

**Query from Greg Horner, Cedar Tree Foundation:  
February, 2008**

Hello SAFSF listserv members -

I've recently heard several bits of news about nitrogen fertilizers and soil composition:

- 1) from a cooperative extension agronomist: (paraphrased) farmers almost always over-apply nitrogen fertilizer, wasting money and exacerbating environmental problems. They do this because it is hard to tell just how much nitrogen is needed, and they would rather overdo it than not have enough.
- 2) from a Washington Post article on climate change and ag: "new technologies that measure soil nutrient levels are allowing farmers to add only as much fertilizer as is really needed - important because the excess nitrogen in those chemicals gets converted in the soil into nitrous oxide, which has 300 times the greenhouse activity of carbon dioxide"

I'm interested to hear if anyone knows more about these "new technologies" and if any of you are working on this problem, from this angle or another.

seems like there could be some low-hanging fruit here, if we could speed the adoption of technology that would reduce the excess application of nitrogen, helping conventional farming get one step closer to sustainable.

thanks  
Greg

**Oran Hesterman, Fair Food Foundation:**

This is an issue that many agronomists have been working on for many years. In my early career as an Extension agronomist I focused a lot of attention on trying to get farmers to apply nitrogen in a more environmentally-friendly manner. These are issues not easily dealt with and even though many organizations would happily take foundation money on projects to reduce nitrogen fertilization in corn, I would be very cautious about spending precious philanthropic dollars on this issue unless there was a truly innovative and promising approach.

And, as to the claim that excess nitrogen fertilizer turns into nitrous oxide, I believe the more common chemical pathway is from nitrate to either ammonia (incorporated into soil organic matter) or N<sub>2</sub> gas, which is put back into the atmosphere, which is already nearly 80% N<sub>2</sub>.

**Ricardo Salvador, WK Kellogg Foundation**

The crux of this question is not that it is difficult to determine how much nitrogen is needed to satisfy a particular yield goal, but rather that it takes much management and commitment to meter the addition of nitrogen in such a way that it becomes available as plants take it up.

Briefly, two dynamics are in play:

- (1) plants take up nitrogen in a particular pattern as they develop (more as they are developing vegetatively than when they are becoming established or filling grain/fruit.)
- (2) nitrogen itself has a cycle of interconversions that is dependent on the form in which it is added, the temperature and moisture conditions of the soil, and the amount of organic matter contained by soil.

Optimal management for nitrogen would consist of adding none such at season beginning, monitoring the amount that becomes available naturally (from decomposition of soil organic matter) just before the point when plant uptake accelerates, and adding only the complement required to make up the difference between that level and the amount required to make yield goals. Optimally, again, that nitrogen would be added in a slow-release form, or in at least two pulses timed to match uptake.

There are many factors mitigating against such “optimal” management, but the critical ones are:

- (1) each application (pass through the field) entails cost for machinery, labor and fuel;
- (2) weather is unpredictable and there is no assurance that field conditions would allow for critically-timed applications (e.g., it might be rainy and unsuitable for machinery to enter the field at the appropriate time.)

So, to counter, what conventional management reduces to in the worst of all cases is:

- (1) application of nitrogen in the fall preceding the cropping year, which avoids the time pressure of spring application, when one never knows if/how long the planting window will be (generally speaking, the earlier crops are established within their climatic adaptation, the greater the yield.)
- (2) application of the most economical form of nitrogen, in the form of anhydrous ammonia, which has the highest nitrogen content per unit volume/weight of all fertilizer forms.

Unfortunately, anhydrous ammonia (a gas under standard temperate and pressure) is among the most fungible forms of nitrogen fertilizer. So, the outcome of the conventional management outlined above is that nitrogen is applied so far in advance of crop uptake (up to six months in the Midwest) that there is ample time/opportunity for losses to occur (through both leaching and volatilization) in early fall and early spring (these translate into surface water contamination and greenhouse gas enrichment, respectively.) Because this is known, fall application rates are deliberately calibrated so that 50 to 75% of the N applied can be lost and yield goals can still be attained. None of this is a revelation in the world of production.

With that setup, it can now be said that the counter is knowledge-based, skilled management (meaning a knowledgeable manager, the investment of time, and the existence of commitment to reduce environmental impact.) Since financial returns are to production, and not to mitigation of environmental impact, we have the situation that obtains at present. This is not a knowledge-limited arena, but one of transforming the incentives and rewards, and creating a culture of stewardship of more than pocketbooks. It has been a real culture war to address this through legislative means (the key arena for this work), and that is what the struggle around the Conservation Security Program vs. standard subsidies for productivity of program crops was about. The more time passes, the more “de-skilled” industrialized farmers we will have, with fewer incentives and a reduced capacity to act on anything more than purchasing an entire “technology package” and robotically deploying same.

One potential window to change this has to do with the climbing costs of nitrogen fertilizer (anhydrous prices are tightly coupled to the cost of oil.) Some highly motivated farmers might see the wisdom of saving on nitrogen costs and obtaining the same yields by exchanging skilled management for what are euphemistically referred to as “maintenance” or “insurance” application rates. This is a matter, partially, of developing the cost/profit curves for a spectrum of application rate and yield response scenarios, and ensuring that this info is broadly disseminated together with the appropriate management practices. Note that it would be best for the “agents” conveying such messages to wear seed-corn caps and boots rather than North Face vests and Birkenstocks ;-).

### **Robin Schoen, National Research Council**

Of course everything Ricardo says about incentives is true, but I think that technology is, in fact, improving so that farmers can proactively fine-tune nitrogen applications. The Iowa soybean people are signing up more and more farmers to adaptive management schemes where each year is a scientific experiment that involves collecting data, such as precisely collecting yield information on every few inches of an entire field to which different levels of nitrogen have been applied. It's no silver bullet, but it shows how different parts of the field respond differently under different conditions. The farmers themselves see the data at the end and it helps the producers learn more about the effectiveness of timing, effects of different soils. They know nitrogen lost is money lost. Remote sensing technologies of soil and crop nitrogen uptake are coming along and sending that information to a farmer's home pc is more and more possible. So I guess my point is that I don't think that “technology packages” necessarily create de-skilled farmers, so long as knowledge comes with it.

Still, I wish we knew how to make a more controllable fertilizer or could find rhizobacteria to fix atmospheric nitrogen for the grains like the legumes have. But that might take technology too !

### **Allen Doyle, Lawson Valentine Foundation**

This is an big problem worked on by coop extension, and many many workers. There may be some new Ag/Enviro alliances to empower, such as are taking off in 6 California counties--Ag Futures Alliances. East Coast farms and workers with higher rainfall and anaerobic conditions (thus n<sub>2</sub>o production), CAFO and dairy operations could be natural focal areas.

Packard Foundation is considering a Nitrogen Pollution focus, I imagine with the same goals in mind, so you may want to check in with their program folks. They sent out a questionnaire/blog a year ago. The board considered it, and they haven't come out with a commitment yet. I understand it's in the incubation phase. They were considering hiring a program officer solely on Nitrogen pollution.

### **Margaret O'Dell, Joyce Foundation**

Soil sampling and precision agriculture (where the farmer works off a GPS system into which have been put detailed data about his farm) are not that new, but expensive and high tech and N

is cheap. Unless there are other incentives or regulation, it's easier for the farmer to just over fertilize.

We've tried a couple of different approaches to deal with this - one was a project to develop a crop insurance instrument that protects the farmer against reduced yield because an untimely rain or whatever washed off some of his N - I still think that is promising (American Farmland Trust took it over from the person who developed the concept, a former congressional staffer who had worked on ag issues for years and was frustrated by the overfertilization issue) but again it's an extra step and right now there is no penalty for using too much fertilizer. The other is a project we're funding for Environmental Defense in which they have a crop consultant who gives talks to farmers and shows some great data about how they lose money putting rowcrops into marginal, frequently flooded, steeply sloping portions of their land - the goal is to get the farmers to plant buffers and sign up for CREP instead. I could send you some info/some of their overheads if you are interested.

Finally, I know Sand County Foundation is doing an on-farm demonstration/measurement project looking at N runoff (we've put some money into that but not as much), and a hydrologist here in Illinois, Donald Hey with the Wetland Institute, is promoting "nitrogen farming" which basically means creating trades to pay farmers for establishing small wetlands in their drainage ditches and at the outflow of their tile lines to absorb the N.

### **Susan Clarke, Columbia Foundation**

You might get some interesting information from Michael Dimock at Roots of Change or Tom Tomich at UCD Agriculture Sustainability Institute.

### **Mark Eiduson, Annenberg Foundation**

The Annenberg Foundation has been looking into projects in this area with the goal of reducing nitrogen run-off into the marine environment (among other things). The most exciting project we've come across at this point comes from MaterialsScience (MATSCI, aka: MicrobeTech—based in Massachusetts), and Kamterter (based in Nebraska). Working together, the two groups have developed some innovative technologies for microbial applications that dramatically reduce the need for nitrogen fertilizers, fumigants, pesticides, etc.

I've also attached a PDF of a Harvard Univ. article that presents a helpful "Microbes 101" explanation.