There Is No Such Thing as a Free Biofuel from Crop Residues

by Rattan Lal

The growing importance of renewable energy and biofuels specifically is indicative of the high economic and environmental costs of fossil fuels and the insatiable energy demands of the globalizing and growing world economy. In his State-of-the-Union address on 23 Jan. 2007, President Bush enthusiastically proposed to cut U.S. gasoline consumption by up to 20% by 2017 through an increase in ethanol production to 35 billion gallons a year, or a fivefold increase over the current requirements. There are now 113 American ethanol plants and an additional 77 under construction, mostly sited in the U.S. Farm Belt. Most of the existing ethanol plants are corn grain-to-ethanol refineries. The long-term goal is to produce 60 billion gallons of ethanol per year to replace 30% of the ground transportation fuel demand of the U.S.

To meet these demands, the use of crop residues is being considered as a source of lignocellulosic feedstock for producing ethanol. One ton of corn stover or any other cellulosic biomass could theoretically produce 100 gallons of ethanol. Production of 60 billion gallons of ethanol from cellulosic biomass would require 600 million tons of biomass per year. The overall goal is to procure 1 billion tons of biomass for the U.S. and about 4 billion tons for the world. The current rate of residue production from all crops is about 500 million tons in the U.S. and 4 billion tons in the world. Some analysts argue that 300 million tons of corn residue could be harvested for meeting the U.S. ethanol demands. Similar to the U.S., 34 straw-burning power plants were being built at the end of 2006 in China's rural areas with a capacity of producing 1.2 million kW of energy. The straw-burning power industry is likely to grow in China. Of the 600 million tons of straw produced annually, China plans to use 300 million tons to produce energy. India, which produces about 440 million tons of crop residues annually, also has plans to build straw-burning power plants.

A Precious Commodity

This is a dangerous trend because crop residue is not a waste. It is a precious commodity and essential to preserving soil quality. In addition to controlling erosion and conserving soil water in the root zone, retaining crop residues on the soil is also necessary for recycling nutrients, improving activity and species diversity of soil micro- and macro-fauna, maintaining soil structure and tilth, reducing nonpoint source pollution and decreasing the risks of hypoxia in the coastal regions, increasing use efficiency of fertilizers and other inputs, sustaining biomass/agronomic yield, and improving/maintaining soil organic matter content. Soil carbon, a tradable commodity that can generate another income stream for farmers, cannot be sequestered without recycling the crop residues back into the soil. Thus, crop residues can be used either to restore soil quality and its carbon pool or for power/biofuel production, but not both. In view of its numerous environmental and agronomic benefits, there is a strong justification for adopting the slogan "grains for people, residues for the soil." This equity is essential to maintaining soil quality at a level at which it can provide all ecosystem services and functions essential to sustainable use of soils for generations to come. Use of biofuels could substantially reduce gaseous emissions, provided that appropriate sources of feedstock are identified, especially those which do not degrade soil and environment quality.

Harvesting crop residues for use as fodder for livestock, residential fuel for cooking and heating, construction material, and other competing uses is a reality in sub-Saharan Africa, South Asia, China, and other developing countries. Therefore, it is not surprising that these are also the regions that have been plagued with severe problems of soil degradation by physical (crusting, compaction, erosion by water and wind, and decline in soil structures and tilth), chemical (acidification, salinization, negative nutrient budget, and elemental imbalance), and biological (depletion of soil organic matter and reduction in soil biodiversity) processes and the attendant low crop yields. With a severe decline in physical quality, degraded soils do not respond to fertilizers even if made available at a subsidized price. Adverse effects of none or low rates of applications of fertilizers and other amendments on agronomic production and soil quality have been exacerbated by the perpetual and indiscriminate removal of crop residues coupled with uncontrolled and excessive communal grazing. The stubborn trends of low crop yields and perpetual hunger and malnutrition in sub-Saharan Africa and in regions of rainfed agriculture in South Asia cannot be reversed without returning crop residues to the soil and also supplementing them with liberal applications of other biosolids (e.g., animal dung and compost) to enhance soil organic matter content and improve soil quality. Over and above the adverse effects on the health of soil and ecosystems, the impact of burning crop residues and animal dung as cooking fuel on the health of women and children in rural Africa and Asia cannot be ignored.

Data of some field experiments have indicated that about 25% of the crop residues (e.g., corn stover) can be harvested for biofuel production and other purposes without severely jeopardizing soil quality and reducing soil organic matter content. However, questions remain as to whether it is economically and technically feasible to harvest only 25% of the crop residues and leave the remainder

> *Crop residues can be used either to restore soil quality and its carbon pool or for power/biofuel production, but not both."*

on the soil. Would the farmer be tempted to harvest more for the short-term economic gains while fully knowing the long-term risks of endangering soil's ecosystem services and functions? What price in soil and environmental degradation are we willing to pay for producing biofuels from crop residues?

Identifying Viable Lignocellulosic Feedstocks

Yet, biofuels are important to the national and international economy and the environment. Therefore, high priority must be given to identifying viable alternative sources of lignocellulosic feedstock by:

1. developing appropriate farming systems in which energy plantations are important components of the rotation cycle;
2. identifying surplus, degraded/marginal lands, and mined lands where biofuel plantations can be established without taking land out of the grain crop or livestock production;
3. creating packages of cultural practices for sustainable management of energy plantations; and
4. choosing appropriate species of warm-season grasses, short-rotation woody perennials, and halophytes, which can be grown in arid regions by irrigation with brackish water.

Some researchers have also argued that biofuels derived from low-input high-density (LIHD) mixtures of native grassland perennials can be a viable source of biofuel feedstock, an option which merits a serious consideration.

Indiscriminate removal of crop residues for bioethanol production has steep environmental costs and also can set in motion undesirable soil degradation trends. Such adverse effects must be objectively and critically reviewed prior to implementing large-scale cellulosic ethanol plants. Short-term gains may be offset by severe adverse changes in soil quality, depletion of the soil C pool, accelerated erosion, increase in nonpoint source pollution and the problem of hypoxia in coastal ecosystems, reduction in agronomic production and economic profitability, and exacerbation of the global warming that we had wished to mitigate by producing biofuels.

National and international biofuel strategy must involve establishment of biofuel plantations in which soils are specifically chosen, plant species are identified for specific ecoregions, and management systems are developed to optimize the resource use. Production systems must be developed so that ethanol produced must be at least C neutral if not C negative. Temptations aside, biofuels produced from crop residues may neither be free nor cheap.

R. Lal, SSSA President; lal.1@osu.edu or 614-292-9069.