Year-End Report (July 2012)

Virginia Wine Board

Assessment of grapevine nitrogen status and optimized nitrogen fertilization practices

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Background on research problem: The aggressive use of cover crops, including under-trellis sward, has been shown to help regulate vine size and vine vigor with overly-vigorous vines in Virginia vineyards (Hatch et al., 2011). Under-trellis cover crops favorably reduce vine size therefore improving vine balance and lowering vineyard management costs. Competition between the under the trellis cover crop and vine for the same soil water and nutrients appears to be the principal mechanism behind the reduction in vine size. Under-trellis cover crops are also important in those situations (e.g., figure 1) where vineyards are being located on steep slopes in order to minimize the potential for soil erosion. The under-trellis (also called intra-row) cover crops are becoming more widely used in the Virginia industry and are either intentionally planted, or adopted as native vegetation (weeds). These companion crops, however, do have some undesirable effects. They can become over-competitive with vines for water, leading to drought stress. This can be avoided by judicious use of irrigation during dry weather to avoid water stress. Another problem encountered with the cover crops is that under-trellis cover crops can compete with the vines for essential nutrients, chiefly nitrogen (N). This research addresses growers' questions about how best to manage the competing goals of suppressing vine size with under-trellis cover crops, while minimizing the negative effects of those cover crops on vine nitrogen status. The overall goal is consistent with sustainable vineyard management practices.

Figure 1. Glen Manor vineyard illustrating steep, hillside plantings.

Objectives:

1) To reassess our tissue sampling protocol and diagnostic standards for evaluating vine nitrogen nutritional status with vigorous grapevines.
2) To determine optimal rates, materials, and timing of nitrogen fertilization in situations where companion cover crops are grown under the trellis to regulate vine growth and/or to minimize the potential for soil erosion.
3) To evaluate the influence of various nitrogen fertilization strategies on basic berry chemistry, must fermentable nitrogen levels, berry color density, and other potential wine quality attributes.

Experiment 1, Glen Manor*:* This experiment evaluates different nitrogen fertilizers, rates and application methods effect on Sauvignon blanc nutrient status, leaf chlorophyll index, vine size, yield components, and fruit chemistry including 'yeast assimilable nitrogen' (YAN) and amino acid profiles in the fruit, which are important in fermentation and some aspects of wine aroma and flavor evolution. Four treatments were applied to 12-year old Sauvignon blanc vines at Glen Manor Vineyards near Front Royal VA during the 2011 season. The vineyard block has been managed with an under-trellis cover crop over the past 5 years and the block has a perennial problem with low N status in the vines and in the must. The treatments were applied to 3-vine panels, each replicated 6 times in a randomized, complete block experimental design.

Treatments at Glen Manor involve:

1) Control: no additional nitrogen added to system
2) 30 kg N/ha applied to soil at bloom (as calcium nitrate)
3) 30 kg N/ha applied to soil at boom and 30 kg N/ha applied 6 weeks post bloom (as calcium nitrate) total application of 60 kg N/ha per season
4) Foliar N (5kg N/ha) applied starting at bloom, 5 total applications equivalent to a total of 30 kg N/ha applied during the season (as urea at rate of 60 gal. water per acre application rate)

Treatment applications began in the 2011 growing season and will be repeated at least 3 years.

Plant tissue analysis conducted at bloom in 2011, before the treatments were initiated, showed similar nutrient levels in the treatment vines (Table 1). A follow-up plant tissue analysis was conducted at véraison (start of final stage of fruit ripening) in late-summer, the earliest that we would expect to see treatment differences. While a statistical analysis has not yet been conducted with the data, the foliar tissue differences in N concentration between treatments were minor.

Leaf chlorophyll concentration was measured optically at véraison in 2011 and showed very small differences in chlorophyll concentration (Table 2). Chlorophyll is the green pigment in plants that is responsible for conversion of sunlight energy into chemical energy that the plant can use. Given that the nitrogen concentration of leaves has a direct impact on chlorophyll concentration and physiologic function, we are interested in monitoring its concentration.

Yield data were collected in late-August at the time of commercial harvest (Table 3). We do not anticipate substantial treatment effects on components of yield and would not expect to see treatment differences in the first year of treatment, in that flower buds and cluster number were determined in the previous year.

Pruning weights were collected in January 2012 and did not reveal substantial differences between treatments (Table 4) as would be expected for the first year of the project. Yeast-assimilable N levels in fruit at harvest are also shown in Table 4. There were either no, or very minor, treatment effects in year 1, which is not entirely surprising as nutrition experiments often don't produce significant differences until the second year.

Table 1 – Tissue concentration of Nitrogen in leaf blades and petioles at two growth stages.

	Nitrogen (%)			
	Bloom*		Véraison	
Treatment	Leaf Blades	Petioles	Blades	Petioles
Control	2.87	0.88	2.50	0.43
30 N Soil	.	.	2.53	0.47
2 X 30 N soil	.	.	2.59	0.48
Foliar N	.	.	2.53	0.48

*Bloom plant tissue samples were composite samples from replicate blocks

Tissue sampling was repeated at bloom in 2012 and we are awaiting results of those analyses from the testing lab (Penn State Analytical Services).

Table 2 – Leaf chlorophyll concentration index by treatment.

Treatment	Chlorophyll Concn Index (veraison, 2011)
Control	19.5
30 N Soil	20.0
2 X 30 N soil	20.6
Foliar N	20.4

Table 3 – Yield components from 2011 by treatment.

Treatment	Number of clusters	Yield per vine (kg)	Cluster weight (g)	Berry weight (g)	Berries per cluster
Control	21.4	6.1	291.0	2.0	144.3
30 N Soil	21.6	6.5	296.7	2.1	142.8
2 X 30 N soil	22.3	6.5	284.8	2.0	142.4
Foliar N	22.1	6.0	277.2	2.0	138.2

Table 4 – Cane pruning weights (2011 season) and fruit yeast-assimilable nitrogen (YAN).

Treatment	Pruning weights (grams/vine)	Yeast assimilable N (mg/L)
Control	803	119.1
30 N Soil	808	138.2
2 X 30 N soil	775	153.9
Foliar N	708	154.6

Experiment 2, Chateau O'Brien: A second experiment was added in January 2012 at Chateau O'Brien vineyard near Markham, VA (approximately 20 miles from Winchester and within 15 miles of the Glen Manor Vineyard). Vineyard block of interest is a 9-year-old planting of Merlot planted on a relatively steep slope where intra-row cover cropping is used to suppress soil erosion and vine vigor. The block has chronically exhibited low nitrogen levels; severely in some cases. Treatments at Chateau O'Brien will be applied to 6-vine panels, replicated 5 times in a randomized, complete block experimental design. Pruning weights were gathered by panel in February 2012, before the start of the experiment. Floor management will be standardized as permanent row middle fescue, with intra-row zones (50-85-cm wide) planted to mixed stand of red fescue and native (weed) vegetation, maintained with a hand-held line trimmer.

Treatments at Chateau O'Brien involve:

1) Control (no additional N)
2) Compost, **low** rate (roughly 33.5 kg/ha of actual N total analysis)
3) Compost, **high** rate (roughly 67 kg/ha of actual N total analysis)
4) Clover and compost, **low** rate (roughly 33.5 kg/ha of actual N total analysis)
5) Clover and compost, **high** rate (roughly 67 kg/ha of actual N total analysis)
6) Calcium nitrate, **low** rate (15 + 15 + 0) [numbers reflect kg/hectare N at one of 3 points in time: early-season + mid-season + post-harvest]
7) Calcium nitrate, **high** rate (30 + 30 + 0)
8) Calcium nitrate, **low** rate, applied post-harvest (0 + 0 + 30)

Treatments began at bloom-time in 2012 and will be repeated each year for a minimum of three consecutive years. Data that has been collected, or will be collected in the remainder of the season includes:

- bloom-time (prior to N application) and véraison leaf petiole and leaf blade total N concentrations (this will allow a comparison of tissue type for assessing N status)
- cane pruning weights collected each winter
- crop components of yield (berry wt., cluster wt., clusters per vine, crop wt. per vine, etc.)
- grape primary chemistry and YANC at harvest
- chlorophyll index of leaf samples at fruit set, véraison, and harvest (measured with Minolta SPAD 502DL chlorophyll meter, calibrated against adequately fertilized set of vines in each vineyard)
- véraison enhanced point quadrant analysis (EPQA) to describe canopy architecture and fruit exposure

Research note: the red clover in treatments 4 and 5 exhibited poor establishment this year. We suspect this was due to dry conditions after seeding and competition with other weeds. To

ensure better establishment next season (2013), the panels will be treated with a nonselective herbicide prior to seeding and we will increase the rate of seed applied.

Experiment 3, Winchester: A third experiment was implemented in June 2012 at the Agricultural Research and Extension Center in Winchester, VA. Vineyard block of interest is a 5 year old planting of Petit Manseng vines with under trellis cover crops which consist primarily of *Trifolium arvense* L. and *Medicago lupulina* L. Treatments are in 5-vine panels, replicated 5 times in a randomized, complete block experimental design. The trial was added to further explore the effects of foliar nitrogen applications at different times in the growing season to cover cropped vines. Data collection will match the work done at Chateau O'Brien.

Treatments at Winchester involve:

1) Cover crop control – no nitrogen additions*
2) Herbicide control– no nitrogen additions*
3) Foliar urea application to cover cropped vines – 5 kg/ha applied 2 weeks prior to véraison, and 5kg/ha applied 1 week prior to véraison (10kg/ha total)
4) Foliar urea application to cover cropped vines– 5 kg/ha applied 1 week post véraison and 5kg/ha applied 2 weeks post véraison (10kg/ha total)

* All panels received 10kg/ha calcium nitrate via soil application on June 1st, 2012. Given that all treatments received the same application, we plan to attribute differences in berry chemistry and other data collection to experimental treatments.

Future Modifications:

Beginning in 2013, data collection will expand to include the following for all treatment plots:

- soil (0 - 60 cm depth) nitrate-N at bud-break, fruit set, véraison, and one month post-harvest (soil nitrate-N with nitrate-specific electrode) (this will allow an assessment of how much mineralization of organic N is occurring and how much is present – and potentially leachable – in the fall)
- season long weather data to record daily rainfall
- early and mid-season determination of cover-crop establishment
- mid-season (pre-mowing) evaluation of carbon and nitrogen levels in cover crop dry weight samples

Outcomes and Benefits Expected:

The primary objectives of this work aim to develop a set of recommendations for accurately assessing vine nitrogen status and providing guidance on the optimal means of augmenting the vine's nitrogen needs in low N environments. While we have historically relied upon bloom-time sampling of leaf petioles to determine N status, there is increased interest in including must analysis of YAN as a diagnostic criterion. Our experiments will allow a direct comparison of must and foliar N levels, addressing both viticultural needs of crop yield and vine size, but also recognizing the importance of N to fermentation and flavor and aroma chemistry.

Registering increased nitrogen reserves in the grapevine, as assessed by tissue analysis, may take 2 or more years. Three or more years of data collection would be necessary before conclusions can be made about the most efficient timing and rate of applied nitrogen. Total rates of N may be adjusted up or down depending on measured responses; however, we would tentatively aim to maintain leaf petiole total N at or above 0.90% N through véraison, and must (juice) levels of yeast-assimilible nitrogen at or above 150 mg/L, but avoid having soil nitrate-N levels in excess of 20 kg/ha 30 days after harvest. This last point relates to our desire to avoid a pool of unused, potentially leachable, nitrates in the soil profile during the dormant period.

Depending on our access to wine-making equipment and analytical instrumentation, we would like to pursue more detailed analyses of musts and wines with respect to treatment impact on flavor and aroma compounds. We expect to make small lots of wine (probably in the 2013 season) and review the finished wines for consumer preference, at minimum, but perhaps for specific metabolites associated with flavor and aroma (e.g., certain thiol compounds in Sauvignon blanc).

Budget notes:
I originally anticipated having a graduate student involved with this project during the 2011/2012 academic year, and funding was accordingly sought for the Graduate Research Assistantship for that period. An exceptional student (Ms. DeAnna D'Attilio) was finally recruited and started in May 2012; however, the monies originally sought for a 2011/2012 graduate assistantship (stipend and tuition) remained unspent at the end of June 2012, about $25,000. This was discussed in the interim project report. Most of the funds that were spent over the last fiscal year were for laboratory services (e.g., tissue analysis), wage assistance with the field work, travel and material supplies.

Year in which project began: 2011

Anticipated years remaining for project: three

Estimated cost of project: $100,025