Final Report of the Oklahoma Vineyard Quality Project

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The purposes of this project are:

1. Identify quality improvements needed in Oklahoma Vineyards and pathways to implement them through educational programs.

2. Identify geographically the grape cultivars grown throughout Oklahoma’s eco-regions.

3. Grow high quality grapes which can be made into high quality juices and/or wines.

4. Provide additional subject matter for incorporation into educational and extension programming.

The primary goal of this project is to gather unbiased, accurate information on Oklahoma’s commercial vineyards in order to identify areas of positive improvement including: educational program content for current and future growers, variety selection by eco-region, and industry growth. Two primary data sheets were used to accomplish this (Figures 6 and 7).

Vineyard quality has many interacting factors that go into whether or not quality fruit will be produced. Quality in fruit can also vary by the end product as well – fruit suitable for fresh consumption may not be suitable for wine and vice versa. Therefore, in this project, measures were put in place to attempt to estimate vineyard quality in different parts of Oklahoma. Since most vineyards in the state are geared toward fruit for wine production, vineyard quality for fresh fruit was not the focus of this project.

The four primary elements that promote high fruit quality in the vineyard are selecting the proper Genotype (cultivar), having a suitable Environment for growing grapes (climate), dedicated and observant Management (viticulture), and choosing a proper Site for the crop (site selection). These four GEMS can be used in combination to enhance fruit quality throughout Oklahoma. Embedded within this is the overall question of sustainability.

Sustainability is a term that encompasses more than one factor. It has three primary constituents as it relates to viticulture. Ohmart (2011) defines them this way: viticultural growing practices that are environmentally sound, socially equitable practices that fulfill the needs of society as a whole, and maintenance of economic feasibility. Much of vineyard quality is tied to sustainability, as all three components are necessary, and often interrelated, for success in the vineyard and in the winery.

**GENOTYPE**

*Cultivar selection*

Grapevine genetics play an important role in site acclimation and adaptation. Species have different abilities to withstand climatic conditions and these are genetically determined due to evolutionary factors (i.e. where is the origin of the species?). Even though these factors are paramount in determining what to grow, there are other determinants
such as demand for certain cultivars by wineries, a cultivar that can produce quality fruit, produce consistent and profitable yields, and tolerate the environment in which it is to be grown. A final decision on cultivar selection should stem from extensive knowledge of the climate, prevalent diseases, genetics of the cultivar, and market for the fruit just to name a few. It is important to realize that all grapes and grape cultivars do not grow well in Oklahoma. To break this down further, below are the components of cultivar selection:

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AC = [(G \times E) + ((SS \times M) + EL)] \times L
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where:

\(AC\) = Appropriate Cultivar

\(G\) = Genetics (the cultivar must have the necessary genetic elements to succeed)

\(E\) = Environment (the environment with interact with the genetic components of the cultivar to impact the outcome, i.e. yields, quality, and survival)

\(SS\) = Site Selection (vines placed on the wrong site, including considerations like water availability and quality, soil quality, nutrient availability, air and water drainage, accessibility, etc. will dictate vine outcomes)

\(M\) = Management (vineyard management can help offset some factors such as less than optimal site selection and improve vine health and fruit quality)

\(LE\) = Learning and Education (education should be a never ending task for a grape grower, but a good knowledge of the basics should be garnered before putting a vine in the ground)

\(L\) = Luck (all of the best laid plans can be disrupted with bad luck — drought, freezes, broken pumps, plugged emitters, birds, plague of locusts, etc., because once your luck turns to zero, so does your AC)

Vinifera grapes are prized because they can make very high quality wine. In general, the vines prefer hot and dry conditions. They also possess recognizable names. However, they are not without detractions. The vines lack cold hardiness, they can be overly vigorous, have little disease resistance, and need to be intensively managed. There are certain vinifera grape cultivars that are not recommend based on past research in Oklahoma — Cabernet franc, Chardonnay, Pinot Gris, Sauvignon Blanc, Shiraz (Syrah), Viognier, and Zinfandel. Others, such as Cabernet Sauvignon, Merlot, Petit Verdot, Riesling, and Ruby Cabernet are still under consideration. In fact, Stafne (2010) stated that, “The consistent production and quality of these grapes (i.e. vinifera) are not yet determined in Oklahoma.” And that, “...long-term sustainability of V. vinifera in Oklahoma is still in question.” Most growers have
had vinifera for 10 or fewer years. That is a proverbial drop in the bucket. If vinifera vines can be grown for 10 years without crop loss (or minimal crop loss) then they are a sustainable (enough) crop. But necessary crop levels for a winery with a vineyard may be different from necessary cropping levels for only a vineyard.

Interspecific hybrid grapevines are another alternative. They exhibit good cold hardiness, better disease resistance, and better productivity. Yet, there is a perceived lack of quality regarding the fruit. Of course, hybrid cultivars do vary widely in fruit quality and other attributes, as impacted by environment and management, but so do vinifera cultivars. The reason hybrid wines are not generally accepted is not because of subpar quality (although that is a case with some, but we have all had subpar vinifera wines as well), but rather ignorance of what they are — or rather the lack of name recognition. Many hybrid grapes are better suited for blending and not varietal wines. Some, like Vignoles, stand up well as a varietal wine. The propensity to produce “varietal” wines has held back grape production in Oklahoma. If blending would be further embraced more and better grapes could be produced with less impact on the environment.

Proper cultivar selection is crucial in Oklahoma. As has been observed over the last 15 years or so, many cultivars have failed to deliver consistent production and quality. Since Oklahoma has an unstable climate, growers and winemakers may wish to look to interspecific hybrids that provide some measure of production from year-to-year. These hybrids can provide a hedge against disasters that would severely reduce or eliminate vinifera production. However, to do this, wineries must accept hybrids as part of the winemaking landscape in Oklahoma. Vineyard survival depends on this acceptance.

ENVIRONMENT

Environmentally Sound Viticulture

Environmentally sound viticulture practices have several components that lead to sustainable practices, including proper site selection, choice of the best cultivar for the site and market, close management of soils, water, pests, and plant, and diligent recordkeeping. All of these contribute to successful vineyard management which in turn results in long-term viability.

Cultivar and Environment

Cold Damage

Oklahoma winters are not kind weather-wise — not to grapevines or humans. In the vineyard most of the severe damage occurs to the vinifera grapes. The hybrids tend to perform better, but some with a high amount of vinifera have also sustained damage. No cultivar under observation in Oklahoma has been entirely spared of some kind of injury, but the cold hardy hybrid vines do better. Grapevines can experience three types of injury: bud injury, trunk
injury, and vine death. Bud injury can usually be corrected with compensatory pruning. Trunk injury is more severe. There are three levels of trunk damage (Amberg, 1994). The first is not severe with only a browning of the phloem in early spring and full recovery. The second level is more severe and is a permanent injury, with death of phloem tissue that leads to some trunk die-back and potential entry for crown gall. The most severe injury is cambium death followed by vine collapse to the ground level. The vine will need to be regrown from the root system (if ungrafted). The impact of vine death is obvious as the vine needs to be replaced altogether. Sometimes trunk damage and vine death is not immediately noticeable when pruning is done in the late winter or early spring. The vine may appear normal at pruning, but fail once normal growth is initiated. This could be due to root injury from severe cold or, more likely, from cambial damage. The essence of the problem is that the vine cannot pump water and nutrients from the storage system (roots) to the growing portion of the vine (cordons, trunk, etc.). The inhibition of water and nutrient movement up the trunk due to damaged cambial tissues result in vines being unable to sustain cordon and trunk well-being.

*High Temperature Effects*

High temperatures affect different grape cultivars differently. It depends on their species background and genetic origin. Generally we think of *Vitis vinifera* grapes as being heat tolerant, but there is variation within the species. Temperatures up to 95 °F have been shown to be acceptable for several cultivars. But what about 110 °F? Few studies have been done to really understand the effects of high temperatures, especially high nighttime temperatures on grapes. Some of the effects (Williams et al., 1994) that occur due to excessive heat during the time of fruit growth and ripening include:

- Reduced number of berries per cluster due to high root temperatures (seen in Cabernet Sauvignon).

- Earlier fruit maturation (short term conditions).

- Delayed fruit maturation and a reduction in fruit quality (excessive and long term conditions).

- Decline in total TA and increased pH through loss of malic acid.

- Increased mono and di-basic salts of tartaric acid.

- Reduced color development (anthocyanins) in red berries.

- Reduction in gas exchange capacity (although this is influenced by vapor pressure deficit).

- Potential elimination or reduction of virus with long term exposure (>30 days).

- Reduction of leaf starch content.

- Reallocation of photosynthates, going to shoot tips at expense of roots, trunks, and clusters.
- Increase in sucrose concentrations in all vine organs.

- Decreased glucose and fructose concentrations in fruit (observed in Chardonnay).

One aspect not discussed in detail was the interaction of water availability and heat stress. On a day with 113 °F at Perkins, OK the canopy temperature did not exceed the ambient air temperature in irrigated vines. In essence, the vines were able to keep themselves cooler by transpiring because they were being irrigated. Even so, it doesn’t mean some of the effects listed above were not occurring as well. Vines should be irrigated whenever conditions dictate a need. Not only can fruit quality be negatively impacted because the vine cannot properly allocate resources (remember during this time of the year fruit development is driven by a healthy canopy and photosynthates are translocated through phloem tissue) due to loss of leaves or heat/drought damaged leaves, but overall vine health can be impacted as well. Root system size could be reduced because of a lack of vine and soil resources to draw upon. An earlier than normal loss of leaf area can result in decreased winter hardiness as well. Vine stress is a real negative going into the fall and winter, especially if they were damaged from previous events.

**MANAGEMENT**

*Proper Management of soils, water, pests, and plant*

Proper management of nutrients in the soil will improve vineyard quality by keeping plants healthy and reducing plant stress. Oklahoma soils are typically low in organic matter, so addition of nutrients, especially nitrogen, is a critical annual practice. Most vineyards require between 50 and 100 pounds of actual nitrogen per acre per year. Other nutrients may also be limited, so annual testing of plant tissues (petiole or leaf) is also important. Annual testing will also eliminate excess applications that are economically and environmentally wasteful. It will also help reduce excess vigor that leads to poor vine balance, reduced cold hardiness, and increased fungal disease susceptibility.

Water is a limited resource that demands close attention. Although Oklahoma receives enough rainfall in a year to sustain grapevines, the timing of the rainfall is the problem. Supplemental irrigation is important for vineyards to reduce vine stress during the summer months and improve winter hardiness. Close attention should be paid to the amount of water added and the amount vines use. This amount will be largest during fruit production and ripening.

Canopy management is the process of modifying canopy density to improve vine microclimate. This includes shoot removal, crop load thinning, and leaf pulling. These processes can significantly impact fruit composition of desired constituents like sugar, acid levels, tannins, and aromatic compounds. Vine balance is a concept used primarily in winegrape production. It has been studied extensively in West Coast viticulture, but largely unstudied in eastern U.S. viticulture. Overall vine health is greatly impacted by prudent balancing of the vegetative and reproductive vine growth. Crop load management is important also for fruit quality, so a vineyard manager must know the amount of
crop to expect (using established crop load estimation methods) and adjust accordingly as needed. A given vine’s capacity to produce fruit is largely dependent on the amount of leaf area and photosynthetic activity.

Inadequate or improper implementation of training (trellis) systems was a common problem across Oklahoma vineyards. Some cultivars were not matched with a training system that matches its growth habit; whereas other vineyards had no discernible training system at all. Training systems like high cordon and Geneva double curtain were devised for cultivars that have a downward growth habit, such as American species (e.g. Concord) and some interspecific hybrids. The VSP system is primarily for vinifera and hybrids that grow upward. Both systems have plusses and minuses, high cordon systems may be less expensive to implement and maintain but create more shading thus perhaps lower sugar levels. VSP systems are more expensive but fit vinifera growth habits better. It is aesthetically pleasing and can lead to high sunlight interception on developing fruit and buds. Other systems also exist that may have utility in Oklahoma, but more research needs to be done.

Pruning is one of the most important jobs for a viticulturist. Proper pruning can improve fruit quality and stabilize production over time. By consistently limiting the number of shoots and leaves via dormant pruning, one is also working to produce the maximum crop without delaying maturity year after year. Failure to prune can lead to improper ripening, reduced cane maturity, reduced productivity of buds the following season, and a decrease in root mass. Therefore, pruning needs to regulate the number and positions of shoots on a vine which in turn regulates cluster number and size. By limiting the total number of buds, growth is concentrated into the remaining shoots and clusters. However, buds need to be selected to keep or remove. Good buds are those on healthy wood that has been exposed to sunlight the prior season.

One issue in Oklahoma is poor pruning techniques. This was very evident during 2014 following a spring freeze event. When a vine has too few buds, vines tend to produce excessive leaf and stem growth and too few clusters. This leads to poor fruit and wood quality and increased fungal disease susceptibility. If too many buds are left, then there tends to be too many clusters that the existing leaves cannot fully ripen. Fruit ripening and cane hardening is impaired and vine stress is increased. Therefore, balanced pruning is a key component of viticulture. Formulas exist for many cultivars. This process is not regularly done in Oklahoma, but should be to help with vine balance.

Selecting the best wood and buds to produce fruit needs to be a top priority. Data taken in 2014 (Figure 1) shows that among all cultivars observed, few spurs were within the desired range of 0.3125 to 0.5 inches diameter. This indicates potential problems such as poor vigor (possibly due to own-rooted vines), poor nutrition, lack of adequate water, poor weed management, too much crop load in previous year, or leaving too many shoot/canes the previous years. Less of a problem was spur internode length (Figure 2). Although within the broad parameters of 1 to 4 inches, most cultivars in Oklahoma fell in the lower part of that range. It would be preferable to see internodes longer (2+ inches) rather than shorter. The number of spurs per linear foot by cultivar was too many for most vineyards in Oklahoma.
The desired range is ~2.5 spurs per linear foot of canopy; however, most observed were greater than 3 and most over 4.

Another problematic pruning issue is compensation after winter injury. If the damage to the primary buds is 20% or less, then don’t do anything different than would normally be done. Most grapevines will produce some crop on secondary buds, so those will act as compensation for the lost 20%. If the primary bud damage is in the 20 to 80% range, then leave more buds in proportion to the amount that was lost due to the cold damage. For example, if one normally leaves 40 buds on a vine and the damage is 70%, the new amount to leave is 68 buds (40 x .7 = 28, 28 + 40 = 68). If the primary bud damage is greater than 80% then only minimal pruning is necessary. Clean up material that is touching the ground, shorten canes so that you can work under the vines, top them (in case of VSP), but leave lots of buds. Don’t remove too many — if there is little or no crop, new growth may be extremely vigorous, leading to unwanted bull canes. Leaving more competing growth will slow down that vigor some. If buds were really damaged with multiple buds dead within the compound bud then there may be wood damage as well to deal with. This may mean the need to retrain cordons and trunks. Choose new canes with good growth, but not excessive vigor, as replacements. Wood damage is not always easy to see; it can look like brown or black streaked or water-soaked. Sometimes vines may break bud normally then crash when heat and other various stresses get to it. The best advice is to know your vines and do your best with good, sound management strategies.

Winter damage has undoubtedly led to damaged vines. Figure 4 shows that the damage is more severe in some regions of the state. Empty fruiting wire is not acceptable for a commercial vineyard. Empty wire means loss of economic potential. No vineyards in Lincoln County were found to have full fruiting wires. Three others (Northeast, Northwest, and Southwest) had between 60 and 80% of wires that had some empty spots. Central Oklahoma vineyards performed the best. Overall throughout the state, 60% of cultivars examined had greater than 5% missing or dead vines (Figure 5).

One of the biggest jobs for a vineyard manager is pest control. In Oklahoma, fungi, insects, weeds, animals, and abiotic issues all can wreak havoc in a vineyard, especially young vineyards. Poor control of fungal diseases like black rot, bunch rots, downy mildew, and anthracnose harm the fruit and the vine, as well as the bottom line. These diseases should be prevented from occurring and so sprays should start early in the season, just at or after budbreak and continue on throughout the growing season. Rotation of chemical classes should be done to reduce the change of resistance development. Insects, like Grape Berry Moth (widely observed in 2014) and stink bugs, should be done on an as needed basis. Non-targeted spraying is a non-sustainable practice. Weed competition also limits vine productivity. Mature vines can withstand some competition, but young vines (<5 years old) can be negatively impacted. Pesticides are important tools for grape growers and should be used prudently. Records should be kept.

Recordkeeping
Ohmart (2010) detailed the importance of keeping records. Obvious tasks is keeping quantitative records of pest levels on a regular and consistent basis and comparing them to important crop parameters such as yield, quality, rate of ripening, etc. This is about the only way to improve pest management over the long run. Our ability to remember things in enough detail to make the right management decisions is not as good as we think. It’s also important to record many other practices such as canopy management, irrigation management, fuel consumption, petiole samples and so forth. The more detailed and quantitative the recordkeeping, the more useful it is. Until records are kept, it is not possible to determine their value, but if they are perceived as not valuable, then no records will be kept. Keeping records of what you do in the vineyard is extremely important. In the long run it will save you time, money, and provide consistency in management practices.

Continuing Education

As a way of relaying the importance of continued education, I will tell this true story. A couple years ago, I went on a site visit to a fruit tree orchard. The trees looked okay for the most part, some with evident drought and heat stress, but the fruit was either non-existent or in poor shape. Once I started asking the grower questions about his spray regiment that is where the real problems arose. First off, he didn’t know why he was spraying what he was spraying. He didn’t know that Agrimycin was not a fungicide, and had no idea why he was spraying it. He also sprayed an insecticide every time he sprayed a fungicide, even though he didn’t know why. He did not scout for insects or diseases. He sprayed on a 14 to 21 day schedule regardless of the weather. He did not recognize symptoms of fungal diseases or insect damage. He did not control weeds sufficiently, he did not water sufficiently, and he did not prune sufficiently. All of this knowledge gap and his orchard was 7 years old. For 7 years, he did not do enough in terms of self-education to create a knowledge base for proper management of his orchard. When I arrived he said to me, “I want you to teach me what I need to know.” Well, there is only so much I can teach and only so much he can retain in 2 hours. As I used to tell attendees of my short courses, we can only teach so much information. The burden of the knowledge gap remains with the grower. Much of this is satisfied through experience and interaction with other growers. Some of it is continued interest in the subject matter; reading, reading, and more reading about the topic to keep current. This is a very important step to improve as a vineyard manager. It was very obvious throughout this project that vineyards where the manager had received viticulture education were far better than those without.

Economic Feasibility

Economic feasibility includes profitability in the vineyard as well as the winery. Within it, comes the need for long-term planning, including disaster management and stringent recordkeeping practices. Without economic stability the endeavor of growing grapes is ultimately futile in a commercial sense.
Most wineries in the state are still hung up on producing varietals — and “name” varietal wines (i.e. vinifera). *Vitis vinifera* grapes can produce the highest quality fruit. There is no disputing that, but the caveat is that they produce the highest quality fruit in the proper conditions. They are a Mediterranean fruit crop that likes hot, dry days and moderate night temperatures. Hybrid grapes like Chardonel and Traminette can produce as high or higher quality fruit than the vinifera grapes under certain conditions. Until the industry embraces the idea that American, hybrid and vinifera grapes can co-exist in Oklahoma (and in the same winery), progress will not be made in the industry. **Vinifera is the major leagues in terms of viticulture.** Hobbyist vineyard managers cannot devote the time and energy to get the highest quality out of those grapes even in the best growing conditions. Oklahoma does not have the best growing conditions.

These are just a few reasons why Oklahoma-grown grapes are not being bought by wineries. Wine is a cultural, artistic, and agricultural product. By bringing in wine or juice from out of state and bottling it significantly decreases the cultural, artistic and agricultural value to Oklahoma. In fact, wine produced this way is really just about making money and not contributing to the Oklahoma grape and wine industry. The need to bring in juice/wine is understandable to a point, but hopefully it would be temporary and partnerships made with growers would enhance both vineyards and wineries.

**Labor**

One of the most important bottlenecks for the Oklahoma grape industry is labor. The availability and cost of a decent labor force to manage and harvest fruit crops is substantial and a “critical mass” of laborers does not currently exist. Many growers are not making enough profit to employ skilled laborers (even if they can be found). This problem will not get better over time; in fact it will only get worse. So, the issue becomes this: How to rise above and expand?

One way is through mechanized management, especially harvesting, but possibly pruning as well. Mechanized harvesting is the standard in California and is becoming the standard in many other winegrape growing regions. Of course the main reason is labor. The cost of good harvest labor is tremendous. A mechanical harvester can do the work in a fraction of the time, although the end result may not be a perfect as if a human were picking the fruit. If you are considering planting a vineyard, always prepare it as though it will be mechanically harvested one day. Some training systems are not compatible with mechanized harvesters.

Most vineyards in Oklahoma are small scale and do not warrant mechanical harvesting by itself; however, a cooperative or custom harvesting (such as is done in the pecan industry) would move things along. Mechanical harvesters are not cheap, but it would be a sound investment for someone who would like to do custom harvesting. There are many vineyards in the state that cannot get enough labor for harvest. The real limitation is that vineyards are often not clustered enough to make the travel of the harvester worthwhile. Another question is this: Who pays for the harvesting? Is it the vineyard owner? The winery? Is it a cost share? Margins for vineyards are
already tight so paying off the top for mechanical harvest may not be worth it for some, but counting on family and friends to help in the vineyard is not sustainable.

Vineyard quality

It is absurd to think that all the needs for 50+ wineries can be met by the grapes and fruit produced in Oklahoma. Not only are there not enough vineyards to supply the grapes, the climatic variability we experience is guaranteed to disrupt the supply to some extent every year. Therefore, supplies from out-of-state are a must at this stage. The industry is too small to depend on Oklahoma-only fruit. Now, that being said, there must be an incentive for grape growers to continue to expand and eventually be able to supply all the need. It all seems so easy — wine makers need grapes, grape growers grow grapes, one supplied the other, problem solved. Yet, this is where the paradox arises:

Wine makers don’t want poor quality grapes. Not enough grape growers understand how to produce high quality grapes.

The solution here seems simple, but is rather complex in reality. Education on grape growing is a non-stop endeavor. One never knows everything about grape growing and a new surprise is just around the corner. Quality can go from good to unacceptable in a very short window of time. Many of the growers in Oklahoma are not “professionals” in the field. They do this as a hobby or to gain some extra cash (or a tax break) on the side. They may not live near the vineyard or even visit it every day. Constant interaction with the vines is needed to keep on top of insect and disease outbreaks, as well as the need to drop leaves, shoots, and clusters in a timely fashion. How does a wine maker combat this problem? Be involved. Be very involved in the day-to-day operations of the vineyard. Go out there frequently to observe and feel the plants. Taste the fruit. Take notes. Look closely at the vineyard records (and make sure the vineyard owner keeps good records). Putting the entire burden on the grape grower is not the way to get quality. What does a grape grower want most of all? Grapes and lots of them. But a winemaker needs a certain quality of grape and that may mean diminishing the crop load. The communication must be there to convey what is needed and why. And the winemaker must also keep in mind that every cluster that hits the vineyard floor is lost revenue for the grape growers, so keep that in mind when paying the tonnage fee at the end.

Wine makers want certain cultivars. Grape growers may not be able to produce those cultivars consistently (or of high enough quality).

Most wineries want vinifera grapes. Vinifera grapes are recognized as making the best wines. But, they are not the vines that grow best in many places in Oklahoma. The risk that growers undertake by growing vinifera is substantial, much more so than hybrid or American grapes. The cost to produce them is more and the reward at the end of the season in terms of price is more (in most cases). Is this a sustainable model though? We should not throw out all vinifera, but we need to consider that some hybrid varieties provide benefits. The idea that no one will buy hybrid wine just isn’t a compelling case. Other states have vibrant wine industries and produce largely (or exclusively)
hybrid wine. There are vinifera grapes that are great in California or Oregon or Bordeaux that are terrible in many places in Oklahoma. Often a particular cultivar is hailed as the “one” for Oklahoma, among them have been Cabernet franc, Merlot, Riesling, etc. So far, Riesling is the most consistent. Vinifera grapes are much more difficult to grow and thus we see the relation to the problem of grape grower education and experience leading to quality.

Wine makers need a consistent supply. Grape growers are at the mercy of the environment for their supply (at least to some extent — enough to make it a considerable issue).

A consistent supply is something a winemaker counts on — the bottles must be filled to be sold. The grape grower also counts on this. No grapes equals no money. We see that the winemaker and grape grower are intrinsically linked by a common product. Yet the climate we live in has a substantial role to play in the delivery of that product. Our continental climate is not well-suited for consistent grape production: extreme cold in the winter, extreme heat in the summer (day and night), hail, poor soils, high humidity, drought, floods, rain during pollination, rain during harvest, spring frosts/freezes, early fall freezes, on and on and on. The challenges are great. Some of these can be mitigated through proper management (choosing the best site, for example). One way is related to the second issue above — cultivar selection. Hybrid and American grapes have tolerances to some of the climate issues we deal with. For example, some cultivars have tomentose leaves thus helping to protect from insect predators. Others have thicker skins and heavy blooms that resist fungal infections on the fruit. Some are substantially more cold-hardy. The climate largely dictates what should and should not be grown. One cannot overcome Mother Nature by desire or will. The Oklahoma grape industry must be continually re-evaluated to move forward. There is room for vinifera as well as hybrids and American grapes and the idea that using only vinifera grapes for wine is one that will lead to never having enough grapes in Oklahoma. What is the incentive for growers to take on the greatest risk? A winemaker can always go out-of-state for product, while the grower goes out-of-business. We need to find a middle ground and bridge the considerable gap that exists between winemakers and grape growers in this state. Prices paid to grape growers must be at levels that are indicative of the grapes true value and quality. Table 1 shows prices paid for particular grapes in other states. Oklahoma vinifera is fetching $1000-$1500 per ton, whereas hybrids are going for far less ($400-$700). Prices need to be in line with other states. Grape growers should shoot for 3 to 4 tons of grapes per acre for vinifera grapes and 5 to 6 tons for many hybrids. In some cases the yields may be higher, but lesser yields will limit profitability. Both winemakers and grape growers stand to benefit from a strong relationship of understanding, compromise, and mutual respect.

SITE

Soils
Proper site selection begins with intimate knowledge of the place where the vines will be planted. First, and foremost, a soil test should be done to ascertain the soil health of the proposed site. A soil test analysis will allow for a modification of soil pH and other lacking nutrients prior to planting. Low spots should be avoided, as cold air sinks and will settle into these areas during critical growing periods. Water also settles in low spots. Soils with heavy soils that do not drain well will restrict root growth and promote root rotting fungi. Maximization of air flow and sunlight should be done to create the best environment for growing grapes. Air flow reduces fungal disease pressure and improves pollination, whereas sunlight improves bud fruitfulness and overall fruit quality and vine health. The most important factor in site selection is to realize that all sites are not good for growing grapes. Sites with high Boron and salinity are detrimental to vine growth and should be avoided. Weber et al. (2005) found that boron was resistant to standard brine remediation techniques and would persist in brine-impacted soils. Goldberg et al. (2004) stated that arid regions have greater chance for boron toxicity to occur because of naturally occurring high boron levels in the soil as well as boron in irrigation water. However, soil minerals can reduce the phytotoxic effects of boron in certain situations (especially higher pH soils). Therefore, a vineyard should be planted on a site specially selected for growing grapes, not just where land is available.

Some of the reported soil problems based on 2014 soil tests were that many soils were lacking in phosphorous and nitrogen. Even though grapes can tolerate a wide range in soil pH, some vineyard soils were too low (5.4) or too high (8.2). Having soil pH outside of the generally accepted range for grapes (~6.0 to 7.5) can limit nutrient availability or create situations where nutrients are too available, leading to toxicity problems.

Climate conditions

What do all of these cities have in common? Tehran, Nashville, Raleigh, Tokyo, Santa Fe, and Oklahoma City

Those cities are all between latitude 35 and 36. The reason I bring this up is because I can’t count the number of times that folks have said to me, “we are in the same latitude as X, so we should be able to grow grapes”. Yes, we should be able to grow grapes, but we need to be realistic about what we can grow. There is much more to site selection than latitude. Elevation and water play big roles as well.

One measure of site suitability is the Continentality Index. Stafne (2007) wrote that continentality is a measure of range between high and low temperatures (Gladstones, 1992) and in its traditional and intended use this means the range of temperature between winter and summer, which is usually defined as the difference between the hottest and coldest months of the year. According to a paper by Smart and Dry (1980), a CI greater than 17.5 is very continental (variable) with levels going down to less than 10 which is a maritime climate (stable). In comparing Fresno, CA with Stillwater, OK the continentality was disparate for 2011. The CI for Fresno was 18.3 and the CI for Stillwater was 27.2. Both were high. But taking a closer look at the extreme temperatures in those months is where the differences appear. In August 2011 the max temperature for Fresno was 104 °F and 113 °F for Stillwater; however, the big
difference came in February when the min temperature for Fresno was 30 °F, whereas the minimum temperature for Perkins was -18 °F. Therein lies one of the biggest challenges for viticulture in Oklahoma — extreme temperatures. In this case the CI doesn’t tell the whole story. Both locations have very continental climates, but the extreme climates are very different.

With that being said, is all lost and we shouldn’t bother to grow wine grapes in Oklahoma? Of course not, but better solutions in terms of cultivar selection need to be found. Jones (2010) stated, “...there are defined winegrape growing areas in the United States (Texas, Oklahoma, and the Mississippi delta region), Brazil (São Francisco Valley), and South Africa (Lower Orange River in the Northern Cape) that are warmer than 22°C during their respective growing seasons. However, these regions have different climate risks, have developed viticultural practices to deal with the warmer climates (e.g., two crops per year, irrigation, etc.), or produce table grapes or raisins, and do not necessarily represent the average wine region.”

Oklahoma is not the average wine region, so the expectation to grow the “average” range of cultivars does not fit with reality. One suitable option is to incorporate adapted germplasm into the vineyard — i.e. hybrid grapes. A big problem is vine stress and V. vinifera grapes are not well adapted to the conditions that are prevalent in Oklahoma. There are so many environmentally related stress factors that can weaken vines. Keeping vines from being stressed is extremely important.

**RECOMMENDATIONS**

Overall there is a great deal to be concerned about regarding viticulture in Oklahoma (See Figures 1 through 5). The primary concern is the long-term sustainability of vineyards throughout the state. Some of the more striking examples in 2014 are the lack of attentive management, poor pruning practices, lack of adequate pest control, poorly balanced vines and overall poor site selection. Many of these can be improved over time. Under current conditions, very few vineyards are well-run and are profitable. Below are recommendations that can lead to better vineyard quality.

Recommendations for GENTOPYE (cultivar) selection:

- Limit vinifera production north of I-40, except on very good sites/soils and choose cold hardy cultivars. Use a rootstock.
- South of I-40 only plant vinifera on very good sites/soils. This region has more options in terms of cultivars to choose from, but quality and quantity of fruit is still a concern.
- Use rootstocks on vinifera and some high-percentage vinifera hybrids
- Look to incorporate high quality hybrids as a hedge against disastrous years
• Wineries must further integrate hybrids into their plans if vineyards are to survive. Prices paid for the fruit must be competitive and reflect the value and quality of the fruit.

• Three to four tons/per acre should be the minimum for production of vinifera. Hybrids should range from 4-8 tons per acre.

Recommendations for **MANAGEMENT** to improve fruit quality:

• Soils in Oklahoma may limit productivity due to low organic matter, high Boron, heavy clay textures, salinity, and other factors. Amend prior to planting and monitor thereafter to improve soil quality.

• Water is a critical element in the vineyard. Increase irrigation to reduce stress during the summer and improve cold hardiness.

• Strive for a well-balanced canopy. Canopy management not only helps to produce higher quality fruit in-year, but also in the future. Balancing vegetative growth and crop load is important for overall vine health.

• Pest control is critical, especially control of fungal diseases, grape berry moth, and weeds in young vineyards. These pests rob vines of critical nutrients, water, sunlight, and other elements, thus weakening the vine.

• Determine if mechanized harvest and pruning is something that can be done in the future. A well-trained and competent labor force is lacking now and will continue into the future.

• Keep detailed records and adjust management strategies from year-to-year as necessary.

Recommendations for **SITE** selection to improve fruit quality:

• Perform a soil test prior to planting and then every 2-3 years after planting.

• Modify and amend the soil if needed, especially pH and macronutrients

• Avoid planting in low spots

• Maximize air flow and sunlight as much as possible

• Recognize that all sites are not good locations for grape production

Recommendations for future **EDUCATION** programming:
• Encourage growers to incorporate the Oklahoma Vineyard Workbook into practice. Workshops that explain the book and allocate time for completing the ratings are necessary for better participation

• More educational programs on plant and soil nutrition, irrigation and water allocation, and pest management (including disease, insects, weeds, and animal) are needed

• Refreshers on proper pruning practices, including balanced pruning methods

• Specific Workshops on pest management, pruning, plant and soil nutrition, canopy management (including crop load management, shoot and leaf thinning, and crop load estimation), and irrigation are needed to get current growers up-to-speed on the latest strategies for improving overall vineyard and fruit quality.
  
  o Pest management – During the course of this project the evaluators saw too much disease, insect damage, and poor weed control. Some vineyards were good, but most were poor. It seems there is a lack of understanding about the prevalent pests, timing of control, and products used for control. This is an area that, with a little diligence, can really help vine health and fruit quality.

  o Pruning – One outstanding problem among so many vineyards was poor pruning practices. Some obviously had no idea how to prune. It is a skill that takes practice and a keen eye, but it is not a difficult thing. Some untrained vineyard managers are scared to make a cut because they don’t want to remove too much. This is a common mistake. Along with proper pruning is estimation of bud and cane winter injury. Of course it may not be necessary every year, but in years where temps drop very low it is important to do this in order to ensure vine balance.

  o Plant and soil nutrition – Nutritional status of the plant and soil may be the area that is least understood in Oklahoma vineyards. It is important do deal with the health of the vine and the soil. Petiole and soil tests cost money and are often considered "optional". They should not be. They are a mandatory part of any good management program; however, the manager must be educated in methods to improve nutritional problems.

  o Canopy Management – Canopy management is a labor intensive endeavor if leaf-pulling, shoot removal, and crop load dropping is done. This is a definite area that needs improvement in Oklahoma. However, this topic is secondary to the three above because those have so much bearing on vine longevity. Canopy management also affects that, but not as critically as the others.

  o Irrigation -- Irrigation is not being used to its full potential in Oklahoma viticulture. The vines can survive without irrigation, but they will be better off with a good irrigation management
program. Tools exist within the Mesonet that along with good soil moisture monitoring would reduce vine stress and improve overall vine longevity.

CONCLUDING COMMENTS

Since much of Oklahoma viticulture is predicated on winegrape production, the end product must be considered. What makes Oklahoma wine different from its competitors? What makes Oklahoma wine special? Is it, or can it be, integrated into the social fabric of Oklahoma’s citizenry? If the products and industry as a whole are embraced by the public as a critical component of the state’s heritage, then long-term sustainability will be achieved. This requires an understanding of the state’s history as well as an acute perception of its future. All wineries and vineyard owners must work together as a team. It is essential to recognize that one in-state winery is not in competition with another. The competition is out-of-state wine. This leads back to the point of making Oklahoma wine special. How can it be made an essential point of pride for Oklahomans?

1. Please continue to support OSU’s viticulture and enology efforts.

2. Contribute your voice to an industry organization and keep abreast of what is happening in the industry now.

3. Growers and wineries need to stick together and display a unified front to legislators. Find a way past the differences and work together. To be honest, other states have really gotten their acts together and formed cohesive state organizations that get a lot done. It might be a good idea to talk with leaders from other states that are on a similar scale to Oklahoma (like Kansas, Minnesota, Iowa, Nebraska, etc. to find out what they are doing that is successful).

4. Stay positive. Oklahoma is a difficult place to grow grapes, but it can be done (with proper variety selection, site selection, management, and education). Setbacks will happen, but Oklahoma has a terroir different from anywhere else, so it is exciting to be able to taste that through the grapes. “Taste Native Oklahoma” is something to strive for. Will it be possible to have an industry built entirely on Oklahoma grapes? I don’t know, but with a positive attitude anything is possible.

5. Continue a life-long education in viticulture.
REFERENCES


Special thanks to Becky Carroll, Gene Clifton, Dennis Flaming, Richard and JoAnn Hale, ODAFF, OGIC, Jill Stichler, and Dianne Stowers.
Figure 1. Mean spur diameter (in) by cultivar over all locations in Oklahoma taken in April, 2014.
Figure 2. Mean spur internode length (in) by cultivar over all locations taken in Oklahoma April, 2014.

Where (120 rows excluded)
Each error bar is constructed using the min and max of the data.
Figure 3. Mean number of spurs per linear foot of canopy by cultivar over all vineyards in Oklahoma taken April, 2014.
Figure 4. Percentage of cultivars in vineyards with empty fruiting wire over all vineyards in each region taken July, 2014.
Figure 5. Percentage of cultivars in vineyards with 0-5% missing and dead vines in Oklahoma taken July 2014.

Where (17 rows excluded)
Table 1. Price per ton of other grape producing states for certain cultivars also grown in Oklahoma. Oklahoma vinifera grapes range from $1000 to $1500 per ton and hybrids from $400 to $700 per ton.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Midwest $/ton</th>
<th>MO $/ton</th>
<th>KY/TN $/ton</th>
<th>IN/IL $/ton</th>
<th>IA $/ton</th>
<th>NE $/ton</th>
<th>OH $/ton</th>
<th>VA $/ton</th>
<th>NY $/ton</th>
<th>OR $/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cab S</td>
<td>1617</td>
<td>1250</td>
<td>1750</td>
<td>2000</td>
<td>.</td>
<td>.</td>
<td>1650</td>
<td>1959</td>
<td>1622</td>
<td>2124</td>
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<td>Cab F</td>
<td>1536</td>
<td>1500</td>
<td>1675</td>
<td>1625</td>
<td>.</td>
<td>.</td>
<td>1650</td>
<td>2000</td>
<td>1330</td>
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</tr>
<tr>
<td>Chard</td>
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<td>1200</td>
<td>1700</td>
<td>1950</td>
<td>.</td>
<td>.</td>
<td>1475</td>
<td>1851</td>
<td>1100</td>
<td>2236</td>
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<tr>
<td>Merlot</td>
<td>1527</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>1983</td>
<td>1756</td>
<td>1874</td>
<td></td>
</tr>
<tr>
<td>Riesling</td>
<td>1425</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>1570</td>
<td>1300</td>
<td>1507</td>
<td></td>
</tr>
<tr>
<td>Sangio</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>1825</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syrah</td>
<td>1873</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>1997</td>
<td>1750</td>
<td>2154</td>
<td></td>
</tr>
<tr>
<td>Zin</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>1959</td>
<td></td>
</tr>
<tr>
<td>Cynth</td>
<td>1001</td>
<td>1000</td>
<td>900</td>
<td>1100</td>
<td>.</td>
<td>1250</td>
<td>1000</td>
<td>1650</td>
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</tr>
<tr>
<td>Chamb</td>
<td>1011</td>
<td>1000</td>
<td>1250</td>
<td>1025</td>
<td>1300</td>
<td>1250</td>
<td>850</td>
<td>1095</td>
<td>765</td>
<td>.</td>
</tr>
<tr>
<td>Chardl</td>
<td>952</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>750</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>Tram</td>
<td>1014</td>
<td>950</td>
<td>1100</td>
<td>1075</td>
<td>.</td>
<td>.</td>
<td>900</td>
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<td>Seyval</td>
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<td>.</td>
<td>.</td>
<td>1300</td>
<td>1250</td>
<td>.</td>
<td>1143</td>
<td>578</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>Vignol</td>
<td>1120</td>
<td>.</td>
<td>.</td>
<td>1300</td>
<td>1250</td>
<td>.</td>
<td>.</td>
<td>733</td>
<td>.</td>
<td></td>
</tr>
</tbody>
</table>
Figure 6. Data sheet for April 2014 vineyard quality analysis.
### Oklahoma Vineyard Quality Project
**Assessment Form 2**
*Between Veraison and Harvest, Mature Vineyard*

<table>
<thead>
<tr>
<th>Vineyard Capacity</th>
<th>% of vineyards deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 5% Missing or Dead Vines</td>
<td>64%</td>
</tr>
<tr>
<td>0 to 2% empty fruited wire (exclusive of missing/dead vines)</td>
<td>92%</td>
</tr>
<tr>
<td>4-6 shoots per linear foot of canopy (on average)</td>
<td>14%</td>
</tr>
<tr>
<td>1-2 clusters per shoot</td>
<td>20%</td>
</tr>
<tr>
<td>Good fruit set; clusters well-filled; berry size normal</td>
<td>80%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Canopy Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoot length 3 to 5 feet</td>
<td>80%</td>
</tr>
<tr>
<td>15-20 leaves per shoot</td>
<td>96%</td>
</tr>
<tr>
<td>Leaves appropriate size for cultivar</td>
<td>72%</td>
</tr>
<tr>
<td>Shoot tip growth stopped or very slow</td>
<td>64%</td>
</tr>
<tr>
<td>Lateral shoots absent or short; no more than 2-4 leaves per lateral</td>
<td>76%</td>
</tr>
<tr>
<td>Clusters receiving indirect or filtered light; not full shade, not full sun</td>
<td>70% low because of crop load</td>
</tr>
<tr>
<td>Fruit ripening uniformly</td>
<td>48% low – many had no fruit</td>
</tr>
<tr>
<td>Normal leaf color</td>
<td>52%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vine and Fruit Health</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Absence of fruit diseases</td>
<td>76%</td>
</tr>
<tr>
<td>Absence of foliar diseases</td>
<td>90%</td>
</tr>
<tr>
<td>Absence of grape berry moth damage to fruit</td>
<td>56%</td>
</tr>
<tr>
<td>Absence of green June beetle damage to fruit</td>
<td>3%</td>
</tr>
<tr>
<td>Spray records are available and up-to-date</td>
<td>15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vineyard Floor</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover crop appropriate for soil and climate (coverage and competition)</td>
<td>4%</td>
</tr>
<tr>
<td>Weed growth short and covers ≥ 50% of under-vine area</td>
<td>56%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vineyard Business</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance-based (e.g., yield, brix, TA, etc.) contract for all of crop</td>
<td>16%</td>
</tr>
<tr>
<td>Crop Load Estimate</td>
<td>100%</td>
</tr>
</tbody>
</table>

Adapted from Texas A&M “Great Vineyards Program”

25 Vineyards visited

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Figure 7. Data sheet for July 2014 vineyard quality analysis.