WASHINGTON STATE UNIVERSITY

Email report to mark.hoffmann@ncsu.edu AND rhhassan@ncsu.edu by Oct. 23

1. List your research and extension projects under the official NCCC 212 objectives, emphasizing collaborative projects with other researchers. A suggested format is below.

Title Example: *Evaluation of non-chemical pre-plant soil management alternatives in strawberry.* M. Hoffmann, NC State University, Raleigh NC; S. Fennimore, UC Davis, Salinas CA. F. Louws, NC State University, Raleigh NC;

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

Blackberry and Raspberry:

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.

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.

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.

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.

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.

Strawberry:

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.

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

Blackberry and Raspberry:
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.

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.

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

Blueberry & Huckleberry:
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.

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.

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.

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.

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

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).

Strawberry:
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. Perez-Garcia, 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.

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.

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

Blackberry and Raspberry:
Blueberry & Huckleberry:
Grapes:
Elderberry:
Ribes:
Strawberry:
Other small fruit crops:

3. Include any data, gemplasm/cultivar descriptions, research results, etc. that you would like to discuss at the meeting. Please keep this brief, highlighting no more than three discussion points within 500 words. Additional information (data tables, abstracts, etc…) can be included in an appendix.

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

Blackberry and Raspberry:

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.

- Raspberry selections were planted in research plots at WSU-Puyallup in 2017 and 2018, and evaluated for yield and fruit quality for the 2nd and 1st year, respectively, in 2020. Yields and fruit size were smaller than normal for this field, probably due to delayed or missed windows for weed management caused by COVID-related restrictions on labor in 2020.
- Both selection trials will be held over a third year to capture better data in 2021.

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.

- Raspberry, blackberry, and black raspberry selections were planted in research plots in a field at WSU-Puyallup infested with *Phytophthora rubi*, the causal organism for root rot. *Rubus* plants represented advanced selections from the public breeding programs in Oregon, Washington, and British Columbia.
- Four plants of each selection and standard cultivars were planted in 2016, 2017, 2018, and 2019. In the year following planting, the plants were scored for survival. In the 2nd year, plants were rated for vigor on a scale from 0 (plant died) to 5 (vigorous plants).
- WSU 2298, ORUS 4289-4, WSU 2068, and WSU 2377 were the most tolerant red raspberry selections in the trial planted in 2017. WSU 2442, WSU 2377, WSU 2385, WSU 2603 were very tolerant in the trial planted in 2018.

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.

- ‘Cascade Premier’ was released in 2018 as an early season cultivar with a midpoint of harvest similar to that of ‘Willamette’ in Washington. It has large, firm fruit with good flavor, good yield, and fruit that machine-harvests well. WSU 2188 is an advanced selection that is recommended for release pending results of its performance in individually quick frozen (IQF) processing. The objective of this project is to compare the new cultivar ‘Cascade Premier’ and WSU 2188 with industry standard cultivars for IQF processing quality, yield, pest tolerance, and winter hardiness.
- Plantings were established in 2019 and 2020, and in the period Sept 2020-Sept 2021, plantings of ‘Cascade Premier’ and WSU 2188 will be evaluated for plant growth and vigor, pest symptoms, overall yield.
- Harvested fruit will be subjected to IQF processing and the resulting product will be evaluated for fruit quality compared with standard cultivars used for IQF.

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

Blackberry and Raspberry:

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.

- Our multi-year studies have found polyethylene (PE) mulch and biodegradable plastic mulches (BDMs) improve establishment and first-year yields compared to bare ground cultivation in spring-planted, floricane red raspberry planted as tissue culture plugs.
- PE and BDMs in fall/late-summer planted floricane raspberry planted as tissue culture transplants improves weed management, but yield is the same as bare ground cultivation.
- In-soil biodegradation that estimate BDMs deterioration was low (91% of the BDM area remained after 18 month), likely due to cool soil temperatures.

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.

- Commercial mycorrhizae did not increase raspberry growth nor impact nutrient uptake in a greenhouse experiment; growth measurements more impacted by fertilizer treatment than mycorrhizal inoculants
- Although overall colonization of mycorrhizae in roots was low, plants formed more mycorrhizae with MYKOS (Xtreme Gardening, Gilroy, CA) and Bio-Organics (Bio-Organics, LLC, New Hope, PA) than Endo-Mycorrhizae Mycorrhizal Applications, Grants Pass, OR
- A separate experiment showed some inoculants did confer some increased tolerance to Phytophtora root rot (*Phytophora rubi*), but not root lesion nematodes (*Pratylenchus penetrans*).

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

- Nitrate and calcium sap results in primocanes of ‘Meeker’ raspberry were positively correlated with tissue nitrogen and calcium, respectively, between mid-July and late Aug (15 July-25 Aug.). However, the correlation was weak (R^2=0.73; *P* value = 0.0007 for nitrate; R^2=0.41; *P* value = 0.003 for calcium).
- Potassium sap results were negatively correlated to tissue K content during the season
- Nitrate and potassium sap analysis have the potential to be used for rapid monitoring of these nutrients, but further validation is needed.

Blueberry & Huckleberry:
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.

- This is a new, specialty-crop research project
- Activities we will accomplish within the 4-year project period include: compare and conduct cost-benefit analyses of different strategies for honey bee pollination; determine pollination requirements and pollinator attraction across new and existing cultivars; determine how variable weather conditions affect blueberry pollination; develop predictive models of pollination, fruit set, and yield for development of a Pollination Planner; and deliver information on improved blueberry pollination to the industry.

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.

- Additional machine harvest trials using a modified OXBO 7440 were done in 2020 and some of these machines have been purchased by growers.
- Resultant fruit quality of the modified harvesters is generally improved compared to traditional machine harvest but is not equivalent to hand harvested fruit. Proper harvest timing and postharvest management is essential to achieve quality fresh market fruit, which is a knowledge gap among growers shifting from processed to fresh market production.
- Food safety and sanitization work of new, harvester surfaces was delayed due to the pandemic, but should be produced in 2021.

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.

- Eastern Washington is a unique blueberry growing environment with soils that are low in organic matter, calcareous, and naturally high in pH (>7.8). They also have access to different organic fertilizer sources compared to other important production regions in the Pacific Northwest. However, eastern Washington is a very important contributor to the national organic blueberry market. The industry lacks information on organic nutrient management for their unique environment and this project seeks to generate this needed information.
- Research evaluating optimal organic nitrogen fertilizer sources and rates has been ongoing since 2018. Fish emulsion, WISErganic (a liquid fertilizer made from digested food products), blood meal, and a combination of blood meal and WISErganic at 50, 100, and 150 lbs/acre N have been applied to ‘Duke’ at a grower cooperator site. No statistically

significant effects on yield nor fruit quality have been observed to date, but plants fertilized at the low rate with fish emulsion are trending to have greater yields. This experiment is ongoing.

- Another experiment assessed the timing of organic fertilizer nitrogen cut-off times in an early fruiting cultivar ('Duke'). Treatments were 100, 80, 70 or 60% of the nitrogen fertilizer (125 lbs/acre; applied as WISErganic) applied pre-harvest and the remaining 0, 20, 30, or 40% applied post-harvest. No yield nor fruit quality effects have been observed over the three years of the experiment. Cold-hardiness decreased during fall acclimation with increasing lateness of fertilizer applications, however plants remained cold-hardy to temperatures below the average monthly temperature minimums for the region.

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.

- Cold hardiness models are being developed for western and eastern Washington using 'Duke', 'Draper', 'Liberty', and 'Aurora'. Models for 'Duke' and 'Liberty' are more advanced and should be validated as a β version on WSU AgWeather Net soon. Cold hardiness work for 'Draper' and 'Aurora' is ongoing with more field assessments scheduled for winter 2020/2021.
- Relative water content may improve cold hardiness models, but validation is still underway.
- Khot and Hoheisel are working on developing a nondestructive method for sensing bud damage using hyperspectral imaging. Work is ongoing.

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

- Soil organic matter content varies from 3-60% in commercial blueberry fields in western Washington. Some growers struggle to manage fertility in these fields due to unpredictable release of nitrogen through mineralization.
- Incubation studies are underway to quantify nitrogen mineralization from histosols with varying soil organic matter content.
- Four on-farm experiments were established in 2019 in 'Duke' fields with a range in soil organic matter content (i.e., high, medium, and low). Fertilizer rate was adjusted in a randomized complete block design experiment within each site to assess plant response to these different rates within a range of soil organic matter concentrations. No yield, tissue nutrient, nor fruit quality effects have been observed to date, but work is ongoing.

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.

- Growers in eastern Washington and Oregon grow blueberry on soils with native soil pH of >7.8 and alkaline irrigation water. There is concern about effective and long-term management of soil pH for sustained production in these systems. A field project was recently established in Hermiston, OR, and is testing different methods to acidify blueberry soils. Treatments include wet and dry applications of prilled sulfur (incorporated or surface applied), micronized sulfur, and their combinations as pre- and post-plant applications.
- High soil temperatures in the region can also lead to rapid oxidation and loss of soil organic matter. Traditional sources of organic matter (Douglas fir sawdust) is also limited in availability east of the Cascade Range. However, the region has substantial amounts of grape pomace due to the grape and wine industry. A separate greenhouse experiment in Mount Vernon is testing the suitability and acidification requirements of composted grape pomace as a soil amendment in organic blueberry. Work was delayed due to the pandemic, but is ongoing.
- Biochar made from crop prunings is also being tested as a source of organic matter.

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).

- This multi-institutional project is being led by Massimo Iorizzo.
- According to the website, "*VacCAP is a nationwide coordinated transdisciplinary project focused on addressing major bottlenecks limiting the growth of the U.S. Vaccinium industry by developing and implementing marker assisted selection (MAS) capacity in breeding programs. Completing this will enable breeders to select and pyramid fruit characteristics that positively contribute to fruit quality and market value*."
- This project brings together the Vaccinium breeding community and should result in valuable knowledge, technologies, and partnerships that will accelerate and improve breeding efforts for blueberry and cranberry.

Strawberry:

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. Perez-Garcia, 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.

- This planning grant met remotely in 2020 and is working on a full SCRI proposal to test, develop, and deliver new technologies that will improve

end-of-life management of agricultural plastics with an emphasis on mulches in strawberry systems.

- The project team and in partnership with Western SARE (project led by Miles) has contributed to many extension outputs regarding end-of-life management and biodegradable plastics. Training opportunities for your stakeholders or students on biodegradable plastics are available for free. Contact Lisa DeVetter (lisa.devetter@wsu.edu) or Carol Miles (milesc@wsu.edu).
- If our pending SCRI CAP proposal is successful, we would like to partner with other institutions to deliver information about the project to undergraduate and graduate students, as they are the next generation of scientists that have opportunities to address improved management of agricultural plastics.

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.

- Biodegradable plastic mulches (BDMs) are a promising alternative to traditional plastic mulches, yet are 2-3 times more expensive. While cost savings from labor for removal and disposal are eliminated with BDMs, cost concerns nevertheless have the potential to limit adoption of this technology. In small, diverse cropping systems, double-cropping could extend the value of BDMs if the crop production and quality is maintained. We have established a field experiment where 'Albion' strawberry is being double cropped with head lettuce. Project results are pending for the first year of the trial.
- BDMs degrade on the surface, resulting in losses in tension and elasticity over time. This may impact splash dispersal of fungal and/or bacterial spores carried in rain droplets. We are testing this hypothesis through global splash dispersal studies and more refined bioassays in collaboration with a plant pathologist (Tymon) and bio-fluid mechanic scientist (Jung).

4. List retrievable or archived publications arising from your collaborative research projects including journal articles, book chapters, review articles, theses, proceedings, and extension publications. Please use ASHS style.

Peer-reviewed articles, Refereed:

Zhang, H., C. Miles, M. Flury, H. Liu, and L.W. DeVetter. 2020. Soil-biodegradable plastic mulches undergo minimal in-soil degradation in a perennial raspberry system after 18 months. Horticulturae. 6(3). doi.org/10.3390/horticulturae6030047.

Zhang, H., C. Miles, S. Ghimire, C. Benedict, I. Zasada, H. Liu, and L.W. DeVetter. 2020. Plastic mulches improved plant growth and suppressed weeds in late summer-planted floricane raspberry. HortScience 55:565–572.

Gan, W., H. Zhang, N. Bostan, and L.W. DeVetter. 2020. Pollen germination and growth rates differ among cultivars of northern highbush blueberry (*Vaccinium corymbosum*). Journal of the American Pomological Society 74: 66-75.

Zhang, H., L.W. DeVetter, E. Scheenstra, and L.W. DeVetter. 2020. Weed pressure, yield, and adhesion of soil-biodegradable mulches with pie pumpkin (*Cucurbita pepo*). HortScience. 55: 1014–1021.

Alegea, F.P., G.J. Miitoa, L.W. DeVetter, H. Tao, and P.M. Ndegwa. 2020. effects of blending dairy manure compost and canola meal on pellets quality and nutrients concentrations. Journal of Cleaner Production. *In press*.

Rudolph, L.W., I.A. Zasada, C. Hesse, and L.W. DeVetter. 2020. Effects of annual and perennial alleyway cover crops on physical, chemical, and biological properties of soil quality in Pacific Northwest red raspberry. HortScience 55:344-352.

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

Theses:
Bhasin, A. 2020. Evaluating organic nitrogen fertilizer sources, rates, and timing in northern highbush blueberry grown in high pH soils of eastern Washington. MS Thesis, Washington State University, Pullman, WA.

Zhang, H. 2020. Tissue culture red raspberry production systems with plastic mulches. PhD Dissertation, Washington State University, Pullman, WA.