Grasses have potential as alternate ethanol crop, study finds

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Money may not grow on trees, but energy could grow in grass. Researchers at the University of Illinois have completed the first extensive geographic yield and economic analysis of potential bioenergy grass crops in the Midwestern United States.

Demand for biofuels is increasing as Americans seek to expand renewable energy sources and mitigate the effects of fluctuating energy prices. Corn ethanol is the main biofuel on the market, but demand for ethanol competes with corn's availability as a food, and rising ethanol consumption could lead to higher food costs.

In recognition of this problem, federal regulations mandate that 79 billion liters of biofuels must be produced annually from non-corn biomass by 2022. Large grasses, such as switchgrass and miscanthus, could provide biomass with the added benefits of better nitrogen fixation and carbon capture, higher ethanol volumes per acre and lower water requirements than corn.

"It's a better way to achieve our goals of energy security and climate change mitigation," said Madhu Khanna, a professor of agricultural and consumer economics at U. of I. "These two particular crops are among the more promising nonfood crops currently available for large-scale production."

Switchgrass is large prairie grass native to the Midwest, and Miscanthus, a sterile hybrid, is already widely cultivated in Europe as a biofuel crop.

The Illinois team wanted to determine whether biofuel grasses could be viable cash crops in the U.S. and to explore how this viability varies by location.

"This is the first study to look at both the agricultural potential and socioeconomic costs of grass crop production," said atmospheric sciences professor Atul Jain. "We came to the conclusion that in order to study the potential to grow these grasses in this region, we have to have an integrated assessment study of socioeconomics and biophysical aspects."

The team published its results in the October issue of the journal *Global Change Biology Bioenergy*.

Recognizing that growing conditions throughout the Midwest can vary widely, the team performed a county-by-county analysis to gain a high-resolution picture of crop potential rather than generalizing the study across the entire region.

"This research suggests that in order to induce land owners to use their land for bioenergy crops, yield is a critical factor that will influence that decision," Khanna said. "We wanted to look not only at the implication for a representative land owner, but also how it differs across location."

The team began by predicting local yields for the two grass crops. They used an integrated sciences system model, a biophysical model used not only for yields but also estimated carbon uptake and possible atmospheric effects from changes in land use.

"We have to consider the biophysical aspects – where the crops can grow in terms of soil, water and nutrient availability, and climate conditions," Jain said.

The researchers found that, in general, the yield is very high for miscanthus – up to three times higher than switchgrass in the Midwest. Even through switchgrass is native to the region, it doesn't grow well in higher latitudes like Minnesota or Wisconsin because it has poor tolerance for cold temperatures.

For both grasses, yield varies considerably throughout the Midwest, generally lower in the north and much higher in the south.

Most notably, for the southernmost counties – much of southern Illinois and nearly all of Missouri – the model predicts greater production of grasses than of current corn and soy crops. This could be a key factor in farmers' decisions to cultivate biofuel crops.

Next, the researchers estimated the minimum price at which landowner would need to sell the two grasses to break even on costs. They conducted a detailed analysis of production over the life of the plants and the costs involved at each step, and then compared the cost to the return from corn and soybeans.

"There's a number of factors that would impact the profitability of growing these crops as opposed to growing corn and soybeans, which include the cost of establishing these grasses as well as maintaining, storing and transporting them," Khanna said. "Another issue is the cost of the land itself. A farmer who converts land from corn and soybeans to miscanthus or switchgrass is giving up his profits from corn and soy."

Unlike annual crops that provide a farmer with a crop every year, miscanthus and switchgrass require a lag of at least two years before harvesting. In addition, the cost of harvesting is nearly one-third of the cost of producing biomass, according to Khanna. In the U.S., such large-scale grass harvesting hasn't been attempted, making cost estimates difficult. The most comparable crops currently grown are hay and

alfalfa, which have yields only one-sixth to one-tenth of the possible volume from miscanthus.

In addition, the costs very between switchgrass and miscanthus. Miscanthus has a much higher yield, but also a much higher initial cost. Miscanthus is planted from small sprouts called rhizomes, which are much more expensive than switchgrass seed. However, miscanthus has a longer lifespan, so planting would be less frequent. These are tradeoffs farmers would have to consider when deciding to cultivate biofuel grasses.

Ultimately, the study found that biofuel grasses could be a viable crop in the U.S. – under certain conditions.

"We find it's more profitable to grow miscanthus and switchgrass in areas where the yield of miscanthus and switchgrass is high, but the yield of corn and soybeans is low," Khanna said. "In areas like southern Illinois or Missouri where corn is not as productive as in central and northern Illinois or Iowa, these grasses are likely to be more competitive."

Next, the team will explore the cost of growing these grasses on non-cropland, or marginal land that's ill suited for food productions. The grasses require less water and less fertilizer than corn or soybeans, and could thrive on land that's currently unused for reasons of soil composition or difficult maintenance. It would cost a lot less for farmers to convert that land than acreagethat's currently producing high amounts of other crops, ameliorating one of the major tradeoffs of biomass production.

"We clearly found that even if the yield of grasses is much higher, we need to think about the cost of producing them. That's the bottom line," Jain said.

More information: The paper, "An Integrated Biogeochemical and Economic Analysis of Bioenergy crops in the Midwestern United States," is available online at onlinelibrary.wiley.com/doi/10 … 07.2010.01041.x/full

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