

**Enology and Viticulture Program
University of Arkansas Division of Agriculture
Institute of Food Science and Engineering
Fayetteville, Arkansas**

SERA 14 Progress Report on Research Projects 2005-2006

Dr. Justin Morris
Director, Institute of Food Science and Engineering
Distinguished Professor, Department of Food Science
2650 N Young Avenue
Fayetteville AR 72704

Telephone: (479) 575-4040 Fax: (479) 575-2165 jumorris@uark.edu

Dr. Gary Main
Associate in Enology and Viticulture
Telephone: (479) 575-7126 Fax: (479) 575-2165

gmain@uark.edu

Dr. Renee Threlfall
Associate in Enology and Viticulture
Telephone: (479) 575-4677 Fax: (479) 575-2165

rthrelf@uark.edu

Dr. Janice Blevins
Research Associate II
Telephone: (479) 575-4677 Fax: (479) 575-2165

jblevins@uark.edu

Dr. Pamela Brady
Program Associate
Telephone: (479) 575-7042 Fax: (479) 575-2165

pbrady@uark.edu

Dr. Michael Thomsen
Associate Professor of Agricultural Economics and Agri Business
Telephone: (479) 575-3932 Fax: (479) 575-5306

mthomsen@uark.edu

Dr. R. Keith Striegler
Research Co-investigator
Director and Viticulture Program Leader, ICCVE
University of Missouri - Columbia

Telephone: (573) 882-6681 Fax: (573) 882-0596 strieglerk@missouri.edu

Commercialization of the University of Arkansas Patent for Complete Vineyard Mechanization

Justin R. Morris

Since 1966 a major research thrust in the University of Arkansas Enology and Viticulture Program has been the development of a total vineyard mechanization system. Ideally, this system would allow the mechanization of almost all vineyard activities, including dormant pruning, summer pruning, leaf removal, shoot and fruit thinning, canopy management, and harvesting, while maintaining or enhancing fruit quality. Research efforts looked at developing and/or adapting machines to accomplish these tasks on each of the 12 major trellising systems used throughout the world. Also derived were plans for the sequencing and timing of operations on each of the trellis systems. More than 30 publications were prepared reporting on this work. The developmental stages of this research culminated in 2002 when the University of Arkansas received a patent for the Morris-Oldridge Vineyard Mechanization System.

Once the developmental process had been completed, the task of commercializing the equipment and processes began. OXBO International Corporation purchased the patent and began production and marketing of system components under their name vMech™ Vineyard Mechanization System. Working along with an OXBO viticulturalist and engineers, University of Arkansas scientists began research to refine the operation of the System and to determine its effectiveness in a commercial setting. French Camp Vineyards, near Paso Robles, California, was chosen for these studies because the owners and management had an interest in mechanizing the 1750 acre vineyard. They offered a well-established vineyard suitable for developing large research plots with a number of different cultivars and trellis systems, were in a viticultural region that would benefit from the implementation of mechanization, and the vineyard manager, Hank Ashby, was extremely interested in pursuing mechanization for this operation. Mr. Ashby has provided many suggestions that were invaluable in the commercial adaptation of the system.

Mechanization at French Camp Vineyards has utilized our balanced cropping concept which incorporated three operations:

- 1) Machine dormant pruning - to retain the number of nodes necessary to achieve an estimated 200% of the final desired yield level (based on past vineyard records of yield and dormant pruning weights);
- 2) Machine shoot thinning - performed when the new shoots were 10 to 20 cm (four to eight inches) to achieve an estimated 130 to 150% of the desired final yield level; and
- 3) Machine fruit thinning - if the vines were still overcropped for the target yield after the dormant pruning and shoot thinning operations, mechanized fruit thinning during or after the berry growth 'lag phase' was used to reach the desired crop levels.

Results of research in the 2002-2005 seasons have shown that yield and quality characteristics of machine-farmed grapes were not statistically different from those of hand-farmed grapes for the cultivars in this study (Chardonnay, Sauvignon blanc, Merlot, Syrah, Zinfandel, and Sangiovese). After appropriate aging, large batches of wine made from each cultivar were taste tested by a professional wine analysis service. No differences were found between wines from the two farming systems. To date, four publications have reported aspects of the commercialization studies.

In 2005, cost estimates were derived for each of the vineyard activities necessary to achieve balanced cropping. Data for these estimates were obtained from records maintained by the vineyard manager as well as from actual operating costs during the study. Production operations that were not mechanized were assumed to be the same for both farming systems and were not included in the cost estimates. For hand farming, costs were mainly those associated with maintaining a large enough labor pool to assure all operations were performed in a timely fashion. Factors influencing the costs of machine farming included the costs of purchasing or leasing equipment, equipment maintenance and repair, labor to operate and maintain the equipment, and fuel and lubrication costs. Also included in cost calculations was the fact that machine farming increased trellis maintenance requirements by 1% for Lyre and VSP systems. Machine farming resulted in a 42% savings over hand farming for grapes produced on the VSP system, 47% savings on the lyre trellis, and 60% savings on the Quad trellis (Table 1).

Table 1. Comparison of the costs of operations for balanced cropping completed by the vMechtm System vs. hand labor on 3 trellis systems at French Camp Vineyards, California in 2005*

	Total Costs (\$/acre)		
	VSP	Lyre	Quad
Machine farmed			
Prune	119.84	239.67	157.28
Follow-up	67.35	72.08	47.36
Shoot thin	88.97	177.93	133.45
Fruit thin	78.46	78.46	58.84
TOTAL	354.62	568.14	396.93
Hand farmed			
Pre-prune	20.20	40.40	28.40
Prune	251.04	386.92	317.76
Shoot thin	232.00	463.99	463.99
Fruit thin	109.16	175.87	175.87
TOTAL	612.40	1067.18	986.02
DIFFERENCE (Hand - machine)	257.78	499.04	589.09

* Hank Ashby and Drew Piazza of French Camp Vineyards and Greg Berg, OXBO International, Kingsbury, California are acknowledged for their efforts in collecting this data

Economics of Vineyard Mechanization

Michael R. Thomsen and Justin R. Morris

Pruning, shoot thinning, and fruit thinning are three labor intensive operations that can be mechanized within the Morris-Oldridge Vineyard Mechanization System (M-O System). OXBO International Corp. has commercially implemented the M-O System through machinery marketed under the trade name vMechtm. In June 2006 University of Arkansas researchers traveled to the French Camp Vineyards near Paso Robles, California where research studies continue to be conducted to validate the effectiveness of the M-O System. Data from these studies have been used to develop budgets to estimate the economic impacts of mechanizing these operations. Budgets were developed for three trellising systems used by French Camp Vineyards and common to other commercial vineyards in the region. These are the vertical shoot positioned (VSP), modified 2 ft. lyre, and 3 ft. quadrilateral (quad) trellising systems. The manager of the cooperating vineyard has five years experience with the equipment and provided field

speeds, material usage, and other information necessary to compute the costs of machine farming

The costs of mechanically pruning, shoot thinning, and fruit thinning reflect the costs of owning and operating the vMechtm equipment. In the region being studied, shoot thinning is necessary in most years while fruit thinning is necessary in about one of two years. For this reason, the budgets reflect the full costs of a shoot thinning operation and one-half of the costs of a fruit thinning operation. Hand labor is used to follow-up after the pruning operation and is charged as a piece rate. The mechanized operations greatly reduce but do not entirely eliminate the need for hand labor. Small ground crews are needed to follow-up, measure, and provide information to machine operators. Hand farming costs used in the budgets reflect typical practices in the region. Hand pruning is charged as a piece rate and follows a pre-pruning operation. Hand labor for shoot and fruit thinning are charged hourly.

The results show that costs saved through mechanization are economically significant (Table 1). Cost savings range from roughly \$260/acre for vineyards on VSP to nearly \$600/acre for vineyards on quad trellising. Differences in cost savings amongst the trellising systems largely reflect differences in vine spacing that impact field speeds. Piece rates for pruning operations also vary by trellising system. These cost savings range from 42 to 60 percent of the costs of traditional farming methods. The largest cost savings are realized from the shoot thinning and fruit thinning operations. While not directly evident from Table 1, hand labor costs under mechanized farming are only 8 to 15 percent of those under traditional methods.

While these savings are large, the vineyard manager noted that mechanization provides other advantages not reflected in the budgets. First, mechanization helps to stabilize grape yield through the concept of “balanced cropping”. The grower is able to make the final adjustment on crop size late in the growing season and is thereby afforded an opportunity to compensate for crop losses due to frost injury, poor growing conditions, or poor fruit set. Second, by eliminating reliance on hand labor, the vineyard is able to retain fewer but better trained workers. Over time, this promises to reduce overhead for human resources related expenses and lower costs associated with managing liability.

Effect of freezing grape berries and heating must samples on extraction of components and composition parameters of red wine grape varieties

Renee T. Threlfall, Gary L. Main and Justin R. Morris

Juices from grape samples subjected to two storage methods (fresh and frozen) and two post-homogenization treatments (21°C and 71°C) were examined for extraction of grape berry components and compared to a microvinified wine made from the same lot of fresh grapes. Cabernet Franc (*Vitis vinifera*) and Cynthiana (*Vitis aestivalis*) grapes were evaluated in 2003. Cabernet Franc, Cabernet Sauvignon (*Vitis vinifera*),

Chambourcin (interspecific hybrid) and Cynthiana grapes were evaluated in 2004. Fresh grapes from each variety were sampled, analyzed and prepared for microvinification. Frozen grapes of all varieties were thawed and analyzed at the same time. For all varieties in both years, heating the must of fresh or frozen grapes increased the titratable acidity (11–58%), tartaric acid levels (12–110%), potassium content (15–62%), darkness (31–97%), red color (54–1517%) and total red pigment values (36–1171%) of juice as compared to the juice from unheated must. For all varieties in 2004, heating the must from fresh or frozen grapes increased total phenolics (43–619%) of juice as compared to the juice from unheated must. Compared to fresh grape processing, freezing the grapes and then processing at 21°C or 71°C had varying results (increases and decreases) regarding the extraction of components in all varieties and both years but usually provided juice with composition most similar to that of the red wine produced by microvinification. Although the degree of extraction of individual components in the juice is influenced by selection of grape storage and must processing procedures, consistency of handling and procedure provided consistent results with low variability.

Sensory characteristics in relation to composition and nutraceutical content of juice from eight *Vitis rotundifolia* (Muscadine grapes) cultivars

Renee T. Threlfall, Justin R. Morris, Jean-François Meullenet and R. Keith Striegler

Vitis rotundifolia (Muscadine) black cultivars (Black Beauty, Ison, Nesbitt, Southern Home, and Supreme) and bronze cultivars (Carlos, Granny Val, and Summit) were evaluated. The vines yielded 58-74 kg/vine. The juice yields were 473-551 L/t with acceptable soluble solids (12.6-14.6%) and pH (3.09-3.42). Juice total phenolics (179-373 mg/L), total anthocyanins (2-104 mg/L), and Oxygen Radical Absorbance Capacity (2-4 $\mu\text{mol/mL TE}$) were measured. Sixty-one consumers and a trained descriptive panel evaluated the muscadine juices plus two commercial juices (bronze and black). Consumer evaluation on a 9-point hedonic scale for overall liking indicated Black Beauty, Granny Val, Ison, Southern Home, and Summit rated highest. The descriptive panel created a sensory Lexicon with major attributes identified as sweet, sour, cooked muscadine, cooked grape, and astringent. The cooked muscadine flavor was highest in Carlos, Granny Val, and Summit and lowest in Black Beauty, Ison, Nesbitt, Supreme, and commercial black. Descriptive results for sweetness were in agreement with consumer assessment of sweetness on a 5-point Just About Right scale. Sensory results indicated a preference for juice sweetness with soluble solids of $\approx 14\%$ and soluble solids/acid ratios of 31-42 and appearance attributes of juice from black cultivars. Results indicated that these muscadine cultivars can produce quality juice acceptable to consumers with potential nutraceutical impact to expand marketing of muscadine products.

Product Development and Nutraceutical Analysis to Enhance the Value of Dried Fruit

Renee T. Threlfall, Justin R. Morris and Jean-François Meullenet

Value-added fruit products suitable for production by small-scale farmers and processors were developed and evaluated. Apples, blueberries, peaches and strawberries from local growers were processed into a dried fruit product. The total phenolics, total anthocyanins and Oxygen Radical Absorbing Capacity (ORAC) were determined. Drying the fruit increased total phenolics, total anthocyanins and ORAC levels as compared to fresh fruit. The nutraceutical components of the blueberries, peaches and strawberries of the local dried fruit were higher than those of commercial dried fruit purchased at a natural food store. The dried fruit from both the local and commercial fruit was used to create a fruit pie filling for consumer evaluation. Consumer acceptance of fruit pie filling from dried fruit grown locally and dried commercial fruits was evaluated using a 9-point verbal hedonic scale and a 5-point Just About Right scale. In terms of consumer evaluation, the pie fillings made from local dried fruits were either better or at parity with those from commercial products. In addition to the nutraceutical benefits, the pie fillings were products acceptable to consumers that could represent an avenue for small-scale farmers to add value to surplus fruit.

Bioconversion of Malic Acid in Norton and Vignoles Using Genetically Enhanced and Natural Microbes

Gary L. Main, Renee T. Threlfall and R. Justin Morris

The red grape Norton (*Vitis aestivalis Michx.*) and the white grape Vignoles (interspecific hybrid Seibel 6905 X Pinot Noir), can have high malic acid levels that result in tart wines with high levels of malate or lactate. Naturally selected yeast and bacteria were compared to genetically enhanced yeast, ML01, for bioconversion/deacidification of malic acid in production of Norton and Vignoles wines. For Norton, the yeast, BRL97 + malolactic bacteria Lalvin 31, was compared to ML01. For Vignoles, the yeasts ICV-GRE, 71B, ML01 and ICV-GRE + Lalvin 31 were compared to ML01. Wines were produced in triplicate from both cultivars. ML01 converted all the malic acid to lactic acid after 60 hours of fermentation in both cultivars. The 71B yeast metabolized 1.2 g/L malic acid in Vignoles and did not produce lactic acid. ICV-GRE and BRL97 consumed 0.6 and 0.3 g/L malic acid; this resulted in ML01 producing more lactic acid than the yeast/bacteria combinations. Residual sugar was 0.85 g/L higher in ML01 than ICV-GRE and 1.1 g/L higher than BRL97. Reduction of malic acid and/or conversion of malic to lactic acid is feasible with both genetically enhanced and naturally selected microorganisms. However, ML01 generated more lactic acid than the yeast/malolactic bacteria combination and may not be desirable for fermenting high malate must due to the quantity of lactic acid produced.

Rootstock Effects on 'Sunbelt' Productivity and Fruit Composition

Justin R. Morris, Gary L. Main and R. Keith Striegler

'Sunbelt' is a 'Concord'-type juice grape suitable for warm climates. Initial reports indicated that yields for 'Sunbelt' were in the 2.7 to 4.9 tons/acre range. This yield was too low for commercial juice grape production. An experiment was initiated to examine the potential for rootstocks to increase vine capacity and yield of 'Sunbelt' grapes. Treatments included nongrafted 'Sunbelt' and 'Sunbelt' grafted onto Couderc 3309, 'Extra', and 1103 Paulsen rootstocks. Data was collected for two years on a bilateral cordon (BC) training system. Vines were then converted to a Geneva Double Curtain (GDC) training system, and an additional two years of data were collected. Vines were unbalanced on the BC system with low yields and high pruning weights. After conversion to the GDC system, yields tripled with acceptable yield to pruning weight ratios. Rootstock yields averaged across years were 4.3 tons/acre on the BC system and 13 tons/acre on the GDC system. Fruit composition and petiole mineral nutrient values were similar among grafted and nongrafted vines. Statistically significant differences observed among rootstocks were small, differences were not considered great enough to benefit from rootstock use. With proper canopy management, 'Sunbelt' can produce commercially acceptable yield and fruit composition when grown on its own roots. Therefore, unless there are mitigating factors, such as soil pests, or soil type, the use of rootstocks does not appear necessary for 'Sunbelt' grapes

Publications

Morris, J.R. 2005. Successful total vineyard mechanization. *Vineyard & Winery Management*. 31(1):84-90.

Morris, J.R. 2006. Development and incorporation of mechanization into intensely managed grape vineyards. Paper and Abstract Book, *Wine Growing for the Future*, 6th International Cool Climate Symposium for Viticulture and Enology. Pp 68-83

Morris, J.R. 2006. University of Arkansas Grape and Wine Program: The Muscadine Experience. *Proceeds of the Georgia-South Carolina Muscadine Conference*, Savannah, Georgia. Jan. 5-8. Pp. 16-30.

Threlfall, R.T., G.L. Main and J.R. Morris. 2006. Effect of Freezing Grape Berries and Heating Must Samples on Extraction of Components and Composition Parameters of Red Wine Grape Varieties. *Australian J. Grape and Wine Res.* 12:161-169.

Papers Presented at Meetings

Kolympiris, C., M.R. Thomsen, and J.R. Morris. 2006. "An Optimization Model for Winery Capacity Use." Selected Paper to be Presented at the Annual Meetings of the Southern Agricultural Economics Association, Orlando, Florida. February 2006.

Main, G.L., R.T. Threlfall, and J.R. Morris. Bioconversion of malic acid in Norton and Vignoles using genetically enhanced and natural microorganisms. Presented at the 31st Annual Meeting of the American Society for Enology and Viticulture/Eastern Section. Rochester, NY. July 9-11, 2006.

Threlfall, R.T., J.R. Morris, J-F. Meullenet, and R.K. Striegler. 2006. Juice composition, nutraceutical content, and sensory analysis of eight *Vitis Rotundifolia* (Muscadine Grapes) cultivars. Presented at the 31st Annual Meeting of the American Society for Enology and Viticulture/Eastern Section. Rochester, NY. July 9-11, 2006.

Invited Presentations

Morris, Justin R. Developing a Muscadine grape industry: Why research is critical. Southeastern Regional Muscadine Grape Growers Association, Savannah GA. Jan. 2006.

Morris, Justin R. Development and Incorporation of Mechanization into Intensely Managed Grape Vineyards. Keynote Speech at the 6th International Cool Climate Symposium for Viticulture and Oenology, Christchurch, New Zealand. Feb. 2006.

Morris, Justin R. Convener and Facilitator for Panel Discussion: Taking Mechanization Research into the Vineyard at the 6th International Cool Climate Symposium for Viticulture and Oenology, Christchurch, New Zealand. Feb. 2006.

Morris, Justin R. Mechanized vs. Hand: Canopy and Crop Load Management: Effects on Productivity and Wine Quality. Missouri Grape Growers 25th Annual Meeting. St. Genevieve, Missouri. March 11, 2006.

Morris, J.R. Status of Total Vineyard Mechanization, to French Camp Vineyards cooperators and employees. Paso Robles, California. June 22, 2006.