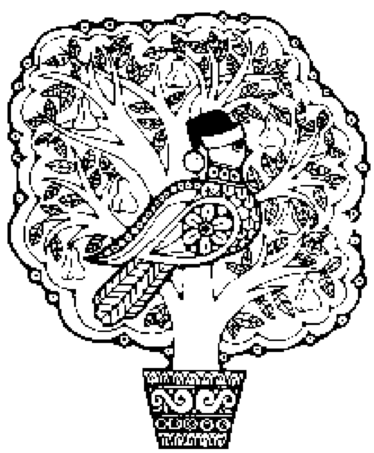
RUTGERS COOPERATIVE EXTENSION AT THE NEW JERSEY AGRICULTURAL EXPERIMENT STATION

PLANT & PEST ADVISORY

ORGANIC FARMING EDITION $1.50 DECEMBER 6, 2001/WINTER ISSUE



INSIDE

Soil Nitrate Testing as a Guide to Nitrogen Management, Part I

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Reprinted from The Soil Profile, Summer 2001, Rutgers Cooperative Extension.

Soil nitrate testing is an evolving diagnostic tool that can aid in predicting the sufficiency of the soil N supply for a variety of crops. The testing procedure is often referred to as the pre-sidedress soil nitrate test (PSNT). The PSNT was originally developed in Vermont for use with field corn to predict need for sidedressing nitrogen (N). Its usefulness, however, has since moved beyond corn to an increasing number of vegetable crops. Approaches to using the PSNT or soil nitrate testing in general depend on the crop and soil system. This article will discuss cropping systems where soil nitrate testing has been found to be most useful.

Matching supply of N from soil with plant demand for this nutrient is one of the nutrient management challenges of crop production. Striking a balance between having too little or too much N available from soil is important to yield, crop quality, farm profitability, and the environment. Soil nitrate testing, when used appropriately, can provide information to improve N management in a variety of cropping systems. Nitrogen availability from soil can change rapidly and soil testing for nitrate should be viewed as a snapshot in time of the soil's current N status. Crop demand for N uptake also changes during the course of the growing season. Thus, time of soil sampling is critical to the correct use and interpretation of soil nitrate test data. Appropriate use of soil nitrate testing should, therefore, be guided both by an understanding of the dynamic behavior of nitrate in soil and crop demand for nitrate uptake.

Supply of Nitrate in Soil

In contrast to P and K, which are relatively stable in soil, concentrations of nitrate are susceptible to rapid change, particularly in regions of higher rainfall. Listed below are some of the major factors influencing nitrate concentrations in soil.

- **Rain:** Heavy rainfall can cause nitrate to leach below the depth of soil sampling or even below the root zone. Also, when soils remain saturated for a period of time, significant amounts of nitrate can be converted to gaseous forms of N and lost to the atmosphere.
- **Temperature:** Soil organic matter releases N slowly in the spring when soils are cool and more rapidly as soils become warm.

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- **Field History:** Fields where manure has been applied or where legumes are in the rotation generally have higher levels of soil nitrate.
- **Soil Texture:** Sandy soils generally have lower organic matter content and soil nitrate concentrations than loam soils.
- **Mineralization:** When organic matter decomposes in soil, the N that is released to soil first accumulates in the form of ammonium (NH_4^+). In warm soils with a favorable soil pH most of the NH_4^+ is rapidly converted to nitrate.
- **Carbon to Nitrogen Ratio:** The quality of plant material, especially in terms of its carbon to nitrogen content, influences the rate of decomposition and the availability of N in soil. Plant materials such as straw have a high carbon to nitrogen ratio and temporarily consume soil nitrate as they begin to decompose in soil. Plant materials such as grass clippings have a low carbon to nitrogen ratio and generally cause soil nitrate concentrations to increase.
- **Crop Uptake:** Once crops are planted and the roots expand into the soil, nitrate is taken up and concentrations of nitrate may decrease.
- **Growing Season:** In general, soil nitrate tends to accumulate in spring and decrease during summer due to crop uptake. Much of the nitrate that is left over at the end of the growing season is vulnerable to leaching from soil during the winter. Late season plantings of cole crops or cover crops may utilize this residual N.

Crop Demand for Nitrogen

Soil nitrate testing is most suitable for use with annual crops which accumulate N rapidly within a single growing season. Typical patterns of biomass and N accumulation for annual crops are shown in Fig. 1 and 2. Note that these patterns are similar and suggest that the accumulation of biomass and N are closely linked. Thus, the rate of plant growth roughly approximates the rate of plant N accumulation or plant demand for N uptake.

In annual crops, nitrogen accumulation more closely follows the pattern of dry matter accumulation during vegetative growth than during reproductive growth and maturation. This is because in the maturing crop, N uptake slows because much of the N already in the plant is redistributed from vegetative tissues to reproductive growth. The important point is the pattern of N uptake by an annual crop is approximated by its pattern of growth and this pattern suggests the appropriate times for soil nitrate testing and N fertilization.

A more detailed description of the pattern of cumulative nitrogen uptake over the growing season shows that it follows a sigmoid or 'S' curve that may be divided into three phases (Fig. 2). A key time for soil nitrate testing is when a crop nears the end of the first phase and is about to enter the second phase of N uptake.

During the first growth phase early plant growth and N uptake are relatively slow (Fig. 1 and 2). The use of a starter fertilizer at time of planting typically can satisfy this early demand for N uptake.

In the second growth phase (Fig. 2) there is a period of rapid N uptake, which corresponds with rapid vegetative growth. Demand for N during this growth phase is the highest of the growing season. As much as 50 to 85% of the total N uptake for the growing season is taken up during this growth phase. Becoming familiar with the growth pattern of a particular annual crop enables producers to anticipate this growth phase. Any needed N fertilizer should be applied in advance of this growth phase to ensure that N is not limiting. The value of soil nitrate testing performed at this growth stage is that the soil nitrate concentration can be used to predict whether the supply of N from soil is adequate to meet the demands of the second growth phase. Another consideration with regards to N fertilization is that the enlarging crop canopy may make later applications of N fertilizer difficult.

In the third growth phase (Fig. 2), vegetative growth (stems, leaves etc.) has largely ended while reproductive

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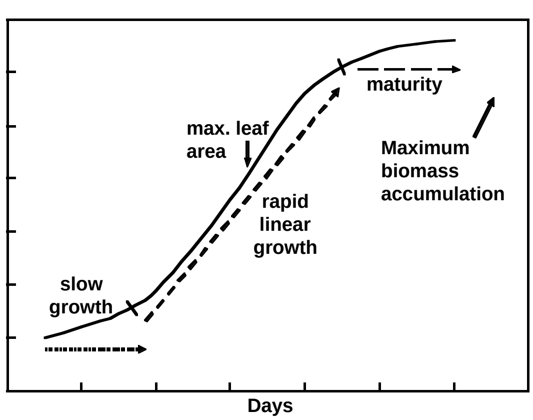

Figure 1. Typical biomass accumulation curve for annual crops.

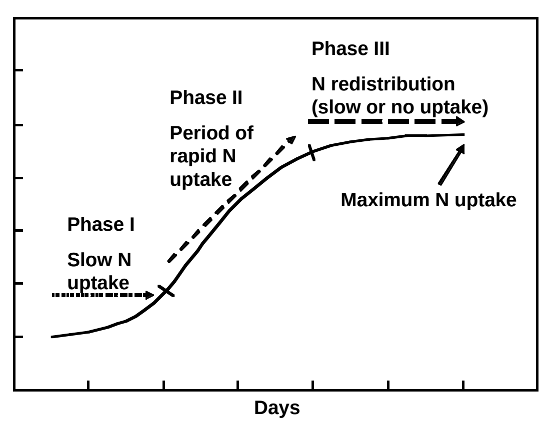

Figure 2. Typical N accumulation curve for annual crops.

CROP DEMAND FROM PAGE 2

structures (seed, fruit, tubers) are in development. As the crop approaches maturity, N is redistributed within the plant from vegetative to reproductive tissues. Nitrogen uptake from soil is slow. Applying N fertilizer during this final growth phase is seldom effective for increasing crop yields. Late applications of N may also slow maturation and reduce crop quality. A possible exception where late N fertilization may be useful is on an indeterminate fruiting crop such as tomato.

Time for Soil Nitrate Testing

The dynamic nature of soil nitrate concentrations and the changes in N demand during crop growth are key considerations in the effective use of soil nitrate testing. In general, soil sampling should be performed just prior to the period of rapid N uptake by the crop. This allows the many environmental factors that influence soil nitrate concentration to operate as long as possible before the start of the crop growth period with the highest requirement for N uptake and before making a decision about N fertilization.

For certain crops, soil nitrate tests may be performed at other times. For example, multiple sidedressings of N fertilizer are often recommended for the production of vegetable crops such as celery, peppers, and tomatoes. In each case the decision as to whether any of these sidedressings are needed can be based on the results of a current soil nitrate test. Note, however, that if an earlier application of sidedress N was placed in a zone rather than uniformly over the field this may make the following soil sampling and soil nitrate test interpretation difficult or impossible.

In the production of winter wheat, soil nitrate tests can be performed just prior to planting to determine if any N fertilization is required at time of planting. In this case soil nitrate testing is being used to determine if sufficient N is available from the soil to support wheat seedling development and tillering in the fall.

Where to Use Soil Nitrate Tests

Time, labor, and costs of conducting soil nitrate tests limit the number of field sites that can be tested. Efforts should therefore be directed towards fields/cropping systems where soil nitrate testing can provide useful information. To prioritize fields for testing consider the following:

- **Soil Type:** Soils with a sandy texture or low organic matter content can be expected to have low soil nitrate levels. There is little useful information to be gained by performing soil nitrate tests on such soils because crop need for N fertilizer is already predictable.
- **Manured Fields:** Fields that have received recent applications of manure, compost, or other N rich amendments are good candidates for soil nitrate tests. The soils in these fields will likely have elevated levels of soil nitrate. Questions remain, however, whether soil N availability will be adequate for crop production. This represents the classic example of where soil nitrate testing is especially useful in predicting whether or not supplemental N fertilizer is needed.
- **Leaching of Broadcast N:** Fields that have received broadcast applications of N fertilizer at time of planting may also be appropriate for soil nitrate testing. The interpretation of soil nitrate tests in this instance may depend on the amount of rainfall received since the time of applying the broadcast N. When rainfall has been below normal it is generally safe to assume that much of the N that had been broadcast is still available to the growing crop. However, when rainfall has been above normal, there is a concern about leaching and about whether enough N is still present to grow the crop. (Soil nitrate tests will measure both the N contribution from the applied fertilizer and any mineral N released from soil organic matter and converted to nitrate.) In either case soil nitrate testing can be helpful in predicting if there is a need for additional N application.

When rainfall has been below normal it is safe to assume that much of the N that had been broadcast is still available to the growing crop. However, when rainfall has been above normal, there is a concern about leaching and about whether enough N is still present to grow the crop.

- **Double Cropping:** When cabbage and other vegetables are grown as a fall crop following the harvest of early season vegetables such as sweet corn, peas, snapbean or lettuce, in some cases enough carryover N from the early crop is available to grow the fall crop. Soil nitrate test can be used to measure both the carry-over N and the release of N from the incorporation of the previous crop's residue.
- **Legume Cover Crops:** When N-fixing crops are grown in the rotation and plowed down, soil nitrate testing can be used to predict if sufficient N has become available for the production of the non-legume crop that follows.

Continued in Part II, in the next issue of Plant & Pest Advisory, Organic Farming edition. ❑

Do Organic Farming Practices Reduce Nitrate Leaching?

Holger Kirchmann and Lars Bergstrom, Swedish University of Agricultural Sciences, Department of Soil Sciences.

The following are the abstract and concluding remarks from a study published in Communications in Soil Science and Plant Analysis, Vol. 32(7&8), pgs. 997 - 1028, 2001.

Abstract

Agriculture is a contributor of nitrate to natural waters and there is concern about the excess nitrogen burden loadings from agriculture on natural waters. Agricultural practices that reduce nitrate leaching from arable land are needed. It is postulated by certain groups that organic farming practices reduce nitrate leaching among other environmental benefits. The objectives of this paper are: 1) to compile, summarize and critically analyse information about NO_3-N leaching from farming systems that were managed according to organic farming principles; 2) to compare NO_3-N leaching from organic farming systems with that from conventional systems. This review consists of several parts. The available literature on leaching of NO_3-N from organic farming and conventional farming systems was analysed. Leachable amounts of NO_3-N in soils from two types of farming systems were compared. Finally NO_3-N leaching from animal manure versus inorganic fertilizer was examined.

In all studies we found in the literature, both the sequence and type of crops grown, and input intensity of N was different in organic and conventional systems. Organic farming systems had on average a lower N input and more legumes in rotation. Average leaching of NO_3-N from organic farming systems over a crop rotation period was somewhat lower than in conventional agriculture.

If the different input intensities of N between organic and conventional systems were taken into account and corrected for, no differences in leaching losses between systems were found. However, a proper comparison of leaching between the two types of systems should take the yield into account. Attempting to do this in this review, we found only two studies which provided data for this. In both studies, specific conditions of the soil - a high organic matter content resulting in a high N mineralization at one site and a heavy clay texture resulting in very small leaching losses at the other site - did not enable us to come up with a clear-cut answer. Nevertheless, we could not find any evidence that nitrate leaching will be reduced by the introduction of organic farming practices, if the goal is to maintain the same crop yield levels as in conventional farming systems. Reduction of nitrate leaching is not a question of organic or conventional farming, but rather of introduction and use of appropriate counter-measures. This insight should guide our thinking when developing environmentally friendly and sustainable cropping systems.

Concluding Remarks

- Lower yields due to lower nutrient inputs in organic cropping systems are often followed by lower N leaching loads than in more intensive conventional systems. If the different N use intensities between organic and conventional systems are taken into account and corrected for, no differences in leaching between systems were found. The same reasoning can be applied concerning leaching of N per unit of yield. At similar yields, leaching will at least not be decreased through organic farming compared with conventional farming.
- One of the most important factors affecting N leaching, irrespective of whether the system is organic or conventional, is the design of the crop rotation and the sequences of crops used.
- There are strong indications that the positive role of overwintering leys for the reduction of nitrate leaching in conventional systems is of minor importance in organic systems, probably due to the flush of nitrogen mineralization upon plowing legume-rich leys, which tend to mask the “positive” effect of the ley.
- Since the type of crop has such a large impact on leaching, we need great flexibility when designing crop rotations leading to low leaching losses. This is more difficult in organic farming systems, which are reliant on legumes for their N supply. Relying on nitrogen fixation through legumes for the supply of N to other crops gives very few options for control and thereby little chance of a reduction in leaching loads.
- In farming systems including animals, and thereby use of manures as an N input, there was a clear tendency for increased leaching loads compared with farming systems without animals. This is corroborated by studies in which leaching from 15-N-labeled manures and inorganic fertilizer was compared. The difference was attributed to poor synchronicity between crop demand and delivery, and larger amounts of manure N remaining in soil over time (residual effect) than N from inorganic fertilizer.
- Reduction of nitrate leaching is not a question of organic or conventional farming, but rather introduction and use of counter-measures such as catch crops, minimum tillage, etc., and most importantly keeping the N intensity at a level which assures long-term sustainability of the cropping system; this would require a reduction of the N input to levels somewhat below the expected optimum yield.

Submitted by Joseph R. Heckman, Ph.D., Specialist in Soil Science. ❑

Recycling Grass Clippings Sustains Soil Fertility

Joseph R. Heckman, Ph.D., Specialist in Soil Fertility

Leaving clippings on the lawn recycles plant nutrients and enhances turfgrass quality. A recent study conducted at Rutgers concluded that when clippings are returned, an equivalent or better turf color can be achieved by using only 2 pounds of nitrogen per 1000 square feet per year instead of the usual rate of 4 pounds of nitrogen per 1000 square feet per year (Table 1). Leaving clippings was also found to reduce the population of weeds in turf.

In 1994, the first year the plots with the two different mowing practices were established, turf color improved throughout the growing season where clippings were returned when compared to where they were removed. A darker green, more luxuriant appearance was apparent within four months of initiating the practice of returning clippings. This difference in turf color continued during the following fall, winter, and spring months. In subsequent years of returning or removing clippings, a better turf color was consistently maintained when clippings were returned. These results suggest that the improved turf color was a result of nutrients being recycled within the turfgrass system.

When clippings are removed about 300 pounds of fresh clippings (58 pounds of dry matter) are collected per 1000 square feet of lawn in one year. Leaving these clippings on the turf would instead recycle an estimated (pounds per 1000 square feet per year) 2 pounds of nitrogen, 0.18 pounds of phosphorus (0.4 pounds P_2O_5) and 1.2 pounds of potassium (1.4 pounds K_2O). Thus, the recycling of clippings after a period of years may be expected to maintain soil fertility levels better than when clippings are removed.

After six years of comparing mowing practices, soil test results confirm as predicted that higher levels of soil fertility are maintained when clippings are recycled (Table 2). Soil nutrient supplies to turfgrass were significantly greater for nitrogen, potassium, and magnesium where clippings were returned. The soil organic matter content was also increased by the return of clippings. These findings support the recommendation that fertilizer rates should be reduced when clippings are being recycled.

Based on the findings of the current study and previous research (Heckman et al., 2000) Rutgers Cooperative Extension recommendations for turf management when leaving clippings are as follows:

- Use a slow release fertilizer to reduce surge growth and amount of clipping residue.
- Apply less fertilizer. The nitrogen application rate should generally not exceed 2 pounds of nitrogen per 1000 square feet per year. Phosphorus and potassium application rates may also be reduced but the amounts to apply should be based on the results of regular soil sampling and testing.
- Increase the frequency of mowing during periods of rapid growth.

Table 2. Influence of six years of mowing practice (clippings returned vs. clippings removed) on soil fertility (Mehlich-3 soil test method) of a Kentucky bluegrass turf at the Rutgers Hort Farm II. Soil sampling was performed on May 10, 2000 from the 0 to 2 inch depth.

Soil Test Item	Clippings Returned	Clippings Removed	Statistics†
Soil pH	6.3	6.3	NS
Exchange Capacity (meq/100g)	8.8	8.5	**
Soil Organic Matter %	3.3	3.0	**
Nitrate, NO_3-N (ppm)	2.3	1.7	*
Ammonium, NH_4-N (ppm)	8.7	5.3	**
Soluble Sulfur (ppm)	21	21	NS
Phosphorus (ppm)	245	244	NS
Potassium (ppm)	168	125	***
Calcium (ppm)	992	978	NS
Magnesium (ppm)	244	221	***

†,*,**,*** Significant at the 0.05, 0.01, and 0.001 levels, respectively.
NS = not significant.

References: Heckman, J.R., H. Liu, W.J. Hill, M. DeMillia, and W.L. Anastasia, 2000. Kentucky Bluegrass Responses To Mowing Practice and Nitrogen Fertility Management. Journal of Sustainable Agriculture. 15:25-35. ❑

Table 1. Turfgrass color responses to nitrogen application rate and mowing practice.

Nitrogen Rate	Season Average Turf Color Rating	
Pounds N per 1000 Square feet per year	Clippings Returned	Clippings Removed
	Color Rating[1]	
0	5.2	3.2
2	6.9	5.5
4	7.7	6.4

[1]A 1-10 color scale was used with 1 representing brown turf and 10 representing dark green color.

NOFA Announces First-Ever Standards for Organic Land Care

October 26, 2001 Press Release.

To help meet the growing demand for organic lawn and yard care, the Massachusetts and Connecticut Chapters of the Northeast Organic Farming Association (NOFA) have created Standards for Organic Land Care: Practices for Design and Maintenance of Ecological Landscapes. The NOFA Standards are the first of their kind, and are expected to become a model for organic land care throughout the United States. The NOFA Organic Land Care Committee, consisting of land care professionals, scientists, educators, and activists, worked for two years to write the Standards. According to Kim Stoner, Ph.D., the chair of the Committee, "these Standards are just as rigorous as those set for organic agriculture by Connecticut and Massachusetts NOFA chapters, but they have also been adapted to address the special issues and challenges of designing and maintaining landscapes."

The 60-page Standards spell out recommended, allowed, and prohibited practices to conform to organic standards. The Committee is currently developing a 30-hour course to certify land care professionals in organic landscape management. This will be held in Massachusetts in February 2002, and the graduates of this course will make up the NOFA list of accredited organic land care professionals. Programs for the public are being planned for spring 2002 to highlight the benefits of organic land care methods and materials. Also, a survey will soon be underway to identify which garden centers and chain stores in Massachusetts offer organic soil amendments and materials for sale to consumers. The survey results and list of accredited professionals will be included in the upcoming "A Citizen's Guide to Organic Land Care".

The Organic Land Care Committee's mission is: education of land care professionals and concerned citizens in the practice of organic land care, with the goals of maintaining soil health, eliminating synthetic pesticide and synthetic fertilize use, increasing landscape diversity, and improving the health and well-being of the people and web of life in our care. Printed copies of the Standards are now available for $20 each from NOFA/Mass, 411 Sheldon Road, Barre, MA 01005; (978) 355-2853; www.massorganic.org.

For more information about the Organic Land Care Standards or to be notified of courses and publications, please contact Marilyn Castriotta, Organic Land Care Program Administrator, at (781) 646-6322 or castriotta@aol.com.

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Submitted by Jim Willmott, Camden County Agricultural Agent. ❏

Regional Direct Marketing Conference

Direct marketers of agricultural products need to head in the right direction – to York, PA, February 20-23, 2002 for the Mid-Atlantic Direct Marketing Conference and Trade Show at the Holidome & Conference Center. This annual event provides expert advice and information for agricultural direct sales businesses including pick-your-own operations, roadside stands, CSA's (community-supported agriculture operations) and farmers' markets.

The theme of this year's conference is "What Direction Are YOU Headed?"

Conference sessions will explore such topics as starting a garden center, adding a bakery, product development, salesmanship, visual presentation, farm transition, marketing on a shoestring, and selling to chefs and restaurants. With more than 50 educational sessions, as well as plenty of networking time, attendees are certain to find new ways to get their businesses on the right track.

A pre-conference seminar on consumer solutions will be offered by the food marketing faculty of St. Joseph's University. In addition, there are workshops on farmers' markets, fruit baskets, and CSA's.

Two pre-conference tours will be offered – one a farm market tour featuring retailers of produce, a butcher, orchards, organics, greenhouses and Central Market, as well as a factory tour including Martin's Potato Chips, Harley-Davidson, Wolfgang Candy and The Murals of York.

The industry specific trade show will feature more than 50 exhibitors with products and services ranging from cookbooks and other gift shop items to seed companies, packaging and labeling supplies, baskets and co-packers.

For reservation information, contact John Berry, jwb15@psu.edu, (610) 391-9840 or visit the conference Web site at www.madmc.com.

Hosts for the conference include the Pennsylvania Retail Farm Market Association in conjunction with the land grant universities, extension services and departments of agriculture in Delaware, Maryland, New Jersey, Pennsylvania and Virginia.

Submitted by Ramu Govindasamy, Ph.D., Specialist in Marketing. ❏

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