RESEARCH BULLETIN

University of Nevada, Reno

AGRICULTURAL EXPERIMENT STATION

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FEBRUARY 2005 • NAES PUBLICATION #51055382

# Towards Wine Grape *(Vitis vinifera)* Vineyard Establishment in Northern Nevada

Varietal Studies in a Dry Desert Climate

The Nevada Agricultural Experiment Station factsheet series is designed to provide information about research related to the understanding of biological, environmental, natural resource and social systems to enhance agriculture, community and economic vitality.

## INTRODUCTION

Several publications illustrate the feasibility of cultivating seeded and seedless table grapes (*Vitis labrusca* and their hybrids) in northern Nevada (1, 2, 3), but little research to date has been done towards establishment of premium wine vineyards of *Vitis vinifera* because they are less cold tolerant. The economic impact of a wine industry in Nevada could be substantial.

In 2002, the California wine industry had a $44 billion dollar economic impact on the state (18). The wine industry in Washington State, which began in 1963, has over 29,000 acres of wine grape, and 240 wineries as of 2004, generating an average of $2.4 billion in annual retail sales (19). Colorado has some of the highest vineyards in the world, ranging between 4,000 and 6,400 feet above sea level. In 2003, Colorado had 80 vineyards (the first one was established in 1968) which produced 1,500 tons of grapes on 650 acres with a wine retail value of over $6.5 million. Between 1993 and 2004, Colorado wineries have increased from 5 to 58 (20). The climates of grape growing regions in Washington State and Colorado are similar to that of Northern Nevada. In addition to retail sales of wine, wineries and vineyards generate tourism dollars.

FIGURE 1. Products produced at the University of Nevada, Reno's vineyard and winery.

Traditionally, agricultural production in Nevada has centered on cattle, alfalfa, hay, dairy, potatoes, and minor crops such as onions, garlic, small grains, mint, truck crops, ornamentals, and sod. Growers continually seek alternative crops, particularly those that have high value (Figure 1), produce well, and are resource efficient; i.e. require less fertilizer, fewer pesticides, and little water.

Consequently, a one-acre experimental vineyard was established in 1995 at the College of Agriculture, Biotechnology, and Natural Resources' Valley Road Field Laboratory (VRFL) on the University of

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**FIGURE 2.** University of Nevada, Reno's experimental vineyard, summer 2004.

Nevada, Reno campus (Figure 2). The intent was to evaluate how well 12 varieties of wine grapes would survive, grow, and yield in northern Nevada, what their water efficiency would be in comparison to other crops, as well as whether or not a quality wine could be produced from their fruit.

Wine grape varieties have been shown to be sensitive to cold temperatures, with spring freezes having detrimental impacts on vine survival, fruit production, and juice quality (15).

Cold hardiness methodologies (7, 8, 9) have shown that premium wine grapes can be successfully cultivated despite the presence of chilling temperatures in the spring. Likewise, growers and researchers use cultural practices, including irrigation regulation, fertilizer application and pruning to manage vine growth, development, and fruit quality (1, 2, 3, 16, 17).

Survival statistics from the 12 varieties at the VRFL have been collected since the vineyard was established. Fruit and juice characteristics have been recorded since 2001 when regulated deficit irrigation began. Each variety responds differently to the influence of regional microclimates in terms of survival and fruit quality. Here we report preliminary findings on the growth and survival of desirable varieties of wine grapes grown in northern Nevada, and their response to reduced water consumption as a result of regulated deficit irrigation at the VRFL experimental vineyard.

## WEATHER

Microclimatic weather patterns have the most profound impact upon vine survival and fruit quality. Wine grapes can be extremely susceptible to freezing temperatures, which represents the greatest potential hazard to growers. Of most significance is the extreme low temperature of the growing season. A single day of sufficiently cold weather can greatly impact the season's crop. Figure 3 shows a plot of average annual high and low temperatures for 1997 through 2003 as recorded by the National Climate Data Center (NCDC) (11).

Low temperatures in conjunction with the sensitivity of young grapevines could be a factor in the lower rate of survival during the first years of this project; however, similarly low temperatures in 2002 had no effect upon vineyard survival once the vines were fully established and regulated deficit irrigation had been implemented (Figure 4).

The number of growing degree days in a potential growing area is also critical to appropriate fruit ripening and wine quality. Table 1 shows the average number of growing degree days for established grape growing regions as well as Reno and Fallon, Nevada. Northwest Nevada has the potential to produce high quality wines based upon growing degree day analysis.

## VINE SURVIVAL

Significant differences exist among 12 different varieties of *Vitis vinifera* studied for survival, growth, and production. Survival was profoundly affected by irrigation management. Survival counts were measured by observing primary bud break in the early spring, followed by a count in June to observe any growth coming from the ground. (Non-survival is defined as total root death with no shoot production whatsoever throughout the growing season.) Two varieties, *Muscat Blanc* and *Muller Thurgau*, are not included in this report due to their removal from the vineyard in 2001 for poor survival and production.

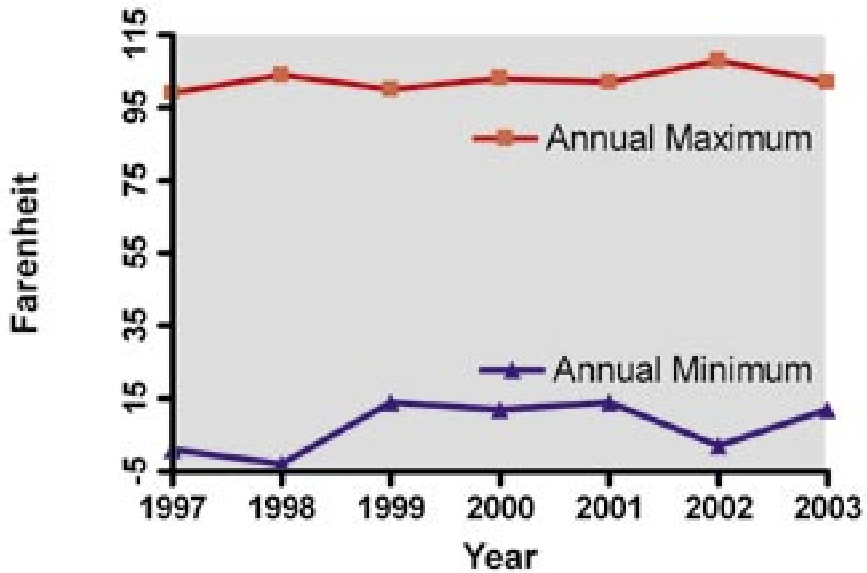


**FIGURE 3.** Average annual temperature extremes at the Valley Road Field Laboratory from 1997-2003.

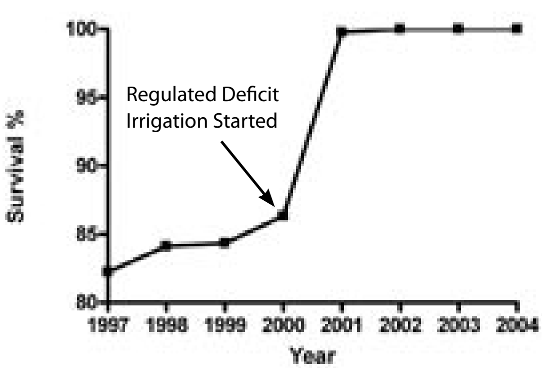


**FIGURE 4.** Average percentage of winter survival of grapes in years after planting, and after regulated deficit irrigation was begun from 2001-2004.

## IRRIGATION SYSTEM AND SCHEDULING

The vineyard is irrigated by a drip system separated into six circuits. These zones are primarily used for experimental reasons, but a similar system may be necessary in a production vineyard if water pressure is a limiting factor. Drip irrigation lines were hung from the bottom trellis wire, and one, two-gallon per hour emitter was installed on each side of every plant, with vines spaced five feet on center.

The vineyard was irrigated weekly during the season for the first five years, and then a regulated deficit irrigation regime was initiated based upon plant water status. In addition, the vineyard was given a deep watering of 16 gallons per plant at the beginning and end of

**TABLE 1**: Average number of annual growing degree days for areas of interest.

| Location | Average Annual Degree Days[1] |
|---|---|
| Napa | 3363 |
| Napa Carneros | 2491 |
| Yakima, WA | 2573 |
| Reno | 2298 |
| Fallon | 2640 |

1. The established values to produce grapes that give premium quality wines are between 2500 and 3500 growing degree days.

**Propagating Replacement Cuttings**

Dormant cuttings were taken in February or March each year to replace vines that did not survive. Cuttings were pruned to three to five buds, treated with rooting hormone, potted in a 50:50 perlite and peat moss mixture, and allowed to grow in a green-house under controlled conditions (70 to 80° F day, 55 to 65° F night) for 10 to 15 weeks. Vineyard replacement of dead vines took place in the first week of June as necessary. The replacements were given approximately three to four gallons of water twice weekly during the season in addition to irrigation applied to the entire field under the RDI regime.

every growing season. This was to ensure normal bud and flower development after a long dry winter and sufficient carbohydrate reserves before entering dormancy, respectively.

## REGULATED DEFICIT IRRIGATION (RDI)

A central theme in the success of the vineyard has been the implementation of regulated deficit irrigation. In short, this is an irrigation regimen based solely on the needs of the vine, rather than the set weekly irrigation schedule that occurred during the establishment of the vineyard. Water application has been strictly controlled over the past four years, with irrigation levels being dictated by stem water potential measurements (a measure of the internal water status of the plant), and evapotranspiration (ET). Water status was measured using a pressure chamber, with stem water potential measurements taken weekly and irrigation scheduled accordingly (6). The drought stressed state of a grapevine has been defined as a leaf water potential of less than –1.0 mega pascals (MPa) (5, 12). Irrigations were scheduled to return the water lost from the plant as calculated for a 60% or 80% deficit of water lost due to ET. This differential was instigated for purposes of other research not reported here. For the VRFL vineyard, ET was measured by the Desert Research Institute's Evapotranspiration Weather Station, and calculations were made from data on their Web site (10). In the event such a weather station is not available, or cannot be established in your vineyard, Reference ET can be estimated based on local temperature values. While this will not give an accurate microclimate value, it will provide a general value that could still be used to schedule irrigation. By calculating the irrigation application, not only can the producer determine the water management's effects on survival and juice quality, but also on wine quality. Reference ET is a method of approximating vine water loss to the atmosphere via comparison to the water loss of one acre of tall fescue grass. A crop coefficient (Kc) unique to each crop must be determined to calculate the percentage of water lost. For our irrigation calculations, a Kc of 0.2 has been used. When a weekly irrigation plan is adopted, the total Reference ET for the week must be taken into account, not just that of a single day (see the box below, Figure 5).

The dates presented in Table 2 represent observed growth patterns from 2001-2003. This information is useful to prevent selection of cultivars showing a coincidence of budburst or harvest with potentially damaging frosts in prospective growing areas.

## SURVIVAL

Cold temperatures have caused observable injury to several varieties of grapes in the form of dieback. In addition,

Figure 5. Example reference evapotranspiration (ET) calculations.

**Scheduling Irrigation of Wine Grapes using Reference ET:** Calculate water lost since your last irrigation using daily Reference ET. For daily Reference ET data by month go to http://www.washoeet.dri.edu. Add up the daily Reference ETs since your last irrigation, for example:

| | Day of Month | Total Reference ET, Inches |
|---|---|---|
| Last irrigation → | 4 | 0.30 |
| | 5 | 0.31 |
| | 6 | 0.35 |
| | 7 | 0.38 |
| | 8 | 0.32 |
| | 9 | 0.42 |
| | **Total ET since irrigation** | **1.78 inches** |

Basic Information

Grape crop coefficient = 0.2

Recommended irrigation return = 75% of total water lost since last irrigation

1 acre foot of water = 325,851 gallons/acre-foot

1 acre inch of water = 27,154 gallons/acre-inch

43,560 square feet = 1 acre

817 vines/acre are in the VRFL vineyard

2, 2-gallon emitters/plant = 3268 gallons/acre/hour

ET x crop coefficient = inches of water loss from crop since last irrigation
1.78 X 0.2 = 0.356 inches

Inches water loss x gallons/acre-inch = required gallons of water to replace water lost by crop
0.356 inches x 27,154 gallons/acre-inch = 9,667 gallons/acre lost since last irrigation

Replacement gallons per plant = replacement gallons/acre ÷ by the number of plants/acre X percent recommended irrigation return
8.87 gallons/plant = 9,667 gallons/acre ÷ 817 plants/acre X 0.75

Irrigation run time = gallons/plant ÷ (gallons/hour/emitter x emitters/plant)
2.2 hours run time for the irrigation = 8.87 gallons/plant ÷ 4 or (2 gallons/hour/emitter x 2 emitters/plant)


**FIGURE 6.** Clusters of red and white wine grapes produced at the Valley Road Field Laboratory, Reno, Nevada

vines infected with crown gall (*Agrobacterium vitis*) suffered, regardless of the variety. It was necessary to replant 15% to 20% of the vines annually during the first five years, but nearly 100% survival has been observed over the last four years (Figure 6). Of the original twelve varieties, *Muscat Blanc* and *Muller Thurgau* were removed in the spring of 2001 and replaced with *Syrah* and *Merlot*. The *Muscat Blanc* and *Muller Thurgau* were the most sensitive varieties to this environment and did not produce any fruit. Further varietal trials may indicate that other cultivars are similarly inappropriate for this area.

Irrigation can have an important impact on grapevine survival in semi-arid regions. Regulated deficit irrigation has substantially impacted survival of the grapes over winter since it was introduced three years ago (Figure 4). Only two plants in the entire vineyard died in the winter of 2001-2002, along with very low levels of observed dieback. Annually, we have observed some winter dieback across the vineyard; however, there was 100% survival among the established vines once deficit irrigation was initiated.

Fruit yields are variety dependant (Figure 7) and are greatly influenced by pruning and other cultural practices. All the grapes at the VRFL vineyard were pruned similarly.

The percentage of vines producing clusters has varied among varieties. The average number of vines producing fruit from 2001-2004 is reported in Figure 7, as well as the total percentage of vines producing fruit annually from 2001-2004 in Table 3.

Table 2: **RANGE OF OBSERVED DATES OF GRAPE PHENOLOGY**

| Phenological Stage[1] | Date of Onset[2] | Early/Late Varieties[2] |
|---|---|---|
| Bud break | April 12th – May 11th | April 12th – Chardonnay |
| Bloom | May 29th – June 22nd | |
| Veraison | July 24th – August 20th | |
| Harvest | September 3rd – October 22nd | October 22nd – Lemberger and White Riesling |

1. Definitions for the phenological stages of the grapes' life cycle are given in the sidebar below (15).
2. The range of observed dates coinciding with a specific developmental stage in the vine's annual growth cycle. Varieties which may be active during local spring or autumn frosts are listed as the early and late varieties, respectively. Since bloom and veraison generally lie within the growing season, no early or late varieties are listed.

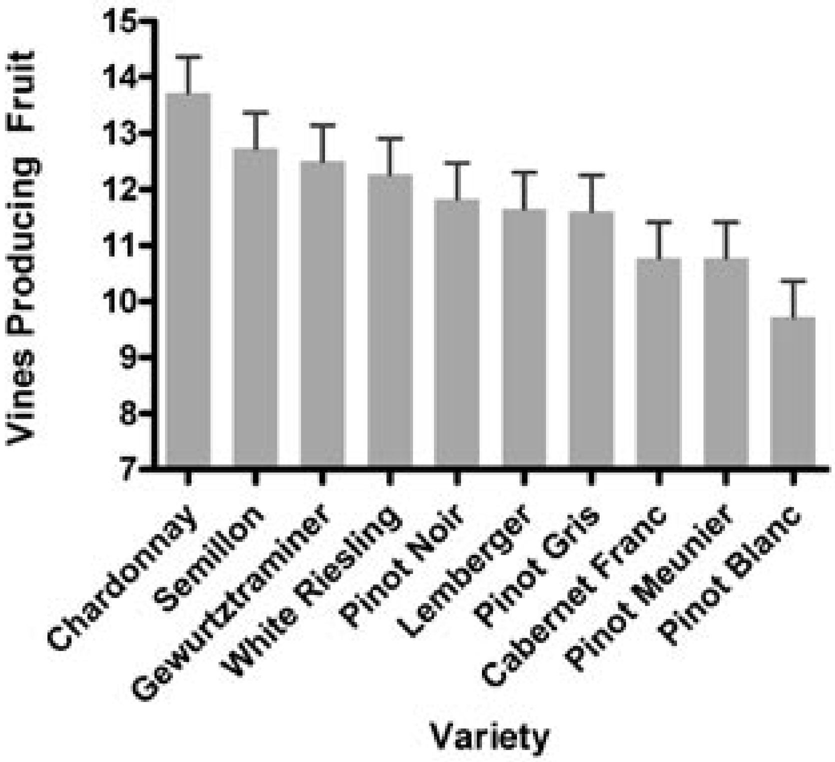


**FIGURE 7:** Average number of fruit producing vines out of 15 plants, by variety, from 2001-2004 at the Valley Road Field Laboratory vineyard.

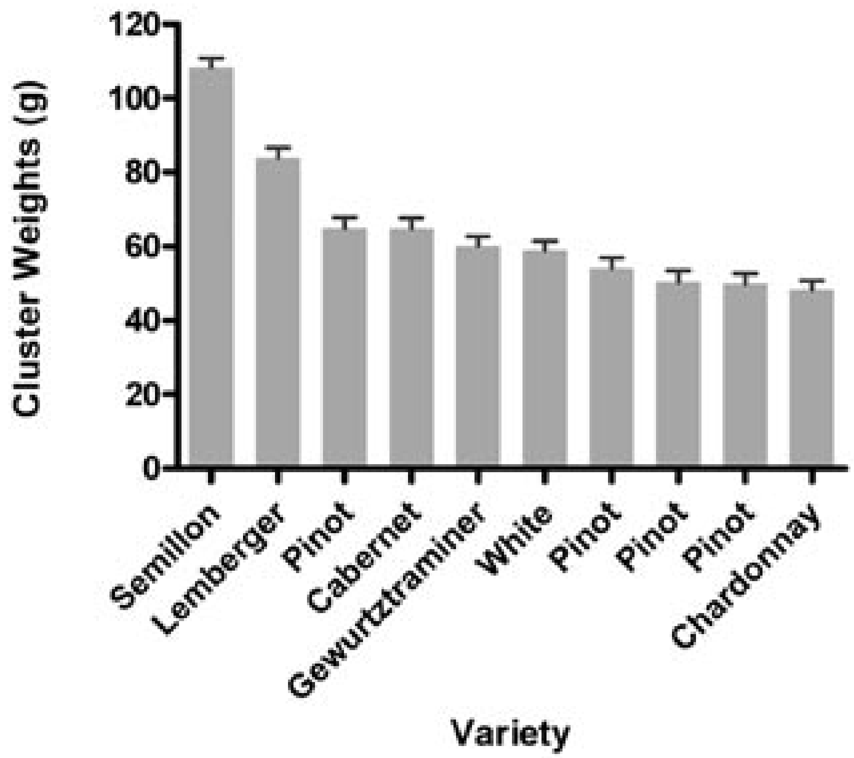


**FIGURE 8.** Average cluster weight by variety over three harvest years, 2001-2003.

There are also significant differences in average cluster weights among varieties (Figure 8).

This is due largely to varietal characteristics, but also illustrates some failures in terms of fruit yield for northern Nevada due to spring frosts. For example, for the last two years, Chardonnay has broken bud first, and as such, has suffered damage due to spring freezes. This has lead to a detrimental impact on cluster weight and numbers. The sugar to acid ratio (Brix/TA) of the musts from all varieties have reached optimum quality values ranging from 3.0 to 4.0 Brix/TA over the three grape producing seasons, (2001 to 2003), indicating that high quality fruit can be produced in northern Nevada (13,14).

## IRRIGATION LEVELS

The low irrigation requirements of Vitis vinifera are well suited for arid Nevada. Results from the VRFL vineyard indicate that premium wine grapes use only one-twelfth the amount of water as alfalfa, one of Nevada's major crops. For example, Churchill County farmers produce quality alfalfa hay with an average application of 3.5 acre-feet of water per acre per season, versus 0.27 acre feet of water per acre per season applied to grapes at the VRFL vineyard in Reno using regulated deficit irrigation.

The implementation of a regulated deficit irrigation scheduling upon established vineyards would represent a substantial savings in irrigation application as compared to present water consumption levels for general agriculture.

In the summer of 2000, irrigation was applied at 75% of crop ET, once plants reached a water potential of -1 MPa. There were a total of nine applications for the entire season resulting in an 80% reduction in water use from the previous year (when regulated-deficit irrigation was not being used). Observations suggest that wine grapes are intolerant to excessive moisture, indicating that water should only be added when needed.

In the summer of 2002, for purposes of other related analyses, the vineyard was divided into two treatments, drought-stressed and well watered. In two of the six blocks, vine water potentials were maintained below –1 MPa, the drought-stressed treatment. To maintain these levels, 60% ET was returned to the plants weekly, in addition to weekly water potential measurements to verify stress

**FIGURE 9.** Grapes vines were protected from birds with netting. Shortly after veraison through full ripening, birds eat the fruit and can destroy the crop.

**Phenological States "The Grapevine Cycle"**

**Bud Break:** Bud completely opens and nascent leaves unfold.

**Bloom:** Fifty percent of the flowers have lost fifty percent of their caps.

**Veraison:** Fifty percent of the fruit changes color and berries soften. Red grapes turn red, white grapes turn gold.

**Harvest:** The sugar to acid ratio (Brix/TA) measures between 3 and 4.

levels. In the other four blocks, 80% ET was returned weekly, along with weekly water potential measurements to certify the vines were maintained with an internal water status between –0.5 and –1.0 MPa. From 2001-2003, using regulated deficit irrigation, an average of 0.27 acre feet of water has been applied per year (a very low level of water application). Overall vine quality, (in terms of survival and dieback) was improved with this watering schedule. The intent is to continue this regulated deficit irrigation regime in future years. This water savings is extremely significant in arid Nevada. The harvests in these reported years were of excellent quality, and wines of the 2003 vintage were highly received at a recent public wine tasting. For a detailed description of the wine tasting results, please see the Nevada Wine Web site: *www.ag.unr.edu/cramer/nevadawinegrapes.htm*.

There is a great deal of promise in the burgeoning Nevada wine industry (Figure 9). Relatively inexpensive land available for viticulture, low water use, and wine tasting along with the bed and breakfast industry make wine grape vineyards an attractive prospect. This investigation explored the possibility of establishing a successful vineyard in northern Nevada and evaluation of the wines produced therein. Results of this study demonstrate the possibility of establishing a successful vineyard in northwestern Nevada with the potential to produce excellent quality wines. Thus, it seems that northwestern Nevada has its own unique set of conditions which favor growing certain wine grape varieties previously thought not to survive and produce here. Further varietal trials are warranted, and should be expanded to include other locations and other desirable varietals.

**TABLE 3:** Percentage of fruit producing vines at the VRFL vineyard from 2001-2004.

| Year | % of Vines Producing Fruit |
|---|---|
| 2001 | 62.4% |
| 2002 | 85.8% |
| 2003 | 87.3% |
| 2004 | 92.8% |

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The researchers gratefully acknowledge the assistance and contribution of *Tahoe Ridge Vineyard and Winery* in their help in establishing the VRFL vineyard at the University of Nevada, Reno.

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