Northwest Center for Small Fruits Research

2011 Annual Conference

Welcome to the 20th annual conference of the Northwest Center for Small Fruits Research in Portland, OR. We hope you will find this year's program interesting and useful.

Research Priorities: During the conference, time is set aside to revisit all research priorities by commodity. Commodity groups will meet separately to review and revise priorities. Please refer to the enclosed schedule for the time and room assignments. Copies of all priorities can be found at the back of this booklet.

Organizational Handbook: The Organizational Handbook has been included in your registration packet. This booklet provides an overview of the NCSFR operations, detailed funding information and a member directory.

Wine Tasting: Prior to this evening's dinner, we will have the opportunity to enjoy sampling a variety of wines from the state.

Guest Speaker: The guest dinner speaker for the Annual Conference will be Bill Nelson, Former President of Wine America and one of the original architects of the Northwest Center for Small Fruits Research. His talk, "Opportunities and Challenges in a New Political Age" will address the changing landscape of federal agricultural research funding and provide insights into how the Center may continue to thrive.

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Berry / Grape Processing

Storing Cranberry Fruit on the Vine–Impacts on Fruit Physiology, Yield and Quality

Linda White, OSU, Coos County Extension

Bernadine Strik, OSU

Cooperators: Joan Davenport, WSU; Ron and Mary Puhl, Cape Blanco Cranberries

Oregon and Washington harvest over 60 million pounds of cranberries per year. Currently, the majority of the Oregon fruit is sent to the processed market; however, the interest by growers in the fresh fruit market is increasing as the price for fresh fruit is significantly higher than for processed fruit. Due to the nature of the Oregon climate, cranberries can be harvested very late in the season – potentially into December. This "late harvest" may be advantageous to growers of fruit for the fresh market by increasing certain fruit quality parameters and post-harvest storage life; however, growers need recommendations on when to harvest to optimize fruit quality.

The objectives of this study are to 1) determine the effect of storing fruit on the vine (delaying harvest) on the post-harvest storage life of fresh cranberry fruit; 2) ascertain the effect of storing fruit on the vine on fruit yield and quality (color, acidity, sugar content), and the incidence of fruit disease or decay; 3) model the development of cranberry fruit size, dry weight, percent soluble solids, total acidity, total anthocyanins, and total phenols through the season, including past the "traditional" harvest period, on growing degree days over two years; and 4) measure the impact of nitrogen fertilization rate on the N concentration of fruit and fresh fruit storage life and quality.

Cranberry fruit were harvested from a 'Stevens' bed from July through December in 2007, and from the same bed, applying three nitrogen rates, 30, 50 and 70 lbs./A from July through December in 2008 and 2009. In both 2007 and 2008, fresh fruit weight peaked in early October, however, °brix, and total anthocyanin content peaked in mid-November. In 2009, fresh fruit weight peaked approximately 2 weeks earlier. Fruit quality parameters, such as berry firmness, size, and weight, were significantly higher at the low nitrogen rate. Storing fruit at room temperature for 3 weeks significantly, and negatively, impacted the percentage of fruit rot, berry weight and firmness. Based on the current results of this study, Oregon cranberry growers may safely harvest cranberries late in the season with few negative impacts to fruit quality.

Development of Value-Added Products from Wine Pomace

Yanyun Zhao, OSU

Cooperators: John Simonson

Four studies on the wine grape pomace (WGP) from US NW region were conducted for the goal of developing their value-added applications: 1) dietary fiber and phenolics composition of five major NW WGP (Morio Muscat, Muller Thurgau, Cabernet Sauvignon, Pinot Noir, and Merlot) were determined; 2) the effects of different drying methods on the chemical composition and bioactive compounds of WGP containing skin only and skin and seeds were evaluated, and their application as "antioxidant dietary fibers" for food application were studied; 3) edible films using WGP extracts were developed and their antioxidant and antimicrobial functions were investigated; and 4) the internal bonding performance of pomace with binding materials, crosslinking agents, and other functional additives for producing pomace based biocomposite boards using thermo-compression method were studied, the potential application of the board as biodegradable nursery pots were evaluated. Results quantified the dietary fiber composition and bioactive compounds of different WGP that are critical for developing their potential applications, and identified the optimized formulation for making WGP biocomposite and edible films as packaging materials, and the optimal drying methods for processing the wet WGP.

Dehydration of Berry Purees to Produce Value-Added Powders of High Quality for use in Nutritional Supplements

Kerry Ringer, WSU; Joan Davenport, WSU, IAREC; Jungmin Lee, USDA-ARS-HCRU; and James Harbertson, WSU

An important aspect of the nutrition industry is the dried powders made from fruits, vegetables, and plant extracts found in many nutraceutical products. In the nutrition industry, powders are typically made by manufacturers and sold in bulk quantities to companies that then use them in consumer products. A key component that has been severely lacking in this market is economical powders that are also high quality. The majority of puree powders on the market are low quality because they contain high amounts of additives (up to 80%) such as maltodextrin or cornstarch, are heat damaged, or oxidized. In order to address this need for high quality nutritional supplement powders, marionberry puree (made from IQF fruit), was dried with no carriers. The liquid was dried on a commercial Radiant Zone Dryer Ô (Columbia PhytoTechnology, LLC, Dallesport, WA). We are currently analyzing total phenolics, total anthocyanins of the raspberry and marionberry puree and powder. The Radiant ZoneÔ dried raspberry and marionberry powders were milled using a commercial sized Quadro-Comil and evaluated for physical characteristics including moisture content, water activity, flowability, and potential for clumping. Production of high quality, value-added berry powders using freeze drying and/or Radiant ZoneÔ drying may be a first step in establishing the Northwest as a producer of premium nutritional supplement powders as both of these drying technologies are located at companies in the Pacific Northwest. This type of research provides a use for damaged, bruised, or overproduced fruit that may not be suitable for sale in the fresh and frozen market as well as for berry waste streams from the juicing industry.

GENETICS

Cultivar Development of Edible-Fruited Honeysuckle (Lonicera caerulea L.)

Maxine Thompson, OSU

Plant breeding activities were carried on as in previous years. Controlled pollinations were made between parents whose traits complement each other. This year, second generation seedlings were used as parents to create third generation offspring from original seed imports. Seedlings from 2010 crosses were planted. Evaluations of older seedlings included bloom and harvest time, berry yields and quality factors. Eighteen of the most promising selections were propagated for distribution to grower-cooperators. Feedback from growers is valuable because this project does not have enough space for advanced trial plots. Sufficient evaluations are essential to identifying the very best selections worthy of cultivar status. With additional evaluations of the chosen 18 selections that appear the most promising, I expect to identify a few worthy of release as cultivars.

Establishment of Hardy Kiwifruit (*Actinidia arguta*) Selection Evaluation Trial

Chad Finn, USDA-ARS

Cooperators: Kim Hummer, USDA-ARS and Joe Snead, USDA-ARS

The goal of this project was to establish a replicated trial of kiwifruit selections that might complement or replace the current standard 'Ananasnaya'. Fifteen female selections from the USDA-ARS National Clonal Germplasm Repository or from the USDA-ARS breeding program were established in a trial that will allow us to objectively evaluate them. Most of the selections are from populations collected in northern China and, when grown in the Pacific Northwest, these are very early fruiting up to 6 weeks ahead of 'Ananasnaya'. The selections and controls have been propagated and the planting established. While there was some plant loss due to poor planting stock, the planting in general is in good shape and the vines will be ready for evaluation of yield and fruit quality in 2012 or 2013 successfully seeking funding for harvest.

Evaluation of Wild Black Raspberry (*Rubus occidentalis*) Populations for Disease Resistance, Fruit Quality and Vigor

Chad Finn, USDA-ARS HCRL

Black raspberry production in the NW is limited by several disease problems leading to decline in productivity and short planting life. Current black raspberry cultivars do not have the resistance needed to address these problems through breeding without the use of other germplasm. The aim of this project was to evaluate more than 130 black raspberry populations derived from wild-collected seed for future use in breeding by screening for aphid resistance in the greenhouse and evaluation of their performance in the field. The large raspberry aphid (*Amphorophora agathonica*) is an important vector in the spread of a variety of viruses including *Black raspberry necrosis virus* that infect black raspberry (*Rubus occidentalis*). This disease has been implicated as one of the main limiting factors on black raspberry production in the Pacific Northwest, where the life of commercial plantings has declined to an average of 3 or 4 harvest seasons. Wild black raspberry (*Rubus occidentalis* L.) populations from across the native range in eastern North America were evaluated in the greenhouse for resistance to the large raspberry aphid *Amphorophora agathonica*. Three sources of very strong resistance to the aphid were identified and characterized. Resistance from these three populations is controlled by dominant genes and should be easy to use in breeding new cultivars. In addition, replicated plots from 110 populations and unreplicated plots of an additional 23 populations have been established in the field with 'Jewel', 'Munger', and 'Mac Black' for comparison. These plants were evaluated for vigor, fruit size, season, and disease resistance in the field over a two year period. There were significant differences among populations (P) for all traits in the 2007 and 2008 planted trials. For all the traits in both trials that were evaluated in multiple years, there were significant differences due to years (Y). Population x Year (P x Y) interaction was only significant for vigor, and Verticillium wilt incidence in the 2007 and 2008 plantings and for winter cane injury in the 2007 planting. More than 50 selections were made from this material and we have already begun to use some of them in breeding.

Molecular Markers for Aphid Resistance in Black Raspberry

Chad Finn, USDA-ARS HCRL and Nahla Bassil, USDA-ARS NCGR

The large raspberry aphid (*Amphorophora agathonica*) is an important vector in the spread of a variety of viruses including *Black raspberry necrosis virus* that infect black raspberry (*Rubus occidentalis*). This disease has been implicated as one of the main limiting factors on black raspberry production in the Pacific Northwest, where the life of commercial plantings has declined to an average of 3 or 4 harvest seasons. Resistance to the large raspberry aphid identified in wild black raspberry populations has been crossed into elite germplasm in an effort to transfer this valuable trait into genotypes with commercial fruit quality and yield. We have developed populations segregating for aphid resistance from 3 different wild sources and are looking for genetic markers that are linked to aphid resistance in these populations which may then be used in the future for selecting for this trait. Currently we are working on testing microsatellite, or SSR markers for this project as well as identifying single nucleotide polymorphisms, or SNP markers, from the SSR primers that aren't useful. Once we have finished identifying informative markers in these populations we will genotype the progeny of the populations and determine whether any of the markers are linked to aphid resistance. To date, less than 5% of the black raspberry EST markers studied have been informative in these populations. However, these markers and those found to be transferable from red raspberry and blackberry have been useful for gauging genetic diversity in black raspberry germplasm and to inform breeding strategy. Future work will focus on finishing the screening of available markers and developing additional markers to be used for genetic mapping of aphid resistance genes.

Evaluation of Fruit Chemistry Traits in Wild Black Raspberry Germplasm

Jungmin Lee, USDA-ARS-HCRU; Chad Finn, USDA-ARS HCRL; and Michael Dossett, Agriculture and Agri-Food Canada - Pacific Agri-Food Research Centre

Black raspberry (*Rubus occidentalis* L.) has long been recognized as a rich source of anthocyanins. Despite renewed interest in this crop for its possible health benefits, its range of anthocyanin content and variation, or its other phenolic compounds have not been adequately examined. We examined anthocyanins, total phenolics, and other basic chemistry properties of fruit from wild black raspberry seedlings from more than 120 wild populations over two growing seasons. Total anthocyanin content ranged widely and about half of the populations surveyed had anthocyanin concentrations equivalent to or higher than commercial standards. These findings will be useful for developers of nutraceutical products, researchers studying potential health benefits of black raspberry consumption, and for breeders creating improved cultivars of black raspberry.

We also report on wild black raspberry mutants discovered during this project, the fruits of which lack certain anthocyanins compared to normal black raspberries. To the best of our knowledge, these are the first black raspberry variants reported in the literature with this unique anthocyanin profile. Their mutation offers a possible key to deciphering genetic control of rutinoside glycosylation in anthocyanin biosynthesis.

Pest Management

New Opportunities for Control of Bindweed in Blackberries

Ed Peachey, OSU

Cooperators: Eric Coombs, ODA; Diane Kaufman, NWREC; Jessica Green, FRA, OSU; and Joe DeFrancesco, NWREC

This interim report highlights progress made with control of field bindweed (*Convolvulus arvensis*) in small fruit acreage throughout the Willamette Valley. The herbicide quinclorac was applied 30 days before harvest, after harvest, and near the first frost in the fall to both EY and AY blackberries, raspberries, and blackberry and raspberry transplants. Quinclorac provided 80 to 90% control of bindweed and did not harm caneberries. A biological control agent, *Aceria malherbae*, was successfully established at three field sites, and caused galling of leaf tissue at all locations. In an experiment with potted bindweed plants, we found that pots receiving the high level of irrigation were colonized more by *A. malherbae*. Pots inoculated with mites in Year 1 had greater root mass in Year 2 compared to un-inoculated pots, in contrast to our expectations that mites feeding on bindweed would reduce root growth. Quinclorac applications reduced bindweed growth by 60% nearly one year later.

Integration of Mite Biological Control Using Timed Miticide Applications and Organic and Low Input Fungus Programs

Vaughn Walton, OSU; Amy Dreves, FRA, OSU; and Walt Mahaffee, USDA-ARS

Cooperators: Angela Noelle Gadino, OSU; David Gent, USDA-ARS; and Jay Pscheidt, OSU

Vineyards throughout Oregon have recently developed Short Shoot Syndrome, which is correlated to the pest mite, *Calepitrimerusvitis*. This vineyard specific pest feeds on developing buds resulting in stunted shoots and crop (cluster) loss. *Typhlodromuspyri* is the dominant predatory mite in western Oregon vineyards and is believed to play an integral role in managing *C. vitis* populations. Intense fungicide programs are maintained in vineyards throughout the growing season and are believed to be detrimental to predatory mite populations causing increased pest mite outbreaks. Predatory mite preservation and enhancement are integral to successful biological control programs in western vineyards.

In field trials, the use of synthetic fungicides interspersed with sulfur resulted in adequate pest mite control without negatively affecting *T. pyri* populations. Sulfur-only applications sometimes resulted in pest mite outbreaks. Synthetic fungicide-only applications resulted in higher pest and predator mite numbers. Our laboratory trials confirm trends observed in the field. Sulfur applications negatively affected juvenile *T. pyri* longevity and reproduction but not adults. Stylet oil had a negative impact on beneficial mite populations. Laboratory trials on pest mites showed that a sticker/spreader such as oil plays an important role to control pest mite populations.

Field Scouting to Assess Treatment Efficacy and Monitoring Protocols for the Spotted Wing Drosophila

Denny Bruck, USDA-ARS-HCRU

Cooperators: Thomas Peerbolt, Peerbolt Crop Management Inc; and Jana Lee, USDA-ARS-HCRU

The regional distribution of *Drosophila suzukii*, spotted wing Drosophila (SWD), is still unknown as are the best ways to monitor or manage this pest. The overall objectives of this project are to field test monitoring protocols, collect and analyze field data and quickly disseminate this information to researchers and growers. Effective monitoring has the potential to minimize the economic damage and limit ineffective and/or ill timed pesticide applications while supporting the efforts of other researchers to develop effective monitoring and management protocols. There's a wide variation in berry crops and cropping systems (Organic, sustainable, conventional, fresh local, fresh for shipping, processed for IQF, processed for puree, etc.) that will be affected differently and have different economic thresholds for this pest. Some adapting of any basic treatment options, monitoring and economic assessment tools to the specific situations will be necessary. We have assembled a representative sampling of fields that will cover the major berry crops and cropping systems which are scouted weekly. We are tracking SWD populations, testing various monitoring techniques and evaluating treatment option efficacy.

Fruit Preference and Damage by the Invasive Spotted Wing Drosophila

Jana Lee, USDA-ARS-HCRU and Denny Bruck, USDA-ARS-HCRU

The spotted wing drosophila (SWD) was first detected in the North American mainland and Europe in 2008-2010 and is a serious economic pest to stone and small fruits. The female lays eggs within ripening fruit on a plant before harvest which can lead to crop loss. This study determined: 1) the fecundity of SWD, 2) the susceptibility of blackberries, blueberries, cherries, grapes, raspberries, and strawberries with various ripeness stages and cultivars, 3) basic visual and odor preference of SWD for trapping, and 4) the damage patterns of infested fruit over time. The fecundity ranged from 85 to 161 over four weeks in the laboratory using colony flies given artificial diet, and wild flies given 'Elliot' blueberries, and 'Pinot noir' grapes. Fruits were generally susceptible to SWD once fruits started to color based on 26 no-choice and choice replicated laboratory tests. Strawberry, raspberry, blackberry, cherry and blueberry were more susceptible to *D. suzukii* than green table grapes. In the field, red traps caught more SWD females than black and clear traps. Various semiochemicals were tested in the field, but none so far have been more effective than the current standards of apple cider vinegar or yeast-sugar-water. The visual indications of damage caused by SWD were documented on pictoral factsheets available online with USDA ARS and Oregon State University Extension Service.

Evaluation of *Rubus* spp. Hybrids for *Pratylenchus penetrans* Resistance

Inga Zasada, USDA-ARS and Patrick Moore, WSU

At WSU-Puyallup, tissue cultures of the F_1s and backcrosses were initiated from surface-sterilized shoots from plants of each genotype. Once sufficient plants were produced, the tissue cultured plants were placed on rooting media and then rooted in a greenhouse. Approximately three months after rooting, the tissue culture plants were transported to USDA-ARS HCRL and planted into 1-gal pots containing steam-sterilized soil and allowed to establish. The red raspberry variety 'Meeker' was also established in 1-gal pots as an industry standard comparison. After approximately one month plants were inoculated with *P. penetrans*. Nematodes used for inoculation were extracted from roots with intermittent mist and were inoculated onto the roots of established raspberry plants at 2,500 nematodes per plant or 1 nematode/g dry soil (a damaging population density is considered to be one *P. penetrans*/gram soil). A noninoculated set of plants for each F_1 hybrid or backcrosse served as a control. After inoculation the plants will be grown for 3-4 more months, corresponding to approximately 3-4 nematode generations. At the end of the experiment the following parameters will be measured: shoot dry weight; root dry weight; number of *P. penetrans*/gram dry soil, and; number of *P. penetrans*/gram dry root. Nematodes will be extracted from soil by sieving/centrifugation, and from roots with intermittent mist. All genotypes that were inoculated with *P. penetrans* will be replicated 8 times, noninoculated genotypes were replicated 4 times. Differences in resistance among the *Rubus* F_1s and backcrosses will be determined by Analysis of Variance and means separated with Tukey's Adjustment for Multiple Comparisons ($P < 0.05$).

The greenhouse study evaluating F1s and backcrosses has been initiated. In our greenhouse screening of *Rubus* spp. material against *P. penetrans* in 2010 *R. leucodermis*, *R. niveus*, *R. odoratus*, and *R. sumatranus* all appeared to have some level of resistance to *P. penetrans* compared to the other *Rubus* spp. tested as well as Meeker.

Population Dynamics of *Pseudomonas syringae* and Management of Bacterial Canker on Blueberry

Joyce Loper, USDA-ARS, HCRL, and Virginia Stockwell, OSU

Cooperators: Jay Pscheidt, OSU

A major objective of this project is to develop basic information on the biology of *P. syringae* and the epidemiology of bacterial canker of blueberry. We assessed the population dynamics of *P. syringae* on two blueberry cultivars ('Berkeley' and 'Bluetta') grown in experimental research plots near Corvallis, OR. We sampled buds, blossoms, or leaves periodically from September 2010 through June 2011. *P. syringae* was infrequently detected on buds sampled in the fall. By January, about 40% of the buds had detectable populations of the pathogen. In the experimental research plots, diseased tissues were not removed and >80% of sampled tissues in the spring harbored detectable populations of the pathogen. Our results mirror those obtained in the previous year and support our hypothesis that infected bud tissues provide an inoculum source for populations observed on floral tissues in the spring. A second objective was to develop a reliable inoculation method for this disease. We evaluated two inoculation methods for *P. syringae* and applied them to eight cultivars of blueberry to evaluate cultivar sensitivity to the pathogen. The information developed through this project can be used in the future to develop new management strategies for bacterial canker.

Native Habitat Restoration, Sustainable IPM and Beneficial Insect Conservation for Washington Viticulture

David James, WSU

Cooperators: Gwen-Alyn Hoheisel, WSU; Steven Link, WSU-Tri Cities; and Robert Pyle, Insect Conservationist, Xerces Society

Funding from NCSFR was not available in 2010 (arriving, March 2011). Four commercial vineyards were recruited in early 2011 to be part of this project by adopting habitat restoration strategies aimed at improving sustainability of biologically-based pest management. These vineyards are located in the Columbia Valley, Walla Walla, Othello and Yakima Valley viticultural areas and are paired with 'conventional' vineyards (not adopting habitat restoration), for comparison of pest and beneficial arthropod populations. Monitoring of plant and arthropod communities in habitat restored and conventional vineyards commenced in April-May 2011 and will continue during April-October for the next 3 seasons. Recruited vineyards are progressive and began habitat restoration prior to being part of this project, thus hopefully reducing the time needed to demonstrate differences in pest management sustainability from conventional vineyards. Data on attraction of beneficial insects to native flowering perennial plants were collected in 2010 and 2011 and will guide future choices of plant additions to habitat-restored vineyards.

Weed and Insect Control in Cranberry Beds

Kim Patten, WSU

Results on herbicide screening trials in 2011 indicate that one new herbicides has registration potential for cranberries, as it had both efficacy and crop safety, and had registrant support. Two previously tested herbicides, rimsulfuron and quinclorac, have been tested on additional weeds. A Section 18 was submitted for quinclorac and an IR4 project was initiated on rimsulfuron. Research trials in OR and WA on our main target weed, *Lysimachia terrestris,* showed complete control with one to two applications of rimsulfuron, or quinclorac, or a combination of chlorimuron + mesotrione. Crop yield and efficacy data will continue to be collected for the year after treatment. Fast progress toward industry utilization of these chemistries is occurring.

Farm trials to assess efficacy of spring *Metarhizium anisopliae* as a blackvine weevil larvicide were not successful. For chemigation treatment of blackheaded fireworm (BHFW), Delegate, Altacor and Cyazypyr all had excellent efficacy. Five separate whole farm chemigation trials of Delegate provided comparable efficacy to commercial applications of Diazinon.

Genetic Diversity Among Grapevine Viruses in the Pacific Northwest

Naidu Rayapati, WSU

Cooperators: Robert Martin, USDA-ARS HCRL

Grapevines, due to their perennial nature, can harbor genetically diverse viruses and their strains in a single plant. Genetically diverse populations of grapevine viruses, frequently generated owing to the error-prone nature of the viral replicase, can accumulate with time due to clonal propagation of grapevine cultivars and disseminated via cuttings into new areas causing a sustained threat to the wine grape industry in the affected areas. In this context, analyzing the spectrum of viruses and their variants from different wine grape cultivars will improve our understanding of the sanitary status of vineyards in the Pacific Northwest region and provide necessary information for the development of better diagnostic tools and sound management practices resulting in reduced spread and economic impact of several debilitating viruses and their variants. During this year, we have documented the presence of genetically distinct variants of Grapevine leafroll-associated virus 1 (GLRaV-1) and Grapevine virus A (GVA), and four viroids viroids (Australian grapevine viroid, Hop stunt viroid, Grapevine yellow speckle viroid-1 and Grapevine yellow

speckle viroid -2) in the Pacific Northwest vineyards. This knowledge is helping us to improve the sanitary status of vineyards in the region. Genetic diversity in GLRaV-1 is enabling to better understand the epidemiology of grapevine leafroll disease across the Pacific Northwest vineyards and providing avenues for the development of robust strategies to mitigate negative impacts of the disease on sustainability of the wine grape industry in the region. The knowledge of genetic variability in GLRaV-1 and GVA obtained in this study is also benefiting grape clean plant programs across the country in improving the sanitary status of planting materials provided to nurseries and growers. The information and resources derived from this project is giving impetus to maintain 'clean' plant materials in certified nurseries and Foundation Block vineyard at Prosser, WA. The project outputs have been disseminated to various stakeholders through extension and outreach programs for increased knowledge of viruses and their impacts on sustainability of the wine grape industry in the region.

Biological and Chemical Alternatives to Broadcast Fumigation for Raspberry

Thomas Walters, WSU-Mount Vernon, NWREC and Inga Zasada, USDA-ARS-HCRL

Cooperators: Nik Grünwald, USDA-ARS-HCRL

We are developing short and long-term alternatives to broadcast fumigation for raspberry growers. This includes including development of an improved PCR assay for *Phytophthora rubi*, the most common cause of raspberry root rot. This assay will ultimately help us evaluate the success of treatments in controlling *P. rubi*, and will help growers determine the need for fumigation or other preplant treatments. We conducted greenhouse and field evaluations of solarization and brassicaceous seed meals, determining that the combination of solarization and amendment with *B. juncea* seed meal substantially reduced *P. rubi* viability as well as root lesion nematode population densities. We established five grower trials comparing bed fumigation with broadcast fumigation, and have begun to evaluate the effectiveness of bed fumigation and alleyway management for disease, nematode and weed control.

Production / Physiology

Effects of Cluster Zone Leaf Removal on Norisoprenoids of Pinot Noir Fruit and Wine-Part 2: Grape Composition and Wine Aroma

Michael Qian, OSU

Cooperators: Patty Skinkis, OSU

Canopy microclimate is important in determining fruit and wine composition. Excessive canopy density is known to produce unbalanced musts, resulting in poor wine quality. Canopy management, such as selective leaf removal in a grapevine canopy may increase the photosynthetic activity of the remaining leaves and can positively influence fruit composition. Cluster thinning, the removal of entire clusters from the vine is a common practice employed by grape growers. Cluster thinning is performed to increase the leaf area: fruit weight ratio in order to prevent over cropping, as well as to improve fruit size and composition. Earlier studies have shown that cluster thinning reduces fruit yield and increases the berry weight, soluble solids, and color of table grapes. While cluster thinning is a common practice, the impact of the timing of cluster thinning on subsequent berry growth and fruit flavor composition has not been widely investigated. The main objective of the present study was to fill these gaps and to evaluate such effects in association with grape and wine aroma composition in Pinot noir grapes and wine.

High vegetative vigor is common in the cool-climate winegrowing region of Oregon, management strategies including leaf removal and crop thinning were investigated to reduce vine size and increase fruit quality of Pinot noir. Three leaf removal management, including 0% removal (Control), 50% removal and 100% removal were studied in 2010. Grape samples were analyzed for °Brix, citric, tartaric and malic acids, volatile aroma compounds and potential

aroma compounds. Leaf removal had no impact on grape °Brix, citric and tartaric acids. Leaf removal at 50% and 100% levels had lower average malic acid although there was no statistical difference ($p=0.06$). Leaf removal had no effect on C6 alcohols and aldehydes, both free and bound form. Leaf removal significantly ($p<0.05$) increased the concentration of glycosidically linked cis-linalool oxide, trans-linalool oxide, linalool, á-terpineol, and geraniol. The total amount of terpene alcohol glycosides increased linearly with removal. Similar increasing trends were observed with free â-damascenone as well as some bound C_{13}-norisoprenoids . The total bound C_{13}-norisoprenoids significantly increased with leaf removal.

Another massive trial based on managing crop level were studied in 2010, crop levels were moderately or severely thinned at pre-bloom, fruit set, lag phase, or veraison and compared to non-thinned treatment. The experiment was carried out in both high density field and modest density field. The experiment was too big to give definite answer. The study was not in the original research objective.

Effects of Cluster Zone Leaf Removal on Norisoprenoids of Pinot Noir Fruit and Wine, Part 1: Canopy Microclimate and Fruit Quality

Patricia Skinkis, OSU

Cooperators: Michael Qian, OSU

Obtaining adequate vine balance through canopy management is critical to production of high quality fruit for wine production. High vine vigor impacts canopy density and fruit quality and increases management inputs required for quality wine grape production. Different vineyard management practices can alter vine balance. Vine balance is the level at which the vegetative growth (vine canopy) is in balance with the fruit load on the vine to support full ripening and quality composition of the fruit at harvest. Manipulating the two components of vine balance: canopy and fruit, allows one to manipulate vine balance, so we chose to study the impacts of crop thinning (fruit removal) and leaf pulling (leaf removal) on vine balance and the resulting fruit composition and quality. The real question behind understanding best management practices in the vineyard is whether grape ripening and fruit quality are being influenced more by physiological responses in vine growth and development or by microclimate modifications caused by these canopy or fruit removal practices. A 3-year project began in 2010 to identify proper timing and intensity of crop thinning for production of high quality Pinot Noir fruit. At the same time a cluster-zone leaf removal experiment was also begun to determine impacts on fruit quality by modifying cluster exposure. The goal of this work is to come up with better metrics for the grape grower to use to determine adequate vine balance in cool climates such as Oregon.

Within this the first year of this study (2010), we have measured the impact of various timing of crop removal and leaf pulling on vine growth and fruit composition. The crop thinning treatments reduced total vine yield by 40 to 70% compared to non-thinned vines, but it did not increase fruit concentrations of sugars, total color or other quality-related compounds such as tannins and phenolics which are important for mouth-feel and overall wine sensory response. Leaving heavier yields until later in the season did not decrease vine growth of these vigorous vines, and the vines continued to be very vigorous, requiring just as much vine management (hedging, leaf pulling, etc) as earlier crop-thinned vines. Therefore, there is little reason to wait until late in the season to crop thin if it is going to be conducted. Results indicate that there is no fruit quality effect of reducing yields in 2010. Vines were not over-cropped and a full crop load will not hurt the sustainability of the vines.

Within the first year of the leaf pulling trial (2010), we observed little benefit of leaf pulling in terms of fruit composition. While there were differences in cluster exposure with increased leaf removal, there were no differences in berry sugar, acid, tannin, phenolic or color composition. Leaf pulling at the trialed levels did not decrease vine growth and fruit ripening. While little difference was observed in this trial for basic fruit composition and vine growth, the impacts of leaf pulling may be beneficial for preventing fruit rots.

Further analysis of fruit in both the crop load and leaf pulling trials may yield differences in aroma compounds, such as norisoprenoids, which are still under analysis. Further field and lab research continues in 2011 and 2012 to provide additional data from which to draw more solid conclusions and develop metrics for grape growers to make informed decisions in crop thinning and leaf removal.

Effects of Vineyard Cover Crop Management on Soil Moisture, Vine Growth and Nutrition in Establishing Young Vines

Patricia Skinkis, OSU

Cooperators: Dean Underwood, Vineyard Manager, Olsen Family Vineyards

A three-year trial is in progress to determine the effects of using cover crop residues to enhance young vine growth and vineyard establishment. The trial is being conducted at a newly planted commercial vineyard in the Willamette Valley of Oregon. Each fall, a cover crop mix of cereal rye and crimson clover is sown into vineyard alleyways and grown into the following spring. When the cover crop reaches significant growth and the clover begins to flower, the cover crop is mowed and the residues applied as mulches in the vine row at two densities (1X and 3X rate), placed in the alleyway as is typical for mowing, or removed from the alleyways. Cover cropped treatments are compared to an unplanted treatment which was never planted to cover crop and kept free of vegetation by tillage and/or herbicide for the duration of the study. The hypothesis is that cover crop residues can be managed as mulch within vine rows to conserve soil moisture, reduce weed growth, and increase vine growth through either soil moisture conservation and/or added nutrition. Placement of mowed residue in alleyways or removing it all together allowed us to conduct paired comparisons of the data to determine best use of cover crop residues.

A winter annual cover crop was managed in the vineyard in 2009-2011. Vine growth has been monitored to determine differences between field treatments. Growth has been quantified through various vine measurements: shoot length, leaf area, fruitfulness, pruning weights, trunk diameters, and root growth. Soil moisture and vine water status have been monitored throughout the seasons of the study to explain any growth differences that may occur. Vine nutrition was assessed through vine tissue samples taken at bloom and véraison (beginning of ripening). In addition, the carbon (C) and nitrogen (N) composition of the cover crop biomass was analyzed to determine the potential contribution of the cover crop to the vineyard system. Since mulching can be an effective means of reducing weeds, density and coverage of weed growth was assessed both in the vine row and in the alleyway.

Results indicate a trend towards increased vine growth with cover crop mulching based on greater shoot and root growth, increased potential yield, and dormant pruning weight in 2010. Mulched vines also have higher leaf chlorophyll (are greener) as compared to the unplanted treatments, indicating potentially higher nitrogen in mulched vines. However, there were no differences in vine nitrogen concentration by treatment in 2010. Increased vine growth may be due to higher total nutrient *content* in the mulched vines which are larger despite having similar nitrogen concentrations as other treatments. Greater water conservation and decreased soil compaction may also be allowing increased root and shoot growth in mulched treatments compared to non-mulched treatments. Reductions in weed growth with mulch were observed in 2009 and 2010, and this may also allow for greater vine growth. There was no difference in water status of any of the treatments, indicating that young vines can be managed with a cover crop and without irrigation in similar vineyard sites within the Willamette Valley.

Research continues for the remainder of 2011 and the 2012 growing season. The combination of all the years of this research trial will help us better understand how a young vineyard is established and the extent at which these treatments can increase vine health and productivity in establishment years and enhance vineyard sustainability longer term.

Organic Blueberry Production Systems

Bernadine Strik, OSU

Cooperators: David Bryla, USDA-ARS; Dan Sullivan and James Julian; Gil Buller and Emily Vollmer, Research Assistants; Eric Pond, AgriCare Inc.

A 0.4 ha (1 acre) planting of blueberry was established in Oct. 2006 to evaluate the effects of cultivar (Duke and Liberty), bed type (flat versus raised beds), weed management [sawdust mulch and hand-weed control; sawdust+compost mulch with acetic acid, flaming, and hand control used as needed; and weed mat], and type and rate of fertilizer (feathermeal and liquid fish emulsion at 57 and 112 $kg \cdot ha^{-1}$ N) on plant growth, yield, fruit quality, irrigation requirements, and weed presence. The site was certified organic in 2008. In the establishment years, plants grown on raised beds were larger than those on flat ground, but they required more irrigation, particularly with weed mat. To date, weed mat has resulted in the fewest weeds, while sawdust+compost has had the most weeds. Cumulative yield from years 2-4 was 48% greater on raised beds than flat ground, corresponding to improved plant growth measured on raised beds in 2007 and 2008. Although the soil at this research site is considered to be well-drained, there was still an advantage of raised beds. Fertilization with the low rate of fish emulsion or the high rate of feather meal resulted in high yields in 2009 and 2010. In 'Duke', fertilization with the high rate of fish emulsion resulted in lower yields and lower average berry weight than with the low rate of fish emulsion or either rate of feather meal, but this was not the case in 'Liberty'. Compost+sawdust and weed mat mulched plots produced greater yield than those mulched with sawdust in 2009 and 2010, though compost+sawdust had the highest yield in 2009. Both 'Duke' and 'Liberty' had lower fruit firmness when fertilized with the low rate of feather meal than with fish emulsion or the high rate of feather meal. Duke fruit were firmer and had higher percent soluble solids (Brix) when fertilized with a high rate of fish emulsion.

Weed, Water, and Nutrient Management Practices for Organic Blackberry Production

Bernadine Strik, OSU

Cooperators: Gil Buller, NWREC/OSU; Emily Vollmer, OSU; Yanyun Zhao and Mark Daeschel, OSU; Diane Kaufman, NWREC/OSU; Chad Finn, USDA-ARS; Eric Pond, AgriCare Inc.

Trailing blackberry cultivars are being evaluated in various organic production systems for the processed market. Treatments include: cultivar (Marion and Black Diamond); irrigation (post-harvest and no post-harvest irrigation); weed management (weed mat, hand-hoed, and non-weeded); and primocane training date (August and February). The planting was established in May, 2010. Primocanes were trained as they grew. In February, 2011, plants were cut to crown height to improve plant growth, as is typical for commercial production. The planting will fruit for the first time in 2012. Data were collected on plant dry weight and nutrient accumulation as affected by weed management treatment. Growth data are presently being collected.

Variety Evaluation and Crop Adjustment to Improve Fruit Quality of Table Grapes

Esmaeil Fallahi, University of Idaho

Cooperators: John Clark, University of Arkansas

Adaptability and crop load adjustment of several table grape cultivars under climatic conditions of Intermountain Western USA are being studied in this project. For this propose, the ground was prepared and fumigated with Telone 2 before planting. In spring of 2010, 15 promising selections from the University of Arkansas Table Grape Breeding Program were selected and planted at the University of Idaho Parma Research and Extension Center Pomology and Viticulture vineyard. Some of these selections were also planted at the Oregon State University Lewis Brown Farm under Dr. Strike's supervision for comparison. In addition to these selections, several new cultivars,

including 'Autumn Royal', 'Fantasy', 'Red Globe', 'Emerald', 'Ralli' ('Anahita'),'Strawberry', 'Kashishi', 'Kathie K', 'Princess', 'Autumn King', 'Sweet Scarlet', 'Scarlet Royal', 'Sugar Thirteen', 'Bidaneh', 'Mehdi Khani', 'Askari', and 'Kandahar' were also propagated and added to the experiment in 2010 and 2011. The experimental design in this objective is a complete randomized design with at least 10 single-vine replications. A drip irrigation system was installed during the spring of 2010 and 2011. A Trellis system was installed in 2010 and will be completed in 2011. Results from established vines of 'Jupiter', 'Bidaneh', and 'Emerald' and 'Alborz' were very satisfactory and these cultivars can potentially be recommended at a commercial-scale production under conditions of Intermountain Western USA.

Irrigation Guidelines for Sprinkler Frost Protection in Cranberry

David Bryla, USDA-ARS HCRL and Linda White, OSU, Extension Service, Coos County

Cooperators: Knute Anderssen, Sea Wind Farms, Inc.; Bob Donaldson, OR Cranberry Grower's Assn.; David Kranick, Kranberry Acres, Inc.; and Kim Patten, WSU

Sprinkler irrigation is required for frost protection of cranberry and is arguably the most important cultural practice used in production of the crop. Growers in Oregon and Washington struggle however with questions on what temperatures to begin sprinkler frost protection, how much water is needed, and at what stages of development are the plants most susceptible to frost. If applied too early or too often, irrigation water may run out. When missed or applied too late, crop damage will result.

This past year, a chamber was developed and tested for controlling cranberry plant temperatures in the field. Next year, plants will be exposed to a range of freezing temperatures at various times over the season and evaluated for frost damage. Freeze thresholds will be expressed both in terms of 1) the lowest temperature in which the leaves, fruit, and buds survive and results in little to no crop loss and 2) the range of temperatures in which 10% to 90% of leaves, fruit, and buds are damaged. All thresholds will be related to the stage of crop development, ranging from the tight, dormant bud stage in February and March to flowering and fruit set in May and June. Once the thresholds are identified, the water application rates required at any given temperature and wind speed will be calculated based on standard thermodynamic equations for sprinkler frost protection.

Is Timing the Key to Good Fruit Phenolics?

Jungmin Lee, USDA-ARS-HCRU and Julie Tarara, USDA-ARS-HCRU

Cooperators: Patricia Skinkis, OSU

Anthocyanins (natural pigments; phytochemicals) are important quality indicators in red colored fruit. We report our findings on the effect light exclusion boxes had on 'Merlot' grapes' anthocyanin profile and accumulation. Unlike previous reports, this study was unique in that temperature, light intensity, and humidity (microclimate variables) were continually measured for the entire duration of the experiment. Light exclusion during ripening lowered red grape anthocyanin levels compared to control (naturally shaded and exposed) clusters. This work contributes towards our growing body of knowledge on environmental stresses and anthocyanin development in fruit.

Trellis Tension Monitor: Tool for Vineyard Sampling and Yield Estimation

Julie Tarara, USDA-ARS HCRU and Paul Blom, USDA-ARS

Cooperators: Luis Sanchez and Nick Dokoozlian

Most yield estimation practices for commercial vineyards are based on longstanding but variable industry protocols that rely on hand-sampling fruit at a small number of dates during the growing season. Limitations associated with these static estimates may be overcome by deployment of Trellis Tension Monitors (TTMs), systems that provide dynamic measurement of changes in the tension of the main trellis wire, referred to as the 'cordon' wire. TTMs were installed in several commercial vineyards. We analyzed three years' data from juice grape vineyards to compare the processors' method of estimating yield (juice) and actual yields (juice, wine) with the estimation from TTM data. On average, TTM data produced more accurate estimates of actual yield at harvest than did the protocols of the juice processors. However, there was high variability among sites. The juice processors' protocols appeared to be more sensitive to the selection of which previous years were used as reference data for the current year's prediction. Dynamic tracking of vine growth and development also can be used to pinpoint key phenological stages to schedule hand sampling for traditional yield estimation. Three years' data from wine grape vineyards demonstrated the sensitivity of detection by the TTM of the 'lag phase' of grape berries, commonly used to time traditional hand sampling. The median difference in detection of the start of lag phase between the TTM and expert observers was 4 d. The TTM also offers real-time information that can be used to manage crop level or to revise yield estimates on-the-fly, something that is not feasible currently. Other data will be used for determining the spatial sensitivity of the TTM.

Practical Implications of the Relationship Between Vigor and Xylem Vessel Anatomy in Grapevine

Bhaskar Bondada, WSU - Tri Cities

Cooperators: Markus Keller, WSU IAREC

To gain an understanding of the mechanistic basis of vigor phenomenon in grapevines, the Merlot cultivar was induced to develop different shoot lengths, an index of vigor by pruning the vines to a range of bud numbers. Physiological and anatomical measurements were recorded at specific phenological events in all vigor levels. In a given shoot, the successive internode lengths and the corresponding leaf area increased linearly at the proximal end, whereas opposite occurred at the distal end (shoot tip). Shoot structure exhibited modular characteristics, in which internode without tendril at the bottom tended to be shorter and bear more lateral branches. Significant relationship was found between internode length and leaf size above or beneath that internode. Vessel lumen diameter, vessel number, hydraulic conductivity, the number of radial sectors (RS) bordered by xylem parenchyma and vessel number per RS were smaller at the distal ends than at proximal ends, while vessel density followed the opposite trend. Average shoot length exhibited a negative relationship with bud number. Shoot fresh weight, internode number, total leaf area, cluster weight, stomatal conductance, soluble solids and nutrient levels increased with shoot length, whereas soluble solids decreased with cluster number per shoot. pH increased with shoot length in September 2010 and did not show significant relationship with shoot length in 2009 or October 2010. Leaf area/ fruit weight (LA/F) ratio increased with shoot length in 2010. However, no significant relationship between LA/F ratio and shoot length in 2009 was detected, neither the relationship between LA/F ratio and soluble solids, LA/F ratio and pH. Vessel number per cross-sectional area, sapwood area, vessel lumen diameter, total vessel area per cross-section and hydraulic conductance increased with shoot length, whereas vessel density decreased with shoot length. This study showed that when shoot length was used as a vigor indicator, shoot vigor was strongly related with hydraulic conductivity of the shoot which was determined by xylem anatomy.

Understanding and Applying Physiological and Anatomical Adjustments of Grapevine to Identify Drought Resistant Cultivars for Sustaining Grape Production in Drought Conditions

Bhaskar Bondada, WSU - Tri Cities

Cooperators: Markus Keller, WSU IAREC

We used potted vines of Cabernet Sauvignon, Grenache, and Zinfandel to understand physiological and anatomical drought adaptive features for identifying drought resistant cultivars. To achieve this goal, the three cultivars, Zinfandel, Grenache and Cabernet Sauvignon were subjected to four water regimes (0%, 33%, 67% and 100% irrigation). Stomatal conductance decreased with increasing water stress levels. In a similar pattern, leaf water potential was lowest at the highest water stress level. Generally, leaves under high levels of water stress had higher wax content and higher relative water content under well watered conditions. The leaves followed reticulate venation pattern in which veinlets circumscribed small areas of mesophyll known as areola confining free vein endings of different density. In future studies, an integrated approach involving physiological, anatomical, and morphological measurements will be used to identify drought resistant cultivars.

Developing a Grape Site Selection GIS for the Inland Pacific Northwest

Joan Davenport, WSU IAREC; Greg Jones, Southern Oregon University; Andrew Duff; and Ian Yau

Cooperators: Richard Rupp; Markus Keller, WSU IAREC; and Wade Wolfe, Thurston Wolfe Winery

We have compiled map layers representing environmental variables influencing likelihood of success of both juice and wine grape vineyards in eastern Washington, northeaster Oregon and around the Snake River Valley in Oregon and Idaho. The layers comprise climatic, topographic and soil factors. The layers are composited to produce overall site suitability scores with climatic data informing recommendations for wine grape cultivars by ripening potential categories. The data layers have been organized by county into map documents accessible with ESRI ArcGIS software (Redmonds, CA). Users can locate and query locations for overall suitability and examine specific factors that may be beneficial or limit a site's suitability. Preliminary validation efforts indicate soil characteristics in the model generally concur with growers' perceptions. Climatic modeling represents conditions at a scale more broad than those directly affecting grapevines. Pairing this data with topographic data, slope and aspect, gives a better indication of heat accumulation and frost risk.

Late Season Foliar N Supplements to Improve Wine Quality

Joan Davenport, WSU-IAREC and Kerry Ringer, WSU-IAREC

Cooperators: Leif Olsen, Olsen Brother

Two commercial vineyard blocks (one Riesling and one Merlot) both four and a half acre blocks north of Benton City, WA (latitude 46.3, longitude -119.6), planted in 2000 are being used for this experiment. It was planted to a 6 x 8 spacing with drip irrigation on a gently north facing slope. Both vineyards have a history of low tissue nitrogen concentration.

Twelve plots were established in a four block pattern with each row serving as a block and replicated at each vineyard site. Each plot is ten vines long the center eight will be used as data vines. In 2009 and 2010, vines were treated with a 6% solution of liquid urea in the form of UAN-32 (44.3% NH_4NO_3: 35.4% urea: 20.3% water; representing 32% actual N) (JR Simplot, Boise, ID), applied at weekly intervals using backpack sprayers beginning at veraison, for five total applications (total of 16.9 kg N / ha), for the conventional nitrogen (CN) treatment. For the organic N treatment (ON) a single rate of Biolink Vegan Nitrogen (6-0-0) (Westbridge Agricultural Products, Vista, CA) was applied at the same rate for the same duration of time. There was a water control treatment as well (X).

A Link Between Grapevine Bleeding and Budbreak, Shoot Growth, and Fruit Set: Causes and Consequences for Vineyard Management

Markus Keller, WSU IAREC

Cooperator: Bhaskar Bondada, WSU - Tri Cities

There is reason to believe that the stunted shoot growth and poor fruit set observed in unirrigated inland Northwest vineyards after the dry winter of 2004/05 (23-45% of normal precipitation) may have been caused by the vines' inability to initiate sufficient sap flow ('bleeding') before budbreak. This may have led to failure of their hydraulic system, leading to inadequate water supply to the developing canopy. We began investigating these questions in the spring of 2011, using pot experiments designed to vary soil moisture before and during budbreak. The resulting differences in budbreak and grapevine vigor were assessed by measuring shoot length. Bleeding sap was collected to determine whether spring shoot vigor is related to the bleeding rate and/or content. All data collected to date point to the existence of a soil moisture threshold below which bleeding cannot be initiated by grapevine roots. This appears to be associated with an inability of buds to break. Under severe drought stress, vines died. But under moderate stress, budbreak was possible albeit followed by stunted shoot growth and abortion of clusters.

Relationship Between Shoot Number and Vigor in Grapevines: Physiological Causes and Practical Implications

Markus Keller, WSU IAREC

Cooperator: Bhaskar Bondada, WSU - Tri Cities

One of the first lessons a viticulturist is taught is that high quality grapes are dependent on the ideal balance between shoot and fruit growth. One of the basic principles of viticulture is that shoot vigor is inversely related to the number of shoots per vine. As most of the shoot growth occurs before fruit set, it seems that competition between berry and shoot growth cannot be the main reason for the reduction of shoot vigor in vines with many shoots. We tested the hypothesis that hydraulic limitation may be the cause of the differences in vigor of vines with varying shoot numbers. Field-grown Merlot vines were pruned to a large range of bud numbers, and the vines were subjected to repeated cycles of water stress and irrigation. Contrary to our hypothesis, the inverse relationship between shoot number and vigor was not caused by hydraulic limitation: the vines' resistance to water flow was higher in vines with fewer, more vigorous shoots and lower in vines with more shoots. Thus, rather than being hydraulically challenged, the vines with more shoots and hence greater total leaf area compensated by reducing the resistance to water flow up their trunk. Nevertheless, the vulnerability of vines to water stress increased slightly with increasing shoot number, possibly due to having a larger leaf canopy and crop yield. The increased transpiration of vines with more shoots may have caused the decreased hydraulic resistance as more water was needed to sustain a larger canopy. At harvest, mean cluster weight decreased with increasing shoot number per vine, while yield increased as the vines had more and smaller clusters. Soluble solids decreased as the number of shoots per vine increased, but shoot number had little effect on pH, titratable acidity, and color.

Small Fruit Initiative

Evaluation of Small Fruit Germplasm at the North Willamette Research & Extension Center, Oregon State University

Bernadine Strik, OSU and Chad Finn, USDA-ARS-HCRL

All aspects of a breeding program are being conducted including parental selection, crossing, selection and testing for strawberry, blackberry, raspberry and blueberry. Recently under this project, nine new strawberry cultivars (Sweet Bliss, Independence, Firecracker, Tillamook, Pinnacle, Puget Crimson, Valley Red, Puget Summer, Stolo), four genetically thornless blackberries (Black Diamond, Black Pearl, Nightfall, Wild Treasure), six thorny trailing blackberries especially suited to the fresh market (Siskiyou, Black Butte, Obsidian, Metolius, Newberry, Onyx), two thorny erect primocane fruiting blackberries (Prime-Jan, Prime-Jim), two primocane-fruiting raspberries (Vintage, Chinook), five summer-bearing red raspberries (Coho, Lewis, Esquimalt, Saanich, Cascade Bounty), and two blueberries (Chandler, Pink Lemonade) have been developed or co-developed and released. 'Vintage' and 'Onyx' have been approved for us to seek patent protection. Several of these have been tremendous successes and have become widely planted. While the strawberry cultivars will be grown primarily in the PNW, the raspberry, blackberry, and blueberry cultivars are grown in many other production regions in North America and the world. Appropriate cultural practices for optimum yield and quality of advanced selections and new cultivars have been researched and established. For 2009, the total estimated impact of cultivars released since 2001 in this program was about $15 million for the PNW including fruit sales and plant nursery sales. This annual impact increases to $34 million when including cultivars we co-developed with other breeding programs and to $37 million when including all cultivars released from this cooperative program (including those prior to Finn and Strik).

Quality Evaluation of Berry Selections and Varieties

Brian Yorgey, OSU and Yanyun Zhao, OSU

Cooperators: Chad Finn, USDA-ARS-HCRL; Pat Moore, WSU; and Chaim Kempler, Agriculture & Agri-Food Canada

Our part in this group effort to bring new berry varieties to the growers, processors and consumers of the Northwest is focused on fruit quality evaluation. Berries from the breeding plots at the North Willamette Research and Extension Center were picked weekly and brought to the OSU Food Science Department in Corvallis for evaluation from early June through September 2010. Basic chemical data were collected on strawberries, red raspberries, black raspberries, blackberries, and blueberries for multiple harvest dates throughout this period. Samples were frozen and were displayed to industry representatives and researchers during the fall, winter and early spring. This information will be used with field data to select the berries which will be included in further breeding trials.

Small Fruit Breeding for the Pacific Northwest at Washington State University Puyallup

Patrick Moore, WSU and Wendy Hoashi-Erhardt, WSU

This project will develop new red raspberry cultivars adapted to the PNW that are machine harvestable and suitable for processing. Important traits like resistance to raspberry bushy dwarf virus (RBDV) and tolerance to root rot are also being pursued for new raspberry cultivars.

Once raspberry seedlings are selected, they are then planted in small plots with a cooperating grower and evaluated for machine harvestability. Selections that appear to machine harvest well are tested for yield, fruit size, and fruit firmness in replicated trials at WSU Puyallup, and also evaluated for susceptibility to root rot and raspberry

bushy dwarf virus. Selections possessing several promising traits are propagated into quantities suitable for grower trials. In 2011, a new machine harvesting planting was established with 80 WSU selections, 16 BC selections, three cultivars and a plot of black raspberry. This planting will be machine harvested and evaluated in 2013 and 2014. Additionally, the 2008 planting will be evaluated (because of cool weather, evaluations are just starting) for the second season in 2011. The planting established in 2009 will be evaluated for the season in 2011. Promising selections in each planting will be identified. Among the 9,300 raspberry seedlings evaluated at WSU Puyallup in 2011, 37 preliminary selections have been made, with more anticipated. Additionally, selections will be made among 2,100 seedlings planted with a cooperating grower. These selections will be based on machine harvesting performance. Additional observations of root rot and RBDV susceptibility among advanced selections have led to the identification of some selections that are machine harvestable, root rot tolerant and RBDV resistant. Virus-negative plants of a promising yellow-fruited raspberry selection were planted in replicated plots at Puyallup in 2007. It has performed well and was released as 'Cascade Gold' in 2010.

The project will also develop new strawberry cultivars adapted to the PNW and that have higher picking efficiency than current industry standards. Additional aims for new strawberry cultivars are fruit firmness and disease resistance. Ongoing strawberry breeding work is focusing on parents with large fruit size, firm fruit and high productivity. Thirty-four selections were made in 2011 among the 3,900 seedlings planted in 2010. These selections will be propagated for planting in yield plots in 2012. Plants of a very large, late season, productive selection with excellent flavor were propagated via tissue culture and were planted with six cooperating growers in Oregon and Washington in 2009. Evaluations of the selection were positive. Dormant plants were also planted for testing in 2010. This selection was released as 'Puget Crimson' in 2010.

Wine Processing

Impact of *Pediococcus* spp. on the Quality of Washington and Oregon Red Wines

James Osborne, OSU and C.G Edwards, WSU

Pediococcus have been isolated from wines worldwide and are generally regarded as being wine spoilage organisms. However, little is known concerning the occurrence of these organisms in Washington and Oregon state wines or their impact, if any, on quality. *Pediococcus* were isolated from Oregon and Washington state wines and to date seven isolates have been identified as *P. parvulus,* one was identified as *P. damnosus,* while one was identified as *P. inopinatus.* Isolates were inoculated into a Pinot noir wine produced at the OSU research winery (sterile filtered, pH 3.75, no SO_2 addition, and no malolactic fermentation). After significant growth of all isolates had occurred wines had 30 mg/L SO_2 added and were sterile filtered and bottled. Samples were analyzed for a number of spoilage products including biogenic amines (ETS analyses). Most of the isolates degraded some malic acid but only three, OW-1, OW-2, and OW-7, completed the MLF. Very low concentrations of biogenic amines were measured in most of the wines (< 3 mg/L total) with only the wine inoculated with *P. inopinatus* OW-8 having greater than 5 mg/L. D-lactic acid production varied between isolates with OW-7 producing the highest concentration (264 mg/L). Diacetyl content of the wines also varied greatly. Some wines contained very low levels of diacetyl (< 0.5 mg/L) while others contained very high concentrations (> 15 mg/L) that were well above sensory threshold. Color and polymeric pigment content of the wines also varied with wine inoculated with OW-7 containing 30% less polymeric pigment than the control. This may be related to acetaldehyde content as a number of *Pediococcus* isolates, including OW-7, reduced the acetaldehyde content of the wine. Preliminary sensory analysis of the wines by a winemaker panel demonstrated large sensory differences between the wines. Some wines were described as having a muted aroma compared to the control while others had intense aromas described as "buttery", "lactic", "wonder-bread", "plastic", "musty", or "rotten". In mouth flavor and mouthfeel differences between the wines were also noted. More robust sensory analysis of the wines will be conducted in the future to determine some of the specific sensory impacts of *Pediococcus* spoilage and differences between species and strains.

Detection and Quality Impact of *Zygosaccharomyces* in Wines

C.G Edwards, WSU

Cooperators: Kerry Ringer, WSU; Carolyn Ross, WSU; and J. Zuehlke

The research compares methods used to detect *Zygosaccharomyces* spp. present in grape musts and wines. In addition, non-spoilage strains are being evaluated that could potentially utilize residual sugars from wines where alcoholic fermentation prematurely ceased. Decreasing water activity (a_w) in synthetic media using glycerol, glucose, or fructose, or lysine as sole nitrogen source did not select exclusively for *Zygosaccharomyces* as growth was slowed equally in comparison to other wine microorganisms. Ethanol tolerances of the *Zygosaccharomyces* isolates were similar to those *Saccharomyces* (limited growth >15.5% v/v). A red wine undergoing a stuck alcoholic fermentation (stoppage at ~10°Balling) was divided into three-gallon carboys, with (a) no additional inoculation or (b) inoculations of *Z. bailli* ZB2, ZB6, or W3, *S. cerevisiae* EC1118, or *S. bayanus* Uvaferm 43 at ~10^5 cfu/mL. Culturable populations of all yeasts slowly decreased, although all three strains of *Zygosaccharomyces* remained viable 150 days after inoculation (~10^3 cfu/mL). Changes in residual glucose or fructose concentrations were not observed, thereby suggesting that the strains remained viable but not metabolically active. Reasons for strain inactivity remain unknown but additional research will attempt to identify appropriate situations for application of *Zygosaccharomyces* and any impact on wine quality.

Impact of Specific Amino Acids and Pantothenic Acid on Yeast Metabolism and H_2S Formation

C.G Edwards, WSU

Cooperators: Jeff Bohlscheid, WSU; Carolyn Ross, WSU; and J.Q. Sturgeon

Synthetic and natural grape juices were prepared with either 60 or 150 mg/L "yeast assimilable nitrogen" (YAN), respectively. Appropriate amounts of diammonium phosphate (DAP), aspartic acid (Asp), or glutamine (Gln) were then added to increase YAN to 250 mg/L prior to fermentation. Most fermentations achieved dryness, the exceptions being those with Asp added and inoculated with UCD 522 where sluggish fermentations were observed. Synthetic or natural grape juice fermentations which did not have additional nitrogen added produced far more H_2S than those with added nitrogen, the amount depending on the yeast strain. Very little H_2S (<50 µg/L) was produced by EC1118 with addition of some form of nitrogen unlike those fermented by UCD 522. For those ferments supplemented with nitrogen, the concentrations of most amino acids decreased after fermentation with the exception of glycine which increased. Both yeasts metabolized some of the Asp or Gln added prior to fermentation. Sensory analyses yielded few significant differences between treatments. Given residual concentrations of Gln in synthetic and natural ferments supplemented with that amino acids were high (918 and 1020 mg/L, respectively), these findings suggest that this amino acid could be added in lower concentrations yet allow fermentation to achieve dryness with minimal amounts of H_2S produced.

Impact of Ethanol on the Aroma and Flavor Perception of Red Wine

Carolyn Ross, WSU

Cooperator: Charles Edwards, WSU

The objective of the current research was to examine the impact of alcohol (ethanol) and its interaction with other wine matrices, flavor and aroma compounds on the chemical and sensory properties of red wine. To examine the impact of ethanol concentration on the recovery of aroma compounds in a model wine, eight odorants representing the major aroma categories commonly were spiked into a model red wine that different in ethanol concentration (0-16%). All matrix components studied including ethanol, fructose and tannin were involved in three-way interactions impacting the recovery of aroma compounds from the wine matrix. Although both fructose and tannin levels

influenced the recovery of odorants in model wine solutions, their impact was heavily dependent on the level of ethanol.

Higher ethanol, tannin and fructose levels favored retention of larger, hydrophobic compounds. Thus the lowest concentration of odorant in the headspace was found in the presence of high fructose and tannin at 16% ethanol. These interactions are important as they may reduce the perception of these aromas in wine during sniffing and consumption.

To determine the impact of ethanol on sensory aroma threshold, five concentrations of eugenol and hexanol were prepared in ethanol (0, 8, 12, 16 and 40%). Results for both aroma compounds showed that the presence of ethanol resulted in an increased aroma threshold, indicating that ethanol decreased the concentration of aroma compound in the headspace. To determine the impact of the watering back winemaking technique on sensory properties of the wine, wines were made using five different treatments. Treatment 1 was a control (no treatment applied, 27°Brix). Treatment 2 was a watered back treatment, adding water to the must to 23°Brix. Treatment 3 involved first watering back the must to 23 °Brix, followed by the addition of sucrose to raise the sugar back to the original 27 °Brix. Treatment 4 was a watered back treatment, adding water to bring the °Brix down to 19°Brix. Treatment 5 was watered back to 19 °Brix, with sucrose added to raise the °Brix back to the original 27°Brix. The wine treatment significantly impacted the final ethanol concentration of the wine, with ethanol concentrations ranging from 15.7% in the control treatment to 12.2% in the watered back to 19°Brix treatment. Sensory difference testing showed that consumers were able to distinguish between the 19°Brix treatment and the 27°Brix treatment ($p<0.05$). In consumer acceptance testing, differences in aroma acceptance were found with lower acceptance in the control treatment ($p<0.05$). The mouthfeel attributes of astringency and alcohol burn also significantly differed between treatments, with the acceptance of both of these attributes highest in the 19°Brix treatment. Alcohol burn acceptance was lowest in the 27°Brix treatment, the wine treatment highest in alcohol concentration. Trained panel evaluation of these wines showed that watering back may increase the intensity of some attributes (nutty notes) but decrease the intensity of others (vegetal, caramel and spicy notes). Also, the 30% amelioration treatment decreased bitterness and heat intensity, but a 15% amelioration treatment had little effect. The impact of saignee/watering back was examined in wines that were industrially prepared were examined using a trained sensory panel and a consumer acceptance panel. Among the treatments, control (22°or 23°Brix), bleed to 7% and bleed to replace, trained panelists were able to identify specific aroma and flavor differences while consumers displayed differences in acceptance. The results suggested that the sensory modifications that saignee and watering back techniques have on the final wine may improve consumer acceptance with regard to certain attributes.

Taken together, these results demonstrate the influence of ethanol concentration on aroma compound recovery, sensory aroma threshold and consumer acceptance of specific wine sensory attributes.

NCSFR Research Priorities for 2012-2013

Northwest Center for Small Fruits Research

Grape (Table) Viticulture Research Priorities

for 2012-2013 funding

Revised December 2010

1A)	Evaluation of varieties to increase berry and cluster quality.
B)	Study canopy design to maximize berry quality and yield at harvest and after storage.
C)	Study of impact of varieties and canopy design on fruit set and yield components.
D)	Nutritional management for different varieties and canopies.
E)	Variety and canopy effects on water management.
2A)	Photosynthesis and carbon positioning under different canopy systems and varieties.
B)	Disease resistance in different vine architectural systems.
C)	Density of canopy affecting insect populations.
D)	Comparison of flavor components in different regions.
E)	Effect of rootstock on scion, berry quality and yield.
3A)	Develop web tools for sustainable site development.
B)	Evaluation of rootstock on cultivar vigor.
C)	Rootstock effect on canopy volume and nutrition.
D)	Effect of nematodes on vine growth.
E)	Studying culture of galls in table grapes.

Northwest Center for Small Fruits Research

Grape (Wine & Juice) Viticulture Research Priorities
for 2012-2013 funding
Revised December 2010

1A)	Water management to optimize grape and wine flavors.
B)	Incidence, impact, spread and management of grape vine viruses.
C)	Nutrient management for optimizing plant health and wine quality.
D)	Biology and management of exotic pests: mealy bug, mites, leafhoppers, nematodes, and Spotted Wing Drosophila.
E)	Grapevine physiological disorders that affect yield: bunch stem and inflorescence necrosis, fruit set problems, etc.
2A)	Biology and management of fungal pathogens: Powdery mildew, Botrytis, etc.
B)	Development and evaluation of integrated/ stainable production systems.
C)	Factors influencing fruit ripening.
D)	Grapevine hormonal response to cultural practices.
E)	Yield modeling and estimation.
3A)	Optimizing cluster architecture.
B)	Climate change as it pertains to grape production.
C)	Evaluation of scions and Rootstocks for the PNW.
D)	Development of web based research data accumulation tool in order to provide variety and site suitability for grape and wine production in the PNW.

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Wine Processing Research Priorities
for 2012-2013 funding
Revised December 2010

1A)	Methods of measuring grape and wine phenolics and their precursors to impact wine color and flavor.
B)	Identification of aroma and flavor compounds and their individual and combined impact on wine quality.
C)	Yeast nutrient status of PNW wines.
D)	Interaction of native and inoculated yeast and bacteria – managing native and inoculated fermentations.
E)	Avoidance and removal of sulfide and other reduction compounds.
2A)	Managing stuck and sluggish fermentations.
B)	Incidence of biogenic amines in PNW wines.
C)	Alternate methods for heat stability in white wines.
D)	Methods of organic wine production.
E)	Incidence and control of Brettanomyces, Pediococcus and Lactobacillus
3A)	Utilization of value added products.
B)	Winery waste management.
C)	Pre-fermentation fruit handling.
D)	Effects of vineyard cultural practices (to include rootstocks, clones, water management, cover crops, vine nutrition, and fruit maturation) on grape and wine quality.
E)	Processing technology e.g. high pressure filtration, alternate methods for wine sterilization.

Note: The subheadings under priorities are not presented in any order and simply represent key areas to be investigated.

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Blueberry Research Priorities
for 2012-2013 funding
Revised December 2010

1A)	Plant breeding/varietal evaluation
B)	Pollination
C)	Biology and management of Spotted Wing Drosophila
D)	Organic production systems
E)	Biology and management of pseudomonas
2A)	Management of virus complex
B)	Bird management
C)	Fertility management
D)	Improved irrigation management/irrigation guidelines
E)	Food safety
3A)	Biology and management of arthropod pests including garden symphylan, root weevil, gall midge, winter moth, wireworms and Spotted Wing Drosophila
B)	Biology and management of diseases, especially root rot, mummy berry and pseudomonas
C)	Methods to reduce cost of labor (i.e., mechanical harvester, pruner, weed mat, etc.)
D)	Improve or extend fresh market, controlled atmosphere packaging, mechanized harvesting, physical covers or chemicals, post-harvest handling and cultural inputs
E)	Vertebrate control

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Cranberry Research Priorities
for 2012-2013 funding
Revised December 2010

1A)	New herbicides for yellowweed control
B)	Alternative controls for black vine weevil
C)	Organophosphate alternatives for tipworm and fireworm control which are effective with chemigation
D)	Improving protocol for frost protection monitoring systems and protection with irrigation
E)	Evaluation of new cranberry varieties adapted to the Pacific Northwest
2A)	Controlling weeds difficult to manage with current herbicide and cultural practices
B)	Mowing established beds in a multiyear cycle as an alternative to sanding
C)	Improving fresh fruit quality through alternative harvest methods
D)	Using cultural practices to improve native pollinator numbers and efficiency in cranberry pollination
E)	Finding more reliable, wireless, frost detection units for field placement
3A)	Understanding the limiting factors to high yield production in the Pacific Northwest and establishing management practices that take these factors into account
B)	Control of dieback causes in new and established plantings
C)	Market expansion through nutraceuticals/health or sustainable practices
D)	Improving cultural practices to maintain genetic purity

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Strawberry Research Priorities
for 2012-2013 funding
Revised December 2010

1A)	Alternate production systems for economic efficiency, increased yield and cultivar management
B)	Accelerate the introduction and commercialization of promising selections (grower trials)
C)	Develop cultivars with processed and fresh market potential, including earlier and later ripening
D)	Methods to reduce harvest costs
E)	Biology and management of botrytis
2A)	Biology and management of Spotted Wing Drosophila
B)	Biology and management of root weevil
C)	Nutritional and nutraceutical benefits
D)	Soil Fumigation
E)	Post harvest management fruit
3A)	Weed control
B)	Irrigation management
C)	Vertebrate pest management
D)	Food safety/sanitation/security
E)	Value added products