

Nitrogen Loss Cuts Into 2009 Corn Profits

By Peter Scharf

Missouri produced a near-record corn crop in 2009, but not without some struggle. Late planting, widespread replanting, nitrogen loss, and harvest delays were some of the challenges that faced Missouri producers due to high rainfall throughout the season. Although it made for difficult logistics, the wet year guaranteed an adequate supply of water to most corn fields in the state. Water is usually the factor that most limits the yield of corn in Missouri, and the abundant supply created very high yield potential.

Unfortunately, a substantial part of our potential yield was not realized due to widespread deficiencies of nitrogen. Wet weather can lead to loss of N, both fertilizer N and soil N, through leaching and denitrification. Visual deficiency symptoms were widespread across the state in windshield surveys and aerial surveys that I conducted in August 2009. Based on these surveys and my estimates of how much yield potential was lost due to the deficiency symptoms I saw, I estimate that N deficiency reduced Missouri's corn crop

in 2009 by about 100 million bushels. Compared to the 438 million bushels that we did produce, this suggests that we could have grown at least 20% more if the crop had not been limited by N deficiency.

There was a wide range of severity, from few or no symptoms to severely yellowed fields. It was not unusual to see adjacent fields in which one had a much greater deficiency than the other, showing that N management affected the degree of deficiency.

I'm not too sure which N management strategies were most successful, except to say that N applied in-season to growing corn worked very well in 2009. In an experiment near Columbia, 153 pounds N per acre applied to knee-high corn gave yields 68 bushels per acre greater than when 180 pounds N was applied on the day of planting. Ammonium nitrate was the N source.

Spring-applied anhydrous ammonia was probably the most successful all-preplant program this year. All N fertilizer is converted to nitrate in the soil, but ammonia takes longer than

other N sources to convert. Nitrate is the form of N that is vulnerable to loss.

How extensive was this problem?

My rule of thumb is that more than 16" of rain from April through June (or more than a foot in May & June) will lead to nitrogen deficiency problems in a substantial number of corn fields. In 2009, nearly all of Missouri, Arkansas, Kentucky, and Tennessee, most of Illinois, southern Indiana, and eastern Kansas all had more than 16" of rain from April through June. This suggests the possibility of nitrogen deficiency across a wide area. During August, I drove about 2000 miles through Missouri, Illinois, Indiana, and Wisconsin, and had about 1500 aerial photographs taken in Missouri, Illinois, and Indiana. My conclusions from these observations was that N deficiency problems in most of Illinois were serious, causing over 20 bushels per acre yield loss on average. This translated into an estimated yield loss of 250 million bushels over the state of Illinois. My estimate for yield loss in Indiana was slightly lower, around 15 bushels per acre on average in the affected areas. Over eight states (Illinois, Missouri, Indiana, Iowa, Kansas, Kentucky, Arkansas, and Tennessee) I estimate yield loss of over 500 million bushels. This is on top of 2008 yield losses due to N deficiency that I estimated at just short of 500 million bushels across the midwest, giving a 2-year total estimated yield loss of around 1 billion bushels.

How did N deficiency affect profit?

Ray Massey and I put together a corn production budget for 2009 of \$490 per acre. This means that, if you were able to sell corn at \$3.80 (which was an average price for 2009), it took a yield of 130 bushels per acre to cover the cost of production. State-average corn yield

Continued on page 21



Figure 1.



Figure 2.

for 2009 was a near-record 151 bushels per acre, meaning that $151 - 130 = 20$ bushels per acre went to pure profit for corn producers. This is an excellent profit level.

However, I believe that profit would have been more than twice this amount if all our corn acres had had a sufficient nitrogen supply. I estimate that average yield loss due to N deficiency was 30 bushels per acre for Missouri.

Risk of N loss with different management strategies

Anhydrous ammonia is the source with the lowest risk of loss due to wet weather. This is because it is the slowest to convert to nitrate in soil. Nitrate is the form of N that is susceptible to loss during wet weather. All nitrogen fertilizer eventually converts to nitrate in the soil, but more slowly for anhydrous ammonia.

Sidedress application of anhydrous ammonia is virtually loss-proof. Sidedress application of other forms of N fertilizer also has a very low risk of loss because the time between application and uptake is short.

Preplant application of anhydrous ammonia within a month of planting

has the lowest risk of loss among all-preplant systems. Preplant applications of other forms of N can succeed in many years, but probably did not provide adequate delivery of N in 2008 or 2009. Limited evidence suggests that applying dry or liquid N a month before planting creates a substantially greater risk of loss than when applied just before planting. I would rate fall application of anhydrous ammonia in the same risk category as early-spring applications of dry or liquid N, which is the highest-risk category. However, even fall application of anhydrous ammonia is a successful N management system in many years and soils.

The solution: Rescue applications of nitrogen

Rescue applications of nitrogen fertilizer can be highly profitable when earlier N applications have been lost due to wet weather. Wayne Flanary increased corn yield by 50 bushels per acre with rescue N in northwest Missouri in 2009. The corn had been fertilized with 180 pounds of anhydrous ammonia N in late November, but appeared N-deficient during spring

growth. It went on to produce 170 bushels per acre, but where Wayne applied additional topdress urea in June it produced 220 bushels per acre. This illustrates the excellent yield potential for much of this year's corn crop. It also shows that the good yields produced in many fields could possibly have been substantially better by correcting N deficiency.

Another example comes from eastern Kansas in 2005. Rescue N was applied in late June to 7-foot tall corn as liquid N dribbled between rows at 40 pounds N per acre. Between each 100-foot pass of the applicator, the producers left a 100-foot pass without rescue N. Comparison of the yields between passes with and without N revealed a 35-bushel response in the half of the field where N deficiency symptoms were visible.

Many producers can be discouraged and think, "It's too late," when they see deficiency symptoms in their corn fields. My research suggests that the corn can respond to N very effectively at surprisingly late application timings. Up until four feet in height, average corn yield from a single application did not depend on timing. That is, a single application of N gave the same yield on average if it was applied at planting, when corn was two feet tall, or when corn was four feet tall. This finding is backed up by extensive data from Nebraska, Minnesota, Iowa, and Oklahoma. Even at tasseling, yield was still above 90% of its full potential if rescue N was applied at that stage. Limited data suggests that a profitable yield response is likely to happen until two weeks after tassels emerge in corn that is experiencing significant N stress.

My conclusion is that the logistics of getting the N applied is a much greater obstacle than the ability of the crop to use the N. High-clearance applicators, airplanes, and pivot irrigation systems can all be effective ways to deliver N to stressed corn. Among these options, sprayers are the most widely available

Continued on page 22

option in Missouri but many are not plumbed to accommodate drop nozzles between rows. And this represents the biggest obstacle to making rescue N applications that I have seen: lack of preparation. My firm belief after the last two years is that every producer and every retail organization needs to have a plan for making rescue N applications in place before the season starts. Getting the necessary preparations done during the season just isn't going to happen. Whether it's plumbing sprayers or making contact with aerial applicators, now is the time to make your plan.

Broadcast applications of dry N can be a fast and effective way to apply rescue N. We conducted a series of experiments around the state to see how much leaf burn would affect yield. We found that with good-quality (not dusty) urea applied when there was no water on the leaves, burn was quite visible but caused no more than 4 bushels of lost yield (compared to dropping the urea between the rows). Agrotain treatment of urea gave a profitable yield response when urea was broadcast on corn up to two feet tall, but not when corn was three or four feet tall. Ammonium nitrate burn reduced yield by about 20 bushels per acre when broadcast over 3- or 4-foot-tall corn, thus urea is the product of choice when broadcasting N on corn this size. UAN solution caused even larger yield losses, up to 70 bushels per acre, and should only be applied between corn rows using drop nozzles.

Diagnosis: Do I need to apply rescue N?

Last year, I initiated a feature on my website called 'Nitrogen Watch.' I plan to have this feature again this year, starting in late April and continuing through the end of June. This product is based on maps of cumulative rainfall (based on radar records) and identifies areas that are on track to have problems with N loss. However, being 'on track' in mid-spring will not necessarily mean problems by the time the growing season is in full swing—this will depend

March 3, 2010

on whether above-normal rainfall continues to accumulate.

The appearance of the corn crop is an excellent diagnostic tool. Corn that is light green or yellow-green is N-deficient nearly 100% of the time in Missouri. However, corn growing in waterlogged soil will be N-deficient even if the N has not been lost. This makes correct diagnosis more difficult. Sometimes this yellow corn will 'green up' when the soil dries out, and no additional N is needed. By the time you've been able to walk through the field for a week, the corn should look substantially better if the N is still in the soil. If not, a rescue N application is called for. However, waiting for that week of drying can reduce the window of time available to treat the corn.

Aerial photographs are my top choice as a diagnostic tool for N deficiency. You can get through all your acres much more quickly and thoroughly based on aerial photos than by ground-based inspection. At fairly early stages (knee-high), aerial photos can help you identify likely problem areas, but should be ground-truthed. At later stages (waist-high or later), aerial photos provide reliable indicators of which areas are experiencing N stress, and how severe it is.

My research suggests that aerial photographs can be translated into yield loss maps to help producers understand the magnitude of the problem. This makes it a lot easier to decide how much can be spent to correct the problem. Aerial photographs can also be translated into variable-rate N maps that can be plugged into a variable-rate applicator. Nitrogen loss is nearly always patchy, resulting in some areas of the field that need high rates of rescue N to reach their full yield, and other areas where no additional N is needed.

This year we partnered with the AgriVision consulting company to offer a service called NVision to provide producers with yield loss maps and variable-rate N maps based on aerial photos. I believe that this product will

continue to be offered in 2010 if the season warrants it.

Deep soil samples are another option for diagnosis, but are slow and labor-intensive. Samples need to be at least two feet deep. If it's been wet enough to cause N loss, it's certainly been wet enough to move N out of the topsoil. You should expect to find the fertilizer that you applied plus 50 pounds of N that is normally present in the soil before any fertilizer is applied.

Computer models may provide a way to integrate weather data with information on soils and N management to evaluate possible N loss. Such a system is currently available in New York state. Although I doubt that this approach will have the accuracy of assessing visual symptoms in each field, it will have the advantage of potentially providing an 'early warning' system. This could make the logistics of getting rescue N applied considerably easier.

Summary

2009 was a year with very good growing conditions for corn, resulting in a near-record harvest in Missouri and the U.S. Unfortunately, the abundant rainfall caused widespread N loss, reducing production by over 500 million bushels in the southern corn belt and the mid-south. Profits from corn production were good in Missouri but could have been twice as large if additional N had been applied to all fields that needed it.

Peter Scharf
ScharfP@missouri.edu
(573) 882-0777