Using the Soil Nitrate Test in Minnesota

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Use of the *soil nitrate test* has been fine-tuned by research and has now evolved as an accepted best management practice (BMP) to improve the accuracy of making nitrogen (N) fertilizer recommendations in Minnesota. This measure of residual or carryover nitrogen present in the soil in the form of nitrate-nitrogen (NO_3-N) can be used effectively to fine-tune the nitrogen fertilizer recommendations for a variety of crops in the state.

The majority of the N used by non-legume crops is absorbed from soils in the nitrate (NO_3) form. This NO_3 can be supplied to the root system from: 1) decomposition of animal manure, 2) previous legume crops in the rotation, 3) decomposition of soil organic matter and crop residues, and 4) commercial N fertilizers.

There can be several situations where the amount of NO_3-N supplied to the crop in combination with NO_3-N in the soil system during one or more growing seasons can exceed the amount absorbed by the crop. The amount of excess NO_3-N can be either lost from the soil system or carried over to succeeding crops. If carried over, a measurement of the residual NO_3-N can be used to fine-tune N fertilizer recommendations. The *soil nitrate test* is designed to provide a meaningful measure of the amount of residual or carryover NO_3-N.

Sampling For Nitrate Nitrogen

The *soil nitrate test* used in Minnesota is designed to measure the amount of residual or carryover N in the active root zone. Past research over a period of several years has shown that the majority of the residual NO_3-N found accumulates in the top 2 feet of the soil. The procedures suggested for the collection of soil samples recognize this accumulation pattern. There is no consistent relationship between the amount of NO_3-N found at the depth of 0 to 12 inches to the amount found at a depth of 12 to 24 inches.

The amount of residual NO_3-N found at the various depths is strongly influenced by rainfall, water holding capacity, soil texture, and the rooting pattern of the previous crop. There is a
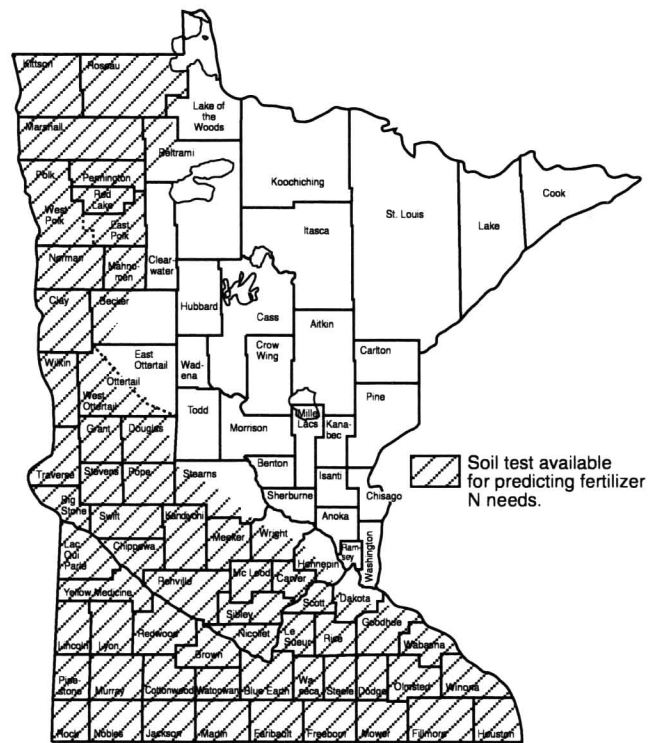

Figure 1. The soil nitrate test with samples collected in fall or early spring should be used in the counties that are shaded.

substantial amount of variability among these factors in Minnesota. Recognition of this variability has a strong influence on the recommendations for timing the sample collection. These recommendations are discussed in detail in the sections that follow.

Western and Northwestern Minnesota:

Collection of soil samples for analysis for NO_3-N has been recommended for several years in western Minnesota. In this region, N fertilizer recommendations are based on the amount of

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NO_3-N measured in soil samples collected either in the fall or early spring before planting. This measurement of residual NO_3-N is used to adjust nitrogen fertilizer recommendations for corn, small grains, edible beans, sugarbeets, canola, and sunflowers.

South-Central, Southeastern, and East-Central Minnesota:

There is now a recommended procedure for measuring residual NO_3-N in South-Central, Southeastern, and East-Central Minnesota. In contrast to the suggested collection of soil samples in the fall, in western Minnesota, suggestions for these regions are to collect soil samples to a depth of 2 feet in the spring before planting, at planting, or immediately after planting. After measuring the amount of residual NO_3-N, the rate of N fertilizer recommended can be applied as a preplant, planting time, or early sidedress application. At the present time, the measurement of NO_3-N in soil samples collected in the spring is used only for adjustment of N fertilizer recommendations for corn.

Collection of soil samples in the fall is not recommended for these regions of the state because the amount of NO_3-N found in the spring is not closely related to the amount of NO_3-N measured in the fall (**Table 1**). Average rainfall in South-Central, Southeastern, and East-Central Minnesota is higher than the average rainfall measured in the western and northwestern regions of the state. This added precipitation either causes leaching losses of NO_3-N from fall to spring or results in losses of NO_3-N due to denitrification. The change in NO_3-N from fall to spring is not constant over time (see **Table 1**). Therefore, fall collection of soil samples for measurement of NO_3-N can be very misleading in these regions of the state.

This *soil nitrate test* is not suggested for all fields in these regions of the state. In deciding to use this test, the corn producer should first evaluate whether conditions exist for the accumulation of residual NO_3-N. Factors such as previous crop, soil texture, manure history, and rainfall for the past growing season have substantial impact on the accumulation of residual NO_3-N.

A crop rotation in which corn follows corn generally provides the greatest potential for residual N. Small and consistent amounts of residual NO_3-N have been measured following a typical soybean crop. Similar low soil NO_3-N values are found when corn follows alfalfa; thus, this test should not be used for corn following alfalfa.

Table 1. Reduction in Soil NO_3-N from fall to spring in southern Minnesota as a function of previous N rate.

| N Applied | Change From | |
	Fall 1982 to Spring 1983	Fall 1983 to Spring 1984
lb./acre	% of Fall NO_3-N Measured in Spring	
0	54	28
75	40	25
100	-	50
150	34	40
200	36	41

The *soil nitrate test* works best for medium textured soils derived from loess or glacial till. In general, sandy soils have relatively low values for carryover of NO_3-N. There is an exception to this generalization for fields that have received high rates of manure.

The amount of carryover NO_3-N found in the root zone is also affected by the rainfall received during the previous growing season. In a year following a serious drought (1989 for example), many fields where corn was fertilized with typical rates of fertilizer N had a substantial amount of residual NO_3-N. Following either typical or wet years, however, small amounts of residual NO_3-N can be expected unless an excessive amount of N from any source has been applied during the previous growing season.

Because this *soil nitrate test* is not appropriate for all fields, **Figure 2** can be used as a guide in deciding which fields have the greatest probability of containing residual NO_3-N. As shown in **Figure 2**, measurement of residual NO_3-N in the root zone is not suggested for the following situations:

• corn following alfalfa

• corn will follow soybeans where no manure has been applied before the soybean crop

• corn will follow corn where no manure has been applied and precipitation for the past growing season was above normal.
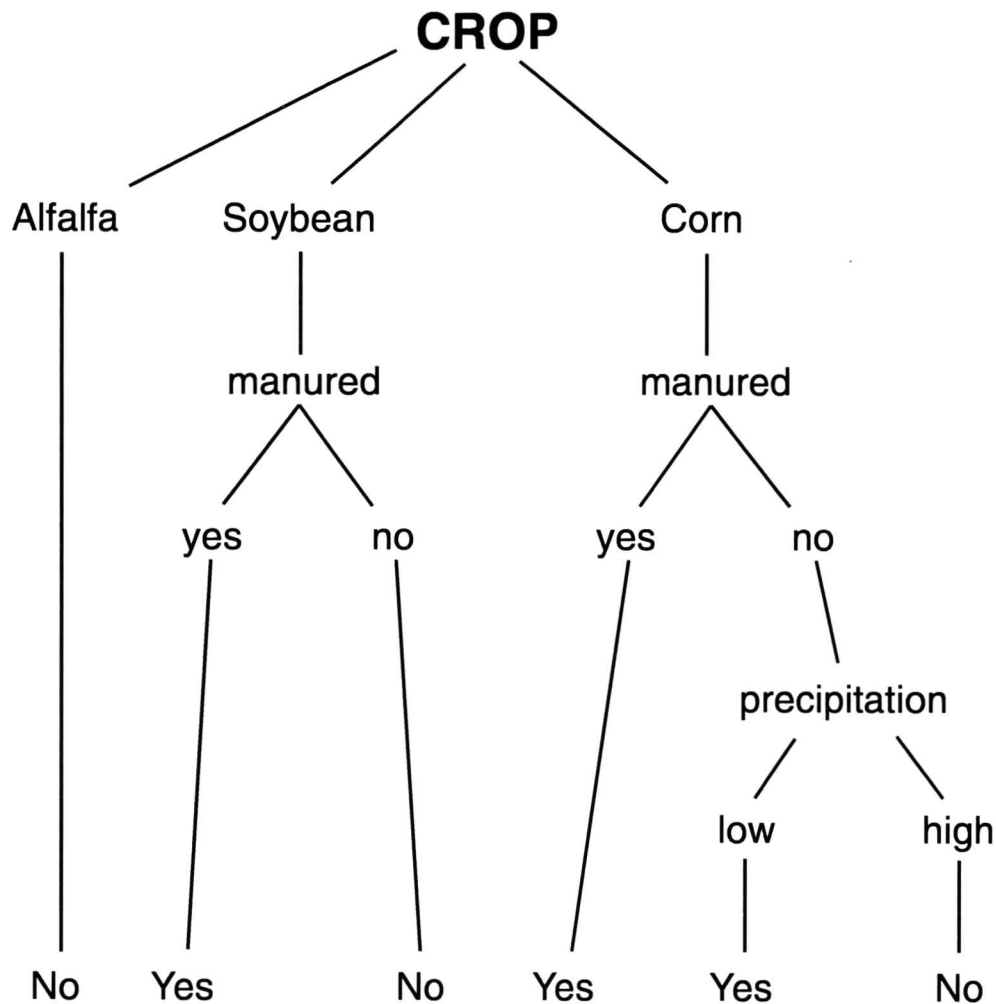
CROP

Alfalfa   Soybean   Corn

manured   manured

yes   no   yes   no

precipitation

low   high

No   Yes   No   Yes   Yes   No

Figure 2. Decision-aid for determining the probability of having significant residual NO₃-N in the soil for South-Central, Southeastern, and East-Central Minnesota.

The spring *soil nitrate test* should be a critical component of all cropping systems that include manure applications. The spring nitrate test will measure manure's mineralized organic N and/or nitrified ammonium-N from a recent application. This test does not predict available N released from manure between the time of sampling and crop uptake.

Therefore, the time of manure application should be considered before this test is used. **Do not** expect the analysis of soil samples collected in the spring to reflect the amount of NO_3-N available from manure applied during the previous November or December. Nitrogen from the organic fraction of manure applied in the previous September and October should be mineralized during the fall with the amount that has been converted to NO_3-N reflected in the test when samples are collected during the following spring.

Sampling Procedure

The collection of soil samples from depths below the plow layer or tillage zone is necessary before the amount of residual or carryover NO_3-N can be measured. Normally, soil samples are collected from a depth of 0 to 6 or 0 to 8 inches. Soil from this depth is routinely analyzed for pH, organic matter content, phosphorus (P) and potassium (K).

For measurement of residual NO_3-N with either the fall or spring *soil nitrate test*, soil should be collected to a depth of 24 inches. Two soil sampling strategies can be used in the collection of the 0 to 24 inch sample. When collecting samples for analysis of pH, P and K, analyze the topsoil for NO_3-N and collect another sample from a depth of 6 to 24 inches. This sample should also be analyzed for NO_3-N.

The soil sample should be representative of the field or area within the field. This requires that

several cores be used for each sample that is submitted to the laboratory. Grid sampling and sampling by soil type will be discussed in another section.

The samples must be dried as quickly as possible after collection. To dry, spread the samples on a clean sheet of plastic or other material that will not contaminate the sample with NO_3-N. Forced air passing over the sample will speed the drying process. Samples should be completely air dry within 24 to 36 hours. The samples (each clearly marked with the appropriate depth) can then be sent to the soil testing laboratory.

Spatial Variability of Nitrate-Nitrogen

Measurement of the spatial variability of phosphorus (P) and potassium (K) has been used as the basis for the variable rate application of phosphate and potash fertilizers. Based on the experiences of some who are using more intensive sampling to measure the spatial variability of immobile nutrients, it's reasonable to ask if spatial measurement of NO_3-N will improve the N fertilizer recommendations. If the measurement of the variability of soil NO_3-N can be used to improve the recommendations for fertilizer N, this practice could have positive effects on both environmental quality and farm profitability.

The value of the measurement of spatially variable NO_3-N was tested at four locations over two years in Central and South-Central Minnesota. The results from that research showed that N fertilizer recommendations based on the spatial measurement were not substantially better than the N recommendations based on the average amount of NO_3-N found in the field. When the cost of sampling and laboratory analysis is considered, spatial measurement of NO_3-N as a basis for making N fertilizer recommendations becomes less attractive from a farm profitability standpoint.

When considering the use of the soil nitrate test in adjusting fertilizer N recommendations for both corn and small grains, there does not appear to be a strong justification for spatial measurement of NO_3-N. This management tool may be more appropriate for the high-value sugarbeet crop. Detailed measurement of NO_3-N is encouraged for sugarbeet production in the Red River Valley. Although experiences with using this measurement for sugarbeet production in southern Minnesota are limited, spatial measurement of NO_3-N for sugarbeet production in this region is not strongly recommended at this time.