PROJECT PROPOSAL

July 1, 2006 – June 30, 2007

TITLE:

Viticulture and Enology programs for the Colorado Wine Industry

PRINCIPAL INVESTIGATOR

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COLLABORATING INSTITUTIONS

- Colorado Department of Agriculture
- The Colorado Wine Industry Development Board
- Colorado State University

JUSTIFICATION

The Colorado grape and wine industry continues to expand. Preliminary results from the "2005 Colorado Wine Grower Survey" conducted by Colorado State University (Caspari, unpublished) indicate a producing area around 650 acres for 2005, compared to about 250 acres in 1998. The total vineyard area is estimated at 800-850 acres. The number of licensed wineries has increased to 66 as of March 2006. Grape production in 2005 was a new record crop estimated at 1,500-1,800 tons. Early indications are that Colorado's grape production will exceed 2,000 tons in 2006. The grape value alone of such a crop would exceed $2.5 million. Approximately 50 acres of new vineyards were added annually since 1999, and there is no sign of a decline in new plantings. It is expected that the mismatch between grape production and winery capacity / wine sales will continue to widen.

While there is a potential for a further significant increase in the total Colorado grape production, the average yield per acre remains at a fairly low level: the 10-year average is a meager 2.5 tons per acre. In 2005, the average yield was indeed 2.5 tons per acre. Several factors contribute to this low production. First, Colorado has a relatively high percentage of young grape plantings that are just starting to produce a crop. Second, many growers are new to the grape industry and are struggling with some of the basic growing practices. And third, cold temperature injuries (in late fall, winter, and spring) continue to reduce yields on some vineyards to often very low levels. In fact, the low average yields in 2003 and 2004 were due in part to severe cold events in late November 2002 and 2003, and in part to spring frosts. In 2004, about one third of the producing area had damage levels of 50 % and more. For 2005, growers reported damage levels of 10 % or more from winter or spring cold injury on about 100 acres, about 1/6 of the producing area.

Although current production is less than the industry goal the Colorado grape and wine industry is fortunate in that the main growing regions are relatively free of many of the pests and diseases that bedevil other grape growing regions of the world. This lack of

many pests and diseases provides Colorado with a competitive advantage over other areas in the world in the development of "integrated", "sustainable" or "organic" production systems. The research and extension program outlined below continues our long-term goal to develop an "Integrated Production System" for wine grapes in Colorado. Most of the early development and research will be conducted in the research vineyard of the Western Colorado Research Center at Orchard Mesa. When we are confident that these new techniques are beneficial and/or not detrimental, we plan to set up larger-scale trials on grower properties.

The current proposal is a continuation of the previous proposals since 2001. Much of the research efforts that were started in 2001 will continue either in the original form or with minor modifications. The development of an Integrated Production System requires many different skills so there is a continued emphasis on a multi-disciplinary or team approach to research. While the State Viticulturist retains overall responsibility for the research program and delivery of the outcomes, other team members will be the lead investigators in their field of expertise. As an example, CSU scientists Dr Harold Larsen, Department of Horticulture and Landscape Architecture, and Dr Rick Zimmerman, Department of Bioagricultural Sciences and Pest Management, will lead the research efforts in disease and pest control, respectively. Another example of collaborative efforts across state boundaries is the NE-1020 project "Multi-state evaluation of winegrape clones and cultivars" involving viticulture researchers from 20 states.

RESEARCH PROGRAM

I. Development of Integrated Wine Grape Production

1. Disease Control

The long-term objective of our research is to reduce the amount and toxicity levels of disease control substances. There are a number of avenues through which this can be achieved. First, sprays should be applied only if and when needed. Second, alternative control substances with lower toxicity may be used. And third, other cultural practices that may reduce disease development should be utilized (e.g. canopy management, use of natural control organisms). This latter point illustrates the link to and need for an inter-disciplinary approach to research.

Powdery mildew (*Uncinula necator*) continues to be the most important disease of grapevines in Colorado. In recent years, we have provided evidence that a calendar-based spray program to control powdery mildew often results in spray applications in excess of what is needed. Since 2001 we have shown in several studies that the number of powdery mildew sprays can be reduced without increasing the incidence or severity of powdery mildew infections (Larsen and Caspari, 2001; Caspari and Larsen, 2003; Larsen and Caspari, 2004, 2005, 2006). Based largely on our research results, many growers have adopted a more restrictive spray program. We plan to continue our research on powdery mildew control with both testing of new control materials as well as application of GPS/GIS systems to identify infected areas that can be treated separately in an attempt to further reduce pesticide applications. Specific projects for the 2006 season include:

- Test and further develop "soft" control strategies for powdery mildew (Larsen, Caspari)

  There are many control substances with low toxicity levels now available for the control of powdery mildew. Such alternative or soft control substances include

oils (e.g. Stylet oil or jojoba oil), biocontrol agents [(e.g. *Ampelomyces quisqualis* isolate M-10, (AQ10)], and plant defense elicitors. In addition, new products are being released on a continual basis. As the results from previous seasons have been very promising, we will continue to test the efficacy of a number of those substances to control powdery mildew under Colorado conditions. We plan to evaluate those control substances that offer good powdery mildew control and fit well within the framework of an Integrated Production System.

- Application of crop modeling for sustainable grape production (Caspari, Larsen)
  This is an extension of the project previously funded through a Specialty Crops grant, RMAVV and EPA. We are now into the second year of a 2-year extension from EPA Region 8 to investigate the potential of GPS/GIS systems to further reduce pesticide applications in Colorado vineyards. In previous years we have found that powdery mildew infections might be limited to certain areas ("hot spots") within a block/vineyard. If the infected area(s) could be correctly identified, it might be possible to restrict powdery mildew sprays to the infected area(s) (plus a buffer zone). Alternatively, the infected area might be sprayed with a different control substance than the remainder of the vineyard (e.g. a DMI or strobilurin in the infected area and a sulfur in the remaining area).
  In 2005, we have successfully used the approach of spraying hot spots (plus buffer zone) in CSU's research vineyard on Orchard Mesa (Caspari and Larsen, 2006). While there were three fungicide applications over the season, the first and second application was restricted to hot spots, with the final application to the entire vineyard area. As only a combined 90 % of the vineyard area was treated with the first two applications, this approach eliminated the equivalent of 1.1 sprays.
  Similar to 2005, field scouts will evaluate the incidence and severity of powdery mildew on two commercial Chardonnay vineyards on a weekly basis. Scouts will carry a Trimble DGPS system so that we can geo-reference the field observations. As our control strategy is responsive in nature we can not predict when spray applications will be made, what materials will be used, or how much of the vineyard blocks will be treated. Incidence and severity of powdery mildew in our blocks will be compared to similar-sized blocks treated according to the growers' standards.
  In addition, one of our collaborators has another Chardonnay block with a history of a hot spot, and we will evaluate our approach in this commercial block.

2. Pest Control

As mentioned above for disease control, the long-term objective of our research is to reduce the amount and toxicity levels of pest control substances. At present, the grape mealybug, *Pseudococcus maritimus*, is the major pest of grapevines in Colorado. The main damage caused by the grape mealybug is the production of honeydew and/or sooty mold on the fruit which greatly reduces fruit quality. A potentially even bigger threat is the fact that the grape mealybug has also been identified as a vector for grapevine leafroll virus. During the 2004 season we have visited a number of vineyards where vines showed symptoms of grapevine leafroll virus. In at least one case infected vines are thought to have been brought in from the nursery as infected vines were spread randomly

within the vineyard and we did not find any mealybugs. However, with infected vines present the potential exist for further spread should mealybugs ever get established within this vineyard.

Kondratieff and Cranshaw (1994) conducted a survey of grape pests in western Colorado. They observed several species of insects to occur in wine grapes. However, only the grape leafhoppers, *Erythroneura vulnerata* Fitch and *Erythroneura ziczac* Walsh (Homoptera: Cicadellidae) were considered to be of economic importance in western Colorado vineyards. The populations of other insect pests such as grape mealybug, *Pseudococcus maritimus*, and grape berry moth, *Endopiza viteana* (Clemens), were so low they considered it to by highly unlikely for them to ever become significant pests in Western Colorado wine grapes. In 1994 and 1995, Zimmerman et al. (1996) conducted a two-year population study of the grape leafhoppers, *E. vulnerata* Fitch and *E. ziczac* Walsh. They observed these two grape leafhopper species to be the only insects that had populations significantly high enough to warrant control measures.

Since the studies conducted by Kondratieff and Cranshaw (1994) and Zimmerman et al. (1996), there has been a significant increase in grape mealybug populations. During the study of grape leafhopper populations conducted by Zimmerman et al. (1996), only a single small colony of grape mealybug was observed in a single vineyard located on the far east side of Orchard Mesa (Zimmerman, personal observation). In 2001, grape mealybug populations had spread throughout the grape growing region of Mesa County (size of valley). Populations may spread to Delta County vineyards in the future as they have been observed on pears in Delta County (R. Zimmerman, unpublished). Currently grape mealybug populations are causing significant economic damage in some vineyards.

- Determine population dynamics of the grape mealybug, *Pseudococcus maritimus*, in Western Colorado (Zimmerman, Caspari)

  This objective seeks to 1) identify the number of mealybug generations per season; 2) determine the within-vine distribution of mealybug populations; and 3) determine at what part of the growing season crawlers emerge from cryptic locations on the vine.

  Currently, the lifecycle of the grape mealybug is not well understood in Colorado. The lack of critical information regarding grape mealybug population dynamics has been an important reason that growers are having a difficult time controlling grape mealybug populations. Geiger and Daane (2001) found that grape mealybugs inhabit different parts of a vine during different parts of the year, and the majority of grape mealybugs are found in concealed locations.

  Effective chemical control is based on targeting the most vulnerable stages in the grape mealybug lifecycle. The most vulnerable grape mealybug stage is the immature crawler stage. At this stage the crawlers emerge from concealed locations and settle new vine growth and leaves (Geiger and Daane 2001). A grower's ability to control grape mealybug will, in part, depend on targeting this small window of opportunity. There are no degree day models available for predicting the emergence and development of the grape mealybug. This study will attempt to provide biological indicators (i.e. bud burst, grape bloom, etc.) to assist growers in determining emergence of the crawlers from these cryptic locations. A number of Mesa county vineyards with a history of grape mealybug

infestations were scouted on a weekly basis during 2003, and on a less regular basis in 2004. Field observations will continue in the 2006 season.

- Evaluation of new narrow-spectrum insecticides for control of grape mealybugs (Zimmerman, Caspari)
  Currently, growers depend almost entirely on the organophosphate, Lorsban (chlorpyrifos). Insecticides are either applied after honeydew has been observed on vines or as a prophylactic. Both methods have proven to be ineffective to control grape mealybug. In fact, the use of broad-spectrum insecticides in vineyards is considered to be a major contributing factor why mealybugs have become an important pest in vineyards. Monitoring tools such as treatment thresholds are not available for grape mealybugs. Exacerbating the problem of future mealybug control is the potential loss of Lorsban for use in vineyards.
  In the past few years, several new classes of narrow-spectrum insecticides have been developed which have been proven to be active against grape mealybugs in other areas of the United States. The timing and efficacy of these chemicals have not been evaluated under western Colorado conditions: dry climate and high UV levels. However, in 2005 we used the narrow-spectrum insecticide "Applaud" (material donated by Nichino America Inc) at CSU's research vineyard when we had a limited outbreak of grape mealybug infestations. Similar to our approach with grape powdery mildew (see above) we restricted the insecticide application to "hot spots" (plus one or two buffer vines). The control of mealybugs was excellent, and so far our field observations in late May 2006 indicate very low levels of grape mealybugs (only one adult found). Although results are promising it should be noted that this was not a replicated study.
  The use of broad-spectrum insecticides for controlling grape mealybug populations pre-empts the movement of growers into “soft” pest management programs. “Soft” being defined as the use of pest control methods that are narrow-spectrum in nature and have a minimal impact on the environment and human health. These new pesticide chemistries allow growers to take advantage of native natural enemies for control of insect pests. The progress in this objective depends on finding suitable vineyard sites and collaborating growers, as well as at least partial funding from chemical manufacturers.

3. Sustainable resource use

Within an Integrated Production System there is a holistic view of the vineyard environment that requires a sustainable use of vineyard resources, including soil, water, and air. Again, the individual projects listed below are the continuation of our long-term program on the sustainable use of resources.

- Water use of grapevines
  There is a definite lack of understanding of the water needs for grapevines in the Colorado climate. Irrigation inputs vary widely within the Colorado grape industry from too little to grossly excessive watering. An understanding of grapevine water use is a prerequisite for the development of sound irrigation practices. In addition, irrigation management can be a powerful tool to influence

not only grapevine growth but also fruit quality. In the 2001 season, we have used the heat-pulse technique in an attempt to determine the water use of mature grapevines growing at the Western Colorado Research Center at Orchard Mesa. While some progress was made, further work on the heat-pulse technique with grapevines was required. In collaboration with Dr Steve Green of HortResearch in New Zealand, heat-pulse probes were installed in July 2004 in two mature Cabernet Sauvignon vines growing at the Western Colorado Research Center at Orchard Mesa and sap flow recorded for more than three months. In 2005, sap flow was recorded in four Merlot vines from late June until leaf fall, and we plan to repeat this experiment with mature vines during the 2006 season.

II. Cropping reliability

The emphasis in this project is to develop techniques that reduce the risk of crop losses due to cold temperature injuries. Cold temperature injuries include damages caused by winter injury as well as late spring or early autumn frosts.

1. Grape varieties and rootstocks for Colorado

This is an ongoing, long-term study into the suitability of 35 varieties and 4 rootstocks for the Colorado climate. Growth and development of the varieties as well as Chardonnay grafted to four different rootstocks will be monitored throughout the growing season, and yield and fruit quality data will be collected.

We are also part of a US-wide variety evaluation program that received approval in late 2004. The first planning meeting took place in late May 2005 at UC Davis, and the annual meeting was held in November 2005.

- New variety and clonal trial at Rogers Mesa (Caspari)
  A new vineyard was planted at the Western Colorado Research Center at Rogers Mesa in the spring of 2004, with additional vines added in the spring of 2005 and 2006. With the exception of a few missing vines, this planting is now complete. Some of the varieties will have a small crop in 2006, yet the bulk of the block will should into full production in 2008. Genetic background of the varieties include both hybrids, mainly from the grapevine breeding program from Geneva, NY, and *Vitis vinifera*.

- Multi-state evaluation of wine grape cultivars and clones (Caspari)
  This is a long-term (2003-2017), multi-state research project that will test the performance of clones of the major global cultivars and of new or previously neglected wine grape cultivars in the different wine grape growing regions within the U.S. The project is a collaboration of at least 20 states. All participating states will follow the same experimental protocol, which has yet to be finalized by the project's guidance committee. The first meeting of project participants took place at UC Davis in late May 2005, and the annual meeting was held at Virginia Tech's AHS Jr. Agricultural Research and Extension Center near Winchester, VA. Aside from the business meeting (election of officers for next year, etc) the main emphasis of those meetings was to further define the Material and Methods. Three sub-committees were formed during the latter meeting to develop protocols

for 1) juice analysis, 2) nutrition, and 3) meteorology. Also, researchers with existing trials receiving funding via the Viticulture Consortium (East and West) agreed to coordinate both their proposals and methodology for the upcoming funding cycle.
A prioritized list of varieties for the first planting was provided to the Chair in November 2005. Plant material is being prepared for new plantings starting in spring 2007.

- Early hardiness of wine grape cultivars and clones (Caspari)
  This is a new project to evaluate hardiness of grape cultivars at the early dormancy stage. Severe cold events in both November 2003 and 2004 have caused significant bud injury in many vineyards. In fact, these late-fall freeze events appear to have caused more damage than mid-winter and spring freezes. Certain varieties seem to be more susceptible than others, with Merlot and Syrah most sensitive. While much information is available about cultivar differences in maximum cold hardiness, little is known about differences at the early stage of dormancy. Under Colorado conditions, early cold hardiness might be as important, if not more important, than mid-winter hardiness.
  Controlled-freezing tests were conducted in fall 2005 to determine the temperature thresholds at which Colorado's most important grape varieties sustain damage. Results so far indicate that both Merlot and Syrah were acclimating slower than most of the other varieties grown in CSU's variety trial, but gained mid-winter hardiness levels similar to most *V. vinifera* varieties. Those results suggest that the higher damage observed on Merlot and Syrah compared to other varieties following the November cold events in 2003 and 2004 are indeed due to varietal differences in fall acclimation. We will repeat the controlled-freezing test in fall of 2006.

- New rootstock trial with Sauvignon blanc (Caspari)
  A rootstock evaluation project has been initiated with a commercial grower in the Grande Valley AVA. This study will compare the performance of Sauvignon blanc grafted to five different rootstock (four of which have not yet been evaluated under Colorado conditons) to own-rooted vines. The first vines were planted in spring 2006, with some vines to be planted in spring 2007.

2. *Delay of bud burst*
   - Delay of bud burst using spray-on materials (Caspari)
     Late spring freezes can cause significant crop losses. Varieties that break bud early, e.g. Chardonnay and Gewürztraminer, are most at-risk. If cultural pratices can be developed that delay bud break they will reduce the risk of crop losses, and thereby increase the profitability of growing grapes in Colorado's high elevation. Studies have so far focused on materials that might be sprayed onto grapevines during dormancy to delay bud break. We will continue to evaluate spray materials as they become available.

- Effect of pruning time/method on bud burst (Caspari)
  Another option to delay bud break is through timing and/or method of pruning. Early pruning is thought to accelerate bud break, and may reduce winter hardiness. We have evaluated the effect of pruning time on bud break of Chardonnay over the last five years. In the last two years the study was expanded to include all 20 varieties in our variety block. Although some aspects of the studies differed between years, early pruning (late December or early January) was comapred to late pruning (early to mid April) in each year. Generally, time of pruning did not alter the timing of bud break.
  In the winter 2005/06 we also evaluated the effect of pruning method on bud break. Standard spur pruing was compared to the so-called double-pruning method. Shoots were pruned to either short (the standard 2-3 buds) or long spurs (~8 buds). Each pruning method was applied in late December as well as early April. In the spring of 2006, as buds started to push on the top of long spurs, these spurs were pruned again (back to 2-3 buds). Although data analysis has not been completed, field observations indicate a strong delay of bud break with the double-pruning technique, but again no influence of time of pruning. This experiment will be repeated in the next dormant season.

III. Grape and wine quality

The emphasis in this project is to continually improve the quality of the grapes, and the wines made from those grapes. Improving the quality of Colorado wines has been a high-priority area for the Colorado Wine Industry Development Board. While much of the work done so far has and continues to contribute towards the production of high quality grapes, we have not had a specific project on grape and wine quality. This lack of a quality project is due in large parts to limited resources. Grapes are processed into wine, and the final assessment of grape quality is the assessment of the resulting wine. While CSU does have micro-vinification capabilities at the Western Colorado Research Center we currently have neither the staff resources nor the required expertise to make wine from various viticultural experiments. However, with the help of Bill Musgnung, the consulting winemaker contracted by CWIDB, wine was made from a crop load trial initiated in the 2005 season. This trial will continue for another two seasons.

- Effect of crop load on grape and wine quality (Caspari, TBD)
  It is generally accepted that there is a negative relationship between grape yield and grape (and thus wine) quality. In simple terms, as yield per vine increases the quality of the grapes decreases. Initially, a small increase in yield may not alter grape quality at all or cause only a small decrease, but as the grape yield increases each subsequent yield increment leads to a stronger negative effect on quality. And while such yield:quality relationships have been shown in many studies in different parts of the world, there are no data from Coloado. A trial was established in 2005 to provide such data.
  A crop load trial was established on three different commercial vineyards (two Cabernet Sauvignon, one Cabernet Franc) in 2005. On each site, a low crop load was established on 15 vines by removing ~25-33 % of bunches just prior to veraison. Another 15 vines that had no crop removed were selected as control (high crop load). Berry samples were collected for juice analysis about every ten

days starting in early September. At harvest, bunch number and yield was determined for each vine, and a 100-berry sample taken for juice analysis. For each site, fruit from each crop load treatment were pooled, then crushed and fermented separately at CSU's Western Colorado Research Center. Wines were bottled in April 2005.

Vines were pruned in February/March 2006 and the pruning weight determined for each vine. Vines were shoot-thinned in May 2006. Crop load will again be adjusted at the onset of veraison. Data collection and microvinification will follow the same protocol as described above. This experiment will be repeated again in the 2007 season.

TECHNICAL ASSISTANCE

1. Technical assistance to growers

This consists of office consultations, inquiries via phone calls, fax, or e-mails, and field visits addressing a wide range of viticultural aspects. We will also continue to work on updating the "Colorado Grape Growers' Guide" (Bulletin 550A, Colorado State University Cooperative Extension). This Bulletin 550A is currently out of print but the complete text can be downloaded from the web page of the Western Colorado Research Center (www.colostate.edu/programs/wcrc). Since November 2003, many articles have been added to our re-designed viticulture web site, and we will continue to use this web site as the primary means to provide information resources for Colorado growers. Also, as part of the "Application of Crop Modeling for Sustainable Grape Production" project, current weather information from seven vineyard sites is now accessible to grape growers and the public via the internet. We will continue to service both the software and hardware for this weather station network. In addition, meteorological data from a GroWeather station located at the Western Colorado Research Center at Orchard Mesa are also accessible to growers via the web page of the Western Colorado Research Center. A second station has been set up on Stewart Mesa, near Paonia, in the spring of 2001 and a third station was set up in a vineyard in McElmo Canyon, near Cortez, in the spring of 2004. Although meteorological data are being collected, they are currently not available via our web page due to technical limitations.

2. Field demonstrations/workshops/tours

We will continue to provide grape growers with annual field demonstrations (e.g. pruning) and workshops. Tours of the research vineyard and/or the research facilities are provided upon request.

3. Off-station research and demonstration plots

We know from past experience that the uptake of new research results and new production techniques is fastest when growers are directly involved in their development. One way of involving growers in research is to establish research plots on grower properties. Where feasible, we plan to establish research trials in grower vineyards. We will continue to use the vineyard at the Western Colorado Research Center at Orchard Mesa in the first or early stages of testing of new methods and/or trials that carry a high risk of crop damage. However, it is envisaged that off-station research and demonstration plots will play an important part in transferring new technologies once they have been found to be successful. The project "Application of Crop Modeling for

Sustainable Grape Production" involved five commercial vineyards, and we will use two of those vineyards for the GPS study. In addition, one of our collaborators in this study has provided a second Chardonnay block for evaluation. The crop load study started in 2005 is located on three commercial vineyards. Also, in spring 2006 a new rootstock trial with Sauvignon blanc has been initiated on a commercial vineyard. The new vineyard at Rogers Mesa Research Center also will fill a need for more demonstration resources in Delta county.

4. Colorado Wine Grower Survey

Colorado State University has conducted this annual survey for a number of years. The survey will again be conducted in late autumn / early winter 2006. The data will be compiled, summarized and presented to the CWIDB as well as at the RMAVV meeting. A summary will also be available via the viticulture web page.

DURATION

The duration of this project will be from July 1, 2006 through June 30, 2007. However, the research activities that occur during this period will be a continuation and expansion of the entire mission, goals and objectives of the Colorado Wine Industry Development Board.

RESULTS

Results of this project will be presented to the Wine Board directors in the form of progress reports and up-to-date articles posted on the viticulture web page. Research results will also be presented to the general public locally through newsletter, web pages, presentations at RMAVV and grower meetings, and/or state- and nation-wide through scientific presentations and journals.

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BUDGET OUTLINE
July 1, 2006 –June 30, 2007

Salaries	$100,000
Fringe Benefits[1] (payroll costs)	$20,040
Domestic Travel	$1,500
International Travel[2]	$5,000
Materials and Supplies[3]	$7,227
Equipment[4]	$6,000
Total Direct Costs	$140,127
Indirect Costs @ 26 % (excluding equipment)	$34,873
TOTAL BUDGET	**$175,000**

This budget does NOT include the $25,000 approved by the CWIDB for the enology position

Note: This is an estimated budget. As appropriate, the allocation among budget categories, as well as the total amount, may need to be altered.

[1] 20.4 % of salaries
[2] Attendance and presentation at the 5th International Symposium of Irrigation of Horticultural Crops, 28 August - 2 September 2006, Mildura, Australia
[3] for field and laboratory research; includes chemicals, glassware, parts, plant materials, vineyard materials – no office supplies
[4] items in excess of $5,000