Mixtures of bioenergy species yield as well as monocultures

by Madeline Fisher

For those hoping to sow some diversity back into the Corn Belt with dedicated bioenergy crops, mixtures of native prairie species seem like an obvious choice. Farmers, though, need to manage biofuels crops for maximum yields and returns. So for them, simple monocultures of switchgrass fertilized with nitrogen may be best.

A study in the September–October 2015 issue of *Agronomy Journal* (http://bit.ly/1NusPO2) now suggests the options aren’t quite so black or white. In a seven-year experiment spanning nine locations in Minnesota and North Dakota, an eight-species mixture, or polyculture, of perennial grasses and legumes produced as much biomass as switchgrass monocultures when plots weren’t fertilized. And yields of another polyculture—an assemblage of four grasses—rivaled those of switchgrass when nitrogen was added.

Although the bioenergy industry has taken a hit recently from plummeting oil and gas prices, a few commercial cellulosic ethanol plants are now in operation—notably the POET-DSM plant in Emmetsburg, IA. In the meantime, many Midwest farmers are interested in restoring native prairie vegetation for non-commercial reasons, says Jacob Jungers, the study’s lead author. But they also can’t neglect the bottom line.

“We’ve spoken to producers who want to manage a polyculture because it provides wildlife habitat and other ecosystem services. But they also want to make sure it’s an economically feasible system that will produce some level of biomass to make a return,” explains the University of Minnesota postdoctoral researcher fellow. “So we hope the results from this study can help inform that decision-making process.”

Although it remains controversial, the hypothesis that systems with higher plant diversity are more productive is well supported by ecological research. In a seminal 2006 paper, for example, University of Minnesota ecologist David Tilman reported that on an abandoned farm with unproductive soils, diverse mixtures of prairie grasses and forbs produced 238% more bioenergy, on average, than monocultures of switchgrass or other species.

However, Tilman’s study was “a classical plant community ecology experiment,” not an agricultural one, says Jungers, who worked on the project as an undergrad—leaving many unconvinced that a real bioenergy production system would yield similar results. In 2006, Jungers’ advisers Don Wyse and Craig Sheaffer decided to put this to the test. In true agronomic fashion, their experiment compared yields of mixtures and monocultures across a wide range of soil, temperature, and other growing conditions. They tested the effects of adding nitrogen; selected biofuels species—such as Canada wild rye and big blue stem—that are relatively cheap and easy to establish; and harvested plant biomass at the end of each season just like producers would.

They also collected data for seven years. “Natural succession takes place in any polyculture, whether it’s managed or not, and we didn’t know how management would steer the succession,” Jungers explains. A particular question was how adding nitrogen might alter the mixtures, since previous research has documented the loss of species with fertilization.

Most of the time, switchgrass monocultures were the star performers, the team found. What they didn’t expect is that an eight-species mixture of grasses and legumes would...
generate as much biomass as switchgrass in unfertilized plots; 5.1 Mg/ha\(^{-1}\) on average. With nitrogen fertilizer, switchgrass yields jumped to 6.8 Mg/ha\(^{-1}\). But even then, a fertilized, four-species grass mixture kept pace, producing 6.4 Mg/ha\(^{-1}\), on average.

In contrast to previous work, nitrogen fertilizer also didn’t reduce diversity over time—even in polycultures with as many as 12 and 24 species. The reason, Jungers believes, is that biomass was harvested each season. Additions of fertilizer tend to favor species that can take up nitrogen quickly and efficiently, allowing them to outcompete and eventually exclude other plants. “However, when you harvest, you’re giving another set of species an advantage,” he says—specifically those that flourish in the extra light that biomass removal lets in. Put another way, harvesting “resets” the system each year, helping ensure no one species can take over.

All in all, the findings suggest that while managing agricultural lands for greater diversity and ecological functions will never be easy, it’s more feasible than people once thought. “Natural phenomena do still play out”—and can be leveraged—in plant communities subjected to harvesting, fertilizing, and other management practices, Jungers says.

Still, even he admits to being surprised—and relieved, he adds with a laugh, since he wants to make a career in agroecology. “All the work that’s been done in the past, the basic ecology, is holding up, even though we’re manipulating these systems.”

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