# Sustainable Dairy Cropping Systems Designed to Produce Forage, Feed and Fuel

Our goal is to sustainably produce the forage, feed and fuel for a 65 cow, 240-acre dairy farm in Pennsylvania and to minimize off-farm inputs. With funding from a NESARE USDA grant, our team of PSU and USDA-ARS scientists designed two cropping systems to: 1) minimize nutrient and soil loss, build soil organic matter and nutrient pools, and promote biological processes for nutrient acquisition, 2) enhance biological diversity and ecological interactions, and 3) be energetically efficient, productive, profitable, and sustainable.

We consulted with an Advisory panel to ensure that the cropping systems are relevant to farmers and researchers. Using farm-scale equipment and manure from a neighboring dairy, we initiated the cropping systems in spring 2010 at 1/20th scale on 12 acres of Penn State's Russell E Larson Agronomy Research Farm. The cropping system strategies include two six-year rotations with legumes, cover crops, perennials, no-till, integrated pest management, and manure injection. To reduce herbicide-use and herbicide resistance, we are evaluating a combination of weed management practices including a cover crop roller-crimper, herbicides applied over the crop row, a high-residue cultivator, tillage once in 6 years, and companion crops. Winter canola provides some of the fuel for a straight vegetable oil-powered tractor and meal for the dairy ration. We have also included a conventionally managed corn-soybean grain rotation for research comparison purposes, which adds another two acres to what we manage.

To evaluate the performance of the cropping system strategies, we are monitoring performance indicators such as crop yield and quality, soil health, nutrient conservation, greenhouse gas emissions, weed, insect, and mycorrhizal populations; energy use and production; and farm profitability. Twelve field "lysimeter" areas (90' x 50') were installed, to compare the impact of the manure management strategies on nitrogen, phosphorus and soil conservation, as well as atmospheric emissions (ammonia, greenhouse gases). Using the crop yields and feed and forage quality results, two dairy nutrition and production models are used to predict the performance of the virtual dairy herd.

## Project Team:

Craig Altemose (2010-12), PSU Cooperative Extension Dir. Centre Co. Timothy Beck, PSU Extension Ed., Ag Bus. Management, Cumberland Co. Douglas Beegle, PSU Soil Science William Curran, PSU Weed Science Curtis Dell, USDA-ARS Univ. Park Soil Science Ronald Hoover, PSU Coordinator of On-Farm Research Virginia Ishler, PSU Dairy & Animal Sciences Heather Karsten, PSU Plant Science, Project Director Peter Kleinman, USDA-ARS Univ. Park Soil Science Roger Koide (2010-12), PSU Plant Science, Mycorrhizae Glenna Malcolm, PSU Plant Science, Research Associate/Project Manager Tom Richard, PSU Agricultural and Biological Engineering John Tooker, PSU Entomology



Project webpage: http://cropsoil.psu.edu/research/cropping-systems

### Graduate Students:

Anna Busch, Entomology; Gustavo Camargo, Ag Engineering; Katherine Caswell, Plant Science; Maggie Douglas (2010-2012), Entomology; Emily Duncan, Plant Science; Kristin Haider (2010-2012), Ecology; Robert Meinen, Plant Science; Rachel Milliron, Plant Science; Elina Snyder, Plant Science (2011-2013)

### **Technical Support:**

Scott Harkcom, PSU Agronomy Farm Manager Gordon Folmar, USDA-ARS Univ. Park, Hydrologic Technician Louis Saporito, USDA-ARS Univ. Park, Soil Scientist Dave Sandy, PSU Weed Science, Lab & Field Manager Justin Dillon, PSU Senior Extension Associate Matt Peoples, PSU Lab Technician, Dept. of Plant Science Andrew Aschwanden, PSU Lab Technician, Dept. of Entomology Mark Dempsey, PSU Lab Technician, Dept. of Plant Science

### Undergraduate Research Assistants:

Caitlin Andler, Fabien Balaguer (France), Joy Beam, Benjamin Crooke, Díanna Duran (Costa Rica), Brian Gray, Elaine Hinrich (Oberlin College), Allison Lush-,Heidi Musshafen, Marissa Keys, Curtis Kennedy, Andrew Kirk, Roni Pasi, Andrew Puglia, Sarah Rihl, Samantha Rosado, Erika Samain (France), Julie Schubert, Adam Seitz, Joshua Walker

#### 2014-2015 PENN STATE SUSTAINABLE DAIRY CROPPING SYSTEMS (All systems are no-till, except in the 'Reduced Herbicide Grain Rotation')

or Fertilizer

or

Fertilizer

#### J F MA M J J A S O N D J F MA M J J A S O N D J F MA M J J A S O N D J F MA M J J A S O N D J F MA M J J A S O N PEST MANAGEMENT COMPARISON Alfalfa Canola Soybean Corn Sil. Oats Alfalfa Herbicide Rve cover crop 15 & 30" rows Rve cover c. Scout for weeds pre-plant **BMP Standard** Herbicide Broadleaf Inject Manure Spray weeds & Spray Broadcast & Broadcast & Herbicide volunteer can. (if needed) Herbicide Rye Post-Emerg. Post-Emergent (SH) Herbicide Inject Manure Herbicide (if needed) Alfalfa + Grass Canola Soybean Corn Sil. Oats Alfalfa+Orchard Grass+ Rve+canola Triticale Broadcast Manure 30" rows Rye cover c. Reduced Moldboard Plow Mow volunteer Spray Rye Banded Herbicide Banded Scout for weeds pre-plant Herbicide canola & plant & Canola Herbicide Herbicide PLH-Resistant Alfalfa Variety (if needed) Annual Triticale for (RH) rye to create mix High Residue Inject Manure **High Residue** Roll if needed Cultivator x2 Cultivator x2 Weed Suppression or Broadcast Post Herbicide or Broadcast Post Herbicide Manure Management Rotation: injection vs. broadcast manure, green manure comparison, standard herbicides, IPM for insect pests, and non-Bt corn J F MA M J A S O N D J F MA M J A S O N D J F MA M J A S O N D J F MA M J A S O N D J F MA M J A S O N D J F MA M J A S O N MANURE MANAGEMENT COMPARISON Alfalfa+ Corn Grain Ann. Rye Corn Sil. Rye silage underseeded with Red Clover Corn Sil. Oats Alfalfa + Orchardgrass Grass Broadcast & Clovers Broadcast Broadcast or Broadcast Broadcast Manure Manure Manure Manure Manure Interseeder **Crimson Clover** (BM) Rye silage SS grass Alfalfa+ Corn Grain Corn Sil. Rye silage underseeded with Red Clover Corn Sil. Alfalfa + Orchardgrass Ann. Rye Oats Inject Grass Inject & Clovers Inject Inject Inject or PLH Resistant Alfalfa Variety Manure Manure Manure Manure Manure (IM) Interseeder Rve silage SS grass Crimson Clover Corn-Soy Conventional Grain Rotation: manure or fertilizer, standard herbicide regime, prophylactic insecticides, and Bt corn J F M A M J A S O N D J F M A M J A S O N D J F M A M J A S O N D J F M A M J A S O N D J F M A M J A S O N D J F M A M J A S O N NUTRIENT MANAGEMENT COMPARISON Corn Grain Sovbean Corn Grain Sovbean Corn Grain Sovbean 15 " rows 15 " rows 15 " rows Broadcast **BM** BM **RM** Manure (BM) Fertilizer Fertilizer Fertilizer or or or or Fertilizer Inject Corn Grain Soybean Corn Grain Soybean Corn Grain Soybean Manure (IM) 15 " rows 15 " rows 15 " rows

IM

or

Fertilizer

IM

or

Fertilizer

Pest Management Rotation: IPM for insect pests, multiple tactics for weed control (RH), inject manure for canola (SH) and rye cover crop before corn silage