NCCC212 “Small Fruit and Viticulture” Report

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Oregon State University

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Note: Not everyone working on berries or grapes at OSU contributed to this report

Objective 1 - Develop improved small fruit germplasm through cooperative breeding and evaluation programs:

Bernadine Strik is the OSU-lead on the USDA-ARS & OSU Cooperative Breeding Program formerly led by Dr. Chad Finn, USDA-ARS, HCRU, Corvallis; Dr. Michael Hardigan is the new caneberry breeder and Dr. Claire Luby is the new blueberry breeder (also leading strawberries at this time). Related activities have been summarized in a USDA/ARS report.

Objective 2 - Develop practices for small fruit production tailored for climatic and market needs of growers.

Blueberry

*Can humic acids improve production in mature organic northern highbush blueberry? (**study in progress**)*

A.J. Davis, B.C. Strik, and D.R. Bryla. Oregon State University and USDA-ARS.

Growers of both conventional and organic blueberries have begun using humic acids in an effort to improve plant growth and production, however research into their effects on established plants is limited. A 1-acre organic blueberry trial has been in place since 2006, with varied levels of soil organic matter, nutrient levels, and historic yield due to past fertilizer and mulch treatments. The goal of this research is to determine if adding humic acids to a standard organic fertigation program will improve yield or alter soil characteristics and plant nutrient levels over a 3-year period. Treatments include 'Duke' and 'Liberty' with or without humic acid (BioGro Premium 6, 0–0–1, 8.5% humic acids) applied at a rate of 1 gal/acre/application for seven bi-weekly applications (April 21 – July 2, 2021). Data were collected on yield, fruit and leaf tissue nutrient concentration, and soil nutrients in the first year (2021) and will continue through 2023. In 2021, adding humic acids, on average, did not increase yield in either cultivar. 'Liberty' had higher yield (7.3 kg/plant) than 'Duke' (5.4 kg/plant) as we have seen throughout all prior studies. We will continue to analyze whether addition of humic acids improves production considering the various soil conditions (soil organic matter and pH) and plant and soil nutrient status that resulted from prior mulch and fertilization practices. At the conclusion of the study, we will be able to provide better guidance to growers on whether this is a cost-effective way to improve and yield and alter soil characteristics in mature blueberry systems.

*Long-term Organic Production Systems in Northern Highbush Blueberry – Placing Weed Mat over Existing Organic Mulches and Changing to Nitrogen-only Fertilizer Sources Increased Yield **(Published)***

A.J. Davis and B.C. Strik. Oregon State University.

In long-lived organic blueberry production systems, nutrient imbalances caused by some fertilization and mulching practices can reduce plant growth and yield. The ability to

balance nutrient levels and thus improve productivity over time was evaluated in a mature planting of 'Duke' and 'Liberty' that had been used to study different mulching practices [sawdust (9-cm deep), yard-debris compost (4-cm) topped with sawdust (5-cm), and weed mat] and various rates and sources of N fertilizer (feather meal or fish solubles, each applied initially at "low" or "high" rates of 29 and 57 kg·ha^{-1} N in 2007–08 and then increased incrementally as the planting matured to 73 and 140 kg·ha^{-1} N in 2013–2016). In winter 2016-17, existing weed mat was removed and replaced where it was present, and new weed mat was installed on top of any existing organic mulches, thus changing the mulch treatments to weed mat (over bare soil), weed mat over sawdust, and weed mat over compost + sawdust from 2017 to 2020. A hydrolyzed soy protein-based fertilizer containing essentially only N was applied at a moderate rate (106 kg·ha^{-1} N) relative to prior treatments. Plants grown on flat and raised beds were evaluated separately. From 2016 to 2020, yield of 'Duke' and 'Liberty' increased by an average of 19% and 56%, respectively, on flat beds and 8% and 42%, respectively, on raised beds. On flat or raised beds, plants that had weed mat placed over the existing sawdust or compost + sawdust mulch had a greater increase in yield (averaging 41%) than those with weed mat alone (over bare soil; averaging 12%). Soil under weed mat alone continued to have the lowest organic matter content (averaging 3%) throughout the study. Prior fertilization source and rate had no impact on the increase in yield of 'Duke', whereas 'Liberty' plants previously fertilized with feather meal had a larger increase in yield through 2020 than those fertilized with fish solubles. Fertilizing with an intermediate rate of N from 2017 to 2020 increased yield regardless of whether plants received the low or high N rate from 2007 to 2016, confirming our previous conclusion that the low rate provided sufficient N. Soil K and leaf %K declined after discontinuing fertilization with fish solubles and use of yard-debris compost, likely a factor in yield improvement. However, there were still negative correlations between yield and leaf %K in multiple years. This study illustrated that changing mulch and fertility practices in established organic blueberry to mitigate prior applications of high K can improve plant performance, nutrient imbalances, and yield within a relatively short period of time.

Low-input pruning options in 'Mini Blues' for specialized processed markets reduce production costs while maintaining yield and quality ***(in press; Acta Hort)***

B.C. Strik, A.J. Davis, and P.A. Jones. Oregon State University

'Mini Blues', a small-fruited northern highbush blueberry with uniform, sweet (> 16% soluble solids, 0.8 g/berry), flavorful fruit, is ideal for specialty processed markets and well-suited for machine harvest. Plants are vigorous and produce many small laterals making typical highbush pruning methods time consuming and costly. A planting was established in October 2015 to evaluate pruning options for 'Mini Blues'. Pruning removed all fruit for the first 2 seasons; treatments began prior to the third growing season (2018). Pruning treatments were: 1) conventional highbush pruning (Control); 2) removing one or two of the oldest canes per bush (Speed); 3) unpruned from 2017-2021 (Unpruned); and 4) hedging immediately after fruit harvest starting in summer 2018 (Hedge). In winter 2019-2020, pruning required 423 h·ha^{-1} for the control, while speed pruning took 85 h·ha^{-1}; the hedge and unpruned treatments required an average of 32 h·ha^{-1} to remove low-growing

branches that would interfere with machine harvest. Hedging was only done in 2018 because it severely reduced yield; it is not a viable pruning method in this region due to insufficient time for growth and flower bud development after hedging. Harvested yield was not affected by treatment in 2018 or 2020 and was only reduced by hedging in 2019. Berry weight was lower for unpruned plants in 2018 and 2020 compared to the control (0.57 g and 0.73 g, respectively in 2020). Control pruning led to a more concentrated ripening period which would reduce machine harvests needed and cost. However, yield and fruit quality were similar to unpruned and speed pruning and the increase in pruning labor for the control was not enough to compensate for lower harvest costs. We will continue to study these techniques for long-term impacts on yield, quality, and cost of production, particularly the likelihood of needing to renovate unpruned treatment plants.

Machine harvesting and low-input pruning options in 'Mini Blues' for specialized processed markets (**paper in progress**)

B.C. Strik, A.J. Davis, and P. Jones. Oregon State University

'Mini Blues', a small-fruited northern highbush blueberry with uniform, sweet (> 16% soluble solids, 0.8 g/berry), flavorful fruit, is ideal for specialty processed markets and well-suited for machine harvest. Plants are vigorous and produce many small laterals making typical highbush pruning methods time consuming and costly. A planting was established in October 2015 to evaluate pruning options for 'Mini Blues'. Pruning removed all fruit for the first 2 seasons; treatments began prior to the third growing season (2018). Pruning treatments were: 1) conventional highbush pruning (control); 2) removing one or two of the oldest canes per bush (Speed); 3) unpruned from 2017-2021 (unpruned); and 4) hedging immediately after fruit harvest starting in summer 2018 (hedge). Mechanical hedging was not done after harvest in 2019–2021 because it was apparent that shoots that regrew after hedging in 2018 did not have enough time to develop fruit buds, resulting in reduced yield in 2019. This past year, 2021, was the fourth season in which fruit were machine harvested. Yield increased as expected as plants matured from an average of 0.8 kg/plant in 2018 to 3.5 kg/plant in 2021, except for 2020 when there were heavy losses from birds. Averaged over the 4 years of harvest, speed and control pruning had higher harvested yield (averaged 2.3 kg/plant) than hedged plants, but not significantly more than unpruned plants (1.9 kg/plant). The amount or percentage of dropped fruit was generally not affected by pruning, while the amount and percentage of fruit remaining on the bush after harvest was lowest with control pruning (5% in 2021) especially compared to unpruned (15%). Speed pruning had the greatest total fruit production (including ground losses and fruit remaining on the bush after harvest, 3.7 kg/plant) compared to all other treatments (3.0 kg/plant, averaged 2018–2021). Berry weights were quite low in 2021 (0.34g for unpruned to 0.39 g for speed and control), likely a result of the heat dome that occurred during fruit ripening, that caused shriveling of the early fruit and seemed to hinder enlargement of later ripening berries. On average, berry weight was highest for control pruning (0.64g) but speed pruned plants had similar berry weight (0.61g), whereas unpruned plants had significantly smaller berries (0.55 g). Brix (averaged 17.3%) was not affected by pruning in any year. As we have seen berry weight and harvested yield drop significantly in unpruned plants relative

to speed and control plants, we will renovate bushes (cut back to about 1 ft above the crown) in winter 2021-22 and then manage and monitor re-growth and production. Speed pruning has been a successful way to drastically reduce pruning costs while maintaining good yield and fruit quality for this cultivar.

Pruning and training options for improving production efficiency in 'Legacy' blueberry (**paper in progress**)

B.C. Strik, A.J. Davis, and P. Jones. Oregon State University

This study is being conducted at the NWREC in a 0.25-acre conventional planting established in Oct. 2015. Treatments are designed to develop best management practices for hand and machine harvest of 'Legacy' which has a growth habit and yield different from most northern highbush blueberries grown in Oregon. Three pruning/training treatments began in winter 2017-18 (prior to year 3): 1) Typical northern highbush pruning (HB); 2) standard 'Legacy' pruning, leaving more small, thin fruiting wood ("control"; per Strik's recommendation for this cultivar); and 3) control plus training to a V-shaped trellis with a goal of more efficient hand and machine harvest. In 2 of the 4 years of pruning these treatments (2018-19 and 2020-21), the "V-trellis" plants required more time due to the additional work of tucking canes between the wires (561 hr/ha in 2020-21) compared to the control (482 hr/ha) and HB treatments (358 hr/ha), while in the other 2 years pruning treatment had no effect on time required. In general, more wood has been removed with HB pruning (1.5 kg/plant in 2020-21) compared to the control (1.0 kg/plant) while the V-trellis was typically intermediate as a result of removing extra canes from the center of the bushes prior to tucking canes between wires. Since 2019, harvest has been done using a combination of hand (for the first 2 harvests) and machine picking (3rd and 4th harvests, as necessary). Pruning did not affect yield in 2018 or 2019, while in 2020 and 2021, plants in the control treatment, with or without a V-trellis, produced 9.3 kg/plant while HB pruning resulted in a yield of 8.5 kg/plant. In 3 out of 4 years, pruning did not affect speed of fruit ripening, while in 2020, HB pruning resulted in slightly faster ripening, with 56% of fruit harvested on the first pick compared to 50% for the V-trellis, but there were no differences in subsequent harvests. To date, pruning has not affected berry weight or Brix (15.5%). However, in 2021, berry weight was smaller than typical due to negative effects of the heat dome on fruit sizing (1.44 g compared to 2.12 g). Pruning treatment has had no effect on the percentage of fruit dropped on the ground during hand harvest (6-7% in 2018-2021). Generally, the amount of fruit dropped on the ground during machine harvest has not been affected by pruning either (averaged 15% in 2021). All pruning treatments had the same picking efficiency or time required to harvest a kg of fruit. Pruning according to our recommended methods for 'Legacy' has increased yield without a negative effect on fruit size or Brix. We will conduct a cost-benefit analysis of these treatments in Autumn 2021 to further determine if this the best recommendation for growers going forward.

*Individual and Combined Use of Sawdust and Weed Mat Mulch in a New Planting of Northern Highbush Blueberry III. Yield and Fruit Quality (**Published**)*

B.C Strik and A.J. Davis. Oregon State University

A 4-year trial was established in Oct. 2016 in western Oregon to evaluate the effects of various in-row mulch treatments on yield, fruit quality, and costs of installation and maintenance during establishment of northern highbush blueberry (*Vaccinium corymbosum* L. 'Duke'). The treatments included douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco] sawdust, black weed mat (woven polypropylene ground cover), green weed mat, and sawdust covered with black or green weed mat. Fruit were harvested in 2018–2020 (second through fourth growing seasons). Weed mat color had no effect on yield or fruit quality. In 2018, yield was higher with black weed mat over sawdust mulch compared to black weed mat alone, while mulch had no effect in 2019 and 2020, or on cumulative yield. Percent total soluble solids in the berries was highest with sawdust and weed mat alone compared to weed mat over sawdust mulches, while berry weight, diameter, and firmness were not affected by mulch. Sawdust was the most expensive mulch over the lifespan of the planting as it required replenishment after 2 years. Black weed mat over sawdust resulted in the highest net profit when fruit sales and cost of materials and labor were considered.

*Management Techniques to Optimize Soil pH and Nutrient Availability in Organic Highbush Blueberry Grown East of the Cascade Range (**study in progress, year 2 of 3**)*

S.B. Lukas[1], L.W. DeVetter[2], D.R. Bryla[3], B.C. Strik[1], J. Fernandez-Salvador[1] and S. Galinato[2]. [1]Oregon State University, [2]Washington State University and [3]USDA -ARS

This project is being conducted in Oregon and Washington focusing on Organic northern highbush blueberry production located in the semi-arid region east of the Cascade Range. The goal of this project, which is in year 2 of 3, is to develop optimized nutrient strategies to streamline soil pH modification and increase soil organic matter. Three separate trials are underway which individually evaluate: 1) novel methods to acidify soil; 2) impacts of utilizing grape pomace to increase soil organic matter; and 3) locally sourced organic amendments to improve soil functions. Research will be complimented in yr-3 with a complete cost-benefit analysis to determine the economic impacts and viability of investigated practices. Preliminary results to-date have identified acidification methods utilizing micronized sulfur S^o in combination with dry S^o prills at planting can reduce soil pH to levels comparable to the current grower methods without a 1-yr acidification waiting period. Methods to improve soil function and increase organic matter have indicated that grape pomace, when co-composted with biochar from apple wood feedstock pyrolyzed at 350 ℃ optimize northern highbush blueberry growth compared to standard grower practices. Detailed data and results will be produced and shared when the project data is validated after the end of yr-3 (Q4, 2022).

*Performance and Economics of Electric Weed Control in Organic Perennial Crops: A Multiregional approach (**study in progress, year 1 of 3**)*

M.L. Moretti, L. Brewer. A. Formiga, E. Chernoh, B.D. Hanson, B. Goodrich, L.M. Sosnoskie
Oregon State University, UC Davis, and Cornell University.

This project will consider the performance, safety, and economic and environmental sustainability of electric weed control (EWC) in perennial crops under organic production systems, with an emphasis on blueberry. Studies will be initiated in 2022 in Oregon, California, and New York. Four interlinked objectives will be evaluated: developing site- and weed-specific recommendations for EWC, describing the long-term impact of electric weeder use on weed population, plant growth, soil health indicators, and labor in perennial crops, conducting cost and profitability analyses of EWC in berry systems, and engaging stakeholders via diverse approaches, including local and national efforts through eOrganic. Weed management is a significant constraint in organic orchard and berry production, due to limitations on crop rotation and within- and between-row tillage. Organic weed control requires frequent soil disturbance, hand labor, high rates of organic herbicides, or the application of large amounts of organic or synthetic mulches. We expect EWC to improve weed management and system sustainability in a range of organic perennial crop systems in three key production regions.

*Screening New Post-Emergence Herbicides for Weed Control and Crop Safety in Blueberry **(study in progress)***

M.L. Moretti, Oregon State University

The goal of this project is to study the impact of unregistered herbicides on highbush blueberry growth, yield, and weed control. A study was initiated at the Lewis Brown research farm in Corvallis in a blueberry field planted in 1995 to the cultivars ‘Duke’ and ‘Elliot’, under drip irrigation. Each variety is considered an independent experiment. Treatments included the herbicides tiafenacil, tolpyralate, and florpyrauxifen benzyl. Each herbicide application, via CO_2 pressurized backpack sprayer, was directed to the plant base with shield protectors in place. The treatments included one or two applications, with the first application after petal fall and the second application three weeks later. Assessments included visual estimation of crop injury and weed control. Yield was calculated as all berries from a single bush per plot. Injury was only observed to lower leaves that were directly exposed to the treatments. Neither new shoots, their length and caliper, nor crop yield were affected by the treatments. Treatments will be reapplied in 2022, and additional data will be collected. These results will support future registration in blueberry.

Mitigating European Foulbrood disease in honey bee colonies pollinating blueberries to enhance pollination

R.R. Sagili, M. Bozkus and C. Breece, Department of Horticulture, Oregon State University, Corvallis, OR,

European foulbrood (EFB) is a bacterial disease that infects honey bee larvae. Honey bee colonies infected with this disease become weak and fail to grow during spring and summer. Over the past three years, beekeepers in Oregon and the PNW region have reported unusually high incidence of this disease, especially when colonies are pollinating blueberries. There are several hypotheses regarding why EFB incidence and prevalence in honey bee colonies is high during blueberry pollination, which include poor nutrition, inclement weather, a relatively new virulent strain of EFB and exposure of colonies to fungicides. In this study, we examined potential factors contributing to higher incidence of EFB in honey bee colonies pollinating blueberries. We collaborated with four Oregon commercial beekeepers that rent honey bee colonies for blueberry pollination. Each beekeeper had 48 colonies from their apiary in blueberry fields, and another group of 48 colonies were either placed in another crop that bloomed during the same time as blueberries, or were placed in a holding yard (no crop pollination). We performed colony evaluations (number of frames of bees, amount of brood, number of diseased larvae infected with EFB, amount of pollen and nectar) at the beginning of the study, two weeks after the initiation of the study and at the termination of the study. We also collected larvae exhibiting EFB disease symptoms for genetic analysis. The data analysis is still pending. The findings from this research will provide new insights on factors contributing to high incidence of EFB and help beekeepers improve colony health and maintain strong colonies for pollination.

Blackberry/Raspberry

*Impact of planting density and pruning and training method on growth, yield and machine-harvest efficiency of 'Columbia Star' trailing blackberry (**study in progress**)*

Strik, B.C., A.J. Davis, and D.R. Bryla. Oregon State University and USDA-ARS

A planting of 'Columbia Star' trailing blackberry was established in spring 2020 to study the impact of plant spacing (0.75 m vs. 1.5 m), primocane management (with or without chemical primocane suppression), and pruning/training (August training vs. unpruned or "new-over-old") treatments on growth, yield, fruit quality, machine-harvest efficiency, and labor requirements. Primocanes were trained as they grew in 2020 and the first machine harvest occurred in 2021. Primocanes receiving the chemical suppression treatment were sprayed on April 21 when canes averaged approximately 0.3 m and suppression date was not affected by plant spacing. Four harvests occurred between June 24 and July 5, 2021. The extreme heat dome that occurred June 26-28 reduced yield in our research plot by approximately 30% due to sunburn, shriveled fruit (much higher cull/unmarketable fruit than usual), and reduced berry size. Yield per plant was higher for

plants spaced at 1.5 m (2.2 kg) compared to 0.75 m (1.5 kg) however yield per hectare was higher for the high density spacing (6558 kg) compared to the lower density spacing (4782 kg). A higher percentage of fruit was dropped with the 1.5 m spacing (20%), perhaps because there were more gaps in the canopy than when plants were spaced closer together (15% drop). Primocane suppression resulted in slightly smaller berries (7.2 g) compared to no suppression (7.4 g) but did not affect yield or rate of ripening in 2021. Plants were caned out (August training only) and trained in mid-August and number of primocanes counted and measured for all treatments. Plants grown at 1.5 m had more primocanes (15/plant) than at 0.75 m (9/plant), as did those that received the primocane suppression treatment (14/plant compared to 10/plant with no suppression). However, primocane length was not affected by either treatment. There was a trend (P=0.0598) for more floricanes per plant with 1.5 m spacing as well (17/plant vs 11/plant for 0.75 m spacing), while floricane length, fruiting lateral number, length, or berry number per lateral were not affected by spacing or primocane suppression treatment. Caning out and training primocanes for plants grown at 0.75 m in the August trained treatment required about 30% more time per linear m of row than those at 1.5 m, but less time per plant (3.9 min. compared to 5.6 min. at 1.5 m). New-over-old training required a similar training time no matter the plant spacing (~22 sec./plant), and significantly less time than August training. Data will continue to be collected in future years to better understand treatment effects on mature yield and cost of production for each of these treatment combinations.

*Performance of Glufosinate on Caneberry (**study in progress**)*

M.L. Moretti, D. Lightle Oregon State University

The goal of this project is to study the tolerance, growth, and yield of blackberry and raspberry to glufosinate herbicide. A study was initiated at the North Willamette Research and Extension Center on a mature 'Marion' blackberry field trained bear on primocanes. A raspberry field will be established in the spring of 2022. Treatments include a nontreated control and glufosinate at 1.76 and 3.51 lb. active ingredient per acre and saflufenacil at 0.176 active ingredient per acre. In the mature blackberry, treatments will be applied in the fall and again two weeks before anticipated primocane emergence. In the newly planted raspberry, treatments will be applied 30 days after planting and repeated after 30 days. The study will continue in 2023, and additional data will be collected. These results will support the registration of glufosinate in caneberry.

Investigating the feasibility of raspberry and strawberry production in Central Oregon under protected and unprotected culture. (**study complete, WSARE report published**)

C. Sullivan, Extension Agronomist – Central Oregon, Small Farms & Specialty Crops, Oregon State University

The USDA plant hardiness zones in Central Oregon range from 3 to 5, with pasture and forages as the traditional crops grown in the area. High tunnels are used to grow multiple high-value vegetable crops in one season, but there is almost no fruit production in the region. Raspberries and strawberries are the most suitable berries for Central Oregon due

to their cold hardiness, but yield loss due to winter injury and frosts are a major concern. This projected evaluated the performance of multiple strawberry and raspberry cultivars in protected and unprotected culture in Central Oregon to help guide growers in management decisions.

Four varieties of day-neutral strawberries (Albion, Evie 2, Mara des Bois, Seascape) and primocane-bearing raspberries (Anne, Caroline, Heritage, Joan J) were planted in high tunnels and the open field in May 2019. The trial was managed organically and yield results were recorded for two growing seasons (2019 & 2020). Total marketable yield averaged across all strawberry varieties and production systems was 0.9 lbs/plant in 2019, and 1.8 lbs/plant in 2020. High tunnel strawberry production was significantly greater than outdoor production for both growing seasons, but the high tunnel yield increase was more dramatic in 2020 (30-70% increase). Evie 2 was the highest yielding berry throughout the trial, followed by Mara des Bois, Seascape, and Albion.

Total marketable yield averaged across all raspberry varieties and production systems was 0.3 lbs/ft in 2019, and 0.7 lbs/ft in 2020. However, the outdoor raspberry canes suffered serious crop loss in the winter of 2019/2020, and outdoor berry production was close to zero. High tunnel raspberry yields improved 24-80% over field production in 2019, and more than 800% in 2020. Joan J stood out as the highest yielding raspberry in both years, and in 2020 produced 2.2 lbs/ft in the high tunnel. Caroline and Anne produced similar yields, followed by Heritage.

Based on strawberry pint weights and a price of $4/pint, a 14x50ft high tunnel with three beds of strawberries would add ~$2,000 to a grower's income over two years compared to the same bed space of strawberries outdoors. Based on raspberry half-pint weights and a price of $4/half pint, a 30x 50ft high tunnel with four rows of raspberries would add ~$3,000 to a grower's income over two years compared to the same bed space of raspberries outdoors.

Strawberry

Evaluation of low tunnels for season extension of fresh-market, day-neutral strawberries in Oregon's Willamette Valley

Javier Fernandez-Salvador, Erica Chernoh, and Cora Bobo-Shisler, Oregon State University.

A two-year study (2019-2020) conducted at the OSU North Willamette Research and Extension Center (NWREC) in Aurora, OR tracking the growth and production of day-neutral strawberries grown in low tunnel plasticulture. Containerized transplants potted from bare-root plants were grown in the greenhouse for 6 weeks before field planting on raised beds covered with single use, polyethylene black plastic mulch in April 2019, and covered with low tunnels, two weeks after field planting. The trial was set up with four replicates for three day-neutral cultivars in a split plot design, and the following treatments: plants grown under a) solid 4-mil plastic, b) slitted 0.8-mil plastic and c) in open field conditions (control). Plants were managed using certified organic production

practices. Yield, leaf tissue and soil nutrient concentration, leaf, crown and runner biomass data were collected. Results from the 2019 trial, show that late-season marketable yield was greater under solid and slitted tunnel treatments compared to open beds (44.3, 17.4, and 2.5g/plant, respectively; $P<0.001$). Analysis of the combined 2019 and 2020 data continues, but preliminary results show that marketable yield was higher under solid tunnel treatments compared to slitted plastic and open field. One manuscript has been published with results from the 2019 trial, and a second manuscript is in progress. A new trial beginning fall of 2021 will evaluate two cultivars in plastic culture systems grown under low tunnels and high tunnels to extend the season and improve the viability of day-neutrals strawberries grown for fresh market in Oregon.

Substrate strawberry production systems for fresh market in greenhouse elevated benches (**preliminary study**)

Javier Fernandez-Salvador, Erica Chernoh, Cora Bobo-Shisler, Oregon State University.

This project expanded upon the fresh market, day-neutral strawberry production research currently underway at OSU NWREC, by exploring elevated bench, substrate greenhouse production systems. While fresh organic strawberries can be profitable for growers, their production is labor intensive, requiring frequent weeding and application of pesticides and hand harvest at ground level. Elevated substrate systems in greenhouses or tunnels could reduce labor and resource costs over multiple seasons, by cutting down on pest pressure, and making plants more easily accessible for fast and efficient management and harvest. The goal of this project was to conduct a preliminary study on bench substrate technologies that may improve efficiencies and yields in Oregon strawberries. This preliminary study explored the feasibility and equipment needs for two different system designs, and evaluated different cultivars, planting media and fertilizer combinations for elevated substrate production of strawberries under greenhouse cover in Oregon. Data is being analyzed and results will be presented at a later date.

Grapes

Statewide Crop Load Project: Defining Yield Management Practices for Quality Pinot noir in Oregon

Patricia A. Skinkis* and Cody Copp, Department of Horticulture, Oregon State University, Corvallis, OR, James Osborne* and Elizabeth Tomasino*, Department of Food Science & Technology, Oregon State University, Corvallis, OR, Katherine McLaughlin, Oregon State University, Corvallis, R. Paul Schreiner*, USDA-ARS, Corvallis, OR. *Member of the Oregon Wine Research Institute at Oregon State University

Crop thinning is conducted in Oregon Pinot noir vineyards as it is thought to ensure premium quality fruit and hasten ripening in cool climate regions of the state. The industry-wide yield target through 2012 had been 2 to 2.75 tons/acre. However, these targets were not scientifically-founded yet were applied universally, regardless of

vineyard productivity, vine density, or seasonal heat units. Furthermore, there were no vine balance metrics to evaluate the yield-quality relationship, and metrics defined by other regions have not worked well. To develop better yield management guidelines for industry, a 10-year industry collaborative research project began in 2012. A total of 25 companies participated in the research. Each company applied cluster thinning treatments in replicated plots within commercial Pinot noir vineyards. Vineyard data was collected by the collaborators according to OSU provided protocols. Data included fruitfulness, cluster and shoot counts, véraison tissue analysis for macro- and micro-nutrients, yields, and pruning weight. Fruit samples at harvest were analyzed for basic ripeness parameters (total soluble solids, pH, and titratable acidity), organic acids, fermentable nitrogen, anthocyanins, and phenolic compounds. Wines were produced by each participating winery using a minimum of 1 ton of fruit for each crop level. Wines were evaluated by a winemaker sensory panel after 2 years of bottle-aging. Mean yields from 2012-2020, based on thinning treatments, ranged from 0.4 to 3.1 kg/m (0.2 to 20 lb/ft) annually. The annual mean yield was 1.42 kg/m (0.92 lb/ft). Despite multiple years of cropping at high or low levels, there was no effect of yield on dormant pruning weight or vine nutrient status in most vineyards. After nine years, there are no signs of vineyards being over-cropped and all could physiologically handle the levels of fruit in the full crop treatments. Fruit composition at harvest did not differ by cluster thinning within 15-45% of sites each year. For the remaining 45-85% of sites, there were few consistent differences. In fact, there were fewer differences by crop level in the highest yielding years. However, anthocyanin concentration increased by reduced yields in 21% of sites across the nine-year period. Sensory evaluation of wines show that yield does not affect wine characteristics (mouthfeel, aroma, etc.). This project just completed the 2021 harvest. This long-term data set is being used to develop yield management guidelines that are suited to different climates, years and winery production targets (bottle prices). Two manuscripts are published from the study, focusing on the yield management practices and methods for developing an industry-citizen science project. Manuscripts for the full project duration are in progress.

Vine pruning and training techniques to ameliorate impacts of grapevine trunk disease

Patricia A. Skinkis*, Department of Horticulture, Oregon State University, Corvallis, OR; Erica Miller, Argyle Winery, Dundee, OR; Jason Tosch, Stoller Wine Group, Dayton, OR. *Member of the Oregon Wine Research Institute at OSU

Grapevine trunk disease (GTD) is a major issue for vineyards on the West Coast. Many GTD pathogens are present in mature vineyards (>20 years old) in Oregon, and the wet winter conditions are optimal for infection of pruning wounds. While studies are being conducted regionally to understand the specific GTD pathogens present, there is a need to understand management practices for renovating a vineyard severely impacted by GTD. A three-year pruning trial was conducted in a commercial vineyard in Dayton, OR. The vineyard was confirmed to have multiple trunk disease pathogens in the grapevines, and the entire block was assumed to be infected. At the outset of the trial, vines were individually assessed for vine vigor level (high, moderate, moderate-low, or low). Three pruning techniques were applied to vines of each vigor level in a randomized complete block design. Treatments included control (spur pruning as normal), trunk renewal (cutting the vine down to the base of the trunk and renewing the trunk with a sucker), or

cane renewal (removing the cordon and training out a new cane). Pruning treatments were applied at dormancy each year on individual vine plots. There were ten field replicates for each trial within the four vine vigor levels. Vines with trunk renewal in year 1 were cane pruned in following years. Vines with cane renewal had the cordon removed in year 1 but were cane pruned in all years that followed. The project was carried out during the 2019 to 2021 crop years. Results to date show that cane renewal improved yield by 55% compared to the control in the first year. Trunk renewal did not improve yields in year 1, and that is likely due to the drastic reduction in number of fruitful buds on suckers replacing the trunk and cane. None of the pruning practices improved yield in moderate-low or low vigor vines in year 1, and this may be due to vines needing more time to recuperate. High vigor vines were also not impacted by the pruning methods, but that is likely due to the naturally high vigor and/or lesser disease impacts requiring amelioration. However, all trunk renewal and cane renewal treatments had larger cluster weights than control in year 1, regardless of vigor level. Data acquisition is still in progress for 2021, and 2020 data still need to be analyzed as of this reporting. The results of this study will be helpful to growers seeking options of managing trunk disease in mature vineyards without requiring rouging and replanting

Characterizing Willamette Valley Soil Moisture and Grapevine Response under Drying Seasonal Conditions

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Willamette Valley vineyards experience late season water stress that may be limiting vine growth and production, depending on soil type and season. Producers need to understand how to manage vineyard soil water, whether through irrigation or vineyard floor management. Since most vineyards in the Willamette Valley are dry-farmed, management techniques are challenging and must forecast the impacts late season. At three-year project was developed to understand soil moisture and Pinot noir grapevine growth, water stress, and fruit development in three soil types typical to the region. This research is underway in a commercial vineyard comprised of sedimentary soil, volcanic soil, and marine sediment soil. All vineyard blocks are Pinot noir grafted to 101-14 rootstock, a common rootstock in the region. Soil moisture, weather data, and vine growth responses were measured in 2020 and 2021. Sensors measured soil moisture, soil temperature, and electrical conductivity at two monitoring locations per soil type to a depth of 18 and 36 inches under-vine and in the middle of the alley between rows. Soil moisture remained relatively consistent through spring, with the start of soil moisture decline in mid-June, shortly after bloom, and continued through summer. Soil moisture decline was greatest at the 18” depth. The marine sediment soil had the greatest decline in soil moisture yet the largest vine size (based on dormant pruning weight), suggesting that the higher vigor vines in that soil type required more water from the soil profile than vines in the other two soils. There were no clear differences in vine water stress of the three soil types. Berry weight lagged slightly for vines in the marine sediment soil, but there were no differences in the berry development curve. By harvest, yields were similar from each soil type. However, the berries from vines in marine sediment soil had lower Brix and sugar per berry compared to the other two soils. These same vines also had

greater tissue N at véraison and berry YAN at harvest compared to vines in the other two soils. Since the site was not irrigated and no fertilizers added, the differences in growth and berry composition reflect differences in soil fertility and moisture.

The project continues through 2022. Results of the study will be summarized and compared with other soil moisture monitoring efforts in other Willamette Valley research blocks. The project results are useful in determining regional soil moisture management strategies, including best vineyard floor and vine balance guidelines based on soil and productivity potential. We will develop future research projects that will build upon foundational knowledge gained from this study (e.g., timing and type of vineyard floor practices).

Rootstock effects on mature Pinot noir growth and productivity under cool climate, dry-farmed conditions

Patricia A. Skinkis* and Jeremy Schuster, Department of Horticulture, Oregon State University, Corvallis, OR. *Member of the Oregon Wine Research Institute at Oregon State University

Oregon vineyards are experiencing warmer and drier summers. The majority of vineyards in Oregon are planted to three vigor reducing rootstocks (101-14, 3309 and Riparia Gloire) that have limited drought tolerance. With the changing climate, growers are seeking other rootstocks that may help improve vine performance (yield and fruit quality) under the region's dry-farmed conditions. A three-year trial began in 2020 evaluating an established OSU rootstock trial (planted in 1997), with focus on Pinot noir growth response on 19 rootstocks. The trial also includes own-rooted vines. Vine growth, yield, and fruit composition of Pinot noir grafted to 19 rootstocks and own-rooted vines were quantified during 2020 and 2021. Given the vineyard's age, we hypothesized cumulative impacts of the rootstock on vine growth would be distinguished by rootstock. Specifically, we hypothesized that Riparia Gloire and other vigor-reducing rootstocks such as 101-14, 3309C, and 420A would have reduced canopy growth compared to other rootstocks not commonly planted in Oregon due to high vigor potential, such as 110R, 140R, 1103P, and 161-49. Results show that the majority of rootstocks performed similarly for vine canopy growth and fruit production. However, Riparia Gloire, 44-53, and 3309C had the lowest pruning weights, indicating low vigor vines, and 161-49 and 1616 had the highest pruning weights, indicating vigorous vines. Despite vigor differences, there were no differences in growth stage advancement at bud break, bloom, or fruit set. By the start of véraison Riparia Gloire and SO4 had the most advanced color development while 101-14, 3309C, and own-rooted were the least advanced. However, within six days, the rootstocks became less different in percent of berries colored, and 3309C had the highest rate of color change. There were no differences in rootstock yield except for Riparia Gloire and SO4, which had the lowest and highest yields, respectively. Berry ripeness did not differ for most rootstocks. However, Schawarzmann had higher Brix than 420A, 5BB, 125AA, own-rooted, 5CTE and 99R. There were few differences in pH and variable differences in titratable acidity. We anticipated that rootstock may impact berry phenolics through vine stress and/or differences in canopy microclimate. However, there were no rootstock differences in total anthocyanin or phenolic content, and only minor differences in total tannins. We also anticipated that vine vigor conferred

by rootstock may affect berry nitrogen, but there were few differences in juice primary amino N except for 1616 and 5BB that had more than double the primary amino N than 44-53 and own-rooted vines. This 2020 data suggests that rootstock has the greatest impact on vegetative growth and yield, thereby causing some differences in vine balance. There is less impact on Pinot noir phenological advancement, fruit ripeness, berry N, or phenolics at harvest. Two field seasons of research have been completed by this reporting. However, year two field data analyses and fruit analyses are in progress. Findings from this research will help growers make new vineyard plant material selections, by allowing them to consider the performance of varied rootstocks locally and under dry-farmed conditions.

High-Resolution Vineyard Nutrient Management

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A research team at Oregon State University and USDA-ARS embarked on a four-year research project (2020-2023) investigating vineyard nutrient management. The project is funded NIFA-SCRI. Schreiner, Skinkis, and Woodill are representing Oregon as part of this multi-state project led by Washington State University. A primary goal of this national project is to develop new tools for growers to more rapidly monitor grapevine nutrient status. This technology will work in addition to current practices, namely tissue and soil sampling. Oregon team members are involved in regional viticulture research, understanding grower decision-making nation-wide, project outreach, and economic implications. Each of the Oregon-based projects are highlighted below.

Patty Skinkis is a project co-director, coordinating outreach, economics, and social science aspects of the research team. She is working with the entire project team to ensure that the information generated is shared with industry and supportive services, such as Extension agents. In particular, she plans to ensure that new methodologies and nutrient guidelines are communicated to growers, consultants, and Extension agents through web-based means and a podcast series. Please be sure to check out the project website and follow project developments on Instagram, Twitter, and LinkedIn.

The Outreach, Economics, and Social Science Team conducted a nationwide survey during spring 2021. The survey included questions about how growers monitor and manage vineyard nutrition and what technology they use. Growers from across the nation completed the survey, representing nearly 176,000 acres, or 10% of the US acreage. The greatest survey participation was in California (22%), Oregon (20.5%), and Washington (13.5%). This information is being used to benchmark progress of research outcomes and determine whether deliverables are adopted by industry. Results are still being analyzed as of this reporting, but a summary of the survey can be found here.

Paul Schreiner is a project co-director, leading the Plant Nutrition and Product Quality Team. He is coordinating viticulture trials with project partners across the US. The goal is to conduct parallel studies across different climates, cultivars, and production systems. They are carrying some of the projects through wine production. He is also involved in on-farm trials in Oregon. Results are not yet available from the project, as the team recently finished its first season harvest.

As part of the Outreach, Economics, and Social Science Team, John Woodhill is evaluating the economic impact and feasibility of vineyard nutrient management decisions. Using vineyard nutrient data from Oregon and other states, John uses econometric models to study how changes in nutrient levels, farm-level decisions, and weather impact yields. These models are being applied throughout the project to better understand economic impact of nutrient levels in vineyards.

Developing a GMO-free RNA Interference Approach to mitigate Red Blotch negative impacts on grape berry ripening (study in progress, year 1)

Christian Mandelli and Laurent Deluc, Oregon State University

Grapevine red blotch virus (GRBV) is a single-stranded DNA geminivirus which has been identified as the etiological agent of the Grapevine red blotch disease. This last is associated with the development of red blotches on the leaves surface of grapevine plants, and with a significant impact on fruit ripening dynamics and quality, that could lead to economic losses up to $70,000/ha.

Geminiviruses are known to reprogram the infected cell cycle; their replication, as well as the transcription of the viral proteins, rely on the host cellular machineries. In the early phases of infection, viral-derived small interfering RNAs (vsiRNAs) are generated via the plant RNA interference (RNAi) machinery, which represents one of the first antiviral responses activated by plants. This results in either viral mRNA degradation, known as Post-Transcriptional Gene Silencing (PTGS), or in the DNA methylation of the viral genome, known as Transcriptional Gene Silencing (TGS). With that said, this project aims to build the foundational knowledge related to the plant-pathogen interaction, for the future development of a Spray Induced Gene Silencing (SIGS)-based treatment to counteract the negative impact of GRBV on grapevine plants.

The research project includes three main aims. We are currently working on Aim 1 which mainly focuses on the identification of the viral genomic “hotspots” targeted by the plant RNAi machinery. A closer view on the virus-host interaction during the very early phases

of infection will allow us to characterize specific sequences that are produced by either the plant and the virus in response to the activity of each other. The output of this first aim will be generated *in silico* analyses of transcriptome, sRNAome and methylome, as well as by the secondary structure prediction of viral sRNAs from leave samples infected by the virus via Agrodrenching. Once the potential regions of the virus will be identified, we will propose to validate *their* use through spray application of artificial dsRNAs containing these "hotspots" regions. The optimization of the spray methodology will include with the use of carriers like clay nanoparticle (Layered Double Hydroxyde) to either stabilize or extend the lifespan of the dsRNA molecules in a field-based environment. If successful, this could represent in the long-term a reliable and economically sustainable alternative to intense labor management and/or removal of GRBV infected plants.

Developing a Spray Induced Gene Silencing (SIGS) Method for the Control of Grape Powdery Mildew (Erysiphe necator) (study in progress)

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The emergence of fungicide resistance for Grape Powdery Mildew (*Erysiphe necator*) suggests the need to develop new strategies to control GPM. Recent research demonstrates that agricultural pests, such as insects, nematodes, and fungi, can be controlled through the exogenous application of RNA molecules to trigger RNA interference (RNAi). The primary goal of this project is to develop a Spray-Induced Gene Silencing (SIGS) to induce RNA interference mechanisms targeting both the grapevine and the fungus. The plant genes targeted for RNAi belong to a susceptibility-gene family to *Erysiphe necator* (Mildew Locus O: MLO genes). Additionally, three pathogen-regulated genes critical to the life cycle of the pathogen. Our first objective of the project is to identify stretches of RNA molecules with the maximum interference activity to repress endogenous MLO genes (*VitviMLO 3,4,6,9,13,17*) and fungal genes (*Dicer*-like protein 1 and 2 and *CYP51*). As the first step, we have successfully cloned and validated by sequencing 200-1000 base pair amplicons corresponding to candidate genes' coding regions which are used to generate dsRNA molecules. Using these clones as a template, we have produced the dsRNA molecules using a commercial kit. Previous work has shown the ability for uptake of dsRNA via root soaking. Grapevines exposed to dsRNA for 0, 3, 7 and 14 days were harvested, and RNA extraction is underway. Complimentary-DNA synthesis and real-time PCR will follow. At this time, we do not have data related to silencing effects, but the analysis is ongoing. After initial silencing results in plants, we will aim to monitor the growth of inoculated *Erysiphe necator* on leaves sprayed with dsRNA solutions targeting fungal genes' activity. We will also apply mixed populations of dsRNA solutions (plant- and fungal-related) to identify the best combinations of dsRNA species to control grape powdery mildew growth. In conjunction with the primary objective, a second objective involves examining the uptake and movement of fluorescently labeled dsRNA throughout plant tissues to understand potential systemic effect of the RNAi signal. Initial assays conducted by root soaking with fluorescently labeled dsRNA has shown the potential for uptake of dsRNA and movement into root cells. This will be replicated with a higher concentration of labeled dsRNA and sections of plant roots, shoots and petioles will

illustrate the pathway and timeline of systemic movement of RNA molecules throughout plant tissues over the course of forty-eight hours.
The third objective will be to test the efficacy of clay nanoparticles (Layered Double Hydroxide [LDH]) to prolong dsRNA's lifespan on the surface of grapevine leaves, potentially extending silencing effects. Upon success of our primary objective, this technology can help sustain silencing for longer periods of time, making it a more feasible approach for plant protections outside of laboratory environments. Overall, we would like to demonstrate a new approach for the induction of disease resistance in the grape vine plant via this non-transgenic approach for gene silencing.

Novel coatings to prevent uptake of smokes into wine grapes (study in progress)

Y. Zhao, E. Tomasino, M. Penner, Oregon State University

The recent wildfires impacted wine regions throughout the states of Oregon, Washington and California, with many wineries and vineyards not picking fruit or producing wine. The wines made from affected grapes can develop smoke related off-aromas and flavors associated with negative wine quality. This project is aimed to: 1) develop novel coating formulations for vineyard applications that can effectively sequester volatile smoke compounds, thus preventing their uptake into wine grapes; 2) conduct initial technoeconomic analyses to determine feasibility for scale-up to vineyard applications; 3) validate the effectiveness of developed coatings resulting from Objectives 1 and 2 through field trials in collaboration with wine grape producers; and 4) engage stakeholders and project partners to foster implementation of developed technology by Oregon wine growers as the need arises. During 2021 wine grape production, Pinot noir grapes grown at the Southern Oregon Research and Extension Center in Central Point, Oregon, were coated with three different coating treatments. To determine if the coatings would impact the overall grape quality and optimal application time, the grapes were coated at three separate occasions: once during pre-veraison, once during veraison, and a double application before and during veraison. The grapes were harvested and analyzed for Brix, pH, titratable acidity, weight, and size. GCMS and HPLC will be used to measure any smoke residue since a natural smoke event occurred during the duration of the study. In parallel, the coatings will also be made into films to characterize the interactions between the coatings, grape skin, and smoke compounds. We are in the middle of data collection now. The results of this study will help determine if edible coatings can mitigate smoke taint in grapes without affecting the overall wine quality.

Integrated pest management in small fruit production (blueberry, caneberry, strawberry and winegrape) systems

Vaughn M. Walton, Gabriella, Serhan Mermer, Ryan Chave and Jana Lee

During the reporting year we focused on alternative management techniques for Spotted Wing Drosophila (SWD), Brown Marmorated Stink Bug, Red Blotch vector insects, and potential invasive insect pests including Spotted Lanternfly.

For SWD we either identified or patented at least four new technologies, three of which are behavioral pest management technologies, and the fourth causing mortality. The first of the patented technologies are currently being commercialized, resulting in at least 30% reduction in damage and significant reductions in cost and improvements in productivity. We also refined conventional pest management techniques, including conventional insecticides. Here we used data from laboratory and field trials, combined with mathematical modeling to improve application techniques, sequence, and frequency. We also showed significant improvements in insect management by using weed fabric, drip irrigation and pruning techniques. Finally, we obtained permits for release of natural enemies after ~11 years of foreign exploration. These permits will enable mass rearing and release to help fight damage caused by SWD. This natural resource will also significantly reduce input costs to manage this damaging insect pest.

For BMSB we were able to identify new volatiles that can be used both for attractancy and repellency of this highly damaging insect pest. We showed both significant attractancy and repellency under controlled behavioral trials, indicating possible value for commercial implementation. During future years of study, we will focus on formulation of these volatiles as environmentally-friendly pest management tools that can be used in all affected crop systems.

For Spotted Lanternfly, we worked with national specialists to produce an extension document that will help growers and stakeholders to identify, report and mitigate spread of possible finds of this highly damaging insect pest. This insect is rapidly spreading in eastern USA production regions. This is extremely worrying as there is currently no quarantine in place to mitigate the potential of spread of this insect into Oregon.

For Red Blotch, we are developing a universal vibration trap that can be used to trap insects that may be vectors of the Red Blotch virus in vineyards. We aim to use and play back vibrational signals that these insects use for mating, thereby pulling them into traps, and possibly away from susceptible vineyards. This trap can be used to identify host plants, activity periods, and diurnal activity levels. It can also be used for possible mating disruption or the creation of disruption technologies that are environmentally friendly.

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Impact (Objective 2):

<u>Blueberries</u>

(Davis et al.) Humic acid. Growers are using humic acids in mature blueberry plantings although no research has been published to date on any possible benefits. The goal of this research is to determine if humic acids increase yield or change soil composition, leaf, and fruit nutrient concentrations in an established planting with varying conditions based on past research treatments (mulch, fertilizer, and cultivar). At the conclusion of the study, we will be able to

provide better guidance to growers on whether this is a cost-effective way to improve and yield and alter soil characteristics.

(Strik and Davis) In organic blueberries, the common use of fertilizer sources with high K increased leaf and soil nutrient levels reducing yield (published papers). The goal of our continuing research was to provide growers with important information on how quickly changing fertilizer practices may adjust soil and plant nutrient status and impact yield. Some changes, such as a reduction in soil and leaf K have been relatively rapid and positive for plant health, although there were still negative correlations between yield and leaf %K in multiple years. Yield increased across all treatments in 3 of the 4 growing seasons since switching fertilizer and mulch systems. This study illustrated that changing mulch and fertility practices in established organic blueberry to mitigate prior applications of high K can improve plant performance, nutrient imbalances, and yield within a relatively short period of time

(Strik et al.) Weed mat. Our recently published study on development of 10 cultivars from planting to maturity in two certified organic mulching/amendment systems illustrated the importance of mulch type and the possibility of mitigating a measured decline in soil organic matter under weed mat by adding a sawdust mulch layer underneath. Building upon what was learned in this long-term study, we initiated a new study with a goal of better understanding the relationships between mulching practices, soil properties and characteristics, and plant growth and establishment in blueberry. We have determined that the addition of sawdust under weed mat may justify the extra production cost through improved plant growth during establishment, and increased yield in the first production year, along with reduced soil temperatures and vole presence. While the addition of sawdust mulch under weed mat does not rapidly increase soil organic matter, it may help mitigate the long-term losses we saw in past research. Since weed mat color did not have an impact on plant growth, we recommend continuing to use the industry standard and widely available black weed mat. Overall impacts of mulch on fruit quality across three years of study were minor, and fruiting season was not affected despite differences in soil temperature under the mulches and canopy temperature in the first season.

(Strik et al.) With reduced labor availability and higher labor costs, we have developed a reduced labor production system for ‘Mini Blues’ blueberry. Using a “speed pruning” technique (removing 1-2 older canes per bush each year) resulted in similar yield and fruit quality as those pruned using typical methods, while drastically reducing pruning time and thus costs. ‘Mini Blues’ that were left unpruned for more than 3 years began to show lower yield and smaller fruit size and need renovation after 5 years.

(Strik et al.) After 4 years of implementing different pruning and trellising techniques, yield in ‘Legacy’ was improved in 2020 and 2021 using the revised pruning technique recommended by Dr. Strik compared to typical northern highbush style pruning. Fruit quality has not been impacted.

Grapes

(Skinkis; crop load) Cluster thinning has less impact on fruit and wine quality than vineyard site, and it is not consistent in achieving certain fruit quality parameters between years or sites. Through active engagement in this research, vineyard managers and winemakers have learned

how to implement research on their site and how to utilize data collection protocols. Many of them report having a greater understanding of the whole vineyard system, are much more observant in the vineyard, and are beginning to look at yield management differently. Project collaborators have confidently increased yields by 0.5 ton per acre annually without compromising quality. This has led to a 25% increase in yields, which can harness an additional $1500/acre in grape sales on average (across the 17,744 bearing Pinot noir acres in the state), resulting in additional $2.3 million per year in farm gate value for Pinot noir grapes. Many collaborators also said that the increased yield is leading to more volume of quality wine (with no reduction in bottle price), as they have not seen a reduction in fruit or wine quality with yield increases between 0.5-1.0 tons per acre.

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Strik, B.C. and J.A. Fernandez-Salvador. 2021. A tribute to Dr. Chad E. Finn (1962-2019). International Strawberry Symposium, May 2021, Italy. Acta Hort. 1309:ix-x

Objective 3 - Evaluate pre- and postharvest fruit quality components, including enhanced flavor, texture/firmness, shelf life, and phytonutrients

Blueberry

Investigation of principles and technologies to stabilize fruit anthocyanin pigments for retaining integrity, nutritional and sensory qualities of processed whole fruit (study in progress)

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Anthocyanins are responsible for dark purple/blue pigmentation of blueberries, and also provide health promotion benefit. Unfortunately, retaining anthocyanins in fruit during food processing has been an extremely challenging task since anthocyanins degrade at high temperature and when exposure to oxygen, plus anthocyanins are highly water-soluble. This project is aimed to: 1) investigate the mechanisms of anthocyanin pigment stabilization in processed whole fruit using blueberries and other anthocyanin rich fruit as model system through co-pigmentation and strengthening cell wall structures, 2) optimize water- and heat-resistant layer-by-layer coatings for strengthening outer epidermal wall structures, blocking anthocyanins leakage, and retaining integrity of fruit during fruit processing and storage in aqueous media, 3) investigate the effectiveness of thermal and high hydrostatic pressure processing to inactivate concerned microorganisms for ensuring food safety of blueberries and other whole fruit while applying above approaches for retaining anthocyanins, and 4) implement the developed technologies in different fruit products (canned blueberries, blueberries in mixed fruit cup, etc.) and validate quality, consumer acceptance, and shelf-life of the products.

During the first year of the project, our efforts have been focused on Objective 1 and 2. Specifically, copigmentation of blueberry anthocyanins with different phenolic compounds and surface treatments to enhance interaction of co-pigmentation compounds with blueberry surface anthocyanins were studied. In addition, different mechanisms between co-pigmentation reactions with anthocyanin extracts vs. with anthocyanins in whole fruit (much more complex system) were investigated using a simulated canning process. Through these experiments, we identified the most effective phenolic compounds and surface treatment to achieve optimal copigmentation treatments for stabilizing blueberry anthocyanins. Meanwhile, layer-by-layer coatings with good adhesion on blueberry surface and water/heat resistance during thermal processing in aqueous media and during storage were developed. Two manuscripts are under preparation now.

Objective 4 - Identify opportunities and collaborate on the development of extension resources for multistate, regional, national, and/or international audiences

Blueberry

*Revised leaf tissue nutrient sufficiency standards for northern highbush blueberry in Oregon (in press; **Acta Hort**)*

B.C. Strik and A.J. Davis. Oregon State University.

Leaf tissue sampling to determine nutrient concentration is a common practice. Lab results are compared to published sufficiency levels to help inform nutrient management programs. Published tissue nutrient standards were developed from research experiments and estimates from large databases that relate tissue nutrient levels to high yielding fields. Current leaf sufficiency levels are similar for nutrient management guides published in various regions for northern highbush blueberry. Standards are based on nutrient concentrations in recent, fully expanded leaves on lateral shoots located below the fruiting zone. Since leaf nutrient levels vary over the growing season, recommended sampling time is when most or all nutrients are relatively stable to allow for comparison among years. Commonly grown cultivars with fruiting seasons ranging from late-June to mid-September including 'Duke', 'Bluecrop', 'Draper', 'Liberty', 'Legacy', and 'Aurora' were evaluated in conventional and organic production systems. Cultivars differed in leaf nutrient levels, but all were best sampled from late July to early August despite differences in fruiting season. While yield was typical in research studies done from 2013–2020, levels of some tissue nutrients were outside of currently published sufficiency standards for the region, particularly for leaf P, K, Ca, and Cu. Leaf tissue sufficiency standards have thus been revised to 1) account for broader variation among cultivars that may result from differences in fruiting season and nutrient allocation, 2) narrow or lower sufficiency standards where research has shown a negative correlation with yield at the higher levels within current sufficiency standards, and 3) provide typical levels for Al; while Al is not an essential nutrient in northern highbush blueberry, leaf Al concentrations may be used along with leaf Mn to monitor changes in soil pH over time. Revised leaf sufficiency standards for macro- and micronutrients will be presented.

Extension publications:

Mermer, S., G. Tait, J. Vlach, J. Lee., MJ Choi and **VM Walton** 2021. Spotted Lanternfly is an invasive insect that may impact Oregon. Oregon State University Extension Service EM 9312

Mermer, S., L. Brewer, D. Dalton, R. Nieri, K. Park, F. Pfab, M. V. Rossi-Stacconi, and **V. Walton**. 2020. Improved Chemical Control Strategies for Spotted-wing Drosophila. Oregon State University Extension Service EM 9265.

Mermer, S., G. A. Hoheisel, H. Y. Bahlol, L. Khot, D. Rendon, L. Brewer, D. Dalton, R. Nieri, K. Park, F. Pfab, M. V. Rossi-Stacconi, and **V. Walton**. 2020. Optimizing Chemical Control of Spotted-wing Drosophila. Oregon State University Extension Service EM 9266.

Rendon, D., S. Mermer, L. Brewer, D. Dalton, C. B. D. Silva, J. Lee, R. Nieri, K. Park, F. Pfab, G. Tait, N. Wiman, and **V. Walton**. 2020. Cultural Control Strategies to Manage Spotted-wing Drosophila. Oregon State University Extension Service EM 9262.

Rossi-Stacconi, M. V., L. Brewer, D. Dalton, J. Lee, R. Nieri, K. Park, F. Pfab, G. Tait, and **V. Walton**. 2020. Host Range and Characteristics Affecting Fruit Susceptibility to Spotted-wing Drosophila. Oregon State University Extension Service EM 9263.

Rossi-Stacconi, M. V., L. Brewer, B. Miller, D. Dalton, J. Lee, K. Park, F. Pfab, **V. Walton**, and C. B. D. Silva. 2020. Biocontrol of Spotted-wing Drosophila. Oregon State University Extension Service EM 9229.

Silva, C. B. D., B. E. Price, D. Dalton, D. Rendon, K. Park, L. Brewer, **V. Walton**, and M. V. Rossi-Stacconi. 2020. Potential Impacts of Irrigation and Biocontrol on Spotted-wing Drosophila Populations. Oregon State University Extension Service EM 9268.

Tait, G., D. Rendon, L. Brewer, D. Dalton, J. Lee, R. Nieri, K. Park, F. Pfab, M. V. Rossi-Stacconi, and **V. Walton**. 2020. Noncrop Host Plants Used By Spotted-wing Drosophila. 3.

Tait, G., M. V. Rossi-Stacconi, B. Miller, D. Dalton, J. Lee, K. Park, **V. Walton**, T. Peerbolt, and L. Brewer. n.d. Monitoring Techniques for Spotted-wing Drosophila. Oregon State University Extension Service EM 9267.

Walton, V., L. Brewer, D. Dalton, S. Tochen, R. Nieri, K. Park, F. Pfab, D. Rendon, G. Tait, N. Wiman, and M. V. Rossi. 2020. How Seasons Affect Population Structure, Behavior and Risk on Spotted-wing Drosophila. Oregon State University Extension Service EM 9261

Skinkis, P., J. Pscheidt, A KC, M. Moretti, V. Walton, and C. Kaiser. 2021. Pest management guide for wine grapes in Oregon. Oregon State University Extension Publishing. EM 8413.

Skinkis, P., V. Walton, J. DeFrancesco, B. Edmunds and N. Bell. 2021. "Grape Pests" In Pacific Northwest Insect Pest Management Handbook. Pacific Northwest Extension Publishing.

Strik, B, E. Dixon, A.J. Detweiler, and N. Sanchez. 2021. Growing Kiwifruit in Your Home Garden: Willamette Valley – Southern Oregon – Central Oregon – Eastern Oregon. EC 9322. May 2021

Strik, B, and A. Davis. 2021. Growing Kiwifruit – A Guide to Growing Kiwiberries and Fuzzy Kiwifruit for Pacific Northwest Producers. PNW 507. March 2021, 32 pp.

Strik, B, E. Dixon, A.J. Detweiler, and N. Sanchez. 2020. Growing Blueberries in Your Home Garden: Willamette Valley – Southern Oregon – Central Oregon – Eastern Oregon. EC 1304. December 2020

Proceedings articles:

Strik, B.C. and A.J. Davis. 2021. Revised leaf tissue nutrient sufficiency standards for northern highbush blueberry in Oregon. Acta Hort. (in press)

Online Education:

Grower course for blueberry production physiology through OSU PACE (https://workspace.oregonstate.edu/course/online-blueberry-physiology-production-systems-management) by **Strik et al**. (last course offered Sept-Nov. 2021); Bernadine is retiring.

Strik, B. 2020 - onwards. **Pruning and training modules (individually) for blueberries, kiwifruit, table grapes, blackberries, and raspberries.** 1.25 to 2.5 hours of on-line education, per crop for a home garden and small farmer audience. Through OSU PACE (https://workspace.oregonstate.edu/course/pruning-series) by **Strik** (self-paced, available all year)

OSU Extension Principles of Vineyard Management online class, **Spring 2021**

This is an online offering to the industry or public, held simultaneous with credit-based on-campus instruction by **Skinkis** (offered once per year, non-credit)

Websites:

Oregon Wine Research Institute is a research cooperative at Oregon State University and includes the Viticulture and Enology Research and Extension programs. The Institute has a website where program information and industry outreach are available. (http://owri.oregonstate.edu)

Oregon State University Extension Wine Grape Webpages includes technical information for wine grape growers and wineries in Oregon and the Pacific Northwest. Wine grape production (https://extension.oregonstate.edu/crop-production/wine-grapes) and wine production (https://extension.oregonstate.edu/food/wine-beer) content are available.

Spotted Wing Drosophila Website – c.a. 98,546 page views/year for past two years, visitors from 50 countries: https://spottedwing.org/

BMSB: https://agsci.oregonstate.edu/bmsb/brown-marmorated-stink-bug

Honey Bee Lab Website: https://honeybeelab.oregonstate.edu/

Oregon Master Beekeeper Program Website: https://mb.extension.oregonstate.edu/

Berry Crops Web site, NWREC: https://extension.oregonstate.edu/nwrec/berry-crops

Berry Crops Web site, College of Agricultural Sciences: https://agsci.oregonstate.edu/berries-and-small-fruits