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PENN STATE | NEWS

Experimental biomass harvest a step toward sustainable, biofuels-powered future

Jeff Mulhollem
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The first harvest of 34 acres of fast-growing shrub willow from a Penn State demonstration field this winter is a milestone in developing a sustainable biomass supply for renewable energy and bio-based economic development, according to researchers in Penn State's College of Agricultural Sciences.
The shrub willow plantation is part of a broader five-year program called NEWBio, which is aimed at investigating and promoting sustainable production of woody biomass and warmseason grasses for energy in the Northeast. Planted in 2012 on land formerly owned by the State Correctional Institution at Rockview, the biomass crop will regrow and will be harvested every three years from now on.

NEWBio, a regional consortium of institutions lead by Penn State and funded by the U.S. Department of Agriculture's National Institute of Food and Agriculture, is one of seven regional projects across the United States. Other consortium partners are Cornell University, SUNY College of Environmental Science and Forestry, West Virginia University, Delaware State University, Ohio State University, Rutgers University, USDA's Eastern Regional Research Center, and the U.S. Department of Energy's Oak Ridge National Laboratory and Idaho National Laboratory.

Researchers involved in the project include plant scientists, agricultural and biological engineers, agricultural safety and health specialists, agronomists, agricultural and forest economists, rural sociologists, supply-chain and business-development experts, and extension educators.

"The shrub willow stand at Rockview can continue producing biomass for more than 20 years, and we hope to use it both as a source of renewable energy and as a platform for sustainability research," said Armen Kemanian, associate professor of production systems and modeling in the Department of Plant Science, one of the lead researchers in the project.
"This is an excellent site to investigate impacts on soil and water quality, biodiversity, avoided carbon dioxide emissions, and the potential for growing a regional bio-based economy," he said. "Students from our college visit the site and have a firsthand and close-up view of this new crop for the region."

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The shrub willow stand at the Rockview site can continue producing biomass for more than 20 years, according to researchers who intend to use it both as a source of renewable energy and as a platform for sustainability studies. They believe it is an excellent site to investigate impacts on soil and water quality, biodiversity, avoided carbon dioxide emissions, and the potential for growing a regional bio-based economy.

Image: Penn State

Pausing during the recent shrub willow harvest are (from left) Felipe Montes, research associate in the Department of Plant Science, Armen Kemanian, associate professor of production systems and modeling in the Department of Plant Science, and Michael Jacobson, professor of forest resources in the Department of Ecosystem Science and Management.
Image: Penn State

Why shrub willow? Because the woody perennial likes to be cut, explained Kemanian. He noted that visitors to Grand Teton National Park in Wyoming may remember the "willow flats," grazed to a uniform height by moose and elk.

"At the Rockview site we don't have moose, but we do take advantage of shrub willow's vigorous regrowth to harvest for multiple cycles," he said. "As perennial plants, they establish a root system that stabilizes the soil and stores substantial amounts of carbon that otherwise would be lost to the atmosphere."

Perennial biomass crops shrub willow, switchgrass and miscanthus -- all of which are being investigated at other experimental sites around the Northeast -- also store and recycle nutrients, so they do not require much fertilizer and can improve water quality in streams, rivers and estuaries, such as the Chesapeake Bay. Increasing perennial vegetation is a critical component of Pennsylvania's water quality strategy, and these biomass crops allow vulnerable parts of the landscape to remain economically productive while protecting water quality.

Shrub willow can produce the same amount of biomass as a corn crop with only a third of the nitrogen fertilizer, Kemanian pointed out. When the plants grow, they take carbon dioxide from the atmosphere. After harvest, when the biomass is combusted either as wood chips or as a liquid biofuel, the carbon dioxide returns to the atmosphere to complete the cycle.

Researchers planted shrub willow seedlings in 2012 on land formerly owned by the State Correctional Institution at Rockview. The biomass crop will regrow and will be harvested every three years.
Image: Penn State

Felipe Montes, a research associate in the Department of Plant Science, established an array of sensors to measure carbon dioxide and water vapor fluxes, which are giving a vivid picture of the growth potential in the region. Shrub willow is one the first plants to leaf out in early spring and dies back late in the fall, and this long growing season makes it extremely efficient in converting sunlight and nutrients to a bioenergy feedstock.
"We estimate that we can harvest 20 to 30 units of energy per unit of fossil energy invested in producing the crop, leading to fuel with a very low carbon footprint," Montes said. "The fact that this biomass can be converted to liquid fuel is one of the main advantages of shrub willow and other biomass crops. Low carbon liquid fuels are especially important for long distance transportation, shipping and aviation, where electric vehicles are not practical."

Biomass energy could provide the social, economic and ecological drivers for a sustainable rural renaissance in the Northeast, according to NEWBio project leader Tom Richard, professor of agricultural and biological engineering and director of the Penn State Institutes of Energy and the Environment. He believes perennial energy crops are particularly well suited for the region, where forests and pasture long have dominated the landscape.
Rocky and sloped soils are more compatible with perennial crops, while perennial root systems better tolerate wet springs and occasional summer drought, Richard said. Northeast biomass production has high water-use efficiency (biomass produced per unit of water transpired by plants) owing to the region's moderate temperatures and relatively high humidity. These perennial crops also increase organic matter in the soil, and coupled with efficient refining and manufacturing processes can produce carbon-negative energy and materials.

"Concerns about energy, environmental and human health, rural economic development, and the need to diversify agricultural products and markets have made the development of sustainably produced biomass feedstocks for biofuels, bioproducts and bioenergy a critical national priority," said Richard.

"Perennial bioenergy systems, such as the shrub willow demonstrated at Penn State, appear to hold an important key to future economic development for our region. But to unlock that future, we need to learn how to economically handle the harvesting, transportation and storage of massive volumes, which constitutes 40 to 60 percent of the cost of biomass. This project is providing the knowledge and experience needed for a regional bioeconomy to achieve commercial success."

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