Lessons from the big dig: dry matter, nitrogen uptake and fertilizer efficiency

Grapes 101

Grapes 101 is a series of brief articles highlighting the fundamentals of cool climate grape and wine production.

By Terry Bates, Tim Martinson, Lailiang Cheng, and Alan Lakso

The 'Big Dig' project at the Vineyard Laboratory in Fredonia involved removing mature Concord vines and quantifying dry matter, carbohydrate, and nitrogen content of different tissues, including roots.

Nitrogen availability and uptake from the soil is a major factor (but not the only one) determining vine size and growth. Excess nitrogen, along with ample available water, can promote excess shoot growth, shading, and unfruitful buds for renewal next year.

Excessive shoot growth, canopy fill, and shading can be a concern with any grower. Among grape growers, wine grape growers on the premium end often worry the most about excess vigor and respond by reducing or eliminating N fertilization and intensively managing the canopy through hedging, leaf removal, and shoot thinning to achieve adequate light exposure to the fruiting zone.

On the other hand, juice and bulk grape growers who aim to maximize yield at the appropriate maturity level (brix and acidity) often cope with inadequate vine vigor – and tend to view higher nitrogen inputs as a way of increasing vine size and yield. Historically, many have viewed nitrogen fertilization as 'cheap insurance,' and application rates of up to 150 lb/acre actual N (450 lb/acre ammonium nitrate) were made, just to insure that lack of nitrogen was not the factor that was limiting vine growth and yield.

The need to optimize nitrogen.

Unfortunately, applying excess nitrogen has some environmental risks. Excess N can leach into ground water and make it unsafe for use as drinking water. On a larger scale, as N moves through our watershed, accumulation in estuaries, like the mouth of the St. Lawrence river, is associated with a 'dead zone' in the ocean which is depleted of oxygen. Finally, a portion of excess N is converted into nitrous oxide – a greenhouse gas 300 times as potent, molecule for molecule, as carbon dioxide.

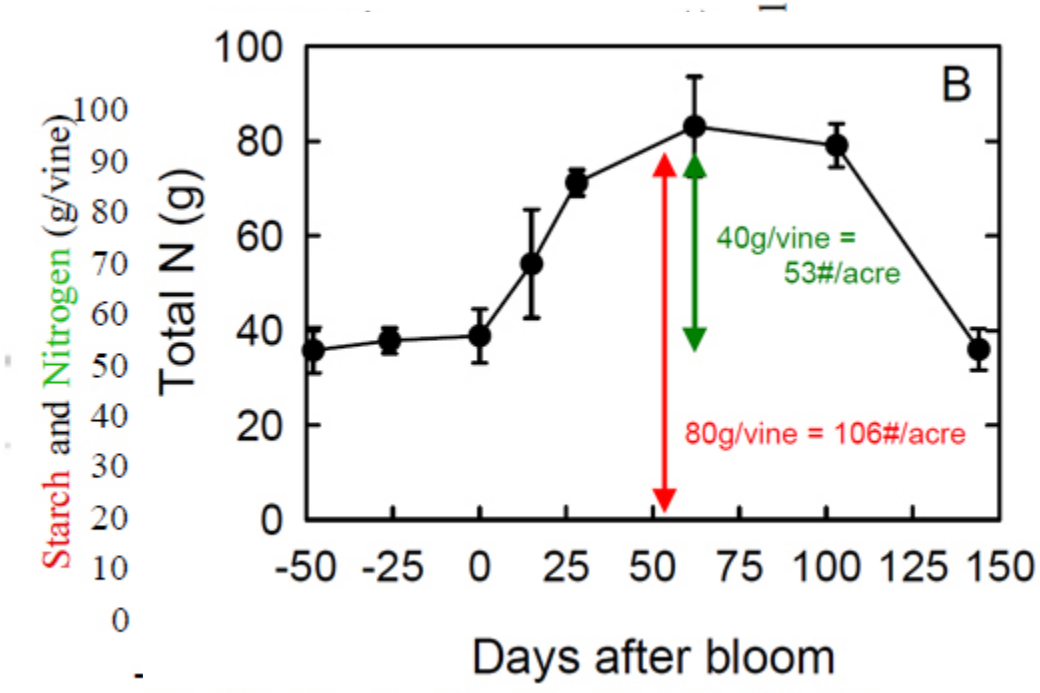
So there are both sound environmental and viticultural reasons for avoiding excess nitrogen application to vineyards. Goals and strategies for N use vary among growers, but hitting the 'sweet spot' – whether it be 10 or 50 lb/acre actual N– should be a goal for all growers, whether bulk or premium.

The Big Dig:

So what is the sweet spot? How much N comes from the soil and how much from fertilizer inputs? How much does a vine need to support growth and fruit development? Some answers have come from a 2005 Concord study at the vineyard laboratory in Fredonia, N.Y., called 'the big dig,' and a concurrent study (informally called the 'little dig') that evaluated potted Concord vines.

Dry Weight	Starch	N	P
41%	16%	25%	23%
59%	84%	75%	77%

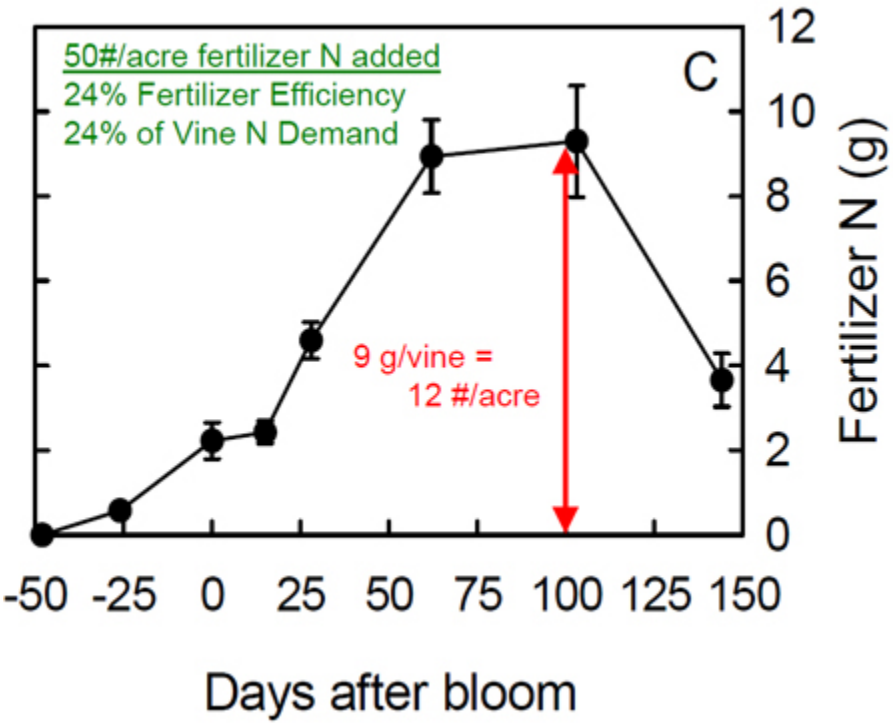
1. In this study, researchers tracked changes in stored carbohydrates (CHO) and N in Concord vines at different times of the season. At intervals during the following growing seasons, whole vines were dug up, separated into leaf, fruit, cane, trunk, and root tissue to analyze N and CHO content and dry weight of the different tissues. Vines were fertilized with N fertilizer labeled with a heavier isotope of N, so researchers could distinguish between native N (from soil) and the N they applied.
2. In dormant vines, roots were the dominant storage organ for both nitrogen (75%) and starches (84%)



Days From Bloom

3. From bud burst to bloom, starches (red line) and nitrogen (green line) are mobilized from reserves to support early season growth. Note that the dry weight of the vine doesn't increase much until after bloom, as photosynthate from the growing canopy kicks in to support shoot and fruit growth. Note that the N content ramps up following fruit set, peaking at veraison.

4. **How much N do vines need?** In the big dig study, note that the total amount of N present in vines reached a peak of 80 g/vine at around 60 days after bloom before dropping back down to 40 g/vine after harvest, leaf fall, and pruning. This suggests that mature vines need to take up 40 g/vine, or about 53 lb/acre of nitrogen, to support growth and crop development.



5. **How much of the nitrogen came from fertilizer?** In this study, researchers applied 50 lb/acre of labeled nitrogen, which allowed them to distinguish between soil-derived and fertilizer-derived nitrogen in grapevine tissues. Vines in the study took up 9 g/vine or about 12 lb of the N applied as fertilizer. In total, fertilizer contributed about 24% of the total vine demand for N, while soil-generated N contributed the remaining 76%.

	Soil Organic Matter			
	1%	2%	3%	4%
Vine N need	50	50	50	50
N from Organic Matter	20	40	60	80
	30	10	(10)	(30)
Fertilizer N at 25% Efficiency	120	40	0	0

6. **How much N do growers need to apply in different soils?** Soils generate around 20 lb of N for each percentage of organic matter present in the soil. If

mature Concord vines 'need' 50 lb/acre of N to support canopy and fruit growth, then the N required to make up for what the soil can't supply would amount to 30 lb/acre at 1% organic matter, 10 lb/acre at 2%, and no additional fertilizer at 3 to 4% organic matter. Most loamy and gravelly loam soils in upstate New York have an organic matter content of 2 to 4%. Sandy soils on Long Island have about 1%.

Implications for management.

These study results provide a good framework for thinking about how much N mature, high yielding Concord vines use. They tie in well with a long term (40 year) dataset called the West Tier Factorial. In that study, one of several factors that researchers varied was the amount of nitrogen applied. There were three rates: zero, 50, and 100 lb/acre of N equivalent. Increasing N from zero to 50 lb per acre greatly increased vine size and yield. But applying an additional 50 lb/acre provided no additional yield and only modestly increased pruning weight (+0.1 lb/vine, on average). In other words, the extra 50 lb/acre provided no measurable benefit to the vines, nor economic benefit to the producer.

Your results may vary.

Although soils with high organic matter can release sufficient N overall, please keep in mind that soil temperature, moisture and rainfall can greatly influence how much N a soil releases (N-releasing microbes are less active in cool soils) and how much N it retains in the rooting zone (N is mobile, and heavy rainfall can leach it out of the soil). Although the overall amount of N may be sufficient to supply the vine's needs, vine demand can exceed the soil's ability to supply enough N, particularly at 'peak demand' times (e.g., after fruit set when the canopy is rapidly developing). For production-minded growers, this argues for a modestly conservative approach, to ensure sufficient N availability at the right time.

Growers of *vinifera* and hybrids for wine production often find it difficult to hang a heavy enough crop to restrain shoot growth. So the amount of N needed and utilized by the vine may be somewhat lower, but the principles illustrated by the 'big dig' are the same. N availability is largely dependent upon soil organic matter, and weather that influences its release and movement through the soil. Adjustments in N fertilization – including 'no N' for several years – may not have as big an effect upon vine size and vigor as a grower may hope. Floor management options such as cover crops under the trellis that are too competitive for high-yielding Concord grapes can be an effective tool for restraining vine vigor on fertile sites.

Those with sandy soils and installed irrigation, like many on Long Island, have the opportunity to see modest adjustments in N fertilization produce impressive

results, and N can be supplied very efficiently and at appropriate times through fertigation.

The bottom line still comes back to the grower: While tissue tests taken at bloom can help diagnose N deficiency or excess, the best guide is still a grower's visual assessment of leaf appearance, canopy fill, and the timing at which shoot growth slows (hopefully before veraison) to judge the adequacy of N fertilization and where adjustments can be made to improve efficiency.

References:

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