Interdisciplinary research looks at whole-farm sustainability

July 9 2012

A recent graduate from Penn State's College of Agricultural Sciences holds a jar of pressed and filtered canola oil while standing by canola plants and the New Holland tractor that was converted to run on straight vegetable oil.

Weeds, manure, slugs, cows and a vegetable oil-powered tractor are all part of a unique study being conducted in Penn State's College of Agricultural Sciences.

Begun in 2010, the Sustainable Dairy Cropping Systems research project involves researchers from several areas of expertise to examine dairy farm sustainability. It simulates a Pennsylvania dairy farm of 240 acres and 65 lactating cows, including young-stock, by growing crops on 12

acres of Penn State's Agronomy Research Farm at Rock Springs and using a computer program to model herd management.

Combining previous research conducted on a small scale into crop rotations at a farm-scale, the study takes a holistic approach to look at several components of a dairy farm. Various crops are grown for feed and energy use, yield and feed and forage quality are measured, and milk production for the farm's dairy cows is simulated with a computer model.

Heather Karsten, associate professor of crop production and ecology and lead director of the project, said the goal is to design and identify management practices that will increase farm sustainability by minimizing off-farm inputs and reducing environmental impacts.

"We are looking at ways to conserve soil, nutrients, biodiversity and energy to design a farm that is productive as well as economically and environmentally sustainable," she said. "By using diverse crop rotations and innovative conservation practices, we think we can promote ecological processes to reduce fertilizer and pesticide use, protect soil and water quality, and sustain farm productivity."

Karsten said dairy is an important part of the agricultural economy, but many farmers are under pressure because of the environmental needs to manage nutrients, protect water quality, and reduce soil erosion and nutrient losses, while seeing to the economic needs of managing a farm.

"Dairy farmers must deal with the rising cost of feed and fuel, as well as unpredictability and instability in the milk price," she said. "A big part of our goal is to figure out how we can help dairy producers reduce their off-farm inputs so they are more profitable."

The project combines disciplines such as agronomy, agricultural and

biological engineering, entomology, dairy science and agricultural economics. Contributors include scientists from Penn State and the U.S. Department of Agriculture's Agricultural Research Service; graduate students in agronomy, soil science, ecology, entomology and agricultural engineering; and undergraduate students in various majors serving as research assistants.

Glenna Malcolm, postdoctoral research associate in plant science, is the project manager.

The feed portion of the project involves two, six-year rotations of grains and forages. Both rotations are managed with no-till. The grain rotation uses a combination of weed management practices to reduce herbicide use in a rotation of alfalfa and orchardgrass, canola, rye, soybeans and corn.

The forage rotation evaluates shallow-disk manure injection as an alternative to surface application in a rotation that includes alfalfa and orchardgrass, corn silage, winter wheat, red clover or hairy vetch, and canola.

In both rotations, legumes are planted for "green manure" -- plants that add nutrients and organic matter to the soil -- and for integrated pest management, while cover crops are used to protect the soil.

Karsten said that the rotations provide several benefits, such as promoting biodiversity. The researchers hope to encourage beneficial insects, such as spiders and bees, and to combat pests such as slugs, which are a major problem in no-till systems.

Another important component of the research is energy. Canola is included in the rotations to produce fuel for a straight-vegetable-oil-powered tractor, which is being evaluated for its performance by New

Holland. The canola is pressed for the oil, which is put straight into the tractor with no need to convert it to biodiesel. The leftover canola meal serves as a feed for the farm's dairy cows.

The animals' rations are maintained by Virginia Ishler, nutrient management specialist. She enters data based on the field results into a computer program to measure feed intake and milk production.

She noted that her work as manager of the Penn State dairy complex contributes to the model.

"The University cows are my barometer," she said. "When their milk production goes up, the virtual cows' milk production goes up."

The model consists of two different scenarios that use the two different crop rotations, so Ishler performs each calculation twice. She compares cow performance and feed costs in both scenarios to see if one is more profitable than the other.

The cows' diets in both scenarios consist of corn silage. In one scenario, cows are fed alfalfa haylage, while in the other, they receive alfalfa grass.

"We grow our own corn grain and soybeans," Ishler said. "We're optimizing home-raised feed to minimize what we purchase off-farm."

To monitor income for the virtual dairy farm, Ishler uses the milk prices paid at Penn State. Another source of income is the sale of excess feed produced on the farm.

She also calculates feed costs each month and tracks the "income over feed costs" -- the portion of income left to pay for inputs such as electricity and labor after paying for feed (measured per cow per day).

Ishler uses a feed price list to compare a farm growing its own feed to buying feed on the open market.

"With the high cost of purchased feed, the more farmers can grow on the farm, the better," she said.

She also makes a cash-flow plan based on a database of normal expenses, such as electricity and labor, which stay consistent for the scenario.

Ishler said one of the important aspects of the project is the timeframe.

"We're not looking at just one point in time, we're seeing how this rotation holds up over multiple years," she said. "The project is constantly in motion."

"This is what the producers really want to see," Ishler said. "We're typically in our own boxes -- crop and soil science, nutrient management, weed science, entomology, engineering, animal science or economics. Now we all sit at the same table and hear what others are doing, and we learn from each other. There is no other work being done like this across the country. We're incorporating multiple disciplines."

The two years of research conducted so far have shown that producing all of the feed for the farm, including both grain and forage crops, is economically successful, according to Karsten.

Researchers also found that canola yields are higher when planting canola after alfalfa instead of planting it after corn silage.

Even though neither of the crop rotations has been completed, the conservation practices used are being promoted across Pennsylvania and applied in four Pennsylvania counties located in the Chesapeake Bay

watershed. Farms in these counties participate as demonstration farms, utilizing practices examined in the research, such as rolling cover crops to essentially serve as mulch and injecting manure into the ground.

To help promote these practices, equipment was purchased through a Conservation Innovation Grant from the Natural Resources Conservation Service.

Karsten said the team hopes the results of the study can be used beyond central Pennsylvania.

"We hope to use the principles and results to inform researchers, educators and growers about strategies and some options, but of course they would have to be fine-tuned to different regions, soils and climates," she said.

The project was fueled by a $400,000 grant from the U.S. Department of Agriculture's Sustainable Agriculture Research Education Fund, a $200,000 match from Penn State and additional funds from the USDA's Agricultural Research Service. Dairy farmers, employees of the USDA's Natural Resources Conservation Service and other researchers serve on an advisory panel that helps guide the research.

Provided by Pennsylvania State University