Biofuels for Aviation Summit
Feedstocks Availability Session
Thelen Q/A

Question: Which crops have the greatest potential for low cost production (cost per MJ of bioenergy produced)?

Answer: Biofuels have the potential to be cost competitive with fossil fuels. Lynd et al. (2008) estimated the cost of liquid transportation fuels derived from cellulosic feedstocks to be at $3.00 per MJ compared to $8.70 for gasoline. Additionally, the authors project costs of $13.80 and $6.60 per MJ for soy biodiesel and corn grain ethanol respectively. Determining the best feedstock for biofuel production is confounded by several issues. A wide disparity between reported economic and energy input costs exists in the literature. Shapouri et al. reported the energy requirement of farm inputs for corn production in nine states to average 52 MJ per bushel compared to 100 MJ per bushel estimated by Pimentel and Patzek.

My own experience in working with farmers the past 20 years has shown a tremendous diversity in management between farms and even between years for the same farm. Decisions on which tillage operations to perform, which and how much fertilizer, pesticide, and seed traits to use are often based on a myriad of temporal economic, climatic, and environmental factors and interactions. Biological systems, including farming, are fraught with variability. Therefore, significant variability in the cost per MJ of bioenergy produced will continue to be observed. However, some generalizations can be made. When comparing enterprise cropping budgets for input costs and energy requirements, several items consistently rank near the top. These include nitrogen fertilizer, seed, and field machinery operations. Therefore, cropping systems that minimize these primary input cost items while maintaining yield will generally result in being more efficient on a cost per MJ of bioenergy produced basis. For example, perennial grass crops such as switchgrass have the potential for lower cost per MJ produced by virtue of their perennial life cycle (lower planting costs since a stand will last about 10 years) and lower nitrogen fertilizer costs (perennials will translocate some nutrients to root system in fall) compared to an annual grass crop such as corn. On soils responsive to reduced tillage, switching to no-till management can improve economic and energy returns with annual crops such as corn. Furthermore, the efficiency of annual crop systems can be improved by double-copping a winter annual biomass crop such as winter cereal rye, with corn or soybean.

To date, oilseed feedstocks for biodiesel such as soybean have tended to be less competitive than starch feedstock for ethanol. This is primarily due to competition for oilseed feedstock from food markets, which as demonstrated in 2008, can pay far more for vegetable oil feedstock than bioenergy markets. Additionally, with a limited land base and associated high land costs, the bioenergy quality component yield on a land area basis for a particular feedstock is critical. Soybean yielding 50 bushel per acre will produce roughly 75 gallons of biodiesel compared to 432 gallons of ethanol produced from a 6-ton switchgrass yield on comparable soils.

Question: What are the comparative carbon and greenhouse gas implications of the potential biofuel feedstock crops?

Answer: Similar to as described above for economic and energy effeciency, the diversity of management practices used by growers results in tremendous variability in the net global warming potential of various bioenergy cropping systems and even between the same crop grown on different farms. However, some generalizations can be made when estimating the carbon footprint of various bioenergy cropping systems. The inputs that tend to have the highest carbon cost associated with them are often the same inputs having the highest energy and economic costs such as nitrogen fertilizer and costs associated with stand establishment. Additionally, minimizing soil disturbance to reduce microbial decomposition of existing soil carbon stores is beneficial in reducing the carbon footprint of a cropping system. Therefore, perennial crop systems, with their extensive root systems and reduced fertilizer and pesticide inputs generally have a significantly lower carbon footprint relative to annual crop systems.

It is fairly straight forward to compare the direct carbon footprint of gasoline relative to a biofuel such as corn ethanol. According to the USEPA, for each gallon of gasoline burned in an automobile, 19.4 lb of CO_2 are emitted to the atmosphere. This is just from the carbon actually contained in the gasoline and does not include the carbon from extracting the crude oil, transporting the crude oil, refining the crude oil, and transporting the gasoline. By comparison, the net global warming potential of an equivalent amount of corn grain ethanol (1.4 gallons of ethanol per gallon of gasoline) is significantly lower. This is because the carbon contained in biofuel ethanol is autotrophically derived, meaning it came from the atmosphere in the first place (through photosynthesis of the corn plant from which the ethanol was made). Using international carbon accounting practices established by the International Panel on Climate Change (IPCC), and typical Michigan corn production inputs, a 150 bushel per acre corn crop will require approximately 28,000 seeds; 150 lb of N, 55 lb of P_2O_5, and 85 lb of K_2O fertilizers; 2 quarts of herbicide, and 5 gallons of fuel/lub/oil. On a per acre basis, these inputs would run up a carbon debt of about 1250 lb CO_2 equivalents per acre. The same acre would produce about 420 gallons of ethanol, giving a carbon footprint of only 2.9 lb. of CO_2 per gallon of ethanol. Or, on a gasoline equivalent basis, 4.2 lb of CO_2 emitted for each 1.4 gallons of ethanol burned which represents a 78% reduction in net global warming potential simply by using ethanol instead of gasoline. Even more promising, the carbon footprint of 2nd generation biofuels made from perennial grasses will be substantially lower yet – estimated at a 94% reduction from gasoline!

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