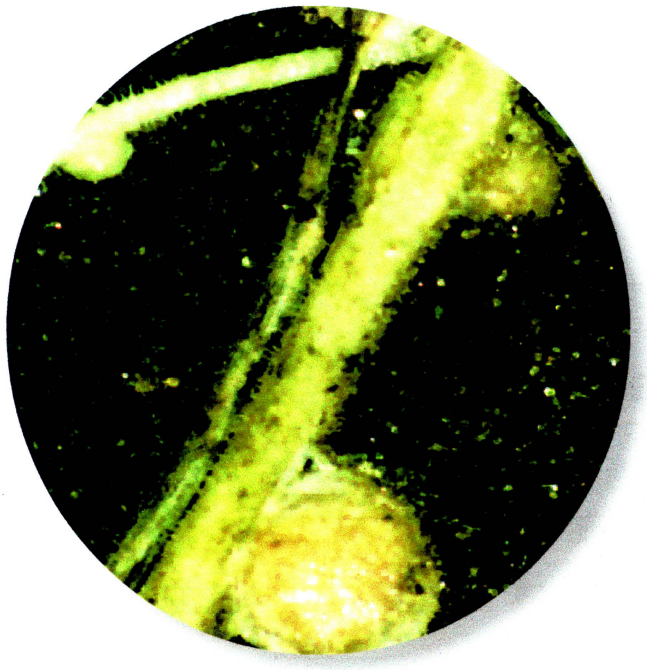
Keeping Nitrogen Out of Waterways

Legume crops may help farmers manage manure

MARKUS DUBACH (D152-1)



These tiny (2 mm) round organs, called "root nodules," are filled with specialized bacteria that capture nitrogen from the air and trade it to the legume plant for sugars the plant produces. The pink color comes from a compound similar to the hemoglobin in animal red blood cells.

Farmers use manure as a source of nitrogen for their crops and as a way to dispose of it. Many also apply commercial nitrogen fertilizer, since there's no way to know exactly how much nitrogen is in the manure. This practice ensures that the plants get enough of the nutrient to produce profitable yields.

But an unintended result can often be too much nitrogen—more than the plants can use before it washes away in rain, snowmelt runoff, or subsurface drainage to surface waters. In the Mississippi River Basin, some of that nitrogen eventually ends up in the Gulf of Mexico, where it can create periodic dead zones. Marine animals either move out of these oxygen-starved waters or they perish.

Surprisingly, using manure to fertilize legumes may help keep excess crop nitrogen out of bodies of water like the Gulf of Mexico, says soil scientist Michael P. Russelle.

"The role legumes can play in reducing excess nitrogen in the nitrogen cycle is not widely recognized," says Russelle, who is in the ARS Plant Science Research Unit at St. Paul, Minnesota. "Most growers think that legumes only make their own nitrogen. But capturing nitrogen from the air for use as fertilizer is simply an option these plants have, not a requirement. If they can get adequate nitrogen from the soil, legumes will do that and not make new nitrogen until they run out of the ready-made kind."

Soybeans, alfalfa, and all other legumes can capture nitrogen from the air with assistance from bacteria that live in nodules on their roots. The bacteria "fix" the nitrogen, converting it into amino acids that plants use to make proteins. The bacteria in turn get nutrients and energy from the plants. For this reason, farmers usually don't apply manure to these crops—let alone commercial fertilizer.

"'Why fertilize a crop that makes its own fertilizer?' is the common feeling," Russelle says.

But he suggests that growers might skip the manure on non-legume crops like corn and use it instead on leguminous crops that self-adjust for manure nitrogen content. It's a way to dispose of manure with little risk of either excess fertilizer or yield loss. "They can let the legume be their insurance. If the manure doesn't have enough nitrogen, the legume will start making its own."

Maps To Show You Where It's At

USDA estimates that in 2004 farmers harvested 3.15 billion bushels of soybeans from 74 million acres nationally, which are both records. The estimated acreage for alfalfa harvested in 2004 is more than 22 million acres nationally.

Russelle doesn't suggest that farmers apply manure to all fields of legumes—just those fields with the highest nitrogen-fixation rates, because those plants are hungry for an easy supply of nitrogen. The best candidate fields are those that are also high-yielding.

Toward that end, Russelle and Adam Birr, a graduate student

at the University of Minnesota, have drawn the first large-scale maps to show nitrogen-fixation rates in small watersheds within the Mississippi River basin. They've made these maps for soybeans and alfalfa.

To do this, they analyzed reports and estimates of crop yields and protein concentrations, along with soil nitrogen content and atmospheric deposition rates. They used records of protein concentrations for soybeans from 1997 to 2002 published by the American Soybean Association and the United Soybean Board. Extension specialists and private and public laboratories provided similar estimates for alfalfa. From this information on protein content in the harvested crops, the scientists were able to estimate how much nitrogen was in the full-grown crop.

Using research results from ARS scientists Mike Burkart and David James at the National Soil Tilth Laboratory in Ames, Iowa, they then estimated how much of the crop nitrogen was supplied by nitrogen fixation and how much of it came from other sources such as decomposition of soil organic matter and deposition of atmospheric nitrogen.

"While our numbers are estimates—because assumptions had to be made where data has never yet been collected—we believe the relative ranges in nitrogen-fixation rates are accurate," Russelle says. "We show the high and low spots in the basin for nitrogen-fixation rates for both these crops. And we've proven that you can't manage nitrogen in local areas while using fixation rates averaged over an entire river basin."

"For example, we found the basinwide average rate for nitrogen fixation by alfalfa was nearly 80 percent, meaning plants made 80 percent of their own nitrogen," Russelle says. "But when we looked at small watersheds, we got a very different story. We found alfalfa nitrogen-fixation rates ranging from less than 29 percent to 99 percent over various locations in the basin." For soybeans, Russelle and colleagues found the rates fluctuated even more wildly by location, from 0 to 96 percent, with an average of 57 percent.

This means that while water-quality experts and watershed managers will be able to use these basin-scale maps to help determine good candidate areas for manure application to legume crops, farmers will need to use more detailed information about their fields to best use the manure to derive both production and water-quality benefits.—By **Don Comis,** ARS.

This research is part of Soil Resource Management (#202) and Rangeland, Pasture, and Forages (#205), two ARS National Programs described on the World Wide Web at www.nps.ars.usda.gov.

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MICHAEL RUSSELLE (D151-1)

A young soybean field in Wisconsin. Like other legumes, a soybean plant can capture and fix some of the nitrogen it needs from the air.

MICHAEL RUSSELLE (D149-1)

Alternating strips of alfalfa and corn helps reduce soil erosion on this southern Wisconsin farm. In addition, alfalfa adds valuable nitrogen to the soil.

JOANN LAMB (D150-1)

Swine manure is sprayed on growing alfalfa with a research-scale manure applicator.