NCCC212 “Small Fruit and Viticulture” Report

October 27–28 2020
North Carolina State University (virtual)

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; Chad tragically passed away Dec. 17 2019. 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

Development of alternate fertilization programs to mitigate nutrient problems found in long-term organic blueberry production systems (study in progress)

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

The goal of this project is to study the impact of alternative OMRI-approved fertilizers to mitigate the negative impacts observed with long-term use of a yard debris compost and fish solubles fertilizer as nutrient courses in organic blueberry. After eleven years of research on the impact of organic fertilizer source and mulch type on soil and plant tissue nutrients and plant performance, we learned that applications of high K through addition of yard-debris compost or via fertigation with fish solubles led to higher leaf and soil K and lower leaf Mg and Ca; these nutrient changes were correlated with lower yield in 'Duke'. Most organic growers in the Pacific Northwest rely heavily on fish solubles as a fertilizer source and many use composts (plant or animal based) as part of their nutrient management program. We thus expect that similar problems are occurring in many organic fields – unrealized yield through imbalances in soil and plant nutrient status from of high applications of K through compost and fertilizer programs. We are assessing the impact of changing fertilizer source and mulch type on improving soil and plant nutrient status to address these issues. The use of compost was ceased after the 2016 growing season, and the N-fertilizer source was changed from fish to a vegan product that can be fertigated (liquid BioLink 5.5–0–0 in 2017, water soluble BioLink 14–0–0 in 2018-20; Westbridge Agricultural Products). We planned to add Ca and Mg through use of other sources like feather meal, soybean meal, and gypsum but these were not necessary during the study. In addition, previous mulches (sawdust, sawdust with a layer of yard-debris compost underneath, or black weed mat), were either covered (sawdust and sawdust + compost) or replaced (weed mat) with new weed mat. Changes in yield and soil and plant nutrient status were measured. Since 2016, yield has generally increased except in 2017 when bird pressure was high and pollination was poor, as evidenced by reduced fruit and seed set. In both raised and flat beds, yield has increased the most in plots that previously had sawdust mulch and the least in plots that previously had weed mat. In flat beds, plots previously fertilized with the high rate of fish fertilizer continue to have lower yield than those fertilized with low rates of feather meal despite a 7–20% reduction of soil K. The addition of sulfur in spring 2019 mitigated what had been an increase in soil pH since 2016; pH dropped by around 10% by the fall of 2019 (soil samples for fall 2020 are

forthcoming). Soil organic matter continues to be influenced by previous mulches (highest in the plots that previously had sawdust + compost and lowest in plots with weed mat alone). Leaf N (%) has been consistently higher since 2016 while leaf K, Ca, Mg, and B have decreased across most treatments in all years. Correlation analysis (nutrient levels and yield) and analysis of changes in nutrient status will be evaluated for 200 treatment plots after the remaining data is collected for 2020.

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

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

This study is being conducted at the NWREC in a 0.25-acre conventional planting of 'Mini Blues' established in Oct. 2015. Treatments are designed to develop best management practices for machine harvest using pruning techniques started in the winter of 2017-18 (after the second growing season): 1) a conventional pruning method including bottom and top cuts to the bush; 2) unpruned for several years [pruned hard every few years]; 3) hedging immediately after fruit harvest in summer; and 4) hand "speed" pruning in winter making only big cuts to base of bush. In winter 2019-20, dormant pruning required 171 hours/acre for conventional pruning, while speed pruning took only 34 hours/acre, and the hedge and no pruning treatments required an average of 13 hours/acre to clean up low growing branches. Mechanical hedging was not done after harvest in 2019 or 2020 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. 2020 was the third season in which fruit were machine harvested. Yield in the hedged plants recovered to a similar level as other treatments after a year of recovery. While in 2019 speed pruned plants had higher overall yield than hedged plants, in 2020 there were no significant differences in harvested yield or total plant yield (including dropped fruit and fruit remaining on the plant after harvest) among treatments. However, we did have increased bird pressure in 2020 resulting in greater variability and lower overall yield in all treatments except hedged than in the previous year. Unpruned plants had the most fruit remaining on the plant (606 g, or 23% of total yield) compared to speed and control treatments (averaging 272 g, or 9% of total yield). Control plants had a much higher percentage of fruit harvested on the first harvest (82%) compared to all other treatments (averaged 58%). Berry weight has also greater (0.7g/berry) compared to hedged and unpruned plants (0.6g) while speed pruned plants were intermediate (0.64 g). Brix (average 16.2%) was not affected by pruning. Leaf and soil nutrient status are being monitored, and an economic cost-benefit analysis will be done when the study is complete.

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

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

This study is being conducted at the NWREC in a 0.25-acre conventional planting of 'Legacy' 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; 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 the prior winter (2018-19), pruning of the "V-trellis" plants required more time due to the additional work of tucking canes between the wires (196 hr/acre) compared to "control" (144 hr/acre) and "HB" (131 hrs/acre), while in the 2019-20 winter season, there was no significant difference between pruning methods, though the control and V trellis averaged approximately 30 hr/acre more than HB pruning. There was no difference in the amount of pruning wood removed in the 2019-20 dormant season (1.1 kg/plant for control and V; 1.4 kg/plant for HB). In 2020, the first two harvests were by hand and the third harvest was done by machine. Due to heavy bird pressure, we had lower than expected yield. However, 2020 was the first harvest year in which yield was affected by pruning. Plants with the standard 'Legacy' pruning on a V-trellis produced 9.5 tons/acre while HB pruning yielded 8.1 tons/acre (control yield was 9.2 tons/acre). HB pruning resulted in slightly faster ripening, with 56% of fruit harvested on the first pick compared to 50% in the V-trellis, but no differences were found in subsequent harvests. To date, pruning has not affected berry weight (2.2 g), Brix (14.7%), or percentage of fruit dropped on the ground during hand harvest (7-8% in 2018-2020). A greater fruit weight was dropped during machine harvest with the V-trellis in 2020, but the percentage of total yield dropped was not different from other treatments (averaged 18%). All pruning treatments required the same amount of time to harvest per kg of fruit.

*Individual and Combined Use of Sawdust and Weed Mat Mulch in a New Planting of Northern Highbush Blueberry I. Impacts on Plant Growth and Soil and Canopy Temperature (**Published**)*

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

A 2-year trial was established in Oct. 2016 in western Oregon to evaluate the effects of various in-row mulch treatments on 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. Soil temperature was unaffected by the color of the weed mat but was often higher during the day in beds with weed mat mulch than in those with sawdust alone or sawdust covered with weed mat. Black or green weed mat also resulted in higher canopy temperatures, particularly when sawdust was underneath the weed mat. For the most part, plant growth was

unaffected by the color of the weed mat, and the maximum depth of root system was similar among the mulch treatments. However, plants grown with sawdust mulch, with or without weed mat, had greater canopy width and volume in year 2, a wider root system in both years, and more dry weight (DW) in the crown in year 1 and in the whips in year 2 than those with weed mat alone. Furthermore, plants with weed mat over sawdust were taller in year 1 and had greater canopy cover and more DW in new wood in year 2 than those with sawdust alone, and they had a larger canopy, more root development, and greater DW in the crown, new and old wood, fruit, and pruning wood in one or both years than those with weed mat alone. Over the 2 years of the study, net gain in total plant DW was lowest when the plants were grown with black weed mat and highest when they were grown with black weed mat over sawdust. While it was more expensive initially, the use of weed mat over sawdust resulted in more plant growth than weed mat alone due to the insulating properties of the sawdust and was more effective for weed control than using sawdust alone.

*Individual and Combined Use of Sawdust and Weed Mat Mulch in a New Planting of Northern Highbush Blueberry II. Nutrient Uptake and Allocation (**in press; HortScience**)*

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

A 2-year trial was established in Oct. 2016 in western Oregon to evaluate the effects of various in-row mulch treatments on 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. For the most part, plant nutrient concentration and content were unaffected by the color of the weed mat. In both years, mulching with weed mat over sawdust reduced soil NO_3-N as compared to weed mat alone. The only other soil nutrient affected by mulch was K, which was highest with sawdust mulch and intermediate with black weed mat alone in year 2. There were inconsistent effects of mulch on leaf nutrient concentration during the study. In 2018, leaf N concentration was lowest with black weed mat over sawdust. There were few mulch effects on nutrient concentrations in senescent leaves in both years and in harvested fruit in year 2. Mulch had more effect on nutrient concentration in dormant plant parts after the second growing season than after the first, with the addition of sawdust under weed mat leading to significant differences for many nutrients in various plant parts as compared to weed mat alone. Total uptake of N ranged from 12 $kg \cdot ha^{-1}$ (black weed mat) to 17 $kg \cdot ha^{-1}$ (black weed mat over sawdust) in year 1 and averaged 33 $kg \cdot ha^{-1}$ in year 2, with no effect of mulch. Fertilizer use efficiency for N was 8% to 12% in year 1 and 42% in year 2. Uptake of other nutrients was unaffected by mulch and, depending on the year, ranged from 1.3–4.3 $kg \cdot ha^{-1}$ P, 4.0–8.0 $kg \cdot ha^{-1}$ K, 2.1–4.9 $kg \cdot ha^{-1}$ Ca, and 1.0–1.5 $kg \cdot ha^{-1}$ Mg. Each of these other nutrients were derived from the soil or decomposing roots.

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

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 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. In 2018, yield was higher in black+sawdust compared to black, while there were no differences in yield for 2019, 2020, or cumulatively. Berry weight and berry diameter were greater in 2018 and 2020 compared to 2019 while total soluble solids (TSS) and firmness were highest in 2018 compared to other years. Across all three years, black+sawdust had larger fruit (18.5 mm diameter) than black (18.1 mm) while black and sawdust alone had higher TSS (averaged 13.9%) than black+sawdust and green+sawdust (averaged 13.2%). Fruit were ripe earlier with sawdust mulch in 2018 while timing of harvest was not affected by mulch in 2019 or 2020. Berry weight and firmness were not affected by mulch treatment in any year.

Management Techniques to Optimize Soil pH and Nutrient Availability in Organic Highbush Blueberry Grown East of the Cascade Range (study in progress, year 1 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

Organic blueberry production in Oregon and Washington is predominately located in the semi-arid region east of the Cascade Range. While the size of the industry has increased, research support has not. Consequently, many of the horticultural issues that have emerged remain unresolved, specifically regarding nutrient management. Growers report that managing soil pH and organic matter are their foremost concerns that limit production and long-term viability. Blueberry requires very specific pH and organic matter conditions. There are limited research-based recommendations to advise growers on how to best modify soil pH and provide organic matter. The goal of this project is to develop optimized nutrient strategies to facilitate industry expansion and environmental stewardship. Specifically, we are evaluating modified practices including (obj. 1) the novel use of pelleted sulfur as a slow release method, (obj. 2) acidified grape pomace, and (obj. 3) alternative biochar feedstocks produced at reduced temperatures for lower pH. These objectives are intended to relieve industry bottlenecks to improve pH and organic matter in organic blueberry. Research will be complimented with (obj. 4) a complete cost-benefit analysis to determine the economic impacts and viability of investigated practices. We will develop (obj. 5) rigorous educational programs related to planting establishment and nutrient management, including dissemination of project information and evaluation of impact. This project will provide producers in this region and throughout the U.S. with valuable applied outcomes to optimize production.

Blackberry/Raspberry

*Alignment between University Nutrient Guidelines and Grower Practices for Blackberry and Red and Black Raspberry in Oregon (**in press; J. Amer. Pom. Soc.**)*

Jones, P.A., A.J. Davis, and B.C. Strik. Sr. Faculty Research Assistant I, Sr. Faculty Research Assistant I, and Professor, Oregon State University

Information was gathered from 13 caneberry (blackberry and red and black raspberry; *Rubus* spp.) growers in Oregon's Willamette Valley in 2018 to learn which nutrient management tools growers were using and to determine relationships between plant (leaf and fruit) and soil nutrient status and planting performance for various cultivars. The floricane-fruiting caneberry cultivars studied were 'Meeker' red raspberry, 'Munger' black raspberry; 'Black Diamond', 'Columbia Star', 'Marion', and 'Obsidian' trailing blackberry; and 'Triple Crown' semi-erect blackberry. Our goal was to understand key challenges and questions that remain after many years of nutrient management research and extension outreach. Considerable variation in fertilization practices among grower sites was found. Several growers were applying fertilizer within the recommended rates and had good plant growth and yield, but many sites in this study included fields that were not performing to their full potential. Key problems identified that may have reduced plant performance and yield included soil pH lower than the recommended range of 5.6–6.5, likely reducing nutrient availability; in the study, 28% had a soil pH below 5.6 and some had a pH as low as 4.6. Soil levels of P, K, and Mg were generally high across grower sites indicating no fertilizer was needed, yet many growers fertilized with P and K regardless. Many growers applied excessive rates of N fertilizer from sources that would exacerbate low pH, and timed applications improperly based upon existing extension recommendations. Site or grower management impacted the concentration of almost all leaf nutrients within cultivars, with deficient levels for N, P, K, and Ca at many sites. Site had a significant impact on the concentration of many fruit nutrients. Fruit %P, K, Ca, Mg, and S were positively correlated with their respective leaf concentrations. Percent moisture content of fruit ranged from 72–86% and was affected by grower management for 'Black Diamond', 'Munger', 'Obsidian', and 'Triple Crown'. Despite adequate to high N fertilizer rates being applied, leaf %N was low or just sufficient, supporting the hypothesis that management practices were limiting fertilizer uptake. Some growers applied granular product while drip irrigating, likely reducing availability of nutrients during periods of demand. Insufficient irrigation at key times of the season or stages of plant development may have limited plant uptake of N and K. While current recommendations are to collect soil samples every few years and leaf tissue samples annually to assess nutrient management programs, many growers were not doing so. Growers most frequently relied on fertilizer company field representatives regarding best nutrient management practices rather than using free extension resources for sampling and fertilization methods. Improved outreach to company representatives and revising nutrient management publications to incorporate new research-based information will be key in helping the industry better monitor soil and leaf nutrient status and manage fertilizer requirements in their caneberry crops.

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

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

A new 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. un-pruned or "new-over-old") treatments on growth, yield, fruit quality, machine-harvest efficiency, and labor requirements. Primocanes were trained as they grew in 2020. First machine harvest and pruning and training treatments will begin in 2021.

Strawberry

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

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

A two-year study (2019-2020) is being 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). The field was fertilized with 68 lbs of N pre-planting and then fertigated through the drip irrigation every 1.5 weeks for a total of 130 lbs N applied for the season. Plants are being managed using certified organic production practices. Yield, leaf tissue and soil nutrient concentration, leaf, crown and runner biomass are being collected. Preliminary 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; $P<0.001$). The 2020 season is ongoing, and data collection and analysis continue.

Strawberry transplant production for early and late production in Oregon: effects of container size on cost, ease of planting and plant development (study in progress)

Javier Fernandez-Salvador, Erica Chernoh, Tessa Barker (graduate student) and Steve Tao (undergraduate student), Oregon State University.

The objective of this study is to determine the optimal size of transplant container for ease of planting and reduced production costs, without affecting plant development for applications in field and in substrate day neutral strawberry production systems. This two year (2018-2019) study was conducted at the OSU North Willamette Research and

Extension Center. Two cultivars, ‘Albion’ and ‘Seascape’ were grown in organically approved planting media (tree bark byproducts, peat-moss, pumice and feather meal fertilizer) in two container sizes (234 cm^3 and 614 cm^3). Bare-root strawberry plants were potted into containers in early March and kept in an unheated greenhouse. Plant growth and development was measured every week including leaf area, crown number and width, as well as mortality, and before field planting root and complete plant biomass were determined in a subsample of the treatments. In the spring of 2019, the plugs were planted into the field, along with bare-root plants (control) for comparison, in a split plot design with six replicates. Plant biomass, crown diameter, and yield (marketable, cull and total yield) data were collected from the field experiment over the course of 16 weeks. In 2018, ‘Seascape” and large container sized plants produced the highest marketable and total yields compared to ‘Albion’ and small container plants. In 2019, ‘Seascape’ once again produced higher yields compared to ‘Albion’, however, the bare-root plants produced the greatest marketable and total yields compared to large and small container plants.

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

Javier Fernandez-Salvador, Erica Chernoh, Avery Pheil Oregon State University.

This project will expand 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 is to conduct a preliminary study on bench substrate technologies that may improve efficiencies and yields in Oregon strawberries. This preliminary study will explore the feasibility and equipment needs for two different system designs, evaluate different planting media combinations, determine best practices for fertilizer use, and determine overall equipment and labor costs for elevated substrate production of strawberries under greenhouse cover in Oregon.

Current state of the strawberry industry in Oregon and grower needs assessment survey (in progress)

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

A needs assessment survey was conducted to examine the current state and needs of the strawberry industry in Oregon. The objectives of this project are to guide future research, improve collaboration between extension, industry, and growers, in order to meet producer needs. The comprehensive study contains questions about farming practices (production, cultivars, irrigation, season extension, and pest management), grower needs and challenges, as well as services provided by extension, and grower interest in future

research. This project will provide valuable information to OSU Extension Service to guide future programing, in addition to establishing a means to connect with growers for collaboration and upcoming research, including a Strawberry Fertility and Nutrient survey by the Principal Investigator, Javier Fernandez-Salvador. The first stage of the survey has been completed and data is being analyzed. A follow-up study is being planned to present results and gather further information for the strawberry industry. Results from the survey show that *Botrytis cinerea*, slugs, voles and Spotted Wing Drosophila to be the most problematic pests for growers. Survey respondents reported labor cost and availability and pest management to be their greatest challenges; with pest management, cultivar development, and nutrient management to be the most pressing research needs. Due to COVID-19, the focus group meetings have been postponed to 2021.

The relationship between fertilization practices, soil and plant nutrient status and yield in strawberry cultivars (in progress)

Javier Fernandez-Salvador, Avery Pheil, Erica Chernoh. Oregon State University

A fertility survey is being conducted with strawberry growers in Oregon to better understand the impacts of the varying practices used on yield. This information will be gathered to better inform new research and extension programs on nutrient and fertilizer management in the state. The study goal is to help the strawberry industry increase the efficiency of fertilizer programs leading to benefits including minimizing input and costs while maximizing productivity thus increasing the economic viability of strawberry farmers. The objective of the research is to work with commercial growers of widely grown strawberry cultivars in Oregon to determine their current and previous year fertilizer management practices, collect yield data, and sample tissue (fruit and leaf nutrient concentration), and soil nutrients at each of these collaborator sites. This study will help us define the relationship between fertilizer application practices and yield, soil and plant nutrient status by cultivar. In 2019, 31 fields across 17 grower sites were sampled. Soil analyses showed that 29% of the fields sampled met the standards for strawberries for soil nutrients, pH and organic matter. Nearly two-thirds of fields with June-bearing cultivars had a high or low soil pH, almost half of the day-neutral fields had a high pH. Leaf tissue sampling indicated that nearly half of the sampled fields were above or below essential nutrients sufficiency ranges. Boron deficiency was most common, found in 25 of the 31 sampled fields. Results of the study show that Oregon specific nutrient management guidelines, particularly for day-neutral cultivars, could be improved.

Grapes

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

Patricia A. Skinkis*, 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, Amelia Doyle, Department of Horticulture, Oregon State University. *member of the Oregon Wine Research Institute at Oregon State University

Crop thinning is conducted in the majority of Pinot noir vineyards in Oregon, as it is thought to ensure premium quality fruit and hasten ripening in the cool climate regions of the state. The industry-wide yield target for Pinot noir has been 2 to 2.75 tons/acre. However, these targets are not scientifically-founded yet are universally applied across Oregon vineyards, regardless of vineyard productivity, vine density, or seasonal heat units. Furthermore, there are no vine balance metrics by which to evaluate the yield-quality relationship, and metrics defined by other crop level studies from different regions have not worked nor have elicited change in this strong-held belief that low yield equals high quality. To develop better yield management guidelines for industry, a long-term industry collaborative research project has been in progress since 2012. To date, 22 industry collaborators participated in the research. Each collaborator applied two or more crop levels by cluster thinning replicated plots within commercial Pinot noir vineyards during lag-phase of berry development. Vineyard data was collected by the collaborator (according to protocols designed by OSU), including 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 as well as various acids, fermentable nitrogen, anthocyanins, and phenolic compounds. Wines were produced by each participating winery using 1.5 tons of each crop level. Wines were evaluated by a winemaker sensory panel after 2 years of bottle-aging. Crop levels ranged from 0.4 to 1.5 kg/m in 2012 and 2013, 0.7 to 1.9 kg/m in 2014, 0.8 to 2.7 kg/m in 2015, 0.6 to 1.6 kg/m in 2016, 0.8 to 2.8 kg/m in 2017, 0.9 to 2.1 kg/m in 2018, and 0.7 to 1.87 kg/m in 2019. 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 eight 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 67-85% of sites, there were few consistent differences. In fact, there were some of the fewest differences by crop level in the highest yielding years (2015 and 2017). However, anthocyanin concentration increased by reduced yields in 20% of sites across the eight-year period. Sensory evaluation of 2012-2016 wines show that yield does not affect wine characteristics (mouthfeel, aroma, etc.). In-house sensory evaluations of trial wines by the wineries (blind tastings) show that winery staff can determine differences in the wines (difference testing) but quality rankings are not consistent and are not always linear (lowest yield was not always highest wine quality ranking). This project continued in 2020 despite the challenges of COVID-19, and as of this reporting

12 of 13 vineyards have submitted harvest data and samples. One additional growing seasons remains for this project in 2021. This long-term data set will be 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. Two other manuscripts are in progress for quantitative results for the first 5 years of the study.

Improving cool climate vineyard yield potential through pruning and nitrogen fertilization practices

Patricia A. Skinkis,* Department of Horticulture, Oregon State University, Corvallis, OR, Miranda Ulmer (graduate student), Department of Horticulture, Oregon State University, Corvallis, OR, and R. Paul Schreiner*, USDA-ARS Horticulture Crops Research Lab, Corvallis, OR, all of the Oregon Wine Research Institute at OSU. *member of the Oregon Wine Research Institute at OSU

Pinot noir is a low yielding variety compared to other *Vitis vinifera* wine grape varieties, and prior cultivar trials show that Oregon yields are lower than California for the same Pinot noir clones. Yield consistency is a concern for growers, and we believe that vineyard practices, including dormant pruning and nitrogen (N) management, could alter vineyard yield potential. The majority of Oregon producer use cane pruning, but they are interested in spur pruning because it can be partially mechanized. Prior research in the Skinkis lab shows that Pinot noir basal buds are fruitful and may result in sufficient yields with spur pruning, but it had not been tested until this study. Nitrogen is integral to grapevine growth, floral development and yield. Vegetative vigor and fruitfulness have been shown to be limited by low vine N status. It is common for vineyard managers to avoid N fertilization to prevent vigorous canopies. However, low yields and low berry N may limit quality production. In order to understand the effect of dormant pruning methods and nitrogen fertilization in vineyard productivity, separate field experiments took place from 2017-2019. The pruning trial compared spur and cane pruned vines in a high density vineyard. The nitrogen trial compared N-fertigated vines (60 lb. N/acre in 3 split applications). For each trial, we measured fruitfulness of dormant buds, shoot fruitfulness in-season, fruit set, canopy growth, yield, and pruning weights. The pruning trial revealed that the basal buds are fruitful regardless of pruning method with similar number of inflorescences for the same nodes (1-5). The mean number of inflorescence primordia per bud and the sizes of the inflorescence primordia were similar in cane and spur pruned vines when considering all buds assessed. Furthermore, there was no difference in fruitfulness observed post-bud break. There was no difference in timing of bud break or phenological advancement during the season and no difference in canopy growth. Spur pruned vines had slightly more leaf area and pruning weights but both cane and spur had similar yield to pruning weight ratios. Spur pruned vines have slightly smaller clusters compared to cane pruned vines, but yields were not difference by harvest. The N project shows no differences in the bud fruitfulness or fruitfulness post-budbreak. There were differences in shoot growth but they were minimal, and the impact was not significant enough to cause dormant pruning weights to differ. The lack of vine response to N application suggest that either not enough N was applied to increase

fruitfulness and yield or that the vines had sufficient N resources that further applications did not illicit a physical growth response. Future work will be conducted to explore N application to increase yield uniformity in non-uniform vineyards. Both experiments show that bud fruitfulness is higher in canes that are more vigorous. This suggests that increasing vine vegetative growth and vigor is not detrimental to Pinot noir productivity. This project has been completed and one manuscript was published in June 2020 with another publication in progress.

Understanding symptomology and physiological effects of Red Blotch Disease in vineyards in Oregon's Willamette Valley

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Grapevine Red Blotch Disease has become a major concern for winegrape producers in Oregon and other areas of the US. The disease was identified as Grapevine Red Blotch Virus (GRBV) in 2012. The virus results in symptoms that may severely affect fruit and wine quality and lead to non-economic production. The lack of fruit ripening is a major concern for cool climate regions such as the Willamette Valley where heat units limit the growing season and Pinot noir and other cultivars grown in the region may struggle to reach optimum ripeness in a typical year. As we seek to provide management options for growers, we need information about how this virus may be affecting vine growth, development and fruit ripening. We designed a multi-year study to evaluate the impacts of Grapevine Red Blotch Virus on grapevines in two Pinot noir vineyards in the Willamette Valley. We monitored vine growth, photoassimilation, water status, vine nutrient status, and fruit composition of GRBV+ and GRBV- vines within the same block in two vineyards from 2017-2019. Results varied by vineyard, with one of the sites, Vineyard A, having limited impact on vine water status, leaf photoassimilation, nutrient status, or vine growth based on virus status. In addition, we found no differences in fruit ripeness (Brix, pH, and titratable acidity) or total phenolics, tannins or anthocyanins at Vineyard A. However, there were more differences found in Vineyard B, which had greater intensity of visual symptoms in GRBV+ vines. There was lower photoassimilation and stomatal conductance in basal leaves of GRBV+ vines and vines showing symptoms for the latest sample near harvest. There were no differences in photoassimilation and stomatal conductance of any mid-upper canopy leaves on any of the three late season dates. Vineyard B originally was thought to have both virused and healthy vines, but after further testing revealed that there was 100% virus infected vines. From this vineyard we were able to determine that GRBV+ vines can be asymptomatic, and by the second year of the study, nearly all vines showed no symptoms due to management changes to remove vine stress. The graduate student on this project completed his MS degree program in June 2020. One manuscript is in progress.

Exploring vineyard management practices to mitigate effects of Red Blotch Disease in Oregon's Willamette Valley

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Grapevine red blotch disease (GRBD), a recently identified virus, has reported to reduce fruit and wine quality of wine grapes in the US. Some Oregon producers report reduced wine quality, as infected vines have led to wines that do not meet sensory acceptance during blending to be included in their luxury tier wines. As a result, we designed two management trials to evaluate the effect of vineyard management practices on a commercial GRBD infected vineyard reported to have suffered wine quality impacts. In separate experiments, we tested the impacts of early season leaf removal (pre-bloom and at fruit set) and the application of abscisic acid (ABA) during veraison, as both practices have been shown to impact fruit phenolic development in other vineyard studies. The trials were carried out during the 2018 and 2019 growing seasons. The leaf removal trial included a comparison of three leaf removal treatments, including 100% cluster zone leaf removal by hand just before bloom, leaf removal by machine to the eastern exposure of the canopy cluster zone by machine at fruit set, and leaf removal by machine at fruit set of the east and west sides of the cluster zone. The ABA trial included vines sprayed with Protone in the cluster zone (beginning of veraison and again 2 weeks later). The cluster zone leaf removal 2018 results shows that yields were not affected. However, cluster size was smaller for the early leaf removal treatment compared to the later mechanical leaf removal. However, there were no differences in clusters per vine or berries per cluster. There was not sun burning on the early leaf removal treatment despite full exposure of the clusters. There was no difference in Brix, pH, or TA at harvest in either year. There were no differences in anothcyanin, phenolics, or tannins as result of these treatments in either year, but the wine analysis that was conducted indicates more intense wine color in 2018. For the ABA trial, application to the clusters did not enhance ripening, as there was no differences in primary ripeness (total soluble solids, pH, titratable acidity) or phenolics (total anthocyanin, tannin, or phenolics) with the unsprayed control. The viticulture components of this study were completed in winter 2020, but fruit and wine analysis by colleagues in the Food Science and Technology Department at Oregon State University continues in 2020.

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. There is a need for producers

to understand how to manage vineyard soil water, whether through irrigation or vineyard floor management. During this three-year project, we are monitoring soil moisture and Pinot noir grapevine growth, water stress, and fruit development and composition across three soil types. This work is underway in a commercial vineyard comprised of three soil types that are common to Willamette Valley wine grape vineyards, including a sedimentary soil, volcanic soil, and marine sediment soil. The project began with soil moisture installation in January 2020 and soil moisture and temperature data were logged continuously since that time. Plant growth data, phenology, and fruit samples were collected in the 2020 growing season and await statistical analyses and laboratory analyses, respectively. Information will be useful to regional growers to understand soil moisture management and will lead to regional vine vineyard floor and vine balance guidelines based on soil and productivity potential.

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

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The Oregon wine grape industry has experienced warmer, drier summers over the past decade. The first grafted vineyards were planted to three vigor reducing rootstocks (101-14, 3309 and Riparia Gloire). However, with increasingly drier growing seasons in recent years, growers question the suitability of these rootstocks for the Willamette Valley, and there is great interest in understanding how rootstocks can be selected to help determine suitability for dry-farming and/or optimizing irrigation water in the region. Over three growing seasons, we are evaluating an established OSU rootstock trial (planted in 1997), with focus on Pinot noir growth response on 19 rootstocks and compared to own-rooted vines. We are monitoring phenological advancement, yield, basic fruit ripeness, yeast assimilable nitrogen (YAN), anthocyanins and phenolics of fruit. The project began with preliminary data collection in 2019 with the full set of data collection beginning in 2020 after successful funding from the Oregon industry. The project has been harvested just days before this reporting, and the data and fruit samples are pending analysis. 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.

Re-evaluating pressure chamber methods of water status determination in field-grown grapevine (Vitis spp.) **Completed**

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Despite the fact that the pressure chamber has been used as a tool to assess vine water status and assist in scheduling vineyard irrigation for more than 30 years, there remains some disagreement in sampling protocol with respect to midday leaf water potential (Ψ_{leaf}) and midday stem water potential (Ψ_{stem}) determination. Therefore, the primary goal

of this study was to test various sampling protocols associated with the measurement of these two variables. Specifically, experiments were conducted to test the effects of (1) re-cutting the petiole prior to placing the leaf in the chamber, (2) time span between sample excision and pressurization, (3) sample equilibration time on Ψ_{stem} values, and (4) the effect of operator. Results showed that there was no significant effect of re-cutting the petiole on Ψ_{leaf} values. Furthermore, up to 30 seconds of time span between sample excision and pressurization was acceptable for accurate Ψ_{leaf} determinations, as long as the sample was kept shaded during that time. Finally, only 10 minutes of equilibration time was necessary for accurate Ψ_{stem} determination. In most cases, the effect of operator on all Ψ determinations was greater than any of the sample preparation methods tested. This reinforces the need to properly train vineyard technicians in using the pressure chamber. However, improved flexibility in sampling protocol for either Ψ_{leaf} or Ψ_{stem} determinations may improve efficiency of vine water status monitoring in vineyards, thus reducing labor costs associated with pressure chamber-based irrigation scheduling.

Data driven models for canopy temperature- based irrigation scheduling **Completed**

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Normalized crop canopy temperature, termed crop water stress index (CWSI), was proposed over 40 years ago as an irrigation management tool but has experienced limited adoption in production agriculture. Development of generalized crop-specific upper and lower reference temperature is critical for implementation of CWSI-based irrigation scheduling. The objective of this study was to develop and evaluate data driven models for predicting reference canopy temperatures needed to compute CWSI for sugarbeet and wine grape. Reference canopy temperatures for sugarbeet and wine grape were predicted using machine learning and regression models developed from measured canopy temperatures of sugarbeet, grown in Idaho and Wyoming, and wine grape, grown in Idaho and Oregon, over 5 years under full and severe deficit irrigation. Lower reference temperatures (T_{LL}) were estimated using neural network models with Nash-Sutcliffe model efficiencies exceeding 0.88 and root mean square error less than 1.1 °C. The relationship between T_{LL} minus ambient air temperature and vapor pressure deficit was represented by a linear model that maximized the regression coefficient rather than minimized the sum of squared error. The linear models were used to estimate upper reference temperatures that were nearly double values reported in previous studies. A daily CWSI, calculated as the average of 15-min CWSI values between 13:00 and 16:00 MDT for sugarbeet and 13:00 and 15:00 local time for wine grape, were well correlated with irrigation events and amounts. There was a significant ($p<0.001$) linear relationship

between the daily CWSI and midday leaf water potential of Malbec and Syrah wine grape with an R^2 of 0.53. The data driven models developed in this study to estimate reference temperatures enable automated calculation of the CWSI for effective assessment of crop water stress. However, measurements taken under conditions of wet canopy or low solar radiation should be disregarded as they can result in irrational values of the CWSI.

Water deficits do not improve fruit quality in Grapevine Red Blotch Virus-infected grapevines (Vitis vinifera L.) **Completed**

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Although deficit irrigation is used to improve fruit quality in healthy grapevines, it can potentially amplify negative effects of viral disease and reduce fruit quality in Grapevine Red Blotch Virus (GRBV) infected grapevines. Therefore, a two-year field experiment was conducted to understand the interaction between GRBV infection and water deficits on disease development and vine physiology. Well-watered (WW) vines were irrigated at 100% of estimated crop evapotranspiration (ET_c), while water deficit (WD) vines received water at 66 and 50% ET_c in 2017 and 2018, respectively. Healthy (GRBV-) and infected (GRBV+) vines were confirmed by PCR assays. There were no significant effects of water deficits on foliar symptom onset in either year, but more severe water deficits in 2018 resulted in a more rapid symptom progression. GRBV+ vines had a higher Ψ_{stem} compared to GRBV-vines, but the effects of virus only appeared post-veraison and corresponded to decreased leaf gas exchange. In general, vine vegetative and reproductive growth were not reduced in GRBV+ vines. Yields were highest in WW/GRBV+ vines due to larger clusters containing larger berries. Consistent treatment effects on berry primary chemistry were limited to sugars, with no interactions between factors. Water deficits were able to somewhat increase berry anthocyanin concentration in GRBV+ fruit, but the effects were dependent on year. By comparison, virus status and water deficits interacted on skin tannins concentration such that they were decreased in WD/GRBV+ vines, but increased in WD/GRBV- vines. Water deficits had no effect on seed phenolics, with only virus status having a significant diminution. Although keeping GRBV+ vines well-watered may mitigate some of the negative effects of GRBD, these results suggest that water deficits will not improve overall fruit quality in GRBV+ vines. Ultimately, the control of fruit ripening imparted by GRBV infection seems to be stronger than abiotic control imparted by water deficits.

Efficacy of cultural practices for mitigating negative effects of Grapevine Red Blotch Disease in Oregon Pinot noir **In progress**

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Grapevine Red Blotch Disease (GRBD) has been reported to impact vine physiology and fruit quality in *Vitis vinifera* L. by reducing photosynthetic rate, total soluble solids (TSS), and berry anthocyanin concentration. Currently, growers have few management strategies beyond removal of infected vines, which is particularly costly in young vineyards with high disease incidence. Two studies were established in 2018 and 2019 in commercial Pinot noir vineyards in Southern Oregon. Study A comprises a field survey to further characterize the impact and chronology of GRBD symptoms. Study B is a field trial which investigates the potential of cultural practices (irrigation, fertilization, crop load management) to mitigate the negative effects of the disease on vine physiology and fruit quality. Doubled rates (supplemental) of irrigation and fertilizer were compared against a grower control while crop load management compared thinning (one cluster per shoot) against no thinning. In Study A, GRBD reduced the rate of photosynthesis and stomatal conductance while increasing stem water potential and the leaf concentration of nonstructural carbohydrates. TSS, anthocyanins, and seed phenolics were significantly lower in mature fruit from infected vines. Study A largely confirms the impacts of GRBD reported in other studies but advances the understanding of the chronology of symptoms which may begin with an increase in leaf sugar concentration. The increase in leaf sugar appears to subsequently downregulate photosynthesis and thus induce foliar reddening, close stomates, and raise stem water potential. In Study B, supplemental irrigation significantly reduced disease severity (red leaves per vine) over two years, while supplemental fertilization had no significant effect and, in the second year (2019), thinning significantly increased severity. Supplemental irrigation and crop thinning significantly impacted vine physiology and fruit composition in 2019, but fertilization had no significant effect over two years. Photosynthetic rate, berry weight, and TSS were increased by supplemental irrigation. Supplemental irrigation did not have consistently significant effects on secondary metabolites, but most often reduced anthocyanins and skin phenolics and increased seed phenolics. Crop thinning significantly increased berry weight, pH, and some secondary metabolite concentrations in berry skin. Irrespective of applied water amounts, maintaining a high vine water status was shown to be useful for directly counteracting many of the symptoms observed in Study A. Ultimately, these results suggest that routine viticultural practices such as irrigation and crop thinning have the potential to mitigate the negative effects of GRBD on vine physiology and fruit composition.

Response of fruit growth and composition of Vitis vinifera L. cv. Pinot noir to pre-and postveraison water deficits in a warm climate **In progress**

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Deficit irrigation is used in wine grape production to achieve fruit quality goals like advancing ripening and increasing concentrations of phenolic compounds. The response of *Vitis vinifera* cv. Pinot noir to deficit irrigation is not well documented in the literature and is critical for warm, dry regions as well as cool winegrowing regions with warming climates. The objective of this study was to observe vine and fruit responses to early and late season water deficits and identify water status targets to guide irrigation scheduling. Irrigation treatments consisted of combinations of pre- and postveraison irrigation levels as fractions (100, 75, 50 and 25%) of estimated crop evapotranspiration (ET_c). Vine water status exhibited a strong positive relationship with applied irrigation in both years of the study, with more variation between years preveraison. Preveraison water deficits decreased berry mass and slightly reduced fruit yield. Total soluble solid (TSS) concentrations did not respond consistently to pre- or postveraison water status, though there is some evidence of a positive relationship between preveraison water status and TSS at harvest. Concentrations of phenolics (anthocyanins, tannins, iron-reactive-phenolics) exhibited a negative relationship with preveraison vine water status; the response was stronger in skin-associated phenolics, suggesting that the effect is linked to berry size. Postveraison water deficits also impacted phenolics, but the relationship was nonlinear and phenolics peaked at moderate water deficits (e.g. 75 and 50% of ET_c). TSS, berry mass, and yield were not sensitive to postveraison water deficits. Preveraison water deficits increased phenolics linearly, but the effects are unknown beyond stem water potentials of -1.4 MPa, below which was not observed in this study. Preveraison, ET_c-based irrigation requires frequent monitoring of vine water status due to the increased variability in response to irrigation. Postveraison water status values in the range of -0.9 to -0.5 MPa optimized phenolics concentrations, though this study did not observe the effect of postveraison water deficits below -1.3 MPa. Overall, postveraison water deficits appear to offer fewer benefits relative to preveraison deficits, but also pose fewer consequences and can be more consistently imposed with ET_c-based irrigation. Ultimately, preveraison water deficits may improve fruit quality, especially in production systems where yield is manipulated and attaining target TSS is not of concern.

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Impact (Objective 2):

Blueberries

(Strik et al.) In organic blueberries, the common use of fertilizer sources with high K has increased leaf and soil nutrient levels reducing yield (published papers). The goal of our continuing research is 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 K have been relatively rapid and positive for plant health. Yield has increased across all treatments in 3 of the 4 growing seasons since switching fertilizer and mulch systems.

(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 are in the process of developing a reduced labor production system for 'Mini Blues' blueberry. Leaving 'Mini Blues' unpruned for 3 years has not resulted in lower yield or any loss in fruit quality. Berries from unpruned plants have been slightly smaller but not to the extent that it would be detrimental for this already small-fruited cultivar; over time we expect they will continue to reduce in size indicating the plants need renovating. Considering this technique required 90% less time than the standard method to prune, a huge cost savings for growers, we feel this could be a successful production practice. Work is on-going.

(Strik et al.) After 3 years of implementing different pruning and trellising techniques, yield in 'Legacy' was improved in 2020 using the revised pruning technique recommended by Dr. Strik compared to typical northern highbush style pruning. Fruit quality has not been impacted, and we expect to continue to see differences in yield as work continues for one more year.

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.

(Skinkis; yield potential through pruning and fertilization) Spur pruning is possible without causing loss in yield, fruit ripening, or fruit composition at harvest. This will allow growers to

consider using spur pruning and apply partial mechanization in vineyards to reduce labor costs during pruning. Selecting larger canes at pruning can also allow for greater vine fruitfulness and yield potential. Further work is needed to understand N fertilization practices to enhance yield uniformity in vineyards. This was part of a MS thesis for the graduate student on the project. The research has been published in one peer refereed journal article as of June 2020.

(Skinkis; red blotch) The multi-year and multi-site data suggest that certain vineyards are not impacted greatly by the virus (growth or fruit composition), and vines respond differently by season, possibly due to soil type, vineyard health, and seasonal climatic conditions. It is possible that growers can maintain vineyard blocks rather than removing them merely based on virus infection status. This was part of a MS thesis for the graduate student on the project; the student successfully completed his degree in June 2020.

(Levin et al.; Red Blotch) The first published work documenting effects of Grapevine Red Blotch Disease (GRBD) in Oregon simultaneously confirms, but also extends much of the initial work conducted in California. Many of the previously reported symptoms of GRBD on fruit quality (e.g. reduced berry total soluble solids and anthocyanin concentration) were shown to hold true in a new region (Southern Oregon) and with a different cultivar (Pinot noir) – underscoring the seriousness of the disease. However, our study documented – for the first time – the complex interactions between abiotic stress (i.e. water deficits) and biotic stress (i.e. viral infection). For most factors, these two stressors impacted grapevine physiology independently – in other words did not interact – but for several important berry secondary metabolites imposition of water deficits in the context of GRBD further reduced fruit quality. Supplementary work (that is still in progress) is examining cultural practices that are aimed at reducing plant stress. Early results from this work have been presented at several conferences and grower meetings, and to a large degree, confirm that reduction of abiotic stress can improve – or at the very least mitigate – some of the negative symptoms associated with GRBD. Producers now have a better understanding of GRBD effects on grapevine physiology, and how to manage vineyards in lieu of costly replanting.

(Levin et al.; Water deficits/irrigation management) Significant efforts have been made to validate decades of vineyard irrigation management research conducted in California to the rapidly expanding Southern Oregon grape growing area. Research studies have been conducted to 1) confirm/validate existing technologies used for plant water stress monitoring and irrigation scheduling; 2) develop new, more automated technologies for plant water stress monitoring and irrigation scheduling; and 3) understand responses of Pinot noir cultivar to water deficits. In addition to applied research work, substantial outreach has been ongoing to educate producers on proper irrigation management. Thus far, early results from research have streamlined existing monitoring technologies, and validated existing models regarding new technologies, ultimately reducing associated production costs. Existing regional irrigation scheduling service networks (e.g. AgriMet) have also been shown to greatly overestimate vineyard water requirements, and though this work is ongoing, results indicate that growers could reduce water use by up to 50% with little no drop in productivity. Finally, outreach efforts have resulted in increased sales of plant water stress monitoring equipment, suggesting that wine grape growers are taking a more active role in irrigation management, a practice that will likely lead to continued reduction in vineyard water use.

Papers (published since September 2019) – Objective 2

Refereed papers:

Finn, C.E., **B.C. Strik**, B.M. Yorgey, M.E. Peterson, P.A. Jones, J. Lee, N. Bassil, and R.R. Martin. 2020. 'Twilight' thornless semi-erect blackberry. HortScience 55:1148-1152.

Finn, C.E., **B.C. Strik**, B.M. Yorgey, M.E. Peterson, P.A. Jones[+], Gil Buller[+], J. Lee, N. Bassil, and R.R. Martin. 2020. 'Galaxy' thornless semi-erect blackberry. HortScience 55:967-971.

Finn, C.E., **B.C. Strik**, B.M. Yorgey, M.E. Peterson, P.A. Jones, Gil Buller, S. Serce, J. Lee, N. Bassil, and R.R. Martin. 2020. 'Eclipse' thornless semi-erect blackberry. HortScience 55:749-754.

King, B.A., K.C. Shellie, D.D. Tarkalson, **A.D. Levin**, V. Sharma, D.L. Bjorneberg. *In press*. Data Driven Models for Canopy Temperature Based Irrigation Scheduling. Applied Engineering in Agriculture.

Kingston, P.H., C.F. Scagel, D.R. Bryla, and **B.C. Strik**. 2020. Effect of perlite in peat- and coir-based media on vegetative growth and mineral nutrition of highbush blueberry. HortScience 55:658-663.

Levin, A.D., A.N. KC. 2020. Water deficits do not improve fruit quality in Grapevine Red Blotch Virus-infected grapevines. Frontiers in Plant Science 11:1292.

Levin, A.D., A. Deloire, G.A. Gambetta. 2020. Does water deficit negatively impact wine grape yield over the long term? International Viticulture and Enology Society: Technical Reviews.

Levin, A.D., M.A. Matthews, L.E. Williams. 2020. Effect of Preveraison Water Deficits on the Yield Components of 15 Winegrape Cultivars. American Journal of Enology and Viticulture 71(3):208-221.

Levin, A.D. 2020. Improvement of pressure chamber protocols - Response to Hochberg (2019). Agricultural Water Management 227.

Levin, A.D., L.E. Williams, M.A. Matthews. 2019. Continuum of stomatal responses to water deficits among 17 wine grape cultivars (*Vitis vinifera* L.). Functional Plant Biology 47(1):11-25.

Levin, A.D. 2019. Re-evaluating pressure chamber methods of water status determination in field-grown grapevine (*Vitis spp.*). Agricultural Water Management 221:422-429.

Sales, B.K., D.R. Bryla, K.M. Trippe, J.E. Weiland, C.F. Scagel, and **B.C. Strik**. 2020. Amending sandy soil with wood biochar promotes plant growth and root colonization by mycorrhizal fungi in highbush blueberry. HortScience 55:353-361.

Strik, B.C., A.J. Davis, and D.R. Bryla. 2020. Individual and combined use of sawdust and weed mat mulch in a new planting of northern highbush blueberry I. Impacts on plant growth and soil and canopy temperature. HortScience 55:1280-1287.

Strik, B.C., A.J. Davis, and D.R. Bryla. 2020. Individual and combined use of sawdust and weed mat mulch in a new planting of northern highbush blueberry II. Nutrient uptake and allocation. HortScience 55:1614-1621.

Strik, B.C., A.J. Vance, D.R. Bryla, and D.M. Sullivan. 2019. Organic production systems in northern highbush blueberry: II. Impact of planting method, cultivar, fertilizer, and mulch on leaf and soil nutrient concentrations and relationships with yield from planting through maturity. HortScience 54:1777-1794. ***Outstanding Fruit Publication Award, Amer. Soc. Hort. Sci.***

Ulmer, M.R. and **P.A. Skinkis**. 2020. Cane- and spur-pruned Pinot noir results in similar fruitfulness, yield, and grape ripeness under cool climate conditions. Am. J Enol. Vitic. 4(1):10.

Yang, F-H, D.R. Bryla, S.T. Orr, **B.C. Strik**, and Y. Zhao. 2020. Thermal cooling with over-canopy irrigation systems reduces heat damage and improves fruit quality in northern highbush blueberry. HortScience 55:1365-1371.

Yang, F-H, D.R. Bryla, and **B.C. Strik**. 2019. Critical temperatures and heating times for fruit damage in northern highbush blueberry. HortScience 54:2231-2239.

Yang, F-H, L. DeVetter, **B.C. Strik**, and D.R. Bryla. 2020. Stomatal functioning and its influence on fruit calcium in northern highbush blueberry. HortScience 55:96-102.

Extension publications :

Lukas, S. B., Clark, L., **Davis, A. J.**, Sanchez, D. M., & Brewer, L. J. (2020). Nonlethal bird deterrent strategies in fruit crop production. EM 9286. OSU Extension. https://catalog.extension.oregonstate.edu/em9286

Skinkis, P., J. Pscheidt, A KC, M. Moretti, V. Walton, and C. Kaiser. 2020. 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. 2020. "Grape Pests" In Pacific Northwest Insect Pest Management Handbook. Pacific Northwest Extension Publishing.

Strik, B, E. Dixon, A.J. Detweiler, and N. Sanchez. 2020. Growing Blackberries in Your Home Garden: Willamette Valley – Southern Oregon – Central Oregon – Eastern Oregon. EC 1303. September 2020

Strik, B, E. Dixon, A.J. Detweiler, and N. Sanchez. 2020. Growing Raspberries in Your Home Garden: Willamette Valley – Southern Oregon – Central Oregon – Eastern Oregon. EC 1306. August 2020

Strik, B, E. Dixon, A.J. Detweiler, E. Chernoh, and N. Sanchez. 2020. Growing Strawberries in Your Home Garden: Willamette Valley – Southern Oregon – Central Oregon – Eastern Oregon. EC 1307. July 2020

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**. (offered twice per year, non-credit).

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 2020** (https://extension.oregonstate.edu/events/principles-vineyard-management) 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