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Agricultural Research Service

Grape/Wine Research Summaries
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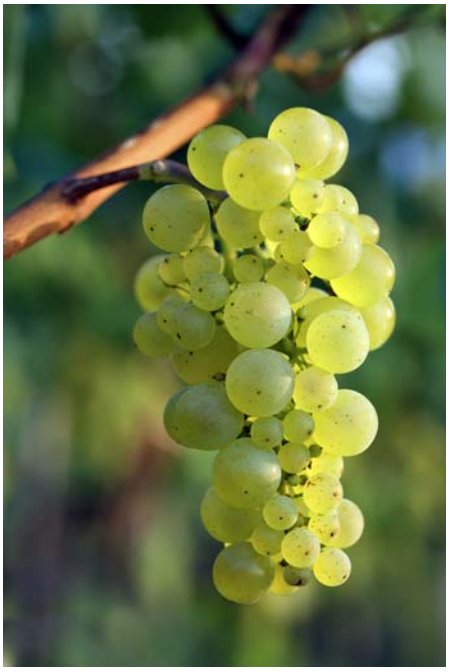

Section I: Breeding/Genetics

Davis, California

- *Development of a National Registry for Grape Varieties and Clones*; Ed Stover

Parlier, California

- *Improvement of Prunus and Vitis Scion and Rootstocks for Fruit Quality and Pest Resistance*; David Ramming and Craig Ledbetter

Geneva, New York

- *Genetics and Genomics of Grape Rootstock and Scion Interactions with Pathogens*; Peter Cousins, Lance Cadle-Davidson, and Gan-Yuan Zhong
- *Genetics and Genomics of Grape Growth, Development and Quality*; Christopher Owens, Amanda Garris, and Gan-Yuan Zhong
- *Conservation and Utilization of the Genetic Resources of Apples, Grapes, and Tart Cherries*; Charles Simon, Angela Baldo, and Philip Forsline

ARS Location:
National Clonal Germplasm Repository
USDA-ARS
One Shields Avenue
Davis, California 95616

Project Title: *Development of a National Registry for Grape Varieties and Clones*

Project Participants:
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Project Objectives:
1. Development of a National Grape Registry, a user-friendly, single-site access to information on availability and characteristics of virtually all grape material in the United States.

Major Accomplishments (2004 – 2007):
In both established and emerging wine regions, there is increasing interest in expanding the diversity of grape varieties, and identifying varieties or clones which may be better suited to individual areas. Quarantine regulations to prevent introduction of diseases make importation of grape varieties from outside the United States an expensive ($1,500-6,000 per accession) and time-consuming option, as a minimum of 2 years of testing is required. The high cost of bringing in new material makes it critical for growers and researchers to be able to verify if there are existing domestic sources bearing appropriate documentation.

Information on grape varieties was collected and assembled, the registry framework and an NGR Web site were developed, variety information was posted to the Web site, and public collections and commercial nurseries were invited and assisted in posting information on their varieties.

Phase 1 of the Web site can be seen at http://ngr.ucdavis.edu/. So far the Web site contains 645 grape varieties, contact information for 64 grape nurseries, and inventory information from all of the major public collections and 13 commercial nurseries.

The National Grape Registry will help viticulturists identify material which is present in the United States, assist them in ordering this material, and will make them aware of the disease testing and identity verification status of the material.

Development of a National Grape Registry (NGR) is one of the identified priorities of the National Grape and Wine Initiative (NGWI).

Technology Transfer/Outreach:
The focus of this project is outreach and education, making information easily available to the grape and wine industries. In addition, to preparing the Web site, efforts have been and will continue to be made to increase awareness of this project. To date, the project has been

described in grower publications (Practical Winery and Vineyard Magazine and FPS Newsletter) and in presentations at client meetings, such as the Unified Grape and Wine Symposium and Foundation Plant Services annual meeting.

External Support:
Viticulture Consortium West
American Vineyard Foundation
Foundation Plant Services, University of California

Collaborators:
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Deborah A. Golino, Director, Foundation Plant Services, Davis, CA
M. Andrew Walker, Professor, Plant Breeder, University of California, Davis, CA

ARS Location:
Grape Genetics Research Unit
630 W. North Street
Geneva, New York 14456

Project Title: *Genetics and Genomics of Grape Rootstock and Scion Interactions with Pathogens*

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Project Objectives:
1. Genetically improve grape scions through the molecular genetic and genomic characterization of disease resistance.
2. Breed, evaluate, and introduce improved grape rootstocks with pest and disease resistance and tolerance to abiotic stress.

Major Accomplishments (2004 – 2007):
Diseases of the fruit, stems, and leaves damage grapevine productivity and reduce grape quality. Improved disease resistant varieties are one management option, but resistance sources must be identified and characterized. More than 1,200 accessions in the Geneva germplasm repository were screened for resistance to the two economically most important fungal pathogens of grapevine, powdery mildew and downy mildew. The 120 accessions in the Geneva grape germplasm repository experimental subset additionally were screened in replicated multilocation tests. These thorough screens provided information to grape breeders, geneticists, plant pathologists, and other researchers seeking durable sources of resistance to these critical diseases. ARS scientists made the first recorded observations of grape berries that do not develop age-related resistance to powdery mildew. Proteins and other grape biochemical constituents associated with resistance to pathogens were characterized. A new grape downy mildew resistance previously found only in cucurbits was identified. The completed screens and the in-depth germplasm characterization that it has stimulated will lead to the breeding and selection of high quality grape varieties with durable disease resistance. This research relates to Processing and Production Efficiency as disease resistant grapevines will require fewer inputs of pesticides and fewer vineyard passes.

Downy mildew is a devastating disease in summer rainfall viticulture regions. Management presently is through fungicides because few varieties with adequate resistance are available. A mapping population from parents in the *Vitis* germplasm collection was developed for identifying molecular markers closely linked to the tissue-specific resistances. Additionally, *Vitis vinifera* germplasm was generated with improved resistance to downy mildew. This work will improve the efficiency of grape scion breeders hoping to select genotypes with resistance to this destructive disease. This research relates to Processing and Production Efficiency as disease resistant grapevines will be more efficiently produced and to Sustainable Practices because the molecular marker associated with resistance will facilitate the improvement of varieties with durable resistance to downy mildew.

Growers of Concord and Niagara grapes in the Lake Erie grape production region desire higher yields of quality fruit. To evaluate the impact of rootstocks on juice grape production, the performance of Concord and Niagara juice grapes on eight rootstocks was observed at two locations, representing poor and well drained vineyards. Although grafted vines suffered more winter injury to trunks than own rooted vines, grafted vines on selected rootstocks produced more fruit than own rooted vines. The observations from these trials will assist growers in choosing a rootstock for their Concord and Niagara vines that will improve performance, fruit quality, and yield. This research relates to Understanding and Improving Quality and to Processing and Production Efficiency as the project was aimed at meeting processor quality standards more efficiently through the use of improved rootstock varieties.

Root-knot nematodes are a serious vineyard pest. Nematode management using methyl bromide and other nematicidal chemicals is not sustainable and virulent nematodes are emerging that can damage important rootstocks. To improve grape rootstocks for resistance to virulent root-knot nematode populations, crosses were made using grape rootstock germplasm and the resistance of over 10,000 unique seedlings was determined by inoculating the plants with infectious virulent root-knot nematodes, then determining nematode reproduction levels following a suitable incubation period. To evaluate the horticultural characteristics of grape rootstock selections and increase plant material for further evaluation and grower trials, 660 grape rootstock selections populations were planted in a vineyard nursery and advanced to horticultural testing. Nematode resistant rootstocks will provide growers with an economical alternative to methyl bromide and preplant fallow. This research relates to Understanding and Improving Quality, Processing and Production Efficiency, and Sustainable Practices as the project will provide alternatives to methyl bromide and provide rootstocks that facilitate production of target quality fruit at economical yields.

Breeding grape rootstocks with improved nematode resistance could be accomplished more efficiently if the inheritance of resistance was fully understood. The allelic relationship of two distinct sources of resistance to virulent nematodes with a third, narrower resistance gene found in common rootstocks like Freedom, was determined. Nematode resistance alleles were combined in one plant, which was crossed to susceptible test parents to reveal possible segregation. Seedlings and parents were screened for nematode resistance in greenhouse testing using egg mass counting. Segregation was observed in populations derived from crosses of both *V. mustangensis* 1842 and *V. vulpina* 1280 with N allele homozygotes, demonstrating that these sources of root-knot nematode resistance are not allelic to the N allele (they are different genes).

Because these accessions have novel sources of nematode resistance that are not allelic to the N allele source, they may be useful in breeding improved nematode resistant rootstocks that do not have the deleterious features associated with N allele nematode resistant rootstocks. Rootstock selections with the novel alleles are in the breeding program and some are in replicated vineyard rootstock trials. This research relates to Sustainable Practices as the project will provide rootstocks with durable, long-term nematode resistance that is an alternative to methyl bromide and other nematicides.

Studying grapevine genetics, genomics, interactions with pests and pathogens, growth and development, and other attributes is challenging because grapevines are relatively large and take several years to flower. In cooperation with the University of California, ARS scientists used tissue culture to develop a dwarf grapevine for experimental and educational purposes. The small stature and continuous flowering of the dwarf grapevine, called Pixie, make the variety useful for research in the greenhouse, growth chamber, and other controlled environments. Pixie grapevines have been distributed to grape researchers and nurseries. This research relates to Extension and Education as the project provides a new tool for scientific study of and teaching about grapevines.

New functional genomics tools are needed in grapevine for leveraging the new complete genome sequence. In collaboration with the Seattle TILLING Project, ARS scientists adapted a method for testing the function of individual genes in grapevine. This technology will allow grape scientists to harness information obtained in other crops and model plants and apply that knowledge to grapevine. This research relates to Extension and Education as it will provide new populations, tools, and methods for genetic evaluation and improvement of grapevines and to Sustainable Practices because these approaches will be used to develop cultivars with durable pest and disease resistance.

Technology Transfer/Outreach:
Improved germplasm has been distributed to extension researchers in Illinois, Missouri, and California, for cooperative variety trials and for grower trials of selections and germplasm in California and New York.

Each year, ARS project scientists participate in industry and grower meetings and transfer research results, information, and technology through presentations, and in response to direct inquiry from grape growers, packers, and processors.

Presentations at Grower Meetings, Field Days, and Industry Scientific Meetings:

- American Society for Enology and Viticulture national meeting: ARS booth with research information and research poster, June 2007
- Origin of major current rootstocks and impact on vine characteristics. Wineries Unlimited, King of Prussia, Pennsylvania, March 2007.
- USDA-ARS grape rootstock breeding program update. Wineries Unlimited, King of Prussia, Pennsylvania, March 2007.
- Why we need rootstocks, why we need research. Illinois Grape Growers and Vintners Association annual meeting, Springfield, Illinois, February 2007.

- Rootstocks growers can use: present and future. Illinois Grape Growers and Vintners Association annual meeting, Springfield, Illinois, February 2007.
- American Society for Enology and Viticulture national meeting: ARS booth with research information and research poster, June 2006.
- Selecting the right rootstock for your vineyard. Ohio Grape-Wine Short Course, Wilmington, Ohio, February 2006.
- Clean plant material for a healthy and productive vineyard. Ohio Grape-Wine Short Course, Wilmington, Ohio, February 2006.
- Breeding Grapevine Rootstocks for the San Joaquin Valley, San Joaquin Valley Grape Field Day, University of California Kearney Research and Extension Center, Parlier, California, August 2005.
- American Society for Enology and Viticulture national meeting: oral presentation of research results, June 2005.
- Evolution, genetics, and breeding: viticultural applications of the origins of our rootstocks. Mid-America Grape and Wine Conference, Lake of the Ozarks, Missouri, February 2005.
- Breeding rootstocks for the San Joaquin Valley. San Joaquin Valley Grape Day, Easton, California, January 2005.
- American Society for Enology and Viticulture national meeting: two research posters, June 2004.

External Support:

Cornell Federal Formula Funds - Employing qPCR-based early detection of *Botrytis cinerea* as a disease management tool.

Cornell Federal Formula Funds - Recessive disease resistance in *Vitis* for the development of durably resistant cultivars.

American Vineyard Foundation/Viticulture Consortium West - Accelerating the development of powdery mildew resistant grapevines through marker-assisted selection.

USDA-ARS Germplasm Evaluation Grant - Evaluation of isolate-specific resistance and field resistance to foliar powdery mildew and downy mildew in a replicated experimental subset of the cold-hardy grapevine collection.

Viticulture Consortium East - A directed, non-transgenic approach to recessive disease resistance in *Vitis* toward development of durably resistant cultivars.

Viticulture Consortium East/New York Wine and Grape Foundation - Molecular Epidemiology And Characterization Of Botrytis Quiescence In Developing Grape Berries.

American Vineyard Foundation, California Table Grape Commission, and California Raisin Marketing Board. - Breeding Rootstocks Resistant to Aggressive Root-Knot Nematodes. (2004-2007).

Cornell Federal Formula Funds, Lake Erie Regional Grape Program, Grape Production Research Fund, New York Wine and Grape Foundation Evaluation of rootstocks for Concord and Niagara

in the Lake Erie production region, Viticulture Consortium and New York Wine and Grape Foundation. (2004-2007).

USDA-CSREES - Applied Grape Genomics CAP conference (July 2007) grant to conduct conference to initiate organization of interdisciplinary teams (research, extension, education, outreach) to deliver benefits of grape genomics to grape growing industry. (2005)

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ARS Location:
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Project Title: *Genetics and Genomics of Grape Growth, Development, and Quality*

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Project Objectives:
1. Determine some of the key genetic factors controlling environmental adaptation and fruit quality differences among cultivated grapes and between cultivated and wild grapes.
2. Develop grape germplasm with novel phenotypes for fruit quality traits.

Major Accomplishments (2004 – 2007):
Adaptation: Low temperature tolerance. Low-temperature damage can cause significant crop loss to grapes in many production regions, and can occasionally require the replanting of new vineyards. In order to better understand the genetic mechanisms underlying the vast amount of variation that exists among cultivated and wild grapes for low-temperature tolerance, populations of siblings from crosses made between parents of different low-temperature tolerance were made. ARS scientists have measured several traits related to low-temperature tolerance and identified the location of many molecular markers within a single population of 130 plants. Regions of the genome that house genes controlling the differences within these populations for low-temperature tolerance have been identified. This information is the starting point for the higher resolution identification of specific genes controlling traits important for determining low-temperature tolerance. Knowledge of the specific low-temperature tolerance genes can be used to more efficiently combine low-temperature tolerance with fruit quality in grape breeding programs and provide basic knowledge on the grapevine's response to low-temperature which could be used to develop new techniques to enhance low-temperature tolerance of existing varieties. This research relates to Processing and Production Efficiency as grapevines with higher levels of low-temperature tolerance will reduce crop and vine losses due to severe winters.

Adaptation: Canopy light microclimate. The radiation microclimate of the grapevine canopy has significant effects on grape yield and quality. In addition, the phytochomes have been suggested

to control aspects of fruit ripening. Experiments with shading of clusters has revealed cluster-specific effects on fruit quality. When increased temperature is experimentally decoupled from light levels, clusters exposed to sunlight are larger, accumulate higher levels of sugars, and show earlier fruit softening. Fruit exposed to light are higher in anthocyanins and phenolics when compared to shaded fruit, and phenylalanine ammonia lyase increases with exposure to light. In order to dissect the relationship between light exposure and quality traits, we have identified five photoreceptor genes in *V. vinifera* and *V. riparia*, determined their location in the grape genome, and assessed differences between *V. vinifera* and *V. riparia*. This research relates to Understanding and Improving Quality, specifically addressing the affect of light exposure on fruit quality.

Fruit quality: color. Fruit ripening, composition, and flavor are regulated by a complex interaction of the grape variety, the environment, and management practices. Our understanding of genetic mechanisms underlying this complex interaction is very limited. To better understand the genetic mechanisms underlying differences in flavonoid and anthocyanin content among cultivars of *V. vinifera,* the structure of a specific gene known to regulate flavonoid accumulation was determined in several hundred cultivars of *V. vinifera*. By analyzing the DNA sequence of specific genes in over 200 individuals with diverse fruit color, it was determined that variation in one key regulatory gene explained a large percentage of the observed fruit color variation in *V. vinifera*, including cultivars that have highly pigmented berry flesh. This information can be used for more efficient combination of important traits in wine and table grape breeding programs and can be also used to develop novel cultivars with enhanced nutritional quality, specifically antioxidant levels. This research relates to Understanding and Improving Quality as greater knowledge of the genetic mechanisms underlying fruit quality traits provides key information in the manipulation of these fruit quality traits both in the generation of new varieties and in the manipulation of these traits in the vineyard.

Grape Germplasm: Frontenac blanc. Combining high fruit quality with outstanding levels of cold hardiness in newly bred grape cultivars is difficult due to the complex genetic nature of the traits involved. By taking advantage of naturally occurring color sports of the existing cold-hardy wine grape cultivar 'Frontenac' it should be possible to generate a novel white-berried color sport of this popular variety for northern viticultural regions. The grey-fruited sport of this cultivar, Frontenac gris, is chimeric in nature, meaning the plant's multiple tissue layers are slightly different genetically. We have successfully separated these tissue layers through tissue culture and are now testing for the emergence of a white-fruited sport through the use of molecular DNA-based markers. Initial results of testing 43 regenerated plants show that a small percentage of these plants are white-fruited and can be transferred to a field setting until they bear fruit for evaluation. The development of a white-sport of Frontenac will provide a new wine grape cultivar with high disease resistance and cold hardiness for cultivation in regions with severe winters. This research relates to Processing and Production efficiency as it seeks to develop a new cultivar for production of high-quality fruit and outstanding cold hardiness.

Grape Germplasm: Vignoles. Vignoles has become a valuable component of the variety mix in the eastern United States, and consumers appreciate its distinctive apricot, peach, and citrus notes in wines. Because it is relatively winter hardy (reliably to –15 ºF), Vignoles is grown in diverse locations. However, Vignoles has small, tight clusters prone to bunch rot later in the season.

Losses up to one third of the crop are possible in rainy years. Despite consumer demand for Vignoles, the production of these wines is limited by the disease susceptibility caused by tight clusters. Our goal is to develop an improved, loose-clustered clone of Vignoles through mutagenesis. To date, 500 mutants have been planted to the Portland Vineyard Lab at Cornell University and 2,000 additional mutants have been generated for planting in May 2008. This research relates to Processing and Production efficiency, as a new clone of Vignoles would improve the production efficiency of the grape variety.

Technology Transfer/Outreach:
We are in regular contact with the publicly funded grape breeders in the United States to develop technology suitable for increasing the breeding efficiency of new grape cultivars. Each year we also participate in industry meetings and transfer information, and research highlights through presentations and in response to direct inquiry from grape growers, processors, and wine-makers.

External Support:
USDA-CSREES Viticulture Consortium East - Quality Improvement in 'Vignoles' Through Clonal Selection

USDA-CSREES Viticulture Consortium - Development of Frontenac Blanc, a Cold-hardy Disease-resistant White Wine Grape. PI: Christopher Owens (co-PIs: D. Tricoli, J. Luby).

USDA-CSREES Viticulture Consortium - Improving the cold hardiness of high-quality wine grape cultivars. PI: Christopher Owens

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John Clark, University of Arkansas
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ARS Location:
Plant Genetic Resources Unit (PGRU)
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Project Title: *Conservation and Utilization of the Genetic Resources of Apples, Grapes, and Tart Cherries*

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Project Objectives:
1. Acquire, maintain, characterize and distribute cold-hardy grape genetic resource collection.
2. Analyze genetic diversity of a large sample of extremely diverse grape germplasm using SSR and sequence based markers.
3. Generate DNA fingerprints (SSR) of entire Geneva grape germplasm collection and coordinate effort with Davis collection.
4. Map and study entomological ecology traits (and others) on extremely wide F1 population.

Major Accomplishments (2004 – 2007):
The Geneva germplasm repository maintains, characterizes, and distributes a collection of some 1,500 grape accessions. About half of those accessions fall into the category commonly called the "French-American hybrids", which have both European and American grape species in their pedigree. Nearly all of the remaining grapes are of North American origin. All of these accessions are documented on the Germplasm Resource Information Network (GRIN) website (www.ars-grin.gov) with nearly complete passport data available, numerous viticultural and phenotypic descriptors, including complete data for 17 key descriptors on 900 accessions, and photo documentation for over 400 grape accessions. Recent additions to the Geneva collection have come through the acquisition of 16 new accessions in 2004 from the collection of the late Minnesota breeder Elmer Swenson, who bred several varieties that have exceptional quality, considering their extreme levels of cold hardiness. In summer 2006, a team of scientists lead by Heidi Schwaninger of the PGRU collected grape seeds and cuttings from wild grapes native to Alabama, Florida, Louisiana, Mississippi, and Texas. Approximately 100 of the accessions collected from this trip are being added to the grape repository in Davis. A third recent example of new acquisition to the Geneva collection is the adoption of a genetic mapping population

created by Cornell grape breeder Bruce Reisch into the USDA collection. This population is significant in that it has at least five, maybe six, grape species in the pedigrees of the parents used to make the cross. It therefore exhibits extreme levels of genetic segregation for many, many traits. More on this population is discussed below.

A 3-year study on the worldwide distribution of genetic diversity in grape to investigate the genetic relationships among and between 42 *Vitis* species is nearly complete. It involves over 300 accessions of *Vitis* sampled from the USDA germplasm collections at Geneva, New York (80), Davis, California (90), and the university at Yangling, Shaanxi, Peoples Republic of China (140). The gene sequences of coding regions are published as public EST sequences. The particular genes used in this study were chosen for their moderate level of sequence polymorphism found within *V. vinifera*. As this study surveys broadly across the genus, genes that were both monomorphic and highly polymorphic in *V. vinifera* were avoided, so that a moderate level of polymorphism could be predicted and utilized in this study. Specifically, 3,972 genes were computationally predicted to show variability in *V. vinifera*, with 96 showing fewer than 20 predicted single nucleotide polymorphisms (SNPs). These were amplified across a panel of *Vitis* species and 30 were chosen that amplified widely across the genus. These 30 sequences were selected for resequencing across the 300+ samples in the survey. Based on the analysis of 29 genes in 260 accessions, these accessions were grouped generally by species and geographic origin. New World, Asian, and European grapes are almost perfectly grouped. Additional analysis by principal component analysis of the sequence variations is being used to identify regions of informative sequence variation that will then be used to develop single nucleotide polymorphism (SNP) assays that can be used across the entire *Vitis* genus.

Establishment and development of SSR fingerprint databases for both the Geneva and Davis grape collections is underway, and is being coordinated with parallel efforts at the French repository in Montpelier. An initial database of 8 SSR loci will be established, with possible eventual expansion to 20 loci. Fingerprints will be determined for every plant in each collection – even reps of clonal accessions – as a measure of "quality control" in labeling, naming, etc.
A project that is in collaboration with three Cornell researchers (funded by an NRI grant) is near the end of its first cycle. This project examines tritrophic relationships of pestiferous and predatory mites on grapes as impacted by grape leaf trichome (hair) anatomy. PGRU contribution includes molecular analysis of a mapping population involving five or six grape species that is segregating broadly for trichome anatomy and distribution, in the interest of dissecting quantitatively inherited genetic factors contributing to trichomes (QTL's). A likely result of this research will be the development of potential marker-assisted selection (MAS) tools for grape breeding, which would also be quite useful for characterization of the USDA collection. Results to date illustrate clearly that trichome covered (hairy) grape surfaces enhance the feeding ability of the predatory mites on the pestiferous mites, suggesting a genetic and breeding approach toward enhanced integrated pest management (IPM) through breeding "hairy" grape varieties. This project further involves the examination of meaningful variation in the North American grape gene pool, as a "byproduct" of the mapping effort should disclose markers of broad utility across the grape genus, since traits beyond trichome features are being examined.

Technology Transfer/Outreach:
Distribution of grape germplasm is a primary mission of the grape repository unit. Since 2004, PGRU has distributed 8,593 grape germplasm samples to 383 requestors. Since 1994, 16,373 samples have been distributed to 901 requestors. The PGRU is also quite active in describing and documenting grape germplasm accessions on the GRIN web site with over 17,000 descriptor data points for the Geneva grape collection and over 400 pictures.

Presentations at grower meetings, field days, and industry scientific meetings:
Our primary outlet for presentations of our projects and the results of our research are in scientific journals and meetings. Since the PGRU primary stakeholder is the grape variety research and development community (breeders, etc.), our interface directly to the grape industry is somewhat limited. Instead, we have a more secondary role in supporting those who have more direct industry support role. We do present our program directly to industry whenever it makes sense to do so, and it is quite gratifying to see how well we are received by the industry, who almost always appreciates the significance of our role. But our "primary" customer remains the grape R&D community.

External Support:
USDA-ARS North Atlantic Area office - develop the grape fingerprint databases. (2006)

USDA-ARS National Program Staff - research on the grape sequence variation project described above. (2005)

NRI - project described above.

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Gan Yuan Zhong, ARS, Geneva, NY
Greg English-Loeb, Cornell University
Jan Nyrop, Cornell University
Bruce Reisch, Cornell University
The National Plant Germplasm System (NPGS) Crop Germplasm Committee (CGC) for grapes,

ARS Location:
Crop Diseases, Pests, and Genetics Research Unit
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Project Title: *Improvement of Prunus and Vitis Scion and Rootstocks for Fruit Quality and Pest Resistance.*

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(Note: Dr. Ledbetter's research is limited to almonds and stone fruits and is not reported here.)

Project Objectives (Grapes only):
1. Develop scion grape cultivars for fresh market with high quality and storage ability.
2. Develop disease and pest resistant *Vitis* scions.
3. Develop genetic information to facilitate selection and enhance breeding efficiency.

Major Grape Research Accomplishments (2004-2007) – (Grapes only):
The California Table Grape Industry needs better seedless table grapes that require less production costs, have large berry size, are productive, and store and ship well. These cultivars need to ripen in a sequence to provide consumers with red, white, and black seedless grapes from May through December. A traditional sexual hybridization program hybridizing seedless with seedless table grapes and utilizing embryo rescue/tissue culture methods is being used to produce new genetic material from which selection of the new cultivars is made. Autumn King and Scarlet Royal table grape cultivars were released to the industry July 13, 2005. Autumn King provides the grape industry with a very large, late ripening white seedless table grape that will extend the season of white grapes after Thompson Seedless. Scarlet Royal provides the grape industry with a large, mid-season, neutral-flavored, red seedless table grape that will fill the gap in red seedless grapes between Flame Seedless and Crimson Seedless. This research relates to Understanding and Improving Quality and to Processing and Production Efficiency.

The California Raisin Industry is suffering from high harvest cost, lack of labor, and low prices for raisins, which make raisin production marginally profitable. Early ripening cultivars that dry without cutting canes on a standard trellis would reduce production costs and increase grower return. A traditional sexual hybridization program crossing seedless with seedless raisin grapes and utilizing embryo rescue/tissue culture methods is being used to produce new genetic material from which selection of the new cultivars is made. One hundred forty three selections with natural dry-on-the-vine capability have been selected and planted in two vine plots. Three

advanced selections with consistent DOV ability have been planted in a replicated production trial. These selections have the potential to provide cultivars that can dry without cutting canes and be mechanically harvested without supplemental drying. This will reduce production costs by reducing hand labor and allow the use of less expensive trellis systems. This research relates to Understanding and Improving Quality and to Processing and Production Efficiency.

Powdery mildew is the most important fungus disease of grapes in California and many other grape production areas of the world. Resistant cultivars are needed to reduce the amount of pesticides used in grape production. Grape germplasm has been identified by field and greenhouse screening and hybridized with high quality table and raisin grapes. Germplasm originating from China has been identified that shows complete leaf resistance or susceptibility without intermediates in the greenhouse and a modified BC2 generation has been created for inheritance and molecular marker studies. This population will help elucidate the mechanism of resistance, the development of molecular markers, and the development of resistant cultivars with high fruit quality. This research relates to Understanding and Improving Quality and to Processing and Production Efficiency.

Technology Transfer/Outreach:

- Patented and assigned table grape cultivars to the California Table Grape Commission for propagation and distribution to the grape industry.
- California Table Grape Commission Research committee participates in the evaluation of new USDA table grape advanced selections.
- Table and raisin grape cultivar releases and status of breeding research is reported at industry meetings and California State University, Fresno, grower field days.

External Support:

Development of Seedless Grapes for the Fresh Market Including Types Resistant to Powdery Mildew.

- California Table Grape Commission (2004 – 2007)
- California Competitive Grants Program for Research in Viticulture and Enology. (2005 – 2007).
- Viticulture Consortium West. (2006)

Evaluation of Advanced Grape Selections in the Coachella Valley.

- California Table Grape Commission (2004 – 2007)

Development of Improved Raisin Grapes for Mechanical Harvest Including Types Resistant to Powdery Mildew.

- California Raisin Marketing Board. (2004 – 2007)
- California Competitive Grants Program for Research in Viticulture and Enology. (2004-2007)

Collaborators:

Gary Takeoka, ARS, Albany, CA
Lance Cadle-Davidson, ARS, Geneva, NY
Hong Lin and Joe Smilinack, ARS, Parlier, CA
Mathew Fidelibus, University of California Cooperative Extension-Davis, CA
Carmen Gispert, University of California Cooperative Extension-Riverside, CA

Section II: Crop Production Systems

Poplarville, Mississippi

- *Small Fruit Cultural and Genetic Research for the Mid-South*; Barbara Smith, James Spiers, and, Stephen Stringer

Corvallis, Oregon

- *Production Systems to Promote Yield and Quality of Grapes in the Pacific Northwest*; Jungmin Lee, Krista Shellie, and Julie Tarara
- *Influence of root growth, development, and function on horticultural crop productivity and quality*; R. Paul Schreiner and Carolyn Scagel

ARS Location:
Horticultural Crops Research Unit
3420 N.W. Orchard Avenue
Corvallis, Oregon 97330

Off-site scientists at:
24106 N. Bunn Rd. (Tarara)
Prosser, Washington 99350

29603 U of I Lane (Lee, Shellie)
Parma, Idaho 83660

Project Title: *Production Systems to Promote Yield and Quality of Grapes in the Pacific Northwest*

Project Participants:
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Julie Tarara, Research Horticulturist
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Project Objectives (2003-2008):
1. Develop irrigation practices that support sustainable production of high quality wine and juice grapes.
2. Determine effects of the variations in temperature found in the field environment on budburst, flowering, and fruit quality of grapevines.
3. Develop and test an automated method for estimating yield in grapevines.
4. Evaluate wine grape varieties and clones grown in a cool, semiarid climate for horticultural characteristics, berry composition, and wine quality.

Major Accomplishments (2004 – 2007):
Often, "new" grape producing regions present the scientist with questions that may on the surface seem uniquely local, but from which one hopes to advance a more general understanding of viticulture and enology. Recent accomplishments from Parma-based ARS scientists of the Horticultural Crops Research Unit exemplify this springboard approach. A descriptive analysis of geologic, soil, and climatic characteristics of the western Snake River Plain was conducted in conjunction with scientists from Boise State University. For the scientific community, the work

was published in *GeoScience Canada*, an international peer-reviewed journal that over the past few years has entertained papers along the theme of *terroir*. This information was used directly by the Idaho Grape Growers and Wine Producers Commission to petition TTB for the first AVA in that state, awarded in 2007. Thus the information addressed the NGWI theme area of 'Extension/Education.' Contact Dr. Krista Shellie for more information.

A demand for more complex biochemical analyses of wine is being driven by broad consumer interest in potential health benefits of wine that have been publicized by mass media. In keeping with the concept of ARS advancing science while benefiting the grape and wine industry, a survey was completed to characterize *antioxidant activity* and *stilbene levels* in wines produced from grapes grown in the Snake River Valley. The industry recognizes the need for sound science to support or refute health-related pronouncements that become hot-button issues or that shift consumer perceptions. Knowledge in the public domain about antioxidant activity and stilbene concentrations in *V. vinifera* wines can be applied by individual wineries and the industry as a whole. Analyses of this type typically are beyond those pursued by in-house winery labs, and require more sophisticated analytical equipment than that maintained by all but the largest wineries. Advances made by ARS scientists in applied phenolic chemistry will make good science available to the industry, the public, and the media. Focused work on analytical methods eventually may make these analyses feasible across the industry, and it addresses the NGWI theme area 'Understanding and Improving Quality.' The overall theme of the research also addresses 'Consumer Insights, Nutrition, and Community.' Contact Dr. Jungmin Lee for more information.

Current industry methods of estimating yield in vineyards rely on costly hand-collected samples that provide only a snapshot of the crop. As an alternative, the Prosser-based ARS team has developed an automated system for continuously monitoring vine growth and crop development. Yields also have been estimated from this system, with estimates refined on a daily basis right up to harvest. This Trellis Tension Monitor (TTM) method involves direct measurement of tension in the trellis wire by load cells, and interpretation of the increase in wire tension during the season to infer crop growth and development, to make estimates of final yield, or to schedule additional hand sampling. Continuous information about vine growth and crop development has not been available before. Thus the potential impact on the industry could be significant if this information helps growers and wineries monitor vineyards more efficiently, improve yield estimations between veraison and harvest, or better allocate labor through improved timing of hand sampling. Large wine companies in the United States and Australia have begun to experiment with the TTM technique, which addresses the NGWI theme area of Processing and Production Efficiency. Contact Dr. Julie Tarara for more information.

Technology Transfer/Outreach:

- Presentations at major industry meetings and industry-targeted short courses across the Pacific Northwest, including those sponsored by the Idaho Grape Growers and Wine Producers, the Washington Association of Wine Grape Growers, the Washington State Grape Society, the Washington Wine Industry Foundation, and Wine Yakima Valley.
- Demonstrations of research during summer field days that are organized by various industry groups and Extension faculty from nearby Land Grant universities.

- Research results regularly are presented at the annual meeting of the Northwest Center for Small Fruits Research, which is open to researchers and interested members of the industry; and the annual meeting of the American Society for Enology and Viticulture.

In 2005, the AOAC, an international body that approves methods in analytical chemistry, accepted the following method that was developed in collaboration with several universities: "determination of monomeric anthocyanin pigment content by pH differential method of fruit juices, beverages, natural colorants, and wines."

In 2005, the Trellis Tension Monitor technology was awarded a U.S. patent, and now is available for licensing from ARS and/or cooperative development towards a marketable product for commercial vineyards. Application of the technique is being tested by a major winery in the United States and one in Australia.

External Support (2004-2007):
USDA ARS, Northwest Center for Small Fruits Research - Particle Film and Deficit Irrigation: Partners to Enhance Wine Grape Quality and Sustainability. In-kind (particle film material) and grant support also provided by Engelhard Corporation (BASF). (2005-2007)

USDA ARS, Northwest Center for Small Fruits Research - Water Management to Optimize Canopy, Yield, and Quality of Cabernet Sauvignon. (2004)

USDA CSREES, Viticulture Consortium-West - Coordinated Wine Grape Variety Evaluations in the Western United States (Co-PI with UC-Davis faculty on *NE1020* regional project). (2007)

USDA ARS, Northwest Center for Small Fruits Research - Understanding micro-oxygenation techniques and the oxidation of grape/wine polyphenolics. (2005-2007)

USDA CSREES, Viticulture Consortium-West - A novel method for continuous monitoring and yield estimation in vineyards. (2005-2007)

USDA RMA, via Washington Wine Industry Foundation - Automated crop load and yield estimation techniques. (2005-2008)

American Vineyard Foundation - Effect of cluster temperature on the composition of berries grown under field conditions. (Co-PI with OSU faculty). (2006-2008)

Collaborators:
Dave Bryla, ARS, Corvallis, OR
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Bob Martin, ARS, Corvallis, OR
Carolyn Scagel, ARS, Corvallis, OR
Paul Schreiner, ARS, Corvallis, OR
Kerri Steenwerth, ARS, Davis, CA
Mike Glenn, ARS, Kearneysville, WV

Universities:
David Wilkins, Boise State University, Boise, ID
Virginia Gillerman, Idaho Geological Survey and Boise State University, Boise, ID
Jim Kennedy, Oregon State University, Corvallis, OR
Michael Qian, Oregon State University, Corvallis, OR
Bernadine Strik, Oregon State University, Corvallis, OR
Ron Wrolstad, Oregon State University, Corvallis, OR
Jim Wolpert, University of California-Davis, Davis, CA
Markus Keller, Washington State University, Prosser, WA

Industry:
Ron Bitner, Bitner Vineyards, Caldwell, ID
Nick Dokoozlian, Ernest & Julio Gallo Winery, Modesto, CA
Jordan Ferrier, Hogue Cellars, Prosser, WA

Grower-Cooperators and Other Industry Partners:
(vineyard and winery access, material support, etc.):
Robin Matson, Engelhard Corporation (BASF), Yakima, WA
National Grape Cooperative, Grandview, WA
Chuck Devlin, Ste. Chapelle Winery, Caldwell, ID
Dominique Mahe, Willakenzie Estate, Yamhill, OR
Dale Jeffers, Winemakers, LLC, Skyline Vineyard, Nampa, ID

ARS Location:
Horticultural Crops Research Laboratory
20 NW Orchard Avenue
Corvallis, Oregon 97330

Project Title: *Influence of root growth, development, and function on horticultural crop productivity and quality.*

Project Participants:
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Project Objectives:
1. Define nutrient requirements and optimize management practices to meet those requirements in grapevines and Rhododendron, emphasizing product quality.
2. Characterize the role of mycorrhizal taxonomic diversity and identify important root-mycorrhizal interactions in cropping systems.

Major Accomplishments (2004-2007 – Grapes Only):
Determined grapevine nutrient uptake and allocation patterns for all major plant nutrients over 2 years in a non-irrigated Willamette Valley vineyard. The timing of nutrient uptake by grapevines and the quantities of nutrients required to produce a high quality fruit crop for Western Oregon climate and soils were unknown. We destructively harvested all vine organs of 21-22 year-old 'Pinot noir' grapevines, measured N, P, K, Ca, Mg, Fe, Mn, B, Zn, and Cu in each organ, and modeled nutrient uptake from soil. Results showed that non-irrigated grapevines grown in Western Oregon acquire nutrients from soil earlier during the growing season, and rely more heavily on stored nutrient reserves in roots and trunks than vines grown in other grape-growing regions. Winegrape growers in Western Oregon now know the annual nutrient requirements for Pinot noir grapevines and have a better understanding of the time that specific nutrients are taken up from soil to guide fertility management. Results from this study will help growers utilize nutrients more efficiently and produce high quality fruit products in a sustainable manner. This research relates to NGWI research priorities 1, 3, and 4; to better understand fruit quality, increase production efficiency, and farm more sustainably. (Schreiner, Scagel & Baham)

Assessed the role of arbuscular mycorrhizal fungi to promote growth and nutrient uptake by grapevines in different soils. All grapevines, including rootstocks, are known to form symbiotic associations with arbuscular mycorrhizal fungi (AMF) in their roots, but the benefits to vines may be dependent on soil properties such as nutrient availability and on the particular fungi

colonizing roots. In a series of greenhouse studies, we determined the growth and nutrient uptake response of Pinot noir grapevines grown in different soils, with different fungi (either native or nonnative to the soil tested) to better understand how these factors influence grapevine benefit from AMF symbiosis. Results showed that vines grown in a typical red hill soil (dominant viticulture soils in Oregon) are completely dependent on AMF to obtain enough P for normal growth, while vines grown in a more fertile valley soil achieved similar levels of growth with or without AMF. The type of AMF fungus and whether or not the fungus was native or exotic to the different soils did not have a large influence on root colonization or on the growth benefit of vines. However, differences in the ability of certain fungi to promote uptake of specific nutrients (copper and sulfur) were found. These experiments show that grapevines planted on sites with red hill soils absolutely require AMF, but growers can be less concerned about AMF when planting vines in valley soils. The use of AMF that are native to a particular soil is not a critical factor for vine establishment. This research relates to NGWI research priorities 3 and 4, to increase production efficiency and farm more sustainably. (Schreiner)

Demonstrated that deficit irrigation reduces fine root growth, but enhances reliance of vines on arbuscular mycorrhizal fungi in an arid vineyard. Effects of water deficits on above-ground physiology of grapevines are known, but little is known about how water deficits alter root or mycorrhizal activity below-ground. We studied fine root and arbuscular mycorrhizal fungi (AMF) colonization responses of Cabernet Sauvignon grapevines to different levels of regulated deficit irrigation (RDI) in an arid Washington vineyard. Vines exposed to greater water deficit (30-35 percent FVET) either prior to veraison or after veraison, as compared to standard water deficit (60-70 percent FVET), produced less fine roots but had higher levels of arbuscules in those roots (indicator of active nutrient exchange between AMF and roots). Results indicate that the vigor reduction due to greater water deficit in arid regions is related to lower root production, but resulting vines appear to be more reliant on AMF to maintain nutrient and water supply to the canopy. Less water can be applied to produce a high quality crop in this region than the standard RDI practice, because roots are more efficiently using AMF. This research relates to NGWI research priorities 1, 3, and 4; to better understand fruit quality, increase production efficiency, and farm more sustainably. (Schreiner, Tarara & Smithyman)

Assessed competition between mowed alleyway cover crops and grapevines for water and nutrients in two Willamette Valley vineyards. Tillage of vineyard alleyways (between rows of vines) has recently increased in Oregon because growers are concerned that alleyway vegetation competes with vines for water or nutrients and reduces must nitrogen and fruit quality. We tested the hypothesis that alleyway cover crops compete with vines for water and nutrients by comparing vine performance in two commercial vineyards with seven different alleyway crop treatments (including a clean cultivated control). Results showed that no cover cropped treatment (with some treatments resulting in high biomass) had reduced vine nutrient uptake, increased vine water stress, or reduced yield or quality over two years with typical summer rainfall patterns. Therefore, winegrape growers in the Willamette Valley should be less concerned about competition from alleyway vegetation and maintain covers in alleyways to promote soil stability on slopes and maintain soil organic matter. This research relates to NGWI research priorities 1, 3, and 4; to better understand fruit quality, increase production efficiency, and farm more sustainably. (Sweet & Schreiner)

Discovered that ring nematode feeding on Pinot noir roots reduces active arbuscular mycorrhizal fungi colonization in roots by limiting carbohydrate availability to symbiotic fungi. Ring nematodes are the most common plant-parasitic nematode infesting Oregon vineyards and were previously shown to reduce arbuscules in fine roots (site of nutrient transfer between arbuscular mycorrhizal fungi (AMF) and roots). We tested the hypothesis that ring nematodes reduce arbuscules in fine roots via carbohydrate limitation to symbiotic fungi by manipulating ring nematodes and light levels in greenhouse studies. Ring nematodes reduced root starch, arbuscules in roots, and plant P and K uptake under controlled conditions supporting our hypothesis. However, plants grown under low light were not more susceptible to ring nematode damage indicating that other factors play a role in nematode-AMF interactions in vine roots. Elucidating how nematodes alter colonization patterns by AMF and root physiology in grapevines will lead to a better understanding of how and when to manage ring nematodes in vineyards. This research relates to NGWI research priorities 3 and 4, to increase production efficiency and farm more sustainably. (Schreiner & Pinkerton)

Technology Transfer/Outreach:

- Peer-reviewed publications (see addendum)
- Reports/Proceedings Publications (see addendum)
- Presentations where growers/managers present (see addendum)

External Support:

Grants:

Northwest Center for Small Fruits Research - Identifying Optimal Nutrient Concentrations for Premium Winegrape Production based on Physiological Needs and Fruit Quality. (2004-2005)

Northwest Center for Small Fruits Research - Water and Nutrient Competition with Cover Crops in Willamette Valley Vineyards. (2004-2005)

Northwest Center for Small Fruits Research - Evaluation of Nematode Resistant Grape Rootstock for Managing *Mesocriconema xenoplax.* (2005-2007)

Northwest Center for Small Fruits Research - Grape Phenolics and Wine Quality: Measuring Spatial Variability in a Commercial Vineyard using Precision Agriculture Tools. (2004)

Northwest Center for Small Fruits Research - Soil solarization as a component of an integrated program to control *Phytophthora* root rot of red raspberry. (2004)

Washington State Concord Grape Research Council - Assessing whole plant mineral nutrient distribution in Concord Grape. (2005)

USDA ARS Pacific Area-Wide Pest Management Program For Integrated Methyl Bromide Alternatives - Methyl Bromide alternatives for red raspberry and forestry nurseries. (2007)

In kind:

Benton Lane Vineyards - land and labor over 3-year study on foliar P fertilizers.
Stoller Vineyard/Argyle - land and chemicals over 3-year study on lime study.

Archery Summit/Jacob Hart Vineyards - land, machinery, and some labor on cover crop trials
Ste. Michelle Wine Estates - land, soil and water data on deficit irrigation trial.
Temperance Hill, King Estate, Doerner, and Walnut Hill Vineyards - land for inoculation trials.
Lorane and Duarte Nurseries – donating plant material (grafted vines) for various studies.

Collaborators:
Leigh Bartholomew - Archery Summit
Allen Holstein/Rollin Soles - Argyle Winery
David Bryla, ARS, Corvallis, OR
Jack Pinkerton, ARS, Corvallis, OR
Carolyn Scagel, ARS, Corvallis, OR
Kendra Baumgartner, ARS, Davis, CA
Jungmin Lee, ARS, Parma, ID
Julie Tarara, ARS, Prosser, WA
Matt Compton - Benton Lane Vineyards
Tom Lodge - Lorane Grapevines
Stirling Fox - Oregon Grape Management
John Baham, Oregon State University
Les Fuchigami, Oregon State University
Jim Kennedy, Oregon State University
John Luna, Oregon State University
Michael Qian, Oregon State University
Patty Skinkis, Oregon State University
Joey Spatafora, Oregon State University
Rebecca Sweet, Oregon State University
Andy Gallagher - Red Hill Soils
Russell Smithyman - Ste. Michelle Wine Estates
Dai Crisp - Temperance Hill Vineyard
Robert Bugg - UC-SAREP
Joan Davenport - Washington State University
Tom Walters - Washington State University

Addendum

Project Title: *Influence of root growth, development, and function on horticultural crop productivity and quality*
(Schreiner, Scagel)

1) Peer-reviewed publications:

Pinkerton, J. N., Schreiner, R. P., Ivors, K. L., and Vasconcelos, M. C. 2004. Effects of *Mesocriconema xenoplax* on *Vitis vinifera* and associated mycorrhizal fungi. Journal of Nematology 36: 193-201.

Schreiner, R. P. and Linderman, R. G. 2005. Mycorrhizal colonization in dryland vineyards of the Willamette Valley, Oregon. Small Fruits Review 4:41-55.

Schreiner, R. P. 2005. Spatial and temporal variation of roots, arbuscular mycorrhizal fungi, and plant and soil nutrients in a mature Pinot noir (*Vitis vinifera* L.) vineyard in Oregon, USA. Plant and Soil 276:219-234.

Schreiner, R. P. 2005. Mycorrhizae and mineral acquisition in grapevines. In Proceedings of the Soil Environment and Vine Mineral Nutrition Symposium. Christensen, L. P. and Smart D. R. (Eds.), American Society of Enology and Viticulture, Davis, CA pp 49-60.

Schreiner, R. P., Scagel, C. F., and Baham, J. 2006. Nutrient uptake and distribution in a mature 'Pinot noir' vineyard. HortScience 41:336-345.

Scagel, C. F. and Schreiner R. P. 2006. Phosphorus supply alters tuber composition, flower production, and mycorrhizal responsiveness of container-grown hybrid Zantedeschia. Plant and Soil 283:323-337.

Schreiner, R. P. 2007. Effects of native and nonnative arbuscular mycorrhizal fungi on growth and nutrient uptake of 'Pinot noir' (*Vitis vinifera* L.) in two soils with contrasting levels of phosphorus. Applied Soil Ecology (accepted March 1, 2007).

Schreiner, R.P., Tarara, J.M. and Smithyman, R. P. 2007. Deficit irrigation promotes arbuscular colonization of fine roots by mycorrhizal fungi in grapevines (*Vitis vinifera* L.) in an arid climate. Mycorrhiza (accepted March 5, 2007).

2) Reports/Proceedings Publications:

Cortell, J., Baham J., Connelly, A., Gallagher, A., Halbleib, M., Pinkerton, J., Righetti, T., Schreiner, R. P., Watson B. and Kennedy, J. 2004. Grape Phenolics and Wine Quality: Measuring Spatial Variability in a Commercial Vineyard using Precision Agriculture Tools. 2004 Proceedings of the Northwest Center for Small Fruits Research. pp. 108-110. (Proceedings)

Schreiner, R. P., Lee, J., Kennedy, J., Qian, M., Connelly, A. Fuchigami, L. Davenport, J., and Campbell, A. 2005. Identifying optimal nutrient concentrations for premium winegrape production based on physiological needs and fruit quality. 2005 Proceedings of the Northwest Center for Small Fruits Research. pp. 79-81. (Proceedings)

Schreiner, R. P. and Sweet R. 2005. Water and nutrient competition with cover crops in Willamette valley vineyards. 2005 Proceedings of the Northwest Center for Small Fruits Research. pp. 82-85. (Proceedings)

Cortell, J., Baham J., Connelly, A., Gallagher, A., Halbleib, M., Pinkerton, J., Righetti, T., Schreiner, R. P., Watson B., and Kennedy, J. 2005. Grape phenolics and wine quality: measuring spatial variability in a commercial vineyard using precision agriculture tools. 2005 Proceedings of the Northwest Center for Small Fruits Research. pp. 119-124. (Proceedings)

Bristow, P. R., Pinkerton J. N., Schreiner, R. P., and Walters T. 2005. Soil solarization as a component of an integrated program to control Phytophthora root rot of red raspberry. 2005 Proceedings of the Northwest Center for Small Fruits Research. pp. 36-37. (Proceedings)

Schreiner, R. P., Lee, J., Kennedy, J., and Qian, M. 2006. Identifying optimal nutrient concentrations for premium winegrape production based on physiological needs and fruit quality. 2006 Proceedings of the Northwest Center for Small Fruits Research. 4 pages. (Proceedings)

Schreiner, R. P. and Sweet R. 2006. Water and nutrient competition with cover crops in Willamette valley vineyards. 2006 Proceedings of the Northwest Center for Small Fruits Research. 4 pages. (Proceedings)

Schreiner, R. P., Pinkerton J. N., and Bryla, D. 2006. Evaluation of nematode resistant grape rootstock for managing Mesocriconema xenoplax. 2006 Proceedings of the Northwest Center for Small Fruits Research. 2 pages. (Proceedings)

Davenport, J. R., Pradubsuk, S., Keller, M., and Schreiner P. 2006. Assessing whole plant mineral nutrient distribution in Concord Grape. Washington State Concord Grape Research Council 2005 Progress Reports. pp. 17-21. (Proceedings)

3) Presentations where growers/managers present:

"Grapevine Nutrition and Management." Department of Horticulture, Oregon State University. (2004)

"Mycorrhizae and Mineral Acquisition in Grapevines." Soil Environment and Vine Nutrition Symposium, 55th Annual Meeting of The American Society for Enology and Viticulture, San Diego, CA. (2004)

"The role of Mycorrhizae in Washington Viticulture." Washington Association of Winegrape Growers Annual Meeting, Yakima, WA. (2005)

"Creative cover-cropping strategies for Willamette Valley vineyards." 56th Annual Meeting of the American Society for Enology and Viticulture, Seattle, WA. (2005)

"Interactions between ring nematodes (*Mesocriconema xenoplax*) and arbuscular mycorrhizal fungi (AMF) in grape roots: competition for photosynthate? Soil Science Society of America Annual Meeting, Indianapolis, IN(2006)

"Soil Biology, Nutrients, Roots, and VAM." Integrated Pest Management for Winegrapes Workshop. Chemeketa Community College, Salem, OR. (2007)

"Cover crops have little influence on Pinot noir performance. 58th Annual Meeting of the American Society for Enology and Viticulture, Reno, NV. (2007)

"Deficit irrigation enhances arbuscular colonization of fine roots by mycorrhizal fungi in grapevines." American Society for Horticultural Science Annual Meeting, Scottsdale, AZ(2007)

Numerous presentations for funded projects at the Annual Northwest Center for Small Fruits Research Meeting. (2004-2007)

ARS Location:
USDA-ARS Thad Cochran Southern Horticulture Laboratory
P.O. Box 287
810 Highway 26 W.
Poplarville, Mississippi 39470

Project Title: *Small Fruit Cultural and Genetic Research for the Mid-South*

Project Participants:
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Stephen Stringer, Research Geneticist
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Project Objectives:
1. Develop improved fresh market and processing muscadine grape germplasm and cultivars that possess enhanced vigor, environmental stress tolerance, expanded harvest seasons, high yield capacity, disease and insect resistance, and improved fruit quality and nutriceutical value to support the southeastern United States muscadine grape industry.
2. Develop new and improved cultural practices, disease and insect control strategies, and management techniques for muscadine grapes to increase yield, minimize production losses, improve fruit quality, and conserve use of natural resources.
3. Determine nutritional and cultural requirements of muscadine cultivars and selections. Identify factors that regulate plant diseases, pollination efficiency, flowering, fruiting, dormancy, yield, cold hardiness, and tolerance to environmental stress in muscadine.
4. Optimize methods of disease and insect control, planting systems, irrigation, and modified cultural systems for muscadines.
5. Develop technology to improve efficiency of handling, harvesting, and cooling of muscadines.

Major Accomplishments (2004 – 2007):
Muscadine grapes are the only cultivated grape native to North America and due to disease pressure from various fungi and bacteria are the only type of grape widely grown in the southern United States. Muscadines have always been highly prized for their unique and pleasant flavors, but more recently are being sought out by consumers for their nutriceutical properties which are associated with high concentrations of phenolic compounds. Fruit from selections developed in

our breeding program and germplasm from various other programs have been screened for fruit quality and nutriceutical value. An advanced strain, CD8-67, originating from the University of Florida was found to have very good horticultural qualities as well as high concentrations of ellagic acid, a phenolic compound known to promote coronary health, and has been released as a new cultivar named Eudora. Since Eudora is a pistillate cultivar, when interplanted in vineyards with sufficient self-fertile pollinators, it will provide growers with a high quality muscadine grape which will allow them to capitalize on value-added health benefits. This work relates to NGWI priorities by providing a new muscadine grape cultivar with improved quality which also possesses relatively high concentrations of nutriceuticals. Muscadine grapes are an excellent source of phytochemicals (such as resveratrol) that are beneficial in the human diet leading to reduced risk of heart disease and cancer. We determined that when diseases of muscadine fruit are controlled the level of resveratrol is severely reduced. We have modified the fungicide spray schedule for control of fruit disease which resulted in increased levels of beneficial phytochemicals in the fruit. We demonstrated that fewer, properly timed, fungicide applications effectively controls the major berry diseases of muscadines and also saves growers the expense of additional chemicals and applications.

Technology Transfer/Outreach:
Several project activities to transfer information on muscadine grapes are conducted annually. An annual muscadine grape field day is conducted at our ARS field site at McNeil, Mississippi, where growers are given the opportunity to learn about muscadine grape production practices and about existing and new cultivars. Presentations have also been given at annual grower association meetings in Alabama, Mississippi, and Georgia to provide updates on research and information on new cultivars and disease control recommendations.

External Support:
None

Collaborators:
Penny Perkins-Veazie, ARS, Lane, OK
Bill Cline, North Carolina State University
Dennis Gray, University of Florida
Patrick Conner, University of Georgia

Section III: Pest Management Systems

Davis, California

- *Sustainable Management of Grapevine Diseases and Weeds*; Dan Kluepfel, Kendra Baumgartner, Kerri Steenwerth, and Andrew McElrone
- *Pacific Area-Wide Pest Management Program for Integrated Methyl Bromide Alternatives*; Greg Browne and Dong Wang

Parlier, California

- *Alternatives to Chemical Control for Stored Production and Quarantine Pests of Fresh/dried Fruits and Nuts;* Judy Johnson, Charles Burks, Lodewyk Kuenen, James Leesch, Joel Siegel, and Victoria Yokoyama
- *Chemically Based Methods as Alternatives to Methyl Bromide for Postharvest and Quarantine Pests*; James Leesch, Charles Burks, Lodewyk Kuenen, Joel Siegel, and Victoria Yokoyama
- *New Technologies to Extend the Postharvest Life of Table Grapes*; Joseph Smilanick
- *Epidemiology and Management of Xylella fastidiosa (Xf) and other Exotic and Invasive Diseases and Insect Pests*; Elaine Backus, Jianchi Chen, Craig Ledbetter, Hon Lin, David Ramming, Mark Sisterson, and Drake Stenger
- *Alternatives to Methyl Bromide for California Cropping Systems*; Dong Wang, Sally Schneider, and Tom Trout

Fort Pierce, Florida

- *Glassy-winged sharpshooter and Pierces Disease*; Wayne Hunter

Columbia, Missouri

- *Development of an Artificial Diet for the Glassy-winged Sharpshooter*; Thomas Coudron.

Fargo, North Dakota

- *Development of Cold Storage Technology for Mass-reared and Laboratory-colonized Insects*; Roger Leopold

Corvallis, Oregon

- *Exotic, Emerging, Re-Emerging and Invasive Plant Diseases of Horticultural Crops*; Walter Mahaffee
- *Integrated Management of Virus Diseases of Small Fruit Crops*; Robert P. Martin
- *Biology and Management of Soilborne Diseases of Horticultural Crops*; J. Pinkerton, Paul Schreiner, and D. Bryla

Weslaco, Texas

- *Biological Control of Invasive and Exotic Pests;* Joseph Patt, Jesus de Leon, John Adamczyk, and John Goolsby

ARS Location:
Biological Control of Insects Research Laboratory
1503 S. Providence Road
Columbia, Missouri 65203

Project Title: *Development of an Artificial Diet for the Glassy-winged Sharpshooter (GWSS)*

Project Participant:
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Project Objectives:
1. Evaluate artificial diet delivery systems for rearing GWSS.
2. Formulate and evaluate artificial diets for the development and reproduction of GWSS.

Major Accomplishments (2004 – 2007):
The inability to rear GWSS has hampered the efforts of researchers to understand and environmentally manage Pierce's disease. The development of an artificial rearing system for GWSS will enable the continuous cost-effective production of high quality GWSS for research and for the production of biological organisms for the control of GWSS. More than 25 diet delivery systems in combination with over 10 diet formulations were simultaneously evaluated. Effective diet delivery systems and functional diets were developed for the artificial rearing of immature and adult stages of GWSS that has the potential to greatly improve production when compared to current plant-based rearing systems. An optimized artificial rearing system for GWSS is expected. The benefit to NGWI will be the development of new and innovative control methods, for an insect pest and a pathogen of grapes, which reduce losses, cost and environmental impacts.

Technology Transfer/Outreach:
These results are being used by Federal and academic researchers studying the transmission of Pierce's disease, and by researchers improving the mass production of beneficial insects for the control of GWSS.

External Support:
California Department of Food and Agriculture.

Collaborators:
Sandra L. Brandt, ARS, Columbia, MO
Wayne Hunter, ARS, Ft. Pierce, FL
Maureen K. Wright, ARS, New Orleans, LA
Elaine Backus, ARS, Parlier, CA
Joe Patt, ARS, Weslaco, TX

ARS Location:
Horticulture Crops Research Laboratory
3420 NW Orchard Avenue
Corvallis, Oregon 97330

Project Title: *Exotic, Emerging, Re-Emerging, and Invasive Plant Diseases of Horticultural Crops*

Project Participant:
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Project Objectives:
1. Describe the pathogen biology of exotic, emerging, re-emerging, and invasive plant pathogens affecting horticultural crops.
2. Characterize host ranges and levels of resistance of hosts to exotic, emerging, re-emerging, and invasive plant pathogens affecting horticultural crops.
3. Apply knowledge of biology, ecology, and epidemiology to the development of improved integrated disease management approaches.

Major Accomplishments (2004 – 2007):
Powdery mildew does not always develop in vineyards each year or disease is not observed until late in the year, indicating that inoculum is not always present. Developing economical methods to determine inoculum presence could reduce the need for some fungicide applications. Methods for trapping aerial borne spores of grape powdery mildew and obtaining DNA that was suitable for detection and quantification using PCR and qPCR analyses were developed. We were able to detect inoculum presence prior to observing symptoms and to use detection to accurately time fungicide applications. These new methods will allow for highly accurate assessments of when an epidemic begins in a specific field and timing of fungicide applications. Preliminary results indicate that two or more applications could be eliminated in most years. It could also result in a more accurate determination of when environmental conditions favorable to spore movement occur and lead to more accurate assessment of disease incidence. (Collaborator Gary Grove)

The Gubler/Thomas model for grape powdery indicates that pesticide applications are needed 30-40 days prior to disease development in the field. Trap plants were used to monitor ascospore release and release events correlated to weather data. This relationship was used to modify the Gubler/Thomas to more accurately reflect ascospore release in the Willamette Valley. Current testing indicates that most ascospores are released prior to bud break and that inoculum initiating the epidemic is originating outside of the field. If these algorithms are accurate, 1-2 early season fungicide applications could be saved, thus increasing sustainability. (Collaborator Gary Grove)

Grape powdery epidemics in the climates of Oregon and Washington do not appear to be accurately modeled by the Gubler/Thomas infection risk forecaster. The model appears to underestimate the impact of high temperatures on infection and inoculum availability. In controlled environments, the effect of diurnal fluctuation in temperature on infection frequency was examined. Days when temperatures were greater than 32C (90F) for 2 or more hours

significantly reduce disease development and killed a large proportion of colonies 1-3 days old. Modifications to the Gubler/Thomas infection risk model are currently being evaluated to improve the timing of fungicide applications in small plots and will be later validated in commercial vineyards. This new information will result in a modified infection risk model of grape powdery mildew that will likely reduce the number of fungicide applications in the hotter grape growing regions. (Collaborator Gary Grove).

A quantitative PCR protocol based on TaqMan probes to detect and quantify the spores with a point mutation in the CYP51 gene that is associated with resistance to sterol biosynthase inhibitors (DMI fungicides) was developed. This technique will be tested for specificity and accuracy under field conditions. If the procedure proves specific for *E. necator* (grape powdery mildew) the technique could help growers determine whether DMI fungicides will be useful in management of grape powdery mildew. (Collaborator Gary Grove).

A system to deliver virtual weather stations on a 1 kilometer grid was developed. Using climate and geographic data publicly available, weather data will be downscaled to 1 kilometer grids and used to run pest and crop models. Growers will be able to obtain accurate historical and forecasted weather data that is suitable for running pest and crops models without the expense of obtaining and maintaining weather equipment. This information will increase growers' ability to make management decisions and improve sustainability. (Collaborators Gary Grove, Leonard Coop, Chris Daly, Paul Jepson, George Taylor, Allan Fox, David Gent, William Pfender, Doug Gubler, and Carla Thomas).

Technology Transfer/Outreach:

- Six presentations to grower groups; eight farm visits to assist with diagnosis of potential disease problems. (2005-2007)
- On-farm research is conducted at three Oregon vineyards to evaluate the practicality and logistics of using the molecular detection technology for scheduling fungicide applications for grape powdery mildew.

External Support:

USDA NRICGP (Biosecurity) with L.C. Coop, P.C. Jepson, C. Daly, G. Taylor. (2006-2009)
USDA CSREES, Western Region IPM Workgroups, P.C. Jepson, L.C. Coop. (2004-2007)
Northwest Center for Small Fruit Research, with G.G. Grove 2004-2006
American Vineyard Foundation (with G.G. Grove). (2005)

Collaborators

David Gent and William Pfender, ARS, Corvallis, OR
Allan Fox - FoxWeather Inc.
Leonard Coop, Chris Daly, Paul Jepson, George Taylor - Oregon State University
Doug Gubler and Carla Thomas - University California, Davis
Gary Grove, Washington State University
Dr. Gary Grove - Washington State University

ARS Location:
Horticultural Crops Research Unit
3420 N.W. Orchard
Corvallis, Oregon 97330

Project Title: *Integrated Management of Virus Diseases of Small Fruit Crops*

Project Participant:
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Project Objectives (2007-2011):
1. Determine the nature and etiology of uncharacterized as well as new and emerging virus diseases of small fruit crops.
2. Develop effective, economic, and environmentally safe methods to manage virus diseases of small fruit crops.
3. Evaluate natural and pathogen derived resistance strategies as a means of controlling virus diseases in small fruit crops.

Major Accomplishments (2004 – 2007):
Identification of viruses most prevalent in vineyards in the Pacific Northwest has been determined. Current efforts include characterization of the variability of the more common viruses (*Rupestris stem pitting associated virus* – RSPaV; *Grapevine leafroll associated virus 1, 2* and *3*, GLRaV – 1, GLRaV – 2, and GLRaV – 3). Understanding the variability of strains of each virus is important for the development of detection methods that will be useful in certification programs. In addition, a Pinot noir research vineyard was established in the spring of 2007 with one clone of Pinot noir (Pommard) on four different root stocks (3309, 101-14, 420-A and Riparia Gloire) as well as self-rooted vines to study the effect of these viruses on vineyard establishment, evenness and timing of fruit ripening, and fruit quality. Vines will be grafted with combinations of the above viruses in the spring of 2008. Growth and graft union compatibility will be evaluated for 2 years, then fruit yield and quality will be evaluated in subsequent years. *Tomato ringspot virus* (ToRSV) recently has been identified in vineyards in Oregon. The nematode vector, *Xiphinema americanum* has been identified in many vineyards in the Pacific Northwest previously. In grafted vines this virus is causing a severe graft union necrosis. Management strategies involving cover crops to reduce soil movement, localized soil treatments to reduce nematodes with replanting, and the use of cover crops that are not hosts for the virus which have been successful for the management of ToRSV in raspberries will be tested to reduce the impact and spread of this virus in vineyards in Oregon.

Technology Transfer/Outreach:
- Research results have been presented at annual industry meetings in Oregon (Oregon Wine Board), Washington (Washington Association of Wine Grape Growers) and Idaho (Idaho Grape Growers and Wine Producers).
- Unit research on grapes has also been made at several industry meetings.

- A stakeholders' meeting was organized at the Research Unit in November 2006 in which all Unit research was presented.
- Research results have also been presented at the annual meeting of the Northwest Center for Small Fruits Research, which is attended by industry members in the Pacific Northwest.

External Support:
Oregon Wine Board - Survey for Viruses and Pierce's Disease in Oregon

Washington Association of Wine and Grape Growers - Survey for Viruses of Vineyards in Washington.

Northwest Center for Small Fruit Research - Profiling viruses associated with grapevine leafroll disease in the vineyards of the Pacific Northwest. (2006-2009)

Northwest Center for Small Fruit Research - Impact of rootstock-scion-virus interactions on grape yield and quality attributes. (2006-2009)

Collaborators:
John Pinkerton, ARS, Corvallis, OR
Jungmin Lee, ARS, Parma, ID
Valerian Dolja, Oregon State University, Corvallis, OR
Patricia Skinkis, Oregon State University, Corvallis, OR
Vaughn Walton, Oregon State University, Corvallis, OR
Ken Eastwell, Washington State University, Prosser, WA
Tessa Grazwitz, Washington State University, Prosser, WA
David James, Washington State University, Prosser, WA
Naidu Rayapati, Washington State University, Prosser, WA

ARS Location:
Horticultural Crops Research Unit
3420 NW Orchard Avenue
Corvallis, Oregon 97330

Project Title: *Biology and Management of Soilborne Diseases of Horticultural Crops*

Project Participants:
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Project Objectives:
1. Evaluate the etiology and epidemiology of soilborne diseases of small fruit and nursery crops and the biology of causal pathogens.
2. Develop, evaluate, and enhance strategies for the management of soilborne diseases of horticultural crops.

Major Accomplishments (2004-2007 Grapes only):
Plant-parasitic nematodes cause an estimated crop loss of seven percent worldwide. The distribution of plant-parasitic nematodes and their impact on vine health and fruit yields in Pacific Northwest vineyards was unknown. Vineyards that represent the diversity found in the Pacific Northwest were selected and soil samples were collected for analysis of nematode populations. Over 400 vineyard blocks were included in the survey. Because the genera and species of nematodes found in the survey were similar for Oregon, Washington, and Idaho vineyards, nematode management strategies may be developed that are suitable for vineyards throughout the region. Most vineyards produced acceptable fruit yields even in the presence of high population densities of one or more species of plant-parasitic nematodes. These data suggest that applications of nematicides should not be based solely on nematode population densities. Our future research direction will be to determine the factors that interact with plant-parasitic nematodes in cases where vines are in poor health. This research relates to NGWI research priority 4 to develop sustainable farming practices. (Shellie, USDA-ARS and Riga, Washington State University)

The ring nematode, *Mesocriconema xenoplax*, is the most common plant-parasitic nematode found in Oregon vineyards. Our previous research demonstrated that *M. xenoplax* can reduce the growth and yield of vines in new plantings of self-rooted Pinot noir and Chardonnay vines.

Many vineyards are being planted on sites with populations of *M. xenoplax*. Since pre-plant soil fumigation is impractical in many Oregon vineyard sites and registered nematicides have been ineffective for control of *M. xenoplax* in established vineyards, we evaluated rootstocks to identify resistance and tolerance that can be used to control this nematode. Two rootstocks – 420A Mgt and 101-14 Mgt – that showed resistance in greenhouse trials also suppressed population densities of *M. xenoplax* in several vineyard trials. Research is in progress in a field microplot study to ascertain the impact of *M. xenoplax* on physiology and growth of resistant and susceptible rootstock. Understanding the reaction of rootstocks to plant-parasitic nematodes will assist in the development of sustainable vineyard management strategies (NGWI Priority 4). (Pinkerton, Schreiner, & Bryla)

Mesocriconema xenoplax has been shown to reduce arbuscules of mycorrhizal fungi in fine roots. We tested the hypothesis that *M. xenoplax* reduces arbuscules in fine root by limiting carbohydrate availability to the fungi by manipulating nematode population densities and light levels in greenhouse studies. The nematode reduced root starch, arbuscules in roots, and vine P and K uptake under controlled conditions supporting the hypothesis, that plants grown under low light were not more susceptible to the nematode feeding effect. Elucidating how nematodes alter root physiology and colonization patterns by arbuscular mycorrhizal fungi in grapevine will lead to a better understanding of how and when to manage *M. xenoplax* in vineyards. This research relates to NGWI research priority 4 to develop sustainable farming practices.

Technology Transfer/Outreach (Grapes only):

Peer-reviewed publications

Pinkerton, J. N., R. P. Schreiner, K. L. Ivors, and M. C. Vasconcelos. 2004. Effects of *Mesocriconema xenoplax* on *Vitis vinifera* and Associated Mycorrhizal Fungi. Journal of Nematology 36:193-201.

Shaffer, R, J. Pinkerton, and M. C. Vasconcelos. 2004. Grapevine rootstocks for Oregon vineyards. Publication EM8882, Oregon State University Extension Service, Corvallis

Pinkerton, J. N., M. C. Vasconcelos, T. L. Sampaio, and R. G. Shaffer. 2005. Reaction of grape rootstocks to ring nematode *Mesocriconema xenoplax*. Amer. J Enology and Viticulture 56:377-385.

Reports/Proceedings Publications

Pinkerton, J. N. and Riga, E. 2004. Epidemiology and management of plant-parasitic nematodes in winegrapes. Proceedings of the Northwest Center for Small Fruit Research

Pinkerton, J. N. and Riga, E. 2005. Epidemiology and management of plant-parasitic nematodes in winegrapes. Proceedings of the Northwest Center for Small Fruit Research

Schreiner, P, Pinkerton, J., and Bryla D. 2006. Evaluation of nematode resistant grape rootstock for managing *Mesocriconema xenoplax*. Proceedings of the Northwest Center for Small Fruit Research

Invited presentations

Pinkerton, J. N. 2007 How do Plant-parasitic Nematodes Impact Wine Grapes in the Pacific Northwest? Annual Washington Association of Wine Grape Growers.

Pinkerton, J. N. 2007. Effects of Plant-parasitic Nematodes on Wine Grapes in the Pacific Northwest. Marlborough Research Institute, Blenheim, New Zealand

External Support (Grapes only**):**
Grants:
Northwest Center for Small Fruit Research, "Effects of plant parasitic nematode densities on grapevine establishment – development of damage thresholds". (2006-2008)

Northwest Center for Small Fruit Research, "Evaluation of nematode resistant grape rootstock for managing *Mesocriconema xenoplax"*. ((2005-2007)

Co-PI. Northwest Center for Small Fruit Research, "Epidemiology and management of plant-parasitic nematode in winegrapes." (2004-2006)

In-kind:
Management study. (Church Vineyard, land, labor)

Collaborators
T. Forge, Agriculture and Agri-Food Canada, Agassiz, BC
K. Shellie, ARS, Parma, ID
M. Keller, Washington State University, Prosser, WA
E. Riga, Washington State University, Prosser, WA

ARS Location:
Crops Pathology and Genetics Research Unit
University of California
Department of Plant Pathology
One Shields Avenue
Davis, California 95616

Project Title: *Sustainable Management of Grapevine Diseases and Weeds*

Project Participants:
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Project Objectives:
1. Develop sustainable disease control practices for grapevines.
2. Develop sustainable vineyard floor management practices.
3. Develop sustainable water management practices for vineyards.
4. Investigate the impacts of vineyard practices on soil microbial ecology.

Major Accomplishments (2004 – 2007)
The presence of riparian areas directly adjacent to North Coast vineyards contributes to Pierce's disease (PD), as evidenced by a correlation between disease incidence and proximity of vines to riparian areas. Riparian hosts of the pathogen *(Xylella fastidiosa)* have been identified from inoculations in the greenhouse, but no one has been able to detect the pathogen in these same hosts in the field. Dr. Baumgartner used a field-based approach to examine the pathogen's host range in the field, to identify riparian species correlated with PD, and to determine the impact of other vector habitats on PD risk in adjacent vineyards. Based on her findings that only one riparian host, *Vinca major* (periwinkle), harbored the most persistent and highest titers of the pathogen, and that the presence of this host alone was positively correlated with a high incidence of PD in adjacent vineyards, it seems that eradication of all riparian hosts may be unnecessary. Given that PD was more common in vineyards that were both adjacent to riparian areas and

surrounded by more vineyard or residential development, as opposed to more natural habitat, vineyards and urban lands may be more important in the spread of PD than previously thought. This research contributes to NGWI's Sustainable Practices priority, elucidating the factors that contribute most to PD risk in order to develop effective pest management techniques.

As soil microorganisms play a crucial role in ecosystem processes (e.g., nutrient cycling, biocontrol), it is important to understand influences of soil heterogeneity and grapevine root distribution on soil microbial communities in vineyards due to recent expansion of vineyard systems worldwide. Dr. Steenwerth and colleagues (Drs. Dave Smart and Kate Scow, University of California-Davis) surveyed a Pinot noir vineyard for the effect of soil depth and roots on soil microbial communities. Soil microbial communities segregated by depth and soil morphology; the gradient in soil resources (e.g., labile carbon) played a primary role in the distribution of soil microbial communities with increasing depth, while soil physical and chemical characteristics played a secondary role. Compared to other systems, the distinct patterns in soil microbial communities as influenced by depth and root distribution in this Pinot noir vineyard suggest that vineyard management practices and deep grapevine root distribution combine to cultivate a unique microbial community in these soil profiles. These shifts in functional groups of soil microorganisms raise the hypothesis that nutrient turnover and decomposition may be unique in these soils. This research contributes to NGWI's Sustainable Practices priority, increasing our understanding of factors influencing microorganisms involved in nutrient turnover and availability.

Cover cropping and tillage are two common practices, and little is known about their effects on soil biology, and carbon and nitrogen cycling in vineyards. Vineyard floor management practices are less intensive than in annual cropping systems. Thus, soil carbon and nitrogen dynamics may be distinct in vineyard systems. From Fall 2005 to Fall 2006 in a Chardonnay vineyard planted in 1997, Dr. Steenwerth biweekly monitored soil C and N dynamics in three vineyard floor treatments: clean, cultivated treatment and two cover crops [i.e., Trios 102 (*Triticale x Triosecale*); Merced Rye (*Secale cereale*)] that had been planted annually for 5 years prior to the study. In general, both cover crops had greater CO_2 and N_2O efflux, microbial biomass C, ammonium pools, and potential rates of nitrification, nitrogen mineralization, and denitrification than the clean, cultivated soil. The cover crop treatments had similar rates among these factors, despite differences in cover crop phenology. Thus, the presence of cover crops enhanced the biological function of the vineyard soils. There is some indication that Merced Rye suppressed weed establishment due to greater aboveground biomass earlier in the season than Trios 102. This research supports NGWI's Sustainable Practices priority, such that it addresses factors related to nutrient retention and practices for soil improvement.

To evaluate the effectiveness of alternative vineyard weed control practices, Drs. Baumgartner and Steenwerth conceived of integrating a non-chemical practice (soil cultivation) with the herbicide glyphosate as a means of both reducing herbicide use and limiting infestations of glyphosate-resistant weeds. Although such practices have been tested in annual crops, the combination of California's Mediterranean climate and the unique deficit irrigation practices in winegrape production means that the effects of glyphosate and cultivation on vineyard weeds are unknown. To maximize grower acceptance, a major obstacle to adoption of non-chemical practices, the project was established at Robert Mondavi Winery's Wappo Hill Ranch in the Napa Valley of northern California. This 3-year field study revealed unique weed infestations with repeated glyphosate (California burclover and sowthistle), cultivation (panicle willowherb),

and their combination (filaree and curly dock). Pairing cultivation with glyphosate was as effective at reducing weed biomass as two glyphosate applications in 2 of 3 years, suggesting that substituting a glyphosate application with cultivation may be an effective method of reducing herbicide use. This research contributes to NGWI's Sustainable Practices priority, identifying methods to control weeds with reduced reliance on herbicides.

In-row soil cultivation for weed control influences soil physical properties and, thus, may affect soil nitrogen (N) retention. Dr. Steenwerth compared the effects of cultivation and herbicides on N leaching. Two weed management practices were imposed underneath grapevines for 5 years prior to this study. These practices were 1) an all cultivation method, using a Clemens vineyard cultivator as needed (ca. four-six times per year) ('Cultivated') and 2) a combination of pre-emergence and post-emergence herbicides (simazine [2.0 lbs. a.i./A) + oxyflourfen [1.5 lbs. a.i./A] applied in winter, followed by 2 percent glyphosate + 25 percent oxyflourfen applied as needed in summer) ('Standard'). Excavated pits were surveyed for bulk density and general soil characteristics, and soil resin bags were inserted below the root zone of grapevines in drip and non-drip zones. In summer, grapevines were fertigated with urea N mixed with humic acid. Nitrous oxide (N_2O), soil N pools, and soil moisture were monitored for two weeks after fertigation. N_2O was greater from the drip zone in the 'Standard' than 'Cultivated' during the first three days after fertigation. Most interestingly, leached soil nitrate was negligible in 'Cultivated', while soil nitrate detected on the resin 1 year after insertion was about 1,200 times greater in 'Standard' than that detected in the 'Cultivated' treatment. Grapevine yield was not influenced by weed treatments. Increased N retention (i.e., reduced leaching) may have been due to the greater weed biomass in 'Cultivated', suggesting that increased plant biomass underneath grapevines may have hidden benefits. This research supports NGWI's Sustainable Practices priority as it addresses factors related to soil nutrient retention.

Arbuscular mycorrhizal fungi (AMF) have a primary role in promoting vine growth when soil P is low, and have been shown to enhance N uptake of other plants. It is possible that the low levels of soil-derived nutrients, due to deficit irrigation and fertilization, make vines dependent on the soil-inhabiting component of the AMF (external hyphae), not only for capture of P, but also N. In a series of three greenhouse experiments using cover crops labeled with an isotope tracer of N, Dr. Baumgartner evaluated the contribution of AMF to N uptake from till and no-till cover crops, the importance of the external hyphae in supporting other soil microbes, and the effects of soil fertility on AMF uptake of N. High levels of the isotope in vines with AMF access to labeled cover crops were indicative of contributions of the external hyphae to N capture, and levels were highest under low soil fertility, suggesting that N uptake from cover crops is limited by fertilization. High microbial biomass in the presence of either external hyphae or roots showed that AMF are important for supporting the wider soil biota involved with nutrient cycling and, thus, have an added role in vine nutrition. This research supports NGWI's Sustainable Practices, improving our understanding of vine nutrition with respect to farming practices that are unique to vineyard production systems.

Systemic fungicides are ineffective because fungal decomposition of root wood disrupts their systemic movement. Instead of re-tooling these ineffective conventional tactics, Dr. Baumgartner conceived of novel, non-chemical controls (root collar excavation and applications of a soil inoculant, 'Vesta') and demonstrated their efficacy. In separate field experiments in four North Coast vineyards, the region most affected by this disease, root collar excavation and annual applications of the soil inoculant significantly increased yields of symptomatic vines, relative to nontreated controls. The mechanisms by which either practice is effective are

unknown, but both practices appear to provide a means of limiting yields losses due to Armillaria root disease. Of course, the most effective long-term control is likely to be resistant rootstocks, which Dr. Baumgartner is currently focusing on. This research contributes to NGWI's Sustainable Practices priority, developing non-chemical, disease control practices that ensure the long-term sustainability of vineyards.

As soil microbial communities can play a role in pathogen suppression, Dr. Kluepfel characterized the microbial community in the grape rhizosphere. Ten 2-m pits were excavated adjacent to vines in a 15-year-old vineyard (Carneros, CA), and soil horizons were identified, and bulk and rhizosphere soil samples were taken from each of the identified horizons in each of the 10 soil pits. The soil samples were serially diluted on both selective and nonselective media, then Prokaryotic population estimates were made and 2,000 isolates were randomly selected, single colony purified, and identified. Significant qualitative and quantitative differences were revealed as a function of soil horizon and pit position in the vineyard. In addition the rhizosphere community was also shown to be significantly different from the adjacent bulk soil; members of the *Pseudomonas* genus represented a minor fraction of the microbial community and spore forming Gram-Positive microbes were the dominant class of microbes. This represents a first step in understanding potential components of the soil microbial community that might be involved in disease suppression.

Technology Transfer/Outreach (2004-2007):
This research is used by Federal agencies (Environmental Protection Agency), State agencies (Departments of Food and Agriculture, Fish and Game, and Pesticide Regulation), local agencies (County Agriculture Commissioners, Irrigation Districts, and Resource Conservation Districts), University Extension Specialists and farm advisors, farmers, the wine industry (California Association of Winegrape Growers), national conservation groups (The Nature Conservancy), pest control advisors, the interested public, and other scientists. Major customers provide input in the research, provide access to commercial vineyards for the research, and participate as partners in the technology transfer component of the project. Products include: 1) Cultural, biological, and genetic controls for grapevine diseases; 2) Guidelines for cultural and biological weed management practices; and 3) Establishment of deficit irrigation practices to enhance grape production. Research is extended to customers through invited presentations to regional grower groups, at national and international scientific meetings, and through publications in peer-reviewed journals.

External Support (2004-2007):
Financial support:
USDA Viticulture Consortium, "Long-term and short-term controls for Armillaria root disease" (Baumgartner 2007).

Organization for Economic Cooperation and Development's Cooperative Research Program in Biological Resource Management for Sustainable Agricultural Systems, "Development of study tools to investigate interactions between fungal pathogens, host resistance, and putative biocontrol agents"; for research at the University of Bristol, School of Biological Sciences, United Kingdom (Baumgartner 2007).

University of California Pierce's Disease Research Grant Program, "The spatial distribution of Pierce's disease across the North Coast: patterns, causes, and implications for management" (Baumgartner 2006).

Western Sustainable Agriculture Research and Education, "Evaluation of the effects of vineyard floor management practices on soil microbiology" (Baumgartner 2005).

California Department of Food and Agriculture, "Significance of riparian plants in the epidemiology of Pierce's disease" (Baumgartner 2004).

In-kind support:
1,000 dormant grapevine rootings (retail rate of $1.59 each) donated by Sunridge Nurseries for, "Inception, Diagnosis, and Consequences of the Berry Shrivel Disorder," and "Long-term and short-term controls for Armillaria root disease" (Baumgartner 2007).

300 dormant grapevine benchgrafts (retail rate $3.29 each) donated by Sunridge Nurseries for, "The roles of mycorrhizal fungi in grapevine health" (Baumgartner 2004-2006).

Collaborators (2004-2007):
Gary Kinard, ARS, Beltsville, MD
Ray Mock, ARS, Beltsville, MD
Robert Li, ARS, Beltsville, MD
Robert Martin, ARS, Corvallis, OR
Paul Schreiner, ARS, Corvallis, OR
Ed Stover, ARS, Davis, CA
Norman Schaad, ARS, Ft. Detrick, MD
Peter Cousins, ARS, Geneva, NY
Brad Hanson, ARS, Parlier, CA
Mark Sisterson, ARS, Parlier, CA
Jungmin Lee, ARS, Parma, ID
Guido Schnabel, Clemson University
Marc Fuchs, Cornell University, Geneva, NY
Andy Bailey, University of Bristol, UK
Robert Bugg, University of California-Davis
Joshua Viers University of California-Davis
Adib Rowhani, Maher Al Rwahnih, and Deborah Golino, University of California, Davis, Foundation Plant Services,
Rhonda Smith, University of California Cooperative Extension, Sonoma County, CA
Anil Shrestha, University of California Cooperative Extension, Kearney Ag. Center, CA
Andrew Walker, University of California, Davis, Department of Viticulture and Enology
Richard Smith, University of California Cooperative Extension, Salinas County, CA

ARS Location:
Crops Pathology and Genetics Research Unit
University of California
Department of Plant Pathology
One Shields Avenue
Davis, California 95616

Project Title: *Pacific Area-Wide Pest Management Program for Integrated Methyl Bromide Alternatives (PAW-MBA) (grapes)*

Project Participants:
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Dong Wang, Research Leader and Project Leader for grapes in PAW-MBA
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Project Objectives:
The overall goal of this project is to facilitate stable adoptions of economical alternatives to soil fumigation with methyl bromide in western U.S. agricultural industries served by Critical Use Exemptions (CUEs) for soil fumigation.

Specific objectives for grape are to:
1. Measure responses of soilborne pests and pathogens to alternative soil fumigation and cover crop treatments for grape.
2. Examine effects of alternative fumigant application and containment methods on fumigant efficacy and emissions.
3. Assess growth and yield responses of replanted grapevines to alternative pre-plant soil fumigation and cover crop treatments.

Major Accomplishments (2004 – 2007):
The PAW-MBA was initiated in fiscal year 2007. Therefore, there are no research accomplishments to report yet. A core team comprised of soil chemists, biologists, growers, and regulatory scientists was formed and developed PAW-MBA program plans, and a customer oversight team helped to review resulting PAW-MBA project proposals, including that for grapes. The teams agreed that, due to increasing regulatory constraints, achieving stable adoptions of methyl bromide alternatives in California will require fundamental improvements in management strategies for soilborne pests and pathogens and reduced fumigant emissions to the atmosphere. Therefore, PAW-MBA program plans prioritize not only adoption of fumigant

alternatives to methyl bromide, but also development of economical alternatives to fumigants and methods to reduce emissions of fumigants when they are used.

The specific objectives for the PAW-MBA grape project reflect the priorities set by the core and oversight teams, and the planned work for grape has begun. A vineyard has been cleared for a grape replant trial, which will include the following pre-plant treatments in early fall this year:

1. Untreated, Fallow
2. Untreated, Cover crop – green manure (mustard or canola)
3. Shank, Methyl bromide (448 kg/ha), HDPE
4. Shank, Telone C35 (610 kg/ha), no tarp
5. Shank, Telone C35 (305 kg/ha), no tarp
6. Shank, Telone C35 (305 kg/ha), VIF
7. Drip, Inline (305 kg/ha), VIF

The trial will include monitoring and assessing the following for each of the above treatments: fumigant emissions, soil pest and pathogen populations, and comprehensive economic assessments that account for all treatment costs and crop yield and quality. The trial will be planted with grapevines in spring 2008, and repeated in the 2008-2009 season at both the San Joaquin Valley Agricultural Sciences Center and a commercial grower's field.

Technology Transfer/Outreach (2004-2007):
The PAW-MBA project for grapes conducted planning outreach to the Central California Winegrowers based in Fresno, California. This industry group holds the CUE for methyl bromide for grapes and accordingly is represented on the PAW-MBA Customer Oversight Team, along with other agricultural industries holding CUEs in the western United States. In addition, planning outreach included an emissions scientist with the California Department of Pesticide Regulation and a regulatory scientist with the EPA. The PAW-MBA program outreach will proceed from planning to trial execution to technology transfer. The PAW-MBA program plans to use multiple methods of technology transfer, including a Web-based outreach, field demonstrations, oral presentations, and popular and peer-reviewed publications.

External Support (2004-2007):
Because the PAW-MBA program for grape is just beginning, no external support has been contributed yet. Tri-Cal intends to provide in-kind support by applying shank fumigation treatments. Future plans include replant trials in commercial fields in the San Joaquin Valley.

Collaborators (2004-2007):
Gary Obenauf, Agricultural Research Consulting, Fresno, CA
Kenneth Vick, ARS, Beltsville, MD
Dan Kluepfel, ARS, Davis, CA
Jack Pinkerton, ARS, Corvallis, OR
Suduan Gao, ARS, Parlier, CA
Jim Gerik, ARS, Parlier, CA
Brad Hanson, ARS, Parlier, CA
Scott Yates, ARS. Riverside, CA
Dan Legard, California Strawberry Commission, Watsonville, CA
Bob Weimer, California Sweet Potato Council, Merced, CA
Carson Smith, Central California Winegrowers, Fresno, CA

Randy Segawa, Department of Pesticide Regulation, Sacramento, CA
Bob Beede, Hanford, CA
Brian R. Correiar, Jackson & Perkins Wholesale, Wasco, CA
David Cox, L.E. Cooke Company, Visalia, CA
Mike (Anthony) Mellano, Mellano & Company, Carlsbad, CA
Joseph MacIlvaine, Paramount Farming Company, Bakersfield, CA
Christopher Winterbottom, Sierra-Cascade Nursery, Inc., Susanville, CA
Scott Stoddard, UCCE, Merced, CA
Husein Ajwa, University of California-Davis, Salinas, CA
Steve Fennimore, University of California-Davis, Salinas, CA
Richard Keigwin, USEPA, Washington, DC
Chuck Masters, Weyerhaeuser Research, Centralia, WA

ARS Location:
USDA-ARS Biosciences Research Laboratory
1605 Albrecht Boulevard
Fargo, North Dakota 58105

Project Title: *Development of Cold Storage Technology for Mass-reared and Laboratory-colonized Insects.*

Project Participants:
Roger A. Leopold, Research Entomologist
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Project Objectives:
1. Develop and/or improve cold storage protocols for insects.
2. Develop quality assurance technology and test insects after cold storage.

Major Accomplishments (2004 – 2007):
The goal of this project is to improve the effectiveness of insects used in Integrated Pest Management Programs and one aspect that limits effectiveness when employing insects as biological control agents is their limited shelf-life. This research involves the design of protocols for lengthening the usability of beneficial insects and testing quality assurance factors such as reproductive capacity, longevity, flight ability and, in the case of insect parasites, host-seeking behavior after applying a shelf-life lengthening protocol.

Our approach is to determine the cold tolerance of an egg parasitoid, such as *Gonatocerus ashmeadi*, and its host (GWSS) when artificial rearing methods are unavailable. We then devise methods for lengthening the usefulness of the parasitoid by employing cold storage and after recovery, identify the limitations of the protocol by examining the various fitness factors that ensure field success in a biological control program.

This research demonstrated that GWSS egg masses purposely killed by chilling can be stored up to 35 days, >70 percent were readily accepted by *G. ashmeadi* as hosts, and >80 percent of the subsequently parasitized eggs yielded wasp progeny. Demographic analysis of the wasp progeny showed that reproductive success decreased after >30 days of storage in the first generation, but the decrease did not extend to the second generation.

Insectary managers in charge of rearing beneficial insects for control programs will be able to accumulate large numbers of wasps for mass release and also have the capability to time the releases to gain peak effectiveness. Biological control is a sustainable, environmentally-friendly, effective and efficient pest management strategy allows for the wine and grape industry.

Collaborators:
David Morgan, California Department of Food and Agriculture, Mt. Rubidoux Field Station, Riverside, CA.
Wenlong Chen, North Dakota State University, Department of Entomology, Fargo, ND

ARS Location:
U.S. Horticultural Research Laboratory
Subtropical Insects Research Unit
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Fort Pierce, Florida 34945

Project title: *Glassy-winged sharpshooter and Pierce's Disease*

Project Participants:
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David Hall, Research Leader, Research Entomologist (0.1 FTE)
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Project Objectives:
1. Advance our understanding of sharpshooter basic biology, pathogens of sharpshooters, and the development of new management strategies against sharpshooters and the spread of *Xylella.*

Major Accomplishments (2004-2007):
New methods of insect management require an in-depth understanding of sharpshooter biology, genomics, and their potential pathogens. We identified numerous genetic transcripts from three sharpshooter species which are vectors of Pierces disease. These genetic materials are linked to feeding, development, and other aspects of leafhopper biology. We also identified three leafhopper infecting viruses which cause increased mortality of the glassy-winged sharpshooter. Furthermore, we produced and screened genetic markers linked to disease and insect resistance in grapes. The genetic goods from the sharpshooters have been used to produce microarrays for functional genomic analysis of sharpshooter leafhopper biology in response to diseases, insecticides, or other treatments. The duel purpose arrays incorporate both leafhopper genetic sequences and a set of insect viral pathogen sequences, providing a method for broad scale monitoring for new viral pathogens in sharpshooters, while performing functional genomic studies on sharpshooter biology. The arrays have been used to identify genes linked to GWSS diapause, and to identify the presence of viruses. The grape genetic markers are being used to screen seedlings of new grape varieties for increased disease and insect resistance thus reducing costs and saving time, in the productivity of the grape breeding program at the Center for Viticulture and Small Farms, Florida A&M University, Tallahassee, Florida.

No genomic data were available for leafhoppers. A genomics approach was used to sequence and identify thousands of sequences for gene transcripts from three leafhoppers which spread *Xylella fastidiosa*. The sequences from leafhopper genomics were used to build tools for further analyses, such as microarrays. These genetic products are being used to: 1) Develop genetic markers for species and biotyping of leafhoppers; 2) Elucidate leafhopper feeding and digestion as relates to disease transmission; 3) Provide the foundation for studies on leafhopper responses to pesticide development.

Previously searching for viral pathogens in leafhoppers has been difficult and costly due to problems in sampling and analysis of field-caught insects. The gene array performs a wide screen across known insect viruses thus providing a rapid detection and identification of virus groups or viral species detected in leafhopper samples.

Plant breeding takes many years. Use of molecular markers can reduce the time needed to develop a new variety for release and save money in grape breeding programs. A national North American Grape Genome database was established and provides access of our data to the research community.

This research addresses NGWI initiative objectives 1, 2, and 5.

Technology Transfer/Outreach

- Submission of genetic datasets to the public database (see Addendum).
- Presentations at scientific and technical meetings (see Addendum).
- Scientific publications (see Addendum).

External Support:

Florida A&M University Science Center Research. Grant - "Development of Marker-Assisted Selections of New Grape Varieties" – Collaboration with Dr. Lu, Florida A&M University (2005-2007).

Florida A&M University Science Center Research. Grant- "Marker Development for Marker-Assisted Selections in Grapes for Disease and Insects". Collaboration with Dr. Lu (2005-2007).

Florida A&M University Science Center Research. Grant – "Bioinformatics /Genomics of Grapes" for sequencing of 10,000 ESTs from Muscadine grape". Collaboration (2006).

T-Star Grant. "Discovery of insect infecting viruses". Collaboration with Dr. C. Powell, University of Florida (end 2006).

Co-founder of "North American Grape Genomic Database", Collaboration Dr. Lu, Florida A&M University, Tallahassee, FL 2005-2006.

Florida A&M University Science Center Research. Grant – "Bioinformatics/Genomics of Grapes" for sequencing of 15,000 ESTs from grape. Collaboration with Dr. Lu (2005).

Capacity Building Grant, in collaboration with Dr. Sheikh, Florida A&M University. "Proteins related to *Xylella* and Pierces Disease" (2004).

Florida A&M University Science Center Research. Grant, in collaboration with Dr. Lu, "Creating genetic markers for disease and insect resistance in grapevine" (2004).

Collaborators:

Specific Cooperative Agreements:

Russell Mizell, , University of Florida, Quincy, FL

- GWSS biology and transmission of *Xylella*,

- Mass rearing of GWSS, understanding oviposition and diapause.

Pete Andersen, University of Florida, Quincy, FL
- *Xylella* and Pierce's Disease
- Xylella gene expression in response to differential media

Non Funded Cooperative Agreements:
Jiang Lu, Florida A&M University, Tallahassee, FL
- Construction of National Grape Genomics Database, FAMU-ARS collaboration.
- First Genomics/Bioinformatics program at 1890s institution, FAMU.
- Facilitating the development of genetic markers from grapes for disease and insect resistance. Produced over 30,000 grape express sequence tags, ESTs, and over 800 genetic markers to develop 'Marker-Assisted Selection' program to produce new grape varieties. First releases will be in 2007-2008.
- A new hybrid bunch grape for a wine variety to be grown in southeast.
- Two other varieties in process of being released, target for 2008. A Muscadine x *Vitis vinifera*, which has disease resistance and is seedless. A second which is a Muscadine var. with large fruit as new fruit variety to schools and stores.

M. Sheikh, Center for Viticulture and Small Farm, FAMU, Tallahassee, FL
- Genetic response of bunch grapes to water stress.
- Genetic response of a unique grape protein to *Xylella* infection.

Other:
Catherine Katsar, APHIS, Fort Lauderdale, FL
Scot Dowd, ARS, Lubbock, TX
Tom Coudron, ARS, Columbia, MO 65203
Elaine Backus, ARS, Parlier, CA
Alexander H. Purcell, University of California at Berkeley, CA 94720 (*Retired 2006*)
Sandra Brandt, University of Missouri, Columbia, MO 65211

Addendum

Project Title: *Glassy-winged sharpshooter and Pierce's Disease (Hunter, Hall)*

Genetic Datasets Submitted to the Public Database:

Hunter, W. B., Dang, P. M., Bausher, M. G., Costa, H., Sinisterra, XH. 2004. Expressed Genes from Glassy-winged Sharpshooter, *Homalodisca coagulata*, (Hemiptera: Cicadellidae). Published 8,316 electronic pages GenBank Acc. no.: CO644458 - CO636163. National Center for Biotechnology Information, NCBI. (Public Database).

Hunter, W. B., Dang, P. M., Puterka G., Shatters R. G., Jr, McKenzie C. L., and X. H. Sinisterra. 2005. 5th Instar Glassy-winged Sharpshooter *Homalodisca coagulata*, (Hemiptera: Cicadellidae) Accession numbers- DN195890-DN203579, 3,921 mRNA sequences. National Center for Biotechnology Information, NCBI. (Public Database).

Hunter, W. B., Mizell, R. F., III, Tipping C., Dang, P. M., and L. E. Hunnicutt. 2005. Adult sharpshooter leafhopper *Oncometopia nigricans*, (Hemiptera: Cicadellidae), cDNA clones, Acc.Nos.-DR755012-DR759538. 4,527 mRNA sequences. NCBI. (Public Database).

Hunter, W. B., Hunnicutt, L. E., Wistrom, C. M., and A. H. Purcell. 2006. Proteins expressed in the Blue-green sharpshooter, *Graphocephala atropunctata* (Hemiptera: Cicadellidae). 44 Proteins, Acc. no.: DQ445499-DQ445542. National Center for Biotechnology Information, NCBI. (Public Database).

Hunter, W. B., Hunnicutt, L. E., Wistrom, C. M., and A. H. Purcell. 2007. Gene expression in adult blue-green sharpshooters, *Graphocephala atropunctata* (Signoret) (Hemiptera: Cicadellidae). 6,481 mRNA sequences. Acc. no.: EH655849-EH662332. National Center for Biotechnology Information, NCBI. (Public Database).

Presentations 2002-2007:

Hunter, W. B., and U. Albrect. 2004. Viral pathogen of the glassy-winged sharpshooter, (Hemiptera: Cicadellidae) *Homalodisca coagulata*. ESA Annual Meeting, November 17, Salt Lake City, UT. D0547.

Hunter, W. B., and P. M. Dang. 2004. Heat shock proteins expressed in adult glassy-winged sharpshooters (Hemiptera: Cicadellidae: *Homalodisca coagulata*). P773. January 11-15, 2004. Plant & Animal Genomics XI Conference, San Diego, CA.

Lu, J., Hunter, W., Dang, P., Huang, H., and S. Leong. 2004. Identifying disease defense- and stress-related genes in the grape *Vitis shuttleworthii*, improving grape varieties an EST program. P42, pg 82. January 11-15, 2004. Plant & Animal Genomics XI Conference, San Diego, CA.

Hall, D., Hunter, et al., 2004. Glassy-Winged Sharpshooter and Pierce's Disease: Current research in biological control at the U.S. Horticultural Research Laboratory. Biological Control and Technology meeting, February 3-4. Greenbelt, MD.

Hunter, W. B. 2005. Genes in Salivary Gland and Midgut of Glassy-winged Sharpshooter. Insect Genomics Workshop, International Plant and Animal Genome Conference, January 15-18, San Diego, CA.

Hunter, W. B. 2005. Leafhoppers and Pierce's Disease. USDA-ARS, Columbia, MO. (Invited).

Hunter, W. B., Katsar, C. S., and E. A. Backus. 2005. Glassy-winged sharpshooter midgut gene expression (Hemiptera: Cicadellidae: *Homalodisca coagulata*). Entomological Society of America Annual Meeting , Ft. Lauderdale, FL. December 15-18. D0344.

Katsar, C. S., and W. B. Hunter. 2005. Entomopathogenic virus from Glassy-winged Sharpshooter. Entomological Society of America Annual Meeting, Ft. Lauderdale, FL. December 15-18.

Sinisterra, X. H., Hunter, W. B., Katsar, C. S., and E. A. Backus. 2005. Salivary gland gene expression in glassy-winged sharpshooters. Entomological Society of America Annual Meeting, December 15-18, Ft. Lauderdale. FL. D0343.

Hunter, W. B., Albrecht, U., and D. Achor. 2005. Reducing glassy-winged sharpshooters using insect-infecting viruses, *Homalodisca coagulata* (Say) (Hemiptera: Cicadellidae). 88th Annual Meeting of the Florida Entomological Society. July 24-27, Ft. Myers, FL.

Katsar, C. S., Hunter, W. B., and J. X. Chaparro. 2005. Molecular Analysis of capsid protein of *Homalodisca Coagulata Virus-1*. A new virus from the glassy-winged sharpshooter, *Homalodisca coagulata* (Say) (Hemiptera: Cicadellidae). 88th Annual Meeting of the Florida Entomological Society. Ft. Myers, FL.

Katsar, C. S., Hunter, W. B., and C. A. Cleland. 2005. Molecular characterization of delta-9 desaturase 1 from the Glassy-winged Sharpshooter, *Homalodisca coagulata* (Hemiptera: Cicadellidae). 88th Annual Meeting of the Florida Entomological Society. July 24-27, Ft. Myers, FL.

Katsar, C. S., and W. B. Hunter. 2005. A Rice Dwarf-like Virus isolated from the Salivary Gland of the Glassy-winged Sharpshooter, the vector of Pierce's Disease of grapes. 88th Annual Meeting of the Florida Entomological Society. July 24-27, Ft. Myers, FL.

Hunter, W. B., Dang, P. M., Backus, E. A., and J. Habibi. 2005. Gene Expression in GWSS Salivary Glands and Midgut tissues (Hemiptera: Cicadellidae: *Homalodisca coagulata*). XIII International Plant and Animal Genome Conference, January 15-19, San Diego, CA.

Mozoruk, J., Hunnicutt, L., Bausher, M., Cave, R., and W. Hunter. 2005. Sharpshooter herbivory: Targeting the bulls-eye between aphid and caterpillar signature defense responses. 88th Annual Meeting of the Florida Entomological Society. July 24-27, Ft. Myers, FL. DSP-15.

Coudron, T., Hunter, W., and J. Labavitch. 2005. Finding the continuum between nutritional needs and feeding processes. Joint: 12th International Auchenorrhyncha Congress and 6th International workshop on Leafhoppers and Planthoppers of Economic Importance. August 8-12, Berkeley, CA.

Katsar, C. S., Hunter, W. B., and R. F. Mizell. 2005. Phytoreoviruses and the glassy-winged sharpshooter (Hemiptera: Cicadellidae). P42. Joint: 12th International Auchenorrhyncha Congress, and 6th International workshop on Leafhoppers and Planthoppers of Economic Importance. August 8-12, Berkeley, CA.

Katsar, C. S., Hunter, W. B., Tipping, C., and R. F. Mizell. 2005. Molecular characterization of delta-9 desaturase from two sharpshooters, Homalodisca coagulata and Oncometopia nigricans (Hemiptera: Cicadellidae). P14. Joint: 12th International Auchenorrhyncha Congress, and 6th International workshop on Leafhoppers and Planthoppers of Economic Importance. August 8-12, Berkeley, CA.

Hunter, W. B. 2005. Inside-Out, using genetics to study the Glassy-winged sharpshooter. Florida A&M University, Science Center of Excellence, U.S. Horticultural Research Lab, Ft. Pierce, FL 34945. June 16-17.

Huang, H., Lu, J., Ren, Z., Hunter, W. B., and P. M. Dang. 2005. A Comparative Genomics Analysis between V. shuttleworthii and V. vinifera Grapes. International Grape Genome Initiative Annual Meeting, July, 12-14. St. Louis, MO.

Huang, H., Brandley, F., Ren, Z., Hunter, W. B., Dang, P. M., and J. Lu. 2005. Discovery of cSNP between *Vitis shuttleworthii* and *Vitis vinifera* 'Cabernet Sauvignon' ESTs, Prediction of Subsequent Amino Acids and Protein Function Changes. International Grape Genome Initiative Annual Meeting, July, 12-14. St. Louis, MO.

Lu, J., Huang, H., Ren, Z., Brandley, F., Hunter, W. B., and P. M. Dang. 2005. Genome Structure and Functional Annotation by Massive EST Analysis of Vitis shuttleworthii Grape and Comparative Genomics Analysis with Vitis vinifera ESTs . International Grape Genome Initiative Annual Meeting, July, 12-14. St. Louis, MO.

Lu, J., Huang, H., Ren, Z., Hunter, W. B., and P. M. Dang. 2005. Development of Grape EST-SSR Markers for Genotyping and Mapping Disease Resistant Genes. International Grape Genome Initiative Annual Meeting, July, 12-14. St. Louis, MO.

Katsar, C. S., and W. B. Hunter. 2005. Entomopathogenic virus from glassy-winged sharpshooter. Entomological Society of America Annual Meeting, December 15-18, Ft. Lauderdale, FL. D0648.

Lu, J., Huang, H., and W. Hunter. 2006. Identification and functional annotation of unique EST sequences between Vitis shuttleworthii and V. vinifera grapes. International Plant and Animal Genome Conference, January 14-18. San Diego, CA.

Hunter, W. B. 2006. Insect Genomics Workshop, organizer. International Plant and Animal Genomes XIV Conference, San Diego, CA.

Hunter, W. B., and L. E. Hunnicutt. 2006. Sequencing and molecular characterization of a vitellogenin cDNA from the glassy-winged sharpshooter, *Homalodisca coagulata* (Hemiptera:

Cicadellidae). International Plant & Animal Genome Conference, January 14-18. San Diego, CA.

Hunnicutt, L. E., Hunter, W. B., and J. Mozoruk. 2006. Rapid detection of *Homalodisca coagulata virus-1* (HoCV-1), a novel dicistronic virus discovered in the glassy-winged sharpshooter. International Plant and Animal Genome Conference, January 14-18. San Diego, CA.

Mozoruk, J., Bausher, M. G., Hunter**,** W. B., and L. E. Hunnicutt. 2006. Cloning and molecular characterization of a novel citrus gene, Csv03, whose expression is induced in response to sap-feeding herbivory. International Plant & Animal Genome Conference, January 14-18. San Diego, CA.

Hunter, W. B., Katsar, C. S., McKenzie, C. L., Shatters, R. G., Weathersbee, A. A., and D. G. Hall. 2006. Gene expression in the Asian citrus psyllid: Vector of citrus greening (Hemiptera: Psyllidae). DS-10. Joint proceedings of the 89th Annual meeting and 6th International Caribbean Conference of Florida Entomological Society.

Hunter, W. B., and C. S. Katsar. 2006. Gene expression in two leafhopper vectors of Pierces Disease of grapes, Glassy-winged sharpshooter and Blue-green sharpshooter (Hemiptera: Cicadellidae). DS-11. Joint proceedings of the 89th Annual meeting and 6th International Caribbean Conference of Florida Entomological Society.

Hunter, W. B. 2007, Participated in the Florida A&M University, Grape Growers Field Day, May 8, Viticulture Center, Tallahassee, FL. Met with State Commissioner of Agriculture, Mr. Charles Bronson, and discussed current problems in Florida viticulture.

Hunter, W. B. 2007. International Workshop on *Xylella fastidiosa*: from Genomics to Function. Campinas, Brazil. August 2007.

Scientific Publications:

Valles, S.M., C.A. Strong, P.M. Dang, W.B. Hunter, R.M. Pereira, D.H. Oi, A.M. Shapiro, D.F. Williams. 2004. A picorna-like virus from the red imported fire ant, *Solenopsis invicta*: Initial discovery, genome sequence, and characterization. Virology 328: 151-157.

Hunter, WB. 2004. Plant Viruses and Insects. *In* Encyclopedia of Entomology, (John L. Capinera, ed). Vol. 3, pg. 1762-1768. Kluwer Academic Publishers.

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ARS Location:
Commodity Protection & Quality Research Unit
San Joaquin Valley Agricultural Sciences Center
9611 So. Riverbend Avenue
Parlier, California 93648

Project Title: *Alternatives to Chemical Control for Stored Product and Quarantine Pests of Fresh/dried Fruits and Nuts*

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Project Objectives:
1. Develop alternative physical controls including in-depth studies of treatment biology.
2. Develop basic biological and environmental data necessary for modeling survival, development, and reproduction of pest and beneficial populations as related to alternative treatment thresholds.
3. Develop innovative systems approaches and integrated pest management control strategies.
4. Develop pathogens and parasitoids as insect control agents.
5. Develop basic information on host-plant relationships and interactions to eliminate or reduce the need for specific quarantine treatments.
6. Develop detection systems based on physical properties, volatile chemicals, or biochemical probes to use these systems to make informed treatment decisions or separate uninfested commodity.

Major Accomplishments (2004 – 2007):
Raisin processors have relied on chemical fumigants to disinfest product of post-harvest insect pests such as Indianmeal moth. Restrictions on the use of these chemicals are being imposed due to environmental and worker safety issues. Scientists at the San Joaquin Valley Agricultural Sciences Center are developing non-chemical physical treatments to disinfest product without fumigants. Low temperature storage, heat treatments using radio frequency, and vacuum treatments applied in inexpensive portable containers all show potential for certain applications within the processing environment. Adoption of these disinfestation methods would reduce use of chemical fumigants by conventional processors, as well as improving the efficiency of postharvest pest management for organic raisins. The research relates to NGWI Research Priority 3: Processing and Production Efficiency, and Research Priority 4: Sustainable Practices.

Raisin processors have relied on chemical fumigants to disinfest product of post-harvest pyralid insect pests such as the raisin moth and Indianmeal moth. Restrictions on the use of these chemicals are being imposed due to environmental and worker safety issues. Scientists at the San Joaquin Valley Agricultural Sciences Center are developing biological controls using parasitoids that attack the overwintering stages of pest pyralids. That information will be used to obtain an exemption for release of these parasitoids into raisin storage facilities. Use of the parasitoids as biological controls will augment other control practices in an integrated pest management system, and reduce or eliminate use of fumigants. The research relates to NGWI Research Priority 3: Processing and Production Efficiency and Priority 4: Sustainable Practices.

Technology Transfer/Outreach

- Results of both the physical treatments and biological control strategy were presented at the Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions 1997-2005.
- In addition, in response to requests by raisin processors, we have provided extensive information on the effect of temperature and vacuum on insect survival.
- One scientist is the senior author for the chapter, “Pests of Stored Raisins” in the latest revision of the University of California Grape Pest Management manual.

External Support
Field-run raisins for vacuum studies and parasitoid tests were provided by the Raisin Advisory Board.

Collaborators
Larry Zettler, APHIS-CPHST, Raleigh, NC (vacuum treatments)
Michael Hurley, California Dried Fruit Association, Fresno, CA (biological control)
Philippe Villers, GrainPro Inc., Concord MA (vacuum treatments)
Tom Phillips, Oklahoma State University, Stillwater, OK (vacuum treatments)
Elizabeth Mitcham, University of California, Davis, CA (heat treatments)
Juming Tang and Shaojin Wang, Washington State University, Pullman, WA (heat treatments)

ARS Location: USDA-ARS
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Project Title: *Chemically Based Methods as Alternatives to Methyl Bromide for Post-harvest and Quarantine Pests.*

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Project Objectives:
1. Develop new and innovative chemical controls, including treatment biology, for post-harvest/quarantine pests to maintain or increase domestic and foreign markets of western annual and deciduous crops.
2. Develop basic biological/environmental data needed to predict infestation levels and treatment thresholds.
3. Develop new technologies for application and/or control of atmospheric emissions where needed for new fumigants.
4. Develop detection methods for infestations using volatiles produced by insects and/or the host commodity to allow use of control methods on a demand basis.

Major Accomplishments (2004 – 2007):
Shipment of grapes to Australia were limited to packaging in wooden boxes (TKV) and fumigation schedules were restricted to this packaging of table grapes. New boxes made of polystyrene (EPS) are more desirable for the export of table grapes. At the San Joaquin Valley Agricultural Sciences Center, we tested grapes packed in both types of boxes to determine if any changes needed to be made to the fumigation schedule if grapes were shipped in EPS boxes. Tests exposing grapes in both types of box were carried out using the established schedule for grapes in TKV boxes and the concentration of the fumigant was followed throughout the fumigation. Analysis of the concentrations showed that although the decline of the fumigant

followed a different rate of adsorption, the total exposure of the grapes to the fumigant in both boxes was similar and no adjustment of the schedule uses for the TKV boxes was necessary when treating grapes in EPS boxes. This research shows that grapes can be exported to Australia using the same export treatment protocols in either TKV or EPS boxes.

A problem in the export of table grapes is the occasional presence of a black widow spider adult in the shipment which arises from the spider being in the grapes coming from the field. These spiders are not wanted in the countries to which we export table grapes. To rid export table grapes of any live black widow spiders, we tested a potential fumigant, ozone, as a means to kill the adult spider in the grapes. We at the San Joaquin Valley Agricultural Sciences Center collected and maintained a colony of the black widow spiders in the laboratory and artificially infested grapes to determine if ozone gas would kill the spiders while not damaging the grapes. The tests showed that a concentration of 10,000 ppm (v/v) of ozone held for 2 hours would indeed kill the spiders while doing minimal damage to the grapes. These tests make it possible to treat grapes being exported so that no adult spiders arrive alive in the countries to which we are exporting table grapes.

Technology Transfer/Outreach:

- The research on shipping boxes was reported to the California Table Grape Commission and used in Bilateral Discussions with Australia on import/export issues in 2006.
- The ozone treatments results were reported to Cosmed Group, a Cooperative Research and Development Agreement (CRADA) partner.
- Results of the treatment were also presented at the Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions held in San Diego, CA on October 31- November 3, 2005.

External Support:
The research on shipping boxes was supported by the California Table Grape Commission under a Trust Agreement; while the research on ozone treatments was supported by Cosmed Group under a CRADA.

Collaborators:
Joseph Smilanick, Plant Pathologist, ARS, Parlier, CA conducted quality assessments of the grapes following the fumigations.

ARS Location:
Commodity Protection and Quality Research Unit
San Joaquin Valley Agricultural Sciences Center
9611 S. Riverbend Avenue
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Project Title: *New Technologies to Extend the Post-harvest Life of Table Grapes*

Project Participant:
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Project Objectives:
1. Evaluate new technologies to replace or supplement sulfur dioxide (SO_2) to control postharvest decay of grapes.

Major Accomplishments (2004 – 2007):
Our goal is to provide information and treatments useful to develop and integrate pre- and post-harvest practices so vineyard and cold storage managers can reliably control post-harvest decay of table grapes. Table grapes are attacked during production in vineyards and after harvest by decay fungi. During storage and marketing, the gray mold fungus, *Botrytis cinerea*, can cause significant losses because it grows at low temperatures and spreads from berry to berry. Pre-harvest actions, such as calcium sprays, vineyard irrigation management, and fungicide applications, including 'reduced risk' fungicides and those acceptable to organic growers to minimize the number of infections present at the time of harvest, so that post-harvest decay losses would be minimized were evaluated. Post-harvest measures to control post-harvest gray mold, including post-harvest ozone (O_3) gas fumigation, continuous biofumigation with in-package generation of volatiles by the fungus *Muscodor albus,* or wet treatments with GRAS substances (e.g., ethanol), were evaluated. Pre-harvest measures including viticultural practices and fungicide applications near harvest reduced post-harvest losses by about 50 percent in preliminary experiments, and many more tests are now in progress or planned where we expect to improve this performance, while post-harvest ozone fumigation, *M. albus* biofumigation, or wet treatments with GRAS substances were generally the most effective treatments in this work. This work relates to NGWI research priority 4.6.1, "…integrated pest and pathogen management and maximization of productivity with respect to financial and human resources."

Technology Transfer:
This work is the subject of two projects supported by the California Table Grape Commission, and a BARD grant from 2002 to 2006. Results of this work been reported at meetings both sponsored by the Commission and the University of California Cooperative Extension, and manuscripts describing it are in six peer-reviewed journal publications,

External Support:
California Table Grape Commission (2002-2006)
BARD grant (3 years)

Italian government supported a visiting scientist for six months in our laboratory (2005)
Research in six grower cooperator vineyards, including donated land, labor and supplies

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Carlos H. Crisosto, University of California, Davis

ARS Location:
Crop Diseases, Pests and Genetics Research Unit
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Project Title: *Epidemiology and Management of Xylella fastidiosa (Xf) and other Exotic and Invasive Diseases and Insect Pests*

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Vacant, Research Plant Pathologist (Recruitment in progress)

Vacant, Research Plant Physiologist/Plant Molecular Biologist (Recruitment in progress)

Project Objectives:

1. Determine the epidemiology of exotic, emerging, re-emerging, and invasive diseases in California, including (but not necessarily limited to) Xf-caused diseases of horticultural, agronomic, and ornamental crops.
2. Determine the nature and mechanism(s) of susceptibility/resistance to Xf infection and subsequent disease development in horticultural and agronomic crops, including (but not necessarily limited to) *Vitis* species and *Prunus* species.
3. Develop effective, economical, environmentally sound strategies to manage exotic, emerging, re-emerging, and invasive diseases, including (but not necessarily limited to) xylellae diseases.

Major Accomplishments (2004 – 2007):

Introduction into California of the glassy-winged sharpshooter (GWSS), an exotic vector of *Xylella fastidiosa* (*Xf*), has worsened the threat of Pierce's Disease epidemics in vineyards. At present, GWSS is under control via area-wide pesticide application, at great cost to growers; however, more sustainable management tactics are needed. Progress in developing such approaches is hindered by lack of knowledge of the mechanisms of transmission of *Xf* by GWSS, and inability to observe and measure transmission in real-time. This deficiency is being met by characterizing GWSS feeding behaviors that control transmission of *Xf*, using electrical penetration graph (EPG) waveforms. Research comparing EPG measurement of transmission behaviors on resistant vs. susceptible grape varieties, and under different climate regimes is in progress. Ultimately, the research will aid development of resistant grape varieties tied to disease progress predictions based on epidemiological modeling. The research relates to the Sustainable Practices research priority of NGWI**.** (E. Backus)

Although pro-phages were found in *X. fastidiosa* genome, evidence of true phages has not been documented. Unique sequences from a large *X. fastidiosa* collection were compared to available whole genome sequences. A mobile phage sequence was identified. This is by far the best evidence for the presence of true phages in *X. fastidiosa*. The information will help to understand pathogen evolution and provide potential new control strategy. This work may be related to NGWI research priorities No 4: Sustainable Practices. (J. Chen)

In the Central Valley, grapevine and almond are often grown side by side. It is important to investigate how the *X. fastidiosa* from one crop relates to other crops. Phenetic and genetic comparisons were performed on a large collection of *X. fastidiosa* strains. Both "grape" and "almond" genotypes/pathotypes were found in almond orchards. This is the first report of a mixed infection by multiple *Xf* strains in a single crop plant and has impact on the epidemiology of PD and almond leaf scorch diseases. This work may be related to NGWI research priorities No 4: Sustainable Practices. (J. Chen)

Easily scorable characters to type strains of *X. fastidiosa* are limited. Characterization of *X. fastidiosa* motility in cultures was performed. Two types of bacterial cell motility were observed. This provides new insight in *X. fastidiosa* surface movement and is a readily scorable trait to aid in strain identification. This work may relate to NGWI research priorities No 4: Sustainable Practices. (J. Chen)

Efficient sample preparation techniques are in need for high throughput detection of *X. fastidiosa*. A simplified PCR procedure by using freeze-dried tissue was developed. A 92 percent detection accuracy (relative to pathogen isolation and culture) was achieved. The Procedure is amenable to processing up to 1,000 samples per day. This work may be related to NGWI research priorities No 4: Sustainable Practices. (J. Chen)

It is known that variation in tandem sequence repeats is common in microbial genomes. The biological role of tandem repeats remains largely unknown. A tandem repeat variation in a protease gene of *X. fastidiosa* was investigated. Evidence shows that this variation may relate to bacterial environmental adaptation. This result points to a new direction in studying host-pathogen interaction for xylellae diseases. This work may be related to NGWI research priorities No 4: Sustainable Practices. (J. Chen)

All *vinifera*-based cultivars are highly susceptible to Pierce's Disease (PD). However, information regarding genetic control of resistance and the molecular understanding of resistance mechanisms to PD is limited. We designed a custom high-density gene chip consisting of 382,900 gene probes derived from PD resistance and susceptibility of *Vitis*. We used this system to analyze and identify genes involving resistant and susceptible responses during the PD development. Nine candidate genes which appear to be directly involved in the defense response at early, mid and late stages of *Xf* infection were identified. An alternative to pesticide application(s) to control the disease and/or insect vector, utilization of grape resistant genes to improve cultivar performance will provide durable resistance. This research strategy is aligned with the NGWI research priorities # 4 in developing an environmentally-friendly and sustainable agricultural production system.

The research project is in conjunction with the PD resistance genetic breeding program at University of California, Davis. Information derived from ARS research will facilitate in developing molecular markers that will be used for molecular-assisted breeding. Research activities have been presented in academia and industrial meetings since 2003. (H. Lin)

In California, the genetic diversity, as well as the genetic, evolutionary, biological, and epidemiological relationships among *Xylella fastidiosa* (*Xf*) strains, is not fully understood. The relationships between pathogenicity and genotypes of *Xf* are needed to develop effective, sustainable disease and insect pest management strategies. DNA markers called Simple Sequence Repeat (SSR) were designed for *Xf*. We further developed this marker system into a high throughput multiplex genetic analysis platform. Combination of *Xf* genetic analyses and environmental parameters provides comprehensive information for better understanding the epidemiological PD. This research is aligned with NGWI research and extension priorities # 4 for integrated pest and pathogen management and maximization of productivity. This is a

collaborative research project with the PD resistance genetic breeding program at University of California, Davis. Information derived from this research has been presented at national and regional academia and industrial meetings since 2004. (H. Lin)

All major table and raisin grape cultivars grown are susceptible to Pierce's Disease (PD) and those with PD resistance have inferior fruit quality. PD resistance has been lost when resistant plants have been back crossed to improve fruit quality. Fruit quality, measured as cluster, berry and seed size, and disease resistance was studied in F1 and BC1 families to determine if fruit quality could be increased equally in resistant and susceptible individuals. F1 and BC1 populations with similar fruit quality independent of their PD resistance or susceptibility have been identified. This means cultivars with PD resistance and good fruit quality can be produced with use of the current greenhouse screening and molecular marker assisted selection methods. This will help the grape industry combat the spread of PD by any vectors that may be in the grape production area. This research relates to Understanding and Improving Quality and to Processing and Production Efficiency. (D. Ramming)

Selection of Pierce Disease (PD) resistant types is very slow when relying on natural infection in the field. This limits the speed with which breeding cycles can be completed, making it difficult to develop resistant cultivars with high fruit quality in a short time. The use of greenhouse inoculation tests and marker-assisted selection has been used to shorten the breeding cycle. Since 2005, 1,049 BC2 seedlings have been screened with molecular markers, 394 identified as resistant, and 14 cross combinations for modified BC3 table and raisin grape generations made. The modified BC3 generation will be 94 percent *V. vinifera* with a very high possibility of having fruit quality very similar to commercial table and raisin grape cultivars. This material will be useful for field trials to show resistance to PD with good *vinifera* type fruit quality can exist. This research relates to Understanding and Improving Quality and to Processing and Production Efficiency. (D. Ramming)

Glassy-winged sharpshooter, the most important vector of Pierce's disease in California, is currently found only in southern portions of the state. Spread of the glassy-winged sharpshooter north is a serious threat to grape production on the north coast. The suitability of the climate of the north coast for glassy-wing sharpshooter overwintering survival is currently unknown. In collaboration with scientists at the University of California, we are developing a degree-day cooling model to predict overwintering survival of glassy-winged sharpshooter. The model will aid in determining which portions of California are suitable for glassy-wing sharpshooter survival. The intent of this research is to determine the threat of glassy-wing sharpshooter to grape growing regions where it is not yet established. This research is related to NGWI Priority 4, sustainable practices. (M. Sisterson)

Available plasmid vectors for stable propagation of genetic material introduced into *Xf* for experimental purposes are of limited utility. Initiated cloning and sequencing of plasmids resident in strains of *Xylella fastidiosa*. Identified a novel plasmid in specific strains of *Xf*; determination of complete plasmid DNA sequence in progress. Potential deliverable of project may be development of a new plasmid shuttle vector for introduction of DNA into *Xf* for experimental determination of *XF* gene function. This work is related to NGWI research priorities No 4: Sustainable Practices, in that improved tools for genetic manipulation of *Xf* will provide new information concerning *Xf* disease mechanisms that may be exploited as targets for disease control. (D. Stenger)

Technology Transfer/Outreach:

- Peer-reviewed publications.
- Presentations at grower/stakeholder meetings (e.g. California Table Grape Commission, annual Pierce's Disease Research Symposium), and the National Viticulture Research Conference (University of California-Davis).
- Presentations at meetings of the American Phytopathological Society.
- Patented and assigned table grape cultivars to the California Table Grape Commission for propagation and distribution to the grape industry.
- California Table Grape Commission Research committee participates in the evaluation of new USDA table grape advanced selections.
- Report table and raisin grape cultivar releases and status of breeding research at industry meetings and California State University, Fresno, field days to growers and researchers.
- Participate in annual Pierce's Disease Research Symposium.
- A cooling degree-day model for GWSS is being developed and will be made publically available.

External support:

University of California DANR Pierce's Disease Research Grant Program – The Role of Glassy-winged Sharpshooter Salivary Enzymes in Infection and Movement of *X. fastidiosa* (2006-2008).

University of California DANR Pierce's Disease Research Grant Program – Where, When, and How Do Ingestion and Other Feeding Behaviors of the Glassy-winged Sharpshooter Allow Inoculation of *Xylella fastidiosa*? (2004-2007).

University of California DANR Pierce's Disease Research Grant Program – Developing a Microarray-PCR-Based Identification and Detection System for *Xylella fastidiosa* Strains Important to California" (2003-2005).

University of California DANR Pierce's Disease Research Grant Program – Developing a Microarray-PCR-Based Identification and Detection System for *Xylella fastidiosa* Strains Important to California" (2003-2005).

California Department Food and Agriculture PD/GWSS Research Program – Developing Transcriptional Profiles and Microarray Expression Analysis of Grape Plant Response to *Xylella fastidiosa* (2004-2007).

University of California DANR Pierce's Disease Grant Program – Multilocus SSR markers for genotyping and genetic diversity assessment of *Xylella fastidiosa* in California (2004-2006).

California Department Food and Agriculture PD/GWSS Research Program – Characterization and Identification PD resistant mechanisms: Analysis of xylem anatomic structures and of natural products in xylem sap among *Vitis*" (2004-2006).

University of California DANR Pierce's Disease Grant Program – Comparative proteomic analysis of stem tissue and xylem sap from Pierce's Disease resistant and susceptible grapevines (2005-2007).

Viticulture Consortium West – Development of Simple Sequence Repeat (SSR) markers for fingerprinting and genetic diversity assessment of *Phylloxera* (*Daktulosphaira vitifoliae*) in California (2007-2008).

Development of Seedless Grapes for the Fresh Market Including Types Resistant to Powdery Mildew.

- California Table Grape Commission (2004, 2005, 2006, 2007)
- California Competitive Grants Program for Research in Viticulture and Enology (2005 – 2007).
- Viticulture Consortium West (2006).

Evaluation of Advanced Grape Selections in the Coachella Valley.

- California Table Grape Commission (2004, 2005, 2006, 2007)

Development of Improved Raisin Grapes for Mechanical Harvest Including Types Resistant to Powdery Mildew.

- California Raisin Marketing Board. (2004, 2005, 2006, 2007)
- California Competitive Grants Program for Research in Viticulture and Enology. (2004, 2005, 2006, 2007)

Breeding Pierce's Disease Resistant Table and Raisin Grapes and the Development of Markers for Additional Sources of Resistance.

- University of California Pierce's Disease Research Program. (2006-2007)
- Consolidated Central Valley Table Grape Pest and Disease Control District (2006-2007)

University of California DANR Pierce's Disease Research Grants Program – Spatial population dynamics and overwintering biology of the glassy-winged sharpshooter and its natural enemies in California's San Joaquin Valley (2004-2006)

University of California DANR Pierce's Disease Research Grants Program Assessing the post-winter threat of glassy-winged sharpshooter populations (2007).

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ARS Location:
Water Management Research Unit (WMRU)
San Joaquin Valley Agricultural Sciences Center (SJVASC)
Parlier, California 93648

Project Title: *Alternatives to Methyl Bromide for California Cropping Systems*

Project Participants:
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Project Overview and Objectives:
The project at the Water Management Research Unit at the San Joaquin Valley Agricultural Sciences Center (SJVASC) is focused on testing methyl bromide alternative chemicals, rates, and application technology for controlling soilborne pests, diseases, weeds, and for reducing atmospheric emissions for a number of cropping systems in California including grapes. The project objectives that pertain specifically to grapes are to develop alternatives to methyl bromide soil fumigation to meet California certification standards for nematode-free production of grapevine field nurseries and to control vineyard replant disorder.

Major Accomplishments (2004–2007):
Grape growers will likely lose productivity when methyl bromide is phased out unless alternatives are found to control soil pests and reduce the effects of the "replant syndrome." ARS scientists at SJVASC, in collaboration with researchers from other ARS locations and the University of California, and with support provided by Tri-Cal (commercial methyl bromide fumigation), numerous chemical companies (materials), and Sunridge Nursery (grape plants), tested several methyl bromide alternatives in replanted vineyards in a series of field trials located at the SJVASC. Emulsified formulations of alternative fumigants 1,3 dichloropropene (1,3-D) and chloropicrin (Pic) applied through subsurface drip irrigation systems produced vine growth and yields equal to methyl bromide; and control of plant parasitic nematodes in vineyard replant plots treated with drip-applied 1,3-D or shank-injected iodomethane (MI) was comparable to control achieved by methyl bromide after 6 growing seasons.

Three drip-applied fumigants were evaluated as methyl bromide alternatives for field-grown grape nurseries at the SJVASC. Sodium azide, 1,3-D + Pic, and MI + Pic were applied to a rootknot nematode infested field prior to planting grape nursery "sticks." When plants were harvested at the end of the 1-year cropping cycle, root galls (which make the vines unmarketable) were found on 92 percent of the Thompson Seedless and 100 percent of the cabernet sauvignon plants in untreated plots, 67 percent of the cabernet sauvignon and 54 percent of Thompson Seedless in azide treated plots, and were absent in the methyl bromide, 1,3-D + Pic, and MI + Pic treated plots. These results suggest that 1,3-D + Pic and MI + Pic are good candidates as alternatives to methyl bromide on the California Department of Food and Agriculture "approved Certified Nursery soil treatment list" for sandy loam soils.

In a vineyard replant trial in a field at the SJVASC from which 60+year old grapevines were removed, all treatments, including InLine (drip-applied 1,3-D + Pic) , Midas (MI + Pic), and sodium azide controlled plant parasitic nematodes to a depth of five feet at the time of planting. After the first and second full growing seasons, rootknot nematode populations on Thompson Seedless in plots treated with sodium azide were comparable to populations in untreated plots while populations in InLine and Midas treated plots were comparable to methyl bromide. Plants grown in methyl bromide treated plots were significantly larger than plants grown in all other treatments. This trial, which will continue for several more years, documents the necessity of measuring not only initial nematode control, but also nematode control over time and plant growth and yield in order to evaluate the potential as a methyl bromide alternative.

Growers of certified propagative material for vineyards must be able to produce crops that are free of plant parasitic nematodes at the end of 1- and 2-year crops. Distribution of some fumigants is not adequate following shank-injection in fine-textured soils and drip fumigation was suggested as a possible solution to obtain better distribution of fumigants in fine textured soils. MI + Pic, 1,3-D alone, and 1,3-D + Pic were applied by standard shank-injection methods and as emulsified formulations through drip irrigation systems and compared to standard methyl bromide fumigation for nematode control in sandy loam, loam, and clay loam soils. Although nematodes at the 15 and 30 cm depths were killed by drip fumigation, nematodes at the 60 and 90 cm depths survived. Under the conditions of this field trial on fine textured soils, drip-applied fumigants provided inadequate nematode control to meet certified nurseries requirements.

Technology Transfer/Outreach:
Demonstrated and extended research on alternative fumigants, application techniques and cultural practices that allow growers to maintain current production levels without the use of methyl bromide through field days, presentations to grower groups, and presentations at the annual Methyl Bromide Alternatives Research Conference and other scientific meetings.

External Support
Arvesta – Efficacy of shank and drip applied iodomethane and iodomethane + chloropicrin combination treatments for nematode and weed control in vineyard replant and grapevine nursery situations.

Dow AgroSciences – Evaluation of shank-injected and drip-applied 1,3-dichloropropene alone and in combination with chloropicrin as alternatives to methyl bromide for vineyard replant and perennial tree, vine, and rose nurseries.

Collaborators
Greg Browne, ARS, Davis, CA
David Cox, L.E. Cooke Co., Visalia, CA
Husein Ajwa, University of California, Davis, CA
Anil Shrestha, University of California, Kearney Agricultural Center, Parlier, CA

ARS Location:
Beneficial Insects Research Unit
Subtropical Agricultural Research Center
2413 Highway 83
Weslaco, Texas 78596

Project Title: *Biological Control of Invasive and Exotic Pests*

Project Participants:
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Project Objectives:
1. Develop molecular markers to determine the geographical origin of populations of Glassy-winged Sharpshooter and its natural enemies.
2. Develop molecular markers to differentiate cryptic species of *Gonatocerus*, wasps that parasitize the eggs Glassy-winged Sharpshooter.
3. Develop diagnostic molecular markers to identify natural enemy complexes of Glassy-winged Sharpshooter.
4. Investigate the host-plant finding behavior of Glassy-winged Sharpshooter.
5. Determine the potential of Big-Eyed Flies (Pipunculidae) to function as biological control agents of immature sharpshooters.

Major Accomplishments (2004 – 2007):
The geographical origin of the insects that developed into the recent epidemic of Glassy-winged Sharpshooter (GWSS) in California was unknown. Using molecular markers, Dr. Jesus de León was the first to determine that Californian populations of GWSS originated in Texas. His studies also uncovered significant genetic diversity in GWSS populations among regions and demonstrated that GWSS populations in the United States are genetically distinct, clustering into two main groups. The research suggested that more than one 'founding event' occurred in

California, and that GWSS invaded French Polynesia via California. Since the origin of the California GWSS infestation is Texas, the most effective pre-adapted natural enemies for release in California should occur in Texas. Tiny wasps (*Gonatocerus ashmeadi*, *G. triguttatus*, and *G. morrilli*) that parasitize GWSS eggs have been collected in Texas. Their release in California has helped suppress GWSS.

The establishment and dispersal of released biological control agents is often difficult to determine. Dr. de León developed molecular markers that showed that one of the primary egg parasitoids used in California was, in fact, two morphologically indistinct species: *G. morrilli* and a novel species *Gonatocerus walkerjonesi* (native to California and named in honor of Dr. Walker Jones, former Research Leader of the Beneficial Insects Research Unit at Weslaco). Prior to his study, the effectiveness of the introduced egg parasitoid, *G. morrilli*, could not be monitored because it was morphologically indistinguishable from the native species, *G. walkerjonesi*. The molecular markers developed by this study will enable us to determine the success of the biological control program in California by evaluating establishment, dispersal, and efficacy of each wasp species, and improve mass rearing by preventing contamination of unwanted species. For example, it has now been determined that *G. walkerjonesi* occurs primarily in the coastal region of California and that *G. morrilli* is now the most frequently recovered egg parasitoid in certain regions of California, suggesting that it is starting to establish in a variety of agricultural habitats.

The genetic structure of GWSS natural enemy populations is often not understood. Dr. de León determined that populations of a primary GWSS egg parasitoid (*Gonatocerus ashmeadi*) from different locations were genetically differentiated. This finding is significant to the biological program in California because parasitoid populations from distinct geographical regions may differ in relevant biological characteristics of importance to biological control. These species are being sent to California for further studies. If one or more of these species is released in the future, then the markers developed during this study will be used to monitor their establishment. He also showed that *Gonatocerus tuberculifemur*, a prospective GWSS biological control agent from South America, is a complex of several species, with three being new species. *G. tuberculifemur* 'clade 2' is from a location in South America that 'climate matches' with California, but not within any region of the southeastern United States. This is critical, because based on climate matching theory, if this species is released in California, it is not expected to migrate to the southeastern region of the United States and attack non-target leafhoppers in that region.

The identification of natural enemies that feed on different life stages of GWSS has not been sufficiently documented. In a collaborative effort with Dr. James Hagler (ARS, U.S. Arid Land Research Center, Maricopa, AZ) and Dr. Kent Daane (Division of Insect Biology, University of California at Berkeley), Dr. de León developed novel molecular diagnostic markers for a GWSS-specific PCR assay that has aided in identifying key predators of GWSS. The markers were highly specific toward GWSS and were also able to identify GWSS remains at all life stages (eggs, nymphs, and adults) in predator gut contents. Field studies combining both molecular markers and the monoclonal antibody have shown excellent success and are leading to the identification of key GWSS predators. The most frequent predators to test positive included the assassin bug, spiders from certain families, lacewings, and praying mantis. This research will aid in evaluating the efficacy of generalist predators and improve our understanding of the ecology

of GWSS-predator interactions. This information can be used to develop more ecologically-based management programs to control GWSS.

Host-plant finding behavior in GWSS is very poorly understood. Dr. Joe Patt was the first to determine that both immature and adult GWSS use foliar odors to locate host-plants. The results of his study suggest that GWSS response to visual cues is enhanced by the presence of olfactory cues. His research also demonstrated that immature GWSS can learn to associate novel odors with the presence of host plants. These results, along with ongoing studies, suggest that GWSS can use odor cues to discriminate between nutritionally favorable and unfavorable host plants. This fundamental research provides a springboard to understanding the behavioral mechanisms involved in host-plant location by GWSS. The information provided by these studies is critical to understanding how GWSS locates its host plants and its commuting behavior amongst various crops. It will eventually help inform the development of management strategies, such as trap cropping via deficit irrigation practices and may lead to better monitoring protocols.

Technology Transfer/Outreach (2004-2007):
This research is used by the California Departments of Food and Agriculture and other scientists. The primary product is enhanced biological control of GWSS through improved monitoring and production of parasitoids. Research is extended to customers through invited presentations to regional grower groups in California and Texas and through publications in peer-reviewed journals.

External Support (2004-2007):
Dr. De León's research on the development of novel molecular diagnostic markers for GWSS-specific PCR assay for identifying key predators is supported, in part, by a grant from CDFA to Dr. James Hagler.

Collaborators (2004-2007):
Jeffrey Skevington, Agriculture Canada, Ottowa
Guillermo Logarzo ARS, Buenos Aires, Argentina
James R. Hagler, ARS, Maricopa, AZ
Walker A. Jones, ARS, Montpelier, France
David J. W. Morgan, California Department of Food and Agriculture
Mamoudou Sétamou, Texas A&M University at Kingsville, Citrus Center
Kent Daane, University of California, Berkeley, Division of Insect Biology
Serguei V. Triapitsyn, University of California, Riverside

Section IV: Waste Management/Environmental Issues

Research at Fort Pierce, Florida; Wooster and Toledo, Ohio; and, McMinneville, Tennessee, relates to optimal water application, water recycling, and wastewater management and mitigation for floral and nursery crops. However, there is currently no research in this area on grape.

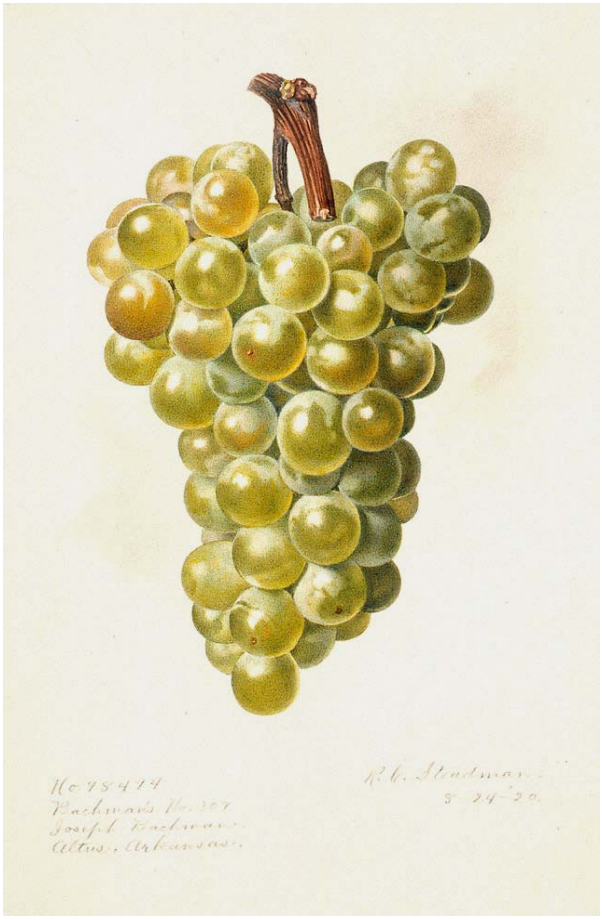
Section V: Quality

Albany, California

- *New Technologies to Process Value-Added, Healthy Foods from Fruits and Vegetables*; John Roberts

Corvallis, Oregon

- See work by J. Lee reported in the Crop Production Systems section.



ARS Location:
Western Regional Research Center
Processed Foods Research Unit
800 Buchanan Street
Albany, California 94710

Project Title: *New Technologies to Process Value-Added, Healthy Foods from Fruits and Vegetables*

Project Participant:
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Project Objectives:
1. Investigate and develop new processing technologies that will permit year-round processing, by manufacturing value-added, convenient, healthy foods from bulk-processed fruits and vegetables and their co-products. The sub-objective of this project was to investigate the use of microwave dehydration to improve the color and quality of raisins.

Major Accomplishments
Drying grapes into raisins using solely convective hot air requires long drying times and results in brownish-reddish raisins if no pretreatment method is applied. Microwave power combined with warm air shortens the drying time, significantly lowers the drying temperature requirement since heat is generated within and does not rely on heat conduction from the surface, improves the end-product quality in terms of color, and requires no chemical pretreatments. The objectives were to: a) Determine drying rates and temperature profiles of microwave assisted drying; and b) Measure the color quality of resulting raisins. The microwave energy requirement was surprisingly low, and this low microwave power/convective warm air drying resulted in better quality end product, lower drying time, and lower overall energy usage than drying using convective hot air alone. Drying of grapes using low microwave power combined with warm air is a promising method, if adequately applied. Without the need of a pretreatment method, drying was much faster than convective drying and resulting raisins had better color quality. Drying is one of the most energy intensive processes in the food industry, and this process has the potential to reduce the energy use and improve the color quality of raisins. This project relates to NGWI research priority on Grape and Grape Product Quality.

Technology Transfer/Outreach
The results of this research were presented at the Institute of Food Technologists (IFT) Annual Meeting in Chicago, Illinois and at the NGWI meeting. We will look for technology transfer partnership opportunities at both of these venues. In addition, several manuscripts are being written to further discriminate the results of this study.

External Support
Istanbul Technical University, Department of Food Engineering, Istanbul, Turkey.

Collaborators

Gokhan BINGOL, and Y. Onur DEVRES, Istanbul Technical University, Department of Food Engineering, Istanbul, Turkey.

Section VI: Nutrition

Albany, California

- *Characterization and Control of Nutritional and Sensory Properties of Raw and Processed Grains, Legumes, and Vegetables*; Gary Takeoka and Lan Dao

Davis, California

- *Micronutrients and Immune Function*; Susan Zunino and Charles B. Stephensen

Beltsville, Maryland

- *Bioavailability and Metabolism of Anathocyanins*; Beverly Clevidence, Janet Novotny, Steven Britz, and Philip Simon

ARS Location:
Western Regional Research Center
Processed Foods Research Unit
800 Buchanan Street
Albany, California 94710

Project Title: *Characterization and Control of Nutritional and Sensory Properties of Raw and Processed Grains, Legumes and Vegetables*

Project Participants:
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Project Objectives:
1. Add value to grains, legumes, fruits and/or vegetables by extrusion technology using processing parameters and texture modifying ingredients to control or enhance nutritional, textural and sensory properties.
2. Isolate and identify biologically active constituents in grains, legumes, fruits and vegetables, and their co-products.

Major Accomplishments:
Anthocyanins impart the desirable red, purple, mauve, and blue colors in grapes and have received increasing attention due to their potential health benefits in reducing the risks of chronic diseases such as cancer, cardiovascular diseases, and Alzheimer's disease. Determining the structure of the anthocyanins present in grapes is critical since their color, stability, and nutritional benefits (absorption/metabolism) are strongly determined by their chemistry. We investigated the anthocyanin content and composition of the skin and flesh of new red grapes developed by David Ramming (Research Horticulturist, ARS, Parlier, California). We identified wide variation in the content and composition of anthocyanins in skin and flesh of different red grapes. This information can be used to optimize the nutritional benefits and color quality and stability of grapes and their co-products. This project relates to NGWI research priority on providing healthy and nutritious grape products and understanding and improving quality.

Technology Transfer/Outreach:
We plan to publish the results of our grape research and are seeking partnership opportunities to further this research.

External Support: None

Collaborators:
David Ramming, ARS, Parlier, CA

ARS Location:
Food Components and Health Lab
Beltsville Agricultural Research Center
Beltsville, Maryland 20705

Project Title: *Bioavailability and Metabolism of Anthocyanins*

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Project Objectives:
Elucidate bioavailability, dose-response, and pathways of metabolism of anthocyanins from various sources

Major Accomplishments:
Anthocyanins are brightly colored pigments found in fruits and vegetables and are associated with numerous health benefits. However, the bioavailability of anthocyanins appears low relative to amount consumed. Through clinical nutrition studies, we investigated the bioavailability and metabolism of various anthocyanins from purple carrot, red cabbage, and strawberries. Results have shown that anthocyanin bioavailability, metabolism, and dose-response depends on the type of anthocyanin consumed, the chemical groups attached to the anthocyanin, and the amount of anthocyanin consumed. As the health benefits of dietary anthocyanins become clearer, the information generated from this project will be useful as dietary recommendations are ultimately developed. This research relates most closely to the NGWI research priority #2 – Consumer Insights, Nutrition, and Community, in that it is in accord with the focus of compiling all known nutritional research related to grapes and grape products.

Technology Transfer/Outreach:
This work has been presented at several scientific conferences and at to the Maryland Technology Development Corporation.

External Support:
CSREES, through the Initiative for Future Agricultural and Food Systems.

ARS Location:
Western Human Nutrition Research Center
430 West Health Sciences Drive
Davis, California 95616

Project Title: *Micronutrients and Immune Function*

Project Participants:
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Project Objectives:
1. Investigate the effect of micronutrients on immune function using human volunteers, animals, and cell culture
2. Determine the optimal levels for maintaining a healthy immune system.

Major Accomplishments:
Juvenile type I diabetes is an autoimmune disease that results in destruction of the insulin producing beta cells in the pancreas by one's own immune cells. Without insulin injections, patients with this disease have severe metabolic disturbances that result in coma and death. We used a well-known mouse model for Type I diabetes to study whether grape-enriched diet could prevent inflammation that causes the destruction of the insulin-producing cells. We found that the grape-enriched diet delayed diabetes in these mice by greater than 50 percent compared to mice receiving normal food and reduced the number of immune cells in the pancreas compared to diabetic mice receiving normal food. These results suggest that grapes contain bioactive components that have potent anti-inflammatory activity and may be useful for managing inflammation due to a number of chronic diseases. This study examined the benefits of grapes in maintaining health, which relates to NGWI research priorities.

Resveratrol is a chemical produced in the skin of grapes to combat fungal infections. Resveratrol has shown both anti-inflammatory and anti-cancer activities in cell culture and in animal models for disease. We have tested resveratrol against high-risk infant leukemia and observed that resveratrol kills these leukemia cells in cell culture. We have determined part of the mechanism by which resveratrol kills these cells and a grant from the National Institutes of Health (NIH), National Cancer Institute has been awarded to study whether resveratrol can prevent leukemia in a mouse model for this disease. The mouse studies are the next step to determine the effectiveness of resveratrol in preventing leukemia and relates to the NGWI priority of exploring the health benefits of grape components.

Obesity is a strong risk factor for the development of a number of chronic diseases which include hypertension, cardiovascular disease, and Type II diabetes mellitus and has now become a major health problem worldwide. Elevated serum cholesterol and lipids are commonly observed in obesity and adipose tissue is a major source of inflammatory molecules. Although these studies are not directly using grapes, strawberries, and grapes share a number of bioactive components that display anti-inflammatory activities. We are currently feeding strawberries to obese volunteers to determine the anti-inflammatory effects of this fruit. We are measuring cholesterol and lipid profiles, the presence of inflammatory molecules in blood, immune responses that may reduce the risk of cardiovascular and other health problems, and changes in gene expression in immune cells. These investigations will provide important information on the ability of bioactive components of fruits to alter immune function and inhibit the inflammation associated with morbidity and mortality in obese individuals. These types of human studies will be important to explore the health benefits of grapes and grape products.

Technology Transfer/Outreach:

- Results from the Type I diabetes and leukemia studies have been published in scientific journals.
- The data on Type I diabetes were presented at the international 2006 Experimental Biology meeting in San Francisco and resulted in a press release by the California Table Grape Commission on May 15, 2007.
- The leukemia studies were the basis of an NIH grant awarded to Dr. Zunino for further studies of resveratrol in a mouse model for leukemia.

External Support:

California Strawberry Commission (PI) – Anti-inflammatory Effects of Strawberries in Obese Individuals.

California Nutrition Research Unit (co-PI), UCLA-UCD, California CNRU External Advisory Committee – Sensitization of high-risk leukemia to chemotherapy by resveratrol and curcumin.

National Cancer Institute (PI), National Institutes of Health – Evaluation of Resveratrol and Curcumin as Therapeutics Against High Risk Leukemia.

Lupus Research Institute (pending) – Suppression of inflammation in lupus-prone mice by polyphenol-enriched diets.