Logistical aspects of using corn stover as a feedstock for bioethanol production

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A variety of biomass feedstocks can be used for near-term bioethanol production, e.g., mill wastes, urban wastes, agricultural residues, and forest residues. Among these resources, agricultural residues dominate in terms of tonnage and were evaluated as potential ethanol feedstocks.

Corn Stover Availability

According to the U.S. Department of Agriculture (USDA), average total acres planted for four major agriculture crops in the United States for 1999-2000 are (in millions of acres): corn (79.6), soybeans (74.5), wheat (62.5), and hay (61.6). While soybean is a major crop in terms of total acreage in production, residue generation is relatively modest. Moreover, soybean residue in the field can rapidly degrade, limiting its utility as a feedstock. Wheat straw is also a potential ethanol feedstock based on planted wheat acreage. Using a sustainable harvest estimate of 0.8 t straw/t grain, about 45 million dry t/yr of wheat straw can be collected, amounting to 50% of the total straw produced.

Based on USDA data for the past four years, average corn production is 245 million t/yr. This is equivalent to 206 million dry t/yr of total above-ground corn stover. According to several estimates, the amount of stover that can be sustainably collected is 80-110 million dry t/yr. These corn stover availability estimates vary because of the different assumptions about what fraction of corn stover can be sustainably collected. An average corn stover availability of 100 million dry t/yr represents about 50% of the total above-ground stover.

Hence, although other residues such as wheat straw and soybean stubble are potential candidates, corn stover is arguably the feedstock of choice for large volume ethanol production as it represents 80% of the total agricultural residue and is concentrated in the Midwestern region of the United States.

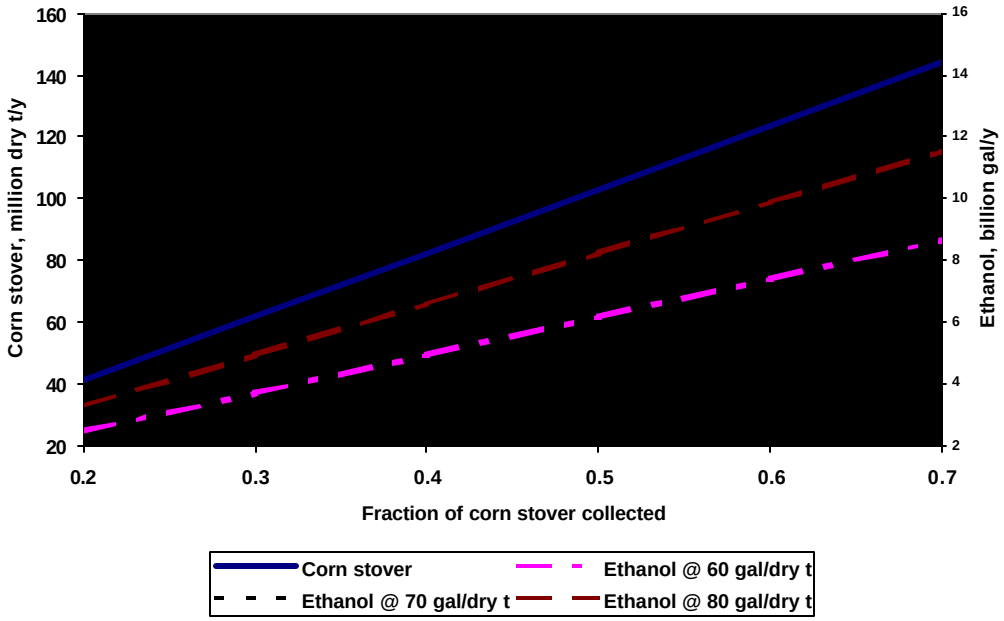
Ethanol Production Potential

Using an average corn stover availability of 100 million dry t/yr, 5–7 billion gallons of ethanol per year can be produced, depending on what ethanol yield is assumed. The accompanying figure plots ethanol production potential (assuming yields of 60, 70, or 80 gal/dry t) as a function of the stover fraction that can be sustainably collected from the above-ground total stover. If the sustainably collectable fraction is only 30%, there is still sufficient stover available to produce 4–5 billion gallons of ethanol per year.

Competing Corn Stover Usage

Less than 5% of the stover is physically collected for current off-field use; this is similar to rice straw off-field usage in California. The possible corn stover uses are: animal feed, animal bedding, fuel for a boiler furnace, composite products such as fiberboard, pulp and paper, chemicals, and liquid fuels. Besides ethanol production, pulp and paper, fiberboard, and chemicals are currently believed to be the only applications, however, for which corn stover may be needed in any substantial quantity. These are further discussed below.

The length of straw/stalk-based fiber is typically 0.5-2.5 mm, with a diameter of 0.01-0.2 mm, and the hemicellulose content is mostly xylans. These factors render straw/stalk-based pulp similar to hardwood pulp, and corn stover can replace hardwood, at least partially, as a fiber source. The hardwood market for pulp production in the United States is about 30 million t/yr. The bleached chemical pulp yields for hardwoods and straw/stalk-based pulp are 40-45% and 35%, respectively. Hence, a potential demand for corn stover is estimated at 18 million dry t/yr, at a market penetration of 50%.



Estimated corn stover availability and ethanol production potential as a function of the stover fraction that can be sustainably collected

The medium-density fiberboard (MDF) production in the United States is 1.5 billion ft^2/yr. Using typical MDF yields, the total corn sover demand is calculated as 1 million dry t/yr for 50% MDF production from stover.

Furfural, an industrial chemical, can be produced from many agricultural residues including corn stover. The U.S. furfural demand is estimated at 140,000 t/yr. This is equivalent to about 1 million t/yr of corn cobs if half of the furfural is made from corn cobs.

Based on these assumptions, 20% of the available corn stover could potentially be diverted to these non-ethanol applications.

Conclusion

The amount of corn stover that can be sustainably collected is estimated to be 80-110 million dry t/yr, a majority of which would be available to ethanol plants in the near term as only a small portion is currently used for other applications. Potential long-term demand for corn stover by non-fermentative applications in the United States is estimated to be 20 million dry t/yr, assuming that corn stover-based products replace 50% each of hardwood pulp and wood-based medium-density fiberboard, and that 50% of all furfural production is from corn cobs. Hence, 60-90 million dry t/yr of corn stover should be available to fermentative routes. To achieve an ethanol production potential of 3 billion gallons per year (a target level for a non-niche feedstock), about 40% of the harvestable corn stover is needed. This amount is readily available as long as the diversion of corn stover to non-ethanol fermentative products remains limited.