Growing Wine Grapes in the Desert

Background

I'm an amateur. I have a small backyard vineyard with 50 vines that I tend in Tucson. I never imagined I'd grow grapes, let alone learn to prune them like a commercial vineyard. I enjoy the work though, and I'm getting better with practice. I welcome visitors to my little vineyard and am happy to discuss my mistakes and successes.

I have always liked making wine and have contacted several AZ growers about buying fresh grapes . One day in 2008, one of my phone calls put me in touch with Peter Lechtenbohmer of Sweet Sunrise Vineyards. Peter had over 30 years of experience, growing both table grapes and wine grapes. He told me he did not have any for sale, but he was teaching a class and had room for one more student, if I was interested. Local grapes are in such short supply and I figured I could grow enough to supply my own needs, so I said yes. The class was once a month for a year and covered everything I could have hoped for. I learned a lot and am trying to put it into practice as well as I can. I also devoured several well-known books such as General Viticulture [1], Grapes into Wine [2] and From Vines to Wine [3]. All three books have good information, but I found General Viticulture to be the most helpful.

This document is my attempt to put into words what I have learned about growing grapes in the middle desert.

The best growing conditions in Arizona are at elevations of 4000-5000 feet, but my backyard is at 2350 feet, so I've had to make some adaptations. I will explain the choices I've made and the rationale behind them.

This document should be used as a starting point for growing grapes. I can't hope to cover all possible topics and I am constantly learning. Grape growing in the southern Arizona desert presents many difficulties, including high heat and summer monsoons. It's a challenging environment to say the least. Fences may need to be erected to keep out deer, and rabbits. Leaf-cutter ants can defoliate young vines and the wide variety of birds that visit around harvest time are not all deterred by the average ¾" netting.

Arizona doesn't have the pest and disease problems that well-known viticulture areas have. So, the advice given in books with regard to spraying does not generally apply here.

Most advice for grape growing is aimed for climates where freezing temperatures can kill plants in the winter and the goal during the growing season is to optimize sunlight. Such advice usually covers growing on south-facing slopes, above the valley bottom both to improve sunlight and avoid killing frosts. This is not necessarily a good thing at lower elevations in the desert southwest. It may be advisable to grow on a north- or east-facing slope to reduce afternoon heating from the sun. Also, the intense solar radiation means that canopies should be heavier than those used in many areas of the world.

Grapes need sun during the day, but they also need cooler temperatures at night to preserve acidity. One of the problems with grapes grown in hot climates is that they tend to be low in acid to to respiration during the warm nights. Varieties that produce lots of acid and can tolerate the heat seem to be good choices for growing here.

I have ignored advice to plant away from the bottom of a river bed because I *wanted* the cold air that flows down at night to cool the grapes off and help preserve acidity. This does present its own problems, but every decision carries with it trade-offs.

The basic steps

1. Clear the ground. Level, trench/rip, backfill. Disk, level.
2. Place end posts and anchors.
3. Run main drip supply (3/4" or 1") along end of rows if the length is less than 200'. Otherwise, run the feed across middle of all rows , splitting each run of ½" drip tubing from the middle to the endposts to lengths less than 200'.
4. Dig plant holes.
5. Place T-posts.
6. Hang drip wire, drip line and add emitters. Hang cordon wire. Catch wires may also be added at this time or later.
7. Plant
    a. Plant
    b. Add vine shelter
    c. Add training rod
    d. Irrigate
8. Install other wires as necessary.

The trellis can be constructed after the first year in order to reduce the costs for the first year. But, I found it easier to do all this while I had the equipment and didn't have to worry about disturbing plants.

Varieties

Several varieties have been grown with some success here in Tucson, mostly at the University of Arizona. I've included this list because I think it helps to know what has already been tried.

Varieties in **bold** performed well at the U of A, according to John Begeman. Varieties marked with an asterisk (*), have not been tried in Tucson to my knowledge. They are grapes I researched using *Jancis Robinson's Guide to Wine Grapes* that may do well in this area. I've listed some characteristics listed in Jancis' book. I would appreciate feedback on other local grower experiences with any of these varieties to update this list.

Aglianico* (Hot climate, tannic, volcanic soils)

Albariño* (White, tolerates dampness, thick skins)

Assyrtico* (White, hot climate, keeps acid, lime& honeysuckle)

Barbera (high acid, hot climate, low alkali tolerance)

Brunello* (Sangiovese clone; small, dense, thick skins)

Carignane

Chennin Blanc* (White, Hot climate)

Dolcetto

Graciano* (Hot climate, high acid, good for blending)

Grenache (Hot climate, low acid)

Lambrusco

Malvasia Bianca (crisp, does well, good off-dry, handles heat, birds love it,)

Malvasia Nera* (good color, perfume)

Nebbiolo* (Difficult, low color)

Negro Amaro*

Nero D'Avola* (Sicilian, not widely available in the US yet)

Petit Manseng* (warm soil)

Petit Sirah

Petit Verdot

Pinot Grigio

Ruby Cabernet

Rubired

Sangiovese (can be light colored and flavored)

Sauvignion Blanc

Shiraz

Souzao

Tannat* (high acid)

Tempranillo

Tinta Cao

Trebbiano* (white)

Touriga Nacional

Uva di Troia*

Viognier

Viura* (mid acid, flowery, almond)

Xynomavra*

Zinfandel (tight clusters, susceptible to fungi)

Rootstocks

Not all growers use rootstocks, but they do offer some advantages over growing on the vines own roots. Rootstocks can be picked for particular conditions (such as alkaline or clay soils) that the vine itself (the scion) doesn't handle well. Also, rootstocks are available that can resist pests such as phylloxera and nematodes. Here's a few I've checked out:

1103P (medium drought and lime tolerance, vigorous)

101-14Mgt (medium drought tolerance, low alkalinity, medium vigor)

110R (good drought and lime tolerance listed, but did not do well in either Elgin or Willcox)

Vines can be ordered with a choice of rootstocks, but you usually need to order them a year in advance if you want something other than what the nursery usually stocks. There will also be a large minimum order if going that route.

Vines can be ordered in the fall for planting the next spring if you don't mind going with what the nursery has already grafted. This is how I ended up with Barbera growing on a 101-14 rootstock. 1103 would have been my first choice, but they didn't have that combination available. As it turns out, the 101-14/Barbera combination is vigorous enough in my location and I'm glad I didn't get the more vigorous 1103P.

Most of the nurseries have their own rootstock chart, or you can use the one at UC Davis:

http://groups.ucanr.org/iv/files/27344.pdf

Some local growers are having very good luck without rootstocks; that is, their vines are growing on their own roots. Vinifera seems to be more tolerant of lime than the various rootstocks and Phylloxera isn't generally a problem in sandy soils. I'm giving this a try myself, since I lost a couple of vines to a hard freeze.

Soil

The preferred soil is at least 3 feet deep, has good drainage, and little or no caliche. Grapes can handle clay or sandy soils, but extreme cases will cause long term problems.

Backyard growers will probably have little flexibility in where they plant the vines. It doesn't help to tell someone they need to plant in the middle third of a south-facing hill if they want to plant some vines in their backyard in Tucson. That advice is standard for commercial vineyards. Other advice is often given pertaining to row orientation, spacing, cover crop, trellis styles, etc. The amount of advice available online can be both overwhelming and contradictory. There are some helpful things to keep in mind, however.

What works in one region doesn't necessarily work in another. I think there are some basic characteristics of grapes that need to be understood so adaptations can be made for local conditions.

In my case, I live in a mid-elevation desert, at 2400'. I have very different problems from the growers in Elgin (at 4800') where day-night temperature swings are larger. Frost is rare at lower elevations and sunlight isn't in short supply, so being on a south-facing slope isn't a necessity. I tried to make the best of what I have.

My property slopes downward to the north. My best soil was near the bottom of the hill, next to a dry wash. This goes against all advice, but it works for me. The cold air flows down the wash at night, giving me a greater temperature drop (5-10 degrees cooler) than I have higher up. Since frost is rare here, I wasn't worried about losing vines in the winter. I couldn't get away with that at 5000' elevation. I did manage to lose a couple of vines due to a late spring freeze in 2011. This may have been caused by having grow-tubes on the vines, which kept the trunks a few degrees warmer than the ambient air. I believe this caused the trunks to come out of dormancy prematurely and I had some frost damage where the upper portion of the grow-tube ended. I have since replaced all grow-tubes with chicken-wire tubes to keep the rabbits away.

The land for the vineyard should be cleared of brush and cactus and prepared by ripping to a depth of 3 feet. This is very important for quickly establishing the vines. I've seen the effects on plant growth with ripping versus not ripping and the difference is dramatic. Vines grown in ripped soil are much more vigorous and establish fatter trunks and arms than those grown without ripping. My first year, my trunks grew to ¾" and I had canes that were nearly ½". I've seen 5 year old plants grown on undisturbed soil that had not achieved those dimensions.

Before planting, it's a good idea to dig a test hole. You can rent an auger for the purpose. You'll need to bore down 3' to make sure the soil has good drainage at least that deep. If you're planting in your backyard, this may seem to be an unnecessary step, but remember that a vineyard is a long term project and you'll have better success if you can get as many things lined up in the right direction as you can. If you're buying land to start a business, a test hole could save you from a big mistake. No sense buying the land for a vineyard if it isn't suitable.

For a small vineyard, a backhoe may be rented to trench down 3 feet. I used a bucket 2 feet wide. The soil should be pushed back into the trench once it's dug. This is done to break up the soil and is a very important step in providing the best possible conditions for the vines to grow. It helps break up any hard layers, and aerates the soil. It also lets you see exactly what you've got down there. Soil amendments are not required. If you like, you can add flakes from a bale of good alfalfa at the bottom of the trench before back-filling. This will be broken down by the time the roots reach it and will provide some nutrition. But generally, count on adding fertilizer each year, as the watering will leach away most of the nutrients.

On larger blocks, a tractor pulling long tines can be used. The driver should rip diagonally across the block in in a criss-cross manner, forming a diamond shaped pattern, rather than a square pattern. This does a better job of breaking up the soil. Afterward, clods may be broken up with a disc. Finally, a box scraper can be used to level the ground.

The area where the end posts will be placed should not be disturbed. It is better to leave it intact so it will provide a firm support for the trellis. Individual blocks need to be separated with lanes so that equipment can be maneuvered at the end of the rows and along the sides.

Also, do not drive heavy equipment over the area just ripped and leveled, to avoid re-compacting the soil you just broke up for the vines. Keep the wheels in the aisles.

For large blocks, the rows should be separated by enough distance to allow equipment to be driven between them. This is usually 9-12 feet.

For small plots, where all work is done by hand, rows can be placed closer together. My vineyard is space 6 x 6. That means 6 feet between plants in a row and 6 feet between rows. I don't even own a tractor.

The Trellis

The trellis needs to be strong enough to bear the vines and crop and withstand the heavy winds. In sandy soils, the endposts need to be set deep, maybe 3'. In clay soil, they can be set 2' deep. Posts should extend 6-7' above the ground.

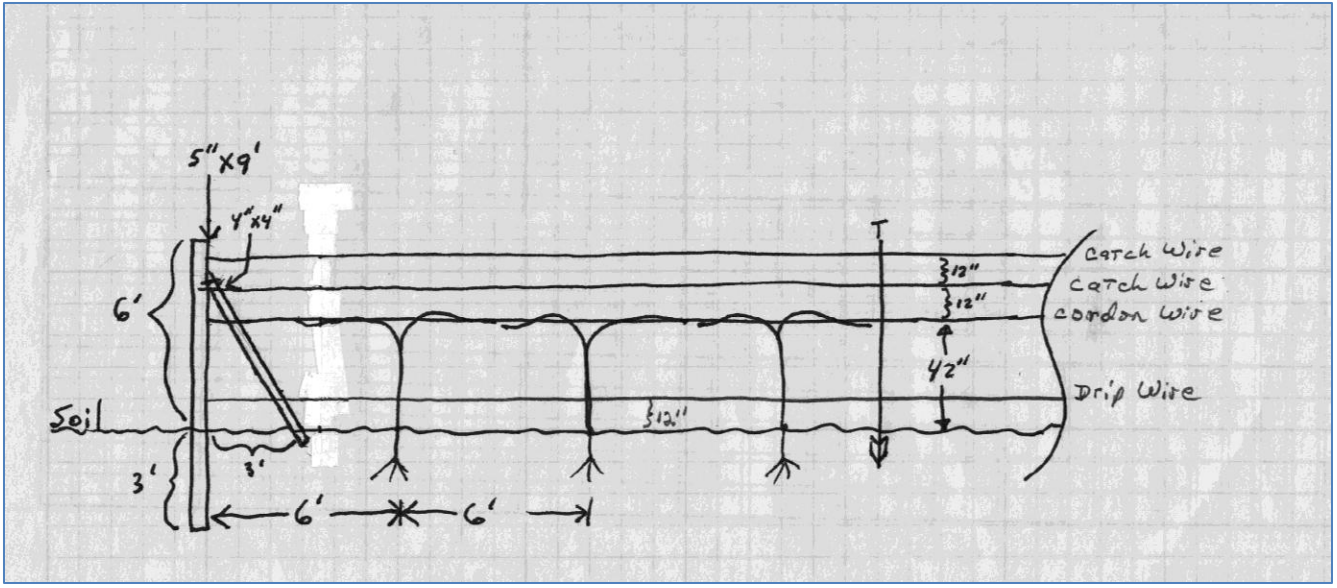
A great presentation on trellis construction is available online at http://viticulture.hort.iastate.edu/info/pdf/domototrellis.pdf.

In my vineyard, I used 4x4 pressure-treated posts for end posts and braces. These are expensive (about $14 ea in 2009).

Large vineyards generally use at least 5" diameter posts or grape stakes. I used internal braces (lean-to) because I wanted to avoid having trip wires out in my yard, but it would have been much cheaper to use wires attached to earth anchors to pull the end posts outwards. The lean-to is clean looking, but shouldn't be used for runs over 200'. Wire can be bought at Arizona Feeds and Biff Baker Fencing in Tucson, and High Lonesome in Elfrida. There may be other places, but mostly I got blank looks when I asked for 12.5 gauge galvanized wire. The high tensile isn't necessary for short rows, under about 300'.

Wire tensioners can be purchased online at Orchard Valley Supply. These are like little ratchets that allow you to crank up the tension of the wire with a ½" drive breaker bar. During the winter, the tension can be backed off so the wire doesn't stretch when the temperature drops. They can be tightened again the following spring before bud-break.

For some soils, 7' T-posts sunk a foot in the ground are ok. For sandy soil, use 8' T-posts and sink them 2' into the ground. T-posts shouldn't be any farther apart than about 21-24'. This works out to 3-4 vines between posts.



I chose to go with bi-lateral cordons and vertical shoot positioning (VSP) as this was the recommended trellis for Barbera.The drip wire should be 12”-20” above the ground. I chose 20” to make it easy for my dog fit under in case she decided to chase a rabbit that happened to run across the vineyard rows.

The cordon wire should be at about 40-42” above the ground. This is simply to make it more comfortable for the person working on the vines and harvesting fruit.

The first catch wire goes 12” above the cordon wire. This may be a single wire or double wires, depending on the variety being grown. The second wire or pair of wires is placed 12-14” above the lower set.

I added 1’ long cross-bars at the level of the top wire to each T-post so I could run two wires side-by-side along the top. The cross bars let me space the double catch-wires 6” or 1’ apart for tucking canes between during the growing season. This saves time since I don’t have to tie all the canes up to keep them vertical. It’s very important to keep the aisles clear so you can move down them to take care of the plants.

Irrigation

I use the cheap flag emitters. They work well and their biggest advantage (besides cost) is that they are easily cleaned. Most of the time, I can just twist the flag back and forth to break up the calcium deposits and the emitter flows normally again. Several types of emitter are available though. Those who run their drip lines down an incline may want to use the pressure-compensated type, which will give more consistent watering rates. Look for a self-cleaning type.

The flag emitters vary quite a bit in tolerance. These should be operated at 25-30 psi. I use the type that has colored, locking (hooked) flags to denote the gph (gallons per hour) rating:

1 gph = Black
2 gph = Blue
4 gph = Grn (not all brands follow this color coding).

The ratings of gph are approximate. Some 1 gph emitters run at over 1 gph, others are way under. This also varies with water pressure, but the differences between emitters seems to be caused by the molding process

used, which isn't very precise. Some flags fit very loosely in the barrel, while others are so tight the flag can barely be rotated. Some trimming can be done to adjust the flow.

The flag can be removed from the barrel by rotating it to line up the hook on the flag with the notch in the barrel and pulling the flag out. I had to swap different flags in the barrels to get the watering rate even across the vineyard.

More expensive, membrane type, emitters are also popular. These have the ability to pass small particles without clogging, reducing the amount of cleaning needed. These are also pressure-compensating, which makes them handy where there's a large elevation difference from one end of the dripline to the other.

Using multiple emitters per plant (one close to the trunk, and one part way to the next trunk) helps compensate for slight differences in emitters and also provides a backup in case on emitter gets clogged. Multiple emitters also allows you to irrigate more ground, which allows wider root coverage.

Training

Plant the dormant vines and let them grow the 1st year with one emitter per plant. Prune the following spring and add a 2nd emitter between plants. I used 1 gph emitters for my soil because there is enough clay to make the water penetrate slowly and watering any faster would just cause runoff.

Follow the planting instructions provided with the vines. Most nurseries offer a guarantee of some degree, if you follow their directions. In general, they recommend that vine shelters should be added at time of planting and tied to training stake. The bottom of the shelter should be covered with a mound of dirt to seal up air flow. This prevents a chimney effect from drying out the young vines. If shelters are not used, then dirt should be mounded over the top of the dormant vines until green growth is seen pushing up through the dirt. The mound should then be removed, making sure to leave the graft union 3-4" above the soil so that the scion won't send out its own roots, bypassing the rootstock.

Peter's training advice follows that given in General Viticulture under "Forming Cordon-Trained Vines", with one difference. He pruned to 1-bud spurs the first year the cordons were on the wire. This was to give a half crop the following year. Succeeding prunings then left two-bud spurs for a full crop.

Here's a quick description. Let the vines grow until one shoot reaches the cordon wire, tying loosely with green tape every foot or so. Be sure to keep ties 12-16" back from the growing tip. Once a shoot has grown a foot or so above the cordon wire, pinch it back to the wire and let laterals grow. Any laterals that are more than 8" or so below the cordon wire should be removed, all the way down the new trunk. This will force lateral growth and will fatten the trunk. If a shoot cannot reach the cordon wire, leave it alone and let the vine grow wild. It can be pruned back down to two buds (just above the graft union) the following winter. A trunk can be grown the following year.

After topping, two laterals (6-8" below the cordon wire) are trained for cordons. All other laterals should be removed. The 2 chosen laterals are allowed to grow naturally until they are a foot or so above the stake. Place a tie around each at the cordon wire. Bend each lateral gently toward the cordon wire and tie loosely. It is very

easy to snap off young laterals, so this is best done when the laterals have reached a diameter of 5/16 – 3/8" and may need to be done in stages. The ties to the cordon wire can be gradually shortened every few days to make the bend a little sharper until the cordons are following the wire. Tie once or twice as the cordon lengthens, keeping 12-16" back from the growing tip so as not to hinder elongation.

Once the new cordons have grown 12-18" past the halfway point to the next vine, snip off the end of the cordon to force lateral growth and tie the cut end to the cordon wire. During the next winter pruning, cordons should be pruned back to the point where they're 3/8" thick or better. If too small, they may be pruned all the way back toward the trunk, leaving one or two buds to start new cordons the next spring. Only one-bud spurs should be left on vigorous cordons at this time. The next year, they may be pruned to two-bud spurs for a full crop.

Lon Rombough [4] recommended leaving a couple of clusters on 2nd year vines. My Barbera tried to set fruit 4 or 5 times the first year, so I left a couple of clusters on the most vigorous vines in the hopes that this would "satisfy" the vines "need" to set fruit. I didn't think it would hurt these few vines that had nearly 1" thick trunks. The less vigorous vines were not allowed to keep any fruit so that they would have a chance to catch up. I could have slowed growth by limiting watering, but I wanted to make sure the vines grew well during the establishment phase.

Irrigation

I've heard many ideas for how much water to give a plant and how often to give it. Grapes don't show wilt as readily as other plants, so it can be difficult to tell. Some watering guidelines reference crop coefficients and evapo-transpiration rates. The simplest advice is that you should water to field capacity, and then wait until the water has mostly been depleted (just above the wilt point) to water again. You don't want to wait until the plants actually show wilt though, as this will hinder development of the vine.

Grapes show water deficiency first in the tendrils. In general, if the tendrils at the shoot tips extend past the shoot tip, they're getting enough water.

Field capacity in layman's terms means the maximum amount of water the soil can hold without running off. You can do a simple experiment to determine the field capacity for your soil. Take a container and put a half gallon or so of soil in it. You can either weigh the container with the soil and again after you add water, or just measure the added water carefully, subtracting any that can be poured off.

The soil should be completely saturated. You can fill it up and let the soil absorb as much as it can, then pour the excess off, keeping track of how much was added. This gives you your field capacity.

For example, I used a 1 gal plastic milk with the top cut off. I measured the volume of dirt by multiplying the depth, width and height of the soil in inches. I converted this to cubic feet (1 cu ft = 1728 cu in). Then, I figured out how much water I'd added and converted that to gallons. Now, I had my field capacity in gallons of water per cubic foot of soil. Finally, I calculated approximately how many cu feet of soil my roots were likely to occupy and that told me how many gallons it would take to get the root zone watered to field capacity. Knowing that I was using 1 gph emitters on my drip system let me then calculate how many hours to run the system to get the number of gallons required. Here's how it worked out for me:

Amount of soil in milk jug = 3.5” high X 6” wide X 6” deep = 126 cu in.

126 cu in / 1728 = .073 cu ft.

It took 11 oz of water to saturate that amount of soil to capacity.

11/128 = .086 gallon of water

My field capacity = (.086 gal) /(.073 cu ft) = 1.178 gal/cu ft.

So, how many cu ft of soil do the roots occupy? My soil is about 70% sand. This means that the water soaks in and goes almost straight down, with very little spreading to the sides. Since the roots tend to follow the water, they’ll also travel downwards. I modeled this as a cylinder to make calculations simple. Soil with a high clay content would cause the water to spread out more like a cone.

For the first year, the drip emitter is placed close to the plant, say 6” away. This waters an area approximately 2 feet in diameter in my sandy soil. Assuming that the roots would grow down 3’, I want to water a cylinder of soil 2 feet in diameter and 3 feet long. The equation for a cylinder is:

$Vol = \pi * r^2 * h = 3.1416*1*3 = 9.4$ cu ft.

The amount of water to reach field capacity is then found by multiplying the gal/cu ft number I calculated above by the volume soil:

FC = 1.178 * 9.4=11.1 gal

Since I am using 1 gph emitters, that means I need to water for 11.1 hrs. Peter had told me I should water for 12 hrs, so this seemed like a good result.

As the plants get larger, the roots will need to spread out. So, in the second year, I added emitters halfway between the plants to water the roots that found their way there. This way, I water the same amount of time, but saturate more of the soil and allow the roots to spread out.

So, how often do I water? As a first approximation, I dig down into the soil and see how long it takes it to dry out. For young plants that don’t have deep roots, I go down 3 or 4”. For older plants, I go down 5-6”. When the soil at that depth is too dry to hold together when squeezed, it’s time to water again. In the spring, this takes about two weeks. In the summer in Tucson, it takes one week. If I notice that the tendrils are getting short or that some of the leaves are getting heat scorch, I’ll increase the watering time. During the first year, during the very hot summer, I added a couple of hours of watering mid week just to help the plants stay cool. I also kept the long deep watering so as to encourage the roots to go deep.

In the second year, I was able to start with 12 hrs of water every other week in the early spring. As the daily temperature approached 100 F, I went to weekly watering. As the summer grew even hotter, I increased the watering to 14 hrs per week. This was sufficient to keep the vines from wilting.

Short, frequent watering schedules develop shallow roots. Shallow roots dry out quickly because the water from the top 4” of soil evaporates quickly. For example, if the vines are watered three times a week and the top two

inches of soil dries out between waterings, 6" worth of water is lost to evaporation each week. On the other hand, if the vines are only watered once per week for the same total length of time, only 4" is lost to evaporation and the plants actually get more water. It's been reported that some evaporative loss may be helpful in cooling the vines, but it's better to give a long deep watering once a week, and a short watering mid week to help cool the vines.

Since salts can build up in the soil, it's important to flush them out regularly. This is another benefit of deep watering – salts are pushed beyond the root zone. Also, the vines need an extra long watering both at the beginning and end of the season. Give them 24 hours of water before bud burst and again right after harvest. This helps the vines coming out of dormancy and watering after harvest helps prepare them for going into dormancy with lots of reserves. The long watering also helps to dilute any salt build-up.

In order to concentrate sugars in the grapes, some farmers will stretch out the watering interval after veraison by as much as 20-30%. So, instead of watering every two weeks in Willcox, the interval will be stretched to every three weeks. In my case, I water weekly, so I would add a half a week. This will need to be evaluated on a case by case basis. Also, a good heavy watering after harvest will be even more necessary to help the vines recover prior to dormancy.

Fertilization

There are many approaches to fertilization. Some people just add a natural fertilizer like compost or cow manure every year and take what they get. A more scientific approach would be to start with a soil analysis to determine what is already there. The test lab can then recommend fertilizer amounts based on the crop. A petiole (leaf stem) analysis can help to fine tune this advice.

My sandy, alkaline soil was mostly devoid of organic matter and most nutrients have been leached out, so I added everything I thought the plants needed. I gave each plant the equivalent of 1tbs/gal of Mir-Acid (or Miracle Grow ACR) 30-10-10 each time I watered from budbreak until bloom for the first two years (don't go > 20%N after 2nd year). After bloom, I only gave Potassium if a deficiency appeared (either due to red spots on the leaves, or to boost sugar levels just prior to harvest).

In year three and onward, I switched to 20-20-20 fertilizer. At 1 application every two weeks for 6 weeks, this works out to a total of 3*.5oz=1.5oz/vine. This compares well with other recommendations I've read for nitrogen (such as 80-100lbs per acre of actual N2)

I had good results with this approach. But, I think that long, deep irrigations are an absolute requirement in order to keep salts from building up. I finally got a soil and petiole analysis in the third year. The Miracle Grow did a good job of supplying the macro and micro nutrients needed, although I did find out I needed to add some elemental sulfur to help bind some of the calcium in the soil. This forms gypsum, which lowers the pH and reduces the available manganese. Adding gypsum was not recommended as it would widen the Ca:Mg ratio in my soil. I would not have known this without the analysis and may have added gypsum (a common recommendation), thinking it would help.

Final Thoughts

This is a work in progress, as I still have much to learn. There are many topics I haven't covered, such as pests, diseases, etc. The interested reader will find much information on the internet, as well as in forums such as Winepress.us. The members of the forum are very helpful and knowledgable. I highly recommend joining and participating in the forum.

[1] C. K. L. Winkler, General Viticulture, Berkely and Los Angeles, CA: University of California Press, 1974.

[2] P. M. Wagner, Grapes Into Wine, New York, NY: Alfred A. Knopf, 1993.

[3] J. Cox, From Vines to Wines, North Adams, MA: Storey Publishing, 1999.

[4] L. Rombough, The Grape Grower, White River Junction, VT: Chelsea Green Publishing Co., 2002.