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Using the Nitrogen Mineralization Soil Test to Predict Spring Fertilizer N Rate for Soft White Winter Wheat Grown in Western Oregon

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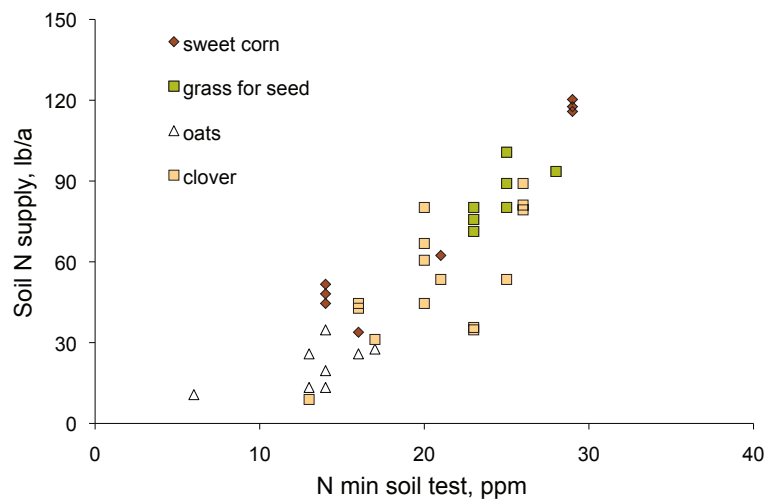
Soft white winter wheat grown in western Oregon requires a spring application of nitrogen (N) fertilizer for optimum production. Determining the amount of N to apply has been a challenge for growers because wheat is produced in numerous rotations that provide varying amounts of N to the wheat crop. Inadequate N results in reduced yield. However, excess N causes lodging, higher-than-desired grain protein, and added expense.

Wheat obtains N from two sources: soil and fertilizer. Soil N is provided in available mineral form (nitrate-N or ammonium-N) and as mineralizable N (nitrogen that will become available during the growing season). Soil nitrate-N and ammonium-N supply only 5% to 15% of the total N requirement. Mineralizable soil N supplies 5% to 40% of the total N requirement. The remainder (40% to 70%) comes from N fertilizer.

Both available and mineralizable N can be measured to predict the spring fertilizer N rate for winter wheat by using the “N-min” soil test developed at Oregon State University (figure 1). Research conducted between 1993 and 2004 identified the relationship between the N-min soil test and available N (figure 2).



Figure 1. Through more than 10 years of research, Neil Christensen, professor emeritus of soil science, developed the N-min test for wheat, a method for accurately predicting the spring fertilizer N requirement. Photo by Mark Mellbye, © Oregon State University.



The N-min test accurately predicted the spring fertilizer N requirement in more than 35 research sites and grower fields. The research was conducted across a range of soil types and crop rotations and in fields using both conventional tillage and direct seeding to establish stands. The test works equally well in all tillage situations. Additionally, the test accurately predicts spring N rate for a range of soils including sandy soils such as Newburg, silt loam soils such as Woodburn, and hill soils such as Steiwer.

Some preceding crops supply a predictable amount of N for wheat. In rotations with tall fescue or perennial ryegrass, a consistently high N-min test value and low recommended spring N rate can be expected. Oats provide little N for a wheat crop; therefore, a low N-min test value and a high recommended spring N rate can be expected. In contrast, the recommended spring N amount for wheat following some other crops is less predictable without use of the N-min test. For example, clover and other legumes do not consistently supply the same amount of N. This is another reason for using the N-min test.

Current research, through summer 2010, has calibrated the N-min test for use only in western Oregon winter wheat. Do not use the N-min soil test for any other crops, including irrigated winter wheat and spring wheat.

Using the N-min Test

Taking a Sample

First, collect a composite soil sample from the 0- to 12-inch depth with a soil sampling tube. The sample should include a minimum of 20 soil cores representing the area to be fertilized. The best time to take soil samples is during the last 2 weeks of January. January is the best time to sample for three reasons:

1. The relationship between the N-min test and wheat N uptake at this time is well correlated.
2. The amount of mineralizable N measured by the N-min test was stable or the variability for the test was lowest in mid-January (figures 3 and 4). Soil samples collected earlier or later than mid-January had a much higher variance than samples collected in the latter half of January. Compared with samples collected in

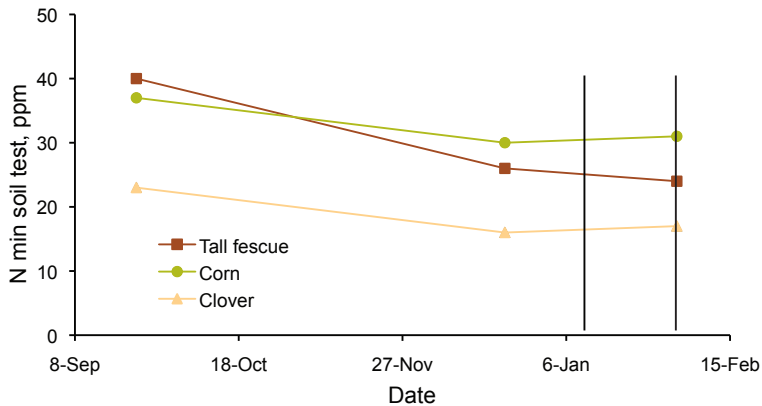


Figure 3. Relationship between time and N-min test value during the 1995 growing season from planting to time of spring N application for wheat planted after tall fescue, corn, or clover. Image by John M. Hart, © Oregon State University.

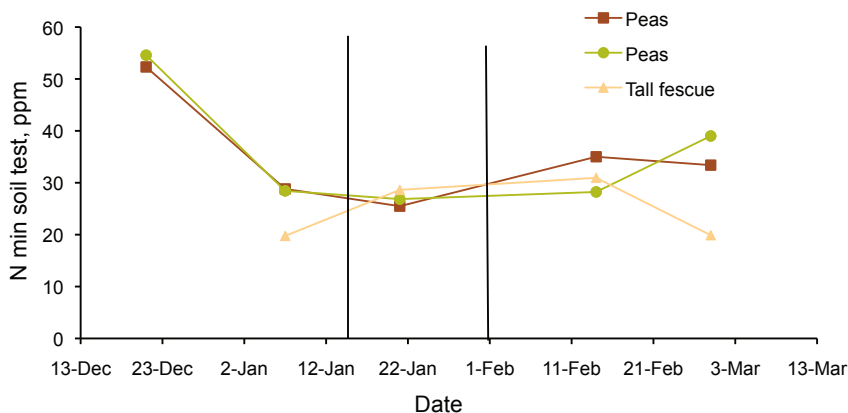


Figure 4. N-min data showing instability until the recommended sampling date during the winter of 2009–10. Image by Nicole P. Anderson and John M. Hart, © Oregon State University.

mid-January, the variance more than doubled for samples collected in early January or mid-February and was five times greater for samples collected in mid-December.

- The N-min test requires a longer analytical time than traditional soil tests.** Sampling in January allows enough time for analysis of the soil sample (about 2 weeks) and calculation of fertilizer needs before application of N fertilizer at Feekes growth stage 5 (generally the end of February). Application of some spring N by Feekes growth stage 5 is critical because rapid N uptake begins at the next development stage. For more information about wheat N use, see Oregon State University Extension publication EM 8963-E, *Soft White Winter Wheat (Western Oregon)*.

Failure to collect samples in this manner will result in inaccurate N-min soil test values.

Sample Handling

Mineralizable N content varies with storage and handling. To ensure useful results, handle samples carefully and according to standard practices. Place the samples in a cooler with ice or an artificial cooling material immediately after collection. If you are collecting samples from multiple fields, cool each sample before moving to the next field.

Laboratories usually prefer cooling and rapid shipment. Follow one of the steps below to ensure reliable soil test data:

- Rapidly air-dry samples at ambient temperature immediately after sampling, and ship them to the laboratory within 24 hours.
- If you cannot dry samples, keep the samples in an iced cooler overnight, and ship them on ice within 24 hours.
- If the previous two options are not possible, freeze the samples, and ship them frozen to the laboratory.

Request three analyses from the laboratory: (1) ammonium-N ($\text{NH}_4\text{-N}$), (2) nitrate-N ($\text{NO}_3\text{-N}$), and (3) mineralizable N. Be sure the laboratory you choose can provide all analyses. Not all laboratories offer a test for mineralizable N by anaerobic incubation. Request that analyses be expressed in parts per million (ppm) or milligrams per kilogram (mg/kg), not as pounds per acre (lb/a).

Finding the Spring N Rate

With the three N analyses in hand, use table 1 to select a spring N fertilizer application rate. The table recommends spring N rates of 80 to 200 lb N/a. Even when the N-min test is high, a minimum amount of fertilizer N is needed for optimum wheat production. OSU research has shown that 80 lb N/a is the minimum amount to apply (shaded portion of table 1).

To find a spring N rate by using table 1, be certain the soil test results are in parts per million (ppm) or milligrams per kilogram (mg/kg). Begin with the N-min soil test results. These values are in the left-hand column of table 1. Follow the N-min column down until you find the N-min soil test value closest to yours.

Next, add your soil test $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ values. Then locate the column heading that contains the sum of these values. Move down that $\text{NH}_4 + \text{NO}_3$ column until you reach the row for your N-min value. The number where the row and column intersect is the recommended spring N rate in pounds of N/acre.

In table 1, N-min test values increase by increments of 4 ppm, and spring N rates increase by increments of 20 lb/a. If your N-min soil test value is between those in table 1, adjust the recommended spring N application rate by 5 lb/a for each 1 ppm N-min.

Table 1. Recommended spring N fertilizer rates based on the N-min soil test and extractable soil $\text{NH}_4\text{-N}$ plus $\text{NO}_3\text{-N}$.

N-min soil test (ppm or mg/kg)	Soil test $\text{NH}_4 + \text{NO}_3$ (ppm or mg/kg)			
	Less than 10	10 to 15	16 to 20	More than 20
	N fertilizer rate (lb N/a)			
12	200	180	165	145
16	180	160	145	125
20	160	140	125	105
24	140	120	105	85
28	120	100	85	80
32	100	80	80	80
36+	80	80	80	80

Example

N-min test value = 20 ppm

$\text{NH}_4\text{-N} + \text{NO}_3\text{-N} = 18 \text{ ppm}$

(6 ppm $\text{NH}_4\text{-N}$ + 12 ppm $\text{NO}_3\text{-N}$)

In this example, the N-min soil test value (left-hand column of table 1) is 20 ppm. The sum of $\text{NH}_4\text{-N}$ plus $\text{NO}_3\text{-N}$ values is 18 ppm. Move down the column labeled “N-min soil test” until you reach “20.” Now find the column labeled “16 to 20.” The intersection of the N-min row and the $\text{NH}_4 + \text{NO}_3$ column is 125. The recommended spring N fertilizer rate is 125 lb N/a.

Laboratory Procedure

Three analyses are necessary to use the test: (1) ammonium-N ($\text{NH}_4\text{-N}$), (2) nitrate-N ($\text{NO}_3\text{-N}$), and (3) mineralizable N. The analytical procedure for mineralizable N determination is very different from that used for other soil nutrient analyses as it involves incubating the sample for 7 days. In contrast, $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ are determined after extraction from a mixture of 20 grams of soil with 75 mL of 2M KCl that has been shaken for 1 hour.

Provide all analyses in parts per million (ppm) or milligrams per kilogram (mg/kg), not as pounds per acre (lb/a).

N-min Soil Test Procedure Anaerobic Incubation

Reagents

Make 2 M KCl (potassium chloride) by dissolving 150 grams of KCl in about 500 mL of distilled water and then diluting the mixture to 1 liter in a volumetric flask.

Procedure

1. Using sample splitter, obtain a soil sample of at least 20 grams. Weigh 20 grams of sample into a 125-mL extraction bottle.
2. Add 25 mL of distilled water, and stir well with a glass rod to ensure that the soil is completely wet. Add another 25 mL of distilled water to rinse the glass rod and side of the jar.
3. Seal the bottle so no air exchange will occur during incubation. Traditionally, the seal is made by placing a sheet of Parafilm and a layer of plastic wrap over the mouth of the bottle and tightly securing the lid. Some laboratories use a Mason jar and new lid for each sample to obtain the necessary seal.

4. Place the sample in an incubator at 40°C ($\pm 0.5^\circ\text{C}$) for 7 days (168 hours).
5. Remove the sample from the incubator, and carefully add 50 mL of 2 M KCl. Replace the plastic covers, and tighten the lid securely.
6. Shake briskly to disperse the soil, and place the sample on a mechanical shaker for 1 hour. Filter through Whatman No. 42 (or equivalent) filter paper into acid-rinsed filter vials.
7. Determine the $\text{NH}_4\text{-N}$ content of the extract solution from the incubated sample with an automated colorimetric analyzer.
8. Determine the initial $\text{NH}_4\text{-N}$ (reference) content in the soil by following steps 1, 2, 4, and 6.

Calculation

$$\text{ppm mineralizable } \text{NH}_4\text{-N} = (\text{ppm } \text{NH}_4\text{-N in incubated extract} - \text{ppm } \text{NH}_4\text{-N in reference extract}) \times 5$$

Comments

This procedure is a modification of the anaerobic incubation described by Keeney (1982). Sample size has been increased from 5 to 20 grams. A 125-mL screw-top extracting bottle is used to accommodate the larger sample size and solution volume.

Compared with many other soil testing procedures, the biological nature of this procedure creates more variability in results. Therefore, all attempts to reduce variation are critical. Suggestions for reducing variability are thorough sample mixing, complete sealing of bottles during incubation, avoidance of floating particles during incubation, and strict temperature control. Excluding oxygen from the headspace by introducing an N_2 atmosphere immediately before sealing the incubation vessel is not recommended.

Refining N Fertilizer Rates

Reviewing grain protein data is an important aspect of managing N in wheat crops and is recommended to evaluate use of the N-min test on western Oregon winter wheat fields. Maximum economic yield is associated with grain protein concentration between 8.5% and 10.5%. Grain protein less than 8.0% suggests that N was inadequate. Grain protein greater than 10.5% suggests that N was excessive or that a factor other than N limited yield.

For More Information

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