December 2019

2019-2020

(FY 2018-2019 Funded Projects)

Research Progress Reports

for the

OREGON

RASPBERRY & BLACKBERRY COMMISSION

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Oregon Raspberry and Blackberry Commission
FY 2018-19 Progress Report

TITLE: Development of biologically-based RNAi insecticide to control spotted wing Drosophila

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Collaborator: Dr. Seung-Joon Ahn (Research associate), Oregon State University, Corvallis, OR,

Specific Objectives for 2018-19
1. Inject RNAi into adult flies and monitor RNAi impacts (*i.e.* mortality) on SWD.
2. Feed RNAi selected into larvae and/or adults, and monitor RNAi impacts on SWD.

Practical and Economic Impact:
The long-term goal of this research is to develop biologically-based pesticides as a chemical insecticide alternative to control SWD in berry crops and small fruits. The results will help growers improve production and fruit quality in the crop, and prevent potential development of chemical insecticide resistance.

Procedures:
Evaluate RNAi impact by injection: DsRNAs of each target SWD gene and GFP were dissolved in RNase free water and injected into adult flies using a Nanoliter injector. After injection of 20-25 flies per treatment, phenotypic changes including mortality were observed. Once we identified best RNAi target genes, feeding assays were conducted for next step.

Evaluate RNAi impact by feeding: Colony reared SWD adults were collected at two days, starved for 24hr, and then exposed to dsRNA treatments, supplemented with a 10% sucrose solution, by means of a 1.5ml moisture wick. For adult feeding assays, various dsRNA concentrations determined from the injection experiment were mixed in a fly diet. Ten flies (5 males & 5 females) were exposed to the treatment for 3-7 days inside a 50ml tube. After the treatment period, flies were moved to a bioassay cage and provided a moisture wick and a 1oz diet cup. The diet cup was replaced each day for 3 days. Mortality was monitored daily and fecundity was measured by the number of eggs laid on each diet cup.

Evaluate RNAi impact on Drosophila cells: As a pilot screening test, 10 different dsRNAs targeting housekeeping genes were synthesized and prepared in three different dosages (1 µg, 5 µg and 10 µg). S2 cells (*Drosophila* cells, Schneider 2 cells originated from *D. melanogaster*) were plated in 96-well plates with 20,000 cells per well. One day later the dsRNAs were treated into the wells and then the cell density was observed every day. Cell density was calculated as a percentage compared to the confluent density (100%). After three days, the cells were harvested and total RNA was extracted from each well. The inhibition of target gene expression by dsRNA treatment was measured by quantitative real-time PCR (qRT-PCR).

Identify genes of dsRNA degradation enzymes in SWD mid-gut: Based on the transcriptome data, two potential genes were expected for the mid-gut dsRNases, and confirmed real genes and enzyme activity through gene characterization. Using known dsRNase gene sequences from other insect such as the desert locust, two dsRNase sequences were annotated from the SWD genome database above. Full-length sequences were successfully amplified by PCR using gene specific primers.

Characterize dsRNA enzyme activity: We dissected the fly digestive tissues, and investigated potential enzyme(s), RNaseIII type enzyme which is to degrade dsRNA only. Various equivalents of mid-gut tissues were homogenated and incubated with dsRNA at 37 °C for 30 min. Then, measured the dsRNA degradation from the incubations. To verify gene expressions of the RNases in the mid-gut, quantitative (Q) or RT- PCR method were applied to measure the gene expression levels.

Results & Discussion

Injection dsRNA into SWD: Thirty two RNAi candidates were screened through 4,000 nano-injections to 20 flies per treatment with 5 replications (Fig. 1). We found effective phenotypic impacts, mainly mortality up to 60%, from some of the RNAi injection into SWD flies (Fig. 2).

Three SWD genes (SWD1, 2, &3) were selected and investigated their gene expression levels to find whether those genes are being suppressed or not after target RNAi injected into SWD. Using the quantitative gene analysis we found all three RNAi target genes have been suppressed up to 70% by dsRNA introduction to SWD flies (Fig. 2).

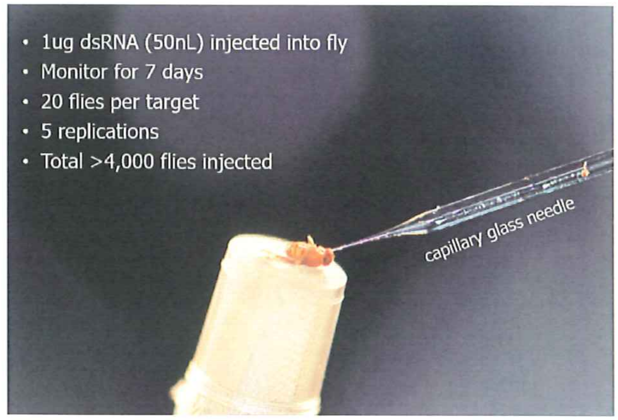


Figure 1. Photo of the nanoinjection with dsRNA into SWD adult. More than 4,000 flies for 32 SWD genes have been pre-screened for RNAi targets through nanoinjection into SWD adults. Used 20 flies per each treatment with 5 replications.

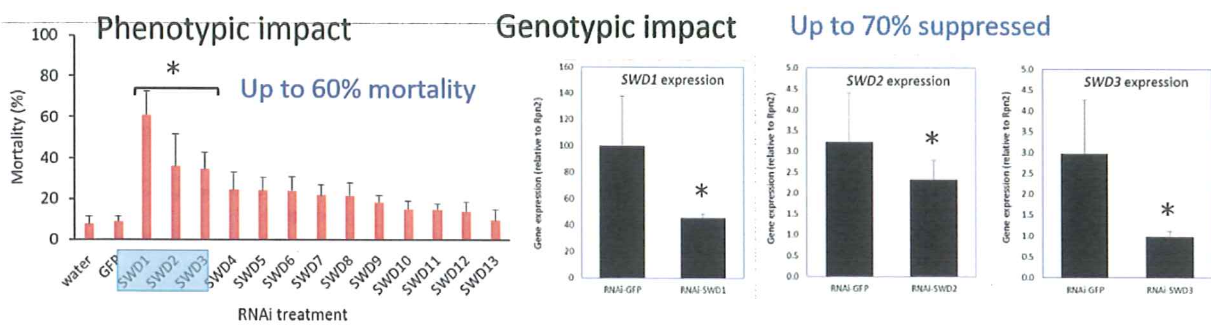


Figure 2. Survival rates of flies injected with dsRNA for 3 days (left). Each treatment was consisted with 20 flies, and replicated 5 times. Suppressions of 3 housekeeping genes expression by RNAi (right). The mRNA expression levels of SWD1, SWD2, and SWD3 at 12h after dsRNA injection. The relative expressions were compared with the RNAi-GFP as a control.

Oral administration (=feeding) of dsRNA: Flies fed dsRNA mixed diet or sprayed onto blueberries, then were monitored for the RNAi impact on the fly survival rates (Fig .3). The percentages of mortality in flies fed on the diet were not significantly different between the water control and dsRNA treatment for 7 days. Various dsRNA feeding tests with diet or blueberry also showed similar results on the fly survival rates. The female fecundity has been investigated with vitellogenin receptor dsRNA fed by flies, the egg reduction was not significant compare to the control (data not shown). The outcome results indicate SWD dsRNA ingested in the flies could be degraded in the midgut or not pass through the midgut membrane (see below).

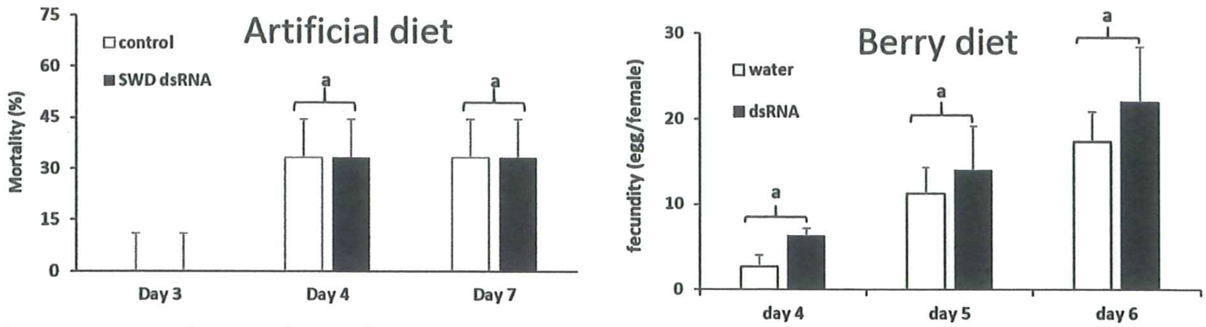


Figure 3. Survival rates of SWD fed on dsRNA mixed in the artificial diet or sprayed onto blueberries. Mortalities between control and treatment were not significantly different.

RNAi with *Drosophila* cells: Because RNAi feeding effect was limited, SWD dsRNA was directly introduced to *Drosophila* cells (Fig. 4). Among nine SWD RNAi showed significantly inhibition of cell

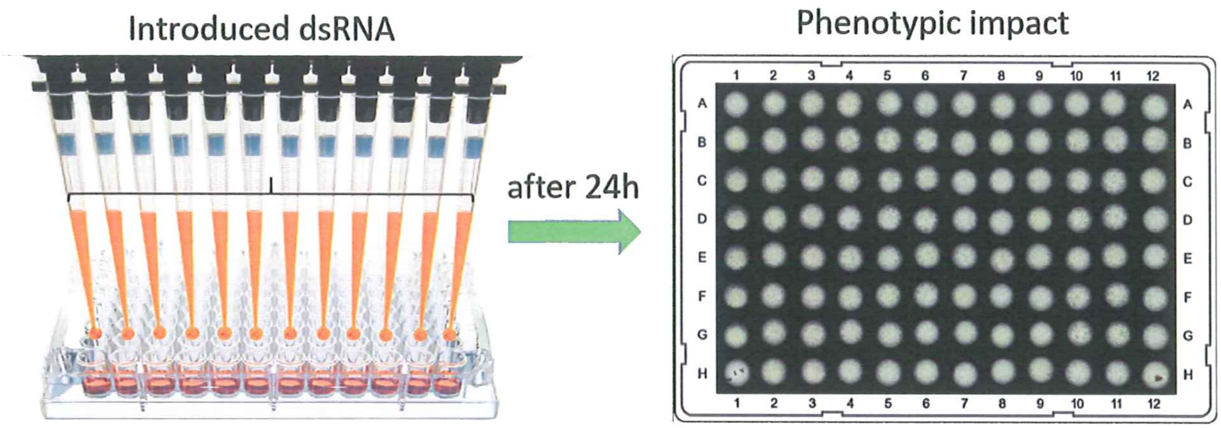


Figure 4. After various dsRNA concentrations (1, 5, or10 µg) were introduced Drosophila cells cultured 96-well plates (left), and monitored cell viability and numbers (= coverage) and target gene expression levels (right).

density (Fig. 4). Their effect on cell growth inhibition was dose-dependent, and resulted in 20% reduction of cell viability (Fig. 4).

The genotypic effects were confirmed by suppression of gene expressions after dsRNA introduction. With different dosages, the lowest dosage (1 µg) was significantly reduced expression in six targets (Fig. 5).

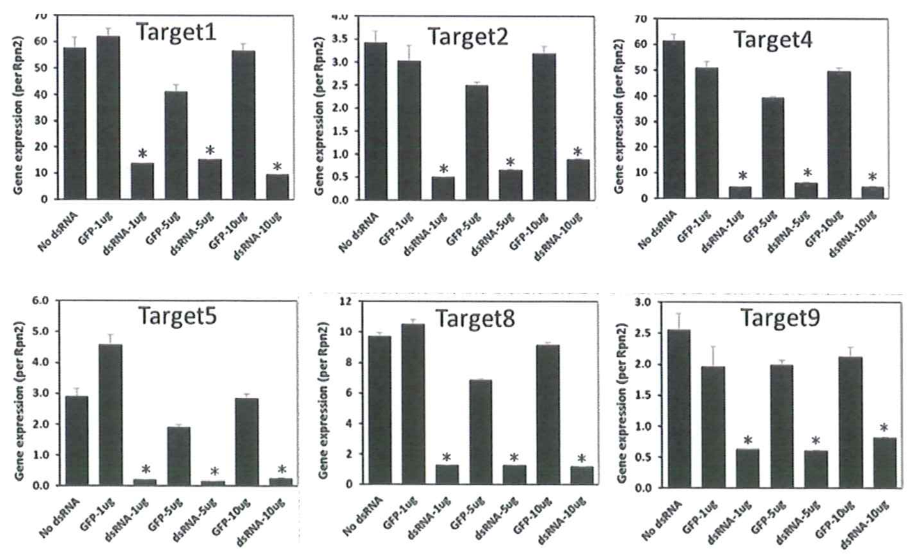


Figure 5. Genotypic effect: six RNAi genes were significantly suppressed after various dsRNAs (1-10 ug per treatment) introduced into *Drosophila* cells.

DsRNA degradation enzymes in the mid-gut: Oral administration (*i.e.* feeding) of dsRNA would be more feasible; however, the target dsRNA must survive in the mid-gut and pass into the hemolymph where it can then act on the target gene. Minimal effect of RNAi by orally delivery could be attributed to extracellular degradation of the dsRNA in the gut lumen. In order to overcome any possible obstacle in the RNAi application to SWD, it is necessary to look into the dsRNA degrading activity in SWD digestive system. Alimentary tract of *Drosophila suzukii* is consisted with fore-gut, mid-gut, and hind-gut (Fig. 6). Crop is a storage organ in the fore-gut section present only in adults.

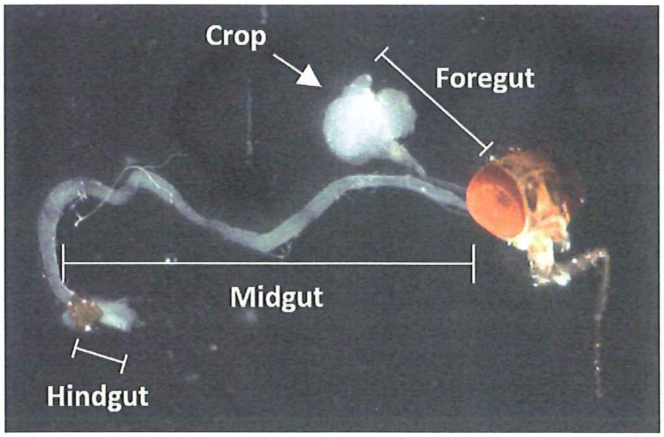
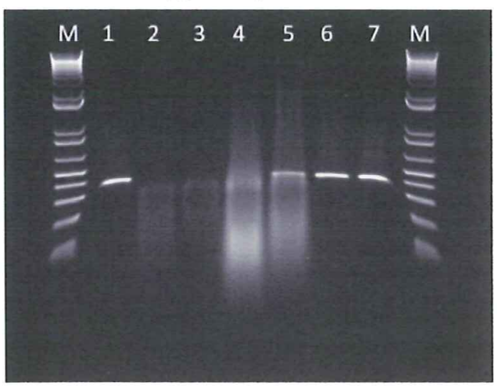


Figure 6. Alimentary tract of *Drosophila suzukii* is consisted with foregut, mid-gut, and hindgut. Crop is a storage organ in the foregut section present only in adults. The gut homogenate used in this study was prepared from mid-gut.

Surprisingly, we found activity of dsRNA degradation in the mid-gut only, not in the other digestive organs (Fig. 7). The putative dsRNA degrading activity was compared between mid-gut and crop of the SWD adult using their crude homogenates. As see the lanes 4 – 7 in the figure 2 the dsRNA has been gradually disappeared when equivalents of SWD mid-gut homogenate were increased and incubated with dsRNA. The result indicates the SWD mid-gut contains the RNaseIII type enzyme which functions to degrade dsRNA.



A. Midgut homogenate

Lane	dsRNA (140 ng)	Treatment
1	dsRNA	buffer
2	-	gut homogenate (1 gut-eq.)
3	dsRNA	RNase III
4	dsRNA	gut homogenate (10 gut-eq.)
5	dsRNA	gut homogenate (5 gut-eq.)
6	dsRNA	gut homogenate (1 gut-eq.)
7	dsRNA	gut homogenate (0.5 gut-eq.)

37 °C, for 30 min

Figure 7. Gel photo (left) of dsRNase treated with buffer only (lane 1) or gut (=mid-gut) homogenates (lanes 4 – 7) (right). The gut homogenate without dsRNA (negative, lane 2) and RNaseIII with dsRNA (positive, lane 3) were used controls.

Identification of dsRNA degradation enzymes in SWD:
We found two potential dsRNases genes from the SWD mid-gut transcriptome and genome data (Fig. 8). Then, full sequences of SWD dsRNase 1 and 2 identified showed similar with the fruit fly, but very different with the locust genes (Fig. 9).

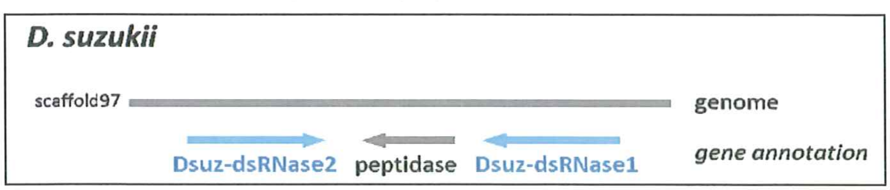


Figure 8. Two dsRNase genes, Dsuz-dsRNase1 and Dsuz-dsRNase2, found in the SWD genomic scaffold.

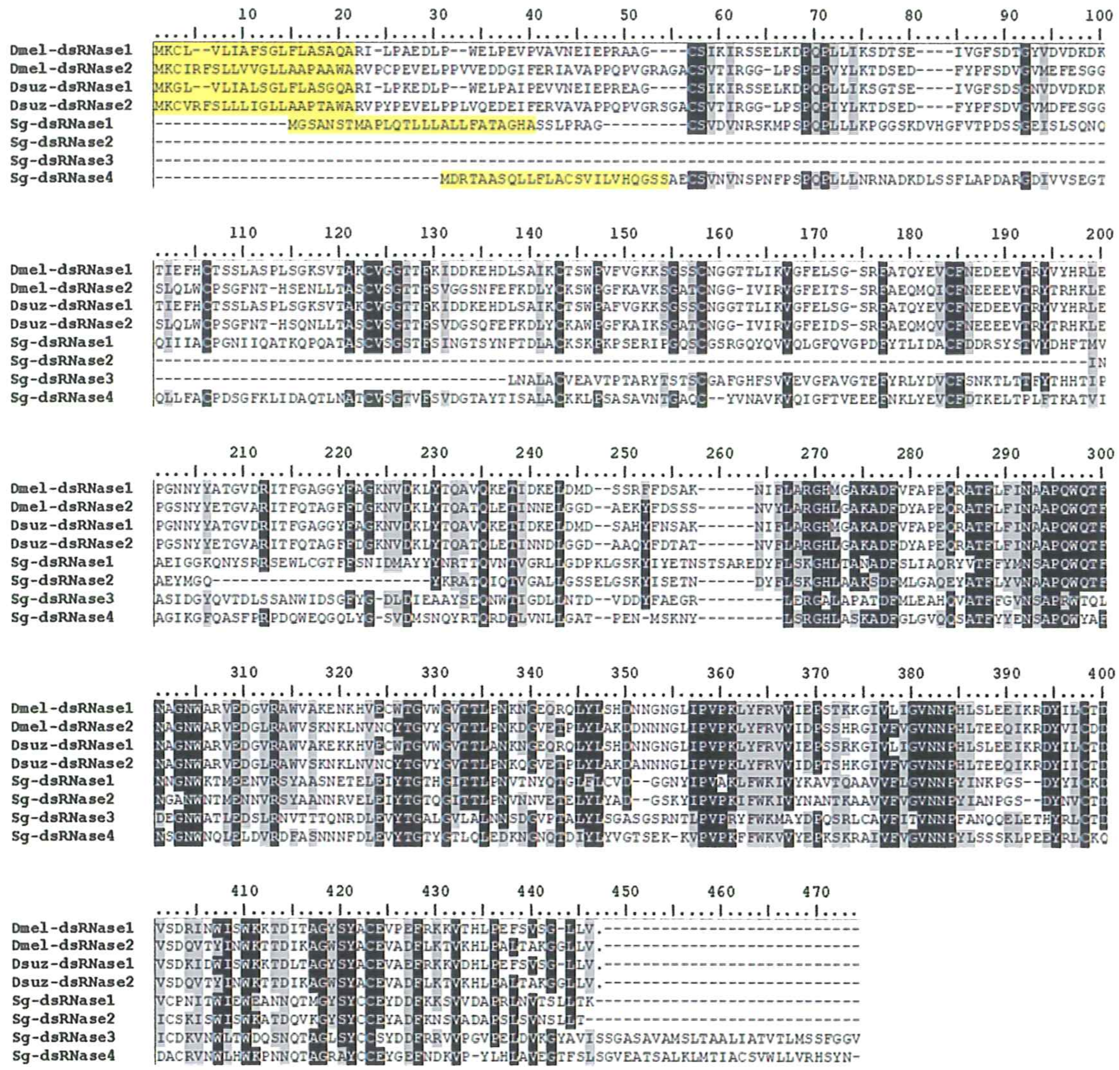


Figure 9. Multiple sequence alignment of dsRNases in SWD, *Drosophila melanogaster*, and *Schistocerca gregaria* (desert locust). Signal peptide indicated in yellow was predicted. Threshold for shading was 70% in black with identical, gray with similar and white background with normal.

Conclusion and future study for SWD RNAi

In this study we selected and screened potential RNAi targets for SWD through nanoinjection into SWD, and confirmed an RNAi effect to inhibit cell growth of *Drosophila* cells. However, oral administration of the SWD dsRNA was limited due to a partial degradation of the dsRNA in the fly mid-gut. In addition, we identified two dsRNA degradation enzymes, RNase III type enzyme, which is specialized to degrade dsRNA in the fly mid-gut. Both enzyme proteins are consisted with 424 amino acids, and being actively expressed in the mid-gut only. We confirmed the homogenate and juice of the mid-gut degrading dsRNA, then decreasing the RNAi effect to SWD.

Although RNAi technology is a promising tool for insect pest management, there are major challenges: 1) identifying suitable target gene(s); 2) developing suitable RNAi delivery; and 3) providing cost-effective dsRNA production. We have established a bacterial-based system produced a large quantity of dsRNA for the cost-effective dsRNA production (Fig. 10), and developed non-toxic sugar as a phagostimulant to enhance RNAi delivery into SWD. Therefore, more study should be focused on how to protect dsRNA arrived in the mid-gut, and to increase the delivery efficacy for SWD RNAi application in the field.

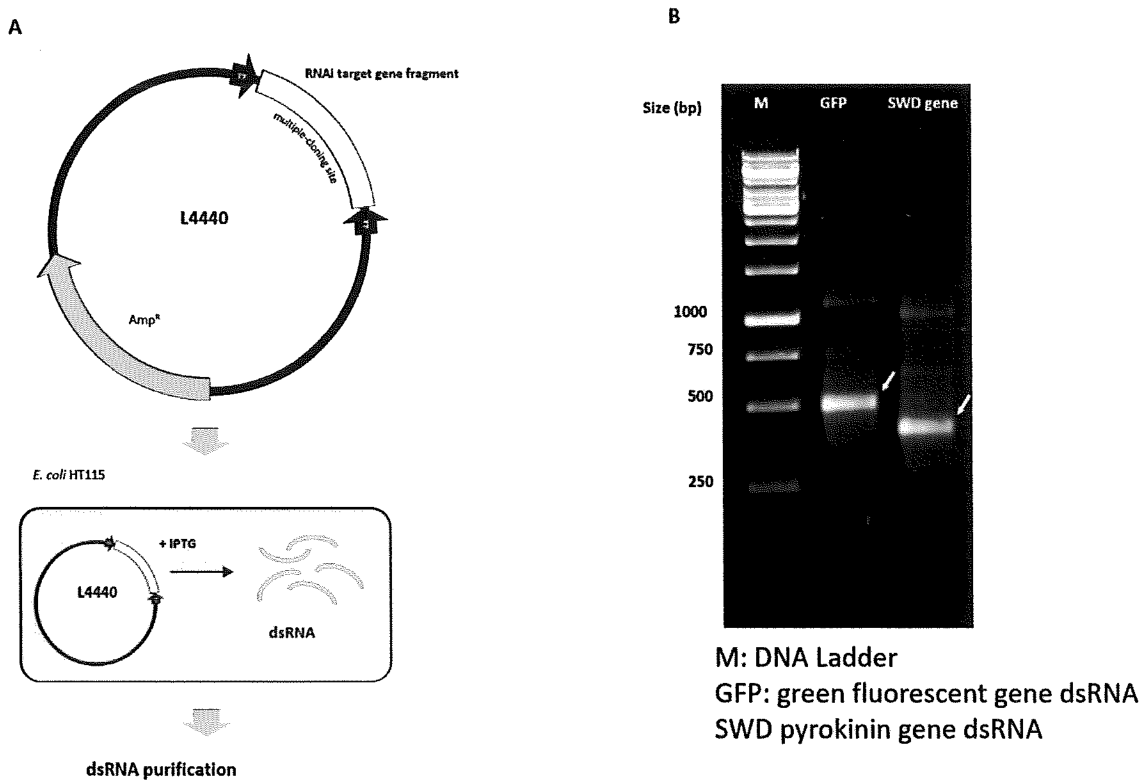


Figure 10. Schematic diagram of the bacterial-expressed dsRNA production system. (A) The target gene fragment is inserted in the multiple-cloning site between two T7 promoter regions in inverted orientation in the expression vector (L4440), which is then transformed into the RNase III-deficient E. coli strain HT115 (DE3). The double-stranded RNA (dsRNA) produced can be purified either by phenol/chloroform/isoamyl alcohol extraction or by spin-column filtration. Amp^R: ampicillin resistance gene. (B) The target dsRNAs isolated from bacterial culture were analyzed by electrophoresis. White arrows indicate the target dsRNAs. M: GeneRuler 1 kb DNA Ladder.

***Publications related in this project*:**

1. Ahn, S. J., K. Donahue, Y. H. Koh, R. Martin, M.-Y. Choi. 2019. Microbial-based double-stranded

RNA production to develop cost-effective RNA interference application for insect pest management. Int J Insect Sci. 11:1-8. 2019

2. Choi, M.-Y., J. Lee. 2019. Insecticidal compositions and methods to kill insects. Application No. 62/863,302 (pending)
3. Choi, M.-Y., H. Lucas, R. Sagili, D. H. Cha, J. C. Lee. 2019. Effect of erythritol on *Drosophila suzukii* in the presence of naturally-occurring sugar sources, and on the survival of *Apis mellifera*. J. Econ. Entomol. 112: 981–985. 2019.
4. Choi, M-Y., R.K. Vander Meer. Phenotypic effects of PBAN RNAi using oral delivery of dsRNA to corn earworm (Lepidoptera: Noctuidae) and tobacco budworm larvae. J. Econ. Entomol. 112: 434–439. 2019.

Oregon Raspberry and Blackberry Commission

Progress Report for 2018-2019 Project entitled:

Fungicide Resistance Profiles of *Botrytis* from Raspberry and Blackberry in Oregon.

Principle Investigator: Virginia Stockwell, USDA-ARS Horticultural Crops Research Unit, Corvallis, Oregon

Objective: Assess the sensitivity of *Botrytis* isolated from caneberries in Oregon in 2018 to fungicides.

Project duration: 6/1/2018 to 5/31/2019

Accomplishments:
The research project will provide important information about the fungicide resistance profiles of isolates of *Botrytis* from Oregon caneberries from the 2018 growing season and will build on previous results from the 2014 to 2017 growing seasons. In the 2018 growing season, we collected >300 isolates of *Botrytis* and will test the isolates for fungicide resistance during the winter of 2019-2020.

Materials and Methods:
Sampling in 2018: We collected asymptomatic berries from 3 raspberry fields and 10 blackberry fields in Oregon. Berries with symptoms of gray mold in fields were uncommon during sampling, but they were collected when seen. Berries were placed in storage trays, placed in an ice chest, and transported to the laboratory the same day. Berries with symptoms of gray mold were placed in individual sealed zip bags (2" X 3") and kept separate from the asymptomatic berries. In the laboratory, a sample of the spores on the rotted fruit was placed directly onto culture media to isolate *Botrytis*.

In the laboratory, we surface-disinfested each asymptomatic berry with a series of treatments of dilute bleach, dilute ethanol, and then two rinses with sterile water. In a laminar-flow hood, the berries were transferred onto grids in a sterile, closed container lined with moistened paper towels. Over a period of 7 days, fruit were scored for symptoms of rot and outgrowth of fungi. This data was collected and the incidence of gray mold infection was calculated.

The outgrowing fungi from these fruits were transferred to individual petri dishes containing ¼ PDA (potato dextrose agar) amended with streptomycin. This culture medium supports growth of *Botrytis* from fruit and suppresses growth of bacteria. Fungal isolates with a morphology similar to *Botrytis* were transferred two more times onto ¼ PDA to ensure that the isolate was clean and free of contaminants. The purified isolates of *Botrytis* were placed cryovials containing 25% glycerol and are stored in an ultralow freezer (-80°C) until they can be tested for resistance to fungicides.

Results:

The incidence of gray mold storage rot from each of the fields sampled in 2018 is presented in Table 1. The percent of berries without symptoms prior to storage that were infected by the gray mold pathogen varied among the fields from 2% to 79%. We hypothesize that the difference in disease incidence is correlated to disease management practices. Fungicide resistance profiles of *Botrytis* in various fields also may have contributed to the differences in disease incidence.

Table 1. Percent of asymptomatic berries that had gray mold when incubated in a moist chamber for one week

Field	Host or cultivar	Number of berries tested	Number of berries with gray mold storage rot	Percent disease
1	Red raspberry	39	1	3
2	Red raspberry	100	19	19
3	Red raspberry	100	23	23
Blackberries				
1	Black Diamond	105	57	54
2	Black Diamond	105	83	79
3	Columbia Star	110	28	25
4	Columbia Star	105	81	77
5	Kotata	105	7	7
6	Kotata	105	29	28
7	Marionberry	105	2	2
8	Marionberry	105	17	16
9	Marionberry	105	30	28
10	Waldo	105	2	2

To date, we have analyzed the fungicide resistance profiles of 445 isolates of *Botrytis* from Oregon caneberries that were collected from 2014 to 2017. Considering all samples, 38% of the isolates were sensitive to boscalid (FRAC 7), cyprodinil (FRAC 9), fenhexamid (FRAC 17) and iprodione (FRAC 2). Nearly 60% of the isolates were resistant to boscalid. Considering all isolates, 23% of the isolates were resistant only to boscalid, 17% were resistant to boscalid plus another fungicide, 20% were resistant to boscalid, fenhexamid and cyprodione. Multi-fungicide resistance in *Botrytis* reduces the options for effective gray mold and complicates disease- and resistance- management programs. Some growers have stopped using boscalid in favor of other chemistries of the FRAC 7 group. We will examine the fungicide resistance data from the 2018 samples for potential shifts in fungicide resistance profiles, especially in the high and low disease incidence fields.

<u>Evaluating the effects of extracts from Oregon black raspberries and blackberries to kill relevant strains of *Helicobacter pylori*.</u>

[1]Gary Stoner, [2]Candace Goodman and [1]Diane Bimczok.

[1]Department of Microbiology and Immunology, Montana State University, Bozeman, Montana 59715

[2]Department of Chemistry, Montana State University, Bozeman, Montana 59741

Helicobacter pylori is an important bacterial pathogen that causes chronic infection of the human stomach, leading to gastritis, peptic ulcer and gastric cancer. *H. pylori* infection is a key risk factor for gastric adenocarcinoma, the second leading cause of cancer-related mortality worldwide. It is estimated that at least one-half of the world's population is infected with *H. pylori*. Treatment with appropriate antibiotics can eliminate *H. pylori* infection and reduce the risk for developing peptic ulcers and stomach cancer. However, *H. pylori* is becoming increasingly resistant to antibiotic therapy, and re-infections with *H. pylori* are also common. Therefore, novel treatment strategies as well as preventive approaches are needed. Previous studies over a period of decades have demonstrated that bioactive compounds such as ellagic acid, quercetin and anthocyanins commonly present in red raspberries have antibiotic effects on a number of bacterial pathogens. In the past two years, we analyzed whole berry powder and organic extracts from black raspberries (BRB, *Rubus occidentalis*) and blackberries (BB, *Rubus plicatus*) obtained from different commercial sources and determined their antibacterial effects on multiple *H. pylori* strains, including two of the most pathogenic strains for humans. For standardization purposes, anthocyanin content of the berry preparations was measured by high-performance liquid chromatography (hplc) and spectrophotometry. We developed a high throughput assay on the OmniLog^{TM} system to monitor growth of *H. pylori* in vitro in the presence of berry preparations. We showed that 2—5% of dried BRB or BB powder or lyophilized extracts was sufficient to completely block bacterial growth. Berry preparations with a high content of cyanidin-3-*O*-rutinoside were especially potent at bacterial killing. However, when we tested BRB powder and extract for its ability to kill *H. pylori* in mice that were experimental infected with the organism by direct administration to the stomach, the berries were not effective in killing the bacterium. We think this may have been due to the fact that we treated the mice with the berries, given either in the diet (powder) or by gavage (extract), for only ten days. Currently, we are testing the possibility that longer term administration of the berry formulations may be effective in killing the bacterium. .

We next used cultured human gastric organoids infected with *H. pylori* as a primary cell infection model. Extract from black raspberries applied to the outside of the organoids significantly blocked *H. pylori* growth in the organoid lumen without negatively epithelial cell viability.

In summary, extracts and dried powders derived from black raspberries and blackberries have potent antibacterial effects against *H. pylori*, can permeate the gastric epithelium and have a low toxicity for primary human gastric epithelial cells. Our data indicate that black raspberry and blackberry products have potential applications for the prevention and treatment of *H. pylori* infection. Although not supported by the Commission, we currently have an ongoing clinical trial in Japan to determine if oral berry administration following treatment of *H. pylori* infected patients with antibiotics will resolve the residual atrophic gastritis and exhibit a regressive effect on pre-neoplastic lesions (intestinal metaplasia and dysplasia).

Progress Report to the Agricultural Research Foundation, 2019-20

Title: Cooperative breeding program - Caneberries

Principal investigators: Bernadine Strik, Professor, Horticulture
Berry Production System Research Leader, NWREC
Chad Finn, USDA/ARS Geneticist

Pat Jones & Amanda Davis, Faculty Research Assistants, NWREC
Mary Peterson, USDA/ARS Technicians

Cooperators: Pat Moore & Wendy Hoashi-Erhardt. WSU, Puyallup
Michael Dossett; Agriculture and Agri-Foods Canada
Zak Weigand, OSU, Dept. Food Science & Tech.
Bob Martin, USDA-ARS
Enfield Farms/Northwest Plants
North American Plant Co.
Northwest Plants
Oregon Raspberry and Blackberry Commission
USDA-ARS - Northwest Center for Small Fruit Research
Oregon and Washington berry growers

Objectives:

- To develop new blackberry cultivars for the Pacific Northwest that are high yielding, thornless, winter tolerant, adapted to mechanical harvesting, and that have excellent fruit quality. While the primary emphasis is on blackberries with excellent processed fruit quality, high quality fresh market cultivars will be pursued as well.
- To develop raspberry cultivars for the Pacific Northwest in cooperation with Agriculture and Agri-Foods Canada and Washington State University that are high-yielding, machine harvestable, disease/virus resistant and that have superior processed fruit quality. While the priority will be on the processed market, fresh market cultivars will be pursued as well.
- To evaluate black raspberry selections and cultivars for their adaptation to the Pacific Northwest and to develop selections that combine similar processed fruit quality to 'Munger' with greater yields and plant longevity (disease tolerance).
- To collect, evaluate and incorporate new *Rubus* germplasm into the breeding program.

Progress:

The USDA-ARS breeding program in cooperation with Oregon State University and the Pacific Northwest industry continues to develop red and black raspberry and blackberry cultivars that meet the industry stated objectives. A primary objective for the Oregon caneberry industry has been the development of thornless blackberry cultivars with outstanding flavor/processing characteristics that can be machine harvested for processing and ideally are firmer and more winter tolerant than 'Marion'. 'Black Diamond' has been the most widely planted cultivar from this effort and has been the #1 for plant sales for several years. In addition, while thorny, 'Obsidian' was released to provide different options for the blackberry fresh market. 'Columbia Star' since its release has been 2nd only to 'Black Diamond' for sales. 'Columbia Sunrise', the earliest ripening thornless blackberry we are aware of was released in 2016. In 2017, the trailing blackberry 'Hall's Beauty' and the semi-erect blackberries 'Eclipse' and 'Galaxy' were released. They will be working their way into the marketplace over the next few years. We released 'Twilight', a semi-erect blackberry, in 2019. We plan to release ORUS 4999-2 primocane-fruiting blackberry in 2020. We have been active in testing WSU and AgCanada raspberry selections to assess what is appropriate for Oregon and we were partners in the new release WSU2166 and the recent release of 'Cascade Harvest' a couple of years ago. We have several selections in machine harvest trials in northern Washington and a few of these are promising. 'Vintage' and 'Kokanee' have found some small marketing niches. We plan to release the very promising ORUS 4716-1 primocane-fruiting red raspberry in 2020. We identified several black raspberry selections for processing that we are moving to the nurseries with the goal of having quantities available for commercial trial soon. While not of great interest to commercial growers, we have a dwarf thornless trailing blackberry that the ornamental nurseries have asked us to release.

In 2019, we evaluated about 4,500 blackberry and red and black raspberry seedlings. We made 45 red raspberry (22 floricane, 23 primocane), 9 black raspberry, and 21 blackberry (11 trailing, 9 semi-erect and 1 primocane) selections. Below are the highlights of the genotypes at various stages of evaluation.

Blackberry
Cultivar Releases

'Hall's Beauty' trailing blackberry released and patented (2019)

'Eclipse' and 'Galaxy' early ripening, semi-erect blackberries released and patented (2019).
Both are early ripening with firm very good quality fruit. They are high yielding but less than 'Chester Thornless'. The fruit are medium size, black, firm, with tough skin and have better flavor than 'Chester Thornless' and have no bitter flavors. Comparing the two, 'Eclipse' is slightly earlier and the fruit are smaller, firmer, and more uniform than for 'Galaxy'. Expect these to grow wherever eastern blackberries like 'Triple Crown', 'Navaho', and 'Chester Thornless;' can be grown. In California's central valley, 'Eclipse' was more erect and vigorous than 'Galaxy'. Both have done well in fresh market storage trials. They both did not survive Quebec winters but did survive winters in Arkansas and North Carolina. 'Eclipse' was susceptible to Fusarium in North Carolina. Until recently we believed that both cultivars were ¼ western trailing blackberry and ¾ eastern erect/semierect background. DNA-fingerprinting by Nahla Bassil, disabused us of this notion. 'Galaxy' is as we expected: ORUS 1393-1 ('Navaho' x ORUS 1122-1) x 'Triple Crown'. 'Eclipse' does not have that pedigree, rather it was from ORUS 1392-1 ('Illini Hardy x Chester Thornless') x 'Triple Crown'.

'Twilight' (ORUS 4370-1) semi-erect blackberry released and patent application filed in 2018
'Twilight' is an early ripening (10d < 'Triple Crown' but later than 'Eclipse' and 'Galaxy') thornless blackberry that is ¾ eastern blackberry and ¼ western blackberry. It has outstanding fruit quality, particularly skin toughness, and a pleasant firmness along with large attractive fruit. Yield was comparable to 'Chester Thornless' in two of three years tested. Can be stored fresh for a couple of weeks with excellent quality.

To be released
ORUS 4535-1 is a dwarf, thornless blackberry for homeowner market. While a floricane type, it has short internodes and its 0.60-0.75 m (2-2.5 ft.) long canes will cascade out of containers. The fruit quality is fine but unremarkable. A patent application is being applied for.

ORUS 4999-2 is an early-ripening, high-yielding primocane-fruiting blackberry. The plants have been vigorous, productive with fruit that ripen with or earlier than 'Prime-Ark® 45'. Yield on **two-**

year-old plots were twice as high as **three**-year-old plots of 'Prime-Ark® 45' (Table BLK5). The fruit were large, firm, tough-skinned, and had a good sweet flavor. A patent application is being applied for.

Grower trials

In addition to the above, the following have been/are being propagated for grower trials

- ORUS 4024-3 **has 'Willamette' red raspberry as a grandparent.** Very attractive glossy red fruit that look like a 'Tayberry'. Picks easily and may even be machine harvestable. Wonderful flavor and commercial growers wanted it after a first look.
- ORUS 4222-1 is thornless and very high yielding, comparable to 'Black Diamond', with fruit size comparable to 'Marion'. Excellent quality for processing but want to test firmness in large-scale machine harvest trials.
- ORUS 4670-1 is a new thornless semi-erect selection that I would release immediately if not for the fact that it is based on just two year's of observation and yield in replicated trial! Excellent eating quality for a semi-erect, much better than 'Chester Thornless' and remarkably it **has had significantly greater yield than 'Chester Thornless'.** It ripens about 10 to 20 days (5% to 50% yield) ahead of 'Chester Thornless' (BLK6)
- ORUS 4663-1 is thornless and high yielding with excellent fruit quality.
- ORUS 4902-1 trailing selection has the **rare combination of extremely firm fruit with outstanding flavor**. Thornless but will not see yield in trial until 2020.
- ORUS 4928-1 is **a sterile, ornamental pink flowering semi-erect blackberry** that is of interest to cut flower growers, it is slated to go into NC State coordinated cut-flower trials in 2020

2016 Trailing Blackberry Planting (Tables BLK1 and BLK6)

- ORUS 4663-1 stood out as thornless with very good yield and large fruit.
- ORUS 4663-4 caught the fresh growers' eyes with its nearly **14 g average fruit size.** Will be put into replicated trial and at a grower site.
- While 'Columbia Star', 'Hall's Beauty' and Columbia Sunrise all had yields comparable to the high yielding 'Black Diamond'.

2017 Trailing Planting (Tables BLK2 and BLK6)

- ORUS 4892-1 was thornless with terrific yield and generally very attractive, high quality fruit. Its tendency to throw a higher than desired number of unevenly set fruit, particularly in northern Washington, was the only really concern and we will monitor this in 2020.
- ORUS 4024-3, a thorny "Tay-type" while thorny should be machine harvestable, which 'Tayberry' is not. Fresh market folks have expressed interest but hard to gauge whether that would translate into significant acreage.

2016 Semi-erect trials (Tables BLK3 and BLK7)

- ORUS 4670-1 is the most exciting semi-erect selection we have had! It had very high **yields, greater than 'Chester Thornless'** in the first year, and higher or similar in the second year. The fruit are similar in size and firmness to 'Chester Thornless' but with **much** better flavor when picked firm. While the season begins a few days later than 'Triple Crown' and 10 d ahead of 'Chester Thornless', it has a long season that extends 14 d later than the season for 'Triple Crown' and only a few days ahead of the end of the season for 'Chester Thornless'. For germplasm geeks.... ORUS 4670-1 is 1/8 *Rubus georgicus*

2016 Semi-erect trials (Tables BLK4 and BLK6)

- Several selections appeared to have outstanding yield, fruit size and fruit quality but none appeared to be better than standards or ORUS 4670-1 in first harvest season.

2016 Planted Primocane-fruiting trials (Table BLK5 and BLK6)

- Nothing appears better than 'Prime-Ark® 45'.

2017 Planted Primocane-fruiting trials (Tables BLK5 and BLK6)

- ORUS 4999-2 looks superior to all cultivars or selections we have trialed in Oregon. I**t will be named as soon as we are confident we have it in propagation**. The pedigree includes Univ. of Arkansas and N.C. State primocane fruiting germplasm. Fruit size and overall quality are excellent. Yield on **two**-year-old plots were twice as high as **three**-year-old plots of 'Prime-Ark® 45' (Table BLK5). The fruit were large, firm, tough-skinned, and had a good sweet flavor. The fruit ripen with or earlier than 'Prime-Ark® 45'. The fruit were large, firm, tough-skinned, and had a good sweet flavor.

2018 Planted Primocane-fruiting trials

- The unharvested "baby crop" on ORUS 5069-1 was excellent. The fruit were large, ripened earlier than 'Prime-Ark® 45', with very good quality.

Winter hardiness and machine harvestability evaluation

Since 2001, hundreds of our blackberry selections have been planted at Enfield Farms (Lynden Wash.), which sits on the Canadian border, to evaluate winter hardiness and machine harvestability in a commercial setting. Most but not all selections have been machine harvestable. 'Columbia Sunrise' and Hall's Beauty', 'Eclipse', 'Galaxy' and 'Twilight' and ORUS 4670-1 were scored as similar to, or much better than, 'Marion' for cold hardiness in comparable years in Lynden.

Seedlings, germplasm/cultivar development

- In 2019, we made 49 crosses (26 trailing, 16 semi-erect/erect, and 7 PF), made 11 trailing, 9 semi-erect and 1 primocane fruiting blackberry selections; and planted ~1500 seedlings.

Red Raspberry

Cultivar Releases

ORUS 4716-1, a **primocane-fruiting** selection, will be released and a plant patent applied for. ORUS 4716-1 has had yields greater than the check 'Heritage' with larger and much higher quality fruit. The fruit can be picked at a range of colors from light pink to full red and still have sweetness and a good flavor. The season starts at about the same time as 'Heritage' but it peaks and finishes about 7 d later than 'Heritage'.

Being propagated for Grower Trial

- ORUS 4371-4. **Floricane** processed. Very good yield machine harvested (MH) fruit at NWREC and Enfield's. Good winter tolerance. High quality fruit.
- ORUS 4373-1, **Floricane** processed. Good yield. Good fruit quality. Excellent root rot resistance at WSU-Puyallup. Fair yield in MH trial in Washington
- ORUS 4462-2, **Floricane** processed. Concerned with light color but very productive, winter hardy in Lynden. Machine harvests.
- ORUS 4600-1, **Floricane** processed. Promising in MH at NWREC. Very high quality. Very good yield.
- ORUS 4600-3, **Floricane** processed. Promising in MH at NWREC. Very high quality. Very good yield.

- ORUS 4607-2, **Floricane** processed. Promising in MH Trial at NWREC and Enfield's. Excellent quality. Main concern is whether fruit get crumbly too quickly.
- ORUS 4089-2, **Primocane or floricane fresh**. Looked very good in Lynden and at NWREC. Bright firm and attractive as PF
- ORUS 4487-1, **Primocane, fresh**. Very early! 10d < 'Heritage'; Concerned with yield, may be good enough for an early cultivar but not incredible.

2016 Floricane Fruiting Trial (Tables RY1 and RY7)

- Due to rose stem girdler infestation in 2017; not harvested in 2018. All harvested with Littau harvester.
- ORUS 4371-4, WSU 2130 and WSU 2088 had excellent machine harvest yields and excellent quality.

2017 Floricane Fruiting Trial (Tables RY2 and RY7)

- WSU 2188 and ORUS 4600-1 had excellent MH yields and excellent quality.

Grower and WRRC machine harvest trials planted in 2017and 2018 (Table RY3)

There was substantial winter injury in northern Washington. While many genotypes rebounded to produce better crops than expected, the following were the spring comments on winter injury:

Field 1

- Meeker; M-H (10-50 to >50% buds dead);
- Wakefield; L-H (<10 to >50% buds dead);
- **ORUS 4371-4; M 10-50% dead buds;**
- ORUS 4465-3; H>50% dead buds;
- ORUS 4607-2; H>50% dead buds;
- **ORUS 4851-1 M 10-50% dead buds;**

Field 2

- Meeker; M-H (10-50 to >50% buds dead);
- Wakefield; M 10-50% dead buds
- **ORUS 4283-2; M 10-50% dead buds;**
- **ORUS 4640-1; L < 10% dead buds;**
- **ORUS 4641-3; L < 10% dead buds;**
- **ORUS 4783-3; M 10-50% dead buds;**
- ORUS 4961-1; H >50% dead buds;

- ORUS 4371-4 had yields comparable to 'Meeker', 'Cascade Harvest' and 'Wake®Field'. ORUS 4371-4 seemed to have better winter tolerance than 'Meeker'. ORUS 4371-4 will be trialed further in grower trials. It had excellent fruit quality with firmness greater than 'Meeker', comparable to 'Cascade Harvest' but less than 'Wake®Field' or 'Wake®Haven'.

2016 Primocane-fruiting Trial (Tables RY4 and RY7)

- Because of rose stem girdler damage in 2017 we only have 2 years of yield for this trial
- The selections had some outstanding traits and yield but seemed to be more parental than cultivar material.
- While there were things to like about the 'Imara', 'Kweli', and 'Kwanza', it is hard to believe they will do well commercially in the NW. 'Imara' has a "greasy" texture, is crumbly, and is very dark. 'Kweli' fruit look a lot like 'Heritage', they were dark, crumbly, and bland. 'Kwanza' was large and bright but very crumbly, low yielding, and is very hard to pick when light colored.

2017 Primocane-fruiting Trial (Tables RY5 and RY7)

- ORUS 4716-1 was outstanding. Every fresh packer who looked at the fruit in the field was interested in trialing the selection. Yields were excellent, the fruit large, and the plants strong. The fruit were very firm and could be picked at a range of colors (and firmness levels) from light pink to fully ripe with good flavor. It will be named and released.

2018 Primocane-fruiting Trial (Tables RY6 and RY7)
- ORUS 4487-1 is early ripening and was similar to 'Polka' for yield. The main concern with it is that the fruit are often not much larger than those for 'Heritage'. While ORUS 4487-1 is one of the first to begin to ripen, its's harvest season was among the longest.
- Several selections had excellent fruit size and yield.

Evaluation of Root Rot resistance at WSU
Pat Moore at WSU has been screening raspberries in root rot trials. Based on his results he identified a range of responses to root rot. While many would appear to be susceptible, it was exciting to see some at the high end of the graph. The results:
- Probably better than 'Meeker': ORUS 4373-1
- Probably comparable to 'Meeker': ORUS 4482-3
- Probably comparable to or worse than 'Meeker': Kokanee, Lewis, Vintage, ORUS 3234-1, ORUS 4090-2, ORUS 4097-1, ORUS 4283-1, ORUS 4289-1, ORUS 4462-2, ORUS 4465-2, and ORUS 4619-1.

Seedlings, Germplasm/Cultivar development
In 2019, we made 35 crosses (18 floricane, 8 primocane), made 45 selections (22 floricane, 23 primocane), and planted ~2,500 seedlings.

Black Raspberry

Developing the Genomic Infrastructure for Breeding Improved Black Raspberries (Bushakra, Bassil, Dossett, Ju. Lee, Weber, Scheerens, Fernandez, Weiland, Ja. Lee, Finn)
Project number 2072-21220-002-04R

While this project is completed, we are further refining the markers for aphid resistance and are using the markers to screen seedlings for aphid resitance. We now have selections that have multiple sources of aphid resistance.

Grower Trial
- ORUS 3021-1 Processing. Larger than 'Munger'. Similar yield but may be more durable. Machine harvests
- ORUS 3032-3 Processing or fresh. Great size and fruit quality. Comparable yield to 'Munger'. Machine harvests.
- ORUS 3381-3 Fresh. While would work for processing, it is as late as 'MacBlack' with better fruit size and quality. Yield comparable to or slightly less than 'Munger' but starts ripening 12 d later. Will probably name
- ORUS 3409-1 produces a nice floricane and primocane crop. Excellent root rot tolerance in WSU-Puyallup trials.
- ORUS 4412-2 Processing. Excellent yield and fruit quality. Machines well.
- ORUS 4499-1 Processing. Excellent yield and fruit quality. Machines well. Excellent root rot tolerance in WSU-Puyallup trials

2015 Planted Trials (Table BLKRY5).
- Trial was not harvested. Each side of each plant in a plot was scored for its potential for a full

crop just as the first fruit ripened before the first harvest; this is represented by N in table where a genotype that had 4 reps of 3 plants would have N=24. The goal was to get some measure of durability of the genotype. The predominant stresses that might impact this score were decline due to virus, verticillium or phytophthora, and in some years, but not 2019, winter injury. The means over all plants and all plots were determined and the best genotypes presented in Table BLKRY5 for the 2015 and 2016 plantings, but not the 2017 planting as all the genotypes generally still looked great in the 2017 planting.

- ORUS 4583-1, ORUS 4553-1, and ORUS 4396-2 had good potential crop scores in 2019 and good yields in 2018 (data not presented). Compared with 'Munger', ORUS 4583-1 was the best as it had a similar potential crop score and higher yield. ORUS 4559-1 for overall quality as well as machine harvestability.

2016 Planted Trials (Tables BLKRY1, BLKRY4, and BLKRY5).

- Harvested with Littau machine harvester.
- A few had yields comparable or higher than 'Munger' with similar berry size and excellent fruit quality. Very exciting but need to see how they stand up.
- ORUS 4583-1 stood out for yield and ORUS 4559-1 for overall quality as well as machine harvestability.

2016 Planted Trials (Tables BLKRY2 and BLKRY4).

- Hand harvested all as observation plots. Rose stem girdler in 2017 caused plant vigor and size to be compromised. Should be fine in 2019.
- ORUS 4585-1, ORUS 4304-192 and ORUS 4311-1 all had sufficient quality and yield to justify targeting for full rep trial.

2017 Planted Trials (Tables BLKRY2 and BLKRY4).

- Several selections appeared to have yield that was similar to or better than 'Munger. Since most selections look good after 2 years in the field, it will take until 2021 before we can identify the selections that are most durable.
- ORUS 4820-1 was particularly interesting due to it being comparable to 'Munger' for yield and fruit size but it was 5-9 d ahead of 'Munger'. Earlier ripening would be advantageous as black raspberry fruit tends to "stick" and cannot be knocked off by machine harvester when the temperatures go over 90F, therefore an earlier ripening cultivar would be less likely to experience these temperatures.
- 'Basha' in its first year was small and had moderate yield.

2018 Planted Primocane Fruiting Trials (Tables BLKRY3 and BLKRY4)

Too early to tell but at least a couple selections may be higher yielding and earlier ripening than 'Niwot' with similar or greater size.

Seedlings, Germplasm/Cultivar development

- In 2019, we made 12 crosses, 9 selections, and planted ~500 seedlings.

Table BLK1. Fruit size and yield in 2018-19 for trailing blackberry genotypes at OSU-NWREC. Planted in 2016. All are thornless except 'Marion' and ORUS 4537-2 is a thorny, "Tay-Type" blackberry.

	Berry size (g)	Yield (tons·a^{-1})		
Genotype	2018-19	2018	2019	2018-19
2018	7.3 a			5.46 b
2019	6.9 a			6.55 a
Replicated				
ORUS 4663-1	8.6 a	7.26 a	7.31 a	7.28 a
Columbia Star	**7.5 b**	**5.57 ab**	**7.47 a**	**6.52 ab**
Black Diamond	**6.6 c**	**3.81 b**	**8.66 a**	**6.24 ab**
ORUS 4057-3	8.3 a	4.92 b	7.15 a	6.03 ab
Marion	**6.0 d**	**5.94 ab**	**4.77 b**	**5.35 b**
Hall's Beauty	**6.5 cd**	**5.37 ab**	**5.34 b**	**5.35 b**
Columbia Sunrise	**6.6 c**	**5.38 ab**	**5.14 b**	**5.26 b**
Nonreplicated				
ORUS 4535-2	5.7	6.15	3.63	4.89
ORUS 4537-2	5.2	5.17	2.81	3.99
ORUS 4663-4	13.8	3.49	3.85	3.67
ORUS 4650-1	4.3	2.35	2.64	2.49

[z] Mean separation within columns by LSD, $p \leq 0.05$.

Table BLK2. Fruit size and yield in 2019 for trailing blackberry genotypes at OSU-NWREC. Planted in 2017. All thornless except 'Marion' and ORUS 4024-3 which is a thorny, "Tay-Type" blackberry.

Genotype	Berry size (g)[z]	Yield (tons·a^{-1})
Replicated		
ORUS 4892-1	8.3 a	8.96 a
Black Diamond	**5.9 c**	**7.82 a**
ORUS 4222-1	5.3 cd	7.81 a
Columbia Star	**7.6 ab**	**7.53 a**
ORUS 4225-1	4.3 d	4.45 b
ORUS 4024-3 ("Tay Type")	7.0 b	3.49 b
Nonreplicated		
Marion	**5.8**	**5.09**
ORUS 4778-3	6.5	2.87
ORUS 4753-1	4.9	1.35
ORUS 4767-1	5.2	1.25

[z] Mean separation within columns by LSD, $p \leq 0.05$.

Table BLK3. Fruit size and yield in 2018-2019 for semi-erect, thornless blackberry genotypes in trial at OSU-NWREC[z]. Planted in 2016.

Genotype	Berry size (g)[z] 2018-19	Yield (tons·a^{-1}) 2018	2019	2018-19
2018	5.9 a			6.89 a
2019	6.6 a			4.97 b
Replicated				
ORUS 4670-1	6.5 a	8.98 a	5.09 a	7.04 a
Chester Thornless	**6.0 a**	**4.80 b**	**4.85 a**	**4.83 b**
Nonreplicated				
Triple Crown	8.6	3.53	3.50	3.52

Table BLK4. Fruit size and yield in 2019 for thornless semi-erect blackberry genotypes in trial at OSU-NWREC planted in 2017.

Genotype	Berry size (g)	Yield (tons·a^{-1})
Nonreplicated		
ORUS 4926-1	9.1	10.41
ORUS 4928-2	8.1	8.26
ORUS 4929-1	7.8	7.61
Triple Crown	**9.0**	**6.66**
Galaxy	**7.5**	**6.60**
Twilight	**9.6**	**6.47**
Chester Thornless	**6.4**	**6.03**
ORUS 4929-2	9.4	5.19
ORUS 2816-3	5.9	3.69
Eclipse	**6.9**	**2.97**

Table BLK 5. Primocane fruiting genotypes planted in **nonreplicated**, observation plots in 2016 or 2017. Harvest stopped in early October each year. All are thorny.

Genotype	Berry size (g)^{z}	Yield (tons·a^{-1})		
		2018	2019	2018-19
2016 Planted				
Prime-Ark®45	**7.4**	**3.75**	**3.19**	**3.47**
ORUS 4801-1	7.6	1.84	1.04	1.44
ORUS 4802-1	7.1	1.15	0.94	1.05
ORUS 4805-2	6.0	0.62	1.87	1.24
2017 Planted				
ORUS 4999-2	7.8		6.85	
ORUS 4939-4	9.4		2.90	
ORUS 4939-3	7.3		1.67	
ORUS 4939-6	6.2		1.36	

Table BLK6. Ripening season, date at which each genotype's yield passed the given percentage, for blackberry genotypes at OSU-NWREC.

Genotype	Type	Year planted	Harvest season 5%	50%	95%	No. yrs. in mean	Rep/ Obsv
Columbia Sunrise	**Tr**	**2016**	**17-Jun**	**22-Jun**	**2-Jul**	**2**	**Rep**
ORUS 4425-1	Tr	2017	11-Jun	25-Jun	2-Jul	1	Rep
ORUS 4753-1	Tr	2017	18-Jun	25-Jun	25-Jun	1	Obsv
ORUS 4767-1	Tr	2017	18-Jun	25-Jun	25-Jun	1	Obsv
Columbia Giant	**Tr**	**2017**	**25-Jun**	**25-Jun**	**25-Jun**	**1**	**Obsv**
Hall's Beauty	**Tr**	**2017**	**25-Jun**	**25-Jun**	**25-Jun**	**1**	**Obsv**
ORUS 4537-2	Tr	2016	18-Jun	25-Jun	6-Jul	2	Obsv
ORUS 4650-1	Tr	2016	22-Jun	29-Jun	2-Jul	2	Obsv
ORUS 4663-4	Tr	2016	25-Jun	29-Jun	9-Jul	2	Obsv
Columbia Star	**Tr**	**2017**	**25-Jun**	**2-Jul**	**9-Jul**	**1**	**Rep**
ORUS 4892-1	Tr	2017	25-Jun	2-Jul	15-Jul	1	Rep
Columbia Star	**Tr**	**2016**	**22-Jun**	**2-Jul**	**9-Jul**	**2**	**Rep**
ORUS 4663-1	Tr	2016	22-Jun	2-Jul	9-Jul	2	Rep
Hall's Beauty	**Tr**	**2016**	**22-Jun**	**2-Jul**	**13-Jul**	**2**	**Rep**
ORUS 4057-3	Tr	2016	22-Jun	2-Jul	20-Jul	2	Rep
Black Diamond	**Tr**	**2016**	**22-Jun**	**6-Jul**	**13-Jul**	**2**	**Rep**
Marion	**Tr**	**2016**	**25-Jun**	**6-Jul**	**13-Jul**	**2**	**Rep**
ORUS 4535-2	Tr	2016	29-Jun	6-Jul	13-Jul	2	Obsv
Black Diamond	**Tr**	**2017**	**25-Jun**	**9-Jul**	**15-Jul**	**1**	**Rep**
ORUS 4222-1	Tr	2017	25-Jun	9-Jul	15-Jul	1	Rep
Marion	**Tr**	**2017**	**2-Jul**	**9-Jul**	**15-Jul**	**1**	**Obsv**
ORUS 4778-3	Tr	2017	2-Jul	9-Jul	15-Jul	1	Obsv
ORUS 4024-3	Tr	2017	9-Jul	9-Jul	15-Jul	1	Rep
ORUS 4674-4	Tr	2017	15-Jul	15-Jul	15-Jul	1	Obsv
ORUS 4926-1	SE	2017	16-Jul	23-Jul	30-Jul	1	Obsv
Triple Crown	**SE**	**2016**	**20-Jul**	**27-Jul**	**3-Aug**	**2**	**Obsv**
Galaxy	**SE**	**2017**	**16-Jul**	**30-Jul**	**5-Aug**	**1**	**Obsv**
Twilight	**SE**	**2017**	**16-Jul**	**30-Jul**	**5-Aug**	**1**	**Obsv**
ORUS 4928-2	SE	2017	16-Jul	30-Jul	20-Aug	1	Obsv
Eclipse	**SE**	**2017**	**23-Jul**	**30-Jul**	**14-Aug**	**1**	**Obsv**
ORUS 4929-1	SE	2017	23-Jul	30-Jul	4-Sep	1	Obsv
ORUS 4670-1	SE	2016	20-Jul	30-Jul	17-Aug	2	Rep
ORUS 2816-3	SE	2017	30-Jul	5-Aug	20-Aug	1	Obsv
Chester Thornless	**SE**	**2016**	**27-Jul**	**10-Aug**	**20-Aug**	**2**	**Rep**
Triple Crown	**SE**	**2017**	**23-Jul**	**14-Aug**	**25-Aug**	**1**	**Obsv**
ORUS 4929-2	SE	2017	30-Jul	14-Aug	25-Aug	1	Obsv
Chester Thornless	**SE**	**2017**	**30-Jul**	**20-Aug**	**4-Sep**	**1**	**Obsv**
Primocane Fruiting							
ORUS 4802-1	PF	2016	17-Aug	24-Aug	7-Sep	2	Obsv
ORUS 4801-1	PF	2016	20-Aug	31-Aug	11-Sep	2	Obsv
ORUS 4805-2	PF	2016	24-Aug	31-Aug	3-Sep	2	Obsv
ORUS 4999-2	PF	2017	25-Aug	11-Sep	24-Sep	1	Obsv
Prime-Ark 45	**PF**	**2016**	**27-Aug**	**11-Sep**	**28-Sep**	**2**	**Obsv**
ORUS 4939-4	PF	2017	3-Sep	11-Sep	24-Sep	1	Obsv
ORUS 4939-3	PF	2017	3-Sep	17-Sep	1-Oct	1	Obsv
ORUS 4939-6	PF	2017	3-Sep	17-Sep	1-Oct	1	Obsv

[y] Tr=Trailing; SE= Semi-erect; PF= Erect primocane fruiting.

[x] Stopped harvest of PF blackberries 10/10/2016, 10/10/17, 10/1/2018, 10/8/2019.

Table RY1. Fruit size and yield in 2019 for floricane fruiting raspberry genotypes at OSU-NWREC planted in 2016. Would normally have been harvested in 2018, two years after harvest, however, due to rose stem girdler damage in 2017, we cut floricanes to the ground and had no crop in 2018. Harvested by Littau Harvester.

Genotype	Berry size (g)[z]	Yield ($tons \cdot a^{-1}$)
Replicated		
ORUS 4371-4	4.1 a	5.93 a
WSU 2130	3.2 d	5.28 ab
ORUS 4692-1	4.3 a	4.74 a-c
WSU 2088	3.5 b	4.68 a-c
WSU 2191	3.2 cd	4.53 a-c
ORUS 4690-1	3.7 b	4.49 a-c
Meeker	**2.8 e**	**4.02 bc**
ORUS 4715-1	3.5 bc	3.99 bc
ORUS 3959-1	3.5 bc	3.56 bc
WSU 2162	3.2 cd	3.04 cd
ORUS 4707-2	3.6 b	3.01 cd
ORUS 4089-2	3.0 de	1.55 d
Nonreplicated		
ORUS 4692-2	4.8	6.75
ORUS 4641-3	3.0	5.00
ORUS 4692-4	3.4	4.98
WSU 2087	3.8	4.73
WSU 2299	2.9	4.61
ORUS 4713-1	3.3	4.44
ORUS 4690-3	3.8	4.39
ORUS 4715-2	4.0	3.96
ORUS 4707-1	3.3	3.52
ORUS 4694-1	2.8	3.20
ORUS 4715-3	4.8	3.14
ORUS 4713-2	3.9	2.63

[z] Mean separation within columns by LSD, $p \leq 0.05$.

Table RY2. Fruit size and yield in 2019 for floricane fruiting raspberry genotypes at OSU-NWREC. Planted in 2017 and harvested by Littau Harvester.

Genotype	Berry size (g)[z]	Yield (tons·a^{-1})
Replicated		
WSU 2188	4.4 a	5.30 a
ORUS 4600-1	3.6 b	4.76 a
Wakefield	**2.9 c**	**4.75 a**
Meeker	**2.8 c**	**4.35 a**
WSU 1914	3.5 b	4.13 a
Nonreplicated		
WSU 2234	3.1	7.57
WSU 2088	4.0	5.56
Georgia	**3.2**	**5.47**
WSU 2421	3.5	5.09
WSU 2298	2.4	4.70
WSU 2123	3.3	4.36
WSU 2366	3.3	4.33
WSU 2299	2.6	4.31
ORUS 4851-2	3.5	4.23
ORUS 4837-2	3.3	4.17
WSU 2205	3.0	3.94
WSU 2195	4.3	3.58
ORUS 4837-1	4.1	3.53
ORUS 1154R-3	2.5	3.53
ORUS 4851-1	3.2	3.47
ORUS 3702-3	4.5	3.06
ORUS 4840-1	2.6	2.85
ORUS 4846-1	4.3	2.73
WSU 2202	2.9	2.29
ORUS 4373-1	4.0	1.93

[z] Mean separation within columns by LSD, $p \leq 0.05$.

Table RY3. Performance of standards and ORUS selections in machine harvest trials in Lynden, Washington at commercial grower fields. Planted in 2017 and 2018.

Genotype	Total yield (tons/acre) 2018	2019	2018-19	Berry weight (g) 2018	Firmness (g/mm) 2018	2019	2018-19	Brix (%) 2018	2019	2018-19	Acidity (%) 2018	pH 2018	Winter injury 2019
Lynden Grower 2017 Planted													
Meeker	**7.91**	**7.62**	**7.76**	**3.85**	**17.7**	**19.4**	**18.5**	**11.6**	**9.4**	**10.5**	**1.4%**	**3.53**	**Med-High**
ORUS 4371-4	7.46	6.98	7.22	5.83	26.0	27.0	26.5	11.3	9.0	10.2	1.9%	3.75	Med
Cascade Harvest	**6.74**	**7.52**	**7.13**	**5.86**	**21.4**	**35.8**	**28.6**	**10.1**	**9.4**	**9.8**	**1.1%**	**3.64**	**Low**
Wakefield	**3.90**	**9.64**	**6.77**	**4.10**	**33.9**	**30.6**	**32.2**	**10.7**	**10.2**	**10.5**	**2.3%**	**3.21**	**Low-Med**
ORUS 4851-1	7.46	5.23	6.34	6.54	22.8	20.6	21.7	10.6	8.4	9.5	1.4%	3.42	Med
ORUS 4607-2	6.50	5.13	5.81	4.86	21.5	23.4	22.5	10.8	8.9	9.9	1.8%	3.30	Low
ORUS 4465-3	**4.98**	**5.55**	**5.26**	**4.71**	**17.5**	**20.7**	**19.1**	**10.1**	**8.3**	**9.2**	**1.4%**	**3.48**	**Med**
Squamish	3.72	6.63	5.18	4.67	24.5	25.3	24.9	11.0	9.1	10.1	1.8%	3.27	Low
Wakehaven		11.49				41.9			9.9				Med-High
Lynden Grower 2018 Planted													
Wake®Haven		**5.7**				**40.8**			**9.8**				**Low**
Cascade Harvest		**4.8**				**30.3**			**9.7**				**Low**
Meeker		**4.5**				**19.9**			**9.5**				**Med**
Wake®Field		**4.5**				**33.2**			**10.2**				**Med**
Squamish		**3.5**				**24.0**			**8.7**				**Low-Med**
ORUS 4640-1		3.0				17.8			9.0				Low
ORUS 4641-3		2.2				19.9			9.8				Low
ORUS 4283-2		1.6				21.3			8.6				Med
ORUS 4783-3		1.4				-			9.0				Med
ORUS 4961-1		0.2				18.2			9.0				High

Table RY4. Mean yield and berry size in 2018-2019 for primocane fruiting raspberry genotypes at OSU-NWREC planted in 2016. Not harvested in 2017 due to rose stem girdler infestation.

Genotype	Berry size (g) 2018-2019	Yield (tons·acre^{-1}) 2018	2019	2018-19
Non replicated				
ORUS 4858-2	3.3	4.59	4.19	4.39
Imara	**3.4**	**4.17**	**4.33**	**4.25**
Kweli	**3.5**	**3.71**	**3.31**	**3.51**
ORUS 4874-1	3.3	4.50	2.24	3.37
Heritage	**2.2**	**2.71**	**3.55**	**3.13**
Kokanee	**3.0**	**2.57**	**2.94**	**2.76**
ORUS 4723-2	4.0	2.79	1.03	1.91
ORUS 4722-2	3.6	1.87	1.79	1.83
Vintage	**2.6**	**2.08**	**1.41**	**1.75**
Kwanza	**4.0**	**1.32**	**1.60**	**1.46**

Table RY5. Mean yield and berry size in 2018-2019 for primocane fruiting raspberry genotypes at OSU-NWREC planted in 2017

Genotype	Berry size (g) 2018-2019	Yield (tons·acre^{-1}) 2018	2019	2018-19
2018	2.5 b			1.8 b
2019	3.2 a			2.9 a
Replicated				
ORUS 4716-1	3.2 a	2.65 a	4.05 a	3.35 a
Heritage	**2.3 b**	**1.86 a**	**2.43 a**	**2.15 b**
ORUS 5005-2	3.1 a	0.92 a	2.08 a	1.50 b
Non replicated				
ORUS 5005-1	4.1	1.70	4.14	2.92
ORUS 4990-1	3.8	2.19	2.07	2.13
ORUS 4989-1	4.4	0.89	3.23	2.06
ORUS 4988-5	3.2	1.47	1.55	1.51
ORUS 5004-3	3.4	0.42	2.48	1.45

Mean separation within columns by LSD, $p \leq 0.05$.

Table RY6. Mean yield and berry size in 2019 for primocane fruiting red raspberry genotypes at OSU-NWREC planted in 2018.

Genotype	Berry size (g)		Yield ($tons \cdot a^{-1}$)	
Replicated				
Polka	**3.4**	**a**	**4.68**	**a**
ORUS 4487-1	2.4	b	4.44	a
Kokanee	**3.2**	**a**	**1.42**	**b**
Non replicated				
ORUS 4858-1	2.9		4.71	
ORUS 5114-1	4.0		4.13	
ORUS 5243-3	3.6		3.96	
ORUS 5118-1	3.1		2.71	
ORUS 5114-2	3.1		2.49	
ORUS 5109-2	3.4		2.04	
ORUS 5243-1	4.6		1.79	
ORUS 5243-2	2.6		1.78	
ORUS 4985-1	3.5		1.68	
Vintage	**3.2**		**1.30**	
ORUS 4291-1	3.2		1.20	

Mean separation within columns by LSD, $p \leq 00.05$.

Table RY7. Ripening season for floricane fruiting red raspberry genotypes at OSU-NWREC. Planted in 2016-17 and harvested by Littau Harvester in 2019.

	Year	Harvest season			No. years	Rep/
Genotype	planted	5%	50%	95%	in mean	Obsv
ORUS 4837-2	2017	11-Jun	24-Jun	8-Jul	1	Obsv.
ORUS 4692-1	2016	18-Jun	24-Jun	8-Jul	1	Rep
ORUS 4837-1	2017	11-Jun	28-Jun	15-Jul	1	Obsv.
WSU 2130	2016	18-Jun	28-Jun	15-Jul	1	Rep
WSU 2298	2017	20-Jun	28-Jun	15-Jul	1	Obsv.
ORUS 4846-1	2017	24-Jun	28-Jun	15-Jul	1	Obsv.
WSU 2191	2016	18-Jun	1-Jul	15-Jul	1	Rep
WSU 2299	2016	18-Jun	1-Jul	15-Jul	1	Obsv.
Georgia	**2017**	**20-Jun**	**1-Jul**	**15-Jul**	**1**	**Obsv.**
WSU 2299	2017	20-Jun	1-Jul	15-Jul	1	Obsv.
ORUS 4692-2	2016	24-Jun	1-Jul	15-Jul	1	Obsv.
ORUS 4713-1	2016	24-Jun	1-Jul	15-Jul	1	Obsv.
ORUS 4715-2	2016	24-Jun	1-Jul	15-Jul	1	Obsv.
WSU 1914	2017	24-Jun	1-Jul	15-Jul	1	Rep
WSU 2205	2017	24-Jun	1-Jul	15-Jul	1	Obsv.
WSU 2421	2017	24-Jun	1-Jul	18-Jul	1	Obsv.
WSU 2123	2017	20-Jun	4-Jul	18-Jul	1	Obsv.
Meeker	**2016**	**24-Jun**	**4-Jul**	**18-Jul**	**1**	**Rep**
Meeker	**2017**	**24-Jun**	**4-Jul**	**18-Jul**	**1**	**Rep**
ORUS 1154R-3	2017	24-Jun	4-Jul	18-Jul	1	Obsv.
ORUS 3702-3	2017	24-Jun	4-Jul	18-Jul	1	Obsv.
ORUS 3959-1	2016	24-Jun	4-Jul	18-Jul	1	Rep
ORUS 4371-4	2016	24-Jun	4-Jul	18-Jul	1	Rep
ORUS 4600-1	2017	24-Jun	4-Jul	18-Jul	1	Rep
ORUS 4641-3	2016	24-Jun	4-Jul	18-Jul	1	Obsv.
ORUS 4690-1	2016	24-Jun	4-Jul	18-Jul	1	Rep
ORUS 4692-4	2016	24-Jun	4-Jul	18-Jul	1	Obsv.
ORUS 4707-1	2016	24-Jun	4-Jul	18-Jul	1	Obsv.
ORUS 4713-2	2016	24-Jun	4-Jul	18-Jul	1	Obsv.
ORUS 4715-1	2016	24-Jun	4-Jul	18-Jul	1	Rep
ORUS 4851-2	2017	24-Jun	4-Jul	18-Jul	1	Obsv.
WSU 2087	2016	24-Jun	4-Jul	18-Jul	1	Obsv.
WSU 2188	2017	24-Jun	4-Jul	18-Jul	1	Rep
WSU 2202	2017	24-Jun	4-Jul	18-Jul	1	Obsv.
WSU 2234	2017	24-Jun	4-Jul	18-Jul	1	Obsv.
WSU 2366	2017	24-Jun	4-Jul	18-Jul	1	Obsv.
ORUS 4373-1	2017	24-Jun	8-Jul	18-Jul	1	Obsv.
ORUS 4690-3	2016	24-Jun	8-Jul	18-Jul	1	Obsv.
ORUS 4694-1	2016	24-Jun	8-Jul	18-Jul	1	Obsv.
ORUS 4707-2	2016	24-Jun	8-Jul	18-Jul	1	Rep
ORUS 4715-3	2016	24-Jun	8-Jul	18-Jul	1	Obsv.
ORUS 4851-1	2017	24-Jun	8-Jul	18-Jul	1	Obsv.
Wakefield	**2017**	**24-Jun**	**8-Jul**	**18-Jul**	**1**	**Rep**
WSU 2088	2016	24-Jun	8-Jul	18-Jul	1	Rep
WSU 2088	2017	24-Jun	8-Jul	18-Jul	1	Obsv.
WSU 2162	2016	24-Jun	8-Jul	18-Jul	1	Rep
WSU 2195	2017	24-Jun	8-Jul	18-Jul	1	Obsv.
ORUS 4840-1	2017	28-Jun	15-Jul	18-Jul	1	Obsv.

Table RY8. Ripening season for primocane fruiting red raspberry genotypes at OSU-NWREC. Planted in 2016, 2017 or 2018 and harvested 2018-19.

Genotype	Year planted	Harvest season 5%	50%	95%	No. years in mean	Rep/ Obsv
ORUS 4291-1	2018	30-Jul	14-Aug	20-Aug	1	Obsv.
ORUS 4988-5	2017	3-Aug	14-Aug	27-Aug	2	Obsv.
ORUS 5005-1	2017	3-Aug	14-Aug	3-Sep	2	Obsv.
ORUS 5005-2	2017	3-Aug	17-Aug	4-Sep	2	Rep
Polka	**2018**	**6-Aug**	**20-Aug**	**11-Sep**	**1**	**Rep**
Imara	**2016**	**6-Aug**	**20-Aug**	**11-Sep**	**2**	**Obsv.**
Heritage	**2017**	**14-Aug**	**20-Aug**	**11-Sep**	**2**	**Rep**
ORUS 4858-2	2016	3-Aug	24-Aug	11-Sep	2	Obsv.
Kweli	**2016**	**6-Aug**	**24-Aug**	**11-Sep**	**2**	**Obsv.**
ORUS 4874-1	2016	10-Aug	24-Aug	7-Sep	2	Obsv.
Heritage	**2016**	**10-Aug**	**24-Aug**	**7-Sep**	**2**	**Rep**
ORUS 4858-1	2018	6-Aug	27-Aug	11-Sep	1	Obsv.
ORUS 5118-1	2018	6-Aug	27-Aug	11-Sep	1	Obsv.
ORUS 4487-1	2018	6-Aug	27-Aug	24-Sep	1	Rep
ORUS 5114-1	2018	14-Aug	27-Aug	11-Sep	1	Obsv.
Vintage	**2016**	**7-Aug**	**27-Aug**	**11-Sep**	**2**	**Rep**
ORUS 4716-1	2017	14-Aug	27-Aug	15-Sep	2	Rep
Kokanee	**2016**	**10-Aug**	**31-Aug**	**18-Sep**	**2**	**Obsv.**
ORUS 4990-1	2017	14-Aug	31-Aug	22-Sep	2	Obsv.
Kwanza	**2016**	**17-Aug**	**31-Aug**	**15-Sep**	**2**	**Obsv.**
ORUS 5109-2	2018	14-Aug	3-Sep	11-Sep	1	Obsv.
Kokanee	**2018**	**14-Aug**	**3-Sep**	**19-Sep**	**1**	**Rep**
ORUS 5114-2	2018	14-Aug	3-Sep	19-Sep	1	Obsv.
ORUS 5243-1	2018	14-Aug	3-Sep	19-Sep	1	Obsv.
Vintage	**2018**	**14-Aug**	**3-Sep**	**19-Sep**	**1**	**Obsv.**
ORUS 4985-1	2018	20-Aug	3-Sep	19-Sep	1	Obsv.
ORUS 4723-2	2016	24-Aug	4-Sep	18-Sep	2	Obsv.
ORUS 4722-2	2016	24-Aug	10-Sep	22-Sep	2	Obsv.
ORUS 5243-3	2018	20-Aug	11-Sep	24-Sep	1	Obsv.
ORUS 5243-2	2018	27-Aug	11-Sep	24-Sep	1	Obsv.
ORUS 4989-1	2017	3-Sep	14-Sep	22-Sep	2	Obsv.
ORUS 5004-3	2017	3-Sep	14-Sep	22-Sep	2	Obsv.

Table BLKRY1. Yield and berry size in 2019 for black raspberry genotypes planted in replicated trial and single observation plots in 2016 at the OSU-NWREC. Due to a rose stem girdler infestation, we could not harvest replicated trial and many of the observation plots in their first year. All plots were hand- harvested.

	Berry size (g)	Yield ($tons \cdot a^{-1}$)
Replicated		
Munger	**1.3**	**2.31 a**
ORUS 4305-66	1.4	1.74 a
ORUS 4305-51	1.2	0.97 b
Nonreplicated		
ORUS 4677-1	1.3	3.18
ORUS 4304-5	1.2	3.50
ORUS 4585-1	1.2	1.95
ORUS 4304-192	1.2	1.97
ORUS 4681-1	1.3	2.19
ORUS 4679-1	0.8	2.10
ORUS 4305-74	1.0	1.45
ORUS 4686-3	0.6	0.87

Mean separation within columns by LSD, $p \leq 0.05$.

Table BLKRY2. Yield and berry size in 2019 for black raspberry genotypes planted in replicated trial and single observation plots in 2017 at the OSU-NWREC. Harvested with Littau Harvester (Stayton, OR).

Genotype	Berry size (g)		Yield (tons·a^{-1})	
Replicated				
ORUS 4833-1	1.4	de	2.94	a
ORUS 4820-1	1.2	e	2.89	a
Munger	**1.3**	**de**	**2.79**	**a**
ORUS 4401-1	1.6	bc	2.54	ab
ORUS 4942-3	1.7	b	2.26	ab
ORUS 4944-1	1.4	cd	2.22	ab
ORUS 4833-3	1.2	de	2.07	ab
ORUS 4497-1	2.1	a	2.00	ab
ORUS 4824-1	1.2	de	1.96	ab
ORUS 4411-3	1.3	de	1.91	ab
ORUS 4412-1	1.6	bc	1.64	b
Non-Replicated				
ORUS 4827-1	1.5		4.08	
ORUS 4944-2	1.3		3.82	
ORUS 3219-2	1.7		3.63	
ORUS 4825-2	1.3		3.45	
ORUS 4956-1	1.1		3.36	
ORUS 4942-4	1.6		3.28	
ORUS 4943-1	1.5		3.25	
ORUS 4833-2	0.9		3.24	
ORUS 4944-4	1.3		3.24	
ORUS 4956-2	1.1		3.20	
ORUS 4942-1	1.2		3.15	
ORUS 4818-2	1.6		2.99	
ORUS 4812-1	1.2		2.93	
ORUS 4951-1	1.5		2.91	
ORUS 4815-1	1.4		2.85	
ORUS 4809-1	1.1		2.81	
ORUS 4948-1	1.6		2.80	
ORUS 4946-1	1.7		2.79	
ORUS 4677-1	1.7		2.71	
ORUS 4952-1	1.0		2.65	
ORUS 4834-1	1.0		2.64	
ORUS 4808-1	1.5		2.63	
ORUS 4808-2	1.3		2.63	
ORUS 4835-1	1.0		2.54	
ORUS 4826-1	1.0		2.54	
ORUS 4836-1	1.1		2.39	
ORUS 4074-3	1.4		2.34	

Table BLKRY2. (continued) Harvested with Littau Harvester (Stayton, OR).

Genotype	Berry size (g)	Yield (tons·a^{-1})
Non-Replicated		
ORUS 4818-1	1.4	2.34
ORUS 4829-3	1.4	2.26
ORUS 4821-2	1.4	2.26
ORUS 4829-1	1.3	2.25
ORUS 4828-1	0.9	2.20
ORUS 4942-2	1.4	2.16
ORUS 4820-2	1.0	2.14
ORUS 3412-1	1.6	2.13
ORUS 4554-1	1.8	2.12
Basha	**1.1**	**2.12**
ORUS 4951-2	1.4	2.08
ORUS 4830-1	1.1	2.00
ORUS 3021-1	1.6	1.94
ORUS 4942-5	1.6	1.93
ORUS 3038-1	1.9	1.90
ORUS 4957-1	1.3	1.80
ORUS 4831-2	1.0	1.76
ORUS 4825-1	1.2	1.72
ORUS 4829-2	1.6	1.70
ORUS 4944-3	1.2	1.64
Mac Black	**1.5**	**1.62**
ORUS 4821-1	1.2	1.56
ORUS 4305-88	1.2	1.45
ORUS 4954-1	1.3	1.14
ORUS 4828-9	0.8	1.08
ORUS 4812-3	1.1	1.00
ORUS 4304-15	1.3	1.00
ORUS 4831-1	1.0	0.74

Mean separation within columns by LSD, $p \leq 0.05$.

Table BLKRY3. Yield and berry size in 2019 for primocane fruiting black raspberry genotypes planted in replicated trial and single observation plots in 2018 at the OSU-NWREC. Harvested by hand.

Genotype	Berry size (g)	Yield ($tons \cdot a^{-1}$)
Nonreplicated		
ORUS 4882-1	2.3	1.62
ORUS 4958-2	1.8	1.59
Niwot	**2.6**	**1.39**
ORUS 4882-4	2.6	0.89
ORUS 3409-1	2.4	0.86
ORUS 4959-1	2.1	0.84
ORUS 4882-3	2.4	0.77

Table BLKRY4. Ripening season for black raspberry genotypes at OSU-NWREC. Planted in 2016-17 and harvested 2018-19.

Genotype	Year planted	Harvest season 5%	50%	95%	No. years in mean	Rep/ Obsv
ORUS 4820-1	2017	11-Jun	20-Jun	28-Jun	1	Rep
ORUS 4305-74	2016	18-Jun	21-Jun	29-Jun	2	Obsv
ORUS 4401-1	2017	20-Jun	24-Jun	1-Jul	1	Rep
ORUS 4818-1	2017	20-Jun	24-Jun	1-Jul	1	Obsv
ORUS 4818-2	2017	20-Jun	24-Jun	1-Jul	1	Obsv
ORUS 4820-2	2017	20-Jun	24-Jun	1-Jul	1	Obsv
ORUS 4833-1	2017	20-Jun	24-Jun	1-Jul	1	Rep
ORUS 4833-2	2017	20-Jun	24-Jun	1-Jul	1	Obsv
ORUS 4836-1	2017	20-Jun	24-Jun	1-Jul	1	Obsv
ORUS 4942-1	2017	20-Jun	24-Jun	1-Jul	1	Obsv
ORUS 4942-2	2017	20-Jun	24-Jun	1-Jul	1	Obsv
ORUS 4942-5	2017	20-Jun	24-Jun	1-Jul	1	Obsv
Munger	**2017**	**20-Jun**	**24-Jun**	**8-Jul**	**1**	**Rep**
ORUS 4831-2	2017	20-Jun	24-Jun	8-Jul	1	Obsv
ORUS 4944-4	2017	20-Jun	24-Jun	8-Jul	1	Obsv
ORUS 4679-1	2016	18-Jun	25-Jun	2-Jul	1	Obsv
ORUS 4681-1	2016	18-Jun	25-Jun	2-Jul	1	Obsv
ORUS 4686-3	2016	21-Jun	25-Jun	29-Jun	2	Obsv
ORUS 4677-1	2016	25-Jun	25-Jun	2-Jul	1	Obsv
ORUS 4305-51	2016	21-Jun	25-Jun	29-Jun	2	Rep
ORUS 4304-5	2016	21-Jun	25-Jun	2-Jul	2	Obsv
ORUS 4829-2	2017	20-Jun	28-Jun	1-Jul	1	Obsv
Basha	**2017**	**20-Jun**	**28-Jun**	**8-Jul**	**1**	**Obsv**
ORUS 3021-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 3038-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4304-156	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4305-88	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4411-3	2017	20-Jun	28-Jun	8-Jul	1	Rep
ORUS 4554-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4677-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4808-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4808-2	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4809-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4812-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4812-3	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4815-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4821-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4821-2	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4824-1	2017	20-Jun	28-Jun	8-Jul	1	Rep
ORUS 4825-2	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4826-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv

ORUS 4828-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4829-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4829-3	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4831-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4833-3	2017	20-Jun	28-Jun	8-Jul	1	Rep
ORUS 4834-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4835-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4944-1	2017	20-Jun	28-Jun	8-Jul	1	Rep
ORUS 4944-2	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4944-3	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4951-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4951-2	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4952-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4956-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4956-2	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4957-1	2017	20-Jun	28-Jun	8-Jul	1	Obsv
ORUS 3219-2	2017	24-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4074-3	2017	24-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4412-1	2017	24-Jun	28-Jun	8-Jul	1	Rep
ORUS 4827-1	2017	24-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4828-3	2017	24-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4830-1	2017	24-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4942-4	2017	24-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4943-1	2017	24-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4948-1	2017	24-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4954-1	2017	24-Jun	28-Jun	8-Jul	1	Obsv
ORUS 4585-1	2016	11-Jun	29-Jun	2-Jul	2	Obsv
Munger	**2016**	**21-Jun**	**29-Jun**	**2-Jul**	**2**	**Rep**
ORUS 4304-192	2016	21-Jun	29-Jun	2-Jul	2	Obsv
ORUS 4497-1	2017	24-Jun	1-Jul	8-Jul	1	Rep
ORUS 4825-1	2017	24-Jun	1-Jul	8-Jul	1	Obsv
ORUS 4942-3	2017	24-Jun	1-Jul	8-Jul	1	Rep
ORUS 4305-66	2016	25-Jun	2-Jul	2-Jul	1	Rep
ORUS 3412-1	2017	8-Jul	8-Jul	16-Jul	1	Obsv
ORUS 4946-1	2017	8-Jul	8-Jul	16-Jul	1	Obsv
Mac Black	**2017**	**8-Jul**	**16-Jul**	**23-Jul**	**1**	**Obsv**
Primocane Fruiting						
ORUS 3409-1	2018	5-Aug	20-Aug	3-Sep	1	Obsv
ORUS 4882-1	2018	14-Aug	27-Aug	11-Sep	1	Obsv
ORUS 4958-2	2018	14-Aug	27-Aug	11-Sep	1	Obsv
Niwot	**2018**	**20-Aug**	**3-Sep**	**11-Sep**	**1**	**Obsv**
ORUS 4882-3	2018	20-Aug	3-Sep	11-Sep	1	Obsv
ORUS 4882-4	2018	20-Aug	3-Sep	11-Sep	1	Obsv
ORUS 4959-1	2018	20-Aug	3-Sep	11-Sep	1	Obsv

Table BLKRY5. Durability; each plant was scored in 2019 just as the fruit were beginning to ripen from each side of the row for the perception of the percent potential crop. The plants were primarily unhealthy due to virus, phytophthora, or verticillium. The highest scores for the trials planted in 2015 and 2016 are presented.

Genotype	Potential crop (%)	N
2015 Planted		
Munger	**77.5**	**24**
ORUS 4553-1	70.8	24
ORUS 4583-1	65.0	24
ORUS 4396-2	63.1	23
ORUS 4549-2	60.0	6
ORUS 4583-2	57.9	24
ORUS 4559-1	57.5	24
2016 Planted		
ORUS 4686-1	98.3	5
ORUS 4677-1	97.5	4
ORUS 4585-1	95.0	6
ORUS 4304-5	91.7	6
ORUS 4679-1	91.7	6
ORUS 4686-3	88.3	6
ORUS 4305-66	88.3	24
ORUS 4304-192	83.3	6
ORUS 4680-1	81.7	6
ORUS 4305-74	80.0	6
ORUS 4681-1	80.0	6
ORUS 4305-44	75.0	6
ORUS 4305-51	71.3	24
ORUS 3808-2	68.6	12
Munger	**64.5**	**22**
ORUS 4179-1	63.3	24
ORUS 4311-1	57.3	20

RESEARCH REPORT
TO THE
OREGON RASPBERRY AND BLACKBERRY COMMISSION
AND THE
AGRICULTURAL RESEARCH FOUNDATION
2018-2019

Title: **Evaluation of processing quality of advanced caneberry breeding selections**

Investigator: Zak Wiegand, Senior Faculty Research Assistant
Food Science & Technology, OSU

Cooperators: Chad Finn, USDA/ARS, Center for Small Fruits Research
Pat Moore, Washington State University

Objectives:
1. Evaluate advanced blackberry and raspberry breeding selections from NWREC and USDA for objective attributes related to processing potential
2. Process samples of advanced selections, selected field crosses, and standard varieties for display to and evaluation by breeders and the industry

Project Duration: July 1, 2018, through June 30, 2019

Funding for 2018-2019: $ 8731

Results:

I have taken over the processing and evaluation of caneberries from Brian Yorgey as of the beginning of 2019 and the processing season was successful!

Processing:
Caneberry varieties and selections from plots at the North Willamette Research and Extension Center were sent to the OSU Department of Food Science & Technology Pilot Plant for analysis and processing from June 16 to September 11, 2019. During the 2019 season the following numbers of genotypes were processed and analyzed:

<u>Blackberries</u> – 6 processing cultivars, 13 ORUS processing selections, 5 fresh market floricane fruiting cultivars, 7 ORUS fresh market floricane fruiting selections, 1 fresh market primocane fruiting cultivars, 7 ORUS fresh market primocane fruiting selections
<u>Red Raspberries</u> – 7 processing cultivars, 23 ORUS processing selections, 4 primocane/fall fruiting cultivars, 20 ORUS primocane/fall fruiting selections, 16 WSU primocane/fall fruiting cultivars.
<u>Black Raspberries</u> - 4 cultivars, 62 ORUS selections

Evaluations:
Samples were displayed at the OSU/NCSFR Research Evaluation in November 2019 and will be displayed at the ORBC Commission Research meeting in December 2019.

Chemistry:
Chemistry data (°brix, pH, and TA) are being compiled and analyzed and will be provided with the final report.

Black Raspberry Puree Evaluation:

In March 2019, I presented purees of nine black raspberry selections from our breeding program along with Munger as the standard to growers, processors, and researchers in a blind evaluaton. Sixty-three people participated.

Results:

Overall Quality
Four selections scored in the highest tier: ORUS 3381-3, ORUS 4499-1, ORUS 4410-1, and ORUS 4559-1. Munger scored the lowest.

Aroma
Munger and all the selections were rated as equivalent.

Color
Munger and all the selections were rated as equivalent.

Flavor
The four highest rated selections were ORUS 3381-3, ORUS 4412-2, ORUS 4499-1, and ORUS 4559-1. Munger scored the lowest.

Discussion:

Comparing the results from the 2016 puree evaluation to the 2019 puree evaluation, Munger consistently the lowest scoring cultivar when there are differences noted in blind tastings.

Oregon Raspberry & Blackberry Research Report 12-12-19

Project Title: Evaluating Rose Stem Girdler's Impact on Oregon Caneberries and Informing Growers of the Pest's Status

Principal Investigators:

- **Tom Peerbolt, Northwest Berry Foundation**
- **Co-PI:** Justin O'Dea WSU ANR Unit (Vancouver, WA)

Note on including Southwest Washington State in the proposal: The area that appears to be most severely affected by RSG is in SW Washington. Fields identified there were the first originally diagnosed with RSG impacts in 2014. Including this portion of the region is highly applicable to understanding the geographic spread patterns of RSG deeper into the greater Willamette Valley and its threat to farms in OR farms contracted with berry growers in SW WA.

In addition, the WSU Extension person in Vancouver, Justin O'Dea, has been instrumental in the RSG work done to this point.

Including SW Washington State: 1) maximizes project continuity; 2) makes best use of our available research resources; 3) includes field sites where collection of galls is most economic; and 4) enables valuable observation/evaluation of this pest's impact on mature raspberry and blackberry fields.

Rationale/ Justification:

In 2017 and 2018 the rose stem girdler (*Agrilus cuprescens,* RSG*)* damaged many raspberry and blackberry fields in Western Oregon and SW Washington. This insect girdles canes, causing dieback and yield loss. Initial field survey and lab work funded by the Oregon Raspberry and Blackberry during the 2018 season answered some of the basic RSG questions regarding the economic risks and management considerations. The work done last season also served to bring into focus those aspects of this pest that still need to be better understood by growers for them to be able to minimize the overall risk of economic damage to a given field as well as the expenditure of resources needed to manage that risk.

RSG was first reported in Utah caneberries in 1955, spread to Northeastern Oregon by 1994, and was identified in Washington State in 2014. The insect's recent spread and the abundance of wild hosts (including wild blackberries) are indications of a high potential for increased economic damage to the region's raspberries and blackberries.

The 2018 survey funded by ORBC of representative Willamette Valley fields found RSG present in many fields with mild to severe damage. Newly planted fields and thin-caned raspberry cultivars appeared to be most affected. Some of the unanswered questions coming out of last year's work are:

- A majority of RSG galls collected in 2018 didn't have any RSG present. Was this due to parasitism, translaminar insecticide efficacy, inadequate collection methods, and/or other causes?

- Many of the blackberry canes with an RSG gall but lacking a viable larva were still very productive. Does this indicate that more economic damage could be done by cane removal in some cases?
- Two species of suspected parasitoids were recovered in 2018 sampling. How large a factor is naturally occurring parasitism in limiting RSG damage?
- Adult emergence in 2018 was around the first week in June right after the major blackberry cultivars had finished blooming. This was much later than anticipated- our current best estimates of emergence timing are based on data from Utah. How much does adult emergence vary from year to year?
- Newly planted fields that receive no insecticide applications appear to be most susceptible to economic damage from RSG. Assuming that a blanket recommendation to treat all newly planted fields is not practical, how can the risk level be determined that would indicate the need for treating a new field to prevent RSG damage?

The 2019 project's main objective is to answer some of these questions and to gain a better understanding in general of this pest's lifecycle in western Oregon. A second major goal is to alert growers to RSG's real-time status in-season when steps can be taken to manage it.

2019 Results:

- RSG galls were collected in Spring in much greater numbers from fields in Oregon and SW Washington. Over 150 galls were collected from each state and delivered to the WSU Vancouver station for incubation.
- The incubation of the galls found highly variable rates of parisitation in different regions. Most parasitoids were identified as belonging to the genus *Baryscapus*.
- Real-time seasonal pest status updates for the industry were included in the commission-sponsored, Small Fruit Update newsletter as appropriate during the spring and summer of 2019.
- Adult emergence timing was recorded in the field (May 24th was the earliest) as well as in the lab from the incubated galls. The last week in May through the second week in June was the recorded emergence window.
- A fact sheet was produced and distributed at the various caneberry field days as well as attached and posted with the Small Fruit Update newsletter.

Small Fruit Update: Annual Audience Report

Oct 2018 – Oct 2019

The SFU, Small Fruit Update, is released via email weekly during the majority of the year, shifting to bimonthly for a handful of months in the winter. Subscribers have grown to a total of **1,432 people with 74% of subscribers highly engaged**, reading each week.

Of the subscribers:

- 218 are in BC, 66 in California, 582 in Oregon, 364 in Washington, 167 Located elsewhere in North America and 35 are located outside North America.
- 713 are growers, 555 are industry members, and 164 are public researchers
- Of growers who reported what they produce: 238 Blackberry, 524 Blueberry, 178 Strawberries, 268 Raspberry

While the newsletter *primarily targets regional producers and processors*, it is regularly *forwarded to buyers to boost sales*. Our readership count is artificially low, as we are unable to directly track readership outside subscription.

In Addition to email, NBF has been experimenting with disseminating the Small Fruit Update through various social media platforms-

Facebook:
The NW Berry Foundation Facebook page was primarily created to feed people back to the NW Berry website, so this page was never officially announced. People using the Facebook platform searched and found our page using the terms "NW Berry Foundation" and "berry u-picks." In July of 2019 it was recognized that this small audience (**90 followers**) bookmarked our page for instant updates. The majority of our current Facebook followers are *produce farmers, berry growers, and regional food service organizations.* Beginning July 2019, the SFU was unofficially released via Facebook. Between July and October, the typical issue received **50 views (Max of 109 views, min of 21 views)**. If this method moves from pilot to a formalized release, it's *expected that readership growth will continue to skew towards producers* because 100% of new followers have been regional farms.

Twitter:
Beginning in September 2019, a NW Berry Foundation Twitter account was established to provide an addition outlet for quickly releasing berry news and the Small Fruit Update. In two weeks of operation, we gained **170 twitter followers** who found our feed on their own. Multiple news and event postings have been retweeted including conference announcements, berry research articles, and ag policy news. The quality of followers is high with retweets from the Packer and WSU/OSU professors and likes primarily from graduate students and industry researchers. It is expected that Twitter followers will continue to *skew more towards small fruit researchers*, but there is a slow current of industry and food service nonprofits following our feed. In this same window there was an uptick (**30 people**) in SFU subscribers from our website. More data is needed to draw meaningful conclusions, but new subscribers were *graduate students and national agriculture news media channels*.