Cover crops are one of the many tools farmers can use to manage nitrogen on the farm and for the environment.

Your nitrogen management goals depend on the circumstances of your individual farm, such as how much manure you have to spread or how much fertilizer you have to buy.

If supplying nitrogen to the next crop is your primary goal, a legume cover crop – like vetch, clover and pea – is the typical choice.

If retaining excess nitrogen over the winter is your primary goal, a grass or brassica cover crop – like cereal rye, annual ryegrass, radish and canola – will work. If you want to balance the goals of nitrogen retention and supply, a mixture of legumes and grasses or brassicas may be the best choice.

We have put this idea to the test in several recent research experiments. At this year’s Penn State Extension Agronomic Field Diagnostic Clinic, we used one of these experiments to show crop consultants, industry representatives, conservationists and educators how to predict and measure the ability of different cover-crop monocultures and mixtures to retain and supply nitrogen.

We focused on characteristics of two cover-crop monocultures, hairy vetch and cereal rye, and a four-species cover-crop mixture of hairy vetch, red clover, cereal rye and canola.

The cover crops in this experiment were planted on August 25, 2012, following spring oats, and terminated on May 25, 2013, prior to corn planting.

Measuring the nitrogen

Evaluating the ability of cover crops to retain and supply nitrogen begins in the winter with measurements of nitrogen losses via nitrate leaching into the subsoil.

To do this, we used a tool called an anion-exchange resin capsule which, put simply, is a PVC ring filled with tiny, positively charged plastic beads.

We installed the capsules at a depth of 1 foot at the time of cover-crop planting. Over the winter, nitrate-laden soil water percolated through the capsules, and the nitrate was trapped on the beads.

We dug up the capsules in the spring and measured the amount of nitrate trapped on each in the lab to estimate a per-acre rate of nitrogen leaching under each cover crop.

In spring, we begin to assess nitrogen supply with measurements of cover-crop biomass and nitrogen content and continue to monitor soil nitrate levels and corn canopy greenness in the summer. At the end of the growing season, corn yield is a strong indicator of the ability of cover crops to supply nitrogen.

Table 1 Measurements made to assess N dynamics following cover crop monocultures and a mixture

	Biomass (lbs/ac)	Nitrogen content (lbs N/ac)	Nitrate leached into subsoil (lbs N/ac)	Soil nitrate at 12" corn (ppm)	V6 corn canopy greenness (NDVI)	2012 Corn yield with 0 N fertilizer (bu/ac)	2012 Corn yield with 135 lb N fertilizer (bu/ac)
Cereal rye	5736	60	1	1	0.65	86	126
Hairy vetch	3463	165	23	23	0.76	156	158
Cereal rye + hairy vetch + canola + red clover	5113	141	3	5	0.74	147	161

At the Diagnostic Clinic, we used data collected over the course of the research experiment as well as data collected by the clinic attendees to summarize and synthesize the effects of the different cover-crop treatments on nitrogen-management outcomes. These data are presented in **Table 1**.

Nitrogen from soil and atmosphere

Cover-crop biomass and nitrogen uptake are among the most important characteristics that affect nitrogen management. Grass and brassica cover crops only take up nitrogen from the soil, while legume cover crops take up nitrogen both from the soil and the atmosphere.

The result is that grasses and brassicas are more aggressive scavengers of soil nitrogen and do a better job reducing nitrate leaching.

As measured by our resin capsules, nitrate leaching under cereal rye was only 1 pound per acre while it was 23 pounds per acre under hairy vetch.

The positive side to a legume’s ability to take up nitrogen from the atmosphere is that it allows the cover crop to accumulate a large quantity of nitrogen in its biomass.

When the legume cover crop is terminated, this nitrogen will quickly become available to the next crop as the cover-crop biomass decomposes.

In our example, the nitrogen content of the hairy vetch cover crop was 165 pounds N per acre while the cereal rye only contained 60 pounds N per acre.

Using corn as an indicator

The next opportunity to evaluate the course of nitrogen supply from cover crops comes when the corn crop is 12 inches tall, right before its demand for nitrogen really takes off.

A soil sample at this stage to measure soil nitrate levels can show differences in the amount of nitrogen released from cover crops as they decompose.

Participants at the diagnostic clinic measured nitrate concentration in soil samples from the field experiment using a simple field test, extracting soil with a weak salt solution and measuring nitrate with a water-quality test strip.

The cereal rye cover crop had a very low soil-nitrate concentration, around 1 ppm, while the hairy vetch cover crop had a soil-nitrate concentration around 25 ppm.

On the date we held the diagnostic clinic, the corn was at the V6 stage, which is the perfect time to measure another indicator of nitrogen supply: the greenness of the corn canopy.

Plant leaves are green because they contain chlorophyll, the molecule that turns sunlight into energy, which is used to fill grain on the ear.

A key building block of chlorophyll is nitrogen. That’s why nitrogen supplied in adequate amounts turns a plant green and increases its yield.


Measuring canopy greenness, then, is an indirect way to measure the nitrogen status of a crop.

We used a sensor to measure corn canopy greenness on a relative scale of 0 to 1 known as the normalized difference vegetation index, with values closer to 1 being greener.

The normalized difference vegetation index of the corn canopy following cereal rye was 0.65, while following hairy vetch it was 0.76.

Reflections in crop yield

Our final indicator of nitrogen supply is crop yield. In looking at corn yields from this same experiment planted last year (in 2012), we saw that corn following the cereal rye monoculture yielded 86 bu per acre without any added nitrogen, while following hairy vetch it yielded 156 bu per acre, beating the county average.

When an additional 135 pounds N per acre was side-dressed, yield of corn following cereal rye increased dramatically (126 bu per acre), while yield of corn following hairy vetch did not (158 bu per acre).

Monocultures versus mixtures

These results paint a clear picture of the nitrogen management benefits and drawbacks of each type of cover crop when grown in monoculture.

Grasses are very good at retaining nitrogen but not at supplying nitrogen – and vice versa for legumes. Can we achieve the benefits of both legumes and grasses without the drawbacks by growing them together in a mixture? Our results so far are promising.

The four-species mixture of hairy vetch, red clover, cereal rye and canola we focused on at the diagnostic clinic reduced nitrate leaching to nearly the same level as the cereal rye monoculture while supplying nitrogen at a similar rate as the hairy vetch monoculture.

Although the soil nitrate and canopy greenness measurements taken at the diagnostic clinic for the four-species cover-crop mix were intermediate between the rye and hairy vetch monocultures, corn yields following the four-species mix in the previous year's experiment were about the same as after hairy vetch.

"You can't manage what you don't measure" is an old saying that certainly holds true for nitrogen management today.

Whether it's nitrogen from fertilizer, manure or cover crops, collecting and synthesizing as much data as possible helps us track how the system is performing and make improvements from year to year.

Hopefully the results from our work, along with measurements you can make on your own farm, will help you fine-tune your cover-crop system to meet your nitrogen management goals. ***FG***

Denise Finney is a graduate student in the ecology program at Penn State.

PHOTOS
TOP RIGHT: Corn growth responds to nitrogen availability following cover crop termination. Corn growing after red clover is tall and dark green.

BOTTOM RIGHT: Corn growing after annual ryegrass is short and pale. No fertilizer nitrogen was applied to the corn. *Photos courtesy of Charlie White.*

Charlie White
Extension Associate Sustainable Agriculture
Penn State Extension