Annual report to Virginia Wine Board
Report covering period July 1 – December 31, 2008

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

Principal Investigator: Tony K. Wolf

Award amount: $25,921

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 site)

Progress:

My most recent progress report on this project focused primarily on the second objective being conducted by PhD student Gill Giese in Dobson, North Carolina. That work continues and a brief summary of activities in 2008 is presented below. This semi-annual report focuses primarily upon Objective #1 which is now entering data collection phase.

Objective #1: This portion of the project aims to explore the impact of under-trellis cover crop, rootstock, and root manipulation on the extent and duration of vegetative vine growth, and impact on fruit composition and, ultimately, wine quality measures. The experiment involves Cabernet Sauvignon clone #337 grown at the AHS AREC in Winchester. Vines were in their third leaf in 2008. The experiment is fully developed at this point. Graduate student Tremain Hatch commenced data collection on a portion of this project during the 2008 growing season. Extensive data were collected on vine shoot growth rate, canopy development (leaf area and degree of lateral shoot development), vine water status and photosynthetic performance, components of crop yield and primary fruit chemistry and fruit color. We are also working with a new graduate student in Food Science and Technology, William May, to extend the primary fruit chemistry analyses into investigation of potential treatment impacts on secondary metabolites that contribute to wine flavor and aroma.

Preliminary findings: The experiment was designed as a split-split field plot that consists of under-trellis cover crops (creeping red fescue) versus a standard herbicide strip as a main plot. Within the main plot, three rootstocks are compared as sub-plots: 101-14, 420-A, and riparia Gloire. The rootstock plots are further divided into sub-sub plots that compare the use of root-restriction bags (RBG) versus no root manipulation (NRM). A third root manipulation sub-sub plot was originally included (root-pruning); however that treatment was not done in 2008. Main plots (and all sub-plots) are replicated six times and buffer panels and guard rows of Petit Manseng are used to separate main plots and cover crop vs. herbicide sub-plots.

Our underlying hypothesis is that the competitive nature of the under-trellis cover crop and the root restriction afforded by a fine mesh root bag can be effectively used to limit vegetative development of vigorous vines and that by so doing, the fruit composition can be favorably affected by changing berry geometry or possibly by altered berry biochemistry, such as through altered synthesis or degradation rates of compounds such as methoxypyrazines that contribute vegetative character to Cabernet Sauvignon. The use of three different rootstocks adds another dimension to the hypothesis in that the rootstocks vary in scion vigor, or so the literature would suggest. The scope of the project is ambitious and our goal with Tremain Hatch's MSc degree research is chiefly to determine how predictably the vegetative growth of the vines can be affected by our range of treatments, and what impact this has on rate of fruit ripening as judged by primary fruit chemistry and berry color density. For 2008, growing season data were generally only collected from the herbicide-strip plots, although fruit yield data and vine pruning weight data were/will be collected from all vines.

Shoot development: Shoots were selected on treatment vines in early May and their length measured on a regular basis to establish rates of shoot growth. Cabernet grafted to 101-14 or 420-A grew at essentially the same rate throughout the period from 23 May to 13 August (Figure 1), while vines grafted to riparia Gloire grew at a relatively slow rate. These data are consistent with the generally accepted knowledge about the relatively lower vigor conferred by riparia Gloire. The data do, however, suggest a limited difference in vigor between 101-14 and 420-A, at least under the test conditions of our vineyard in 2008.

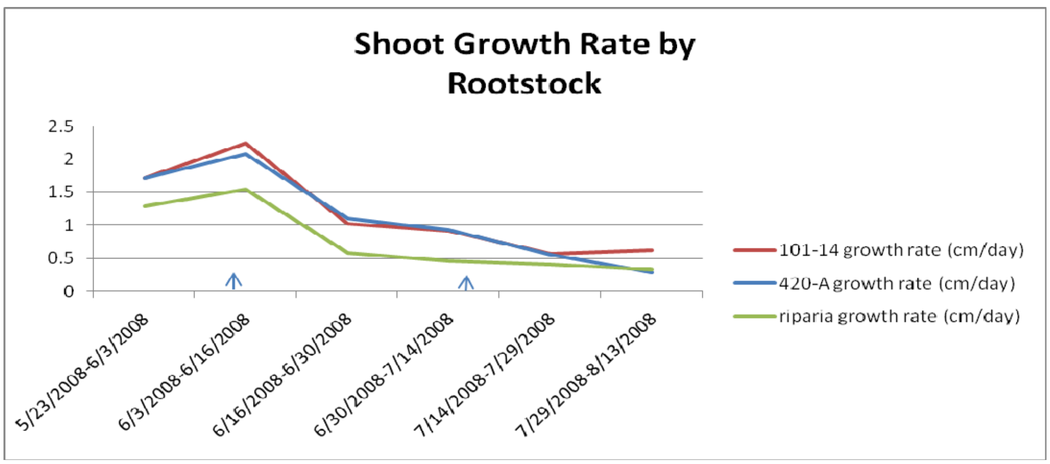

Figure 1. Shoot growth rate during 2008 as a function of rootstock. Arrows indicate dates of bloom and date of first shoot hedging (measurement shoots were not hedged).

Root restriction, by use of root bags, had a profound impact on shoot growth rate when averaged across rootstocks (Figure 2). The lower rate of shoot growth with root-restriction bags translated to less leaf area per vine (data not shown) and we intentionally reduced crop on these vines to keep the crop to leaf area ratio within a generally accepted range of approximately 10 to 12 cm^2 of leaf area per gram of crop.

Both rootstock and root manipulation affected the degree of lateral shoot growth development, with riparia Gloire having less lateral development compared to the other two rootstocks (data not shown). Canopy transects – passing a thin probe through the canopy to quantify leaf layers and the degree of fruit exposure – and measures of sunlight penetration of the canopies were also done during the 2008 season. The inhibition of shoot growth with the root restriction bags did not appear to be due primarily to lack of moisture, as might be expected with the relatively limited rooting volume. We hypothesize, rather, that as root growth is inhibited, the synthesis of plant hormones (cytokinins and gibberellins) is curtailed which translates into less shoot development. So, while we've focused on water being the limiting factor for vegetative growth – and our experiment is designed to limit availability of water – another factor could be the extent or duration of root growth flushes that determine how much above-ground growth occurs.

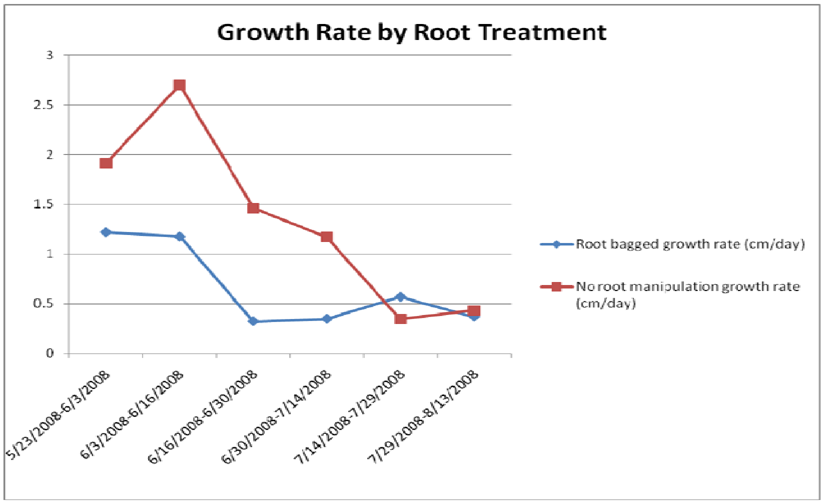

Figure 2. Shoot growth rate during 2008 as a function of root manipulation.

Yield components: Yield per vine was affected by all three experimental treatments, with use of root-restriction bags exerting the greatest effect (Figure 3). Bear in mind, however, that we intentionally limited crop on root-restricted vines in order to target a desirable leaf area to crop ratio. The blue bars in Figure 3 are the yield per vine. Yields were generally higher on the herbicide plots than on the cover crop plots for any of the three rootstocks. Part of the reason for this difference owes to greater berry size with vines on the herbicide plots (Figure 4). This is not surprising and if our goal was simply to promote greater yields, we would argue for using weed-free strips under the trellis as a management tool. If, however, the conditions that cause lower berry weights and lower yields also translate into higher fruit and wine quality, there may be a compelling reason to use under-trellis cover crops. Note also in Figure 3 that choice of rootstock also affects yield. Greatest yields were attained with riparia Gloire, and least with 101-14, regardless of whether vines were grown with under-trellis cover crops or on herbicide strips. Again, note that the pattern of berry size (Figure 4) paralleled this pattern of yield per vine.

Fruit chemistry: Berries were sampled at two-week intervals throughout the growing season and somewhat more frequently just prior to harvest. Primary fruit chemistry at harvest is illustrated in Figure 5. While there are slight differences in Brix between treatments, we intentionally sought to harvest the grapes at essentially the same maturity (Brix) level in order to standardize the subsequent measures of secondary metabolites at the same sugar levels. Fruit pH and titratable acidity were comparable between treatments. Figure 6 compares primary fruit chemistry as a function of root manipulation. Here one can see that the root restriction bags had a depressing effect on soluble solids accumulation, but negligible effects on either pH or titratable acidity.

Additional data have been collected on soil moisture and plant water status (leaf water potential measured with a pressure bomb on several occasions throughout the growing season). We have recently completed berry color assessments for two sample dates and have seen some treatment effects but we need to complete more sample dates in order to draw conclusions. Data analysis will continue in the coming months, including cane pruning weights which have yet to be collected.

Some very preliminary findings are that under-trellis cover crops, choice of rootstock, and use of root restriction bags can all be used to alter the vegetative growth of vigorous vines. We can also alter berry weights which, under some conditions, may translate to increased grape and wine quality. The use of root restriction bags offer a means of dramatically controlling the *duration* of vegetative growth, although not as predictably as desired. The small volume of bag that we chose to use may have been smaller than optimum, and a side project should be conducted to explore several larger volumes of root containment. Restriction of vegetative growth has several positive benefits: less labor needed to hedge vines; less labor needed to thin out lateral shoots; more optimal sunlight exposure of clusters; possibly less vegetative tones in fruit if leaf area development after veraison contributes to herbaceous character of wines. Again, this is a very preliminary report, and a full exploration of impacts on secondary metabolites and, ultimately, wine-making will be needed to fully understand the potential value of the treatments that we are investigating. Nonetheless, we are excited about the preliminary findings.

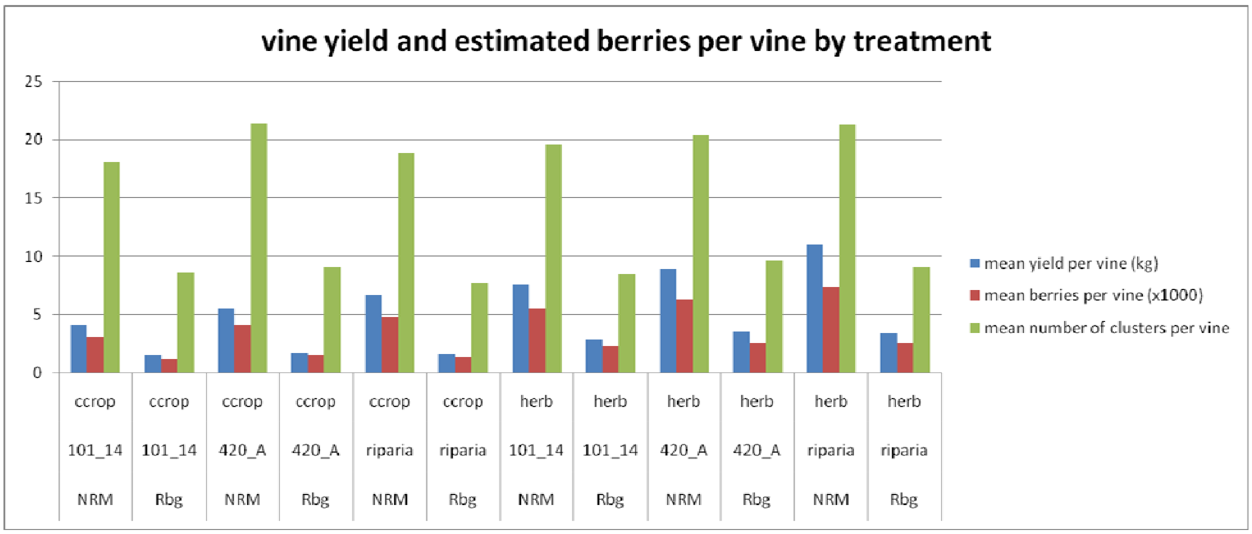

Figure 3. Shoot growth rate during 2008 as a function of root manipulation.

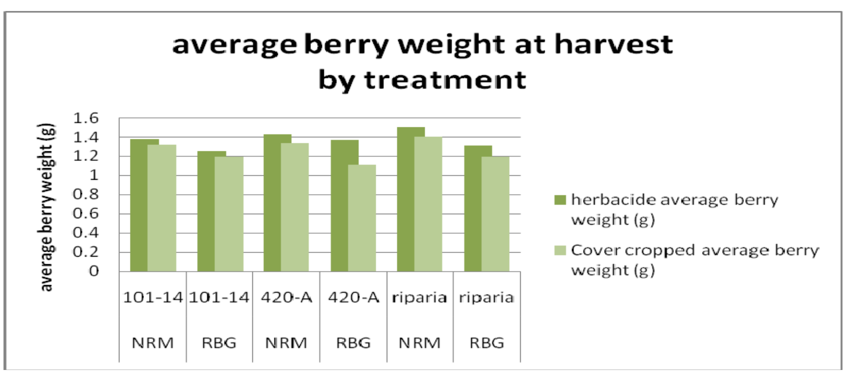

Figure 4. Berry weight at harvest by treatment.

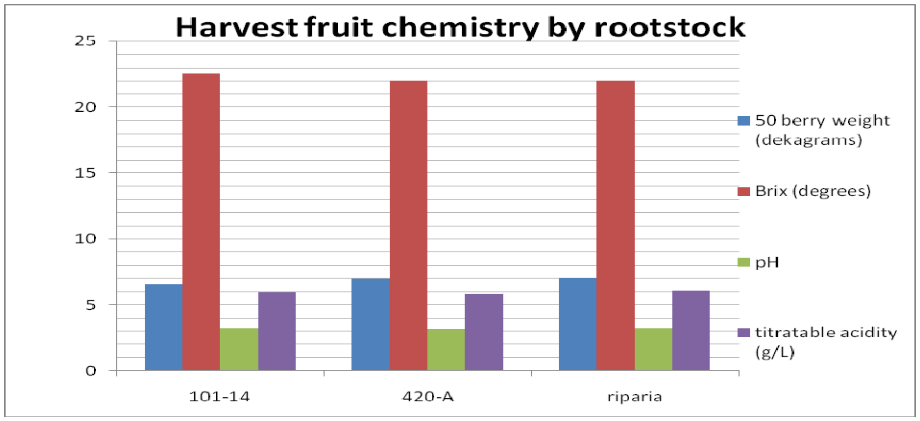

Figure 5. Primary fruit chemistry at harvest as a function of rootstock.

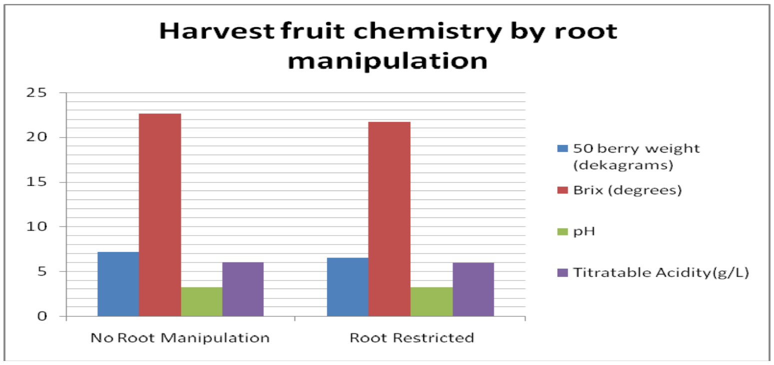

Figure 6. Primary fruit chemistry at harvest by root manipulation (rootstocks and ground cover averaged).

Objective #2: The work of graduate student Gill Giese at Shelton Vineyards in Dobson, NC is proceeding as proposed. This project asks two very basic questions:

- Can the vegetative growth period and berry size of mature Cabernet Sauvignon grapevines be regulated with permanent, under-trellis cover crops or root-pruning?
- If so, do those responses translate to improved grape and wine potential quality?

This project is similar to that in Objective number 1 in that we're trying to alter the amount and/or duration of vegetative growth. Ideally, we'd like vegetative growth of grapevines, particularly shoot extension, to cease at about the time of veraison. The continued vegetative growth of vines in the final ripening of the crop is often associated with "vegetal" character in wines from methoxypyrazines and other compounds that can be formed in young leaves. The continued vegetative development of vines also contributes to fruit rot problems and increased labor for trimming. We'd also like to produce grapes that have relatively small berries. Small berries have a greater surface-to-volume ratio than do large berries; small berries thus have greater concentrations of flavor and aroma compounds (usually, unless the small berries are caused by severe stress, that can diminish quality). Achieving smaller berries and restricted vegetative development might be possible by regulating the water available to vines by competition with under-trellis vegetation, or by root-pruning. Mr. Giese is following that tact by evaluating 5 different grasses as permanent, under-trellis cover crops as main plots, and using root-pruning (or not) as sub-plots.

Mr. Giese presented an update on this work at the VA Vineyards Association's annual technical conference in February 2008. This experiment was reviewed in-depth in the last project report (August 2008) and will not be discussed at length in this semi-annual report, but a few preliminary conclusions are worth repeating. Shoot growth rates, crop yield components, soil moisture readings, and cover crop water use patterns were all evaluated again during the 2008 season as a function of cover crop and root-pruning. Under-trellis cover crops depressed shoot growth rate, which was intended, and perennial ryegrass and orchard grass were particularly effective in this regard. We spent a great deal of time and effort in having root observation pits dug in representative plots and in taking grids of soil blocks out of the pit faces in three dimensions – parallel to row, perpendicular to row, and down. The soil blocks, each of 8,000 cm3, were sieved to extract roots of several size classes. This provided a means of quantifying the root distribution as a function of cover crops and of root-pruning.

We anticipate concluding this objective after the 2009 growing season. The effects of cover crops and root-pruning have been appreciable in terms of vegetative response of vines; however, the impact on fruit chemistry has been negligible and this may be due to the very deep rooting of these vines that we recorded with the rooting profile examination in 2008. We are currently evaluating berry color density of the 2008 fruit.

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