Stochastic modeling of costs of corn stover costs delivered to an intermediate storage facility

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Ethanol from corn grain currently provides 0.5% of transportation fuels (6 billion liters) used in the United States and uses 6% of annual corn production. Ethanol production from corn grain has been increasing over time and with the possible phase out of MTBE as the preferred oxygenate in gasoline, more ethanol production may be needed. There are limits to how much ethanol can be produced from corn grain. As more corn grain is demanded for ethanol production, the price of corn grain rises and prices of feed by-products produced in the ethanol production process decrease, thus making the economics of ethanol production from corn grain less favorable. In the longer run one would expect energy crops [e.g. switchgrass (*Panicum virgatum*), hybrid poplar (*Populus* spp.)] to be the feedstocks for the largest quantity of ethanol. However, corn stover provides a logical bridge between corn grain and energy crops, in part because no additional crop needs to be planted. Presently less than 10% of corn stover is collected. Corn stover is close to existing corn grain-to-ethanol production facilities. Estimates of annual collectible corn stover based on soil erosion models are in the range of 100 to 120 million dry metric tons (110 to 130 dry tons) per year, which would produce approximately 30 billion liters (8 billion gallons) of ethanol [1, 2, 3, 4]. More specific quantities of collectible corn stover with respect to other constraints, such as carbon and nutrient recycling, are yet to be determined.

There are many options to collect and transport corn stover. We have developed a spreadsheet model to cost some of these options. For our baseline case we assume the following: the spreader behind the corn combine is turned off so that a windrow forms behind the combine. Yield is 3.4 dry metric tons/ha (1.5 dry tons/acre) and moisture content is 25% on a wet basis. A 90 kW (120 hp) tractor pulling a large round baler with a megatooth pickup and a crop processor makes bales [1.8 m (6') diameter by 1.5 m (5') wide bales at a density of 144 dry kg/m^3 (9 dry lb/ft^3)]. A 34 kW (45 hp) tractor with a front end loader and a three-point hitch carries two bales at a time from the field to the roadside. A truck tractor and trailer capable of carrying 30 bales is loaded by a telescopic loader. The truck travels 24 km (15 miles) to an intermediate storage facility where the bales are unloaded by another telescopic loader and stacked five high in a covered storage shed. Storage cost is about $6/dry metric ton ($5/dry ton). The baseline case is not the least cost method of corn stover collection, but does represent a reasonable and relatively low capital cost method and represents available equipment on most forage producing farms. Our objective is to determine how variations in parameters such as crop yield, bale density, moisture content, time available for collection of stover, and distance to the storage facility affect costs. Also the impact on costs of some alternative collection methods, such as the use of self loading and unloading bale wagons are examined.

The baseline cost of corn stover delivered to the intermediate storage facility is $36/dry metric ton ($33/dry ton). The cost includes neither transportation to the site of final use nor a price paid to a farmer for the stover. If yield is only 2.5 dry metric tons/ha (1.1 dry tons/acre) then cost increases by $2.80/dry metric ton ($2.50/dry ton) and if yield is 4.3 dry metric tons/ha (1.9 dry tons/acre) then cost decreases by $1.50/dry metric ton ($1.30/dry ton). If bale density is only 112 dry kg/m^3 (7 dry lb/ft^3) then cost increases by $5.10/dry metric ton ($4.60/dry ton) and if bale density is 160 dry kg/m^3 (10 dry lb/ft^3) then cost decreases by $1.10/dry metric ton ($1.00/dry ton). If the farm equipment is operated only half as many hours then cost increases by $1.80/dry metric ton ($1.60/dry ton). The impact of moisture content is limited and for a change to 20% or 30%, the impact is less than $1.30/dry metric ton ($1.20/dry ton). However, this does not include the cost of drying or a penalty for overdried feedstock. For a yield of 5.6

dry metric tons/ha (2.5 dry tons/acre) using mesh wrap, cost is $28/dry metric ton ($25/dry ton). The capital cost of the farm equipment (tractors plus balers) is approximately $120,000. If a self loading and unloading bale wagon and a fast over-the-road tractor are used instead of the 34kW (45 hp) tractor and telescopic loader and truck to move the bales from the field to the storage facility, then an additional $120,000 must be invested.

Using results from the spreadsheet model, such as those presented above, we develop costs of delivering corn stover to a storage facility for a range of parameter values.

References

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