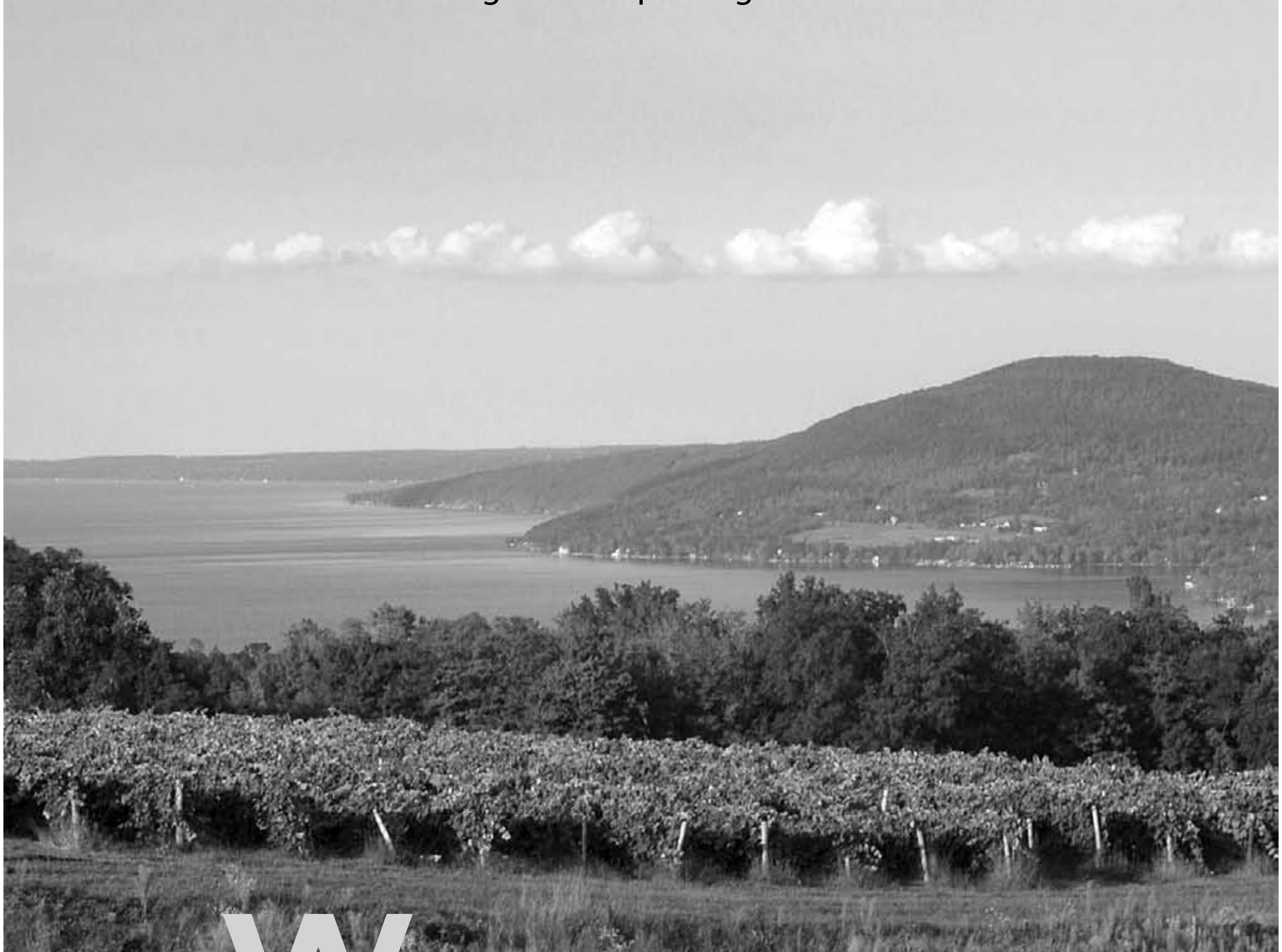
Newsletter

May 2006

Sustainable Viticulture in the NORTHEAST

A publication of the Finger Lakes, Lake Erie, and Long Island Regional Grape Programs



Welcome to the first issue of Sustainable Viticulture in the Northeast. The goal of this newsletter supplement is to provide growers with in-depth discussion of production topics from a sustainable agriculture standpoint. In each article, we will start with a brief summary of sustainability concepts and a bulleted list of management practices. The rest of the article will expand upon those themes, and provide a guide to help you make management decisions on your farm. Where possible, we will also include a grower sidebar, detailing how the grower has put concepts discussed in the article to use on their farm.

The Finger Lakes Grape Program, Long Island Grape Program, and the Lake Erie Regional Grape Program will jointly produce this newsletter, with guidance from the NY sustainable viticulture steering committee, a group of industry representatives that worked on our draft Grower Self-Assessment Workbook currently being tested in 15 vineyards across the state. We thank the New York Farm Viability Institute and the Northeast Center for Risk Management Education for funding this project.

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Optimizing Nitrogen Use in Vineyards

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Nitrogen and the Environment

Excess nutrients can enter ground and surface waters, reducing water quality and promoting detrimental, excessive production in our aquatic habitats – a process known as eutrophication. As a general rule, production in freshwater habitats tends to be limited by phosphorus, while estuarine (where fresh and salt water meet) and marine ecosystems are nitrogen limited.

When nitrogen-rich fresh water enters estuaries, it stimulates extremely high rates of production. The majority of this growth sinks out of the water column, leading to high rates of decomposition at depth. This bacterial breakdown consumes all of the oxygen in the water creating huge areas devoid of life, i.e. dead zones. On a regional level, concerns about nitrogen loading are what led to the creation of Agricultural Environmental Management (AEM) in New York. This voluntary approach seeks to reduce N runoff by encouraging farmers to adopt Best Management Practices (BMPs) to limit nitrogen runoff from agricultural sources.

Nitrogen is mobile in the soil, and excess nitrates can contaminate groundwater and wells. Regulatory agencies have set a limit of 10 ppm for nitrate-N in drinking water, though health risks have been found at lower levels than this standard. Ingestion of nitrate in water has been linked to reproductive problems and higher cancer risks in adults and an interference with blood oxygen levels in infants.

Problems associated with nitrogen runoff and leaching involve many agricultural, industrial and municipal sources. Although grape production is a relatively small contributor to the overall problem, growers can reduce their impact through careful management and planning. It is the combined effort of individuals making responsible decisions about nitrogen use throughout the state that can lead to significant reductions in the nitrogen loading to our environment.

Nitrogen Cost. Ammonium nitrate costs have climbed above $300/ton. The production costs of nitrogen fertilizers are tied to natural gas prices. Producing one ton of anhydrous ammonia (from which ammonium nitrate, urea and solution liquid fertilizer are produced) consumes 33,500 cubic feet of natural gas. As natural gas prices rise, nitrogen fertilizer prices rise in parallel. Efficient, tailored nitrogen use is the key to minimizing cost as prices escalate.

Sustainability Concepts:

Nitrogen is the most commonly applied fertilizer in agriculture. Excess nitrogen contributes to the contamination of both ground and surface waters, leading to potential health risks for humans and environmental degradation of our coastal habitats. Furthermore, the cost of nitrogen fertilizers (tied directly to natural gas prices) is rising. By matching nitrogen supply with vine nitrogen demand and adjusting the rates and timing of supplemental fertilizers, growers can modify nitrogen inputs, often reducing rates without sacrificing yield and quality.

Best Management Practices for Nitrogen Fertilization:

- Delay first application until 2-3 weeks pre-bloom.
- Split the total amount of nitrogen applied into pre-bloom and post-bloom applications.
- Track soil characteristics to assess natural nitrogen supply and vine demand.
- Evaluate vine vigor and adjust rates accordingly.
- Tailor application rates to vine demand on a block-by-block basis.
- Use fertigation to apply nitrogen in irrigated vineyards.
- Optimize soil pH levels.
- Raise soil organic matter levels to increase nitrogen supply from natural sources.
- Maintain detailed records on nitrogen inputs, soil organic matter, vine vigor and yield.

Nitrogen in the Vineyard

Growers that modify the timing, rate and form of nitrogen applied can greatly limit the loss of nitrogen from their farms. In many vineyards, nitrogen application rates can be dramatically reduced without affecting yield or vine size, but doing so requires an understanding of nitrogen sources, seasonal variations in vine demand, and an ability to use data on soils and vine vigor to estimate nitrogen needs within vineyard blocks.

The Nitrogen Cycle. Nitrogen gas (N_2) makes up 78% of our atmosphere, yet this form is unavailable to vines. Instead, N_2 is converted to ammonium (NH_4^+) by nitrogen-fixing bacteria. Decomposition of organic matter also releases ammonium to the soil, and soil bacteria further transform ammonium to nitrite (NO_2^-) and nitrate (NO_3^-) ions through a process called nitrification. Nitrate is the most biologically desirable form of nitrogen, though it is susceptible to loss through leaching (via water movement through the soil) and denitrification (to N_2 by bacteria under anaerobic [low oxygen] conditions). Loss of nitrogen to the atmosphere can also occur via volatilization, especially during dry periods following fertilizer application.

Nitrogen Sources. Nitrogen is supplied naturally in the soils through the breakdown of organic matter (major source) and the weathering of soil minerals (very minor source). The level of available nitrogen is also affected by the cation exchange capacity (CEC) of the soil. Soils carry a net negative ionic charge which attracts and holds positively charged ions (cations: such as NH_4^+, Ca^{2+}, Mg^{2+}, and K^+) in the soil, preventing them from being lost through leaching and maintaining their availability to the vines.

Nitrogen in the Soil. Soil microbes transform the nitrogen compounds in the soil, and their rates of activity are driven by temperature. During the winter months, relatively little decomposition occurs, but as the soils warm in the spring and early summer, microbial activity increases, releasing ammonium from organic matter breakdown and nitrifying the ammonium to nitrate for vine uptake. Moisture conditions also influence soil nitrogen levels. Repeated heavy rainfalls, particularly during spring and early summer when the bulk of nitrogen fertilizers are applied, may promote leaching. During periods of drought, leaching is less common, but vine uptake of nitrogen is diminished unless supplemental irrigation is used.

In strongly acidic soils, aluminum (Al^{3+}) becomes soluble and displaces the essential nutrient cations from the cation exchange sites. Raising the pH back into the optimal range for grape production (5.5-6.5) forces the aluminum to precipitate out, opening the cation exchange sites to the desired cations and restoring the soils' potential to hold nutrients. Soil pH also affects the activity of bacteria in the soil, impacting rates of nitrogen fixation, nitrification, and organic matter breakdown.

Nitrogen in the Vines. Research on Concord has shown that the majority (about 75%) of stored nitrogen in dormant vines is found in the roots, with the remainder stored in trunks and canes (Bates et al. 2002). These stored reserves supply the nitrogen for most of the vines' pre-bloom growth. Uptake of nitrogen from the soil doesn't begin in earnest until midway between budbreak and bloom, as soils warm and new root tips develop. Peak nitrogen demand is split into two distinct periods: the 2-3 weeks prior to bloom and about a month-long stretch (the majority of the canopy development stage) starting 2 weeks after bloom (Figure 1). Overall, the annual nitrogen requirement of Concord vines corresponds to about 50 lb/acre, with a portion derived from the breakdown of organic matter and the remainder supplied by the grower. After harvest, the vines sequester the remaining available nitrogen (found in the soil, leaves and shoots) into their roots and canes in preparation for the next growing season.

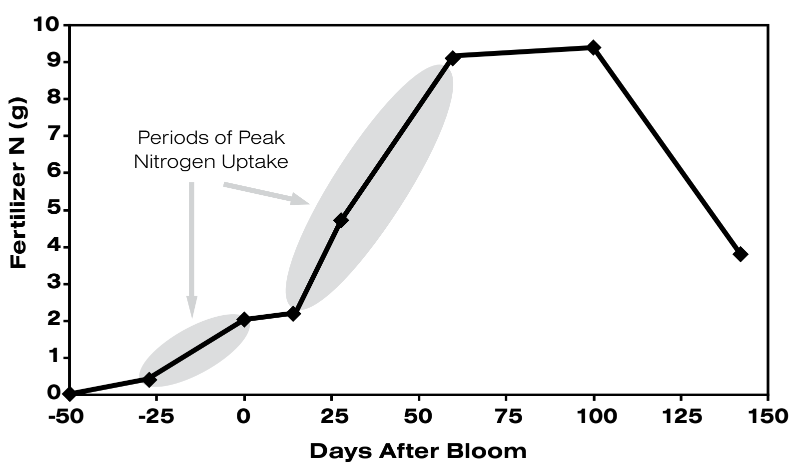

Figure 1. Total vine uptake of fertilizer N by mature Concord vines fertilized with 50 lb N as ^{15}N-enriched ammonium nitrate at budbreak. Redrawn from Cheng et al. 2004.

The ultimate goals of a sustainable nitrogen fertilization program are to:

1. Provide grapevines with sufficient nitrogen to meet quality and yield goals.
2. Match nitrogen supply and demand through use of tailored rates and timing of applications.
3. Minimize inputs of fertilizer nitrogen by improving soil health.
4. Minimize nitrogen losses from leaching, volatilization, and run-off.

While there is no magic formula for determining how much nitrogen to apply, there is a strong case to be made for tailoring application rates and timing to the needs of individual vineyard blocks, rather than uniformly applying a standard rate to all of your vineyards. Doing so involves consideration of the leachability, organic matter content and water holding capacity of your soils, careful observation of vine vigor, and your management goals for the vineyard.

Concords and bulk hybrid varieties are generally managed to maximize cropping level and production, and their responses to N fertilization are well understood. *V. vinifera* grapes and premium hybrids are managed for moderate yields and wine quality, generally at less than their maximum cropping capacity. Therefore, rates for Concord production represent the high end of N requirements in NY vineyards.

Upper Limits. For soils with at least 2% organic matter, there is no yield or vine size response to more than 50 lb/acre of nitrogen. A long-term experiment called the 'West Tier Factorial' has measured the impact of rootstock, cover crops, nitrogen fertilization, and training system on Concord yield and quality over the past 40 years. Three N fertilization rates (0, 50 and 100 lb/acre of actual N) were used on deep, gravelly soils at the Fredonia Vineyard Laboratory. Yield and vine size (as measured by pruning weights) increased with 50 lb/acre of actual nitrogen, but increasing the rate to 100 lb/acre had no effect on yield and increased pruning weight by only 0.1 lb per vine.

Table 1. Estimated contribution by soil organic matter to vine nitrogen needs for mature Concord vines.*

	Soil Organic Matter 1%	2%	3%	4%
Vine nitrogen need (lb/acre)	50	50	50	50
Nitrogen from organic matter	20	40	60	80
N needed	30	10	(10)	(30)
Fertilizer N at 25% Efficiency	120	40	0	0

* Information supplied by Terry Bates

More recently, direct measurement of nitrogen in mature Concord vines indicated that each vine incorporates about 40 grams of N into each season's growth - equivalent to about 53 lb/acre (Bates et al. 2002). In the same study it was found that of the 50 lb/acre actual N applied, about 12 lb/acre was derived from the fertilizer, with the remainder supplied by the 2% organic matter in the soil.

Nitrogen and Vine Size. Although nitrogen promotes vine growth and can lead to excess vigor, it doesn't follow that applying more nitrogen will automatically increase vine size. Inadequate water supply, rooting depth, or drainage, disease and insect infestations, inappropriate cropping levels (too much fruit), low soil pH or other nutrient deficiencies can limit vine size, and applying excess nitrogen won't overcome other factors that limit vigor.

On the other hand, excess vigor caused by overapplica-tion of nitrogen promotes shaded canopies, reducing fruit quality, promoting disease development, and reducing bud fruitfulness.

Organic Matter and Nitrogen Supply. The breakdown of organic matter is a major source of nitrogen. It is im-portant to measure the percentage of soil organic matter in each block of your vineyard, as every 1% supplies 15 to 20 lb/acre/year of nitrogen. This nitrogen is released slowly, and its rate of production increases as soils warm-up and microbial activity increases. Table 1 illustrates the relative contribution of different organic matter levels to N needs. Note that above 3% organic matter, the soil's nitrogen-supplying ability exceeds annual vine demand, though during peak canopy development, a small supplemental application (as low as 10 lb/acre) may still be necessary to match demand.

As inorganic nitrogen costs continue to rise, deriving a greater share of nutrients from organic sources makes good business sense. Pomace, mulch, cover crops, cane prunings and herbaceous plant tissues can all improve soil organic matter over time; the amount of these materials to be applied or utilized will depend upon availability and desired level of amendment.

Timing. From budburst to bloom, vines support the majority of new growth by mobilizing nitrogen and carbohydrates stored in roots, canes, and trunks. It is not necessary nor is it desirable to apply fertilizer nitrogen early. It's better to apply it just ahead of when the vine's demand starts to increase. Delaying soil application until a few weeks before bloom is likely to improve N availability at the time vines start to need it. In New York State, this would correspond to a 2-week window between 15 May and June 1. For heavier soils with adequate depth and high silt and clay content, a single application should be sufficient.

Split Applications, Soil Texture and Leaching. Soil texture influences both the leaching and water holding capacity of soils. Coarse-textured, excessively well-drained soils, such as gravelly loams and sandy soils suffer more N losses via leaching than heavier soils. Split applications, with 1/3 to 1/2 of the total amount applied before bloom and 1/2 to 2/3 applied 1-2 weeks after bloom, should provide extended uptake while limiting losses to leaching.

Adjusting for Cropping Level: Premium *V. vinifera* and hybrid wine varieties are often managed for a moderate crop to maximize quality. These vines will take less nitrogen to maintain vine size than heavily cropped natives and bulk hybrids. Thirty lb N/acre or less is generally a good starting point for premium varieties. Also, growers can omit nitrogen for vines with a small crop due to winter injury.

Post-harvest Application. After harvest, nitrogen taken up by vines is translocated to roots and canes and stored until growth resumes in the spring. In a few situations, a light application of N post-harvest can improve reserve N content to support better spring growth. This is best suited to early ripening varieties that still maintain a green, functioning canopy in the post-harvest period.

Observing Vine Nitrogen Status. Direct observation of vine growth is an important indicator of vine nitrogen status and the need for supplemental nitrogen. Growers need to recognize the signs of both excessive nitrogen uptake and nitrogen deficiency and use these signs to plan their N fertilization programs. Visual symptoms for evaluating vine N status are summarized in Table 2. It's important to note that excess or inadequate vine vigor may or may not be related to vine nitrogen status, as detailed in an earlier section.

Soil and Petiole Tests. Soil samples and grape tissue tests can be tools for determining soil N status or the vine tissue N content, but they have important limitations. Soil nitrate levels can change between sample collection and analysis, due to microbial activity, and may not be good indicators of available nitrogen. Petiole samples, taken at bloom from petioles in the cluster zone, can give some indication of vine N status, but are best used to compare problem areas within vineyards to more 'normal' vines. Many factors, including whether samples are collected on a sunny or cloudy day, cause N content in petioles to fluctuate. Petiole samples collected at 70 days post-bloom are not good indicators of vine nitrogen status. Sampling soils and tissues should always be accompanied by visual estimates of vine vigor.

Adjusting N Fertilization. If excess shoot vigor is observed, it should be safe to omit nitrogen for one year and observe the vines' response. In subsequent years, observe vines and

Table 2. Evaluating the Nitrogen Status of Vines

	Vine Nitrogen Status		
Characteristic	Deficient	Adequate	Excessive
Trellis fill	Poor trellis fill throughout season	Good trellis fill by 1 August	Crowded, with excessive shoot density; fill by mid-July
Cane Pruning Weight	<0.25 lb/foot of canopy	0.3 to 0.4 lb/foot of canopy	>0.4 lb/foot of canopy
Foliage color and leaf size	Pale green or yellowish, leaves small	Green; leaf size characteristic of variety	Dark Green; mature leaves large
Shoot growth	Slow with short internodes; slows in early July	Moderate, with 4-6 inch internodes; shoot growth slows by early August	Fast, with long internodes (>6 in); shoot growth continues into fall
Fruit yields	Low, due to small vine size	Adequate	Low due to excessive shading and low number clusters per node
Ripening and fruit quality	Poor fruit quality, red varieties with poor pigmentation	Maturity characteristic of variety, harvest not delayed	Ripening delayed, poor or variable pigmentation of red varieties
Bloom petiole N concentration	<1.0	1.2-2.0	>2.5

gradually increase N in 10 to 15 lb increments as necessary. When correcting visible nitrogen deficiency, a good starting point is to apply 30-50 lb N per acre for Concord, <10 lb/acre for vinifera in heavier soils, or 10-20 lb/acre for vinifera in sandy soils. Carefully observe results over the following two years. Response may be delayed until the year following first application because of the vines' reliance on stored reserves during early shoot growth.

Fertigation in Irrigated Vineyards. Drip irrigation permits efficient application of fertilizer directly to the root zone. Fertigation avoids the labor expense and nitrogen losses associated with ground-applied materials. Particularly during the summer, ground applied nitrogen is dependent on rainfall for incorporation. Without incorporation, losses to volatilization may be significant.

Foliar-applied N. Small amounts of foliar-applied nitrogen may help growers react to nitrogen deficiencies, particularly under drought conditions when N uptake from the soil might be limited. In dry years, foliar urea (5 lb urea per 100 gal water) applied around veraison can increase available nitrogen in the fruit. This can help wineries avoid stuck fermentations and may also delay the appearance of the atypical aging wine defect in white wines.

Reducing Supplemental Nitrogen Use over the Long Term. Soils in many older vineyards have been depleted of organic matter and subjected to soil compaction. Adding organic matter to soils via cover crops (particularly legumes) or surface application of straw mulch or compost may be an effective strategy for reducing reliance on expensive fertilizer nitrogen. It may take a few years to start seeing significant results, but adding organic matter, much like liming soils, can have long-term benefits in improving many soil characteristics. In addition to its nutritive value, organic matter improves soil structure, enhances soil water holding capacity, buffers soil pH and raises soil CEC.

Summary

The key to sustainably managing nitrogen is understanding the needs of your vines. Fifty lb actual N per acre should be considered an upper limit for N fertilizer use in heavily cropped Concord vines. Moderately cropped premium wine varieties will need less. Organic matter is an important source of nitrogen, and the soil's N-supplying ability should be used to reduce fertilizer N rates. Every grower should test their soils periodically (3-5 years) to determine organic matter content and soil pH and amend as necessary. Nitrogen applications should be split in vineyards with high leaching potential. Vine vigor should be evaluated and used to modify nitrogen rates. Fertigation offers the most efficient delivery of N in irrigated vineyards, and allows growers to make multiple applications at low doses with a minimum of additional labor. Adding organic matter to vineyard soils may reduce dependence on N fertilizers while improving many soil characteristics.

Maintaining detailed records of inputs, soil organic matter, growth and yields through successive years will narrow the focus on the most efficient nitrogen application rates for individual blocks. Strive to minimize inputs (through tailoring rates, incorporating organic matter, etc.) and minimize the loss of inputs (through proper timing and split of application, elimination of surface run-off, etc.). Incorporating the ideals of sustainability into your nitrogen fertilization programs will be cost effective, improve water quality, and reduce health risks to you, your workers, and your communities.

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Modifying Nitrogen Use at Centerra Wine Company

Jamie Hawk

Centerra Vineyard Manager, Matt Doyle

Under the weight of skyrocketing nitrogen fertilizer costs, New York grape growers are rethinking their nitrogen application practices. Led by vineyard manager Matt Doyle, Centerra Wine is working with a vineyard consultant (ACS) to tailor their fertilization program on a block-by-block basis. This spring begins their third consecutive year of intensive soil sampling using GPS (Global Positioning System) to ensure consistency. "Soil samples are taken at the same place and time every year so we can manage how our soil is changing," explains Doyle, "and we're managing our soils, not necessarily the vines – we're kind of getting away from petiole testing. We do some petioles for comparison, but we're really doing intensive soil sampling."

So far their efforts have focused primarily on two aspects of the results of the soil analyses: pH and soil organic matter. "We have pH problems with some of the farms, so we're trying to get the pH up with lime to better balance our soils," notes Doyle. Both pH and organic matter have profound effects upon vine nutrition: low pH reduces the availability of potassium, magnesium, and calcium to the vines, while the breakdown of organic matter provides nitrogen for uptake. "Typically in the past, we'd always done blanket nitrogen applications using the same rate everywhere across the board. Now we want to tailor it more to what the vines need using our soil samples." Sites with soil organic matter at or above about 4% are receiving less inorganic nitrogen. "For sections that had high organic matter, we're just lowering the rate, doing a half rate instead of a full [about 27 lbs/acre actual vs. 55 lbs/acre]. For the sections that have low organic matter, we're going to build it up so we can get away from adding the nitrogen."

To further increase the efficiency of their nitrogen use, Doyle has modified the timing of application as well as the form of nitrogen applied. "Before, we put our nitrogen on with our preemergent herbicides early in the spring, and I don't think it did much for the vines. Now we're trying to apply it closer to bloom so the vines are actually using the nitrogen we put on. And we've gone from liquid to granular forms – we feel we don't get as much loss to the atmosphere with the granular."

This month they've begun their next step, adding composted pomace to the blocks to raise the level of organic matter, which is especially important in those areas where soil analysis indicates a deficiency. "We're going to put our first trial block down this year; the pomace compost has a lot of nitrogen and potash in it, so we're thinking it'll be a good slow-release product. Over time, as organic matter increases in the soil, we'll do less and less nitrogen. And we are seeing in our soil sampling that pH is definitely coming up where we've added lime, and that will help a lot." In regard to the expected time frame to reach their goals, Doyle states, "I think we're looking at 4 or 5 years down the road to be more balanced on everything. We'll track our organic matter continually, and because we have so many acres that are low, it's going to take us a while to get to where we need to be." And the cost of this remediation program? "Actually, what ACS is charging us for the soil samples is not much more than what it would cost us to do it ourselves."

For New York State grape growers, it's time to rethink nitrogen application practices and to specifically tailor rates to individual vineyard blocks. "The price of nitrogen is going through the roof," Doyle stresses, "and for us to keep our budget inputs the same, we either had to cut our rates or try to do it differently. Our struggle is to try to stay efficient and get all our work done, and at the same time be innovative and cost effective too. And we're trying to be sustainable in terms of our vineyards and the environment – if nitrogen isn't necessary, then you shouldn't put it on just because that is what you've always done."

Cornell University
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Finger Lakes Grape Program
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