What’s driving adoption of in-season nitrogen application?  
| By Tanner Ehmke

Fields of yellow, nitrogen-deficient corn have become a common sight at springtime across the Midwest in recent years, thanks to frequent and abundant rains taking nitrogen (N) from farm fields through leaching and denitrification. Call it climate change or bad luck, it’s causing farmers, CCAs, and the fertilizer industry to look more closely at in-season adaptive N management to hedge against future losses.

While there are a number of contributing reasons for increased interest in split N applications, also known as sidedressing, extreme precipitation events commonly associated with climate change have been a key motivator for split-applied N in the spring instead of applying an entire fertilizer budget at or ahead of planting, agronomists say.

The percentage of farmers who have embraced sidedressing has yet to be quantified in a formal study. But according to agronomists like Peter Scharf, CCA, at the University of Missouri, interest has grown appreciably in recent years in response to the increased frequency and intensity of spring rain storms.

“At a field day in northwest Missouri, I found that about half of those who applied in-season N had a planned split-application program, and the other half applied N in-season in response to wet weather,” says Scharf, who specializes in nutrient management. “The last time that I tried to quantify this in 2010, which was also excessively wet for us, I found about 5% had applied in-season N. This excludes the Bootheel, or southeast corner of...
Missouri, where everyone applies in-season N."

The extremely wet years of 2008–2011 and 2013–2014 that caused significant economic losses through lost N have caused farmers to seriously consider split N applications, Scharf says. And fertilizer equipment sales have followed suit, according to CPAg Dan Schaefer, director of Nutrient Stewardship for the Illinois Council on Best Management Practices.

“There’s a lot of post-application equipment being sold in Illinois now,” he says. “If you talk to the fertilizer equipment manufacturers and sales people, post and sidedress equipment sales have just gone through the roof.”

And farmers are seeking out more information and tools to better manage their fertility program amidst increased climactic variability, adds Harold van Es, professor of soil science at Cornell University, who developed the Adapt-N tool found online at adapt-n.cals.cornell.edu for adaptive nitrogen management in corn.

The subscription-based website helps farmers assess more accurately how much N is needed for sidedress, thereby helping them adapt to extreme weather conditions, van Es explains. In most years, he says, this will result in lower fertilizer rates and greater cost savings.

“I can tell you anecdotally that a lot of farmers have started to use our Adapt N tool because it gives you a number on what your N losses are,” van Es says. “In Minnesota this year, because it was a very wet spring, they were surprised at how much they lost. Some farmers lost maybe 100 pounds of nitrogen because of their early application. So now they’re saying, ‘Hey, we need to go to split application because it’s costing me a lot of...”

Below: Interest in sidedressing N has grown appreciably in recent years in response to the increased frequency and intensity of spring rain storms, according to agronomist Peter Scharf, CCA, at the University of Missouri. Photo by Kyle Spradley/University of Missouri.
money.’ And it’s especially playing out now because grain prices have gone down but fertilizer prices are still relatively high. They can’t afford to lose that much nitrogen anymore.”

A changing climate

Farmers’ concerns of losing N to future extreme weather events are not without scientific data. While surveys of farmers across the country reveal that the majority of the farm population maintains a skeptical view of climate change, the climate data indicate there has been a clear shift to more extreme weather events like heavier precipitation in the spring.

Scharf analyzed precipitation data from the Midwest Regional Climate Center for 1900–2013 and found that the area with more than 16 inches of rain during the key N loss months of April to June was steady from 1900 to 1980 but has more than doubled since 1980 to present. He concluded there is a 99.97% chance the trend toward extremely wet springs in the central U.S. is real. If more than 16 inches of rain falls from April to June, he says, there is a high risk of N deficiency, and N must be applied in season.

“I think this increasingly large wet area is part of a changing climate, has been experienced by farmers, and has persuaded them to apply N in season when it’s a wet year,” he says. “Some farmers have been persuaded by the same experiences to plan on splitting their N.”

CCA Dave Mengel, professor of soil fertility and nutrient management at Kansas State University, agrees the gradual shift to a wetter, more extreme climate in the Midwest has influenced farming practices. However, he notes that the concept of a wetter trend isn’t recent.

“I remember talking to a young climatologist back in the mid-1980s who indicated that they were already documenting an increase in the number of high-intensity summer rain storms in Michigan,” he says. “And so if you look at the data, there’s no question that in the last 10 years, there’s been a much higher significance of flooding early season, late season, or during the growing season. If you look at the Missouri, Mississippi, and Ohio river valleys, the flooding events that have occurred there in the last five years, for example, appear to be much more frequent than in the past. And I think that’s caused people to question what has been done in the past [with nitrogen application].”

The biggest risk of N-loss during extremely wet springs is denitrification where microbes in waterlogged soils turn nitrate into nitrogen gas that is lost to the atmosphere, Scharf says.

In sandier soils, losing nitrogen to leaching where the water-soluble nutrient moves with water off the field or through the soil profile is the greater risk when spring rains are...
abundant, adds CPSS Carrie Laboski, soil scientist at University of Wisconsin–Madison.

“In Wisconsin, we have both denitrification and leaching,” Laboski notes. “We have thick soils that are very heavy, and then others that are more of a sandy loam. If you start putting on six inches of rain in two days, it’ll start moving through that sandy loam pretty good. But we also see the denitrification that’s occurring in some of our medium and fine-textured soils.”

The trend of extreme precipitation events has been in place for more than 30 years, say climatologists, with the trend expected to continue with greater extremes and frequency in coming decades as rising concentrations of atmospheric water vapor further intensify precipitation events.

Economic sense

While climate change may present farmers frustrating weather situations in the spring, underlying the growing interest in split applications of N are basic economics.

Reduced fertilizer costs and higher yields are tremendous incentives for farmers to budget their fertilizer needs throughout the season, Schaefer argues.

“It increases the bottom line,” he says. “It’s loss reduction, basically, and it increases yield. That’s what we started seeing back in 2008. We started working with some of this to increase yields by doing multiple applications and spoon-feeding the crop throughout the course of the season versus a one-time application in the fall or spring, or even sidedress. It pays dividends to have multiple applications out there. It’s all about MOM—minimize environmental impact, optimize harvest yield, and maximize input utilization.”

The financial rewards of N loss reduction are achieved by delivering N to the plant during its peak needs, Schaefer says, noting that only 20% of the corn plant’s nitrogen budget is needed prior to the V6 stage, or 40 days after emergence. Applying 100% of the budget in the fall or even in March doesn’t make sense if the farmer plants in mid-April, he says, while only a fraction of the N is used another 40 days after the plant emerges. That long window between application and uptake, he stresses, creates greater risk of N loss and financial risk to the farmer.

The financial cost of N deficiency can be staggering, Scharf adds. If a farmer suffered an average yield loss of 45 bu/ac across 265 ac with corn priced at $3.75/bu, the farmer suffers an economic penalty of $44,720 in lost yield from deficient fertilizer. With those financial risks, farmers are more inclined split applications. However, not every year is guaranteed to payout on every field with split applications, Laboski points out.

On well-drained soils or fields where there is little difference between preplant and sidedress applications, preplant fertilizer is often an acceptable time of application with little risk of N loss. But in extreme precipitation events, even well-drained soils are at risk of N loss, she notes.

“I am concerned that with the weather patterns that we have now, we need to move forward to more sidedressing,” says Carrie Laboski (above), soil scientist at the University of Wisconsin–Madison. Photo courtesy of University of Wisconsin Extension.
so of the total is going back into the soil to recycle through the soil system over a two- or three-year period. We might still be seeing a 10% loss.”

Worldwide, the percentage of applied nitrogen that is taken up by the plant averages roughly 30 to 40%, Mengel says. A target number for N use efficiency in Kansas, meanwhile, is generally 50%. With another 25% of the applied N cycled through the soil system, that leaves about 25% lost to denitrification, leaching, or volatilization, depending on the farmer’s situation. Using split applications that deliver N to the plant at peak needs, he says, can help the farmer shrink the percentage of N lost and reduce overall fertilizer costs while maintaining or improving yield.

The extra trips across the field to deliver multiple applications of N might be considered a cost factor that turns some farmers away from split applications, Schaefer notes. But because each trip uses fewer pounds of product per acre, the farmer is able to cover more acres in less time with each trip.

Applying only 20 to 30 lb N/ac at pre-plant instead of the entire crop’s budget of more than 100 lb/ac means less hassle for the farmer during the spring rush. The lighter loads translate into less time refilling a fertilizer product like liquid UAN or dry urea or by juggling fewer anhydrous tanks.

“By splitting it up we’re moving equipment over acres faster,” he says.

Government influence

Keen on reducing pollution of groundwater or public waters, state and federal governments are coaxing farmers to become more efficient with their fertilizer with financial incentives or by setting goals on N loss reductions. USEPA is also charged with enforcing water quality standards.

One example is the 13-state Mississippi River Basin Initiative (MRBI), which is administered through USDA’s Natural Resources Conservation Service (NRCS) with technical and financial assistance to farmers to reduce downstream nutrient loading. Nitrogen reduction goals might influence farmers in their decisions to adopt in-season applications, van Es says. Meanwhile, goals that individual states set for N loss reduction are often overly ambitious, and the laws lack teeth, he notes.

“Every state in the Mississippi River Basin has developed or is developing a nutrient reduction strategy, mandated by the U.S. Environmental Protection Agency. They are typically more than 40% reduction in N losses, and that’s very ambitious,” van Es says. “Even if you get every farmer to adopt technologies or bring in cover crops, it’s very difficult to achieve 40%. So it’s going to be interesting to see how that will play out or how these nutrient reduction strategies are going to be really serious efforts because there’s not really any heavy regulatory teeth behind it for the individual farmer. It’s going to be mostly voluntary adoption. And then you have to think about what percentage of farmers are actually going to be adopting these practices. It’s not going to be 100%, and it’s going to require probably at least 50% of the farmers to be serious about this.”

Nationwide, NRCS also offers financial support for nutrient stewardship through the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP), both of which are voluntary programs that pay farmers for implementing conservation practices. EQIP and CSP could also be influencing farmers to adopt environment-friendly practices like in-season N application, Mengel says.
Nitrogen is often the most limiting nutrient to cereal crop production, and with phosphorus, poses the greatest environmental challenges of all plant essential nutrients. More producers are switching to split nitrogen and in-season nitrogen applications to limit N losses and limit adverse environmental consequences of N leaching and denitrification. This webinar series will review some of the commercially available models for in-season N management and discuss the utility of optical sensors and soil testing to improve N management. CEUs available. Register now!
But the cost-share is limited, notes Scharf, and participation is strictly voluntary.

“I don’t think that legislation or policy has had any noticeable impact [on split application],” he says. “There’s quite a small cost share available through EQIP for split N applications, but it’s nothing compared with the economic incentive provided by yellow corn and lost yield. Even if the cost share was big enough to really influence decisions, relatively few producers can get EQIP contracts because there are just not enough dollars to go around.”

Barriers to adoption

While interest in split N application is growing among farmers, there still exist barriers to wider adoption. One significant barrier, agronomists say, is that farmers often have a difficult time changing old habits. With delayed N applications, farmers also risk waiting too late for optimal delivery of nutrients to crops if weather is uncooperative, thereby risking yield. But it’s not just farmers who need to be adapting, van Es stresses. Fertilizer companies and retailers should also be embracing split N applications.

“The majority of farmers really get their N recommendations from fertilizer retailers more so than from extension folks or private consultants,” he says. “So I think that the industry needs to take ownership of this, and the best opportunity that they have is to focus less on selling bulk product and start selling knowledge and good nutrient management.”

A good N recommendation saves the farmer fertilizer, which costs the fertilizer company in lost sales, van Es explains. The fertilizer company, though, could charge farmers for making good recommendations.

Fertilizer companies also promote fall or early spring N applications with price incentives, van Es adds, which discourages placement of N in season. But if pre-planted N is lost to leaching or denitrification in a wet spring, the farmer loses whatever financial savings he thought he achieved from early application. Resolving this issue requires structural changes in the fertilizer industry, he says.

“There are some logistical issues. The industry is not very well set up to deliver nitrogen all in a relatively short time, so they like to spread out the time window,” he says. “But it’s also something that can be addressed. It’s not like this has to persist. It may be more advantageous for the industry, but given all the environmental concerns, they’re going to have to adapt and develop an infrastructure that better facilitates in-season application.”

Low corn prices might be another disincentive for farmers to adopt new N management strategies, Schaefer points out. With a sprayer costing roughly $300,000, for example, big investments become harder to justify as corn prices sink.

Coming Soon! Managing Nitrogen in Crop Production Guide

This attractive, readable guide condenses the most important research from 40 of the country’s leading experts on nitrogen. Among crop nutrients, nitrogen has the most complex chemistry and behavior in soil, gives the largest yield responses, and is the most difficult to manage. The book’s objective is to increase understanding of nitrogen and the odds of managing it successfully. Readers will especially appreciate the concise, readable style that is used to explain an enormous body of knowledge in a way that is accessible.

Author Peter Scharf, Nutrient Management Specialist, University of Missouri, brought his years of experience in helping others understand nitrogen to this project and worked with many researchers to provide a broad understanding of nitrogen and useful, practical knowledge.

Managing Nitrogen in Crop Production will be available for purchase from the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America later this year.
“There could be some impairments there with just the economics,” Schaefer says. “But I think if something drives higher yields, the farmers are going to stay with that and try to cut back maybe in some other respect. Maybe they’ll keep their nitrogen management plan in place. That’s what I hope they do. From a water quality standpoint, that’s what we need to be doing, too.”

More information

- Adapt-N Tool, Cornell University: http://adapt-n.cals.cornell.edu/
- Climate Change Indicators in the United States, USEPA: www.epa.gov/climatechange/science/indicators/weather-climate/heavy-precip.html
- Nitrogen Loss, University of Missouri: http://plantsci.missouri.edu/nutrientmanagement/nitrogen/loss.htm
- U.S. Climate Extremes Index, NOAA: www.ncdc.noaa.gov/extremes/cei/

doi:10.2134/cs2014-47-6-1

Videos on Adapt-N, PSNT sampling

Watch a demo of the new Adapt-N interface (left) and to hear from Dr. Carrie Laboski on how and why to take Pre-Sidedress Soil Nitrate Test (PSNT) samples (right).