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VITICULTURE NOTES

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I. Current situation

Vineyards are pruned, tied and ready for bud-break which has commenced in our warmer areas. Another season commences with both promise and suspense. Will the weather cooperate? Will we have a spring frost? Will harvest be a month early… or a month late? How will the economy and the cost of fuel affect sales? Will stink bugs be *the problem* of 2011? Lots of questions, but some things are certain….grape buds will swell, break and shoots will bear another crop, and vineyard crews will repeat the seasonal tasks that go towards bringing those crops towards the 2011 vintage. Good luck with the season!

Included with this newsletter is an in-depth disease management overview provided by Dr. Mizuho Nita. The bulletin is also available at **Dr. Nita's blog** site:
http://grapepathology.blogspot.com/
If you have not visited Dr. Nita's blog, check it out. There is a wealth of information there that can help keep you out of trouble with grape diseases.

The **Pest Management Guide for Commercial Vineyards** is posted on-line. It can be accessed and downloaded directly at: http://pubs.ext.vt.edu/456/456-017/Section-3_Grapes-1.pdf
The "PMG" is a comprehensive listing of chemical pest management strategies for commercial vineyards, covering insects, mites, diseases and weeds.

Both the PMG and Mizuho's Disease review are well worth reviewing. Each year is different in terms of pest pressure, new materials that are registered and some older ones that may be voluntarily cancelled or fall from favor for one or more reasons. New pests (such as the brown marmorated stink bug), and heightened problems with long-standing pests such as ripe rot disease, merit surveillance and possible action on the part of the vineyardist. In addition to the VA Tech information, I would remind the reader about the informative pest management options posters that are available through

VineSmith (http://www.vinesmith.com/toolkit.html). None of the above information is a substitute though for getting out in the vineyard and scouting for problems.

Nick Zetts teaches **EPA's Worker Protection Standards** requirements for farm workers under the auspices of Telamon. Telamon is a non-profit organization and, in Virginia, works in partnership and with funding from the VA Department of Agriculture and Consumer Services. Nick attends some of our grower meetings and you might have met him at previous meetings. His services are free, but you need to contact him if you wish to organize training for your vineyard workers. I've attached a one-page flyer here that explains who Telamon is and how this free training would be of benefit to your organization.

e**Xtension:** eXtension is a web-based, searchable database that offers crop-specific information with local flavor from a national network of land-grant university specialists. The vision of eXtension is the concept of open-access or freely available educational material to end-users, based on the Cooperative Extension network. A grape "Community of Practice" component of eXtension was launched in January 2011. The recommendations and peer-reviewed information available there is based on the knowledge of extension educators throughout the country. Check it out at: http://www.extension.org/grapes. The first featured article that you'll see is a discussion about frost avoidance and frost protection measures.

Question from the field: I'm interested in growing Malbec, but it is not one of the varieties addressed in the Wine Grape Production Guide. I'm trying to determine how best to train it.

Answer: The variety chapter of our 2008 book Wine Grape Production Guide for Eastern North America (http://www.nraes.org/nra_winegrapecontent.html) was actually compiled in 2005 and finalized in 2006. At the time, we had scant experience with Malbec and chose not to include it. In fact, there are several varieties including Albariño, which appear to do well in Virginia, which are not listed in the book. A central clearing-house of varietal information is the National Grapevine Registry (http://ngr.ucdavis.edu/) which is maintained by the University of California, Davis. I would encourage readers to review this site. The Registry contains extensive information on numerous grape varieties, with links to additional reference material. From the Malbec main page, one can find a more in-depth article by the late Ed Weber who describes Malbec's strong upright shoot growth as suitable to vertical shoot positioning. Other information points out the erratic fruit set nature, low yields, and high vigor potential of Malbec. A particularly useful feature of the Registry is the listing of nurseries that carry a particular variety.

II. Spring threats: There are several recurring threats that new and experienced grape growers should be aware of at this time of year. Here's a recap:

a) **Climbing cutworms and flea beetles:**

- Bud swell through 1-inch shoot growth period is prime feeding period for these two grape insect pests. Scout NOW and take action if feeding injury is apparent.
- Climbing cutworms are nocturnal feeders, whereas flea beetles can be found during the day (http://www.ext.vt.edu/news/periodicals/viticulture/03marchapril/03marchapril.html for cutworm photo). In most Virginia vineyards and in *most* years, climbing cutworms are the greater problem.
- Cultural control can be improved by raking leaf and weed litter away from the base of vines. By contrast, sod, mulch and other organic matter at the base of vines appears to increase climbing cutworm damage by providing a daytime refuge for the cutworm larvae.

- Insecticides (at least 12 registered for use; some effective against *both* climbing cut worm and flea beetle; at least one is organically approved) can be used (see Virginia Tech PMG [http://pubs.ext.vt.edu/456/456-017/Section-3_Grapes-1.pdf] for rates, timing and restricted re-entry interval).
- Need to monitor vineyard blocks starting at bud swell. Climbing cutworm damage can increase dramatically (literally overnight) with high populations.
- At least one grower has reported good cutworm control by walking vineyard at night with head-mounted lights and picking larvae off vines. This could work in small vineyards or where "hot spots" exist and where the overall effort is to reduce pesticide usage.

b) Phomopsis:

- See http://www.arec.vaes.vt.edu/alson-h-smith/grapes/pathology/extension/factsheets/phomopsis-cane.pdf for photos and overview
- Early shoot growth period is most important for cluster and base of shoot infections; start fungicide program at ½ to 1 inch of shoot growth if phomopsis has been an historic problem; repeat at 7- to 10-day interval (7-day if wet weather, 10-day if dry weather)
- Early season (through bloom) control will aid late-season fruit rot phase of phomopsis, but some fungicide protection should be continued post-bloom in wet years to reduce mid-season fruit infections (those sprays will help with downy mildew too, if you use the appropriate fungicide)
- Old, even dead wood that was previously infected with phomopsis can continue to serve as a source of inoculum for some years; prune out infected wood where possible
- Fungicides: captan, EBDCs (mancozeb, ziram), Adament, Topsin M
- Need good coverage – and frequent application during rainy weather
- EBDC fungicides can flair mite populations early in season

c) Spring frost avoidance:

- It's mostly about site selection and putting the early budding varieties higher on a slope (passive control), but there are some active measures that can be implemented, depending on your circumstances
- Mow cover crops to increase soil heating during day
- Contact helicopter services well in advance of need if you choose to use this means of protection. Inspect, fuel and test solid-set wind machines if using this approach. Mobile, tractor-powered are fans and heaters are also available and offer some measure of protection. Overhead irrigation is another alternative, but requires large amounts of water.
- Avoid use of crop oils *after bud break* if you are in a frost-prone site (note, research has shown some bud-break delay with some varieties when dormant oils are applied to vines in the dormant period, well before bud break)
- Efficacy of prophylactic sprays ("night before" measures) to minimize frost injury are generally ineffective – they promise much but generally fail to deliver.
- With some variance due to wind speed, cloud cover, and the relative dryness of the air, the temperatures (degrees F) that will damage grape buds and shoots are:

- dormant bud	< 20F
- dormant swollen	26F
- burst bud	28F
- one leaf unfolded	28 - 29F
- two leaves unfolded	29 - 32F

- What happens if your vines get frosted? Should you rush out and remove the frosted shoots? Not much point. I covered this with a detailed response last May (http://www.arec.vaes.vt.edu/alson-h-smith/grapes/viticulture/extension/news/vit-notes-2010/vn-june-2010.pdf) and will stick to that response.

II. PERIODICAL CICADAS: A nuisance and potential threat to grapevine training
(Much of this text was taken from the May-June 2003 Viticulture Notes)

Periodical, 13- and 17-year cicadas emerge over parts of Virginia almost every year, the geographical scope varying with the specific "brood". Some broods emerge within very small areas while others affect a major portion of the state. "Brood X" (17-year) cicadas, as the northern Virginia brood is referred to, last appeared as adults in 2004. Brood II (17-year) emerged over much of the central piedmont in 1996 and will re-emerge in 2013. Brood I (17-year) will re-emerge in parts of the Shenandoah Valley and southern Blue Ridge in 2012, and both 17-year and 13-year broods will emerge in widely scattered areas of the state in May/June of 2011. A map of these emergence areas and more in-depth information on periodical cicadas can be found in a Virginia Cooperative Extension publication on the subject: http://pubs.ext.vt.edu/444/444-276/444-276.html

Biology: Periodical cicadas spend most of their life as a nymph, feeding on xylem sap of tree roots. In the final year of development, nymphs crawl from the soil, climbing tree trunks or any other structure. During the night, the nymphal skin splits along the midline, and the adult emerges. Adults appear in mid- to late-May (a few individuals may be heard as early as late-April). They appear around sunset, males slightly preceding females. Males congregate en masse in "chorusing centers". Singing peaks around 10:00 AM. Adults feed on a wide range of woody plants during the day; such feeding is apparently restricted to the females because the male digestive tract is rudimentary. Egg laying begins about 2 weeks after emergence. Eggs are inserted into twigs in groups of 10-25; the slit into which the eggs are inserted is 1-4 inches (2.5-10 cm) long. Females may lay over 500 eggs. Egg-laying peaks in the early afternoon. Adults are active for about 6 weeks. Eggs hatch 6-10 weeks after egg-laying, whereupon nymphs leave the twigs and drop to the soil. Nymphs tunnel to the roots where they establish themselves for feeding.

Cicadas and grapevines: What threat do cicadas pose to grapevines? Injury by egg-laying is a much greater problem than is the feeding, and injury to young (one- and two-year-old) vines is more significant than is injury to older, mature vines. The cicadas will deposit eggs in grape shoots and smaller cordons of the vine. Unsupported shoots often break beyond the point of egg-laying, but because this occurs relatively early in the growing season (June), lateral regrowth will normally compensate for the loss of a primary shoot tip. In older wood, the egg-laying site typically heals without apparent long-term consequence. The damage to shoots on newly planted vines, however, may render the shoots and developing canes unfit for retention as permanent trunks (or cordons), and this is one of the principal problems that cicadas may pose for vineyardists.

Insecticidal control of cicadas is not very practical because of the extended period of emergence and activity (up to 6 weeks) and because insecticides would have to be applied very frequently to come in contact with newly emerging insects. Netting is an option (see suppliers listed below), but the economics of this approach with grapevines are questionable. Young (first-year) vines are a special consideration in that one is attempting to produce shoots to serve as trunks in the following year. One means of protecting the shoots of young vines would be to use grow tubes, which would discourage cicadas from at least the first 24 to 36 inches of the shoot, depending upon the height of the tube. Because the most significant damage might occur with young vines, during the training of trunks, one effective option is to NOT plant in the year of, or a year or two *before* the emergence of a brood in your locale. This would reduce the risk of egg-laying damage to shoots and young canes that are desired as future trunks. Refer to the maps in the above-mentioned fact sheet to determine if you are in an area of the state that may see cicadas emerge in the near-future.

Two netting companies, if you're interested in this option, are:
Conweb:
http://www.conwedplastics.com/markets_agriculture.asp
Industrial Netting:
http://www.industrialnetting.com/

III. Optimized grape potential through root system and soil moisture manipulations: a research update

A central theme of our viticulture research over the last 5 years has been an evaluation of practical means of favorably regulating vegetative development of vigorous grapevines to create more optimal canopy architecture, vine "balance", fruit ripening conditions, and ultimately improve wine quality potential. Grapevines grown in Virginia and many other locations in the mid-Atlantic are often characterized as having excessive vegetative growth ("high vigor" as many say). To be clear, there are plenty of examples where vine size is *insufficient* for one or more reasons. We've all seen cases where the weak, struggling vines don't fill their trellis space, and such vineyards are not maximizing their profit potential. But healthy, grafted vines grown on fertile soils with ample soil moisture more often fall into the classification of overly vigorous. There is at least a popular view that highest wine quality potential is obtained with both appropriate vine size and canopy fill, and when terminal shoot extension ceases at or around veraison. It would seem that both the *extent* and the *duration* of vegetative growth may affect fruit composition and ultimately wine quality. Excess vegetation can, of course, be removed in one or more canopy management practices such as shoot hedging, lateral shoot removal, or selective leaf removal, but this entails added labor and/or management costs.

Abundant moisture availability to the plant is a principal contributor to the excess vegetation and limiting availability of that moisture, then, is one of our strategies for limiting vegetative development. Water is not the only driver of vine growth, but it's the dominant factor when other growth promoters are non-limiting. Other factors that affect growth include the environmental factors of temperature and sunlight availability, and the internal (to the plant) factors such as nitrogen and carbohydrate reserves, hormonal balances, and phytosanitary condition. If we accept, for the sake of argument, that restricting grapevine vegetative growth to some optimal size will translate into increased wine quality potential, how could we go about this in our "humid" (as opposed to arid) environment? After all, we can't just turn off the water. An important step forward would be to choose vineyard sites that tend to be "lean" on the soil's plant available water level. One can also choose hillside slopes, where both surface water and internal soil moisture tend to move more rapidly out of the vineyard. There is much more detail on these strategies in the site selection chapter of our Wine Grape Production Guide. Other practical measures include use of size-limiting rootstocks, physical root-pruning, use of physical means to restrict grapevine root development, and more aggressive use of cover crops to intentionally compete with vines for water and nutrients. Some of these strategies are currently being evaluated in commercial vineyards.

We established a field experiment at the Agricultural Research and Extension Center in Winchester to evaluate three of these techniques as practical means of restricting growth of Cabernet Sauvignon. The underlying hypothesis of this project is that water availability to the vine can be sufficiently restricted to decrease the rate and duration of vegetative growth, and that the restricted growth will translate to improved grapevine canopy characteristics, including improved cluster exposure, positive changes in fruit chemistry and, ultimately, improved wine quality. The experiment utilizes Cabernet Sauvignon (clone 337) that was planted in 2006. Cabernet Sauvignon was selected for study due to its inherent high vigor. Treatments are arranged in a strip-split-split-plot design comprising 12 treatment combinations. The first treatment is under-trellis ground cover; this has two levels: one is a 2-foot wide herbicide strip below the trellis combined with perennial cover crop in row middles (conventional floor management in Virginia). The second level of this ground cover treatment is a grass sward (creeping red fescue) established beneath the trellis in the fall of 2007. The second level of treatment comprises a comparison of three rootstocks: 101-14, 420-A and Riparia Gloire, listed in what we assumed would be decreasing scion vigor. The last treatment level is a comparison of root restriction versus no root restriction (control). Root restriction is achieved with a fabric bag to restrict the volume of soil available to the vine. The fabric of the bag is made of a UV-stabilized polypropylene material; it restricts root penetration yet allows moisture and nutrient transfer from the bulk soil. An additional treatment was added in 2010 to compare relatively high and low water availability to treatment plots via irrigation. Half of the root-restriction plots were irrigated on a consistent (3-4 times/week) schedule (low stress) and the other half of the main plots (and all sub-plots) were irrigated on an "as needed" basis but to maintain a relatively high water stress situation (high stress), which was easily achieved in the dry, 2010 season. The intention with this added layer of treatment was to further explore how drought interacts with the other treatments and what impact this had on fruit composition and wine quality attributes.

Hypotheses: The underlying hypothesis is that treatments that compete with the vines for water (such as an under-trellis cover crop), or restrict access to water (such as our root bags), will result in "small capacity" vines. These small vines will yield less fruit that is of higher wine quality attributes relative to larger capacity vines. The bases of the increased quality could relate to increased fruit exposure on the smaller vines, reduced berry size, decreased disease incidence, etc. with the smaller vines. In addition, it is hypothesized that vines that are subjected to **low or mild** water stress in the post-veraison period will produce fruit of higher wine quality potential compared to vines that were subjected to high water stress in that period. Though the beneficial effects on fruit quality of small capacity vines may mirror those of water-stressing a vine, too much water stress can result in decreased photosynthesis and impaired fruit ripening.

Some terminology: Vine balance, vine size, and vine capacity are admittedly difficult terms to fully grasp and even to measure. But it's worth a few sentences to explain the terms and visualize their use. Vine "capacity" is loosely synonymous with "vine size" and relates to the vine's potential to produce both crop and vegetative growth. Just as there are large people and small people, there are big vines and small vines. The yardstick for measuring vine size has been the amount (weight) of one-year old wood removed at dormant pruning. Vines that have pruning weights in excess of about 0.4 pounds per foot of canopy are "big" and generally reflective of excessive vigor. "Vigor" refers to the rate of growth; it is often positively associated with excessive vine size and is commonly observed as large diameter of shoots and canes, strong development of summer laterals from the primary shoot, larger than average leaves, and persistent, seasonal shoot development. "Balance", on the other hand, is a relative measure of the current season's crop weight to functional leaf area and/or the vine's pruning weight for that crop season.

Balanced vines have 3 to 6 square feet of leaf area per pound of crop (the higher end of the range preferred) and/or 5 to 10 pounds of crop for each pound of cane prunings (see table 6.2 and related text in the Wine Grape Production Guide). Growers sometimes get hung up on the leaf area measurement, but it needn't be a deterrent to estimating balanced crops. Vines spaced 5' apart in the row with 4' tall canopies have 20 square feet of canopy face. With ideal canopy density of about 1.5 leaf layers, we multiply 20 x 1.5 and derive 30 square feet of canopy – which should support 5 to 10 pounds of crop if leaves are healthy and not completely shaded. Put another way, the same vines should support from one to two pounds of crop per linear feet of canopy length. The admittedly challenging feature of this metric is the complication that arises from non-uniformity of vine canopies, particularly in older vineyards. Just like trying to estimate crop per acre, variability in vine size creates variability in our estimate of "balance." This crude leaf area estimate will probably under-estimate leaf area because few vineyards will have only 1.5 leaf layers (one can perform point-quadrat measures described in our canopy management chapter to more accurately assess this parameter).

There's a final aspect of the "balance" picture that must be considered. The vines are not in balance if we must repeatedly hedge the shoots or pull summer laterals to maintain the leaf area to crop ratio. So my definition of balance includes the proviso that the 3 to 6 square feet of leaf area per pound of crop is a steady-state condition achieved before veraison and persistent through harvest. In effect, the vine achieves a balanced state and we don't have to impose it through remedial canopy management measures.

With those definitions hopefully committed to understanding, let's look at our efforts to promote a balanced vine. A preliminary report of this project is on my website: http://www.arec.vaes.vt.edu/alson-h-smith/grapes/viticulture/research/ground-cover.html
In addition to that description, the research was discussed at the Virginia Vineyards Association annual technical meetings over the last three years. The presentation made in February 2011 can be viewed at the above address. I would also like to acknowledge that much of the work that has been done since 2008 has been by graduate students Tremain Hatch and, currently, by Cain Hickey. Research technician Kay Miller and numerous wage employees are also involved with the project.

Vegetative growth: Numerous measurements of vine vegetative development have been conducted over the past 3 growing seasons. These included shoot growth, canopy density assessments (point quadrat analyses), fruit zone light penetration, lateral shoot and leaf development, and dormant pruning weights. Shoot growth measurements were conducted in the pre-bloom through post-bloom periods; data for 2008 are shown in **Figure 1**. The *rate* of shoot growth does not have much of a bearing on potential wine quality; we measure it though to help understand how the treatments affect overall vegetative development. Briefly, we have found that the root restriction (RR) treatment (growing the vines in root-restrictive fabric bags) reduces vine growth primarily by limiting water availability to the vine. On the other hand, the under-trellis cover crop treatment (data not shown) appears to exert additional effects – perhaps depressed nitrogen or carbohydrate availability to the vines. Rootstock had an effect on the rate and duration of shoot growth in 2008 (slower growth with riparia), but has had limited effect in the last 2 years.

Lateral shoot development has been assessed each year at the onset of veraison. This is done by counting the number of unfolded leaves on each **lateral shoot** that originated from nodes 3 through 7 of 10 primary shoots per treatment replicate. In addition, the shoot tip of each of those shoots was examined and rated as either actively growing or not.

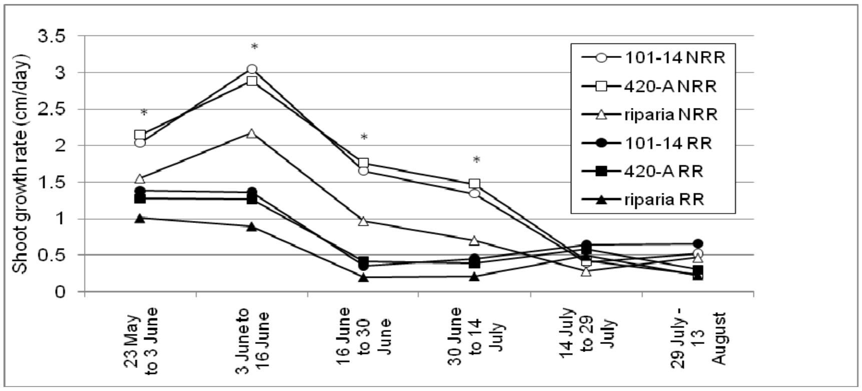

Figure 1. Shoot growth rates as a function of rootstock and root restriction (RR) or no root restriction (NRR) during 2008. Only the vines grown on herbicide main plots were measured for shoot growth rate in 2008.

Our interest with this exercise was to provide a quantitative measure of the extent of lateral leaf area as well as a measure of the duration of shoot growth as a function of our treatments. If it is true that highest wine quality is achieved on vines that cease vegetative growth at or around veraison, then it would be important to assess our treatment impacts on this parameter. Generally, reducing lateral leaf development leads to better cluster light exposure and a reduction in disease potential and the cessation of growth in shoot tips is a signal that the vine is allocating carbohydrates more to fruit ripening than to shoot extension. The sum of lateral leaves at nodes 3 to 7 of vines on herbicide strip plots was reduced by as much as 50% by root restriction (RR) and by another 20 to 30% when RR was combined with under-trellis cover crops (UTCC) (**Figure 2**).

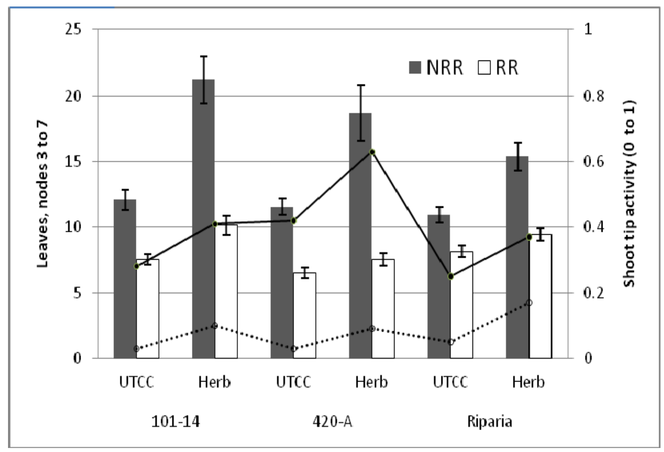

Figure 2. Mean summation of lateral shoot leaves at nodes 3 to 7 (bars) and shoot tip activity at veraison, 2010 for root-restricted, RR, (dashed line) and non-root-restricted, NRR, vines (solid line) for each rootstock and UTGC combination. Vertical lines on bars are the standard errors of mean leaf numbers for each treatment.

There's a lot of information in Figure 2. The impact of root restriction (RR) on lateral shoot development was more pronounced for vines grown on herbicide strips than it was for those grown with an under-trellis cover crop (UTCC). Treatments also affected the *duration* of shoot growth, as judged by the shoot tip activity at veraison (dashed and solid lines in Figure 2). Less than 20% of RR vines exhibited actively growing shoots at veraison, whereas 30 to 60% of NRR vines still had active shoot tips at that time.

For a given rootstock, the vines grown with UTCC were more apt to have ceased shoot elongation by veraison compared to vines maintained with herbicide strips. Among rootstocks, vines grafted to 101-14 tended to have the greatest lateral shoot development, and riparia had the least. That response is consistent with the other measures of rootstock performance that we've made. Thus, our presumed rating of rootstock vigor conferral (101-14 > 420-A > riparia) was accurate with what we're seeing.

We also measured the amount of available sunlight penetrating the fruit zone of the canopy. This was done just prior to veraison, with canopies fully developed. Generally, light levels in the canopy fruit zone were increased by root restriction and by under-trellis cover crop, and by the relatively higher water stress imposed on some of the treatments in 2010. The least amount of light penetration (the most shade) occurred with non-root-restricted vines grown on conventional herbicide strips. Rootstock had minor impact on sunlight penetration of canopies.

Pruning weights: Cane pruning weights were decreased both by under-trellis cover crop (UTCC) and by root restriction (RR), and were affected by rootstock as shown with the data from the 2008 and 2009 seasons (**Figure 3**). The pruning weights shown in Figure 3 are in metric units, which won't detract from the explanation of results. Riparia rootstock produced lower cane pruning weights than did the other two rootstocks, which did not differ from each other. The additive vine size depressive effects of RR and UTCC resulted in vines that were less than 0.35 kg/m of canopy (< 0.24 lbs per foot), whereas the NRR vines maintained with herbicide strips produced the greatest cane pruning weights, regardless of rootstock. Put simply, the "ideal" vine, as measured by pruning weight per unit length of canopy, was most closely obtained by using *either* under-trellis cover crops OR root-restriction, but not both. Vines grown with the conventional practice of keeping an herbicide strip under the trellis were <u>larger than desired</u> with all three rootstocks, while the vines that were subjected to both root-restriction and UTCC were too severely restricted in growth – again with all three rootstocks, but particularly with riparia.

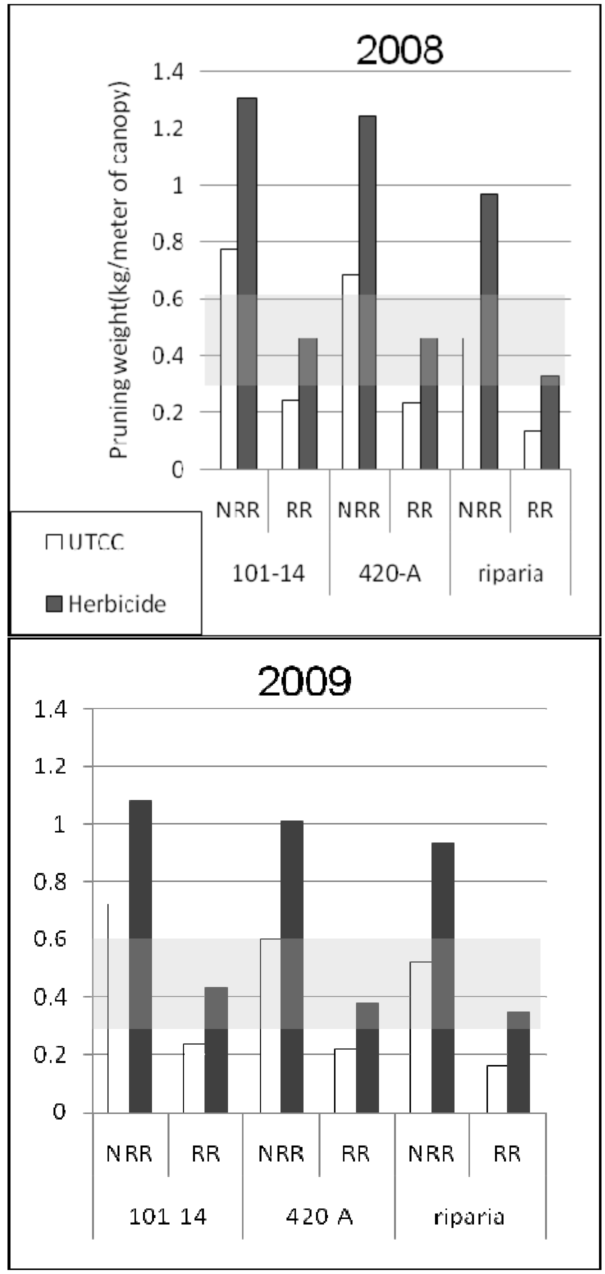

Figure 3. Cane pruning weights by treatment combination, 2008 and 2009. Shaded bands represent optimum pruning weight range for "balanced" vines.

We did, however, achieve our goal of producing a range of vine sizes (and corresponding canopy architecture, cluster exposure, and leaf area development) – from insufficient through optimal and including excessive – our long-term goal is to evaluate wines made from these different vine sizes.

Vine Physiology: Much of the data collection in this project has involved detailed, weekly or bi-weekly measures of vine physiological performance. Specialized equipment is used to measure vine water status – how hydrated or, conversely, how dehydrated the vines are. An example of these measures is the water status of vines shown in **Figure 4**. The units (megaPascals, or MPa) are a measure of the tension with which water is held within the leaf; that's why the numbers are negative. You don't need to know that, but it's helpful to understand that the more negative the number, the more dehydrated the leaf is. A value of -1.0 MPa is indicative of mild to moderate water stress; values of as little as -0.5 or -0.6 MPa are enough to slow shoot growth. The 2009 data shown in Figure 4 show the difference between root-restricted vines (RR) and those that were not restricted (NRR). Basically this confirms that a predominant reason that the RR vines grew slower (Figure 1) and less (Figure 3) was due to water stress. That's no surprise; it's what we were hoping to achieve.

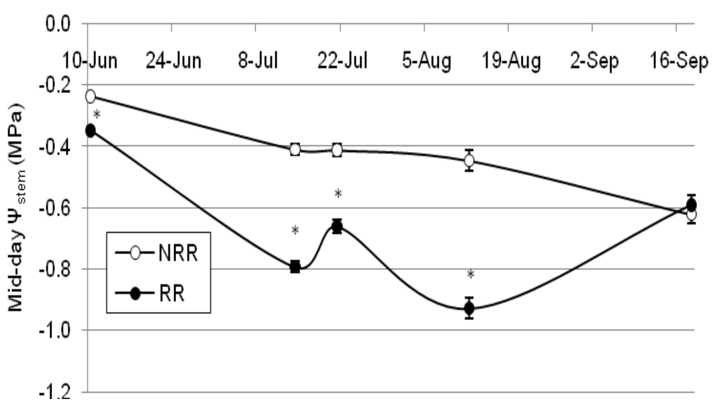

Figure 4. Mid-day ψ_{stem} of root-restricted (RR) or non-root-restricted vines during 2009. Bloom (50%) occurred 8 June while the onset of veraison (10%) occurred 27 July. Asterisks denote significant ($P \leq 0.05$) root restriction effects.

Other equipment is used to measure how well the vines' leaves are exchanging oxygen, carbon dioxide, and water vapor with the surrounding atmosphere. These data, while time-consuming to collect, tell us how effective the leaves are in fixing carbohydrates, and how much water or water vapor they are losing in the process. Ultimately, this information can help us understand how the treatments impact berry ripening dynamics. We believe that mild water stress prior to veraison could be beneficial in terms of promoting certain aspects of grape ripening, and that water stress post-veraison should be avoided. The numerous, repeated measurements that we take provide the basic data that we can use to test those beliefs.

Yield analysis: We have collected fruit composition and yield data each year since 2008. Data from the 2010 season are shown in **Table 1**. We have been slowly increasing the crop allowed on the RR vines since 2008 so as not to over-crop the small vines. Still, crop yields are lower for RR vines and for those grown with under-trellis cover crops. This is one penalty paid for these competitive factors – if you want small vines, you'll have smaller crop (per vine). Absolute yields, even with the LOW stress+RR+CC combination, were around 3.0 tons per acre equivalent in 2010, and I feel that we can increase these yields further, to about 4.0 tons per acre, or about 1.7 pounds of fruit per foot of row, in 2011.

With respect to wine quality one yield component of interest is individual berry weight, as this is likely to affect the skin:pulp ratio of the grape and subsequently affect the relative concentration of skin-derived flavor and aroma compounds, such as anthocyanins, tannins, and other polyphenols – it is generally considered that smaller berries are superior to larger berries from the standpoint of wine quality potential. In this study, we have consistently produced smaller berries on those treatments that produced smaller vine size. Root-restriction is the most effective single treatment in this respect, but RR combined with under-trellis cover crop is even more effective in reducing berry size.

Table 1. Average berry weight, crop yield per vine, and berry soluble solids concentration (Brix) at harvest, September 2010. "High" and "Low" refer to relatively high and low water stress maintained by differential irrigation

Treatment	Avg. Berry Weight	Crop yield/vine (lbs)	°Brix
NRR + Herb	1.29 a	8.5 a	25.04 bc
NRR + CC	1.25 a	7.4 b	25.38 b
LOW + RR + Herb	1.23 ab	7.3 bc	23.42 d
HIGH + RR + Herb	1.12 bc	6.5 bc	24.76 c
LOW + RR + CC	1.06 c	6.3 c	25.94 a
HIGH + RR + CC	0.90 d	4.6 d	23.6 d

*Values followed by common letters are not significantly different at $p = 0.05$. *Yield potential: There are 968 vines per acre. Thus, 8.5 lbs per vine = 4.1 tons/acre equivalent. 6.3 lbs/vine (low stress RR vines) = 3.0 tons/acre.*

Fruit Chemistry: Harvest in 2010 began soon after sampling started as harvest occurred an unexpected month earlier than anticipated. If the relatively high Brix levels were due to dehydration, which was suspected at first, then the most-stressed treatments (both HIGH and RR) would have seen the highest Brix, which was not the case. In fact, the HIGH + RR treatments had the lowest Brix levels and LOW x RR x CC had the highest level, followed by the NRM treatments and then the LOW x RR x Herb treatment (Table 1). These results illustrate the potential pitfall with expecting water stress to hasten grape ripening – more likely, the ripening process (driven by photo-synthesis) was impaired. Again, this argues for avoiding water stress in the post-veraison period. In both the 2009 and the 2010 seasons we have see increased color density (anthocyanins) and increased total phenolics in the berries associated with the RR and the CC treatments. The NRR treatments had the highest pH and both HIGH- and LOW- RR x Herb treatments had the lowest pH values (data not shown).

Winemaking: Wines were made in both 2009 and 2010 in the Food Science department at Virginia Tech. The wines are undergoing sensory evaluation and it's still premature to comment on differences in wines produced from the different treatments. That will come in time though.

General summary comments: The results to date illustrate practical measures that can be used to modify vine vegetative development. These include use of under-trellis cover crops, rootstocks (to a limited extent), and novel, root-restrictive planting bags. The root bags are still very much experimental, but they do help us achieve a wide range of vine capacities. The "cost" of this regulated vine development is an increased management requirement to monitor vine water status and nutrient status, and provide inputs of irrigation and fertilizer (particularly nitrogen) as needed to avoid overly stressing the vines.

Frequently asked questions and practical use of information:

What is the value of your findings to date? The chief benefit that we can point to is a more optimal regulation of vine canopy architecture, vine size, vine balance under vineyard conditions that would normally lead to excessive vine size. This can have benefits in terms of reduced canopy management labor and *potential* for improved wine quality and decreased disease incidence. We are encouraged with some of the fruit chemistry and potential wine quality benefits, but the effects on grape composition and wine quality attributes will take somewhat longer to sort out.

Of the treatments that you evaluated, which should I consider? Don't try to restrict vine size or vigor if you have a low vigor situation – your goal might better be to increase vine size. If you have not yet planted, you might consider the use of riparia rootstock in a high-vigor situation. The under-trellis cover cropping is being used to varying degrees in some commercial vineyards, but there are a number of factors to consider with its use. It reduces nutrient availability, particularly in the initial years, and particularly with nitrogen and phosphorus. The reduction in N has also been observed as reduced yeast-assimilible nitrogen in musts in our work. Our current research is exploring means of supplanting the vines' N needs in concert with using the under-trellis cover crops to limit water availability. Bear in mind too that permanent, under-trellis cover crops are not compatible with annual hilling and de-hilling of graft unions for winter injury protection. Our colleagues at Cornell University are exploring annual cover crops to fill a similar purpose, but which might be more compatible with winter protection measures. We are not generally recommending use of root-restriction, although we are working with a commercial producer to evaluate this technique on a larger scale. Irrigation may be necessary to offset the treatment effects on water completion, particularly during droughty periods of the summer and to avoid post-veraison stress on the vines.

If I use under-trellis cover crops, when should I establish them and how should they be managed? We waited until late-summer of the second year before establishing creeping red fescue under the trellis. This allowed the vines to establish before introducing the competition. In terms of management, we don't do much other than treating a small ring around the base of the vines with herbicides to keep this zone free of the cover crop. The seed heads grow to about 18 inches, well below the height of our cordons. Nitrogen fertilizer is applied in a band under the trellis.

Could a legume be used as an under-trellis cover crop to help meet the vines' need for nitrogen? It's an intriguing question but the preponderance of research suggests that legumes, which fix atmospheric nitrogen, provide the bulk of that N to the vines only when they are destroyed, as through cultivation. But some research has shown that a small amount of the N fixed by legumes is assimilated by the vines. Low-growing, prostrate legumes such as white clover or strawberry clover might be worth a try. White clover is a common "weed" infesting our row middles.

Funding for this work has been provided by the Virginia Wine Board, the Virginia Agricultural Council, and the Viticulture Consortium:East. In addition, the preliminary data from this project was instrumental in supporting our successful application for partnership funding from the USDA/NIFA's Specialty Crop Research Initiative.

III. Upcoming meetings

A series of vineyard meetings, arranged by Virginia Cooperative Extension Educators, have been arranged for the period from April through early August. The format of the meetings is similar to field meetings held in past years and generally include presentations by one to several grape specialists with Virginia Tech, the Extension Educators, and by the vineyard host(s). Meeting topics usually include pest updates, seasonal vineyard management reminders and recommendations, as well as discussions about observations in the host vineyard. There is no fee to attend and you're encouraged to attend.

The following meetings are scheduled for the 2011 growing season; location details of the May 11th meeting will be confirmed as soon as possible. The meetings are scheduled from 11:00 am – 2:00 pm (+ or – on adjournment) and are held rain or shine. The first hour will be a tour of the vineyard, followed by lunch, specialist updates and discussions. Everyone is asked to bring a bag lunch. If you have special topics that you wish to have discussed, please communicate with the listed Extension educator with the meeting.

April 27: De Vault Vineyards
247 Station Lane, Concord VA 24538
http://www.devaultvineyards.com
Phone (434) 993 0722
Directions: At Intersection of Hwy 29 South and Hwy 460, go east (towards Appomattox) on Hwy 460 for 10 miles. Turn right onto Hwy 24 West and travel 0.3 miles. Take second left onto State Rd 741 after 0.2 miles. Vineyard and winery will be on your right.
Contact: Michael Lachance, Nelson County Cooperative Extension (434) 263-4035

May 4: Horton Vineyard and Winery (meeting is at the winery on Rt 33)
Topics – Early Season Disease Control – Dr. Mizuho Nita, Virginia Tech Grape Pathologist. Seasonal Viticultural Management - Dr. Tony Wolf, Virginia Tech Viticulturist. Pesticide Record-keeping requirements.
Directions: Take 29 to Ruckersville, then left onto 33 East; the winery is 8 miles on the left.
Contact: Kenner Love, Rappahannock County Cooperative Extension (540) 675-3619

May 11: TBD
Contact: Michael Lachance, Nelson County Cooperative Extension (434) 263-4035

May 18: Glen Manor Vineyards
2244 Browntown Road - Front Royal, Virginia 22630 (Warren County)
http://www.glenmanorvineyards.com/
Topics: Early season canopy management; vineyard floor management and vine nutrition; pest management updates
Directions: Take Rt 340 south out of Front Royal. Turn left at 2nd traffic light, just past the entrance to Shenandoah National Park, onto Rt 649, Browntown Road. The winery entrance is 5 beautiful mountain miles ahead on the left, 2244 Browntown Road.
Contact: Kenner Love, Rappahannock County Cooperative Extension (540) 675-3619

June 8: Silver Creek Orchards and Vineyards
Business address: 5529 Crabtree Falls Hwy. Tyro, VA 22976
http://www.flippin-seaman.com Phone (434) 277 5824
Directions: From Rt. 151 just south of Roseland, Va. in Nelson County, turn west on Rt. 56. Travel approximately 5 miles. After crossing bridge over Tye River, turn left on Rt. 680 and go approximately 1 mile. Vineyards will be on your right.
Contact: Michael Lachance, Nelson County Cooperative Extension (434) 263-4035

June 15: DuCard Vineyards
40 Gibson Hollow Ln., Etlan (Madison Co.) VA 22719
http://www.ducardvineyards.com/
Directions: Take Rt 29 to Madison, VA, then Rt 231 north and proceed to Etlan. Turn left on Rt 643. Proceed 2.5 miles to a right on Rt. 719 (Gibson Hollow Ln.). Entrance is on the right
Contact: Kenner Love, Rappahannock County Cooperative Extension (540) 675-3619

July 6: Barren Ridge Vineyards
984 Barrenridge Road, Fishersville, VA 22939-3026
http://barrenridgevineyards.com
Phone (540) 248 3300
Directions: Take I-64 West. After crossing Afton Gap at crest of Blue Ridge Mtns. Continue on for 8 miles. Take Exit 91 and turn right onto Va 285/ State Rt. 603. Travel 2 miles. Turn left onto Hwy 250 West and travel 1 mile. Turn right onto Barren Ridge Road and travel 2.4 miles. Vineyard and winery will be on your left.
Contact: Kenner Love, Rappahannock County Cooperative Extension (540) 675-3619

August 3: AHS Jr AREC (Virginia Tech)
595 Laurel Grove Rd., Winchester VA 22602
http://www.arec.vaes.vt.edu/alson-h-smith/index.html
Topics will include review of research projects underway at AREC, including

disease and grape root borer management studies, Cabernet Sauvignon vine size/vigor management study, and several pathology studies

Directions: (Frederick County). From Interstate 81, take the Stephens City exit on the south side of Winchester. Go west into Stephens City (200 yards off of I-81) and proceed straight through traffic light onto Rt. 631. Continue west on Rt. 631 approximately 3.5 miles. Turn right (north) onto Rt. 628 at the "T" intersection. Go 1.5 miles north on Rt. 628 and turn left (west) onto Rt. 629. Go 0.8 miles. The center is on the left side of the road.

Contact: Tony Wolf, Virginia Tech (vitis@vt.edu) or (540) 869-2560 x18

Also: Mark your calendar for two separate events of the Virginia Vineyards Association:

June 11: VVA Summer Social
Location: Cave Ridge Vineyard in Mt. Jackson, Virginia

August 10: VVA Summer Technical Meeting
Location: Rappahannock Cellars in Huntly, Virginia

More information will be provided on these meetings at the VVA website: http://www.virginiavineyardsassociation.com/events.php

Summer employment opportunities:

Family operated winery in Loudoun County VA looking for a summer intern to work in our vineyard from beginning of May to end of August 2011. Eligible candidate would be required to be outside working with the vines for a minimum of 40 hours per week. No experience required, but a passion for learning and hard work are essential. Possibility of full-time employment at the completion of the internship. Contact Kerem Baki at kerem@hillsboroughwine.com

Pinehaven Vineyard and Farm of Charlotte County VA is looking for a motivated worker or workers to help us this summer on our farm. Must be trustworthy, hardworking and have an interest in viticulture. Housing is available if needed. Contact Kevin Trent if interested. 434-660-4260 (cell) or 434-376-3017 (home).