Response Comments to Liska et al. (2014)

Biofuels for crop residue can reduce soil carbon and increase CO_2 emissions

Douglas L. Karlen, USDA-ARS/NLAE

This article makes unrealistic assumptions and uses citations out of context to reinforce the authors' viewpoint. For example, the first sentence citing Wilhelm et al. (2007) fails to make the point that the authors of that publication were pointing out that the initial wind and water erosion projections associated with the Billion Ton Study (BTS), though important, were not sufficient to assess sustainability of the practice and that "excessive" residue removal can decrease soil organic matter. The opening sentence would be acceptable if it stated that 'Excessive removal …
The assumption by Liska et al. (2014) that 6 Mg/ha (2.68 tons/acre) of residue can uniformly be removed each year is also unrealistic, even the highest producing Corn Belt states (*i.e*., Iowa, Illinois, Minnesota) and for the irrigated areas in Nebraska. As stated by several other authors, stover harvest for any use must be site specific, with "site" being best defined as sub-field units. Several recent publications also emphasize that stover harvest guidelines must account for spatial variability in soil resources, management practices, and weather variability. To illustrate how unrealistic the universal 6 Mg/ha removal estimate is, I computed mean corn grain and stover yields for the 10 Corn Belt states [Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska (irrigated and non-irrigated), Ohio, South Dakota, and Wisconsin] using National Agricultural Statistics Service (NASS) data for 2003 through 2013. I then divided the assumed removal rate (2.68 tons/acre) by the average stover production based on a harvest index (mass of dry grain/total above ground biomass) of 0.5. Those results are:

Average NASS grain yield	153 bu/acre
Calculated total stover production	3.61 tons/acre
Amount harvested based on 6 Mg/ha removal	75%

For the highest average non-irrigated yields (Iowa, Illinois, Minnesota) and irrigated yields in Nebraska, the average removal associated with the 6 Mg/ha assumption would be:

State	%	State	%
Iowa	68	Minnesota	70
Illinois	70	Nebraska -- irrigated	60

In contrast, the measured, 4-year average stover harvest at the POET-DSM Project Liberty site near Emmetsburg, IA ranged from 12 to 60%, with treatments exceeding 25% being considered excessive. Collecting 75% of the stover at or after grain harvest is also mechanically impossible without also collecting an excessive amount of soil which fouls the conversion processes.
Harvesting 75% of all corn stover produced in the 10 Corn Belt states is unrealistic, far greater than any projections associated with the BTS or the Revised Billion Ton Report (BT2), and would indeed likely result in a depletion of soil organic matter.

A more realistic and balanced perspective on the potential impacts of stover harvest has recently been published on-line and will be available in print in the 2014 volume 2 of BioEnergy Research. That series of papers summarizes 239 site-years of corn grain and stover yields from 36 research sites and also presents estimates of the additional N-P-K removed by harvesting an average of 3.9 or 7.2 Mg ha^{-1} (1.7 or 3.2 tons/acre) of stover from 28 of those sites. Another paper in that issue uses the current studies as well as an extensive literature base to approximate the minimum amount of crop residue that needs to be returned to sustain SOC levels. Their results emphasize the extreme variability associated with different soils, weather patterns, and crop growth conditions by showing that the estimated average minimum residue return rate for 35 studies was 6.38 ± 2.19 Mg stover ha^{-1} yr^{-1} (2.85 ± 0.98 tons/acre). The most important point of that article, however, is that it refutes any notion that there is a universal minimum residue requirement; rather it reinforces the need for field, or better yet, subfield management decisions.

Greenhouse gas (GHG) responses to stover harvest treatments were also reported. One study summarized static chamber estimates of GHG emissions from nine corn production systems under various crop residue and tillage management practices across the USA Corn Belt. It showed that stover harvest generally decreased total soil CO_2 and N_2O emissions by -4 and -7%, respectively, when compared to no stover removal. Decreased emissions were attributed to less stover C and N inputs and possible microclimate differences due to changes in soil cover. Another study showed no significant difference in N_2O emission as a function of stover harvest, but CO_2 loss from the full removal plots was slightly lower than from the zero removal plots. However, the emission difference between the two treatments was much smaller than the amount of C removed with the stover. This implies that C was being lost from the full removal plots – a phenomenon confirmed by rigorous soil sampling, and expected because the full-removal treatment was considered an "excessive" rate of harvest.

Another article within the special issue of BioEnergy Research and a recent publication in Agrociencia Uruguay provide on-site research results from the POET-DSM Project Liberty site near Emmetsburg, IA. In the Agrociencia article, Figure 3 does show a decline in soil organic matter (SOM) during the first four years of research at the Project Liberty site, but the decrease is only from 4.5 to 4.0% SOM. Data from the next year (2012) which is not yet published shows a value of 4.2% SOM. Furthermore, in 2013 a grid sampling, consisting of 131 samples for the 104 acre research site (0.79 acre cell size) showed an average SOM content of 4.4%, with sample variation ranging from 2.4% to 6.2% SOM independent of any prior stover harvest treatments. The SOM data as well as that for pH, buffer pH, P, K, and B levels showed substantial variation across the site which encompasses four different Des Moines Lobe soils [Canisteo (58%), Clarion (17%), Okoboji (17%), and Nicollet (8%)]. This suggests the initial SOM trend was influenced more by sample variation than stover harvest. Furthermore, in both publications, it is concluded that tillage rather than moderate stover harvest that is affecting SOM.

The bottom line is that stover harvest for any use must be site specific and strive to balance all factors affecting soil carbon and all other factors that influence soil health and sustainability.

Posted with permission of USDA ARS Information Staff.