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Post-harvest Soil Nitrate Testing

for Manured Cropping Systems West of the Cascades

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Contents

What's in this publication?

This publication describes the use of post-harvest soil nitrate testing as a tool for assessment of nitrogen (N) management in manured cropping systems west of the Cascade Mountains in Oregon, Washington, and south coastal British Columbia.

The first section of this publication gives general information on the test and is designed for use by growers and dairy operators. This section gives a brief introduction to soil sampling, but does not provide all of the technical details. The focus is on how to use the post-harvest test to improve nutrient management. This section describes:

- What the post-harvest test measures
- How to collect soil samples
- Units used in soil nitrate testing
- How to interpret soil nitrate test results for grass and silage corn crops

In addition, background information explains the rationale for the test:

- How to use the post-harvest test as a management tool (page 3)
- Crop and soil response to excess plant-available N (page 4)

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The second section of this publication is designed primarily for use by conservation planners and other agricultural professionals working with farmers to implement nutrient management plans. This section is also designed for dairy operators who do their own soil sampling. This section includes detailed suggestions for the following:

- ◆ Collecting, preserving, and analyzing the soil sample
- ◆ Developing a long-term soil sampling plan

The post-harvest test and how to use it

What the post-harvest test measures

The post-harvest soil nitrate test measures the quantity of plant-available nitrogen present in the nitrate form in the surface foot of soil in the late summer or early fall. The test measures nitrate-N not utilized by the recently harvested crop. Because crops differ in their ability to remove nitrate-N from the soil, test interpretation is crop-specific.

The test looks backward in time. It evaluates the balance between N supply and crop uptake for the crops produced during the summer. Nitrate-N accumulates in the soil when more plant-available N is supplied than can be utilized by the summer crop (see "Crop and soil response to excess plant-available N," page 4).

Use the post-harvest test to:

- ◆ Get a general idea of balance between N supply from manure and other sources and crop N demand
- ◆ Identify imbalances in N supply among fields on a farm
- ◆ Identify fields that may respond to changes in timing or amount of manure application or other agronomic practices

Soil sampling protocols

Sampling depth

Sample the 0- to 12-inch depth for the post-harvest test. This shallow sampling depth is a good predictor of nitrate in the rest of the soil profile when (1) in-season irrigation is not excessive, and (2) samples are taken prior to heavy rains in the fall.

Composite soil sample

Collect a composite soil sample consisting of a mixture of 15 to 30 soil cores from each field or management unit. See "Collecting, preserving, and analyzing the soil sample" (page 9) for detailed sampling instructions and suggestions for special situations.

What fields to sample

In general, it is not necessary to sample every field on a farm every year. Consult with your farm advisor to determine any regulatory requirements for sampling frequency. We recommend that you sample selected fields that represent typical manure and crop management practices each year to track long-term trends in post-harvest soil nitrate values. See "Developing a sampling plan" (page 11) for more information.

When to sample

In general, samples for the post-harvest test should be collected as soon as possible after a crop harvest. Avoid sampling a field that has had manure application within the past 30 days.

Samples must be taken before heavy fall rains move nitrate below the 12-inch depth. Because the timing of fall rainfall is unpredictable, the best strategy is to sample fields before October 1 whenever possible.

Collect samples from medium- to fine-textured soils (loams, clay loams, and clays) prior to 5 inches of cumulative fall rainfall. Sandy soils (sand, loamy sand, or sandy loam soil texture) have lower water-holding capacities and should be sampled prior to

continues on page 5

How to use the post-harvest test as a management tool

Sampling depth and timing are critical. Interpretation tables for this test apply only to samples taken to a 12-inch depth. Surface soil (0 to 12 inches) typically contains the highest nitrate-N levels and requires the least time and effort for sample collection. Samples must be taken before heavy fall rains move nitrate below the 12-inch depth. The target sampling period generally is August 15 to October 15.

To get the most value from this test, it is important to understand:

- How the test fits into an overall nutrient management program
- Limitations to interpretation of test results
- How *not* to use the test

Using the test as part of a nutrient management program

The post-harvest test is but one measure of success in nutrient management. Post-harvest nitrate test data should be assessed in the context of the current N management plan and records of manure application. Successful N management involves a number of components, including:

- Assessing crop N needs
- Planning manure application to meet crop N needs
- Applying manure according to the plan
- Recording manure application amount and estimated plant-available N amount
- Measuring crop yield and N content
- Monitoring success of the plan

All components of the nutrient management system should be evaluated together.

Limitations to test results

Interpretive values for post-harvest soil nitrate are:

- Calibrated only for high-rainfall portions of the Pacific Northwest (west of the Cascades). Extrapolation to other environments is not recommended.
- Provided only for corn silage and grass hay/silage crops. Field research has been used as the basis for interpretive levels for these crops. Applicable research data are not available for other crops to determine post-harvest nitrate-N levels associated with good crop and nutrient management practices. However, the test may be used for relative comparisons among fields planted to another crop (e.g., comparisons among grass pasture fields).
- Based on the assumption that summer irrigation is less than, or close to, evapotranspiration to ensure that significant nitrate leaching does not occur before the fall test.
- Designed for fields with a history of applied manure (more than 3 consecutive years of regular manure application). Lower post-harvest soil nitrate test values are attainable where only fertilizer N is used, or where manure is applied infrequently.
- Based on good management of the crop and normal yields. Crop moisture stress, insect damage, or plant disease will reduce crop yield and crop uptake of nitrogen, thus increasing post-harvest soil nitrate test levels.

How *not* to use the post-harvest test

The test will *not*:

- Detect a shortage of plant-available nitrogen for crop production. Continual mineralization of nitrogen (conversion of organic N forms to plant-available N forms in the soil) can provide enough plant-available nitrogen for a crop without accumulation of nitrate-N in soil.
- Determine the source(s) of excess plant-available N. Sources of N may include manure slurry, lagoon water, fertilizer, soil organic matter, or previous crop residues.
- Predict crop response to fall manure or N fertilizer applications. The test does not predict the amount of plant-available N that will be mineralized from soil organic matter or crop residues in the fall.

Crop and soil response to excess plant-available N

Crop response to applied N. Crop N uptake is controlled by the environment, crop N uptake potential, and management. Crops respond to plant-available nitrogen supply (ammonium + nitrate-N) by the law of diminishing returns (Figure 1). Without added N, some crop yield is produced from N supplied by soil organic matter, residual plant-available N, and other non-fertilizer sources (e.g., mineralization of crop residues). Additional N supplied from manure or fertilizer increases crop yield until site yield potential is reached.

The application rate of manure or N fertilizer needed to reach near-maximum yield is termed the *agronomic rate*. Rather than a single agronomic rate, the crop response to N is best described as an agronomic rate range (Figure 1). The agronomic rate range concept allows for variability in crop performance among years and for crop uptake of N beyond the yield maximum (increased protein).

Post-harvest soil nitrate test measures nitrate-N not used by the crop. At excessive plant-available N supply levels, crop yield and crop N uptake do not respond to further N additions. The extra soil N not used by the crop accumulates as nitrate-N.

Elevated post-harvest soil nitrate-N concentrations are an indicator of one or more of the following: (1) excess plant-available N, (2) N supplied too late in the season for crop utilization, or (3) poor crop growing conditions due to insect infestation, moisture/heat stress, plant disease, or other cultural problems. If crop yields are acceptable and crop protein is at typical levels, then the most likely explanation is that plant-available N was supplied in excess of crop needs.

Because grass is more efficient than corn at N uptake, target post-harvest soil nitrate levels given in this publication are lower for grass than for corn. There are two key reasons that grass is more efficient than corn in N removal.

- Grass has a greater capacity to take up N supplied in excess of that needed for maximum yield. After enough N has been supplied for maximum yield, grass protein content increases in response to increased N supply. With grass, soil nitrate increases only when the available N supply exceeds that required to produce near-maximum protein. Corn does not take up additional N after the maximum yield is reached. Corn silage protein does not increase much in response to excess N supply.
- Grass utilizes N mineralized late in the growing season more efficiently. Grass managed for silage or hay continues to take up N until harvest. Corn grown for silage completes its N uptake approximately 4 weeks before harvest. Some of the soil nitrate measured after corn harvest is produced by mineralization of soil organic N to available forms during the final weeks of the growing season.

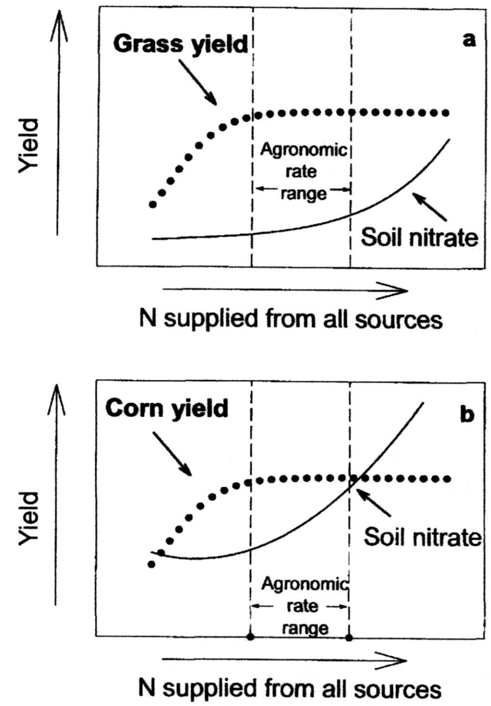

Figure 1.—Crop yield and soil nitrate response to increased N supply. Agronomic rate range = range of N supplied from all sources that results in near-maximum crop yield with acceptable post-harvest nitrate accumulation. Above the agronomic rate range, excess N accumulates as nitrate in soil. More nitrate accumulates in the agronomic rate range with corn (b) than with grass (a).

Table 1.—Average calendar date when cumulative rainfall (after September 1) reaches 5 inches west of the Cascades.[a]

Cumulative rainfall after Sept. 1	Medford (OR)	Salem (OR)	Tillamook (OR)	Coupeville (WA)	Centralia (WA)	Lynden (WA) Abbotsford (BC)	Agassiz (BC)	Comox (BC)
	Calendar date to reach specified cumulative rainfall							
(inches)								
3	10 Nov	20 Oct	26 Sep	31 Oct	8 Oct	1 Oct	26 Sep	10 Oct
5	29 Nov	1 Nov	8 Oct	24 Nov	23 Oct	15 Oct	9 Oct	25 Oct
7	16 Dec	13 Nov	18 Oct	15 Dec	4 Nov	27 Oct	19 Oct	6 Nov

[a]Average daily precipitation data for many other locations is available at: Western Regional Climate Center (http://wrcc.dri.edu) or Environment Canada (http://www.msc-smc.ec.gc.ca/climate/climate_normals/index_e.cfm).

3 inches of cumulative fall rainfall. The starting date for calculating cumulative fall rainfall is September 1. Include inches of irrigation water applied after September 1 in your estimate of cumulative rainfall.

Table 1 shows the average calendar date when cumulative fall rainfall (after September 1) reaches 5 inches at a variety of locations. For most locations, sampling prior to October 15 is acceptable in an average year. In high rainfall areas (coastal areas and the Cascade foothills), plan to sample earlier. A late October sampling date usually is acceptable in lower rainfall areas of southern Oregon, the Puget Sound islands, Olympic Peninsula, or Vancouver Island.

Units used in soil nitrate testing

In this publication, interpretation of a post-harvest soil nitrate test (Tables 3 and 4) is based on units of parts per million (ppm). Some labs report soil test nitrate-N in units of lb/acre by assuming a standard value for soil bulk density. If the lab reports nitrate-N results in pounds per acre, ask them to provide a conversion factor to express data in units of ppm. The conversion factor assumed by laboratories usually is between 3 and 4, because 1 acre-foot of dry soil usually weighs about 3.5 million pounds (3.5 lb per acre-foot = 1 ppm).

Table 2.—Units used to report soil nitrate analyses.

Name	Interpretation	Equivalent units
nitrate-N or NO_3-N	N present in the nitrate form, soil dry weight basis	mg/kg or ppm (dry weight basis)

Interpreting soil nitrate test results

Data quality and variability

The first step in evaluating your soil nitrate data is to verify data quality. Determine whether the sample collection method, timing of sample collection, sample preservation, and laboratory analysis methods are acceptable. Reject data that did not result from reasonable protocols. For example, Tables 3 and 4 should not be used for soil samples collected in November after heavy fall rains.

Make sure that you understand the units used to report test results. See Table 2 for an explanation of units found in soil test reports.

Response of post-harvest soil test N to changes in management

Success in N management is indicated by long-term trends in post-harvest soil nitrate (at least 3 to 5 years). **Because of the large pool of readily mineralizable N in manured soils, fall soil nitrate values may not decline for 3 to 5 years in response to improved management.** For multiyear comparisons, sampling methods and timing must be consistent.

Some portions of a crop rotation will have higher fall nitrate values because of rapid N mineralization stimulated by tillage or incorporation of crop residues. For example, soil nitrate concentrations typically are high, regardless of overall N management, after a perennial grass sod is plowed down and reseeded.

Reductions in fall soil N are most likely to be measured when (1) commercial N fertilizer amounts are reduced or eliminated, (2) cropping systems that maximize N removal in late summer and fall (August to October) are used, and (3) manure or N application is eliminated after August 1. It is more difficult to attain post-harvest soil nitrate-N values of less than 20 ppm for corn than for grass (see "Crop and soil response to excess plant-available N," page 4).

Interpretation for individual fields

Interpretations of soil test nitrate-N should be made first at the field level. You may be able to discover a probable cause for differences in test values among fields. Questions to ask include:

- Are relationships present between known management factors (e.g., manure application rate or timing, crop yield and quality, irrigation frequency, distance to the barn) and soil test values?
- Is a large amount of variation present between fields? Is there a logical explanation for unusual values?
- Are values for grass and corn fields similar?

Annual averages across grass and corn crops

After looking at test values for individual fields, it may be useful to look at averages across all grass or corn fields. You may want to calculate averages only for fields under similar management.

Average nitrate-N test values are most useful for consideration of changes in whole farm nutrient management. Tables 3 and 4 present interpretive information separately for grass and corn fields.

If a few fields have unusual test values, you may be justified in excluding those fields from an average. Although you may want to exclude unusually high test values from the farm average, you definitely should evaluate those fields further to determine the probable cause of the high soil test values. The unusually high test values may reflect the need for management changes or may reflect a soil sampling or analytical error.

Using the interpretive tables (Tables 3 and 4)

Interpretations and management suggestions given in Tables 3 and 4 (pages 7–8) are general in nature and should serve as only one portion of a nutrient management plan evaluation. Some of the management suggestions can be implemented for individual fields, while others need to be implemented on a whole farm basis.

Remember not to focus solely on post-harvest nitrate-N in evaluating N management. Include other important aspects of N management in your evaluation, such as success in following a plan for manure application, calibration of manure application equipment, maintaining good manure application records, and effective irrigation management.

Table 3.—Silage corn. Suggested interpretation for post-harvest soil nitrate-N (0- to 12-inch depth).[a]

If post-harvest nitrate-N is less than 20 ppm (less than approximately 70 lb N per acre)

- ◆ Continue present N management.

If post-harvest nitrate-N is 20 to 45 ppm (approximately 70 to 160 lb N per acre)

- ◆ Reduce or eliminate sidedress N fertilizer application. Use the pre-sidedress nitrate test (PSNT). Apply sidedress N only when PSNT indicates a need.
- ◆ Reduce lagoon water application after August 1.
- ◆ Keep records to document crop yield, dry matter, and crop N removal. Total applied manure-N + fertilizer-N should be less than 125 percent of documented crop N removal.
- ◆ Reduce manure application on fields where corn follows grass sod plow-down.
- ◆ Plan to reduce manure-N application by 10 to 25 percent.
- ◆ Improve whole farm N balance.

If post-harvest nitrate-N is greater than 45 ppm (greater than approximately 160 lb N per acre)

- ◆ Apply only starter N (20 to 40 lb N/acre at planting).
- ◆ Plan not to sidedress N fertilizer in June. Apply sidedress N only when PSNT indicates a need.
- ◆ Eliminate lagoon water application after August 1.
- ◆ Keep records to document crop yield, dry matter, and crop N removal. Apply manure N at a rate less than or equal to crop N removal (approximately 200 lb total N per acre).
- ◆ Eliminate manure application on a few fields or a few strips within a field next year to determine the contribution of mineralized N vs. current-season application of manure.
- ◆ Plan to reduce manure-N application by 25 to 40 percent.
- ◆ Consult experts to improve whole farm nutrient balance.

[a]The post-harvest test values listed above are for the *end* of a growing season. Management changes (if needed) should be implemented in future years. Interpretive values assume near-optimum crop yields. If yield is below average, improve agronomic practices to increase crop yield and crop N uptake.

Table 4.—Grass for hay or silage. Suggested interpretation for post-harvest soil nitrate-N (0- to 12-inch depth).[a]

If post-harvest nitrate-N is less than 15 ppm (less than approximately 55 lb N per acre)

- ◆ Continue present N management.

If post-harvest nitrate-N is 15 to 30 ppm (approximately 55 to 105 lb N/acre)

- ◆ Apply manure earlier in the growing season.
- ◆ Keep records to document crop yield, dry matter, and crop N removal. Total applied manure-N + fertilizer-N should be less than 125 percent of documented crop N removal.
- ◆ Check protein levels in forage. Grass crude protein greater than 21 percent is associated with increased potential for nitrate toxicity to cows.
- ◆ Plan to reduce manure-N application by 10 to 25 percent.
- ◆ Improve whole farm nutrient balance.

If post-harvest nitrate-N is greater than 30 ppm N (greater than approximately 105 lb N/acre)

- ◆ Apply manure earlier in the growing season. Reduce manure application after August 1.
- ◆ Keep records to document crop yield, dry matter, and crop N removal. Total manure-N + fertilizer-N should be less than or equal to crop N removal. Even if calculated crop removal exceeds 400 lb N per acre, apply manure-N + fertilizer-N not to exceed 400 lb N per acre per year.
- ◆ Consider reseeding or interseeding if grass yield is limited by poor stand or undesirable species.
- ◆ Check protein levels in forage. Grass crude protein greater than 21 percent is associated with increased potential for nitrate toxicity to cows.
- ◆ Plan to reduce manure-N application by 25 to 40 percent.
- ◆ Consult experts to improve whole farm nutrient balance and reduce danger of nitrate toxicity to cows.

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[a] The post-harvest test values listed above are for the *end* of a growing season. Management changes (if needed) should be implemented in future years. Interpretive values assume near-optimum crop yields. If yield is below average, improve agronomic practices to increase crop yield and crop N uptake.

Detailed suggestions for soil sampling and planning

Collecting, preserving, and analyzing the soil sample

Tools for field sampling

Collect a sample that is representative of the entire sampling depth. For example, a representative sample for a 0- to 12-inch depth has the same amount of soil from the soil surface (0 to 6 inches) and from the bottom of the sampling depth (6 to 12 inches).

Always use a tool specifically designed for soil sampling. Don't use a shovel, because the samples won't be uniform with depth. Tools for soil sampling often are called soil probes or augers. There are several kinds available.

Push probes are tubes that you push into the soil. They have a T-shaped handle attached to a cylindrical tube (about 1 inch diameter) with a beveled tip. The tube collects a cylinder, or "core," of soil. Push probes work well in soft, uncompacted soils.

Hammer probes are designed for hard or compacted soils. They have a sliding weight (hammer) instead of a T-handle to drive the probe into soil.

Soil test consultants often use hydraulic probes mounted on a tractor or pickup to sample soils. These reduce the time and effort of sampling in hard soils. Gravelly and rocky soils are difficult to sample. A hydraulic probe with a rotating auger can sample some gravelly soils.

A mud auger or bucket auger is the best tool for hand-sampling at sites that are difficult to sample with push probes. Use an auger for compacted, muddy, rocky, or dry soils. Augers can be purchased from several manufacturers. A 2- to 4-inch diameter mud auger (open-sided) works best for most situations because it is easy to remove the sample from the bucket. Use a larger diameter auger for soils with large rocks. Augers sample a 4- to 6-inch depth. You will need to take several bites from the same hole to sample to 12-inch depth. You will collect a larger sample volume, about 5 to 10 times that collected with a push tube. Because of the extra effort required for auger sampling, use this method only if other sampling methods are difficult or impossible.

Field sampling protocol

Plan ahead. Use field maps and soil maps to divide the farm into different management units. A management unit is usually a field, but you may want to subdivide a large field if sections can be managed separately for nutrient application. The simplest approach is to collect a composite sample from the entire management unit. You may choose to restrict sampling to the dominant soil type if the management unit has soils that differ markedly in visual appearance (soil color, texture, organic matter).

Alternatively, you can restrict your sampling to a representative area (usually about an acre in size) within the management unit. Choosing a representative area within the field where manure application rate, timing, and uniformity are well documented is essential. If you use the "representative area" sampling approach, record the sampling location using a GPS receiver or record the distance from a fixed location (e.g., fenceline).

Avoid large buffer zones that are sometimes present adjacent to water bodies or roads, especially with big gun manure applicators. Avoid small atypical areas such as:

- ◆ Swales
- ◆ Very rocky or shallow soil (less than 12 inches deep)
- ◆ Site of an old manure pile or a feeding, watering, or resting area for livestock
- ◆ Abandoned field roads
- ◆ Field edges

Collect 15 to 30 soil cores from each management unit or representative sampling area with a push probe or similar tool. If you use an auger, 10 holes per management unit or zone is sufficient.

Choose sampling locations in a zigzag pattern across the field. Your general route of travel should be across rows, rather than down one row in the field. Make sure you sample within the part of the field where manure is routinely applied. For grazed pastures, choose sampling locations that have average crop growth and productive forage species.

Scrape away loose crop residues or manure present on the soil surface. Sample only the soil. Including the accumulated organic debris from the soil surface in the soil sample will increase variability in test results.

Once you are satisfied with a sampling strategy, repeat the same procedure each year. This will increase the validity of year-to-year comparisons of results.

Obtaining a representative sample from fields where manure has been injected into soil or placed in bands on the soil surface is difficult. The depth of manure injection, the width of injection zone, and the spacing between bands depend on equipment, soil, and the applicator. Some injection equipment can place manure below the 12-inch sampling depth used for the post-harvest nitrate test. Manure may be injected or banded more than one time per year, with several orientations in a field (e.g., north–south or east–west). Because of the added variability associated with manure injection or banding, plan to collect a larger number of soil cores to obtain a representative composite sample.

Sample handling

Mixing. If it is not too hard to break up the soil cores, break them, mix them all together, and homogenize thoroughly. Take a 1-cup subsample for shipment to the lab. If the soil cores are too hard to break apart, send the entire sample to the lab, where they can pass the sample through a mechanical grinder. Check with the lab to make sure they will grind and mix the *entire* sample before subsampling.

Preservation. Soils kept moist and warm continue to accumulate nitrate via biological activity after sampling. The simplest way to limit biological activity is to cool the soil after collection. Put the samples in plastic bags and place them in a cooler on ice while still in the field. Refrigerate them when you return from the field. Freeze the samples if they will be held longer than 48 hours before analysis.

Shipment. Keep the samples refrigerated or frozen until you deliver them to the lab. Contact the lab before you sample, so they will be prepared to receive the samples. Use a shipping method that will get the samples to the lab within 48 hours. You may want to freeze the samples before shipping to make sure they remain cool in transit.

Working with an analytical laboratory

Choose a laboratory that has experience with agricultural samples. Ask if they participate in the North American Proficiency Testing Program or a similar quality assurance program for agricultural testing labs. Find out what extraction and analytical procedures they use. Procedures should be consistent with those recommended for the western states (Gavlak et al., 1994).

Labs may use one of several colorimetric (color-based) lab procedures or they may use an electrode method to measure nitrate. Sample comparisons have shown that the colorimetric procedures usually are more precise than the electrode method.

Some testing labs also have sampling and consulting services. This can be convenient for people who have little experience in sampling or need help with sampling.

Find out how the lab reports soil test data. Standard units for soil nitrate-N are parts per million (ppm, Table 2). If you aren't familiar with the lab, it's a good idea to obtain a copy of a sample laboratory report.

Because you will use sample results to compare post-harvest soil nitrate across years, laboratory consistency over time is a major issue. A standard reference sample (soil sample with known concentration of nitrate) can help you assess laboratory variability. Consider submitting a standard reference sample (approximately 50 to 100 g dry weight) with a nitrate-N concentration of 20 to 45 ppm with each batch of soil samples. Keep track of test results for the standard reference sample over time. If you note a major error in the nitrate concentration reported for the standard reference sample, then the test data is questionable.

Standard reference samples are available from the North American Proficiency Testing Program (see "For more information," page 15). Standard reference samples must be dried, ground, and thoroughly mixed.

We do not recommend that you split a field sample to check laboratory consistency. The one-time nature of such comparisons, the uncertainty of obtaining a homogeneous sample, and the uncertainty of sample preservation in-transit to the lab limit the interpretation of split-sample data.

Developing a sampling plan

Nutrient management plans can be voluntary, required by regulatory agencies, or a part of an agreement with a conservation planning agency (e.g., Natural Resources Conservation Service or conservation district). If your nutrient management plan is not voluntary, consult the agency that supervises your nutrient management plan to determine whether they have specific requirements for how often fields must/should be sampled. Suggestions given here for sampling frequency are general in nature and are not intended to serve as policy for any agency.

Representative fields for long-term monitoring

Representative fields are fields that you sample every year to track trends in sample values over time. Select fields that represent typical management practices. Criteria that can be used to choose representative fields include: (1) records or estimates of annual manure application rate, (2) number of years of continuous manure application, (3) soil test values for P and K. On dairies where P and K fertilizers are not routinely applied, soil test values above 75 ppm P (Bray P1 method) and 400 ppm K (ammonium acetate method) usually reflect substantial manure application in the past.

Sample the representative fields every year to assess trends over time. If you grow corn silage and perennial grass forage, plan to sample at least four grass fields and four corn fields each year. At a small dairy (fewer than four fields), sample all fields each year.

Other fields

Periodically, you will need to evaluate the fields not designated as "representative" fields. Consider sampling all fields every 3 years. Compare whole farm soil data to representative field data.

If you have only a few fields with elevated soil test N, then focus management on those fields. If all fields on the farm give similar test data, then focus your N management efforts at the whole farm level. If representative fields consistently have test values of less than 15 ppm (grass) or less than 20 ppm (corn) over a 3-year period, and all other fields sampled have similar test values, consider reducing the number of post-harvest soil nitrate tests.

Sampling priority

Prioritize fields for fall sampling ahead of time so that you get high-priority fields sampled at an appropriate time. Highest priority should be given to representative fields used to track long-term trends. Fields with high manure application rates or elevated soil test N the previous year should also have a high priority.

Corn fields can be sampled for soil nitrate in June (PSNT, pre-sidedress nitrate test) or in the fall (post-harvest test described in this publication). You will get the most management information by sampling your high-priority representative corn fields both in June (PSNT) and after harvest. You also may want to sample fields with PSNT values greater than 45 ppm nitrate-N again in the fall.

For other corn fields where only one soil test per year is planned, we recommend using the PSNT in preference to the post-harvest soil nitrate test. The PSNT is preferred because test results are applicable to in-season N management. Growers can save money and reduce post-harvest nitrate by omitting sidedress N fertilizer application on fields where sufficient soil nitrate-N is present in June.

Sampling corn fields at PSNT time also will reduce the number of post-harvest samples that need to be collected during the short interval between harvest and the end of the fall sampling window (approximately October 15). If you miss a planned fall sampling on a corn field, consider sampling next year using the PSNT.

Grass fields are best sampled in the fall, using the protocols described in this publication. Think carefully about the best way to achieve consistent timing of sample collection for your fields. The timing of manure application and the timing of grass harvest are key variables to consider.

Samples collected shortly after manure application are not a good indicator of the balance between N supply and crop N demand over the entire growing season. If manure is applied late in the year, postpone soil sampling until after a fall grass harvest. Wait at least 30 days after a late-season manure application before sampling. Sampling need *not* be postponed until after the last manure application or until after the last grass harvest in the fall.

Questions and answers

Why is it difficult to achieve post-harvest nitrate-N less than 15 to 20 ppm with organic sources such as manure?

First, the timing and rate of application for organic sources is less flexible than for fertilizer N. Second, environmental processes that control the quantity and timing of N availability from organic sources are difficult to manage. The biggest factors controlling N availability are soil temperature and moisture. The timing of crop N uptake usually does not match the timing of N supplied from manure and other organic sources. Soil temperature and moisture often support continued release of available N after crop N uptake is complete.

Is there a relationship between soil organic matter content and potential N mineralization?

Research west of the Cascades has demonstrated a lack of correlation between soil organic matter content and N mineralization potential for soils having 3 to 8 percent organic matter. The active fraction of soil organic matter that controls annual N mineralization rates is a small proportion of total organic matter (usually less than 10 percent of total). Recent site management affects soil N mineralization potential; it does not have much effect on soil organic matter content. Because most soil total N is contained in soil organic matter, soil total N is also an unreliable indicator of mineralization potential.

What other soil tests can be used to provide information to guide N management for corn?

Soil nitrate testing in spring and early summer can assist with N management for silage corn. Test soil ammonium + nitrate-N several weeks after a spring manure application to track early-season N availability. Test soil nitrate when corn is at the four- to six-leaf stage (pre-sidedress nitrate test, PSNT) to determine the need for sidedress N application to corn.

How much variability should I expect in post-harvest nitrate-N test values for the same grass field sampled between August 15 and October 15?

It all depends on weather, soil biology, and crop management. A good stand of actively growing grass can maintain nitrate-N concentrations of less than 15 ppm throughout the post-harvest sampling period. Where soil is dry in late summer, increased N availability may occur for 2 or 3 weeks following the first heavy rain. It may be useful to take several soil nitrate tests from the same field in the fall to document changes in nitrate concentration with time. Soil nitrate values given in the interpretive table in this publication are for typical precipitation and sampling date.

Ammonium-N is plant-available. Why doesn't the post-harvest test include ammonium-N analysis?

Post-harvest ammonium-N analyses cost money, and they do not yield reliable interpretive information. Ammonium-N does not accumulate in soils supplied with an excess of plant-available N. It is rapidly converted to nitrate. Soil samples taken at least 30 days after manure application usually have negligible ammonium-N concentrations unless soil has remained dry.

Drying of soils after sampling releases ammonium-N from microbial biomass. Most dried soils have 2 to 20 ppm ammonium-N that is caused by the soil drying process. Dry soil ammonium-N concentrations are poorly correlated with other indices of N availability in controlled experiments.

Should post-harvest nitrate tests be used for fields with organic soils?

Other methods should be used to assess the success of nutrient management plans on organic soils. Goals for post-harvest nitrate-N of less than 20 ppm are difficult if not impossible to attain on organic soils, which contain more than 20 percent organic matter. These soils formed as organic matter accumulated under natural poorly drained conditions. Soil organic matter decomposition and N mineralization processes are greatly accelerated under typical farming practices such as artificial drainage and tillage.

Should I measure or estimate soil bulk density to estimate post-harvest nitrate-N in units of pounds per acre?

The variation in bulk densities among soils typically is less than the variation associated with soil nitrate sampling and testing. Interpretive information in this publication is based on units of parts per million (ppm; mg per kg dry soil). You can approximate soil nitrate-N in the surface foot of soil by assuming typical bulk density (ppm x 3.5 = lb/acre). This conversion factor is based on the weight of 1 acre-foot of soil at a bulk density of 1.3 g cm^3 (1 acre-foot = 3.5 million lb). Organic soils (more than 20 percent organic matter) have lower bulk density (0.6 to 0.8 g cm^3).

What is whole farm nutrient management?

The goals of whole farm management are: (1) to move toward a balance of nutrient imports and exports, and (2) to utilize nutrients on the farm at agronomic rates that minimize nutrient losses to the environment. Managing nutrients at the whole farm level requires knowledge of the major nutrient imports, major nutrient exports, crop utilization of nutrients on the farm, and nutrient losses to air and water.

The Livestock and Poultry Environmental Stewardship (LPES) Curriculum, available through the Midwest Plan Service, includes a Web presentation of whole farm nutrient management principles and a worksheet for evaluating whole farm nutrient balance. See "For more information" (page 15) for details.

What is the role of post-harvest nitrate testing in connection with Comprehensive Nutrient Management Plans (CNMPs)?

CNMPs, developed by the Natural Resources Conservation Service (NRCS) or other nutrient management professionals under NRCS supervision, are broader than just nutrient management. Other components of a CNMP are: (1) manure and wastewater handling and storage, (2) land treatment practices, (3) record-keeping, (4) feed management, and (5) other waste utilization options.

Post-harvest nitrate test values may be used as part of a process to develop a new CNMP or to update an existing CNMP. The CNMP typically includes a plan for regular soil testing. Appropriate timing of the post-harvest nitrate test is critical (see "When to sample," page 2), while soil samples for P and K analysis may be collected any time of the year. Soil samples collected for the post-harvest nitrate test can be analyzed by routine agronomic soil testing procedures and used in developing plans for P and K utilization in a CNMP.

What are the implications of high nitrate concentrations in forages?

Nitrate in ensiled forages can interfere with normal fermentation processes, resulting in poor-quality forage. Forage nitrate affects the distribution of nitrogen compounds in silage. It is difficult to use the silage to formulate rations that meet cow needs for specific protein fractions. Enough nitrate is sometimes present in the silage itself to create a health risk to the animal. Grass silage that is greater than 21 percent crude protein should be tested for the level of nitrate-N. See Johnson et al. (2002) for interpretation of forage nitrate concentrations.

For more information

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Many OSU Extension Service publications, as well as additional gardening information, may be viewed or downloaded from the Web (http://eesc.oregonstate.edu).

Copies of many of our publications and videos also are available from OSU Extension and Experiment Station Communications. For prices and ordering information, visit our online catalog (http://eesc.oregonstate.edu) or contact us by fax (541-737-0817), e-mail (puborders@oregonstate.edu), or phone (541-737-2513).

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Visit the WSU Cooperative Extension publications Web site at http://pubs.wsu.edu

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