Alfalfa Biomass:
Energy Benefits of Alfalfa vs. Corn

by Michael Russelle, USDA-ARS Plant Science Research Unit - St. Paul

Corn grain ethanol has been in the news lately. The price of corn grain has risen because of this expanding market, and both livestock and crop producers are responding – the former by reducing their profit expectations, the latter by planning to plant corn after corn instead of their usual rotation.

Lignocellulosic Biomass

However, grain crops cannot provide enough alternative fuel, so the idea of lignocellulosic biomass has appeared on the radar – President Bush mentioned 'switchgrass' in his State of the Union address last year and Congress and individual states are introducing and adopting legislation that mandates development of renewable energy, including use of lignocellulosic biomass. ('Cellulosic biomass' has become the popular term, but is more properly called lignocellulosic biomass, because plant cell walls are a complex mixture of lignin with cellulose and hemicellulose.)

Woody species, grasses like switchgrass, and more recently mixed prairie species are the typical plants mentioned in relation to lignocellulosic biomass production. They have their place on marginal soils and landscape positions, but on good agricultural land, alfalfa provides great opportunities in biomass production systems.

Advantages of Alfalfa

Forage Focus readers are well aware of alfalfa's benefits to ground and surface water quality, soil quality, and crop rotations. In research by Dr. JoAnn Lamb and her colleagues, alfalfa yields were 40% higher and predicted ethanol production was doubled in a delayed two-harvest biomass production system compared to typical harvest systems for forage. This system also should provide better wildlife habitat compared to a 3- to 5-cut forage system.

An important economic and environmental contribution of alfalfa is the fertilizer N value when rotating to the next crop. The fertilizer N value of alfalfa to first-year corn is often in the range of 100-150 lb N/acre, representing a savings of $40-$60/acre at 40¢/lb fertilizer N costs. In addition, grain crops often have higher yield potential following alfalfa than following grain or soybean crops. Regardless of what causes this non-N rotation effect (decreased diseases, insects, or weeds, improved soil condition, etc.), it represents a real economic benefit to the producer and, furthermore, real energy savings. Alfalfa usually provides additional N credits to the second year of corn too.

Local Considerations

Due to low density and therefore higher shipping costs of biomass, lignocellulosic processing facilities are expected to depend more on locally-produced feedstock than corn ethanol facilities. A study was conducted of a proposed biomass fuelshed centered on the town of Madelia, MN, where there are plans for biomass- and bioproduct-based economic development. Using a crop yield model along with typical production practices, the yields and energy use were estimated for corn grain, corn stover, and alfalfa for each soil type in a 25-mile radius of the town. Removal of corn stover was restricted to 50% to help sustain soil organic matter levels.

Estimated ethanol production is lower for lignocellulosic than starch-based biomass. Estimated ethanol production for soils in the fuelshed ranged from 100-620 gal/a for alfalfa, 175-580 gal/a for corn grain, and 60-195 gal/acre for corn stover. Average estimated ethanol yields for the fuelshed were 385, 495, and 165 gal/a for alfalfa, corn grain, and corn stover, respectively. If ethanol production is the only goal, it's hard to beat corn grain in the Midwest.

But another story can be seen in the energy efficiency of these crops. From input and yield numbers, the net energy each crop would contain once delivered to a processing facility in Madelia was estimated. Energy input for corn production is considerably higher than for alfalfa, principally because of N fertilizer and the need to artificially dry corn grain most years. The net energy production in harvested corn grain and alfalfa was similar. However, the net energy gain (energy outputs divided by energy inputs) was about 25 for alfalfa and only 8 for corn grain and 11 for corn grain plus stover.

This kind of analysis can help local planners decide what kind of biomass processing will provide the desired economic/environmental benefits for their fuelshed. It can help facility managers decide where to concentrate their contracts for the selected feedstock and can also inform policy makers of the trade-offs between the production of a particular product and the broader public benefits each crop or cropping system offers.