The first decade: Team reports on US trials of bioenergy grasses

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Researchers grew *Miscanthus x giganteus* (the taller grass) and switchgrass in side-by-side field trials in seven locations in Illinois. Credit: L. Brian Stauffer

The first long-term U.S. field trials of *Miscanthus x giganteus*, a towering perennial grass used in bioenergy production, reveal that its exceptional yields, though reduced somewhat after five years of growth, are still more than twice those of switchgrass (*Panicum virgatum*), another perennial grass used as a bioenergy feedstock. *Miscanthus* grown in

Illinois also outperforms even the high yields found in earlier studies of the crop in Europe, the researchers found.

The average annual yield of *Miscanthus* grown in seven Illinois locations over a period of eight to 10 years was 10.5 tons per acre, compared with 4.5 tons per acre for switchgrass grown in side-by-side trials in Illinois, the researchers report. *Miscanthus* yields in Europe are about half of those reported in the Midwest.

The study took into account differences in yield that were the result of annual weather changes (primarily heat and precipitation, both of which increased growth).

The new findings appear in the journal *Global Change Biology: Bioenergy*. University of Illinois plant biology and Institute for Genomic Biology professor Stephen P. Long, who led the study, founded and edits the journal. The Energy Biosciences Institute at the U. of I. supported the research.

Miscanthus does almost as well in poor soils as in fertile cropland, Long said.

"That was the earlier finding in Europe and now we can confirm this for the Midwest," Long said.

"It takes a little bit longer to establish Miscanthus in poorer soils, but once it's established the yields seem to be almost as good as in the very best soils," he said. The difference in yield between richer and poorer soils was less than 10 percent.

Several growers in the U.S. pelletize Miscanthus for use as a renewable, carbon-neutral energy source. The pellets are burned to produce electricity or heat. There is a growing market for pelletized Miscanthus

in the U.S. and in Europe, Long said.

"However, the expected long-term and larger market for Miscanthus is in digesting the celluloses in the biomass to sugars for fermentation to ethanol and other liquid fuels," Long said. "This would complement corn ethanol, since it would allow the use of land unsuited or marginal to corn and other row crops," he said.

Long and his colleagues calculated the total land area needed to produce enough Miscanthus to meet the U.S. Renewable Fuel Standard mandate for cellulosic ethanol production by the year 2022. They found that the RFS mandate of 16 billion gallons (60 billion liters) of cellulosic ethanol by 2022 would require 17 million acres of *Miscanthus x giganteus* or 39 million acres of switchgrass.

"That 39 million acres sounds like a lot and is a lot, but keep in mind that the 48 contiguous states are almost 2,000 million acres," he said. "We use only about a fifth of that in our row-crop agriculture – cotton, corn, soybean, wheat, etc. And we actually have at least 550 million acres that have been abandoned from agriculture in the last 150 years. This is not land that has been lost to urban sprawl."

Because *Miscanthus* grows well in poor soils, it could be planted on former agricultural lands left unused after the Dust Bowl to prevent soil erosion, Long said. Or it could be grown on Conservation Reserve Program lands, agricultural areas left fallow to avoid farm surpluses in the U.S., he said.

"We have 40 million acres in the Conservation Reserve Program," he said. "A crop like *Miscanthus* would be suitable for that land because it doesn't have the same erosion problems of an annual crop. You're not plowing the land every year, and you have a dense perennial root system that binds the soil.

"In fact, *Miscanthus* is arguably better than leaving this land fallow," he said. "Not only is it a productive use, but the rapid growth of its root system will bind and improve the soil more rapidly. As well as being productive above-ground, *Miscanthus* was shown in Illinois to accumulate more roots over a period of five years than fallow land or even a native prairie ecosystem."

An added advantage is that *Miscanthus* can be grown with little or no added fertilizer, he said. In the autumn and winter the nutrients drain out of the stems and leaves and are retained in the roots, stimulating new growth the following spring.

The recycling of nutrients is not 100 percent efficient, however, and the team wanted to know if adding nitrogen would compensate for the age-related yield declines.

In another study published in *Bioenergy Research*, Long and his colleagues report that adding nitrogen to *Miscanthus* and switchgrass significantly improved yields over time (by 25 percent and 32 percent, respectively). This eliminated the age-related declines in yield seen in switchgrass and about 40 percent of the loss found in *Miscanthus*. But the increases were small compared to the effects of fertilizing crops such as Zea mays (corn), and probably not large enough to justify the added cost of fertilizer, the team reported.

"The bottom line is if we simply plant *Miscanthus* and leave it, we don't see the same yield at year eight and year 10 that we saw in years three and five," Long said. "But we're still seeing a very high yield."

More information: *GCB: Bioenergy* paper: "Yields of Miscanthus x giganteus and Panicum virgatum Decline With Stand Age in the Midwestern USA," onlinelibrary.wiley.com/doi/10 … /gcbb.12077/abstract

Bioenergy Research paper: "Nitrogen Fertilization Does Significantly Increase Yields of Stands of Miscanthus x giganteus and Panicum virgatum in Multi-Year Trials in Illinois"

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