ARS Grape and Wine Industry Workshop
Breeding, Genetics, and Germplasm Research Presentation
Peter Cousins

ARS research in grape breeding, genetics, and germplasm includes variety improvement and development, conservation, preservation, and characterization of grape varieties and wild species, inheritance studies, and the diagnostic investigation of plant, pathogen, and pest presence, abundance, and identity. ARS scientists at four research locations work in grape breeding, genetics, and germplasm. Other ARS scientists investigating grapes and grape products at those locations contribute to the integration of breeding, genetics, and germplasm with plant physiology and pathology, cultural practices, and fruit and product quality research.

People and Places:
Geneva, New York: Plant Genetic Resources Unit.
Seven ARS scientists working in grape Breeding, Genetics, and Germplasm.

Davis, California: National Clonal Germplasm Repository.
Two ARS scientists working on grape Breeding, Genetics, and Germplasm; seven other ARS scientists working on grapes at this location.

Parlier, California: San Joaquin Valley Agricultural Research Center.
One ARS scientist working in grape Breeding, Genetics, and Germplasm; six other ARS scientists at this location working on grapes.

Poplarville, Mississippi: Small Fruit Research Station.
One ARS scientist working in grape Breeding, Genetics, and Germplasm; one other ARS scientist working on grapes at this location.

Germplasm:
Germplasm conservation and characterization occurs at two repositories, located at Davis, California, and Geneva, New York. The germplasm in the repositories is held as a public trust and the plant material is freely available to growers, breeders, botanists, and others across the United States and around the world. The germplasm collections include varieties, selections, genetic stocks, mapping populations, wild species, and grape relatives. Our national germplasm collection includes nearly 4000 unique accessions and is a treasure trove of flavors, smells, plant forms, disease and pest resistance, and other useful characteristics.

The repositories maintain, characterize, evaluate, document, and distribute the germplasm. Ed Stover is the curator at the repository in Davis. This collection has more than 2700 accessions and has distributed grape germplasm in response to more than 4400 requests over the last five years. Phil Forsline is the curator at the repository in Geneva. This collection has 1200 accessions and has distributed 9000 samples to 600 requests over the last twelve years.

Research activity at the repositories aims to improve our ability to distinguish among grapevine varieties, to characterize the useful characters of accessions in the repository, and to understand the relationship of different grape species. Malli Aradhya at Davis is leading characterization of

the grape collection using molecular marker fingerprinting. Molecular marker fingerprinting technology facilitates grapevine identification and allows easier comparison of varieties. This helps reduce duplication in the collection and contributes to the unambiguous differentiation of varieties. At Geneva, Chuck Simon is investigating the relationship of grape species to one another, which will contribute to collection maintenance and accurate species identification of accession in the collection.

Breeding:
Three locations have research aimed at the production of new grape varieties. At Parlier, California, David Ramming is developing improved grape varieties that address:

- Need for better seedless table grapes that are productive and store and ship well.
- High cost of harvesting raisin grapes and fall rain damage.
- Powdery mildew susceptibility of table and raisin grapes and the cost of control measures as well as protection of the environment from chemicals.
- Susceptibility of table and raisin grapes to Pierce's disease and the increased problem of the disease as caused by the glassy-winged sharpshooter vector.
- Susceptibility of rootstocks to phylloxera

The research program at Parlier uses embryo rescue to hybridize seedless parents, which increases the fraction of seedless offspring that are critical in both table and raisin grape production. Selection of superior individuals includes screening for pest and disease resistance, fruit size, storage ability, and other qualities, viticultural testing to determine appropriate cultural practices, and for raisin types, the ability to dry on the vine without cane cutting.

The ARS program at Parlier bred the leading table grape and raisin grape varieties in production in California and in other important grape producing regions, including the table grapes Crimson Seedless, Autumn Royal, Princess Seedless, Sweet Scarlet, and Flame Seedless and the raisin grapes DOVine, Selma Pete, Diamond Muscat, Summer Muscat, and Fiesta. New grape varieties in development include powdery mildew resistant low and no spray varieties and Pierce's disease resistant types in both table and raisin grape classes.

Stephen Stringer at the Small Fruit Research Station in Poplarville, Mississippi is breeding muscadine grapes with improved fresh market quality and enhanced nutritional compounds, such as antioxidants. Today's muscadine grape varieties are faulted for large seeds, thick skin, and soft texture. Through variety evaluation and hybridization, Dr. Stringer is developing new muscadine grape varieties with superior fresh market quality. More than 70 cultivars and breeding lines have been evaluated since 2001 and breeding populations are in the vineyard for additional evaluation. One selection has been advanced as a candidate fresh market muscadine grape cultivar. Selections are evaluated across the Southeastern United States.

Peter Cousins at the Plant Genetic Resources Unit, Geneva, New York, is breeding rootstocks with enhanced resistance to root-knot nematodes. Root-knot nematodes are the primary root pest on more vineyard acres in the United States than any other pest, including phylloxera. Current management techniques for root-knot nematodes include pre-plant fumigants such as methyl bromide, for which alternates are sought. Contemporary root-knot nematode resistant rootstocks, such as Freedom and Harmony, are being attacked by new aggressive and virulent nematode

populations. New rootstock varieties with resistance to the aggressive virulent nematodes are needed. Screening germplasm for superior nematode resistance identifies suitable parents and hybridization among those parents produces candidate rootstock populations. Since 2001, more than 12,000 seedlings have been screened for resistance to nematodes and over 250 nematode resistant seedlings have been planted to the vineyard. Fifteen selections were grafted to Syrah and planted in vineyard trials in 2005.

Genetics, Genomics, Proteomics, and Bioinformatics:
ARS grape genetics research is centered at the Plant Genetic Resources Unit, Geneva, New York. The scientists investigating grape genetics, genomics, proteomics, and bioinformatics work with growers, breeders, germplasm curators and other researchers to understand the control of important characteristics and facilitate the deployment of this information towards variety improvement and new management practices.

Fungal diseases are one of the most serious challenges to the production of quality grapes. Lance Cadle-Davidson is identifying novel sources of resistance and elucidating the mechanisms of resistance to key fungal pathogens, including powdery mildew, *Botrytis*, and *Phomopsis*. By screening germplasm collections, mapping, breeding, and other experimental populations, varieties that differ in disease resistance and resistance mechanisms are identified. Non-temporal as well as developmentally regulated (or ontogenic) resistance has been described in many genetic backgrounds and the biochemical basis of this resistance is being characterized through genomic and proteomic approaches. This will contribute to the development of improved, disease resistant varieties.

Fruit quality is determined by the interaction of grape variety, environment, and management practices. Christopher Owens seeks to understand the genetic control of grape ripening and fruit quality in order to maximize fruit quality in improved varieties. A single gene has been characterized that influences fruit color, aroma, and tannin accumulation and the role of this gene in regulating fruit color and other quality aspects is being investigated. Additional candidate genes that condition fruit ripening and quality aspects are being examined. Once the role of the genes is understood, breeding and manipulation of these characters will be facilitated.

The interaction of grapevines with their environment is a primary driver of success in the vineyard and in the market. Budbreak, anthesis, fruit set, veraison, leaf fall, and dormancy have large effects on survival, fruit quality, and market value of grapes. However, the genetic basis for the timing of these events with environmental cues is poorly understood. Amanda Garris is investigating the genetic control of the interaction of grapevines with their environment. She is using molecular approaches to characterize the difference among varieties and clones that differ for critical traits. Once the essential genetic difference is understood, breeding and improvement of varieties for that characteristic will be much easier; for example, the development of earlier ripening table grapes or maturation accelerating rootstocks.

Genetic research is increasing our understanding of the fundamental processes that condition grapevine growth, development, and interactions with the environment, pests, and pathogens. Researchers around the world are investigating the grape genome. Characterization of the genes expressed under particular conditions and the differences in gene expression and sequence

among varieties helps explain differences in variety performance, behavior, and quality. Angela Baldo is using bioinformatics—computational analysis of genetic information—to develop markers related to functional genes, characterize phylogenetic relationships, and identify candidate genes for specific characters of interest. This work contributes to the development of tools and techniques used by other grape genetics and genomics scientists investigating grape gene function and genome structure.