

Project/Activity Number: NCCC-212

Project/Activity Title: Small Fruit and Viticulture Research

Period Covered: Oct. 1, 2019 – Sept. 30, 2020

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Annual Meeting Date(s): Oct 26-27, 2020

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Agenda of the 2020 NCCC 212 Meeting:

Tuesday, Oct 27, 2020

- 11:00 AM – 2:30 PM EDT (10-1:30 Central; 9-12:30 Mountain; 8-11:30 Pacific): State Reports Session 1
- 3:00 PM – 5:00 PM EDT (2-4 Central; 1-3 Mountain; 12-2 Pacific): NCCC-212 Business Meeting
- 7:00 PM – 8:30 PM EDT (6-7:30 Central; 5-6:30 Mountain; 4-5:30 Pacific): NCCC-212 Social Hour

Wednesday, Oct 28, 2020

- 11:00 AM – 1:00 PM EDT (10-12 Central; 9-11 Mountain; 8-10 Pacific): Small Fruits Crops Germplasm Committee (Chair: Kim Lewers, USDA)
- 1:00 PM – 3:00 PM EDT (12-2 Central; 11-1 Mountain; 10-12 Pacific): State Reports Session 2
- 5:00 PM – 6:20 PM EDT (4-5:20 Central, 3-4:20 Mountain; 2-3:20 Pacific): NCCC 212 Student and Post-Doc Mixer.

All state reports, minutes and full agenda: <https://smallfruits.cals.ncsu.edu/nccc-212-2020/>

Brief summary of minutes of the annual meeting:

SCRI (Tom Bewick)

Matching Funds are most likely required for the 2021 submissions. The House already passed the bill, and there may be language to be able to waive the fee. This has been discussed with Congress but has not yet been implemented. For now, it is required. SCRI funding amount has not changed. Tom Bewick is responsible for four programs at the moment and staffing issues of the USDA in Kansas lead to delays.

In memoriam of Dr. Chad Finn

Before the state reports were shared, we dedicated a few minutes in memoriam for Chad Finn, during which Gina Fernandez shared about the Chad Finn Ambassador Award that is in the works with American Pomological Society. Chad Finn has passed away due to an accident last year. At the end of the state reports on the second day, memories and a picture of Chad in his office were shared with the group by Jungmin Lee. Thank you Jungmin.

State Reports:

- North Carolina: No Discussion
- Alabama: No Discussion
- Arkansas: **Is the new Primocane plant the same as selection 268?** Yes it is
- **Can you talk more about your project and your objectives:** We think they can be more than just patio plants, we would like to see applications as indoor plants, etc. **How short in stature are they?** I would call them semi dwarfs more than dwarfs. We're still learning the best ways to manage these plants and make them the best they can be **If we**

want to learn more about the High Tunnel Project, who should we contact? Amanda McWhirt

- British Columbia: No Discussion
- Florida: **What's the chilling on the white strawberry?** They essentially have no chilling. That said the plant is pretty adaptable. **What is the consumer appeal of this?** I didn't think anyone was gonna be interested in this, I just thought it would be cool to try getting the white color in Florida. While there are some people who prefer the red strawberries, there are some people who prefer the white. I think this will be more of a specialty item for holidays such as valentines and the fourth of July. It's a totally distinct problem and I think that's what makes it interesting and distinct from red strawberries. **Do you have any info on the nutritional value compared to others?** We haven't done any research on this part but we do plan on looking into allergies.
- Iowa: **Fruit Faculty Position** in extension will be hopefully posted again in 2021. **What is this warning system that you have for the anthracnose?** We do this in collaboration with Florida, I would email Mark for more information on this: mgleason@iastate.edu
- Maine: No Discussion.
- Michigan: No Discussion
- Mississippi: No Discussion
- New Hampshire: No Discussion
- New Jersey: No Discussion
- New York: **How come you chose jewel over other cultivars? Would we find differences with another cultivar?** We wanted something that already had a lot of flavor. You would see differences with other cultivars. **You found no differences in flavors, but we tend to find other flavor components changing during the day so I can't make sense of the different aspects.** How you grow the strawberries on the same farm, they all have the same climate, soil, temperature, etc. Fertilizer and other things didn't have an effect on flavor. **Did you do multiple harvest? Did you look at the difference in flavor between multiple harvests?** Yes we did, we did 5 and we didn't see any variation. **Did you look at temperature during ripening times?** Yes we are working on that right now. We have to figure out which window gives us the best correlation. **Did you try and look at fruit temperature?** No it was more air gross temperature.
- Nova Scotia: No Discussion
- Ontario: **What is the goal of the PCR test for spotted wing drosophila?** The idea is that growers can send in their liquid traps and send to the lab. The Ministry does all the counts for spotted wing and we want to move away from that.
- Oregon: No Discussion
- Pennsylvania: No Discussion
- USDA - Beltsville: No Discussion
- USDA - Corvallis: No Discussion
- USDA Corvallis HCRU: **Can you tell us about the new releases and how adaptable they are outside the pacific northwest?** All three have eastern and western genetics. Adaptation depends on the genetics. A lot of our germplasm we've been able to test on our fresh market. My gut tells me they should be sufficiently hardy. USDA would love to have any of you test these to see if they are adaptable to your region. An issue with most of his selections he sends to NC is heat damage. We've tried lots of Chad's germplasm in

NC and the majority has not done really well. But the new cultivars were comparable to what we grow here, and did well in our observational trials, but we don't take yield data. I need to go back and look at my notes for specific notes.

- Utah: **Do you feel like they're negative as in resistant?** I wouldn't say the new cultivars are resistant, we know the disease is there but we haven't seen it so far. **For the propagation, do you have a protocol that you can go through or send to me?** For the elderberry we're using. **When you were talking about aggie bloom, would you consider naming utah aggie bloom cause I thought about aggie as in texas?** I'm not too worried about that, we have a group looking at plants for landscaping purposes and they have a lot of plants that are desert adapted.
- Virginia: No Discussion
- Washington(State): **Is the pollination system using honey bees?** Yes we focus on honey bees. **About 20% of 35,000 acres of strawberries is organic and the reason why?** **What is the price differential of organic and conventional blueberries?** At least 0.60 cents to \$1 premium. Depends on if it's early season or late season organic. For us it's over \$2.00. **How much of a percent increase is that?** For the right season it's almost 50% higher. **You said there's a new pathologist, is there a new position?** Not new, more of a merging of 2 positions. We merged the position to cover both crops. Right now we have an associate in research covering weed science. No plans to retire the position in the near future.

Business Meeting Minutes:

Present in the meeting:

Kim Lewers, William Baird, Margaret Worthington, Hamid Ashrafi, Kim Hummer, Michael Hardigan, Eric Stafne, Mark Hoffmann, David Handley, Bernadine Strik, Jill Bushakra, Nahla Bassil, Amanda McWhirt, Beatrice Amoyott, Gan Nonnecke, Patrick Edger, Courtney Weber, Marvin Pritt, Lisa De Vetter, Penny Perkins Veazie, Erica Pate, Jessica Spencer, Michael Dossett, Peter Nitzsche, Massimo Iorizzo, Yanis Nitzsche, Vance Whitaker, Kathy Demchak, Mark Ehlenfeldt, Brent Black, Becky Sideman.

Starting and approving last years' minutes:

-Mark Hoffman greeted everyone and called the meeting to order. Amanda McWhirt asked for approval of last year's (2019) minutes. There were no nays, so the minutes got approved.

Fourth Objective

Lisa De Vetter brought up the issue of the project renewal, and the 4th objective of the project was something that was proposed to be added to the project objective by adding working collaboratively on extension and extension projects. William Baird said the new objective needs to be tied up to the previous project objectives. Once the project gets submitted, he will be the person who initially reviews that proposal. Harlen Hatter asked what the possibility that the project does not get renewed is. The deadline to submit the project renewal is Dec 1.

- Someone asked who is on the committee, and the answer was, Lisa, Gina, Harlen, Brent, and Mary Roger for 5 years.

Travel Fund

- Hamid Ashrafi asked about the travel fund. William said, "check with your experimental station representative and ask them to submit your name". The experimental station should handle the travel fund. It seems NC State does not help with the travel fund.

Extension Publication

- Bernadine mentioned that we are encouraged to add extension publications and extension in general to our objectives. She also said we are always encouraged and mandated almost to talk about collaborative efforts across state lines. So an example would be Lisa de Vetter leading the PNW raspberry publication when that is available. Lisa said there is a section requiring proceedings articles and extension key extension outcomes and the impacts of those activities in a particular area. The group then voted to have a section in the proposal for extension impact in the write up when it is due next month (Dec 2020).

Video Conferencing

- The discussion revolved around having the meeting in a video conferencing format like in 2020. Participants expressed the pros and cons of video conferencing. One idea was to have it in a hybrid manner (in-person and video conferencing). Another idea was to alternate it; one year in-person participation and one year online. No decision was made at the end, but the idea is there to think about it.

Extension of the Project to Include Entomologists, Plant Pathologist, and Virologists

- One of the participants said they had been invited in the past, and there will not be any issue asking or inviting them in the future. Therefore, the team agreed to invite plant pathologists and virologists into the meeting.

Email List and Archiving the Reports

- Email lists, reports, and timelines were another agenda item. Mark said we need to ensure that we archive them and send them on to the next host. Mark Hofmann agreed to maintain such an email list and pass it to the next host. New people need to be added to the list, and people who have changed their jobs or moved need to be removed. Mark agreed to make a Google spreadsheet so people can edit it. The team also decided to create an archive for the reports. The website that Mark created was a good idea, and something like that can be done for each year's meeting. Also, the chair of the future meeting being involved in these processes helps him/her be more independent the next time. Lisa De Vetter will provide a list of responsibilities, and Mark Hoffman to flush it out. The current chair also needs to give the timeline of the events that need to happen next year before the meeting. It would be a good idea to write it up. Planning the location of the conference two years ahead of time was agreed to.

New Host

- For the 2021 meeting, a joint meeting between California and Mexico was proposed. Philip Stewart presented this idea for two years in a row. Since he was not in the forum, and someone needed to follow up with him. The team wanted to have a backup plan just in case California-Mexico could not be scheduled. University of Arkansas, Geneva, NY, and Florida were also proposed as potential locations.

Survey on How COVID-19 Has Been Affected Your Program

- A survey will be sent out to learn about: How covid-19 has impacted your work. Did

your institution order you to stay at home? How long and how much of your lab research was affected by covid-19 as a percentage? How much of your field research was impacted by it; again, a percentage of how much of your extension program was affected? What percent of your work is at home now versus in March? Are you in the process of hiring faculty positions? People thought the latter one was interesting too. And if those were affected, are you being able to reopen the position to hire? Any other questions you can think of? Margaret suggested maybe you can ask about how people try to figure out childcare because some of us that have kids.

Forum for Discussion

- Jessica Spencer from NC proposed to form a forum where people can talk to each other and ask questions. A Facebook page was proposed to be created where researchers can exchange ideas.

Accomplishments:

Short-term Outcomes:

Due to the global pandemic, this meeting was held entirely online via Zoom in 2020. The meeting was attended by individuals from 23 institutions, up from 16 institutions in 2021. Despite challenging conditions, most institutions reported that research continued at most sites. Results from the research has been or will be disseminated to grower clientele via state, regional and national meetings and publications (see lists below).

Outputs:

This project has resulted in the evaluation of germplasm and release of at least 14 new strawberry, blackberry, and bunch grape cultivars in the past 2 years and there are at least 10 institutions conducting collaborative cultivar trials. The NCCC-212 collaborations have also resulted in the development of a number of genetic resources and enhanced germplasm evaluation. For example, a very wide reaching collaboration led by the USDA National Clonal Germplasm Repository (NCGR) personnel and Univ. Ark, WSU, BC Berry Cultivar Development, Cornell, University, NCSU, OSU, UC Davis, UFL, MSU, IFAPA (Spain), and others have worked together to identify important candidate genes (blackberry), fingerprinting sets based on SSR's (raspberry, blackberry and blueberry), genetic map for insect resistance in black raspberry, conduct Rubus diversity and GWAS analysis, assist with genomic selection (blueberry). Most of these outputs have been published in peer reviewed journals. In addition the Canadian institutions have a collaborative project within the country, called the Canadian Berry Trial Network, where they trial small fruit germplasm in BC, Nova Scotia, and Ontario. They have invited US breeders to send them germplasm.

Research focused on challenges in small fruit production are numerous within the NCCC-212. For example, several institutions are evaluating the impact of pests that are emerging in their state or region, or developing resistance to chemical controls. Research in the use of high and low tunnels for strawberry and caneberry production are ongoing in several states. In response to low productivity disease outbreaks in strawberry nurseries several institutions are collaborating to develop a multistate SCRI project to optimize a clean plant strawberry propagation system. Work is also ongoing at several institutions looking at soil disinfestation for strawberry production. In addition, several studies at Oregon State University illustrate the need to conduct

long term research that has impactful findings that are useful to growers. Finally, several non traditional small fruits are either being evaluated as alternative crops including passion fruit, goldenberries, Juneberries, chokecherries as well as elderberry and Ribes as alternative crops.

The small fruit industries in both the US states and Canadian provinces have benefited from release of new cultivars and improved cultural practices as a result of research conducted by members of the NCCC-212. In addition, although there is not an objective for Extension projects, many of the projects listed in Objectives 1 and 2 have an outreach component which has helped to disseminate the information to our grower clientele.

See publications at the end of this document.

Activities - Collaborative projects:

Multiple collaborative projects reported for Objective 1, 59 projects for Objective 2, and 4 projects for Objective 3. There is one large multi institutional USDA funded project in blueberry, VacCAP.

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

Blackberry and Raspberry:

University of Arkansas: Two new floricanefruiting cultivars with excellent flavor have been released in the past few years. ‘Caddo’, a high-yielding thornless, erect cultivar with medium-large fruit that are sweet and flavorful was released in 2018. ‘Ponca’, a high-yielding thornless, erect cultivar with medium-sized fruit with enhanced sweetness and good post-harvest handling was released in 2019. One additional primocane-fruited selection has been submitted for release approval by the AES, APF-268, and when approval is complete, it will be available for sale. The projected first offer date is December 1. The proposed name is Prime-Ark® Horizon, and if all goes well, this will be the name. This release is intended to be a complement to Prime-Ark®45 as it is thorny. The floricanefruit potential is very high, among the highest of any blackberry genotype tested in the Arkansas program. Primocane crop is lower, as is the reality with all primocane-fruited cultivars in Arkansas. During testing, the primocane crop ranged from 10 to 74% of the floricanefruit crop among years. APF-268 is large, and average berry size of floricanefruit berries was 7.8 g and primocane berries 7.3 g. The similarity in berry size from these two cane types is much closer than any primocane-fruited cultivar, and suggests more stable berry size stability in summer heat. Postharvest storage potential is good for this new development, particularly for firmness and low leakage; reversion is similar to Prime-Ark®45. Finally, this new development fruits longer in the fall, averaging 8 days longer than Prime-Ark®45 and 19 days longer than Prime-Ark®Traveler. There are a number of other primocane- and floricanefruited blackberry selections in advanced stages of testing. We are also continuing work on breeding blackberries with novel or ‘dwarf’ architecture for home gardeners.

We have also expanded molecular breeding and research activities in blackberry. University of Arkansas researchers are collaborating with NCSU (Dr. Hamid Ashrafi and Dr. Gina Fernandez), USDA-ARS (Dr. Nahla Bassil), and United Kingdom researchers on the development of two

diploid reference genomes. Our team has completed two years of phenotyping on a blackberry genome-wide association study (GWAS) funded by USDA-AFRI and we are looking forward to analyzing genotype data by the end of 2020. Graduate students have measured thorn density, internode length, fruit size and shape, sweetness, acidity, seed size, firmness, and red drupelet reversion in a panel of ~300 UA breeding selections and cultivars for this GWAS project. We are also working with breeders and scientists at Pairwise, NCSU, USDA-ARS, Cornell, and Plant Sciences, Inc. on a unique public-private partnership to identify and characterize the genetic diversity in a diverse *Rubus* collection.

British Columbia: Raspberries In the 2017 Machine Harvest Trial, BC 10-71-27 (1.55 kg/plant) was the highest yielding selection, followed by WSU 2188 (1.24 kg/plant), compared with the standard ‘Chemainus’ (1.04 kg/plant). Both harvested exceptionally well by machine and had good fruit quality. BC 10-71-27 was about a week earlier than WSU 2188. In the 2018 Machine Harvest Trial, WSU 2069 (2.12 kg/plant) and BC 13-31-9 (2.03 kg/plant) were the standouts, with significantly more fruit than ‘Meeker’ (0.46 kg/plant) or ‘Chemainus’ (1.21 kg/plant). Both had nice quality, with WSU 2069 being especially nice. We are currently conducting a large study to examine heritability and correlations between various yield components, yield, fruit quality, and seasonality. The aim is to try to identify selection criteria that will allow us to more effectively put selection pressure on yield and earliness simultaneously, an objective that is difficult because these two traits are negatively correlated. We also received funding in 2020 to work with an economist to help develop a selection index based on grower profitability. As the breeding program continues to increase the proportion of selections that machine harvest easily and show nice quality, this will further help separate those which are worth pursuing and those which are candidates for elimination by estimating and ranking their economic potential for growers and more accurately taking into account economic tradeoffs such as yield with earliness (greater percentage of fruit into IQF grade before processors stop taking IQF fruit for the season in favor of blueberries).

NC State University: *Rubus* GWAS/BSH study, Multi institution phenotyping project initiated with Univ. Ark, Cornell, USDA-ARS Corvallis, BC Berry, Plant Science Inc (Watsonville) and Pairwise Plants (Durham NC) in 2019/2020. In spring and summer of 2020. 5 cultivars were planted at each location and will be phenotyped over the next 2 years. Phenotyping has begun at most locations. New graduate student, Katie Sheehan-Lust (NCSU) will be using this project for her MS research. In addition, Pairwise plants, has developed five scaffold or pseudomolecule genome assemblies, generation genomic resequencing data for approximately 500 (?) public lines, and shared genomic resequencing data on all public lines and associated phenotype measurements in a publicly accessible database.

Washington State University: Five collaborative breeding project were reported as follows:

- 1- Evaluation of performance of red raspberry selections in the Pacific Northwest.
Wendy Hoashi-Erhardt, Washington State University, Bernadine Strik, Pat Jones, Oregon State University, Mary Peterson and Michael Hardigan, USDA-ARS, Corvallis, OR, Michael Dossett, BC Blueberry Council, Abbotsford, BC.
- 2- Evaluation of adaptation of red raspberry selections to machine harvesting.
Wendy Hoashi-Erhardt, Washington State University, Mary Peterson and Michael Hardigan, USDA-ARS, Corvallis, OR, Michael Dossett, BC Blueberry Council,

Abbotsford, BC.

3-Evaluation of raspberry selections to root rot. Wendy Hoashi-Erhardt, Washington State University, Mary Peterson and Michael Hardigan, USDA-ARS, Corvallis, OR, Michael Dossett, BC Blueberry Council, Abbotsford, BC.

4- Evaluation of performance of red raspberry cultivars to individually quick frozen processing. Wendy Hoashi-Erhardt, Washington State University, Tom Walters, Walters Ag Research, Anacortes, WA.

5- Evaluation of performance of advanced red raspberry selections in grower trials in the Pacific Northwest. Wendy Hoashi-Erhardt, Washington State University, Tom Peerbolt and Julie Pond, Northwest Berry Foundation, Portland, OR.

Blueberry & Huckleberry:

NC State University, Raleigh: We were able to send Michael Dossett in British Columbia, Canada softwood cuttings of Reveille x Arlen population of ~300 that have been central to marker studies at NCSU. We will likely need to repeat the process depending on survivability.

As part of AFRI project that was funded in 2019, entitled “ Developing An Economic Standardized Genotyping Tool to Enhance Blueberry Breeding Programs” , PhD student Lauren Redpath, and research associate Rishi Aryal in collaboration with USDA-ARS scientists Dr. Nahla Bassil and her team at National Clonal Germplasm Repository and Dr. Amanda Haulse-Kemp team are working on a diversity panel of advanced selections and cultivars where native species have been hybridized into their pedigrees for trait introgression. As a part of this study 150 individuals at the Sandhills research station in Jackson Springs, NC and 76 individuals at the National Clonal Germplasm Repository were selected and phenotyped over the summers of 2019 and 2020 with 2 to 3 harvests per individual and clonal replication. Phenotyping included bloom time, fruit ripening duration and time, as well as fruit skin color spectrum analysis, firmness, weight, size, area, anthocyanin content, puncturability, soluble solid and acid content determination, titratable acidity. Analysis confirmed that there were significant differences between successive harvests. Within a harvest there were significant differences between individuals for each of the measure traits; these results are anticipated in a diversity panel. Phenotypic measurements were highly correlated over the years of study ($R^2 > 0.55$). These phenotypic measurements are in the process of being associated with genotypic markers in a genome wide association study (GWAS). Sequence capture strategy via Tecan (Allegro Targeted Genotyping) was used to capture 60,000 SNP makers in the gene space of blueberry. The markers were developed as part of the AFRI project as well as a previous project by sequencing of ~54 blueberry accessions from 8 sections and 28 species. For the sequencing capture data, we used two pipelines for variant calling of 251 individuals including the individuals in the phenotyping population and select parents. We initially called 14.5 M variant positions with both FreeBayes and an in-house pipeline, further filtering for previously established Allegro probes, we established 30,000 variant positions for further investigation. These probes have been used in STRUCTURE analysis, wherein patterns of introgressed species clustering has been detected, and GWASpoly for association analysis. Pseudo molecule development and scaffolding is underway to establish linkage groups and present a more accurate representation of association between variant and phenotype.

NC State University, Kannapolis: Characterized fruit quality traits in blueberry germplasm (Massimo Iorizzo in collaboration with Food Scientists and NCGR-OR). Extensive variation for all fruit traits (pH, TA, Brix/TSS, fruit size, anthocyanins, phenolic acids, flavanols, flavonols) evaluated in a Diversity Panel (DP) was detected. Broad sense heritability of the traits estimated in 100 tetraploid accessions, ranged from 20 to 90%, with most traits revealing moderate to high broad sense heritability ($H^2 > 40\%$), suggesting that strong genetic factors control these traits. TSS was positively and significantly correlated with most of the anthocyanins, flavanols, and phenolic acids and pH was positively associated with acylated anthocyanins. Fruit size can be estimated as a proxy of fruit weight or volume and vice versa, and it was negatively correlated with content of most of phytochemicals. However, size-independent variation for anthocyanin content and profile exists in the tetraploid accessions and can be explored to identify other factors such as genes related to the biosynthetic pathway that control this trait (Molla et al., 2020a, Farneti et al., 2020).

Oregon State University - USDA-ARS: Multiple project as follows

1- Developed a genetic framework to improve the efficiency of bioactive delivery from blueberry. Nahla Bassil, Kim Hummer, USDA ARS NCGR-Corvallis, OR; Molla F. Mengist, Haley Burtch, Hawi Debelo, Marti Pottorff, Hamed Bostan, Candace Nunn, Sydney Corbin, Colin D. Kay, Mary Ann Lila, Mario G. Ferruzzi, Massimo Iorizzo, Plants for Human Health Institute, North Carolina State University, Kannapolis, NC

2- Phenotyping blueberry for fruit quality traits. Nahla Bassil, Kim Hummer, USDA ARS NCGRCorvallis, OR; Marti Pottorff, Massimo Iorizzo, Penelope Perkins-Veazie, Mary Ann Lila, Plants for Human Health Institute, North Carolina State University, Kannapolis, NC; Ted Mackey, USDA-ARS-HCRU, Corvallis, OR.

3- Developing a high throughput genotyping platform for blueberry and cranberry. Nahla Bassil, Mandie Driskill, USDA ARS NCGR-Corvallis, OR; Massimo Iorizzo, Plants for Human Health Institute, North Carolina State University, Kannapolis, NC; Patrick Edger, Michigan State University, Department of Horticulture, E. Lansing, MI; Patricio Munoz, University of Florida, Horticultural Science Department, Gainesville, FL; David Chagne, Plant & Food Research Limited, Palmerston North, New Zealand.

4- ARS NCGR-Corvallis, OR; Dongyan Zhao, Moira Sheehan, Cornell University, Department of Plant Biology; Amanda Hulse-Kemp, USDA-ARS; Jodi Humann, Dorrie Main, Washington State University, Department of Horticulture, Pullman, WA

5- Testing Allegro Targeted Genotyping for blueberry genome wide association. Nahla Bassil, USDA ARS NCGR-Corvallis, OR; Amanda Hulse-Kemp, USDA-ARS-GBRU; Lauren Redpath, Rishi Aryal, and Hamid Ashrafi, North Carolina State University, Horticultural Science Department, Raleigh, NC

Pennsylvania State University: Blueberry cultivar comparison on an “upland” soil. R. Marini and K. Demchak, Penn State Univ., University Park, PA; J. Luby, Univ. of Minnesota, Minneapolis, MN; Jim Hancock, Michigan State Univ., East Lansing, MI. No more information was provided about the project.

Grapes:

Auburn University: The following activities have been done in collaboration with UC Davis, UGA and University of Arkansas.

1. Evaluation of UC Davis Developed Pierce's Disease (PD) Resistant Predominantly *V. vinifera* Grapes in AL. E. Coneva, and M. Price, Auburn University, Auburn, AL, and Andy Walker, UC Davis.
2. Assessment of Recently Released Muscadine Grape Cultivars and Advanced Selections from the UoG breeding program in AL conditions. E. Coneva, M. Price, Auburn University, Auburn, AL, and P. Conner, UoG.
3. Assessment of Newly Released UoG Blueberry Cultivars, E. Coneva and M. Price, Auburn University, Auburn, AL, and Scott NeSmith, University of Georgia, Griffin, GA.
4. Evaluation of Newly Bred Seedless Table Grape Selections from the University of Arkansas Breeding Lines. E. Coneva, Auburn University, Auburn, AL; and John Clark, University of Arkansas

University of Arkansas: In collaboration with UGA they have measured firmness of berries analytically and by sensory, validation of a new candidate gene for bronze berry color, investigations into the inheritance of sex and leaf shape in collaboration with Patrick Conner (UGA), and estimation of genetic diversity of wild and cultivated muscadines across the native range.

Strawberry:

University of Florida: In terms of cultivar development and release efforts, at UFL they have continued to work collaboratively with the NCPN by sending tissue cultures of released varieties to the NC State micropropagation unit.

A collaborative germplasm exchange with Dr. Kim Lewers, USDA, Beltsville, MD, was officially established in 2020 in which crosses are being made between UF and USDA accessions to combine flavor from the USDA parents and *Colletotrichum gloeosporioides* resistance from UF parents. Gina Fernandez of NC State continues to trial our new varieties as they become available in order to provide recommendations to growers in the mid-Atlantic. Thus far the newer UF varieties flower too early in the winter in this region.

DNA Test Development – collaborators include Dr. Nahla Bassil, USDA-ARS, Corvallis, OR and Dr. Steven J. Knapp, UC-Davis, Davis, CA. An increasing number of DNA tests are being developed, published, and made available to the strawberry breeding and genetics community.

Genomic Selection Methodology Development – collaborators include Dr. Rex Bernardo, University of Minnesota, St. Paul, MN and Dr. Patricio Munoz, UF Horticultural Science, Gainesville, FL. At UFL they continue to conduct research into effective applications of genomic prediction in strawberry parent and seedling selection, continuing the work that began during RosBREED.

NC State University: Cultivar development. Focus is on improving firmness, flavor, disease resistance and yield. 5000 seedlings evaluated, 122 new selections made in 2020.

Cultivar evaluation and numbered breeding line evaluation in collaboration with Lassen Canyon and Cottle Farms. M. Hoffmann. Evaluation of yield and fruit quality characteristics in an on-

farm field trial. (partly funded by the NC Strawberry Association).

Nova Scotia (Canada): In 2019, K. Hummer sent a collection of 300 *Fragaria x. ananassa* accessions from the USDA clonal germplasm repository in Oregon to the AAFC Kentville Research and Development Centre in Nova Scotia. This collection has previously been genotyped and phenotyped for various plant and fruit characteristics in Corvallis and elsewhere. The collection was planted in Kentville in summer 2020 and will be phenotyped for phenological and fruit quality traits in 2021 and 2022. The Nova Scotia data will be integrated into the larger study to serve as another dimension of genotype x environment for the genome wide association study. The objective is to identify new genetic sources of variation for breeding and selection.

USDA-ARS and Oregon State University: Evaluating genotype x environment interactions for predicting SSC in strawberry. Jason Zurn, Nahla Bassil, USDA ARS NCGR-Corvallis, OR; Mulusew Ali, Craig Hardner University of Queensland, St. Lucia, QLD, Australia; Vance Whitaker, University of Florida, Wimauma, FL; Chad Finn, USDA ARS HCRU-Corvallis, OR; Jim Hancock, Michigan State University, E. Lansing, MI; Iraida Amaya, IFAPA, Malaga, Spain; Helen Cockerton, Richard Harrison, NIAB-EMR, East Malling, United Kingdom; Lise Mahoney, Tom Davis, University of New Hampshire, Durham, NH; Jodi Neal, Queensland Department of Agriculture and Fisheries, Nambour, Australia.

Washington State University: Evaluation of performance of June-bearing and day-neutral strawberry selections in the Pacific Northwest. Wendy Hoashi-Erhardt, Washington State University, Bernadine Strik, Pat Jones, Oregon State University, Ted Mackey and Michael Hardigan, USDA-ARS, Corvallis, OR, Michael Dossett, BC Blueberry Council, Abbotsford, BC.

Other small fruit crops:

General:

British Columbia: The final stage of the breeding program prior to commercialization is to evaluate advanced selections under commercial conditions through grower trials. This portion of the program has been linked with programs in Ontario, Quebec and Nova Scotia to build a network of trials, each region evaluating the other's selections against standard cultivars. Two initial rounds of exchange of raspberry and strawberry selections and cultivars took place in 2019 and 2020 with selections from the Kentville and BC programs being distributed for replicated trials in each province. A first round of blueberry trials is being planned for spring of 2021. These trials will implement replicated comparisons of a range of industry standard cultivars, new cultivars, and non-commercialized selections from a few different breeding programs.

On-farm grower trial evaluations of existing raspberry, strawberry and blueberry trials. In 2020, this included intensive sampling to compare blueberry fruit firmness over five weeks in cooler storage.

Impact of the First Objective:

The major impact of the small fruit breeding effort is in plantings of released blackberry cultivars. The primocane-fruiting cultivars have had significant production now for several years and are now providing for a much-extended blackberry marketing season for domestic production. The florican-fruiting cultivars Ouachita, Natchez and Osage are the most popular and continue to provide for high quality berries. The new releases Caddo and Ponca are expanding production also, and Ponca looks to be a big step up in consistent sweetness in berries

Two new UF strawberry cultivars have been released and patents applied for in July, 2020. These are detailed below. Trade names are in process. 'FL 16.78-109' (PPAF) is a new strawberry variety that produces extremely unique white-colored fruit with a pink blush. This variety will provide strawberry growers and marketers with new opportunities in retail and food service markets. 'FL 16.78-109' fruit are consistently sweet throughout the season and have a unique aroma reminiscent of apricot and pineapple. The first plants have been planted in October 2020 and limited quantities of fruit will be available in select retail markets throughout this winter. FL 16.30-128' (PPAF) is a new strawberry variety that is intended to complement the production of 'Florida Brilliance' and Sweet Sensation (R) 'Florida127' and give growers another variety alternative with excellent early-season yields. Fruit of 'FL 16.30-128' are medium-large sized, firm, uniformly shaped, and have exceptional color and flavor.

'Rocco' (New Strawberry Cultivar from NC State) is gaining popularity in midwest states. Growers are replacing 'Sweet Charlie' with 'Rocco'. Estimated production for 2021 will be between 1.0 and 1.5 M plants.

From Nova Scotia breeding program, Audrey', 'Evelyn' and 'Kate' are June-bearing strawberries with medium-large, firm berries that ripen in the mid-season with 'Mira' and 'Lila'. They have moderate yields in Nova Scotia and Quebec, and are currently being tested in other Canadian provinces. North American plant sales are licensed to Lareault Nursery in Quebec and C.O. Keddy Nursery in Nova Scotia. Variety protection is in progress, and plants will soon be available for sale in the USA.

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

Blackberry and Raspberry:

Arkansas

Broad mite in blackberry and other pest management observations (Cato)

Evaluation of preemergent herbicides for newly planted blackberries (Bertucci, McWhirt, Cato).

Preliminary evaluations of timing and rates of prohexadione calcium on blackberry (A. McWhirt, T. Kon (NCSU))

Rotating Cross Arm Trellis and Standard T-trellis Comparison. (A. McWhirt)

Mississippi

Evaluating blackberry cultivars for tolerance to white drupelet disorder. E. Stafne, Mississippi State University; Barbara J. Smith, USDA-ARS Poplarville.

New York

North Carolina

Managing vigor of blackberry with prohexadione calcium: Effects on vegetative and reproductive development. Gina Fernandez, Tom Kon, Penny Perkins-Veazie and Karen Blaedow. NC State University.

Pest Management Strategic Plan (PMSP) for Blackberry in Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee and Virginia. Gina Fernandez, Karen Blaedow, Hannah Burrack, Sara Villani, Katie Jennings, Wayne Mitchem, Danesha Seth-Carley, Daniel Tregeagle, Roger Batts, Rocco Schiavone, Katie Lohff, Phil Hatfield, Ryan Adams, North Carolina State University, Elizabeth Cieniewicz, Clemson University, Elina Coneva, Edgar Vinson, Arlie Powell, Auburn University, Katheryn Fontenot, Louisiana State University, David Lockwood, University of Tennessee, Amanda McWhirt, University of Arkansas, Rebecca Melanson, Mississippi State University, Jonathan Oliver, University of Georgia, Doug Pfeiffer, Jayesh Samtani, Virginia Polytechnic Institute & State University (Virginia Tech), Guido Schnabel, Clemson University, Ash Sial, University of Georgia, Eric T. Stafne, Mississippi State University.

Survey of fertility use in single and double cropped primocane fruiting blackberries at 2 on-farm locations. Fernandez, Hicks, Blaedow, Shires, Speer, McNicoll, and Gumpertz.

North Dakota

Continue to evaluate ways to get more fruit from primocane blackberry cultivars. North Dakota State University.

Continue to evaluate organic production methods for raspberry and blackberry cultivars. North Dakota University.

Oregon

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.

Impact of planting density and pruning and training method on growth, yield and machineharvest efficiency of 'Columbia Star' trailing blackberry (in progress). Strik, B.C. and A.J. Davis. Oregon State University.

Utah

Develop improved management strategies for high tunnel berry production in a high-elevation arid climate. Utah State University.

Washington

Determining blueberry cold hardiness in Washington. G. Hoheisel and L. Khot, WSU, Prosser, WA; L.W DeVetter, WSU, Mount Vernon, WA; C. Kogan, WSU, Pullman, WA.

Impacts of mycorrhizal fungal inoculants and fertilizer sources on red raspberry. L.W. DeVetter and Q. Lu, WSU, Mount Vernon, WA; and R. Bunn and E. Whitney, Western WA University, Bellingham, WA.

Improving machine harvest efficiency and fruit quality for fresh market blueberry. L.W. DeVetter and Y. Cai, WSU, Mount Vernon, WA; S. Sankaran and C. Zhang, WSU, Pullman, WA; J. Chen, University of Georgia, Athens, GA; W. Yang, OSU, Aurora, OR; F. Takeda, USDA-ARS, Kearneysville, WV; S. Korthuis, B. Foote, and K Van Weerdhuizen, Oxbo, Lynden, WA.

Management techniques to optimize soil pH and nutrient availability in organic highbush blueberry grown east of the Cascade Range. S. Lukas, OSU, Hermiston, OR; L.W. DeVetter, WSU, Mount Vernon, WA; J. Davenport and G. Hoheisel, WSU, Prosser, WA; R. Sero and S. Galinato, WSU, Pullman, WA, D.Bryla, USDA-ARS, Corvallis, OR; B. Strik, J. Fernandez-Salvador, D. Sullivan, and K. Trippe, OSU, Corvallis, OR.

Optimizing blueberry pollination to ensure future yields. R. Isaacs and M. Milbrath, Michigan State University, Lansing, MI; L.W. DeVetter, WSU, Mount Vernon, WA; S. Galinato, WSU, Pullman, WA; R. Malinger, University of Florida, Gainesville, FL; A. Melathopoulos, Oregon State University (OSU), Corvallis, OR.

Optimizing nutrient management for organically grown blueberries in eastern Washington. L.W. DeVetter and A. Bhasin, WSU, Mount Vernon, WA; J. Davenport and G. Hoheisel, WSU, Prosser, WA; N. Stacey, WSU, Puyallup, WA.

Polyethylene and biodegradable plastic mulches for improved establishment of raspberry planted as tissue culture transplants. L.W DeVetter, B. Madrid, H. Zhang, C. Miles, C. Benedict, S. Watkinson, Washington State University (WSU), Mount Vernon, WA; I.A. Zasada, USDA-ARS, Corvallis, OR; S. Ghimire, University of Connecticut, Vernon, CT.

Real-time nutrient analyses of raspberry using petiole sap. L.W. DeVetter, Q. Lu, and C. Miles,

WSU, Mount Vernon, WA.

VacciniumCAP: Leveraging genetic and genomic resources to enable development of blueberry and cranberry cultivars with improved fruit quality attributes. M. Iorizzo, North Carolina State University (NC State), Raleigh, NC; et al. (project team at: <https://www.vacciniumcap.org/team>).

Valuing nitrogen release from high organic matter soils. G. LaHune, C. Sloan, L.W. DeVetter, D. Griffin LaHue, WSU, Mount Vernon, WA.

Blueberry & Huckleberry:

British Columbia

Assessing Harvest and Postharvest Fruit Quality in Blueberry: Dr. Simone Castellarin and Dr. Anubhav Pratap Singh, University of British Columbia

Controlling Blueberry Fruit Development using Plant Growth Regulators: Dr. Charitha Jayasinghe, Research Scientist, Agriculture and Agri-Food Canada

Determining Optimal Wildflower Patch Arrangements to Minimize Pollination Deficits in Cultivated Blueberry: Dr. Rebecca Tyson, Associate Professor, University of British Columbia

Development of PCR Based Methods to Reliably Distinguish Shock or Scorch Virus Infected Blueberry Plants: Dr. Jim Mattsson, Associate Professor, Simon Fraser University

Ecological Pest management for Spotted Wing Drosophila: Dr. Juli Carrillo, Assistant Professor, University of British Columbia

Effects of Host, Pathogen, and Environmental Factors on Increased Incidence of European Foulbrood in Honey Bee Colonies Pollinating Blueberries in BC: Dr. Sarah Wood, University of Saskatchewan

Evaluation of spray-induced gene silencing of blueberry scorch and shock viruses as a method to reduce virus number and symptoms of infected blueberry plants: Dr. Jim Mattsson, Simon Fraser University.

Integrating host resistance and alternatives to copper-based products for sustainable management of bacterial blight: Dr. Rishi Burlakoti, Research Scientist, Agassiz Research and Development Centre (ARDC), Agriculture and Agri-Food Canada (AAFC).

Mitigating cultivar-specific physiological challenges in new blueberry cultivars: Dr. Eric Gerbrandt, Plant Scientist, Sky Blue Horticulture Ltd.

Monitoring of arthropod pests in raspberry and blueberry germplasm: Dr. Michelle Franklin, Research Scientist, Agassiz Research and Development Centre (ARDC), Agriculture and Agri-Food Canada (AAFC).

Arkansas

Evaluation of preemergent herbicides for newly planted blackberries (Bertucci, McWhirt, Cato).

Mississippi

Renovation pruning of blueberry cultivars in Mississippi. E. Stafne, MSU; B.J. Smith, USDA

ARS.

North Carolina

Postharvest shelf life changes in blueberry cultivars. Cooperators: Penelope PerkinsVeazie, Massimo Iorizzo, NCSU.

Shelf Life: Cuticular Wax Bloom of Blueberry Fruit: An Innovated Edible Coating for Enhancing Quality and Shelf-life. Hamid Ashrafi, Mahnaz Kargar. North Carolina State University.

Ontario

Distribution of four major plant parasitic nematodes associated with highbush blueberry in Southern Ontario. T. Sultana, AAFC; E. Pate, OMAFA; E. Thorpe, OMAFRA.

Oregon

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.

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

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.

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.

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.

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. Lukas¹, L.W. DeVetter², D.R. Bryla³, B.C. Strik¹, J. Fernandez-Salvador¹ and S. Galinato². ¹Oregon State University, ²Washington State University and ³USDA -ARS

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.

Pennsylvania

Soil amendments and mulch for blueberry plant establishment. R. Marini and K. Demchak, Penn State Univ., University Park, PA.

Washington

Determining blueberry cold hardiness in Washington. G. Hoheisel and L. Khot, WSU, Prosser, WA; L.W DeVetter, WSU, Mount Vernon, WA; C. Kogan, WSU, Pullman, WA.

Improving machine harvest efficiency and fruit quality for fresh market blueberry. L.W. DeVetter and Y. Cai, WSU, Mount Vernon, WA; S. Sankaran and C. Zhang, WSU, Pullman, WA; J. Chen, University of Georgia, Athens, GA; W. Yang, OSU, Aurora, OR; F. Takeda, USDA-ARS, Kearneysville, WV; S. Korthis, B. Foote, and K Van Weerdhuizen, Oxbo, Lynden, WA.

Management techniques to optimize soil pH and nutrient availability in organic highbush blueberry grown east of the Cascade Range. S. Lukas, OSU, Hermiston, OR; L.W. DeVetter, WSU, Mount Vernon, WA; J. Davenport and G. Hoheisel, WSU, Prosser, WA; R. Sero and S. Galinato, WSU, Pullman, WA, D. Bryla, USDA-ARS, Corvallis, OR; B. Strik, J. Fernandez-Salvador, D. Sullivan, and K. Trippe, OSU, Corvallis, OR.

Optimizing blueberry pollination to ensure future yields. R. Isaacs and M. Milbrath, Michigan State University, Lansing, MI; L.W. DeVetter, WSU, Mount Vernon, WA; S. Galinato, WSU, Pullman, WA; R. Malinger, University of Florida, Gainesville, FL; A. Melathopoulos, Oregon State University (OSU), Corvallis, OR.

Optimizing nutrient management for organically grown blueberries in eastern Washington. L.W. DeVetter and A. Bhasin, WSU, Mount Vernon, WA; J. Davenport and G. Hoheisel, WSU, Prosser, WA; N. Stacey, WSU, Puyallup, WA.

VacciniumCAP: Leveraging genetic and genomic resources to enable development of blueberry and cranberry cultivars with improved fruit quality attributes. M. Iorizzo, North Carolina State University (NC State), Raleigh, NC; et al. (project team at: <https://www.vacciniumcap.org/team>).

Valuing nitrogen release from high organic matter soils. G. LaHune, C. Sloan, L.W. DeVetter, D. Griffin LaHue, WSU, Mount Vernon, WA.

Elderberry:

Utah

Develop alternative crops for diversification opportunities. Utah State University.

Grapes:

Alabama

Determining the Optimal Planting Density of Pierce's Disease (PD) Resistant Predominantly V. vinifera Grapes trained to a Watson training System in Alabama conditions. E. Coneva, and M. Price, Auburn University, Auburn, AL, and Andy Walker, UC Davis.

Evaluations of selected scion-rootstock combinations for sustainable hybrid bunch grape production in Alabama. E. Coneva and James Pitts, Auburn University, Auburn, AL.

Arkansas

High Tunnel Grape Production Systems: A Novel Sustainable Approach to Growing Grapes (Cooperators: D. T. Johnson, R. Threlfall UA; J. Lee, A. McWhirt, R. Rainey, UAEX; L. Freeman NCATT).

Florida

Evaluation of viticultural practices for 'Marquette' and 'La Crescent' grapevines grown in single- or double-cordon training systems.

New Hampshire

Yield and performance of eight seedless table grape cultivars grown in two training systems (Munson and VSP) in New Hampshire. NH Agricultural Expt. Station, Hatch Project NH00685. R.G. Sideman, M. Cogswell and K.M. Orde, University of NH, Durham NH; G. Hamilton, University of NH Extension, Goffstown NH.

North Carolina

Evaluation of seasonal differences in nutrient content of muscadine tissue samples M. Hoffmann, T. Rana (MHS thesis). NC State University.

Grape Trunk Disease Management in NC. M. Hoffmann, E. Volk and S. Villani. NC State University.

Grapevine virus survey and development of testing service through the MPRU and PDIC. M. Hoffmann, C. Almeyda, W. Talton, M. AlRwahnih, M. Sudarshana, M. Nita, E. Volk. NC State University.

Optimal pruning and flower removal studies on seedless muscadine cultivars. M. Hoffmann, E. Volk and P. Perkins-Veazie. NC State University.

Shelf Life of seedless and seeded muscadine grapes. M. Hoffmann and P. Perkins Veazie. NC State University.

North Dakota

A trial to examine the effects of four trellis systems for 'Marquette' and 'Petite Pearl' grapes was also severely damaged repeatedly by winter dieback. North Dakota State University.

For two winters in a row devastating dieback of almost all cultivars occurred in a variety trial initiated in 2004 despite what was considered a rather mild winter. North Dakota State University.

Screening the North Dakota State University grape germplasm collection for temperature adaptive acclimation responses. North Dakota University.

Assessment of the effect of viticultural practices (fruit zone leaf removal, shoot thinning, crop positioning, and crop load management) on fruit yield, quality, and vine cold hardiness for 'Frontenac', 'Marquette', and 'Prairie Star'. North Dakota University.

- Identify and discuss major concerns of berry growers, processors, marketers and scientists with a multistate focus for the priority of issues. This will lead to more efficient use of public funds when developing research, teaching and extension programs to address these concerns.
- Collaborative exchange of information and ideas among group members will lead to collaborative projects, stronger grant proposals, more robust publications, and new sources of specialized information. Ideas generated from one state project can be tested regionally and nationally. Such evaluations enable innovations to be site-specific and to hasten adaptation.
- Standardized multi-state and regional germplasm evaluation protocols and multiple site evaluations (environment X genotype studies) will provide important information on adaptability and cultivar performance and improved outreach to scientific community and producers.
- Through participation of a diversity of small fruit and viticulture researchers (breeders, geneticists, molecular biologists, pest management specialists, physiologists and horticulturists from industry, land grant colleges, and USDA in the US and Canada, a forum for multi-disciplinary idea exchange will occur for the discussion of current research topics, cross-exchange of scientific viewpoints and to offer training opportunities for graduate students.

Ontario

Development of a novel method for quantifying SWD in a monitoring program in stone fruit, grapes and berries and determination of impact of SWD on stone fruit and grape varieties. W. McFadden-Smith, OMAFRA; J. Renkema, AAFC; S. Chen, University of Guelph; J. Subramanian, University of Guelph.

Oregon

Characterizing Willamette Valley Soil Moisture and Grapevine Response under Drying Seasonal Conditions Patricia A. Skinkis, Department of Horticulture, Oregon State University, Corvallis, OR, R. Paul Schreiner, USDA-ARS Horticulture Crops Research Lab, both members of the Oregon Wine Research Institute at OSU.

Data driven models for canopy temperature- based irrigation scheduling Completed Bradley A. King, Agricultural Engineer, USDA-ARS Northwest Irrigation and Soils Research; Krista C. Shellie, Research Horticulturist, USDA-ARS; David D. Tarkalson, Research Soil Scientist, USDA-ARS Horticultural Crops Research; Alexander Levin*, Assistant Professor, Department of Horticulture, Southern Oregon Research and Extension Center, Oregon State University; Vivek Sharma, Assistant Professor, Precision Water Management, Department of Agricultural and Biological Engineering, University of Florida, Institute of Food and Agricultural Sciences; David L. Bjorneberg, Supervisory Agricultural Engineer, USDA-ARS Northwest Irrigation and Soils Research; *member of the Oregon Wine Research Institute at OSU.

Efficacy of cultural practices for mitigating negative effects of Grapevine Red Blotch Disease in Oregon Pinot noir (In progress) Cody Copp (graduate student), Department of Horticulture, Oregon State University; Achala KC, Assistant Professor, Department of Botany and Plant Pathology, Southern Oregon Research and Extension Center, Oregon State University; and

Alexander Levin*, Assistant Professor, 17 Department of Horticulture, Southern Oregon Research and Extension Center, Oregon State University; *member of the Oregon Wine Research Institute at OSU.

Exploring vineyard management practices to mitigate effects of Red Blotch Disease in Oregon's Willamette Valley Patricia A. Skinkis*, Department of Horticulture, Oregon State University, Corvallis, OR, Justin Litwin (graduate student), Department of Horticulture, Oregon State University, Bob Martin*, USDA-ARS Horticulture Crops Research Lab, James Osborne*, Department of Food Science & Technology, and Alexander Levin*, Department of Horticulture, Oregon State University – Southern Oregon Research & Extension Center, *member of the Oregon Wine Research Institute at OSU.

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.

Re-evaluating pressure chamber methods of water status determination in field-grown grapevine (*Vitis* spp.) Completed Alexander Levin*, Assistant Professor, Department of Horticulture, Southern Oregon Research and Extension Center, Oregon State University; *member of the Oregon Wine Research Institute at OSU.

Response of fruit growth and composition of *Vitis vinifera* L. cv. Pinot noir to pre-and post veraison water deficits in a warm climate In progress Cody Copp (graduate student), Department of Horticulture, Oregon State University; Alexander Levin*, Assistant Professor, Department of Horticulture, Southern Oregon Research and Extension Center, Oregon State University; *member of the Oregon Wine Research Institute at OSU.

Rootstock effects on mature Pinot noir growth and productivity under cool climate, dry-farmed conditions. Patricia A. Skinkis, Department of Horticulture, Oregon State University, Corvallis, OR.

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.

Understanding symptomology and physiological effects of Red Blotch Disease in vineyards in Oregon's Willamette Valley. Patricia A. Skinkis*, Department of Horticulture, Oregon State University, Corvallis, OR, Justin Litwin (graduate student), Department of Horticulture, Oregon State University, Bob Martin*, USDA-ARS Horticulture Crops Research Lab. *member of the Oregon Wine Research Institute at OSU.

Water deficits do not improve fruit quality in Grapevine Red Blotch Virus-infected grapevines (*Vitis vinifera* L.) Completed Alexander Levin*, Assistant Professor, Department of Horticulture, Southern Oregon Research and Extension Center, Oregon State University; Achala KC, Assistant Professor, Department of Botany and Plant Pathology, Southern Oregon Research and Extension Center, Oregon State University; *member of the Oregon Wine Research Institute at OSU

Ribes:

N/A

Strawberry:

Arkansas

Row covers and planting date for strawberry production 2018-2020 (A. McWhirt).

Strawberry IPM trials and pest management observations (Cato)

Strawberry Variety Trial 2019-2020 (A. McWhirt)

Virtual Strawberry Field walk hosted April 20th, 2020 (McWhirt, Cato)

Florida

Validation of a Florida warning system to control strawberry anthracnose fruit rot, *Colletotrichum acutatum*, for less reliance on fungicide sprays by Midwest strawberry growers.

Maine

2017 Prohexadion-calcium applications for matted row strawberries. University of Maine.

Strawberry Integrated Pest Management Program. University of Maine.

Maryland

Strawberry production in low tunnels. Kim Lewers, Dave Fliesher, Craig Daughtry, Brian Vineyard, USDA, Beltsville, MD.

New Hampshire

Implementing off-season strawberry production and marketing using a long day cultivar with supplemental field lighting. Rutgers University.

Altering current recommendations for fall nitrogen application and row cover management in annual strawberry plasticulture. Rutgers University.

Advancing Strawberry Production in the Northeast. R.G. Sideman and K.M. Orde, University of NH, Durham NH; L. McDermott, Cornell Cooperative Extension, Hudson Falls NY; E Hodgdon, Cornell Cooperative Extension, Plattsburgh NY; D. Conner, University of VT, Burlington VT.

Photosensitive film, mulch color, and low tunnel effects on the day-neutral strawberry cv.

Albion. K. Orde and B. Sideman, University of NH, Durham NH; K. Demchak and R. Marini, Pennsylvania State University, State College, PA.

New York

Effects of weather, farm location and management practices on flavor development in strawberry. Cornell University.

Low tunnel cover effects on day neutral strawberries. Cornell University.

North Carolina

Evaluation of weed and pathogen control efficacy of integrated methods (Steam, AITC, heat releasing substances) over different steam time exposure. M. Hoffmann, J. Neal, S. Fennimore, E Volk. NC State University.

Impact of NO₃ - NH₄ ratio on flower production and daughter plant production in ever-bearing strawberry cultivars. IM. Hoffmann, B. Jackson, X. Shi. NC State University.

Impact of pre-plant fertilizer Nitrogen rates on Nitrogen movement in soil, plant establishment and strawberry production. M. Hoffmann, B. Jackson, A Woodley, M. Schroeder-Moreno, A. Lay. NC State University.

Impact of stolon removal rates on daughter plant production of ever-bearing strawberry cultivars. M. Hoffmann, R. Hernández, G. Fernandez, X. Shi. NC State University.

Steam in combination with AITC as non-chemical alternative to MBM. Hoffmann, S. Fennimore. NC State University.

Ontario

Efficacy of biopesticides and new miticides for cyclamen mite in strawberry. J. Renkema, AAFC; R. Hallett, University of Guelph.

Strawberry Anthracnose Fruit Rot Model Adoption. E. Pate, OMAFRA, K. Schooley, Berry Growers of Ontario.

Waiting bed plants for strawberry fruit production. E. Pate, OMAFRA; K. Schooley, Berry Growers of Ontario.

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.

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.

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.

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.

Substrate strawberry production systems for fresh market in greenhouse elevated benches (preliminary study). Javier Fernandez-Salvador, Erica Chernoh, Avery Pheil Oregon State University.

Virginia

Anaerobic soil disinfestation with different carbon dose rates mixed with yeast in annual hill plasticulture strawberry production. Authors. Danyang Liu, Jayesh B. Samtani, Charles S. Johnson, Jeffrey Derr, Virginia Tech, VA, and David Butler, Department of Plant Sciences, University of Tennessee, Knoxville, Tennessee, USA.

Influence of bacterial endophyte inoculation on strawberry yield in annual hill plasticulture production. Authors. Robert Chretien¹, Sajeewa Amaradasa¹, Chuansheng Mei¹, Scott Lowman¹, The Institute for Advanced Learning and Research, Danville, VA; Jayesh Samtani and Danyang Liu, Virginia Tech, Virginia Beach, VA.

To evaluate yield potential, season extension, and pest susceptibility of strawberry cultivars new to Virginia, in open field and high tunnel, in annual hill plasticulture production systems. Authors. Jayesh Samtani, Danyang Liu, Aman Rana, Virginia Tech, VA.

Washington

Novel production systems for improved production and disease management in strawberry. L.W. DeVetter, C. Miles, X.M. Wang, L. Tymon, WSU, Mount Vernon, WA; S. Galinato, WSU, Pullman, WA; S. Jung, Cornell University, Ithaca, NY.

Planning grant: Implementation of new technologies and improved end-of-life management for sustainable use of agricultural plastics. L.W. DeVetter, C. Miles, D. Griffin LaHue, WSU, Mount Vernon, WA; M. Flury and G. Yorgey, Puyallup, WA; H. Liu, T. Marsh, K. Englund, S. Galinato, J. Goldberger, T. Chi, M. PerezGarcia, WSU, Pullman, WA; C. Benedict, WSU, Bellingham, WA; S. Agehara, UF, Wimauma, FL, M. Bolda, University of California Extension, L. McGowen, NC State, Raleigh, NC.

Other small fruit crops:

North Dakota

Evaluation of SWD distribution and presence in small fruit somewhat unique to North Dakota. North Dakota University.

General:

British Columbia

Development of Molecular Diagnostics for Plant-Parasitic Nematodes in BC: Dr. Tom Forge, Research Scientist, Agriculture and Agri-Food Canada

Evaluating mass trapping as a tool for non-chemical spotted wing drosophila management: Allyson Kang, IPM Consultant, ES Cropconsult Ltd.

Implementing Integrated Pest Management Practices on Small-Scale Farms: Marjolaine Dessureault, Research Director, ES Cropconsult Ltd.

Improving establishment of blueberry and raspberry with non-traditional crop inputs: Dr. Eric Gerbrandt, Plant Scientist, Sky Blue Horticulture Ltd.

Managing berry root health through pathogens characterization, developing screening methods, and exploring good management options: Dr. Rishi Burlakoti, Research Scientist, Agassiz Research and Development Centre (ARDC), Agriculture and Agri-Food Canada (AAFC)

Management of soil-borne pests and diseases in raspberry and strawberry: Dr. Eric Gerbrandt, Plant Scientist, Sky Blue Horticulture Ltd.

Monitoring of arthropod pests in raspberry and blueberry germplasm: Dr. Michelle Franklin, Research Scientist, Agassiz Research and Development Centre (ARDC), Agriculture and Agri-Food Canada (AAFC)

Non-Chemical Vole Control in Berry Fields: Sofi Hindmarch, Project Coordinator, Fraser Valley Conservancy

Maine

Spotted-Wing Drosophila Survey. University of Maine.

Tarnished Plant Bug Parasitism Survey. University of Maine.

New Hampshire

Feasibility of in-ground production of fig in USDA hardiness zone5B using various winter protection strategies. NH Agricultural Expt. Station, Hatch Project NH00685. R.G. Sideman, University of NH, Durham NH.

Objective 3 - Explore the association between fruit constituents and human health impacts.

Blackberry and Raspberry:

ND. Explore the association between fruit constituents and human health impacts. Collaboration with Dr. Shetty to selectively modify and stimulate the phenolic profiles using system-based metabolic innovation and up-regulation of key defense related pathways to enhance both fruit quality and longevity during post-harvest stages for grape and blackberry.

Blueberry & Huckleberry:

NCSU. Characterized bioactive bio-accessibility in blueberry germplasm (Massimo Iorizzo in collaboration with Food Scientists and NCGR-OR). A high-throughput in vitro digestion model was developed and implemented for the first time to evaluate phenolic bioaccessibility in blueberry. Moderate genetic heritability for absolute and relative bioaccessibility was estimated for several phenolics. Acylated anthocyanin had significantly higher relative bioaccessibility. Relative and absolute bioaccessibility can be measured and used as phenotypic traits to improve delivery of phenolics in new blueberry cultivars (Molla et al., 2020b).

Elderberry: NA

Grapes:

NH. Grapes: Effects of cultivar and training system on human health-beneficial phytochemicals in seedless table grape. NH Agricultural Expt. Station, Hatch Project Acc. No. 1020314. M. Lima, A. Chandrakala, M.K. Hanlon, and R.G. Sideman, University of NH, Durham NH.

Ribes: NA

Strawberry:

USDA Beltsville. Strawberry: Title: Effects of low-tunnel production system on strawberry fruit constituents. Tianbao Yang, Kim Lewers, Craig Daughtry, USDA-Beltsville Dissemination: Dong, W., Y. Lu, T. Yang, F. Trough, K.S. Lewers, C.S. Daughtry, and Z.M. Cheng, 2019. Effect of Genotype and Plastic Film Type on Strawberry Fruit Quality and Post-Harvest Shelf Life. Int. J. Fruit Sci. <https://doi.org/10.1080/15538362.2019.1673873> Future plans: None3.

Other small fruit crops: NA

General:

Impacts:

An overarching goal of the project is to give small fruit growers needed tools to adapt to changing conditions and new challenges, thus improving food security as related to berry crop productivity and promoting farmer profitability and sustainability. Through coordinated efforts that this project encourages, as well as by providing opportunities for increased communication and contributions of knowledge, project participants continue to work towards developing and testing new germplasm and cultivars that can be grown under a range of conditions, as well as developing new cultural production techniques that provide growers additional control over growing conditions, pests, and diseases. Examples of impacts from participants in various states and presented on during this reporting period are provided below.

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

There were 16 institutions that reported activity in Objective 1. The majority of these activities were multi institutional and some were multidisciplinary. Full impact statements provided by a few institutions and are copied in their entirety. Other impacts are gleaned from reported activities.

Alabama. At Auburn University, muscadine and bunch grape cultivar trials are ongoing in cooperation with University of Georgia and the University of Arkansas for adaptation to AL and resistant to Pierce's disease.

Arkansas. The major impact of the University of Arkansas small fruit breeding effort is in plantings of released blackberry cultivars. The primocane-fruiting cultivars have had significant production now for several years and are now providing for a much-extended blackberry marketing season for domestic production. The floricane-fruiting cultivars Ouachita, Natchez and Osage are the most popular and continue to provide for high quality berries. The new releases Caddo and Ponca are expanding production also, and Ponca looks to be a big step up in consistent sweetness in berries.

British Columbia. Blueberry, raspberry and strawberry breeding activity was impacted by Covid-19 restrictions. In general greenhouse and lab activities were most impacted, but field assessments were able to be completed. In blueberry assessments, BC 14-40-158 has medium-large fruit and excellent quality. Two machine harvested raspberry cultivars one from BC and one from WSU had good yield data. BC 10-71-27 (1.55 kg/plant) was the highest yielding selection, followed by WSU 2188 (1.24 kg/plant), compared with the standard 'Chemainus' (1.04 kg/plant). Strawberry breeding has increased activity as a result of the Canadian Berry Trial Network (CBTN). The breeding program continues to conduct on-farm grower trial evaluations of existing raspberry, strawberry and blueberry cultivars and selections.

Florida. The UF strawberry varieties 'Florida Brilliance' (released 2017; 55% of acreage) and Sensation® 'Florida127' (released 2013; 35% of acreage) together make up about 90% of the 10,000 acres of strawberries grown in central Florida. Driscoll's proprietary varieties continue to be about 10% of acreage. Several multistate breeding and trialing collaborations are in place as detailed below. In terms of cultivar development and release efforts, we continue to work

collaboratively with the NCPN by sending tissue cultures of released varieties to the NC State Micropropagation unit. A collaborative germplasm exchange with Dr. Kim Lewers, USDA, Beltsville, MD, was officially established in 2020 in which crosses are being made between UF and USDA accessions to combine flavor from the USDA parents and *Colletotrichum gloeosporioides* resistance from UF parents. Gina Fernandez of NC State continues to trial our new varieties as they become available in order to provide recommendations to growers in the mid-Atlantic. Thus far the newer UF varieties flower too early in the winter in this region.

Two new UF strawberry cultivars have been released and patents applied for in July, 2020. These are detailed below. Trade names are in process. 'FL 16.78-109' (PPAF) is a new strawberry variety that produces extremely unique white-colored fruit with a pink blush. This variety will provide strawberry growers and marketers with new opportunities in retail and food service markets. 'FL 16.78-109' fruit are consistently sweet throughout the season and have a unique aroma reminiscent of apricot and pineapple. The first plants have been planted in October 2020 and limited quantities of fruit will be available in select retail markets throughout this winter. 'FL 16.30-128' (PPAF) is a new strawberry variety that is intended to complement the production of 'Florida Brilliance' and Sweet Sensation (R) 'Florida127' and give growers another variety alternative with excellent early-season yields. Fruit of 'FL 16.30-128' are medium-large sized, firm, uniformly shaped, and have exceptional color and flavor.

Maine. The University of Maine has 3 established variety trials for matted row strawberries, elderberry and grape. In addition, New variety trials for matted row strawberries, hardy northern highbush blueberries and red raspberries are being established at Highmoor Farm in Monmouth, ME. This is part of a Maine Specialty Crop Block Grant “Expanding Maine's Berry Industry to Improve Farm Profitability”.

Michigan. Michigan State University has or is developing molecular and genomic tools for blueberry and strawberry. Genomic resources for blueberry are publicly available: [Dataset](#) and [Genome Browser](#). Genomic resources for octoploid strawberry are publicly available: [Dataset](#) and [Genome Browser](#). Genomic resources for diploid *F. vesca* are publicly available: [Dataset](#) and [Genome Browser](#). Genomic resources for diploid *F. iinumae* are publicly available: [Dataset](#) and [Genome Browser](#).

North Carolina. The strawberry ‘Rocco’ is gaining popularity in midwest states. Growers are replacing ‘Sweet Charlie’ with ‘Rocco’. Estimated production for 2021 will be between 1.0 and 1.5 M plants. A multi institutional *Rubus* GWAS and GXE collaboration with the private company Pairwise and 4 other institutions (Cornell, University of Arkansas, BC Berry Breeding Program, and USDA-ARS NCGR) began in 2019.

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

Out of 22 institutions that reported on Objective 2, six gave impact statements on this objective. In general, research focussed on several areas: Evaluation of new released cultivars, improving of cultural practices to lower costs and/or improve returns of an operation, research related to pests, weeds and diseases, development of resources to be used for growers, mostly related to

new pests (e.g. SDW) or diseases (e.g. grapevine viruses).

Alabama: The fruit industry in the state of Alabama is provided new knowledge on the performance of newly released and improved small fruit cultivars and the best production practices for enhanced sustainability and profitability of high-value specialty crops.

Arkansas: Two MS students graduated in the spring of 2020 o Performance Evaluation of Four Arkansas Table Grape Cultivars Grown on Three Trellis Systems Under High Tunnels at Two Locations in Arkansas. Jose Hernandez o Determining Cluster Thinning and Storage Effects on Fruit Quality and Marketability Attributes of Arkansas Table Grapes Grown Under High Tunnel Systems. Virginia Beasley; Results from the preemergence herbicide study will be used to guide recommendations for herbicide in new blackberry plantings, including the University of Arkansas Recommended Chemicals for Weed and Brush Control and the Southeast Regional Caneberries Integrated Management Guide. Data will also be used to solicit supplemental labels and 24(c) registrations for promising herbicides in the southern region.

Maine: Recent program evaluations by growers indicate that nearly all participants have reduced pesticide applications (83%) and costs (100%) as a result of the program. Additionally, growers now time sprays in response to pest monitoring results, and most have adopted at least one non-chemical alternative pest management strategy. Over 200 Maine growers receive the spotted wing drosophila updates. Program surveys found that most growers now aware of this pest and, use this program, to access to management information.

North Carolina: Managing vigor of blackberry with prohexadione calcium: Effects on vegetative and reproductive development. We investigated use of a plant growth regulator, prohexadione calcium (P-Ca), as an alternative primocane growth management strategy of blackberry and PCa did shorten internode length but did not impact yield compared to the manual tipping treatment. Further investigation needed to determine effects on lateral branching. Kon et al. received Specialty Crop Grant (\$100,000) to support this work in 2021. Survey of single and double cropped primocane fruiting blackberries at 2 on-farm locations. Objective was to assess seasonal nutrient status in single and double cropping primocane fruiting cultivars. We found: 1). Sufficiency survey levels do not follow those of floricanes fruiting types, 2) most differences are evident between single and double cropped plants, 3) early season is not a good time for leaf sampling in sobule cropping systems, 4) June is stable for N and K, and 5) cultivars are different (so may need different recommendations). The blackberry Pest Management Strategic Plan (PMSP) was developed by 9 Universities in the southern US and is the first ever PMSP developed for blackberry in the region. The PMSP documents critical regulatory and research priorities as determined by growers and University research and Extension specialists. Grape. Development of Grapevine Virus-Testing Service for North Carolina Growers in collaboration with the Micropropagation and Repository Unit (MPRU), the Clean Plant Network and the NC State PDIC; Securement of a trunk-disease management and identification block grant for North Carolina (\$100,000). Several viticulture webinars on management, diseases, U-pick operations, reached more than 100 people; Agent training on grape cultural and pest management strategies in NC. Development of a muscadine production guide for the Southeast; Distribution of more than 100 hard copies to agents in the Southeast. COVID-19 related outreach: more than 6,000 views in April and May alone on NCSU grape portal; Development of a collaborative multi-state SCRI project on optimizing strawberry plant propagation, with the long-term aim to create tools for clean strawberry plant production; Development of integrated soil disinfestation methods with steam, collaborative effort with UC Davis (\$500,000 USDA Methyl Bromide Transition;

\$110,000 to NC State). Two virtual strawberry field days and one virtual strawberry preplant meeting, in total more than 150 participants. Agent training on strawberry cultural and pest management strategies in NC in December. COVID-19 related outreach: more than 20,000 views in April and May alone on NCSU strawberry portal;

North Dakota: North Dakota has some unique environmental challenges that must be overcome for successful small fruit production. Through germplasm enhancement and by examining practices to hastening ripening or extend the season and avoid winter injury, profitable farm diversification practices and locally produced small fruit will become available.

- **Coordination of Activities:** Major concerns of berry growers, processors, marketers and scientists will be identified and discussed, and a multistate focus will be brought to bear on priority issues. This will lead to more efficient use of public funds when developing research, teaching and extension programs to address these concerns.
- **Collaborative Research Projects:** Exchange of information and ideas, often before formal publication, is an important committee activity. The interaction of group members leads to collaborative projects, stronger grant proposals, more robust publications, and new sources of specialized information. Ideas generated from one state project can be tested regionally and nationally. Such evaluations also enable innovations to be modified for site-specific use or to fit existing technology.
- **Multi-state and Regional Germplasm Evaluation:** Multi-state efforts in germplasm evaluation are a critical part of the NCCC-212 project. Standardized evaluation protocols and multiple site evaluation (environment X genotype studies) will provide important information on adaptability and cultivar performance.
- **Information Exchange:** Members of NCCC-212 cover a range of specialized disciplines, including breeding, molecular biology, whole plant physiology, postharvest physiology, pathology, entomology, ecology, production. Members are from industry, land grant colleges, and USDA, and are from the United States and Canada. This broad spectrum of participants encourages dialogue on key issues and cross-exchange of scientific viewpoints. Committee members often participate in the Small Fruit and Viticulture working group of the American Society for Horticultural Science, and the Southern Small Fruit Workers group, which helps further extend the influence of NCCC-212 activities.

Oregon State: 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. (Skinkis; Irrigation) 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.

Objective 3 - Explore the association between fruit constituents and human health impacts.

Four institutions (out of 23) reported data for this objective. Research focused on identification and bioactivity of phytochemicals in small fruit germplasm and or under different cultural practices. At NDSU, research was conducted to modify and stimulate the phenolic profiles of grape and blackberry to enhance both fruit quality and longevity during post-harvest stages. At NCSU, research documented bio accessibility of anthocyanins in blueberry germplasm. At the USDA in Beltsville, researchers evaluated effects of production practices on strawberry fruit constituents. While in NH, the effect of training systems on grape constituents was evaluated.

Publications:

Journal Articles and Patents

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Maughan, T., B. Black, S. Yao and R. Flynn. 2019. Strawberry cultivars for the Intermountain West – research report. USU Extension, Horticulture/Fruit/2019-01.

Maughan, T., B. Black and D. Rowley. 2019. High tunnel strawberry production for early spring harvest. USU Extension, Horticulture/HighTunnel/2019-01pr.

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Christman, J. and J.B. Samtani. 2019. A survey of strawberry production practices in Virginia. Virginia Cooperative Extension Publication, SPES-150P.

Online Education

Grower course for blueberry production physiology through OSU PACE (<https://workspace.oregonstate.edu/course/online-blueberry-physiology-production-systemsmanagement>) 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)

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 Website, NWREC: <https://extension.oregonstate.edu/nwrec/berry-crops>

Berry Crops Website, College of Agricultural Sciences: <https://agsci.oregonstate.edu/berriesand-small-fruits>

A series of 5 videos "High Tunnel Structures: The Basics". <https://extension.psu.edu/high-tunnel-structures-the-basics>

DeVetter, L.W. and C.A. Miles. 2020. Plastic mulches in Small Fruit Production:
<https://smallfruits.wsu.edu/plastic-mulches/>.

Berry diagnostic tool (<https://blogs.cornell.edu/berrytool/>)

High tunnel production guide for raspberries and blackberries
(<http://www.hort.cornell.edu/fruit/pdfs/high-tunnel-brambles.pdf>)