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Issues with Nitrogen Fertilizer: Fall 2013

With 85 percent of soybean and 74 percent of corn acres harvested by October 27, the annual process of deciding when and how to supply nitrogen fertilizer for the 2014 corn crop is underway.

Lessons from this past year

Following the very dry first half of 2012 and low corn yields, soil sampling last fall revealed an average of about 80 lb N present as nitrate in the top foot of soil in Illinois. With a lot of rain in late winter and early spring, soil N levels by spring had dropped considerably. And early spring application in 2013 was often followed by a lot of rain before the crop started to take up much N.

The 2013 season was wet early then dry late, but with good root systems that took up water and nutrients well to produce good yields. So far overall N loss this past season does not seem to have been greater than normal. Evidence to support this comes from N trial data just coming in. In an on-farm study coordinated in Champaign County by Dan Schaefer of C-BMP, corn responded almost exactly the same, and with the same yield levels, to fall-applied NH3 as to UAN sidedressed in June. In a study with continuous corn at Perry, sampling in June showed that most of the N applied as UAN in April was still present after more than 12 inches of rain, and yields barely increased going from 180 to 240 lb N, at a yield level of about 200 bushels per acre. At Monmouth, supplementing 165 lb of N as UAN applied in early April with 60 more lb of N in early June, after some 18 inches of rain, did not significantly increase yield of about 240 bushels per acre.

High corn yields mean that large amounts of N were taken up. In the 2013 UI corn hybrid trials, the average yield among the three sites where we measure grain protein was 228 bushels per acre, and the average protein content (at 15% moisture) was 8.4 percent. That calculates to removal of 0.74 lb N per bushel, or 169 lb N per acre. We typically estimate that 2/3rds of the N in the plant at maturity is in the grain; that would calculate N uptake at more than 250 lb N/acre. When we can get 250-bushel yields with 180 lb of N as we did in some cases in 2013, it's clear that the soil supplied a great deal of N to the crop.

It does not appear that much of the "extra" N needed for the high corn yields in 2013 came from N that was left over after the drought of 2012. As is typical, soybean fields had very low amounts of soil N after harvest in 2012, yet corn following soybeans is – again, as usual - showing less response to N rates than corn following corn in 2013. What data I have so far indicates that corn following corn may not be taking a big yield hit like we've seen in some areas in recent years. It's possible that some of this is because of leftover N, but corn following corn is also showing a typical response to N rate, so it's not clear that leftover N was a major contributor.

With the weather dry over much of Illinois since August (until rainfall this week), can we expect soil N levels to be high again this fall? I've seen numbers from only a few soil samples so far this fall, and they seem mixed, but generally lower than we saw in fall 2012. The crop clearly had the root system to tap into water that was deep in the soil in order to produce the yields that it did, and it's likely that it brought a considerable amount of N up along with this water. We might expect that this meant removal of much of the N mineralized from soil organic matter, but with some rain now and soil temperatures still in the 50s, there is still some mineralization going on, at least for a few more weeks. But in general, we expect soil N levels to be more or less this fall; we have typically measured only 20 or 30 lb per acre of nitrate-N in the top foot, or even less.

Fall Nitrogen?

The big question that many people have is whether or not to apply N fertilizer this fall or to wait until next spring.

We know from nitrate levels in rivers that an appreciable amount of the N present last fall left fields through tiles lines last spring. Fall-applied N generally went out late enough last fall, and soils turned cold and stayed cold after application, so most of the N lost in tile lines last spring came from leftover N rather than from N fertilizer applied last fall. The fact that we're seeing similar responses to fall- and spring-applied N would support that most fall-applied N stayed in the soil and available to this year's crop. We are not seeing the unusually large responses to applied N this year that we would expect to see following high N losses.

The basics of fall N application have not changed: the form should be anhydrous ammonia (NH3); soil temperatures should be at or below 50 degree F at the time of application; using a stabilizer/nitrification will slow the activity of microorganisms that convert ammonium to nitrate (the form that can leach); soils should not be wet or very dry, but should have enough water to allow the ammonia to spread to a diameter of 4 to 6 inches as it is released in the soil; and application depth should be 6 inches or more so the NH3 gas doesn't escape after application. Fall NH3 application should not be done in southern Illinois due to higher chances of soil warming in the fall and earlier warm-up in the spring, and N losses also go up on poorly-drained soils or very light soils, making fall application more risky.

Except when fall weather is warmer than usual, soil temperatures in Illinois reach the 50-degree mark by about November 1; if they don't, they are usually on the way down and will reach that level soon. You can see soil temperatures in Illinois at a number of websites; the Illinois State Water Survey site at http://www.isws.illinois.edu /warm/soiltemp.asp gives daily minimum and maximum temperatures at the 4-inch depth under bare soil. Minimum values were below 50 in the northern part of the state on October 30, and maximum values were in the mid- to upper 50s through northern and central Illinois. Keep in mind that there will be some biological activity even at 50 degrees, and any warm spell after application will mean more conversion to nitrate. The goal should be to have soils approach freezing temperatures with as much of the N still in the ammonium form as possible.

It is certainly the case that nitrapyrin or other nitrification inhibitors may not be necessary when soil temperatures are low at the time of application and stay low into the spring. Inhibitors also begin to break down as soils warm in the spring (or get or stay unusually warm in the fall), so that by the time the plants are ready to take up N rapidly, often in early June, much of the N will be in the nitrate form. So what we really hope to get from an investment in an inhibitor is a delay in the conversion to nitrate, so that more of the N is still in the ammonium form as soils warm and water starts to move through the soil, taking nitrate with it. On the other hand, when NH3 is applied late enough, the winter is cold, and the spring is dry, there's little N loss regardless of N form, and an inhibitor will provide little benefit. This means that using an inhibitor is an approach to managing risk.

Another approach that some take to managing risk of N loss is to apply high N rates in the fall, with or without inhibitor, with the idea that some N loss can happen but that there will still be enough N available the next spring. This can certainly work in terms of having enough N, but it comes at a high environmental cost. Not only do we know that high yields of corn grown in productive soils often do not need the high N rates that some producers apply, we also know that too-high N rates will, sooner or later, mean more loss of N to the environment. While loos to the environment may not seem to be a "real" cost (though the additional N is a real cost), it is a real cost, in terms of things like water treatment to remove nitrate, and in terms of image.

One practice that some have adopted is to apply only part of the N in the fall, with the rest applied the next spring. This approach should reduce the amount of N loss if soil conditions become conducive to loss of fall-applied N. And it provides one of the underappreciated benefits of fall-applied NH3, which is having N dispersed through the soil and easily accessible to the plant in the spring. The drawback is that NH3 application is rather slow and costly compared to most other methods of N application, and so applying lower rates increases the cost per lb of N applied.

I mentioned a few days ago the use of subsurface banding of P and K, accompanied in some cases by placement of NH3 beneath this band in the same operation. Making one trip to apply fertilizer increases efficiency, and as long as soil temperatures are low enough, this can work well. As is the case with banded P and K, there is little evidence that applying NH3 under the P-K band provides a yield advantage over applying dry and N fertilizers separately. There has been some tendency in the past for such "dual placement" operations to start before soils are cool enough for fall N application, which increases N loss potential.

One issue with fall NH3 application in recent years has been whether or if to combine application with tillage. Some have applied N and then tilled, while others have tilled first and then applied (and sometimes tilled again after that). Ammonia is extremely soluble in water, and once dissolved in soil water it converts to ammonium. So if there is a moderate amount of soil moisture present, losses of NH3 should be relatively small, even if soil is tilled. Tillage does form air pockets in the soil, however, and if a marginally dry soil is tilled before NH3 is applied, some NH3 could be released before it can dissolv. This would be noticeable as puffs of "smoke" (actually, water droplets attracted by ammonia) after the applicator, and as the smell of ammonia.

Tilling after application does turn soil up where the sun can warm it, and the warmer temperatures might increase conversion to nitrate. If the soil is dry, tilling after application could also release some NH3 that was not dissolved, especially if the soil dries even more as a result of tillage. It also is probably worth asking as well if soil following NH3 application really needs tillage.

N Rates

One of the advantages of applying less than full rates of N in the fall is that it delays the final rate decision until the spring, allowing us to note loss conditions, planting dates, and other factors that might affect the rate we apply. At the same time, as we have seen this past year, the amount of N loss can be difficult to determine. This means that the tendency to apply some "insurance" N to make sure there's enough operates in the spring as well as in the (previous) fall. In fact, despite a lot of evidence to the contrary, there's an abiding thought that bringing out full yield potential for a crop that gets off to a good start in the spring will require more than the usual amount of N. We may have had a little less of this than usual this past spring – with the crop planted as late as it was it didn't seem to be off to a great start. The fact that we are hearing of some yields above 250 bushels per acre, often coming with "only" normal amounts of N, should help a few more of us to start to question whether high yields only come when we pour on the N.

The N rate calculator located at http://extension.agron.iastate.edu/soilfertility/nrate.aspx remains our best "range-finder" for guiding the process of determining N rates. For central Illinois corn following soybeans, and with NH3 priced at $680/ton ($0.41/lb N) the current guideline rate is 167 lb N/acre (204 lb of NH3), and the range is 154 to 183. In northern Illinois, the most profitable rate under these same prices calculates to 149 lb N/acre, with a range of 137 to 163. As we have noted before, the ratio of N to corn prices tends to stay relatively constant over time, with a bushel of corn equal in value to about 10 lb of N (in the form of NH3). Changes in fertilizer prices by next spring are likely not to greatly change the guideline rates, but of course adjustments in total N applied can be made in the spring.

Cover crops and N?

Cover crop seed has been dropped or drilled into a lot of Illinois fields this fall. Ongoing dry weather has meant delays in germination in many areas, and temperatures down into the low 20s last week might have damaged some small cover crop plants, especially in harvested fields with cover crop plants more exposed. Growth of the cover crops will hopefully pick up now, but delays at the start may mean less growth before cold weather sets in.

We expect that a cover crop with vigorous growth and a good root system will take up some N left in the soil in the fall, and more N next spring if the cover crop overwinters. Once taken up into cover crop biomass, N is less likely to be lost to tile lines. From a crop standpoint, the N in the cover crop will be of value only if the next crop is one like corn that requires N from outside sources. The breakdown and release of cover crop N and its supply to the next crop is a biological process that depends on the weather. Cover crop residue in the spring can also affect soil temperature and water content, and so can affect the planted crop in ways other than through N supply.

One idea that has been floated is that fall cover crops can help take up fall-applied N, thus keeping it safe from loss and preserving it until the corn crop is up and growing next spring. This may happen to some extent, but fall uptake will usually be limited if the cover crop starts to grow well only after harvest of the crop it's planted into, and if fall N is applied only after soil temperatures reach 50 degrees; this will typically give only a few weeks of uptake, or even less. Applying NH3 into growing cover crops will cause some damage to roots, and when soil temperatures are cool and dropping, it's not likely that such roots will be able to take up much of the fertilizer N up before soil temperatures get low enough to halt root activity.

Uptake of fall-applied N increases as soils warm in the spring, but vigorous cover crops like cereal rye need to be killed in March, and soil temperatures by that time are usually still cool. As an example, average soil temperature at the 4-inch depth reached 61 degrees near Champaign in mid-March of 2012, one of the warmest Marches on record, but reached only 46 degrees by the end of March in 2013 and did not reach 60 this year until the end of April. So while we think that cover crops can have beneficial effects on N nutrition, we don't expect this to be consistent over years. We certainly cannot afford to get sloppy with fall N thinking that cover crops will bail us out to prevent loss.

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