cenusa bioenergy

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Research Summary: Biofuel Quality Improved by Delaying Harvest of Perennial Grass

Research shows how a simple management strategy can decrease nitrogen contaminants in perennial grasses, while also providing additional ecosystem services.

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Abstract

Nitrogen ash and other mineral matter can be a problem in processing perennial grasses into biofuel through the fast pyrolysis method. Delaying biomass harvest until after senescence can dramatically decrease the amount of N contaminants in the final product. In addition, the amount of N in the perennial grass crop is a good predictor of the amount of N in the resulting biofuel.

Research Purpose

Farmers who grazed livestock learned thousands of years ago that the timing of the hay crop harvest was important—their animals much preferred green, leafy forage to older, stemmy grass. But for producers growing perennial grasses such as switchgrass to turn into biofuel, does harvest timing still matter? Danielle Wilson and Emily Heaton of the Department of Agronomy at Iowa State University researched this question as part of CenUSA Bioenergy, a coordinated research and education effort funded by the USDA's National Institute of Food and Agriculture.

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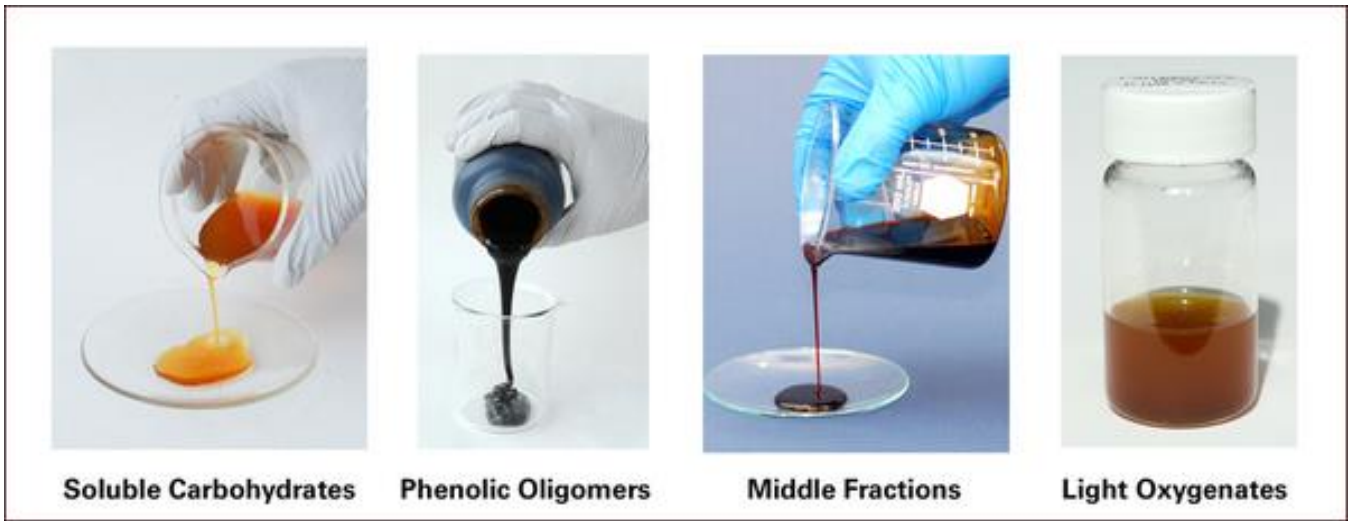
The research was also funded by Phillips 66.

Figure 1. Switchgrass harvesting. Photo: Rob Mitchell, USDA-ARS.

Research Activities

Heaton and Wilson investigated the importance of harvest time on switchgrass, a major biofuel feedstock likely to be processed by fast pyrolysis, a thermal process technology that rapidly heats biomass to convert it into bio-oil. Although fast pyrolysis shows promise as an affordable process to convert biomass into a useable biofuel, contaminants in the biomass itself can reduce the quality of the final bio-oil. Specifically, nitrogen (N) ash and mineral matter in the feedstock can decrease the shelf-stability of the resulting bio-oil.



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Pyrolysis bio-oil can be collected as a number of fractions to better enable upgrading to fuels and chemicals. Photo courtesy of the Bioeconomy Institute, Iowa State University (http://www.biorenew.iastate.edu).

Although methods to reduce mineral contamination in the final biofuel product are common, little is known about the effect of initial feedstock quality on that product. To answer this question, the researchers used a novel field experiment to find out whether the amount of N in the feedstock correlated to the amount of N in the final bio-oil product.

Heaton and Wilson set up switchgrass field trials at Iowa State University's South Reynoldson Research Farm. Plots were harvested at different times throughout the summer and fall of 2010 and the spring of 2011. They processed the harvested switchgrass into bio-oil using fast pyrolysis, and analyzed the N concentrations in the switchgrass feedstock and in the final bio-oil.

What We Have Learned

Heaton and Wilson showed that that the timing of switchgrass harvest does indeed have an effect on crop N concentration, and that crop N concentration can accurately predict the amount of N in the final bio-oil product. Heaton and Wilson found that switchgrass N dropped as much as 68% between June and November, starting after flowering and continuing throughout plant senescence.

Figure 2. Mature switchgrass. Photo: Dennis Pennington, Bioenergy Educator, Michigan State University.

Although holding off on harvest until a killing frost did reduce yields of biomass significantly—22% DM drop between August and November harvests—**more** bio-oil was

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produced per unit of biomass. Therefore, delaying switchgrass harvest past senescence can result in lower contaminant levels in the bio-oil product.

However, there is no further benefit to waiting until the following spring to harvest. The research found that overwintering the crop reduced biomass yields, by 37%, without also reducing N content further.

Why Is This Important?

By understanding the effects of agronomic management on feedstock quality, farmers can plan their harvest for optimal quality and secure higher prices per bale by tailoring their crops to the requirements of the feedstock customers. Refiners will be able to accurately screen the biofuel feedstock they are buying for contaminants and quality.

Figure 3. Meadowlark nest in CenUSA switchgrass demo plot. Photo: F. John Hay.

Agronomic management strategies are also important to the sustainability of biofuel production. N fertilizer can have a high cost, both economically and in carbon emissions. By removing as little N as possible in harvested biomass, less fertilizer N is needed because effective harvest timing can maximize the return of plant N to the soil for future crop growth.

"Improvements in bio-oil quality were realized, not with expensive treatments to the bio-oil, but instead with a simple management strategy, i.e., delayed harvest, that has also

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been shown to…improve the economic and environmental sustainability of biofuels by minimizing external N fertilizer inputs," Heaton and Wilson write.

A management strategy that delays harvest reaps benefits beyond the individual farm and the biofuel industry, for the rest of the public. For example, later harvest of a biofuel feedstock may allow ground-nesting birds such as meadowlarks, bobolinks, quail, and turkeys to finish raising their broods safely and help reverse declining populations of some birds.

Also, reducing the amount of N fertilizer inputs can help improve overall water quality in addition to generating fewer greenhouse gases from a farm operation. Improving wildlife habitat and cutting back on N inputs are just two of the ecosystem services—benefits that ecosystems provide to people—that better agronomic management techniques offer today.

For More Information

- Contact: **Dr. Emily Heaton**, Assistant Professor, Iowa State University heaton@mail.iastate.edu, 515-294-1310.
- Wilson, Danielle M., Dustin L. Dalluge, Marjorie Rover, Emily A. Heaton & Robert C. Brown, Crop Management Impacts Biofuel Quality: Influence of Switchgrass Harvest Time on Yield, Nitrogen and Ash of Fast Pyrolysis Products; BioEnergy Research, July 2012. http://link.springer.com/article/10.1007/s12155-012-9240-0
- Mitchell, Robert , Kenneth Vogel & Gautam Sarath, USDA-ARS. Managing and Enhancing Switchgrass as a Biofuel Feedstock,
- When to Harvest Switchgrass and Miscanthus, BFJ.com podcast with Dr. Emily Heaton, Assistant Professor, Iowa State University.
- **CenUSA Bioenergy Resources CenUSA Project Resources** - Research-based information on the opportunities and challenges in developing a sustainable system for the thermochemical production of biofuels from perennial grasses grown on land marginal for row crop production is available at www.cenusa.iastate.edu

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