Cover Crop Cocktail Hour

Fall 2014

Project Goals:

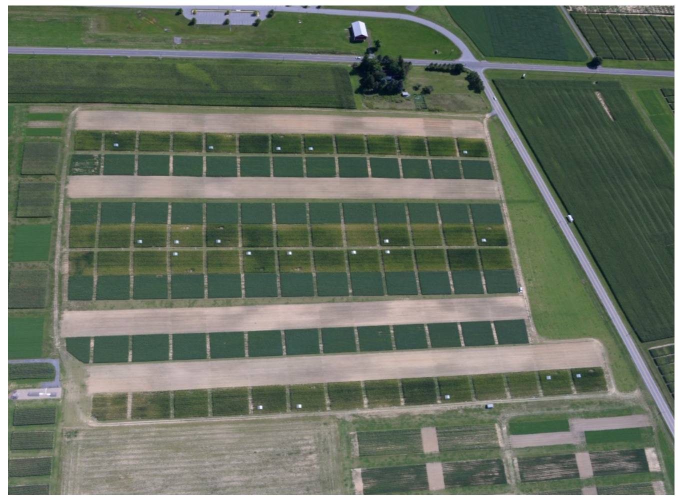
◊ Investigate the benefits and tradeoffs of using winter cover crop mixtures, or "cocktails," instead of monoculture cover crops

◊ Collaborate with farmers in Pennsylvania to conduct on-farm participatory research within realistic management constraints

◊ Complete extension and outreach on farms across Pennsylvania, especially to benefit farmers working in organic feed and forage systems

Inside this issue:

The Cover Crop Cocktails Newsletter



Aerial view of Rock Springs CCC project on 8/28/14.

Greetings to Cover Crop Cocktail (CCC) project members and to all readers interested in learning more about cover crops! We are a USDA-funded research and extension project, and this newsletter is intended to periodically update our Farmer Advisory Board and others interested in cover crop mixtures about the ongoing work of the CCC team. If this is your first glance at our research, then please review our project goals (at top-left of this page), and visit our website for a project summary (see project website link on page 11 of this newsletter).

Inside this edition you will learn more about what team members are doing at our Rock Springs Field Research Station, in related on-farm research projects, and in side projects and analyses all revolving around winter cover crop mixtures for organic feed and forage systems. There are also updates and close-ups with the research and outreach team, and information on past and future research and Extension events across the state. Please don't hesitate to write-in with ideas for future newsletters, general questions, or to submit photos or other content. We hope you enjoy the CCC updates and thanks for your continued participation in the project!

-Jim LaChance
& the CCC team

What's the weather been like?

Some of the articles you'll find in this newsletter will include data from all three years of the CCC project. To put this all in perspective, here's a short summary of what the weather has been like at the Rock Springs research station over the past three years.

Year	Rock Springs general weather
2012	After an average winter, a growing season with moderate precipitation and the highest temps of the past 3 seasons.
2013	After a mild winter, moderate precipitation early in summer turns to dry late summer. Temps moderate.
2014	A hard winter then wet spring and summer, with cooler than average temperatures.

Meet the crew

Dayton Spackman, CCC Field Operations

Dayton Spackman is starting his first full year working for PSU. He worked for Scott Harkcom at the PSU Agronomy Research Farm at Rock Springs for 5 years during the summer and fall while attending classes at PSU. In May 2013 he graduated with a BS degree in Agricultural Sciences with a minor in Agribusiness Management. In April of this year Dayton was hired full time to work as a research technician performing field operations for three different research projects involving cover crop systems and sustainable dairy cropping systems. When Dayton is not out in the field at the PSU Agronomy Farm he is out in the field on his family's farm.

Puneet Randhawa is a graduate student in Entomology at PSU, and did her undergrad in Agriculture and Master's in Entomology at Punjab Agricultural University (PAU), which is one of the premier state agricultural universities in India. After her master's, she worked as an Assistant Entomologist at PAU for six years before joining the CCC project. She is looking forward to conducting high quality research and contributing to the discipline and practice of entomology. She is particularly interested in the use of biological controls for insect pest management in organic systems, and is also excited to explore the role of entomopathogenic fungi as a biological control agent in cover crop mixtures and to further hone her research skills outside of Entomology.

At right: Puneet Randhawa, Entomology PhD student

How the CCCs add up: A 2yr biomass review

By Jim LaChance and Brosi Bradley

We just finished planting our third season of cover crop cocktails, which means that we have two full years of data from which to decipher preliminary themes regarding cover crop cocktail fall and spring biomass. Please see the fieldwork table (below) to review when we have planted, biomass sampled, and terminated our cover crops over the past two years.

In the first year of the project (2012-2013), we drilled the CCCs in late August and moldboard plowed in mid-May, which led to mixtures that were dominated by mature cereal rye biomass, which has a high C:N ratio and a high potential to immobilize N in the following cash crop. As a result, in our second year (2013-2014) we drilled and terminated both of our CCC plantings earlier in hopes that the mixtures would not have as high a C:N ratio in the spring. This is because earlier termination of rye (roughly at the boot stage) should keep the C:N ratio of cereal rye lower as its biomass will not be as lignified.

Dayton plowing pre-corn cover crops

For more information about the makeup of our cover crop cocktails, please see the table on page 10 (*article continues on next page).*

	2012-2013			2013-2014		
CCC Entry	**Drill**	**Biomass sample (fall/spring)**	**Moldboard plow**	**Drill**	**Biomass sample (fall/spring)**	**Moldboard plow**
Post-wheat, pre-corn	25,26-Aug	9-Nov	16-May	8-Aug	29-Oct	8-May
Post-corn, pre-soy	10,11-Oct	19-Nov	21-May	20-Sep	5-Nov	19-May

Cover Crop Biomass - continued:

Post-wheat cover crops (Fig. 1) have been consistent over fall 2012 and 2013, with the earlier planting in 2013 likely leading to more growth in the legumes - clover and pea. Our post-corn cover crops (not pictured), produce significantly less fall biomass (on average, 15 to 30x less), mainly because of the constraints of planting after corn silage. In our climate in central PA, the window for planting cover crops after corn is a small one, with cereal rye generally establishing best in our mixtures.

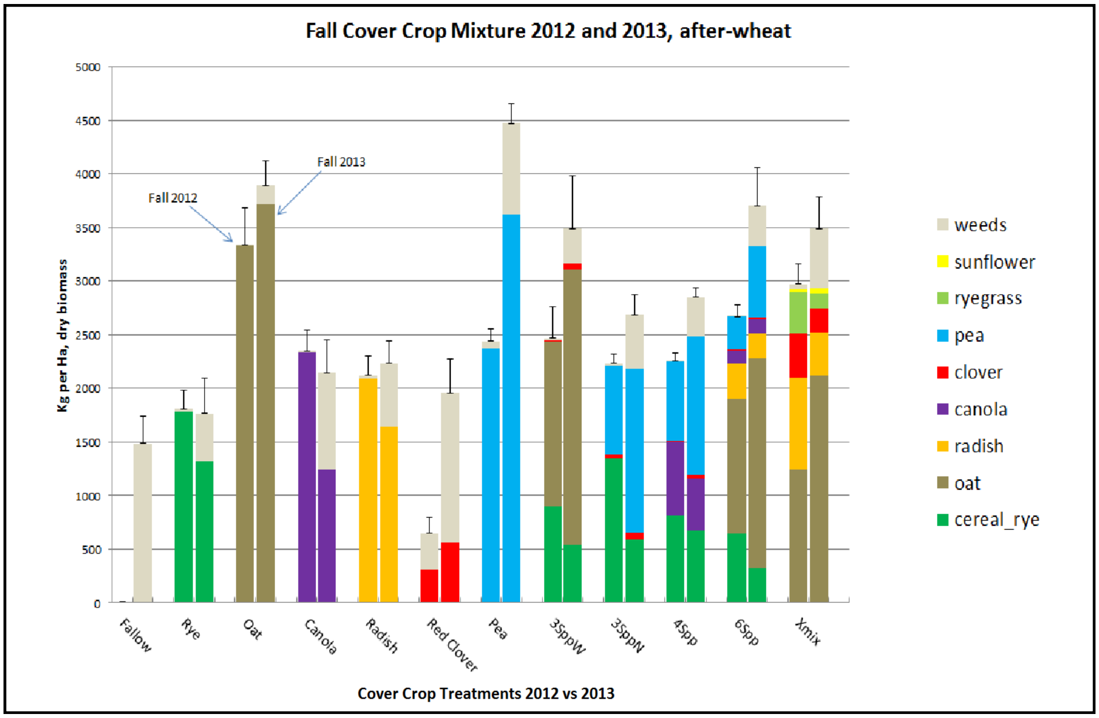


Figure 1. Post-wheat cover crops fall biomass data

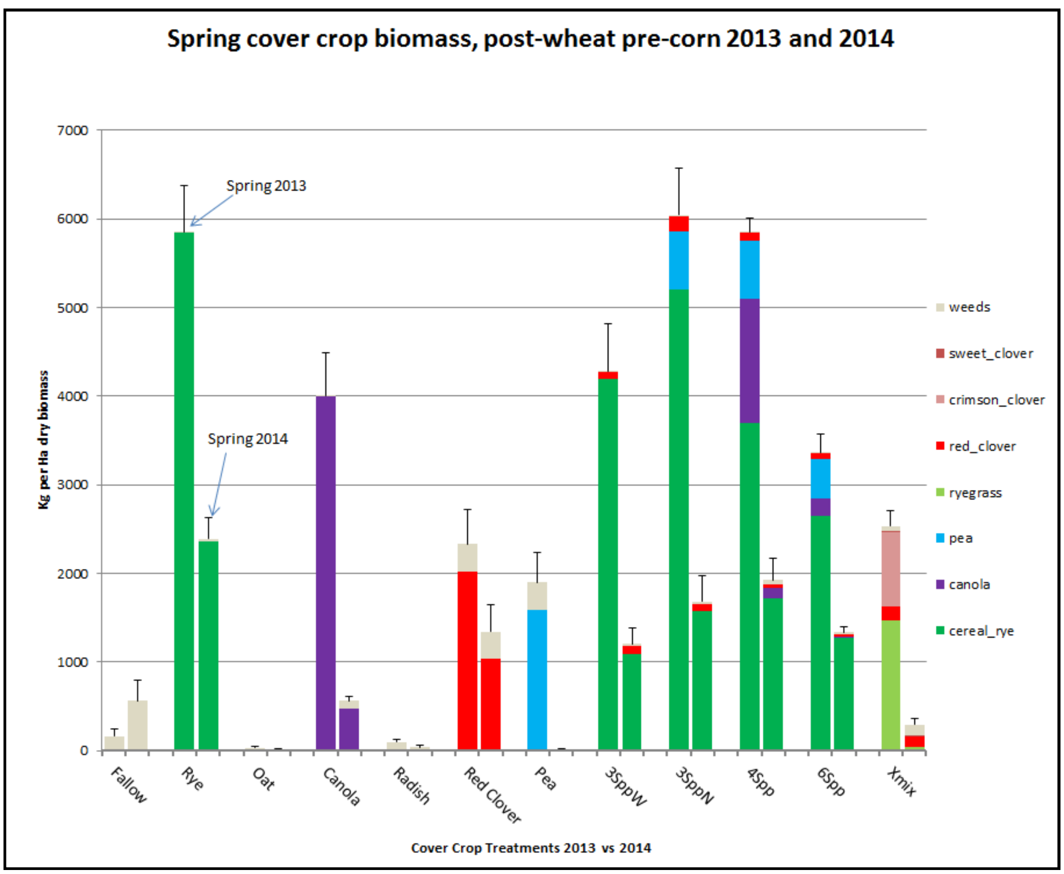


Figure 2. Post-wheat cover crops spring biomass data

Post-wheat cover crop biomass in the spring has varied over 2013 and 2014 because of the change in planting and termination dates. The later planting date in 2012 favored the Austrian winter peas, which winterkilled in 2013-14 after flowering in the fall. Also, post-wheat cover crops in 2014 accumulated less biomass in spring because they were terminated 8-days earlier than in 2012-13. In our post-corn cover crop planting (not shown), most species - aside from rye, ryegrass, and clover - have not been winterhardy. We planted this year's post-wheat cover crops between previous dates, and will wait and see what spring 2015 brings!

Cover Crops and Drought: Boon or Bust?

By Mitch Hunter, PhD student

How do you impose a drought in the middle of a corn field during one of the rainiest summers in recent memory? Simply blocking the rain from above won't cut it, as cloudbursts send water sluicing down any incline. But with lots of shovel work from summer employees (see picture 3) and a little trial and error you can trick a few corn plants into thinking there's a drought on.

1. Rainout shelter in action

That's what we've learned in year 2 of a drought experiment embedded in the CCC project. Why drought? Well, dry conditions occur periodically even in humid Pennsylvania (remember the last two years?), and summer droughts are projected to become more common and severe due to climate change.

To test the effects of cover crops under drought, we have created mini-droughts within the CCC corn plots. We have imposed drought with 9x10 ft rainout shelters placed in the field following the final cultivation in July and raised up as the corn grows (see picture 1). Graduate student Denise Finney is looking into whether diverse cover crops promote resilient microbial communities that perform better under drought. Finney is currently analyzing this data, so stay tuned for her results. I am working with Dr. Dave Mortensen to analyze how cover cropping affects the following corn crop during drought.

We hypothesize that cover crops may either help or hurt the corn, depending on their characteristics. In the best case scenario, cover crops may help the corn weather the drought by providing nutrients and loosening the soil, thereby promoting deeper root exploration and holding off nutrient stress. In addition, cover crops may increase water infiltration and, in the long term, build up organic matter that helps soils retain water. On the other hand, cover crops may deplete soil moisture as they transpire in the spring or tie up nutrients as they decompose in the summer, exacerbating the water and nutrient limitations that are already severe during a drought.

So far, it looks like nutrients may be the biggest driver of cover crop effects on drought-stressed corn. In year 1, we did not see big interactions between cover crop effects and drought effects. This may have been partly due to a high level of nitrogen stress in the corn that followed treatments containing rye. In other words, the cover crop effects swamped the drought effects. In year 2, we terminated the cover crops much earlier, reducing nitrogen immobilization following rye. This seems to have helped. Based on anecdotal observations as I walk the plots taking measurements, it does appear that there is an interaction between the cover crop effects and drought effects. The corn in the rainout shelters does not seem to be hit as hard when it is planted after high-nitrogen cover crops, and it is shorter and yellower when planted after high-carbon cover crops, like rye (see picture 2).

2. Drought-stressed corn.

I will report back at the Advisory Board Meeting to let you know whether these anecdotal results stand up to statistical analysis. If they do, we'll probably be back out there next year for one more summer of building shelters, burying soil moisture probes, and digging moats to protect against summer rains. Who knows what the summer will bring?

3. Summer field staff Sara Prizzi, Mary Lemmon, Matthew Rider, Anna Schwyter, David Kersey and Keirstan Kure with Mitch Hunter.

The CCC project at Rock Springs Agronomy Research Farm, Penn State, on 7/11/14 Rainout shelters dot the project site just days before the wheat is harvested.

Cover Crops in 2012 Ag Census Data

By Abbe Hamilton, Grad student

The purpose of my Master's project is to provide a greater understanding of current cover cropping practices among Pennsylvania farmers. So far this year, this has involved on-farm interviews and sampling as well as an analysis of the 2012 USDA Census of Agriculture.

In April and May I interviewed 22 farmers from across Pennsylvania who had standing cover crops that were planted the previous fall. I hoped to gain a better understanding of how they were using cover crops in their farming system, what other cover cropping techniques they'd tried, and whether their cover crop was likely to provide their farm the ecosystem services the farmers desired. Each visit consisted of a 30 minute interview and soil and biomass sampling from different cover cropped fields.

My sites ranged from thousand-acre conventional grain farms to organic vegetable gardens. Farmers' reasons for cover cropping were diverse, as you might expect, but there were some consistent trends in the responses. Here are some highlights from the interviews:

The majority of farmers weren't required in any way to cover crop. More than a quarter of farmers harvested their own cover crop seed (usually rye). Overall, the greatest reason to cover crop was for erosion control (mentioned by 18 farmers), followed by nitrogen management and organic matter maintenance (both mentioned by 9 farmers). More surprising uses of cover crops (at least to me) included browse for deer and mulch for no-till pumpkins.

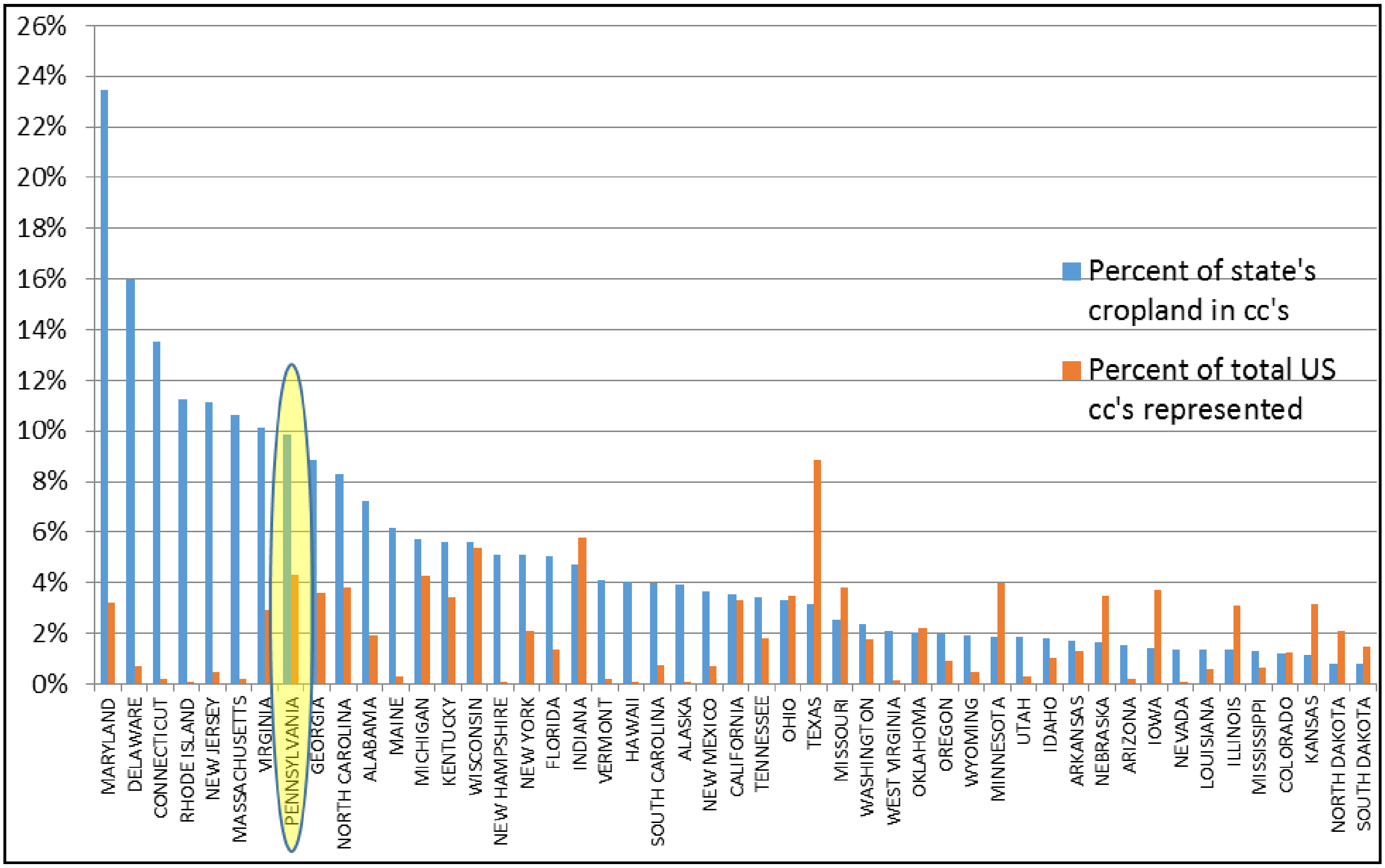
This spring's research was primarily exploratory, but I plan to revisit the sites as well as some new farms this fall, and am modifying my questions and methods so I can use my data more than anecdotally.

> *"Overall, the greatest reason to cover crop was for erosion control (mentioned by 18 farmers)..."*

The 2012 Census of Agriculture report came out in May, and for the first time ever it included data on acres planted to cover crops. I took a look at a state-by-state breakdown of cover cropping intensity *(see next page):*

USDA Ag Census Data - continued:

Summary of CC usage at state and national levels (2012 USDA Census of Ag)



(*con't from previous*) Maryland dominates when it comes to covering cropland, and this is likely due to the state's aggressive incentive campaign. Eastern states cover crop on higher percentages of their cropland than western states, although states' overall contributions to the country's total cover crops are, unsurprisingly, mostly located in states with lots of agricultural land.

See the table at right for a summary of interesting trends for Pennsylvania, and stay tuned for a deeper analysis of trends in unpublished, individual-level census data that I will collect this fall at the Harrisburg Census office.

Summary of some CC trends in Pennsylvania (from 2012 USDA Census of Agriculture data)
• Farms with annual incomes above $100,000 cover crop a significantly higher proportion of their acres than farms with incomes lower than $100,000. This is true of the entire Mid-Atlantic but the trend is weaker in the Midwest.
• Younger farmers are likely to cover crop a higher proportion of their cropland than older farmers, but older farmers manage more land. This trend appears to be unique to Pennsylvania.
• Full time farmers are more likely to plant cover crops than part-time farmers. This is unique to PA and a couple other Mid-Atlantic states.
• Farmers who are part-owners or tenants of land are more likely to cover crop than those who own their land, and farms operated as a partnership cover crop a higher proportion of their land than those run by single operators. These are almost universal trends.

Predators, prey, and preferences?

By Jermaine Hinds, PhD student

Cover crops are often used for various on-farm goals like improving soil fertility, erosion control, and weed management, but they can also influence the types of insects that show up on the farm. This is because insects are closely tied to their host plant species, relying on them for food and shelter. Knowing this, I set out to investigate if cover crops could be used as a reliable resource to support beneficial insects and if diversification of species within cover crop mixtures can attract a wider range of beneficial insects.

Natural enemies such as ladybeetles and spiders play a vital role in suppressing pest insects on farm and keeping them below economically damaging levels. We often think of natural enemies strictly as carnivores, or only those that eat other insects; however, surprisingly many predators *need* plant-based foods like sugar-rich nectar and protein-rich pollen (see photo at top right). Nectar and pollen can sustain natural enemies early in spring when other insects aren't around for them to eat. These

> *Can we manipulate plant species used in cover crop mixtures, not only for soil and weed suppression benefits, but also to attract particularly effective natural enemies based on their favorite host plants?*

early spring meals can give them a "head start" and make them more likely to quickly respond to growing numbers of pest insects. Like humans, natural enemies even have their favorite – or at least preferred – food plants, which often depends on flower shape and size. Out of this basis, can we manipulate plant species used in cover crop mixtures, not only for soil and weed suppression benefits, but also to attract particularly effective natural enemies based on their favorite host plants?

In our CCC project I decided to take a closer look at flowering species in our cover crop mixtures to see if flowers might support natural enemies looking for food early in the spring. Some of the species included in our mixtures are red clover, canola, rye, and Austrian winter pea. These plants range from small and many, to large and few and red to yellow, offering a variety of potential food sources for natural enemies.

Using my trusty sweep net, I sampled cover crops in spring before bloom and continued through until cover crop termination in early May. During our first

Four species cover crop mixture includes red clover, winter canola, rye, and Austrian winter pea. Several natural enemies may be attracted to the different flowers of red clover, canola and the pollen that rye sheds.

field year, 2013, results were fairly underwhelming, natural enemy numbers were low in all cover crop mixtures. This could have been most likely driven by cooler temperatures early in spring. Insects require a specific number of growing degree days to accumulate before emerging from overwintering. It appears that it was not warm enough for natural enemies to emerge in time to take advantage of the flowering cover crops before they were terminated. We changed our approach in the following field year, deciding to preserve strips of

Lady beetle and hoverfly foraging on buckwheat flowers for nectar and pollen.

our cover crop mixtures and sampling for insects longer into the summer months (see picture at left). While this year's samples have not yet been identified and analyzed, results appear to be a bit more promising. Field observations during the cover bloom period suggest that natural enemies, particularly ladybeetles were present and foraging on our cover crop strips (see pictures below). However, these observations are anecdotal.

Results from these studies can inform how growers tailor cover crop mixtures to soil fertility and weed management needs, and also can inform how cover crops can be used to attract specific natural enemies. In an upcoming installment of the CCC newsletter I will be reporting specific data and results from this experiment.

Close up of a parasitoid foraging on a red clover flower for nectar and pollen , which are important sources of energy.

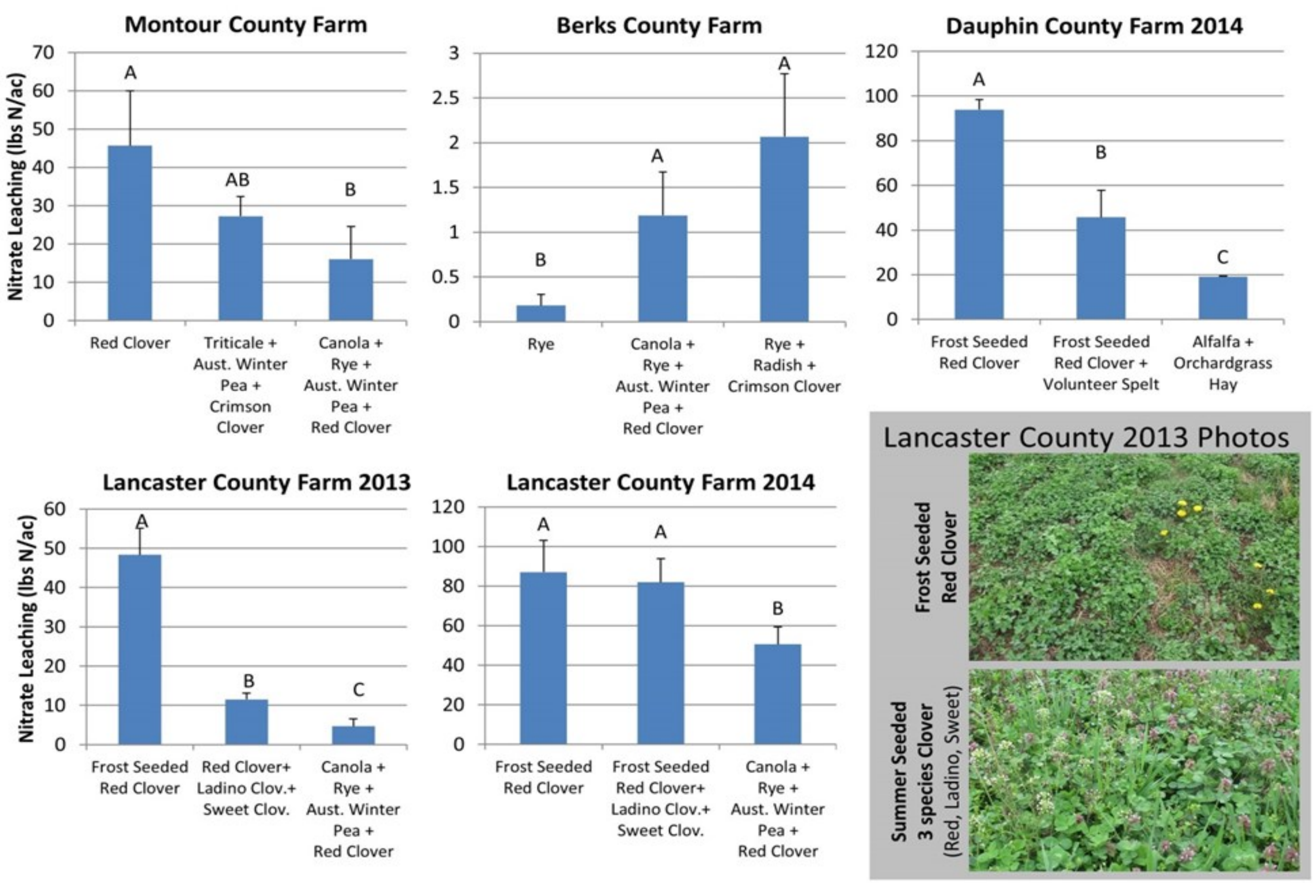
Got Nitrate Leaching?
The right cover crop mixture can help

By Charlie White, Tianna DuPont, Dave Hartman, Mena Hautau, and Jason Kaye

In the humid Northeast, keeping nitrogen where crops need it is a challenge. During heavy rains nitrate leaches below the root zone and can become an environmental pollutant in groundwater, rivers and estuaries. One of the ways that organic farmers can protect against nitrate leaching is by growing a winter cover crop. Winter cover crops reduce nitrate leaching by taking up nitrate left in the soil profile at the end of the growing season and holding it in the cover crop biomass over winter. When the cover crop is killed the next spring, the nitrogen the cover crop took up into its plant material is recycled into soil organic matter and becomes available to feed future crops in the rotation.

Not all species of cover crops are equal in their ability to scavenge nitrogen from the soil. Generally speaking, grasses and brassicas are the best nitrogen scavengers while legumes are relatively weak scavengers. Legume cover crops have pluses and minuses. They are excellent nitrogen fixers but because legumes are able to acquire nitrogen from the atmosphere, they are less aggressive at scavenging nitrogen from the soil. So how can farmers take advantage of the benefits of nitrogen fixation from a legume while also protecting against nitrate leaching? One solution may be to use a cover crop mixture, where legume, grass, and brassica species are planted together.

In our experiments on commercial farms, we have been testing the use of cover crop mixtures planted between a small



Nitrate leaching measured at 4 farm locations in Pennsylvania. The Montour and Berks County data are averages of two years of field experiments. Within a farm, values with different letters are significantly different at the P<0.05 level. The photos show significant weed invasion in the summer seeded 3 species clover mix in the Lancaster County 2013 site.

Got Nitrate Leaching? - continued:

grain cash crop harvested in mid-summer (e.g. wheat, barley, or spelt) and a corn crop planted the next spring. This has proven to be an interesting spot in organic grain crop rotations to study nitrate leaching for several reasons. First, this is a relatively long fallow period between cash crops in the rotation and a good portion of it occurs during late summer and early fall when soils are still warm, so high levels of nitrate can build up in the soil from microbial decomposition of soil organic matter. Second, organic farmers typically plant legume cover crops ahead of their corn crop, and as discussed earlier, legumes are relatively weak scavengers of soil nitrogen. Finally, the fallow period after a small grain cash crop allows for a cover crop planting date that is compatible with many different cover crop species, so planting cover crop mixtures is possible.

We monitored nitrate leaching in two years of cover crop experiments at farms in Lancaster, Berks, Montour, and Dauphin counties. In Lancaster, Berks, and Montour counties, the experiments compared a cover crop monoculture to a 3 species cover crop mixture and a 4 species cover crop mixture. The monoculture and 3 species cover crop mixture varied among the farms, while the 4 species mixture was the same at all farms. In Dauphin County, we compared frost-seeded red clover with or without volunteer spelt regrowth to a perennial alfalfa-orchard grass hay crop.

The main pattern that we observed, which was consistent across all farms and years, was that nitrate leaching rates were relatively high with a legume monoculture but that adding additional species of grasses or brassicas in the 3 species and 4 species mixes reduced leaching rates (see data from Lancaster, Berks, and Dauphin counties). Conversely, a grass monoculture resulted in very low leaching rates, and adding legumes to the mix only led to a very small increase in nitrate leaching (see data from Berks County). There are a few more details from the results worth noting, as well.

For example, in the Lancaster County experiment in 2013, the 3 species clover mix reduced N leaching compared to the frost-seeded red clover monoculture by about 40 lbs N/ac. We think this reduction was due to a significant weed invasion that occurred in the 3 species clover (see photos). In this year of the study, the 3 species clover mix was seeded into a tilled seedbed in August, and by November weeds had taken up about 40 lbs N/ac in their biomass. By comparison, the frost-seeded red clover was nearly weed free. In 2014, both the red clover monoculture and the 3 species clover mix were frost-seeded and nearly weed free, and both leached similar amounts of nitrogen. This example shows that, in some cases, weeds can serve a valuable ecological function.

One area of concern that these data bring up is the relatively high nitrate leaching rates under frost-seeded clover. Because frost-seeded clover is a very common cover cropping practice on organic farms between small grain and corn, it is worth thinking about management practices for frost-seeded clover that could help reduce this leaching. At the Dauphin County farm, we compared resin bags buried under frost-seeded red clover with resin bags buried under strips of the red clover where volunteer spelt had germinated following the combine pass. Areas with volunteer spelt had half as much leaching as where red clover was growing alone, a leaching reduction of 45 lbs N/ac. So one strategy to reduce nitrate leaching in frost seeded red clover might be to spread some extra grain seed back onto the clover during harvest time by setting the combine to spread chaff in a wider swath and slightly boosting the fan speed to get more seed back on the field. Another strategy might be

Cover crop plots in Montour Co.

to frost seed a mixture of clover and a grass, such as annual ryegrass. This could be challenging using a broadcast seeder, as is often used for frost seeding, because the different densities of clover and grass seed will lead to a narrower broadcast width for the grass seed. An alternative seeding method might be to use a drill rather than a broadcast seeder to seed the clover and grass mixture at the normal frost seeding time. Lastly, farmers might consider drilling a grass such as oats or sorghum-sudangrass into the frost-seeded clover in mid-summer, after the small grain crop has been harvested.

Our work at fine tuning cover crop mixtures for use on organic farms will continue into the future and we hope to hear ideas and questions from farmers about this topic. We also hope to work with more organic farmers in the future to measure how cover crops are impacting different ecosystem functions on your farm, such as nutrient cycling, weed suppression and pest control. If you have ideas or questions or want to collaborate, send us a note at cmw29@psu.edu.

Acknowledgements: We would like to thank Dan DeTurk, Wade Esbenshade, Bucky Ziegler, Joel Steigman, and Eric Steigman for hosting the cover crop experiments on their farms. We also thank Brian Moyer, Andrew Puglia, Brosi Bradley, Sara Jones, Matthew Rider, and Katie Speicher for their valuable assistance in the field and lab.

Extension and Study Circle Recap

Thanks to Tianna Dupont, Mena Hautau, Dave Hartman, and Charlie White

Organic Field Crop Study Circles provide an opportunity for producers and researchers to learn from each-other, advance the organic industry, and share the latest in participatory research. Pennsylvania has 581 certified organic farms producing 78 million dollars in product (Ag Census 2012). In collaboration with the 6-county Central Susquehanna Valley Organic Crop Growers' Network and the Southeast Pennsylvania Organic Crop Producers' Network, in 2014 Penn State Extension hosted several field days. In Southeastern PA there were 4 study circle meetings, including a total of 89 participants (5,822 acres when added, 1,913 highest in one). And in Central PA three more events were held in Montour Co., Union Co., and Lycoming Co. drawing another 40+ participants.

A meeting in Union County in August.

A meeting in Lancaster County in April.

Summary of 2014 SE PA Study Circles

- 71% of grower participants learned a great or good deal from the study circle they attended (n=58).
- 54% planned to implement new practices based on what they learned (n=30). Participants planned to "keep detailed records, track costs per crop, work on interceding cover crops into corn, try to incorporate more cover crops into rotations, try yellow mustard in early spring before soybeans," and more.
- 65% of producers that had attended study circles in the past have already put new practices into place on their farms (n=31). They have "used organic no-till, no-tilled alfalfa into small grains, planted cover crops, diversified rotations, and [used] more diverse cover crop blends."

For Reference: Cocktail Mix Seeding Rates and Species

Cocktail Mix Seeding Rates

Mix Name	Seed rate and Species
Red Clover	12 lb/ac
Canola	11 lb/ac
Radish	10 lb/ac
Rye	124 lb/ac
Oat	92 lb/ac
Winter Pea	78 lb/ac
3 N after wheat, before corn	6 Clover, 25 Rye, 39 Pea
3 N after corn, before soybean	8 Radish, 62 Rye, 46 Oat
3 Weed (same in both entries)	8 Clover, 62 Rye, 46 Oat
4 after wheat , before corn	6 Clover, 6 Canola, 25 Rye, 39 Pea
4 after corn, before soybean	6 Canola, 8 Radish, 25 Rye, 39 Pea
6 species	3 Clover, 3 Canola, 3 Radish, 25 Rye, 23 Oat, 19 Pea
Broadcaster Plus	18 lb/acre broadcaster (Annual Ryegrass, Crimson Clover, Medium Red Clover, Radish, Yellow Sweet Clover) + 20 lb Oats, + 1 lb Sunflower

Photos clockwise from top-left:

Crew walking the field in mid-July; A dusty day of cover crop planting after corn; A cover crop mix in the cone about to be drilled; View from the top of the combine at wheat harvest in mid-July.

Acknowledgements:

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Project website:
http://agsci.psu.edu/organic/research-and-extension/cover-crop-cocktails