A CONTINUING PROJECT PROPOSAL TO THE

VIRGINIA WINE BOARD

OPTIMIZED GRAPE POTENTIAL THROUGH ROOT SYSTEM AND SOIL MOISTURE MANIPULATIONS

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Start date: 1 July 2007 (for current funding request)

Amount requested in current year: $20,679

A. Title: Optimized grape potential through root system and soil moisture manipulations

B. Date: 1 April 2007

C. Duration: Seven to nine years (project commenced in 2005)

D. Objectives:

1) Evaluate the impact of complete ground cover vs. under-trellis weed control, three rootstocks, and three root manipulation techniques as means of regulating the vegetative/reproductive balance of Cabernet Sauvignon clone #337 (VA site)
2) Evaluate cover crop species and root pruning to impose water stress on Cabernet Sauvignon vines (NC)

E. Justification/practical importance:

Highest wine quality is most consistently obtained from fruit produced on vines that express an optimal balance of leaf area and crop. "Balance" can be quantitatively expressed as cropload (e.g., 5 to 7 pounds of crop per pound of pruned canes) or as leaf area to crop ratios. For the latter, balance is a steady-state condition at veraison when vines have 1.2 to 1.5 m^2 of healthy, exposed leaf area for each kg of crop. Balance is an elusive goal in many eastern vineyards due to the seasonal availability of rainfall and the depth and fertility of many vineyard sites. The combination of a naturally vigorous cultivar planted on a deep, fertile soil is particularly unsatisfactory with a late-ripening cultivar such as Cabernet Sauvignon. We hypothesize that we can favorably affect vine balance through an aggressive means of root manipulation and soil moisture deprivation. The expected outcome is a sustained, mild water stress in <u>most</u> years that will advance veraison and harvest, that may possibly result in smaller berries, and that both primary (e.g., sugars) and secondary fruit metabolites (e.g., color compounds such as anthocyanins) will be more concentrated in the harvested crops. The "cost" of this approach will include more intensive vine water management, including irrigation maintenance. The benefits, if successful, will include reductions in canopy management labor as well as increased grape and wine potential.

F. Background:

"Excessive" vine vigor is a common problem in mid-Atlantic vineyards, especially when vigorous vines are grown on soils with surplus amounts of nutrients and water. Previous research in Virginia has followed a remedial approach to dealing with excess vegetative growth, including shoot hedging (Wolf et al., 1990), leaf pulling (Zoecklein et al., 1992), and evaluation of chemical growth regulators (Wolf et al., 1991). Size-limiting rootstocks may also offer a proactive means of limiting vine vigor (e.g., Southey, 1992). Cover crops have been used to compete with vines for mineral nutrients and water (Ingels et.al.1998). The use of "permanent" cover crops under the trellis has not been researched in the humid eastern US. Root-restrictive fabrics, commonly used in the nursery industry, have been successfully used to reduce the vigor of apple trees (Byers, 2004) and grapes (Wang et al., 2001). The novelty of the proposed research is the use of a combination of these measures to restrict the amount and duration of vegetative growth under the humid growing conditions of Virginia.

G. Procedures:

Experiment 1 (AHS Agricultural Research and Extension Center [AREC], Winchester VA]): Three factors will be examined for their relative efficacy in regulating the vigor and vegetative growth potential of Cabernet Sauvignon clone #337 in a new vineyard. Treatments will include complete floor cover (including under-trellis) of tall fescue (*Festuca arundinacea*) cv. 'Shenandoah', compared with a conventional scheme of row-middle only grass combined with a 1-m under-trellis weed-free (herbicide) strip. A weed-free under-trellis strip will be maintained for the first two years of the experiment with both treatments. Grass will be established under the trellis in late-summer of the second year for the complete ground cover treatment. A second factor will consist of one of three different rootstocks: riparia Gloire, 420A, and C-3309, listed in the order of *increasing* vigor. A third factor will consist of root manipulation. One level of root manipulation will consist of annual root pruning, commencing during the dormant period between the 3rd and 4th seasons, or later, depending upon vine performance in the 3rd season. A second level of root manipulation will consist of planting the grapevines in root-restrictive fabric bags of approximately 0.5- m diameter and height (about 0.10 m^3). The third level of this treatment will consist of no root manipulation. All plots will be drip-irrigated based on the degree of water stress desired to impose a tolerable stress, but not to affect the sustainability of the vines (Ojeda et al., 2002).

Treatments will be arranged in a split-split-plot experimental design with blocks replicated six times. Main plots will consist of ground cover management (complete vs. herbicide strip). Rootstocks (three levels) will comprise sub-plots and root manipulation (three levels) will comprise sub-sub-plots, for a total of 18 treatments. Experimental units will be 5-vine panels (plots). Buffer panels (5 vines) and a single buffer row will be established between adjacent ground cover plots.

Vine management: Vines will be grafted in 2005 and established in the vineyard in spring 2006. Vine spacing will be 1.5-m apart in the row with rows 3.0-m wide in northeast/southwest-oriented rows. Treatments, including the extension of row middle vegetation under the trellis, will occur at the end of the second season and during the 3rd and subsequent seasons. Vines will be cordon-trained and spur-pruned, with VSP-trained canopies. Crop levels will be regulated within the range of 1.4 to 2.8 kg of fruit per meter of VSP canopy. Shoot density (~ 12/m) will be initially set by dormant pruning, followed by shoot thinning if needed shortly after budbreak.

Experiment 2 (Shelton Vineyards, Dobson, North Carolina): A second experiment is being conducted in Surry County, North Carolina in an established (1999) Cabernet Sauvignon vineyard, by graduate student Gill Giese. Vines are cordon-trained and spur-pruned, with VSP-trained canopies. Treatments include a comparison of complete floor cover (including under the trellis) of five grass species/cultivars including: tall fescue (*Festuca arundinacea*) ('Kentucky 31'), a "turf-type"('Rebel-III') and a glyphosate-tolerant strain ('Aurora'), perennial ryegrass (*Lolium perenne*), and creeping red fescue (*Festuca rubra*). The grasses are compared with each other and with the conventional system of row-middle only grass (tall fescue) combined with a 1-m under trellis weed free (herbicide) strip. Cover crops were established in spring 2005, and were re-seeded in late-summer 2005. Root pruning (the second factor) is applied to both sides of root-pruning treatment plots, 40 to 60 cm from the vine trunks, in a line parallel with trunks. All plots will be drip-irrigated if/as needed (irrigation is installed) to prevent excessive water stress.

Treatments are arranged in a split-plot design with blocks replicated six times. Main plots will contain 12 vines of ground cover management (complete, various species versus herbicide strip). Sub-plots of each ground cover or herbicide treatment (6 vines) will be root-pruned for a total of 12 treatments. Buffer panels are established between blocks with annual ground cover (buckwheat *Fagopyrum esculentum*) to delineate blocks. Treatments were first imposed in spring of 2005, were repeated in 2006 and will be repeated in 2007.

Data collection (generally, both experiments):

Vegetative growth: Commencing in the second or third season, data will be collected on cane pruning weights, shoot growth rate, seasonal growth duration, and leaf area.

Canopy architecture: Measures of canopy density will be made annually and will consist of vine shoot counts, and point quadrat analyses (canopy transects). Canopy point quadrat analyses (PQA) will be made shortly before veraison and will consist of passing a thin probe horizontally through the canopy fruit zone (Smart and Robinson, 1991). PQA data will be used to determine leaf layer number, percent canopy gaps, and percent exposed fruit clusters. Canopy light measures will be made shortly before and after veraison to help characterize the effect of treatments on canopy characteristics.

Leaf gas exchange and water potential: Stomatal conductance and photosynthesis of exposed, healthy leaves will be monitored on a bi-weekly basis in all plots to provide a sequential measure of vine water stress. To the extent possible, measurements will be made mid-day on uniformly clear or hazy sky conditions. Leaf (Ψ_L) and stem (Ψ_S) water potentials will be measured every two weeks from mid-summer through harvest using published methods. Measurements will consist of 4 to 6 single-leaf readings per treatment replicate; however, treatment comparisons may be limited to main plots or select comparisons of sub-plots and sub-sub-plots due to time constraints. Readings will be made at midday on leaves of similar maturity to those selected for gas exchange measurements.

Soil moisture: Soil moisture will be monitored with capacitance probes, such as the EnviroScan (Sentek). PVC access tubes (up to 100 cm deep) will be placed 50 cm from vine trunks with one access tube per plot replicate. Reference soil moisture readings will be taken in winter with soil at full field capacity. Soil moisture data will then be expressed as relative (to FC) soil moisture content.

Plant analysis: Leaf petioles will be collected each bloom (possibly alternate years) to monitor vine nutrient status (75 per treatment replicate. Supplemental N will be applied (summers) to vines if bloom total N concentrations are below 0.90% N and if vines show other symptoms of N deficiency.

Fruit sampling and components of yield: A minimum of 50 berries will be randomly collected from each treatment replicate at 7- to 10-day intervals beginning at approximately 18 °Brix, until and including harvest. Harvest decision will be based upon disease incidence, fruit aroma and taste, and imminent climatic or wildlife threats. Yield components will include clusters per vine, cluster weight, berries per cluster, berry weight, and fruit weight per vine. Vine performance indices such as the Ravaz index (crop/pruning wt.), as well as crop per leaf area, will be determined.

Fruit chemistry: Basic fruit chemistry analyses will be performed at the AHS AREC in Winchester. Soluble solids and pH will be determined on fresh (non-frozen) berry samples within 24 hours of collection. Titratable acidity will be determined either on fresh juice samples or frozen samples. Fruit total anthocyanins (abs @520 nm) and total phenolics (abs. @280 nm) will be measured spectrophotometrically at the AHS AREC following established practices.

Small-lot wine-making: While not within the scope (or budget) of the effort proposed here, small lots of wine could be made from selected treatments over multiple years depending on the magnitude of the treatment effect. This would be coordinated with Dr. Bruce Zoecklein of Virginia Tech's Department of Food Science and Technology and/or at the Surry Community College wine-making facility.

Technology Transfer Plan: This is a long-term, applied research project, and our intention would be to provide meaningful results to growers starting in 2007 or 2008, particularly for the Virginia location. Knowledge gained will be disseminated to grower and vintner application via newsletters ("Viticulture Notes" [http://www.ext.vt.edu/vce/specialty/commhort/main.html]), regional industry meetings, and posted to the PI's web site (http://arecs.vaes.vt.edu/arec.cfm?webname=winchester&section=about_us&pid=vitis). The information will also be incorporated into the instructional media currently used in the viticulture program at Surry Community College. To the extent possible, we will follow an outcomes/impact-

based program logic model to evaluate and assess the impact of our recommendations on grower participation/adoption.

H. Personnel and facilities: Dr. Tony Wolf will oversee all aspects of work. The AHS AREC has all field and laboratory equipment to accomplish the Winchester portion of proposed effort. Mr. Gill Giese will conduct the day-to-day activities associated with the North Carolina portion of the project as part of his PhD studies.

I. Other entities: None

J. Source of other funds: No other funding available/sought for this year.

K. Budget (2007)

Wages		$14,542
Fringes, wage (8.5%)		$1,236
Travel		721
Materials		$2,900
Contractual services		$1,280
Total		**$20,679**

Budget justification and description:

- *Wages:* Wages are for graduate student Gill Giese to cover graduate tuition costs ($7,342) for fall 2007 and spring 2008, and for assistance with vineyard maintenance at both North Carolina experiment and Winchester experiment (figured at $12.00 per hour x 20 hrs/week x 30 weeks = $7,200 in 2007 and spring 2008.
- *Wage fringe rate* of 8.5% is ONR negotiated rate for Virginia Tech, effective 1 July 2006.
- *Travel* is figured at 540 miles round-trip from Winchester to Dobson, NC, 3 trips/year, and a mileage rate used by Virginia Tech of $0.445 per mile = $721
- *Materials* include:
  - Compressed gas and supplies for water status/physiology measures $700
  - Materials for fruit sampling and processing, vineyard supplies, soil moisture probe access tubes $2,200
- *Contractual Services* include:
  - Plant tissue analysis (@ $200) and cost ($180/day) of trencher for use in NC (2006) and VA (for irrigation system) total of 6 days = $1,280

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