# LIHD biofuels: toward a sustainable future

*Linda Wallace, Department of Botany and Microbiology, University of Oklahoma, Norman, OK*

*Michael W Palmer, Department of Botany, Oklahoma State University, Stillwater, OK*

Will biofuels help to wean the US off of oil, or at least off of foreign oil supplies? While politicians and the press answer with a resounding "yes", the answer is not so simple. First, we need to understand what is meant by the term "biofuel". All biofuels are organic, energy-storing materials. Although they are widely perceived as new forms of energy, many biofuels are of ancient origin; crop residues, wood, and dried manure have been used for centuries as solid fuels. What is new is our attempt to make use of uniform feedstock to create liquid fuels, such as diesel, ethanol, and oil, on a large scale. The cultivation of crops like corn, oil palms, and switchgrass to provide such feedstock creates high-input low-diversity (HILD) agricultural systems. HILD systems are characterized by large-scale monocultures subject to large inputs of fertilizer, irrigation water, and pesticides.

HILD cultivation of biofuel feedstock – currently, the most common strategy for biofuel production – is plagued by a number of problems. One of the drawbacks is that it causes land to be diverted from other uses, including the production of agricultural commodities such as food and animal fodder. Another is its effect on markets; the January 2007 Tortilla Protest in Mexico was a reaction to high corn prices driven by the ethanol industry's demand for corn. Expansion of cultivated area for annual crops, such as corn, is predicted to cause increases in soil erosion and decreases in soil fertility. It will also necessitate increased artificial fertilization to promote production. The oft-repeated argument that increased $CO_2$ fixation by corn grown for feedstock will offset $CO_2$ release due to combustion is fallacious, because soil tillage, irrigation, and fertilization increase soil respiration, one of the largest terrestrial releases of $CO_2$. In addition, agrochemical production (including fertilizer production) is energy intensive and substantially compounds atmospheric $CO_2$ releases. To obviate this, some advocate the use of perennial crops such as switchgrass. Less tillage would be required in this scenario, but switchgrass cultivars for biofuels have low root-to-shoot ratios and low stomatal control. To achieve high yields, high fertilization and irrigation would be required, especially on marginal lands, thereby increasing soil respiration. Fertilization also causes increased release of nitrous oxides (potent greenhouse gases) into the atmosphere and of nitrates into surface and groundwater. Nitrates have been linked to digestive disorders, cancers, and the infamous blue-baby syndrome. Finally, HILD cultivation will lead to loss of biodiversity if native grasslands (some of which are currently Conservation Reserve Program lands or are marginal for food production) and other natural habitats are replanted with monocultures.

An alternative strategy to HILD is low-input high-diversity (LIHD) cultivation of biofuel feedstocks, a system advocated by David Tilman. LIHD mixed perennial grasslands are essentially of the same species composition as native prairie, and are mowed for hay, which can be converted into biofuel. LIHD feedstocks may pose special challenges for engineers and fermentation specialists because they are less uniform than the monocultures produced under HILD conditions. However, technologies currently exist, and new ones are being developed, for handling heterogeneous feedstocks. The benefits of LIHD include large reductions in agrichemical inputs (eg fertilizers, pesticides), soil tillage, and water demand.

We believe that LIHD practices are a sustainable use of grasslands because frequent biomass removal by fire or grazers is a common natural feature of many grasslands. Indeed, such removal is key to the maintenance of biodiversity in these systems. The vegetation science literature attests that mowing can mimic the effects of such natural disturbances, enhancing diversity of native species; in Europe, some grasslands of very high conservation value are threatened because centuries-old mowing regimens have been abandoned. LIHD can play a vital role in conservation as well as in the maintenance of ecosystem services.

With creative thinking by agronomists, chemical engineers, ecologists, and microbiologists, LIHD can buy us some time while we wean ourselves from foreign oil supplies. More importantly, it may help to diversify the US energy sector. Some of the benefits of LIHD are not immediate for farmers or ethanol producers; thus, incentives to encourage this type of cultivation must be carefully implemented. The ultimate challenge will be to create a sustainable system. As renowned author Richard Heinberg wrote, "to be sustainable, the use of *renewable* resources must proceed at a rate that is less than or equal to the rate of natural replenishment". LIHD provides a glimmer of hope that this vision of sustainability might not be a mirage.