Welcome to the fall issue of PSU Organic Acres, the bi-annual newsletter associated with our organic cropping systems project. It has been a little over six months since we unveiled the inaugural issue, and a lot has occurred in that time. We look forward to sharing some highlights from the past six months, but before we do, we thought it would be helpful to remind you who we are, what we do, and why we are doing it. Our group is made up of Penn State researchers and educators and an advisory board that includes organic farmers and other agriculture professionals from Pennsylvania. We are currently in the middle of a four-year research project funded by the USDA Risk Avoidance and Mitigation (RAMP) program. Our project is titled Weed management, environmental quality, and profitability in organic feed and forage production systems, and seeks to develop organic management strategies that effectively address weed management challenges while maintaining or improving soil quality and economic and environmental sustainability in organic feed and forage production systems. Our project compares four different organic cropping systems which vary in cropping intensity and disturbance. Each system (1—4) differs in the underlying philosophy driving the management system. Systems 1 and 3 are managed with the goal of maintaining low weed populations, while systems 2 and 4 are managed to improve soil quality. Systems 1 and 2 represent relatively low risk strategies, while systems 3 and 4 represent higher risk strategies. Our goals with this project are to develop a better understanding of organic production systems and to provide useful information to growers and researchers interested in organic management practices. The articles that follow have developed from this project. We hope that you enjoy reading about what we’ve been up to.
Do Organic Cropping Systems Affect Insect Communities?

By Tara P. Gareau, PSU Dept. of Entomology

Reducing tillage and using high biomass cover crops are practices generally used to improve soil quality and fertility, reduce erosion, and suppress weed populations. However, tillage and cover crop practices can also have a direct influence on the insect community. Generally, reducing tillage and increasing plant diversity will increase both the diversity and abundance of insects in the crop field. Why is this? First, by cutting back on the number of tillage events and the intensity of soil disturbance, you decrease insect mortality rates. The survivors then can reproduce and contribute new individuals to the next generation. Second, when the diversity of crops increases in conjunction with a reduced tillage regime, there is more food and habitat for insect herbivores, which in turn supports a richer community of omnivores, predators and parasitoids. From an invertebrate conservation standpoint, an increase in insect diversity is a positive result of reduced tillage systems with cover crops. However, from an agroecological standpoint, we are also interested in receiving ecosystem services from that diversity while not creating or increasing pest problems. In other words, we need to increase the right type of insect diversity to enhance services like biological control, nutrient cycling, and pollination.

The specific effects of tillage and cover crop rotations on the insect community are not well understood. Therefore, the focus of this study is to describe the insect communities associated with the four different rotation systems and to identify potential ecosystem service gains from that diversity as well as potential pest problems. Our four treatments are (1) an intermediate disturbance system with multiple short-season annual cover crops, followed by perennial alfalfa; (2) an intermediate disturbance system with a warm-season grass followed by perennial alfalfa; (3) a high disturbance system with a bare fallow period, followed by a grain-legume cover crop, followed by no-till corn; (4) a minimal disturbance system with perennial grass and legume cover crops, followed by conventionally-tilled corn.

In 2008, we used a sweep net to sample insects from each system (50 sweeps per plot; four plots per sys-
tem) in our first start of the experiment. Systems 1, 2, 3, and 4 were sampled on June 25, July 29, June 16, and June 13, respectively. While there were multiple crops planted in each system in 2008, the sampling times reflected the peak of productivity of the system for that year and occurred prior to a major management event, like mowing or harvesting. The following cover crops were present at the time of sampling: mustard in System 1; sorghum-sudangrass in System 2; and cereal rye/hairy vetch in Systems 3 and 4.

As a first step to understanding the insect community response to the rotational systems, we grouped insects into functional groups: pollinators (bees), parasitoids (parasitic wasps and flies), predators (lady beetles, soldier beetles, syrphid flies, minute pirate bugs, and others) and herbivores (aphids, leafhoppers, tarnished plant bugs, Japanese beetles and others). Results from sweep net samples from the first year of the rotation showed that the minimum-tilled system with cereal rye/hairy vetch (System 4) supported the most balanced proportions of functional groups, as well significantly more pollinators than the other systems. System 3, also in rye/hairy vetch supported the greatest number of parasitoids and predators, which cumulatively exceeded the number of herbivores. In other words, the natural enemy to potential pest ratio was highest in System 3, suggesting that biological control services may also be highest in this system.

Excluding thrips, herbivore abundance was highest in System 1, in which mustard was sampled (mean = 204.8 ± 6.9 SE per sample), yet statistically equal among the other systems (means between 99.2 and 146 per sample).

These preliminary results demonstrate differences in insect abundance and composition between the systems. However, whether or not those differences are due to the localized influence of the cover crop species or to a system wide effect has not yet been determined. To better assess the effects of the rotational systems, in 2009, we increased our sampling effort to three time periods and sampled across all systems on each sampling date. We will then accumulate the data across the season to look at the overall influence of the systems on the insect community as well as test for particular cover crop and tillage effects. Assuming that we continue to find differences in insect community response to the rotational systems, the follow-up study to this project would investigate the impact these differences have on ecosystem services.
When we think about weeds, we often think of those that we can see growing with the crop. However, those weeds typically begin their lives as seeds in the soil. The weed seeds in the soil are termed the weed seed bank. And just as the balance of cash in our bank accounts can impact our quality of life, the balance of seeds in the weed seed bank may impact our crop production systems. However, in the case of the weed seed bank, having a large balance in the bank may not be a desirable thing.

Two strategies
Management of the weed seed bank can be lumped into two main strategies: proactive and reactive. The proactive strategy is based on the assumption that seed banks can be managed and that ensuring a low balance of weed seeds in the seed bank will translate into a lower abundance of weeds in the field and favorable crop yields. This approach involves substantial investment of time and energy into driving down the numbers of weed seeds surviving in the soil. The proactive approach can be labor intensive, and in organic systems relies upon mechanical weed management, suppressive cover crops and seed-damaging organisms, such as ground beetles, to deplete the soil seed bank and prevent germination and eventual weed seed shed. In contrast, the reactive approach assumes that weed seed banks are too difficult or costly to manage and that resources can be better spent on managing the weeds that emerge in the crop field. With the reactive approach, investment of time and energy is primarily on ensuring that crops emerge before weeds and therefore have a competitive advantage, either through well timed and targeted weed management activities or crop transplantation. Less time and energy are devoted to managing weeds that may not directly impede crop production or minimizing weed seed production following crop harvest.

Insight from research
So if there are at least two major strategies for managing the seed bank, how do we decide which approach to follow? From a scientific perspective, the predominant opinion has been that reducing the weed seed bank, the proactive approach, is a worthwhile weed management objective when feasible. In fact, this approach is often a cornerstone of most integrated weed management plans. However, some recent research has begun to question some of the general assumptions that underpin this approach. In studies that assess both the weed seed bank and the weeds that emerge within the crop, there is often no, or only a weak relationship between the density of the weed seed bank and the abundance of weeds that emerge within the crop. In studies where weed seed banks have been experimentally altered, the resulting effects on the abundance of weeds that emerge with the crop are often weaker than expected, or do not persist for
more than one or two growing seasons. Together, these studies suggest that weed seed banks may only be part of the weed management story and that changes in the balance of the weed seed bank may not be as important in determining weed pressure within a field as has been previously assumed. There is also some thought that the utility or feasibility of the proactive and reactive approaches may be dependant on the size of the farm or the structure of the production operation. Our project will lend insight into these questions.

Measuring the weed seed bank

We are measuring the weed seed bank in the spring and fall, just before and after the initiation and completion of the season’s management activities, we collect samples of soil to a depth of four inches in thirty-two locations in each plot. The soil samples from each plot are brought into a greenhouse and placed in plastic flats. We water the flats containing the soil samples and record the emergence of weeds from the soil samples every week for a period of ten months. This gives us an estimate of the density and composition of the viable weed seed bank in each plot.

By counting the weed seedlings that emerge from the soil samples, we will be able to estimate the density and composition of the viable weed seed bank. Weed seedlings in this sample are primarily common chickweed.

We’ll use these data to track changes in the density and composition of soil seed bank from spring to fall for each year of the three-year experiment. Results from our experiment will be used to help guide weed management decisions in organic feed and forage-based cropping systems and may provide further insight into the question of whether and when it is useful to implement management aimed at “breaking the bank.”
Getting the Word Out: Research Publications and Outreach

By Rich Smith, PSU Dept. of Crop and Soil Sciences

A major goal of our project is to communicate the results of our research in organic cropping systems to other researchers and the general public. Here are some recent publications that have been developed by members of the organic cropping systems project team.

Conserving Wild Bees in Pennsylvania

Agriculture in Pennsylvania relies upon insects for crop protection and pollination. Unfortunately, many of our crop production practices can have unintended negative consequences for some beneficial organisms and the valuable agroecological services they provide. Given the recent decline in managed honey bee populations, many growers in Pennsylvania are now looking for alternative ways to ensure pollination of their crops. One way that this can be accomplished is by providing or improving habitat for wild bees. Wild bees, which include native and naturalized bees, already provide some of the pollination services for a number of fruit and vegetable crops in Pennsylvania. Crops pollinated by wild bees in Pennsylvania range from apples, pears, and nuts, to strawberries, tomatoes, peppers, and squash. Therefore, conserving or increasing wild bee populations in the state is an essential step for sustaining agricultural production in Pennsylvania.

What are some strategies for conserving wild bees in Pennsylvania? Project participant Tara P. Gareau, ecology graduate student Nelson DeBarros, and project leaders Mary Barbercheck and Dave Mortensen have developed a beautiful and informative publication titled “Conserving Wild Bees in Pennsylvania” that aims to provide growers and the general public with the information necessary to help conserve these beneficial insects. The publication features the stunning photography of Nelson DeBarros. The bulk of the information provided within the publication covers the use of native plants to conserve bee populations. Gareau and her colleagues point out that native plants are well adapted to the local weather and soil conditions, and have co-evolved with the insect communities in the region, making them ideal for landscaping around the garden or farm. Some of the information provided within the publication includes general suggestions for ways to enhance wild bees, which include conserving natural habitats, planting flowers, providing access to water, preserving or building nesting sites, and reducing bee exposure to pesticides. A special feature of the publication is that it opens up to become an attractive and informative poster suitable for wall hanging. When opened, the poster shows the shapes and sizes of different wild bees, a chart that shows the flowering and growth periods of twenty native plant species, and full-color photographs and descriptions of the seven groups of wild bees that are most important to agriculture in Pennsylvania.

The publication is the first in a series of outreach products to be featured in Penn State’s new Agroecology in Practice series. The publication can be downloaded free of charge from the PSU College of Agriculture’s publication web-site at http://pubs.cas.psu.edu/FreePubs/pdfs/uf023.pdf. For more information, please contact Tara Gareau (tlp19@psu.edu).

Organic Production and Weed-Crop Competition

Most organic growers will admit that their fields are often weedier than the fields belonging to their neighbors who manage weeds conventionally. However, many of these organic growers will also argue that despite their weedier fields, their yields are often similar to those produced by their conventional
neighbors. Three papers soon to be published in the international scientific journal *Weed Research* will shed light on the issue of weeds and their impacts on crop yields in organic cropping systems.

In the first paper, *Weed–crop competition relationships differ between organic and conventional cropping systems*, Penn State weed ecology graduate student Matt Ryan, project participants Rich Smith and Dave Mortensen, and other colleagues from Penn State and the USDA, report data that demonstrate that organically-managed cropping systems can produce yields that are comparable to conventional systems despite substantially higher weed abundance. The data were collected from the Rodale Farming Systems Trial® (FST) in SE Pennsylvania, one of the longest running comparisons of organic and conventional cropping systems in North America. Ryan and his colleagues show that in the two long-term organic systems (one in which soil fertility is manure-based and the other legume-based), yields of corn measured over the 27 year duration of the experiment were similar to those from the conventionally-managed system. The data also show that crop yields in the two organic systems were less affected by changes in weed abundance over the study period than were yields in the conventional system, suggesting that the organic systems may be inherently more “tolerant” of weeds than the conventional system. In the second paper, *Elucidating the apparent maize tolerance to weed competition in long-term organically managed systems*, Matt Ryan, Dave Mortensen, and their colleagues report data from an experiment they performed within the Rodale FST that tested the apparent tolerance to weeds of corn grown organically relative to corn grown conventionally. In that study, corn grown in 2005 and 2006 in the two organic cropping systems was indeed more tolerant to experimentally-altered weed abundance, compared to corn grown in the conventional system. In the third paper, *A new hypothesis for the functional role of diversity in mediating resource pools and weed-crop competition in agroecosystems*, Rich Smith, Dave Mortensen, and Matt Ryan provide a theoretical context for weed-crop competition in agroecosystems and propose that the diversity of crop and soil fertility inputs, through effects on soil resources, may mediate competitive relationships between weeds and crops. Their hypothesis offers a potential explanation for why crops grown organically should be expected to be more tolerant of weeds than crops grown in conventional systems. Smith and his colleagues use crop yield and weed abundance data collected from long-term organic and conventional cropping system trials conducted across the country to test their ideas and find preliminary support for their hypothesis.

Together, these three papers lend new insight into organic crop production and the biological processes that mediate the effects of weeds in diversified agroecosystems. If you are interested in receiving or learning more about any of the papers highlighted above, please contact the lead authors, Matt Ryan (mrr203@psu.edu) or Rich Smith (rgs14@psu.edu).

**Conservation Biological Control**

*O*rganic production practices can impact the abundance and activity of soil organisms that attack soil-dwelling insects. Project leader Mary Barbercheck and her former graduate student, Randa Jabbour, have published two papers in the international journal *Biological Control* that provide insight into how management practices during the transition to certified organic production affect soil-dwelling organisms that provide biological control services. The first paper, *Soil and habitat complexity effects on movement of the entomopathogenic nematode Steinernema carpocapsae in maize*, examines how cropping system structure affects the movement of insect-parasitic nematodes in the soil. The second paper, *Soil management effects on entomopathogenic fungi during the transition to organic agriculture in a feed grain rotation*, examines how cover crops and tillage affect the abundance of soil fungi that infect insects. For more information, or if you would like to receive either of these papers, please contact Mary Barbercheck at (meb34@psu.edu).
That’s a Wrap: Season Two in Pictures

By Tara Gareau and Rich Smith, PSU Depts. of Entomology and Crop and Soil Sciences

It’s that time of the year again. The trees have shed their leaves. The mornings are frosty. And the first snowfall is only a few weeks away (or, depending on where you live, has already come). The harvests are completed and its time to take stock of the field season that has come and gone. The second season of our organic cropping systems project wrapped up in October. So how did the season go? Since they say a picture is worth a thousand words, we thought we would show you.

The pictures in the green boxes show each system as it looked on November 9, 2009—from the perspective of the plot edge (Lateral View) as well as a close-up of the soil surface (Birds Eye View). Below each set of pictures, we provide information about the major management practices that were implemented in each system in 2009. Interspersed among the system pictures are pictures of project participants engaged in various activities associated with the project over the course of the field season. We hope you enjoy a pictorial tour of the systems and the 2009 field season.

System 1: Alfalfa with oats (Nov 9)

Major management events in 2009: S-tined (April 9 and 27); planted alfalfa and oats (April 27); harvested the alfalfa and oats (July 7).

System 2: Alfalfa & Orchard grass (Nov 9)

Major management events in 2009: S-tined (April 9 and 27); planted alfalfa, orchard grass, and oats (April 27); harvested alfalfa, oats, and orchard grass (July 7).

Dave Mortensen, Matt Ryan, Mary Barbercheck, Rich Smith, Shu-Min Wang (visiting researcher from Taiwan), and Dave Sandy in a stand of rye and hairy vetch (May 13).

Tara Gareau inspecting a pit fall trap in a system that was recently tilled. Pitfall traps are used to measure the activity and abundance of soil-dwelling insects and spiders.
Sara Eckert measuring a stand of rye and hairy vetch for biomass production. We measure the production of our cover crop stands to better understand how their management will influence the dynamics of carbon and nutrients in the soil (April 28).

Kathryn Bullington and Christy Mullen, along with a lot of bees, measuring biomass production in a mustard stand (June 25).

Jason Kaye demonstrates how soil characteristics vary across the study site during the project advisory board meeting (March 27).

Common leaf spot began to make an appearance on the alfalfa in Systems 1 and 2 in August. This picture was taken on November 9, 2009.

Kathryn Bullington and Christy Mullen, along with a lot of bees, measuring biomass production in a mustard stand (June 25).
We Have a New Web Site!

Are you looking for the most up-to-date information about our project? Look no further than our new Weed Management, Environmental Quality, and Profitability in Organic Feed and Forage Production Systems website hosted by the PSU College of Agricultural Sciences. Project technician, Christy Mullen, spent countless hours developing the new site, and we believe her time was well spent.

The new website can be found at the following address: (http://agsci.psu.edu/organic/research-and-extension/Organic%20forage) and contains all of the information relevant to the project in one easy-to-navigate location. At our new site you will find details regarding the four cropping system treatments that comprise our project; the people involved in the project, including the researchers and the project advisory board; a project summary; publications resulting from the project, including the monthly and bi-yearly newsletters and extension materials; as well as other useful information related to organic agriculture. We’ll be updating the site regularly to ensure that it continues to serve as a valuable resource for both project participants and agriculture professionals interested in organic management practices. So take a minute or two to visit the site—and let us know what you think. ■

A screen-shot of our new website. The new site will be the source for all project-related news, information, and outreach materials and publications.

Weed Management, Environmental Quality and Profitability in Organic Systems

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