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Warm Fall Increases Nitrogen Loss Potential

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Farmers that applied anhydrous ammonia in the fall for corn in northern Indiana are wondering how much nitrogen (N) they may lose this spring as a result of the warm fall and winter weather. Warm winter temperatures allow ammonium (NH_4^+) derived from anhydrous to be converted to nitrate (NO_3^-). Then, excess soil moisture promotes NO_3^- leaching below the root zone in all soils and NO_3^- conversion to nitrogen gas in poorly drained soils. Nitrogen loss to date has probably been minimal but we are just entering the time period where loss occurs. This article explains the factors that affect N loss from fall-applied N and management strategies to cope with N loss this spring.

Warm Wet Weather Increases Nitrogen Loss

To minimize N loss from fall-applied anhydrous ammonia in Indiana it is suggested that soil temperatures be below 50F and a nitrification inhibitor, such as nitrapyrin (N-Serve™), be included. This approach assumes the nitrification inhibitor will slow the conversion of $NH_4^+$to NO_3^- and soil temperatures will fall to freezing prior to much NO_3^- being produced.

Although conversion of NH_4^+ to NO_3^- is slow at 50F, nitrification does not stop until 32F. Unfortunately last fall, soil temperatures stayed warm after anhydrous ammonia was applied. Average soil temperatures at 8 inches deep were in the mid to low 40's in November and December. At these temperatures, more than 45% of the N applied as anhydrous ammonia was likely in the form of NO_3^- by the first of January. Conversion of NH_4^+ to NO_3^- has resumed with warming temperatures in March and April.

If spring rainfall is heavy, much of the NO_3^- accumulated in the soil may be lost. Research conducted in southern Minnesota (Randall & Vetch, 2005) found that little N loss from fall-applied ammonium fertilizers occurred with spring rainfall of 11.1" (April-June), but 35 and 60% of the N was lost when spring rainfall was 13.8" and 15.0".

Average rainfall for April-June in northern Indiana is 11.6" so minimal losses may be expected with average rainfall. However, above normal rainfall over the next few months could result in substantial N loss. Tile flow and NO_3^- loss through tile drains was typically greatest in May and June in long-term studies conducted in West Lafayette (Brouder et al., 2005). This is also the time period when denitrification is most likely to occur.

Nitrogen and Yield Loss can be Substantial with Fall-Applied Nitrogen

Adding a nitrification inhibitor to fall-applied anhydrous ammonia increased yield in 29 of 43 trials (69%) conducted in Indiana and Illinois (Nelson and Huber, 1992). The average yield increase at responsive sites was 9%. Using grain yield data from an 8-year field study conducted on a Crosby silt loam near Springfield, Ohio, we calculated an average loss of 54 lb N/acre from 160 lb N/acre (34% of that added), equivalent to 12 bushels/acre less yield. In these studies N was applied as anhydrous ammonia after soil temperatures fell below 50F (sometime from November 10th to 20th), so these losses occurred even thought the anhydrous was applied within the suggested application window. Adding nitrapyrin to the anhydrous ammonia reduced N loss to less than 20 lb N/acre, but spring anhydrous was still more efficient and higher yielding (+6 bushels/acre).

Field-specific estimates of N loss are not possible at this time. However, the pre-sidedress nitrate soil test (PSNT) or the chlorophyll meter may be used to assess N availability during the growing season and provide a way to determine additional N needs. Each test has advantages and disadvantages.

Using the Pre-Sidedress Soil Nitrate Test to Assess Nitrogen Needs

The PSNT will require extensive sampling due to the banded application of N, but measurements are made early in the season allowing N application with conventional equipment. Soil analysis for NO_3-N is relatively inexpensive.

One way to get a somewhat better estimate of soil N supply is to take soil cores to a depth of 1 foot and have it analyzed for NO_3^-. The later in the season this is done the better. Standard recommendations suggest sampling when corn is at the 4- to 6-leaf stage; hence it is called the pre-sidedress soil NO_3^- test or PSNT (Brouder & Mengel, 2003b). However, sampling is intensive when banded fertilizers have been applied and may be prohibitively time-consuming and expensive. Soil samples need to be dried before mailing to the laboratory.

Results of the soil NO_3-N test are typically reported in parts per million (ppm) or milligrams per kilogram (mg/kg), which are equivalent in value. If more than 25 ppm NO_3-N is found in the sample then no additional N is recommended. At lower levels of NO_3^-N, adjustments can be made to sidedress N rates. If little NO_3^-N is found it might indicate that NH_4^+ had not yet been converted to NO_3^- as well as indicating loss of NO_3^- from the root zone so some interpretation of the results is needed.

Using a Chlorophyll Meter to Assess Nitrogen Needs

Using a chlorophyll meter (Minolta SPAD™) necessitates installation of a high nitrogen reference strip (adding additional N to a strip in each field), purchase of a chlorophyll meter (>$1,500), and equipment for applying N to tall corn. An accurate assessment of N sufficiency can be attained relatively easily using the chlorophyll meter.

Relative leaf greenness of corn leaf tissue (chlorophyll meter readings) -- at the 8- to 10-leaf stage or later can be used to adjust sidedress N rates. Leaf greenness is an indication of chlorophyll content, which is highly influenced by N level. Other nutritional and environmental factors affect leaf greenness and variety differences also exist. For this reason a reference strip of highly fertilized corn (10-25% more than recommended) is required in each field for each variety grown. Since leaf greenness measurements are made when the corn is tall, N application with high clearance equipment, irrigation, or aerially is necessary. More details of using the chlorophyll meter can be obtained from Purdue Extension publication AY-317-W (Brouder & Mengel, 2003a)

Greenness readings should be made as nearly as possible on the same leaf and leaf position. Prior to tasseling, the uppermost leaf showing a collar should be utilized. At tasseling or later, use the ear leaf. Measure greenness about half way between the leaf tip and base and half way between the edge and midrib. Do not read wet leaf tissue. Calculate the average readings on 30 or more plants per uniform field area and in the reference strip. Average each set of readings and divide the value for the bulk field by the value for the reference strip. Making readings weekly beginning at leaf stage V8 through pollination is helpful in gaining confidence in this technique.

Greenness measurements are converted to an N sufficiency index (SI) by dividing the bulk field greenness reading by the reference greenness and multiplying by 100%.

> **For example:** Let's assume the average bulk field reading is 45 and the average reading for the reference strip is 50. The SI equals (45 divided by 50) = 0.9, then multiply this answer by 100% = 90% SI.

Previous research has shown that sufficiency index ratings of 95% or less will benefit from additional fertilizer. If SI values are 90% to 95% then 30 to 40 pounds of N per acre is recommended. If SI values are less than 90% then 40 to 60 pounds of N per acre should be applied. Recent research results have found that corn responds to higher application rates than previously considered. For example, Iowa State University recommends 100 lb/ac N with SI values less than 88% and 80 lb/ac N with SI values from 89 to 92% (Sawyer et al., 2006).

Summary

The amount of N lost from fall-applied anhydrous will be determined during the next 4 to 8 weeks. We will provide additional guidance on potential loss based on soil temperatures and rainfall as best we can during this time period. However, our guidance will be general because predicting N loss requires many field-specific assumptions. For field specific assessments, consider using the PSNT or chlorophyll meter readings as a way to assess N availability and correct for N loss.

Related References

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