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Baling five hundred acres a day—Photo by Lynn Jaynes.

Progressive Forage Grower, 45,000
Free to growers with over 100 acres of hay, silage or pasture in the U.S. and industry professionals. Progressive Forage Grower is published 10 times annually.
The impact of corn ethanol demand on grain prices over the past few years has brought food versus fuel competition for farmland into sharp focus. “First-generation” bioenergy feedstocks are basically redirected food and feed crops – primarily corn and soybeans. However, if we as a nation are to substantially increase bioenergy production without further affecting food and feed prices, this expansion will have to take place on non-prime marginal farmlands.

When discussing this question, it isn’t long before someone will peremptively ask, “What exactly do you mean by marginal?” And that’s a good question, because at its root, marginal farmlands.

However, lands that are marginal for one crop may still be suitable for others, and that’s where perennial grasses and other “second-generation” bioenergy feedstocks (including short-rotation willow) fit in. Second-generation bioenergy crops are perennials that, once established, have far lower needs for field machinery operations; fertilizer and pesticide requirements are also lower. As a result, their net energy balance (energy produced minus energy inputs) is much greater, and their projected environmental impacts are much smaller.

But the problem is that there hasn’t been much second-generation feedstock research carried out on marginal soils. That’s where we – and other researchers who are part of the USDA’s sustainable bioenergy program – come in.

For our research project, our interest has from the outset been on how perennial grass feedstocks perform on wetness-prone marginal soils common in the Northeast. Former farmlands in the region represent millions of acres. Many abandoned lands have reverted to woodland, and others are now suburbs, but the land base of idled fallow grassland and scrub still represents a significant untapped potential for second-generation bioenergy production.

Our research focuses on switchgrass and reed canarygrass, switchgrass being a warm-season C4 grass that tolerates heat and dry conditions, and most research in the Northeast prior to its selection as a bioenergy feedstock focused on its use as summer pasture. In contrast, although reed canarygrass is often regarded as a sustainable bioenergy feedstock because it needs nitrogen to produce high yields, it is a cool-season C3 grass that is very well-adapted to wet and cool conditions. Both grasses have multiple potential end-uses as bioenergy feedstocks, including conversion to liquid fuels by fermentation or thermochemical conversion as well as direct combustion in bioheat applications.

Whereas most yield trials try to find fields that are reasonably uniform, we intentionally chose fields with a range of soil moisture conditions (one Midwestern colleague calls them “wet to really wet”). Our two primary sites have soil drainage catenas caused by slight changes in slope, resulting in three differing soil series occurring in as little as 100 feet. We set up sampling points along these soil and wetness gradients, and at these sampling points we monitor crop establishment, yields and impacts. One site (slightly better drained, overall) already had a fourth-year stand of switchgrass in place (Shawnee upland variety), whereas the larger, generally wetter site had been fallow aside from occasional mowing for at least 50 years and was dominated by reed canarygrass and mixed broadleaves.

We are measuring a wide range of variables in addition to yields. The USDA is particularly interested in soil carbon trends: Does switchgrass store carbon in the root zone of shallow Northeastern soils as well as it does in the Midwest? Emissions are another primary concern: Wet soils are more prone to denitrification, during which a small percentage ends up as nitrous oxide (N2O). N2O has been steadily increasing in the atmosphere ever since humans learned to make N fertilizer on a large scale, and is considered a primary threat to the ozone layer. The big challenge with measuring N2O losses is that the bulk of emissions can occur in relatively short events when conditions are just right – usually (but not always) following fertilization, with soil warming up and wet (but not too wet). This is why we monitor N2O emissions, not only periodically at many locations in our field to find out the response at our various crop and wetness treatments, but also continuously at a fixed sampling mast location in our field to see what overall emission trends are over time.

Despite relatively low N fertilization rates, the recurring

Perennial grass bioenergy on marginal soils of the Northeast

Brian Richards, Cathelijne Stoof, Julie Hansen, Ryan Crawford and Jamie Crawford for Progressive Forage Grower

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wetness of marginal soils means that we need to work toward minimizing potential NO\(_3\) emissions as the acreage of marginal land devoted to bioenergy feedstock production increases.

We are also tracking multiple measures of soil health each year, including aggregate stability, active carbon, soil hardness and water-holding capacity. Other teams are also making good use of our sites: USDA collaborators Gail Wilson (Oklahoma State) and R. Mike Miller (Argonne National Laboratory) are looking at how symbiotic mycorrhizal micro-organisms bolster switchgrass production.

At the time of writing, we are just finishing our third year of research. While the reed canarygrass plantings established quickly (which is unsurprising given our site conditions), results so far reflect the challenges of establishing switchgrass on wetter sites, at least when the weather is unfavorable. After planting in 2011, we had an abnormally warm early spring in 2012 that brought the switchgrass out of dormancy too soon. That was followed by a hard freeze and snow that damaged the stands in wet areas that we needed to re-seed (with a no-till drill) that summer. Growth since then has been better, but resurgent reed canarygrass in the switchgrass plots has been putting up a fight.

Given that switchgrass takes three years to reach full production under the best conditions, we’re looking forward to seeing what the coming growing season brings us. In contrast, the switchgrass at the already-established site (where switchgrass stands have long ago crowded out any weeds) had a banner growing season this year due to summer rainfalls that were near double normal levels.

In terms of trends so far, the soil organic carbon levels are still recovering from the expected losses caused by the sod plowdown prior to planting. Hydrologic tracking shows that our sampling arrays are capturing the range of soil wetness conditions at both sites, and this approach is working well for making sense of soil organic trends and yields, especially switchgrass establishment.

We are presently calculating and auditing our NO\(_3\) emissions data collected to date and will continue monitoring for two more years as the stands mature and will translate our findings into better recommendations.

Our ultimate goal is to help perennial grass-based renewable bioenergy succeed in the Northeast by maximizing profitability and minimizing adverse impacts from feedstock production on marginal soils.

Brian Richards, Cathelijne Stoof, Julie Hansen, Ryan Crawford and Jamie Crawford are with Cornell University.

A common sight in upstate New York – idled wetland with acres of fallow grasses and goldenrod. This “marginal” land could potentially be used to grow switchgrass for bioenergy. Photo courtesy of Brian Richards.

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