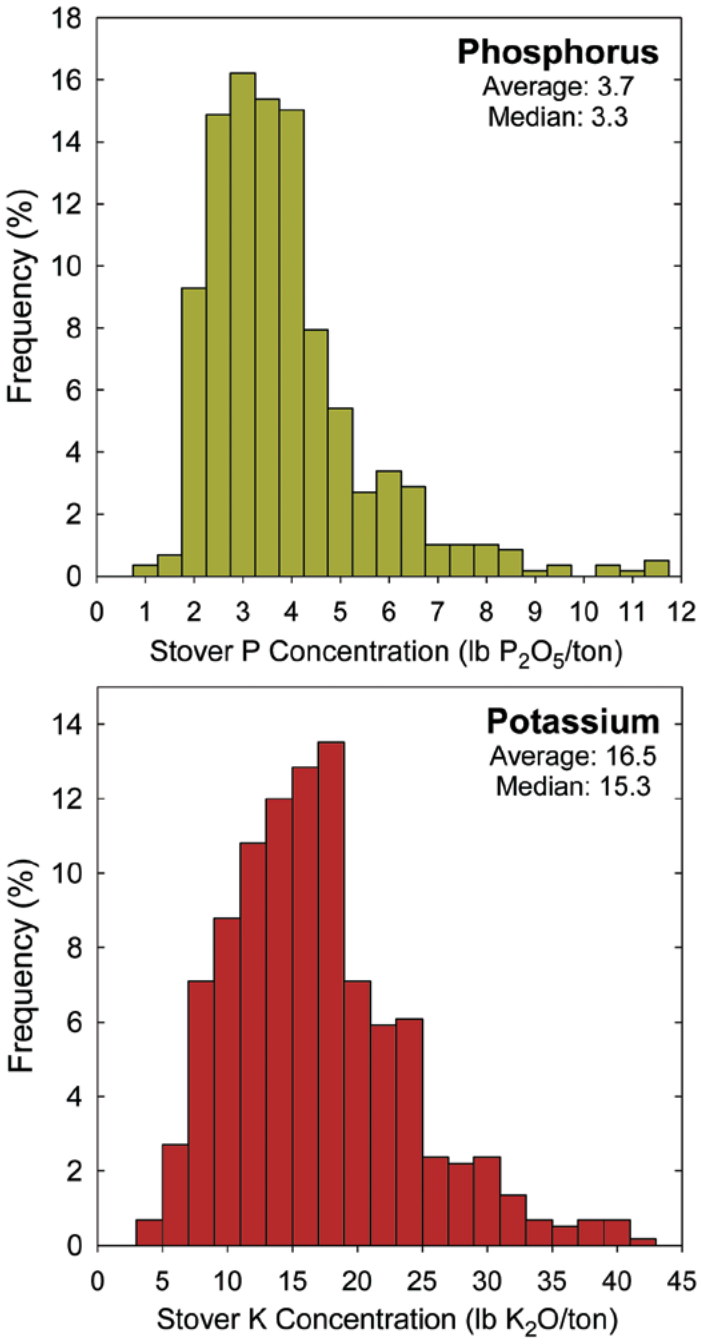

Figure 1. Range of P and K concentrations in corn stover bales from 197 central Iowa fields sampled in 2011 and 2012 (Matt Darr et al., Iowa State University).

Change in Nutrient Content with Time

Phosphorus and K concentrations in corn stover decrease after maturity (Figure 2). The largest decrease occurs from black layer to grain harvest. After that, there is a slow but steady decline for K (the magnitude depending on amount of rainfall) in the fall and spring, but the P concentration stays approximately the same in the fall and then decreases slightly across the wintertime. The large change in stover K concentration with time from harvest until late fall makes estimates of K removal with baling complicated.

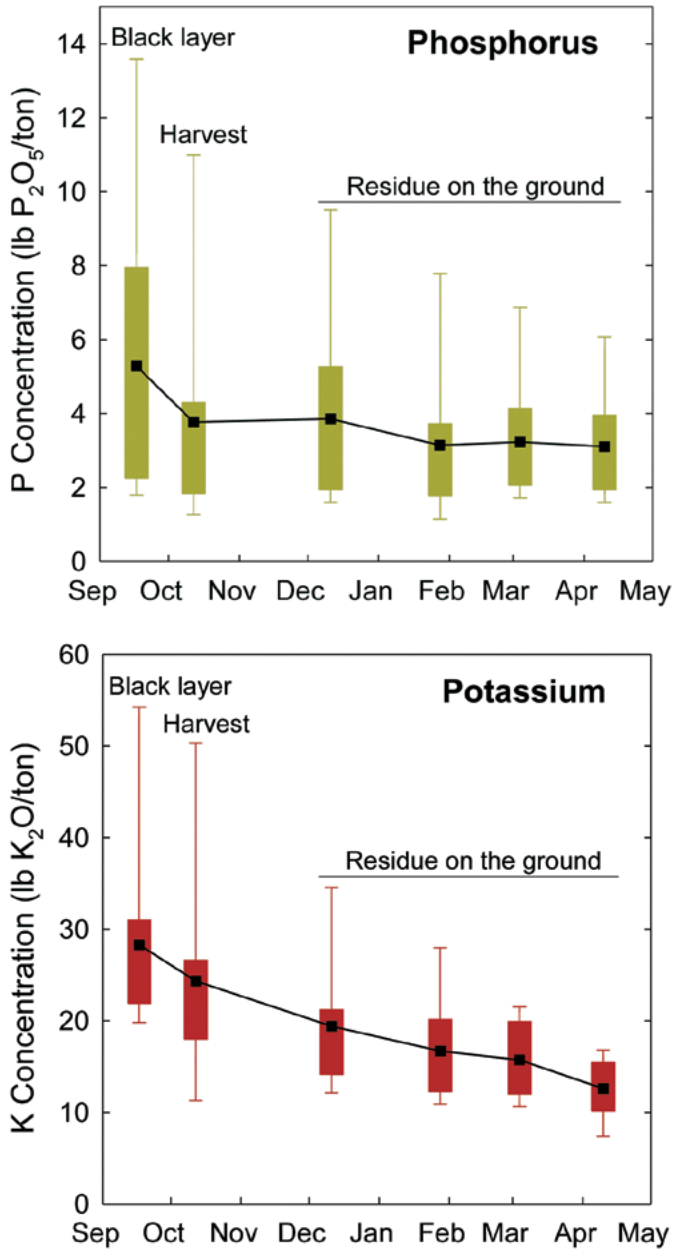

Figure 2. Phosphorus and K concentrations in corn stover across time after plant maturity (R.R. Oltmans and A.P. Mallarino). At each sample time, average (black squares), 50 percent central distribution (green and red boxes), and range (vertical lines) across nine trials and eight plots per trial in 2009 and 2010.

Corn N, P, and K Fertilization after Stover Harvest

Phosphorus and K removal with harvest is an important piece of information needed to maintain desirable soil-test values, and is included in P and K fertilizer recommendations. Although N removal with grain harvest is not used to determine the N fertilizer rate for the next crop, it is reflected in traditional N rate recommendations since field response trials include N removal in grain harvest. Most N response trials have not included stover harvest, however, so an estimate of that removal is of interest due to potential impact of less corn residue return to the soil. In an ongoing continuous corn study at two sites in Iowa, stover harvest reduced the N rate needed for maximum economic yield in the next year corn. The economic optimum N rate has been 20 pounds N/acre less with partial removal (approximately 30 to 40 percent stover harvest) and 40 pounds N/acre less with full removal (approximately 90 percent stover harvest). At first this seems backward as N is removed with stover harvest and a greater N application need would be expected. However, with stover removal there is also less addition of C to soil for microbial processing; therefore, it appears the change in biomass return (with high C:N ratio) to the soil has a greater influence on N fertilization requirement than less return of N.

Summary

Corn stover harvest removes more nutrients compared to grain only harvest. The proportion of nutrients in grain and stover varies for different nutrients. Compared to grain, on a dry matter concentration basis, corn stover has one-half as much N, one-fourth as much P, and three times as much K. This means that different concentrations must be used for estimating harvest removal with grain and stover. Currently suggested average concentrations (per dry ton) are 12 pounds N/ton, 3 pounds P_2O_5/ton, and 19 pounds K_2O/ton. Corn stover nutrient concentrations vary considerably across and within fields as affected by many factors; therefore, calculated removal amounts are only estimates. Of greatest importance in calculating total nutrient removal is the estimate of actual stover harvest amount. The following is an example with 200 bushels/acre corn grain yield and 1.9 ton/acre (DM) stover (40% of total stover). The removal amounts for P would be 75 pounds P_2O_5/acre with grain, 6 pounds P_2O_5/acre with stover, and a total 81 pounds P_2O_5/acre. The removal amounts for K would be 60 pounds K_2O/acre with grain, 36 pounds K_2O/acre with stover, and a total 96 pounds K_2O/acre. Long-term management, including soil testing for P and K, will determine if stover harvest and nutrient removal are being correctly accounted for. Management of N with stover harvest is not straightforward as there is not a direct relationship between removal and need for additional N application in subsequent corn crops. In recent research a small reduction in needed N fertilization rate for continuous corn was found as a result of less corn biomass return to the soil with partial stover harvest.

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