December 2017

2017-2018

(FY 2016-2017 Projects)

Research Progress Reports

for the

OREGON

RASPBERRY & BLACKBERRY COMMISSION

Table of Contents

Progress Report to the Oregon Raspberry & Blackberry Commission

TITLE: Development of Biologically-based RNAi insecticide to control Spotted Wing Drosophila

Principle Investigators: Man-Yeon Choi, USDA-ARS Horticultural Crops Research Unit, Corvallis, OR, Phone office 541-738-4026, e-mail mychoi@ars.usda.gov

Collaborators: Dr. Jana Lee – Research Entomologist, Dr. Robert R. Martin – Research Plant Pathologist (Virologist), USDA-ARS Horticultural Crops Research Laboratory, Corvallis, OR,

Relationship to Commission Research Priorities: Prevention and Management of Spotted Wing Drosophila and other insect pests

Year Initiated: 2015 **Current Year:** 2018 **Terminating Year**: 2019

Summary of Funding (FY 2016-17)

Funding Breakdown	Requested	Funded
OBC	$10,000	$10,000
WBC	$10,000	$0
ORBC	$10,000	$10,000
WRRC	$10,000	$0
Total budget	**$40,000**	**$20,000**

Objectives:

1. Select thirty genes in SWD from neurohormones and receptors involved in critical physiological functions during larval development and in the adult, and other genes involved in essential cellular activity (Yr. 1) – completed
2. Identify target genes from SWD, and design dsRNA sequences of these genes and green fluorescence protein (GFP) as a control gene (Yr. 1 &2) – completed
3. Inject RNAi into adult flies and monitor RNAi impacts (*i.e.* fecundity or mortality) on SWD (Yr.2 &3) – partially completed & continuing
4. Feed RNAi selected into larvae and/or adults, and monitor RNAi impacts on SWD (Yr. 3 & 4) – proposed

Specific Objectives – **Year 1-2**

1. Select thirty genes in SWD from neurohormones and receptors involved in critical physiological functions during larval development and in the adult, and other genes involved in essential cellular activity.

2. Identify target genes from SWD, and design dsRNA sequences of these genes and green fluorescence protein (GFP) as a control gene.
   Inject RNAi into adult flies and monitor RNAi impacts (*i.e.* fecundity or mortality) on SWD (Yr.2 &3).

Materials and Developed Methods - Year 1-2

Selection and identification of candidate genes for SWD RNAi targets - A feasible approach for

RNAi target gene screening is to search previous targets or systems observed already from same or similar insect groups. Based on our RNAi experience, knowledge and previous RNAi reports, we will select 11 potential candidates including neuropeptide hormones, receptors and housekeeping genes for SWD RNAi target(s). We employed a BLAST search with the published *D. suzukii* genome (http://spottedwingflybase.oregonstate.edu) and a PCR-based strategy to identify homologous genes in SWD.

Design and Synthesis dsRNA (= RNAi material) - Using routine molecular biology skills and software, specific primers set with 5'-T7 promoter appended (TAATACGACT CACTATAGGG) will be designed to amplify partial lengths between 200- 400 nucleotides of the each target gene found in the SWD genome data. Amplified actual nucleotides of the genes, then cloned into an appropriate vector for sequencing. Once confirmed the sequence DNA fragments were served as the templates for dsRNA synthesis using a dsRNA synthesis kit. The negative dsRNA control (dsGFP) was also constructed by the same method described above for SWD.

Evaluate RNAi impact(s) on development of SWD: DsRNAs of each target SWD gene and GFP will be dissolved in RNase free water and injected into pupal stages of SWD using a Nanoliter injector. After injection of 20 flies per treatment, phenotypic changes will be monitored. SWD will be monitored for negative impacts including mortality, longevity, fecundity and other parameters (development of progeny, activity). Once we identify best RNAi target genes, feeding assays will be conducted.

Result and Discussion – Year 1-2

1. Identification of RNAi candidate genes from SWD: We identified DNA sequences for 11 candidate genes, designed and synthesized 11 dsRNAs (Table 1).

Table 1. SWD RNAi candidates from three different groups and GFP, and nucleotide lengths of dsRNAs.

RNAi candidates	DNA template for RNAi synthesis	Gene group
SWD ID1	296 nucleotides	Neurohormone
SWD ID2	195 nucleotides	Neurohormone
SWD ID3	399 nucleotides	Hormone receptor
SWD ID4	244 nucleotides	Housekeeping
SWD ID5	253 nucleotides	Housekeeping
SWD ID6	255 nucleotides	Housekeeping
SWD ID7	253 nucleotides	Housekeeping
SWD ID8	250 nucleotides	Housekeeping
SWD ID9	251 nucleotides	Housekeeping
SWD ID10	254 nucleotides	Housekeeping
SWD ID11	254 nucleotides	Housekeeping
GFP	350 nucleotides	unrelated gene as a control

Select RNAi candidate genes → Identify actual genes from SWD → Design DNA templates →

Construct dsRNA (RNAi material) → RNAi bioassay in SWD → Evaluate RNAI impacts on SWD

Figure 1. Outline of the screening process of RNAi targets to

We found some genes identified in this study were very different from those sequences published on the SWD genome data, indicating a wrong annotated or uncompleted the SWD genome that should need to be confirmed actual sequences for each target genes. The length of dsRNA for

SWD ID2 was designed a short because the size corresponds roughly to full sequence (~200 base pairs). SWDID3 is a receptor for a neuropeptide hormone functioning to egg development in the female SWD.

Eight housekeeping genes as constitutive genes are expressed in all cell types at a level that does not fluctuate with the cell cycle. Functional examples of housekeeping genes for RNAi targets are related in the muscle physiology, detoxification, ATP metabolism, protein sorting and transporting, and cell membrane structure in cells. These genes have been selected for RNAi candidates to develop RNAi-based control for insect pests.

3. Initial screening of 13 potential RNAi targets: During two years the 1st screening with over 20 RNAi candidates was completed with over 2,000 nano-injections to flies. We found effective phenotypic impacts, mainly mortality, from some of the RNAi injection into SWD flies (Figs. 2 & 3).

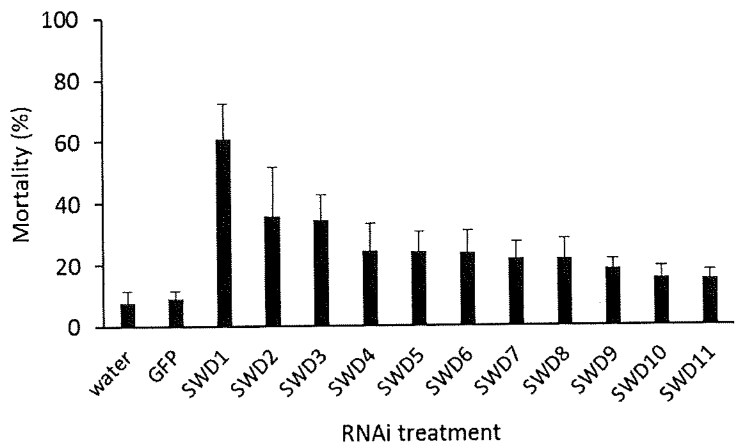
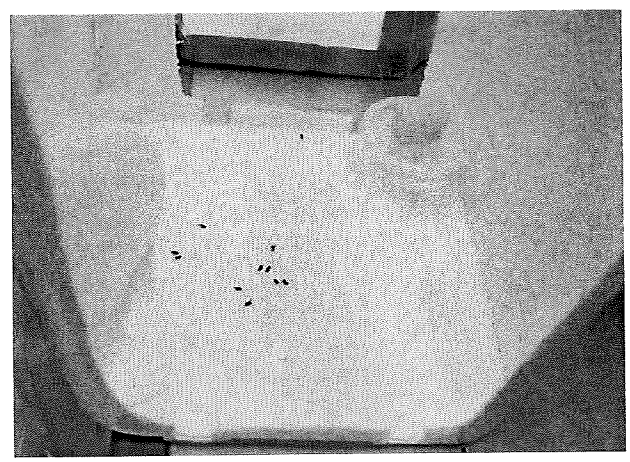


Figure 2. Mortality of SWD adult flies after injected dsRNA (1µg/fly) within 48h. Twenty flies were used with 3 replications at least for each RNAi target.



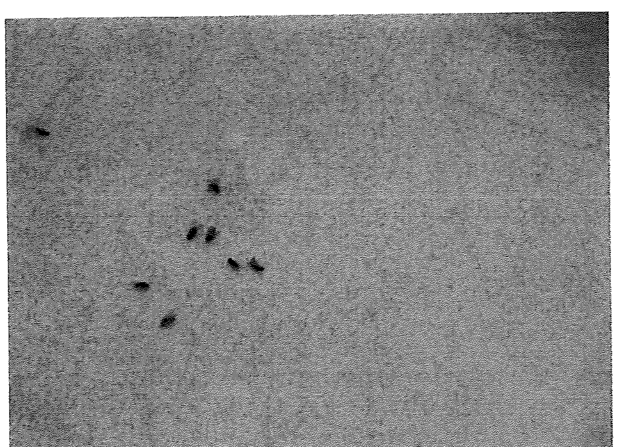


Figure 3. Photos of dead SWD adults after RNAi treatment within 48h.

Then, three most effective RNAi candidates have been selected for further genotypic test that is quantitative PCR (qPCR) analysis for the gene expression after RNAi injection (Table 2).

Table 2. Primers used in the qRT-PCR experiment for the target gene expression in *D. suzukii* that was injected with dsRNA.

Target gene	Primer name	Sequence (5' - 3')	Length (bp)	Product size (bp)
Rpn2	DsRpn2-qF	TCAGCGGCAACTTCTCCTTT	20	103
(reference gene)	DsRpn2-qR	CGCGAGATATTCAGCTCCTCA	21	
SWD1	DsSWD1-qF	CTGCCAGCAGCTCCTCGT	18	141
	DsSWD1-qR	TCTCGTGAATGCCGCAAGCT	20	
SWD2	DsSWD2-qF	TCCTCTGCAAGCTGAAGGAG	20	118
	DsSWD2-qR	ATGGTGAAGATGGCCAGGAC	20	
SWD3	DsSWD3-qF	TCCAAGAGCTACGTGTTCCG	20	117
	DsSWD3-qR	GTAGGTGCACTCCAGCAGAC	20	

4. Genotypic impact of the potential RNAi targets

We investigated the gene expression levels to find whether those genes are being suppressed or not after target RNAi (dsRNA) injected into SWD. Using the quantitative gene analysis we found all three RNAi target genes have been knock downed by dsRNA introduction to SWD (Fig. 4).

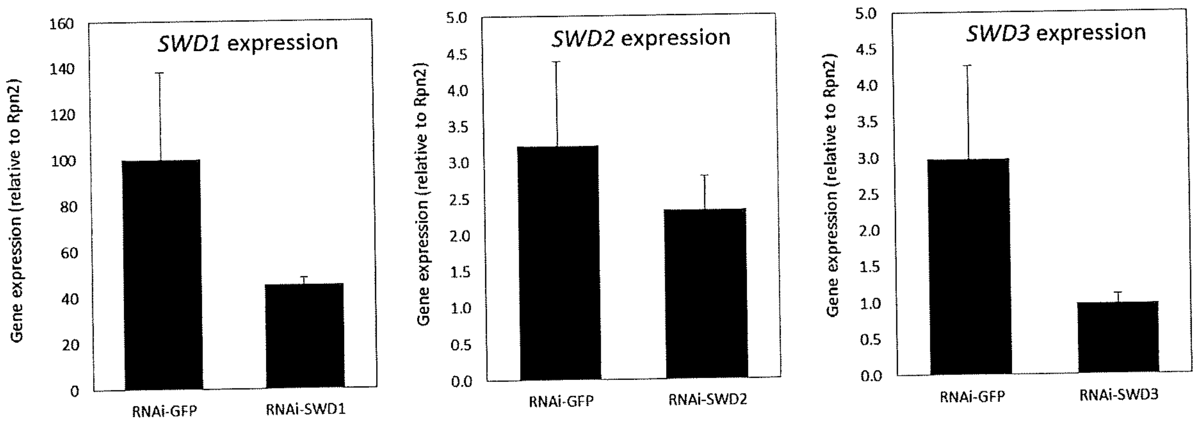


Figure 4. Knock-down of target gene expression by RNAi. Messenger RNA expression levels of *SWD1*, *SWD2*, and *SWD3* were compared between RNAi-GFP and RNAi-target in *D. suzukii* 12h after dsRNA injection of *SWD1*, *SWD2*, *SWD3*, and *GFP*. Gene expression estimates are given per a copy of mRNA for the reference gene *Rpn2*.

Continue and ongoing study

If funding is continued for next year we will complete the evaluation of Objective 3: Inject RNAi into adult flies and monitor RNAi impacts (*i.e.* fecundity or mortality) on SWD (Yr.2 &3), and keep to move for Objective 4: Feed RNAi selected into larvae and/or adults, and monitor RNAi impacts on SWD (Yr. 3 & 4).

Report to the Agricultural Research Foundation

for the Oregon Raspberry and Blackberry Commission

Title: Caneberry Pesticide Registration, Tracking, and New Chemistries

Principal Investigator: Joe DeFrancesco
Oregon State University
North Willamette Research and Extension Center

Funding Period: 2017-2018

Progress:

I. We continue to keep track of pesticide issues affecting the Oregon caneberry industry. Each week, I monitor the published US Federal Register, which is the official venue for notices and actions relating to pesticide registrations at EPA, and follow-up on any issues that may affect the Oregon caneberry industry. Some new US-registered caneberry pesticides are quick to obtain an MRL in foreign markets, while others are slower and still in progress. I continue to work with the USDA-Foreign Agricultural Service and pesticide registrants to get tolerances (MRLs) established for caneberries in foreign markets.

II. The Pesticide Registration Update Chart I develop for caneberry growers and field representatives is updated at least three times a year, most often prior to the ORBC annual meeting, in spring prior to the growing season, and at the NWREC Caneberry Field Day. Growers and other industry representatives indicate this list is widely used as a reference for pest management decisions. I also develop and distribute a list of MRLs (maximum residue levels) for caneberries in the US, Canada, Japan, the EU/UK, Korea, Taiwan, and Codex (international). This helps growers and processor/packers develop a pest management spray regime based on the anticipated destination of their fruit.

III. We communicate with representatives of the caneberry industry and continue to identify and prioritize pest management gaps and needs, which may be created by the loss of currently registered pesticides. The ORBC is kept updated on important pesticide issues via grower meetings, ORBC meetings, newsletters, or personal communication

IV. ***New Pesticide Registrations - 2017:***
The residue and efficacy data we generated and submitted to EPA for review allowed the registration of the following products in caneberries:

(1) Chateau SW (flumioxazin). A pre-emergence herbicide with some post-emergence activity. Will control both broadleaf and grass weeds. Caneberries currently appear on a supplemental label for the SW formulation, and do not appear on the Chateau WDG label.

(2) Alion (indaziflam). Mainly pre-emergence herbicide but has some post-emerge activity. Effective in controlling broadleaf weeds, such as cow thistle, horseweed, purslane, smartweed, and vetch, and some grass weeds.

(3) Sivanto Prime (flupyradifurone). An insecticide for control of aphids and other soft-bodied, piercing/sucking insects. It is also know to provide suppression of thirps. Sivanto is foliar applied and considered bee-safe. Caneberries appear only on the Sivanto Prime label and not on the Sivanto 200 SL label.

(4) Kenja (isofetamid). A fungicide that is very effective in controlling Botrytis fruit rot and powdery mildew. Kenja is in FRAC #7, as is Luna Tranquility and Pristine, but recent testing reveals that Botrytis isolates from OR and WA berry fields show no resistant, as is the case with some currently registered fungicides.

(5) Orondis Gold 200 (oxathiapiprolin). A new active ingredient for control of Phytophthora root rot. For resistance management, Orondis Gold 200 is to be used only in a mixture with Ridomil (mefenoxam), and is currently being sold as a co-pack with Ridomil. In 2018, Syngenta will market the product as a pre-mix (oxathiapiprolin + mefenoxam).

(6) Prolivo (pyriofenone). A new fungicide, in FRAC U8, with preventative and curative properties that is effective in controlling powdery mildew.

V. *Pending Registrations:*

(1) Fusilade (fluazifop-butyl). Fusilade is currently registered for use in non-bearing caneberry fields. The new registration that is pending will allow use in bearing fields; a 1-day PHI has been requested. EPA established a tolerance in September 2017 which allows Syngenta to issue a new label that will include bearing caneberries. We are now waiting for Syngenta to issue a label.

VI. *Impacts and Benefits of this Project:*

The registration of safe and effective pest management solutions helps growers produce a high quality crop, remain economically viable, and enables them to be competitive in the national and international marketplace. Providing growers and the caneberry industry with current information about pest management and pesticide issues helps them be up-to-date and better informed as they make important pest management and marketing decisions that affect their operation. In addition, the registration of new chemistries, with unique modes of action, helps reduce the likelihood of the development of resistance and increase the chances of successful pest management.

Report to the Agricultural Research Foundation
for the Oregon Raspberry and Blackberry Commission

Title: Insecticide Degradation for Oregon Blackberries

Principal Investigator: Joe DeFrancesco
Oregon State University
North Willamette Research and Extension Center

Funding Period: 2016-2017

I. *Objective:*

The objective of this project was to develop residue degradation curves for several insecticides and miticides commonly used in caneberry production, which would enable a grower to apply a pesticide and harvest fruit for export with the confidence that the residue level would meet the standards of the importing country.

II. *Progress:*

A field trial was conducted in a field of 16-year old 'Marion' blackberry plants located at OSU's North Willamette Research and Extension Center in Aurora, OR, to determine pesticide residue levels of 12 different active ingredients found in pesticide products commonly used by Oregon blackberry growers. Experimental design was a randomized complete block with four replications of 6-plant plots for each treatment. The blackberry planting consisted of plants in rows 10 feet apart, with plants spaced 6 feet apart within the row. Similar field trials, using the same protocol, were also conducted in a red raspberry planting at NWREC, and in a raspberry planting in Washington, conducted by WSU colleague, Bev Gerdeman. Results from all three field sites are reported.

Treatments for the blackberry trial were applied on June 20, 2016 with a CO_2 backpack sprayer equipped with a 3-nozzle boom (TeeJet 110-02vs) at 40 psi, delivering 50 gal/A water, with the spray solution directed to both sides of each plant row in two passes. All treatments were mixed with non-chlorinated well-water; the tank mix solutions were well mixed and agitated prior to, and during, application. Fully mature, ripe berries were present at the time of application. All plots were drip-irrigated twice per week, delivering about one inch of water per week. The first rainfall after application was on 23 Jun to (0.4 inches). Precipitation records for the entire period of the experiment can be found in the Appendix.

Fruit was sampled at 1, 3, 5, 7, 10, 14, and 21 days after the 20 Jun application, changing gloves between treatments to reduce risk of contamination. After each sample was harvested, to maintain integrity, it was placed in a zip-lock plastic bag and put into a cooler with blue ice in the field. After the last sample collection was completed on each sample date, the samples were transported to, and placed in, a 0°F freezer within 20 minutes. Frozen berry samples were placed on ice and transported by vehicle to Synergistic Pesticide Laboratory in Portland, Oregon, for residue analysis.

Treatment List:

Active ingredient	Trade name	IRAC	Rate (lb ai/A)	Rate (product/A)	USA PHI (days)
Treatment #1 (T1). A tank mix of the following products:					
acequinocyl	Kanemite 15SC	20B	0.3	31.0 fl. oz.	1
bifenthrin	Brigade 2EC	3A	0.1	6.4 fl. oz.	3
carbaryl	Sevin 4F	1A	2.0	64 fl. oz.	7
hexythiazox	Savey EW	10A	0.1875	24.0 fl. oz.	3
imidacloprid	Admire Pro	4A	0.1	2.8 fl. oz.	3
spinetoram	Delegate WG	5	0.09	6.0 oz.	1
Treatment #2 (T2). A tank mix of the following products:					
cyantraniliprole	Exirel (not registered)	28	0.133	20.5 fl. oz.	3
fenpropathrin	Danitol 2.4EC	3A	0.3	16.0 fl. oz.	3
hexythiazox	Savey 50DF	10A	0.1875	6.0 oz.	3
malathion	Malathion 8F	1B	2.0	32.0 fl. oz.	1
spinosad	Success	5	0.09	6.0 fl. oz.	1
zeta-cypermethrin	Mustang MAXX	3A	0.025	4.0 fl. oz.	1

Harvest Dates:

June 20 (prior to application; sample from all plots)
June 21 (1-day PHI)
June 23 (3-day PHI)
June 25 (5-day PHI)
June 27 (7-day PHI)
June 30 (10-day PHI)
July 4 (14-day PHI)
July 11 (21-day PHI)

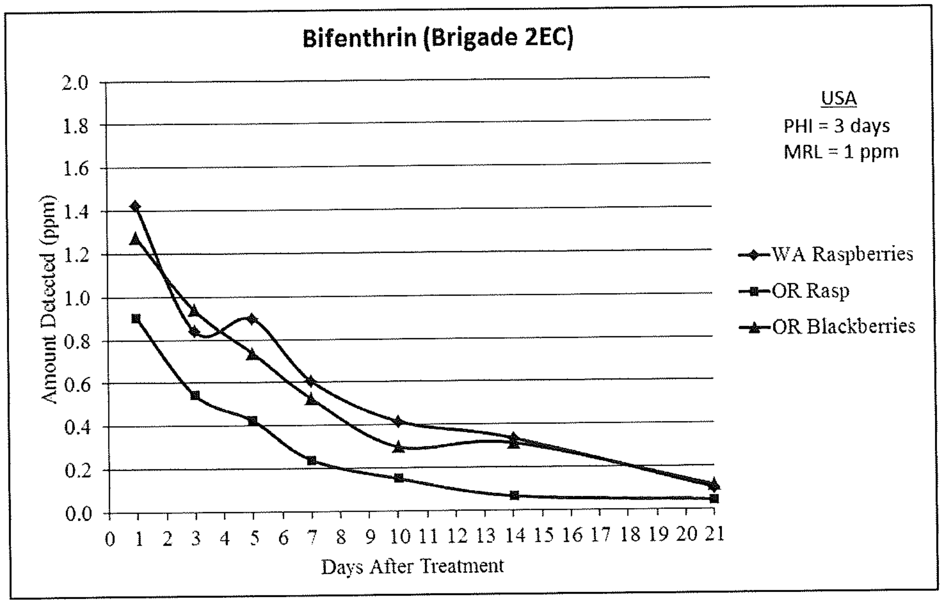
III. *Summary and Discussion:*

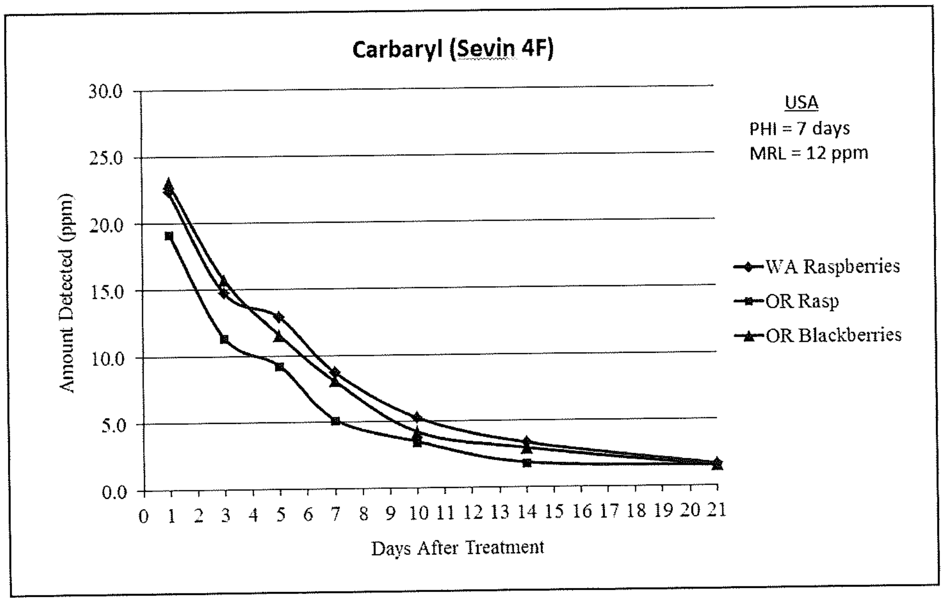
Pesticide degradation graphs are presented below. Armed with these graphs, and the MRL list of any foreign country, a grower will be able to determine how close to harvest a pesticide can be used without the risk of an MRL violation.

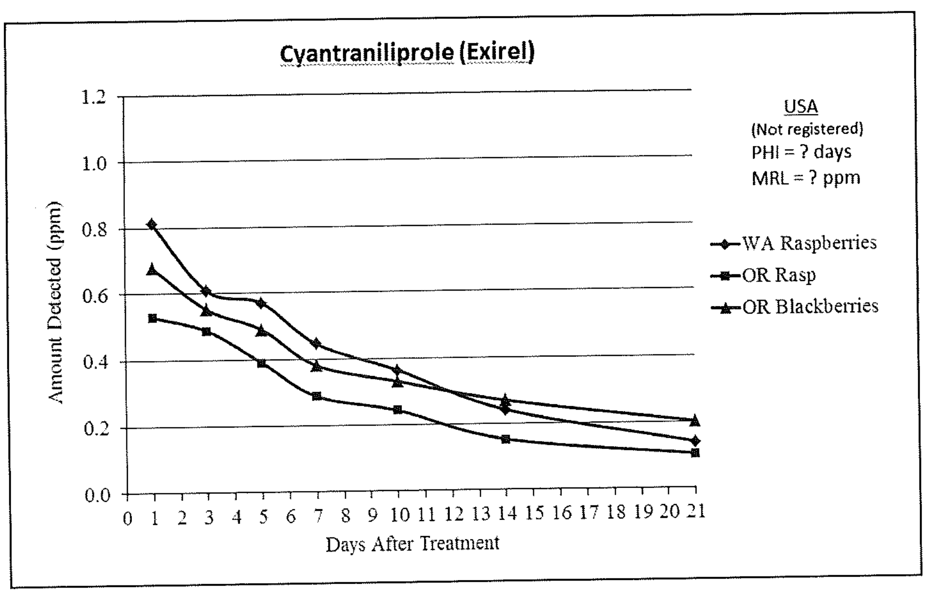
Bifenthrin, imidacloprid, and spinosad met the MRLs for the US and several other countries, such as Australia, Canada, Japan, and Taiwan, while analysis reveals that the other pesticides in this study would meet the MRL of some countries only if harvest was delayed past the US PHI. The data also reveal that residues of some pesticides, such as spinosad, spinetoram, and malathion, decline rapidly in the field while others, such as fenpropathrin and zeta-cypermethrin, decline slowly over time.

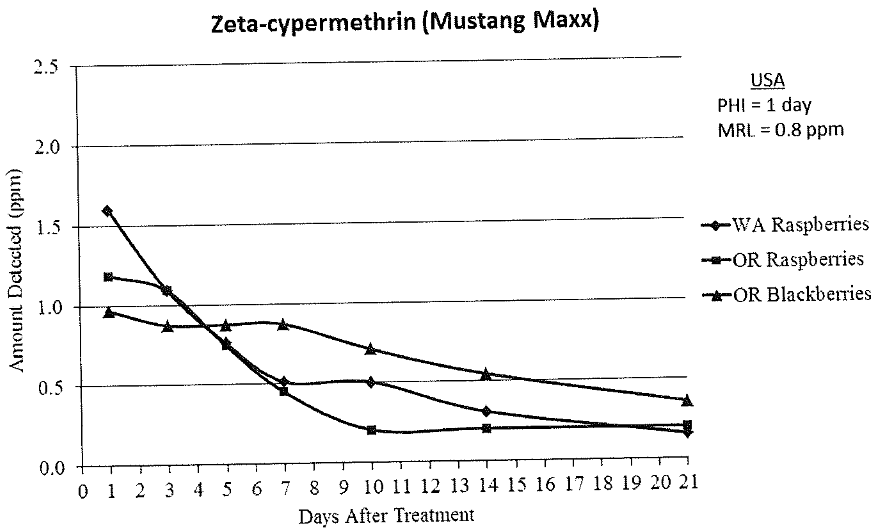
The rate of decline for the two formulations of hexythiazox did not differ but, like zeta-cypermethrin, the residue levels were in excess of the US MRL at the US PHI. We do not know why this occurred; possibly over-application, or a mixing or sampling error.

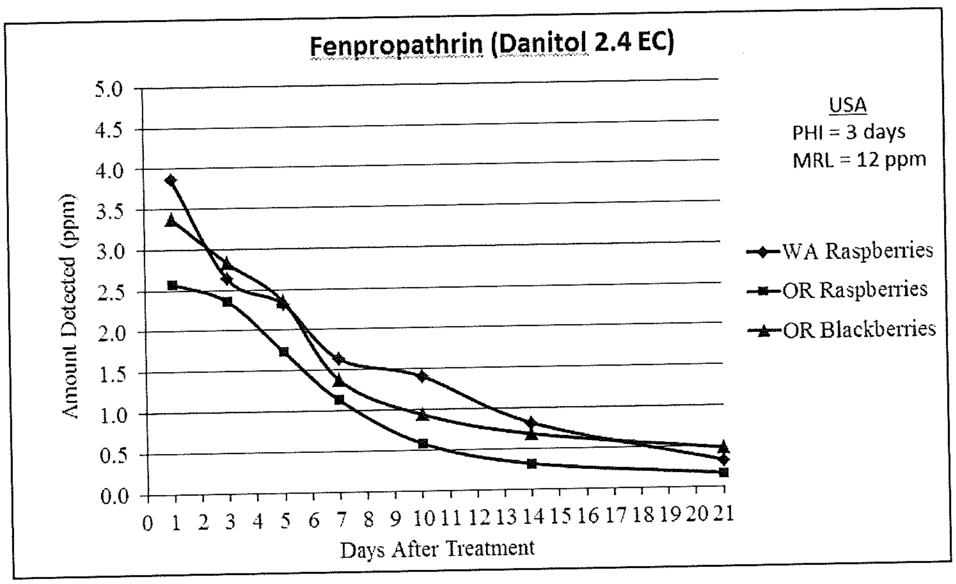
This ORBC-funded project enabled Bev Gerdeman and I to submit for, and be awarded, a USDA-TASC grant to expand the scope of this study and develop pesticide degradation curves for 10 fungicides, 11 insecticides, and three miticides. The TASC-funded studies will be carried out in 2017, 2018, and 2019.

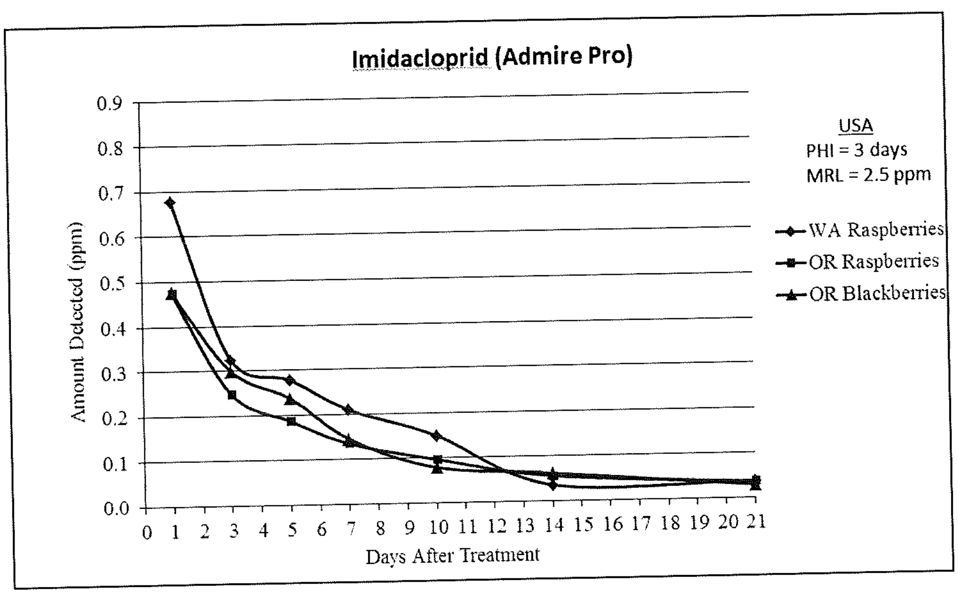

Bifenthrin (Brigade 2EC)
USA
PHI = 3 days
MRL = 1 ppm
WA Raspberries
OR Rasp
OR Blackberries
Amount Detected (ppm)
Days After Treatment

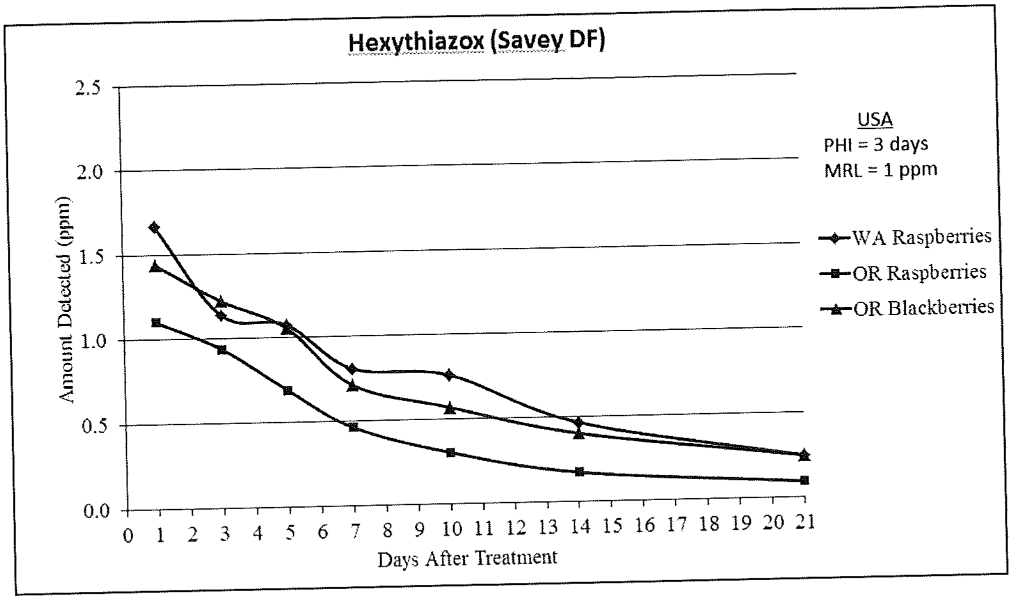

Carbaryl (Sevin 4F)
USA
PHI = 7 days
MRL = 12 ppm
WA Raspberries
OR Rasp
OR Blackberries
Amount Detected (ppm)
Days After Treatment

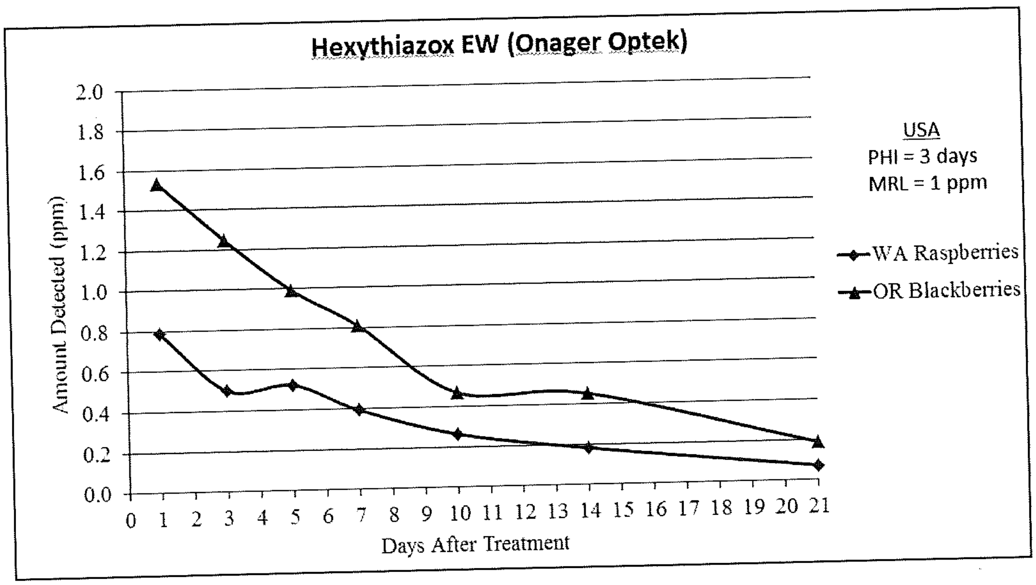

Cyantraniliprole (Exirel)
USA
(Not registered)
PHI = ? days
MRL = ? ppm
WA Raspberries
OR Rasp
OR Blackberries
Amount Detected (ppm)
Days After Treatment

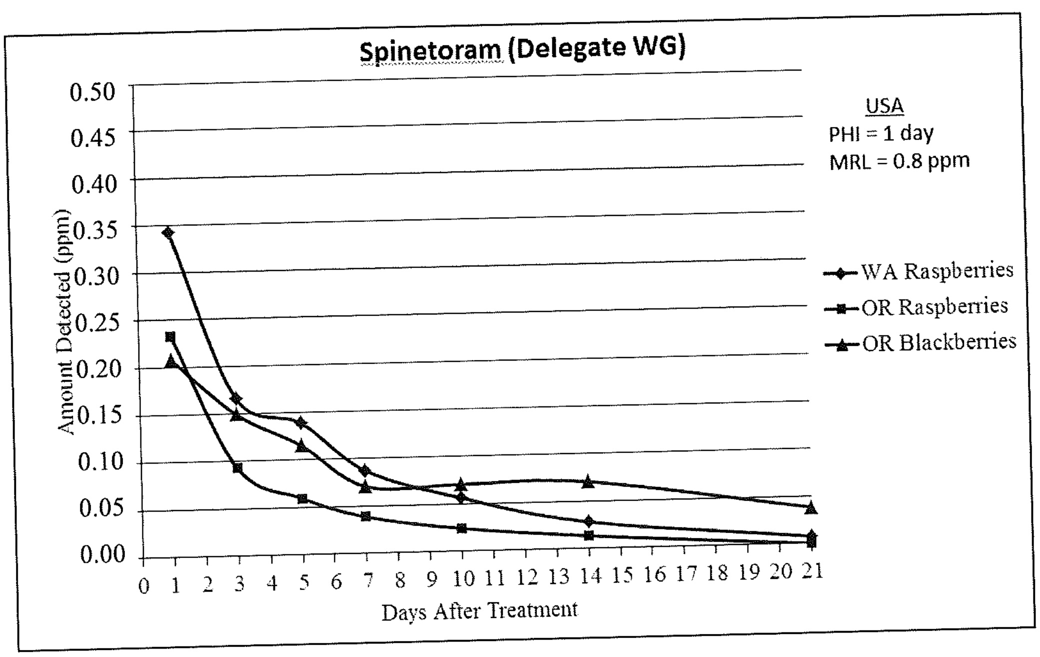

Zeta-cypermethrin (Mustang Maxx)
USA
PHI = 1 day
MRL = 0.8 ppm
WA Raspberries
OR Raspberries
OR Blackberries
Amount Detected (ppm)
Days After Treatment

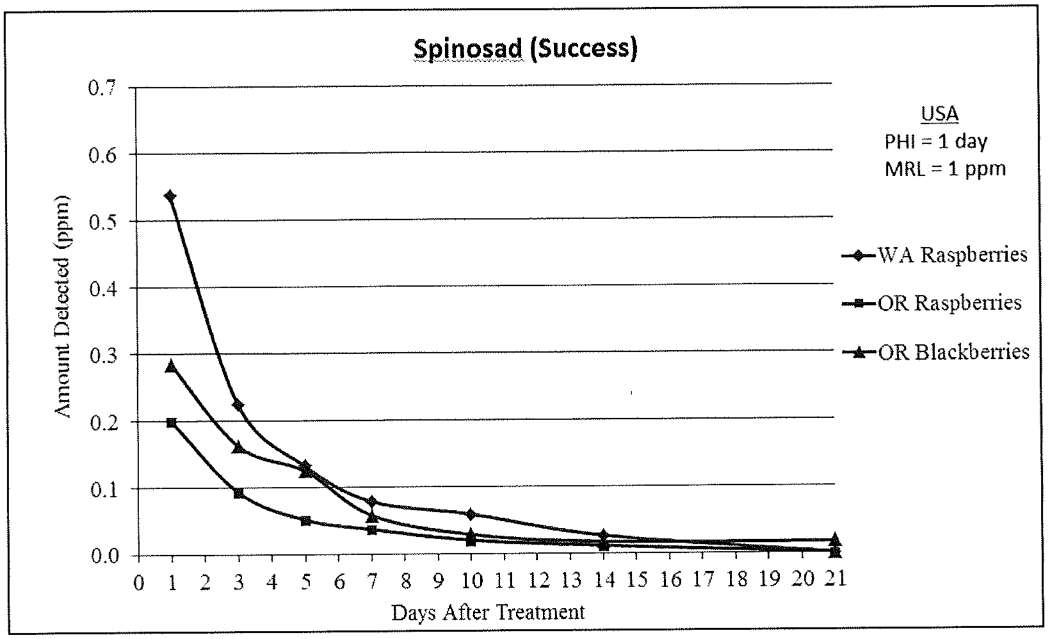

Fenpropathrin (Danitol 2.4 EC)
USA
PHI = 3 days
MRL = 12 ppm
WA Raspberries
OR Raspberries
OR Blackberries
Amount Detected (ppm)
Days After Treatment

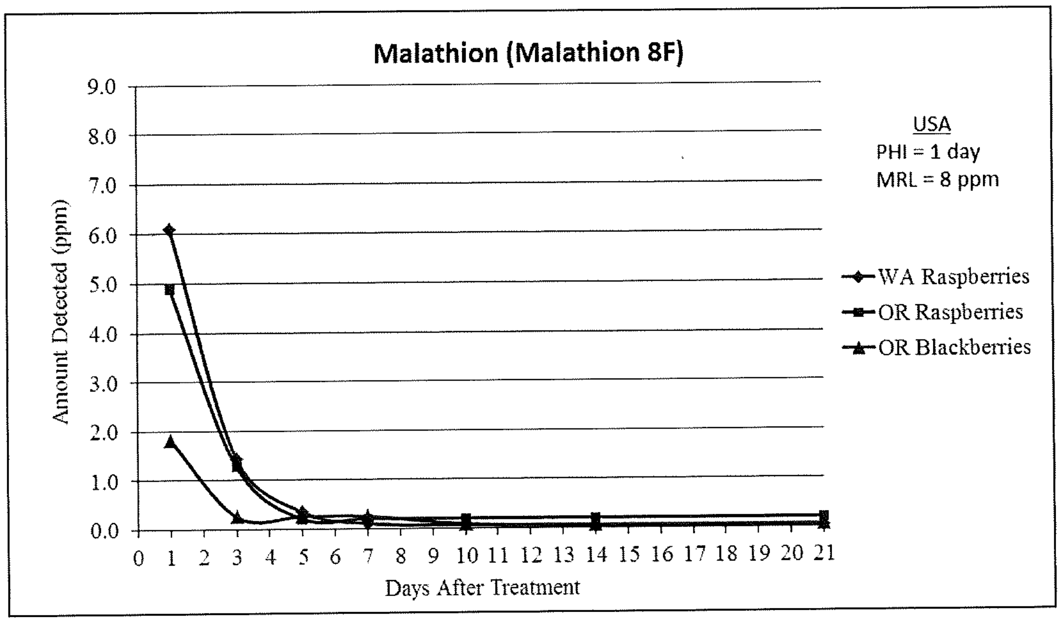

Imidacloprid (Admire Pro)
USA
PHI = 3 days
MRL = 2.5 ppm
WA Raspberries
OR Raspberries
OR Blackberries
Amount Detected (ppm)
Days After Treatment


Hexythiazox (Savey DF)
USA
PHI = 3 days
MRL = 1 ppm
WA Raspberries
OR Raspberries
OR Blackberries
Amount Detected (ppm)
2.5
2.0
1.5
1.0
0.5
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Days After Treatment


Hexythiazox EW (Onager Optek)
USA
PHI = 3 days
MRL = 1 ppm
WA Raspberries
OR Blackberries
Amount Detected (ppm)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Days After Treatment


Spinetoram (Delegate WG)
USA
PHI = 1 day
MRL = 0.8 ppm
WA Raspberries
OR Raspberries
OR Blackberries
Amount Detected (ppm)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Days After Treatment





Acequinocyl (Kanemite): Degradation curves for acequinocyl are not available. Analysis of acequinocyl met with some problems at the laboratory and residue levels could not be determined.

APPENDIX

Weather data during trial period

USBR Pacific Northwest Region - Hydromet/AgriMet System
(https://www.usbr.gov/pn/agrimet/wxdata.html)
NWREC – Aurora Oregon (ARAO Station)

PP = 24 Hour Total Precipitation (Midnight to Midnight) (inches)

DATE	(inches)	
06/20/2016	0.00	← Application
06/21/2016	0.00	← 1-day PHI Harvest
06/22/2016	0.00	
06/23/2016	0.40	← 3-day PHI Harvest
06/24/2016	0.03	
06/25/2016	0.01	← 5-day PHI Harvest
06/26/2016	0.00	
06/27/2016	0.00	← 7-day PHI Harvest
06/28/2016	0.00	
06/29/2016	0.00	
06/30/2016	0.00	← 10-day PHI Harvest
07/01/2016	0.00	
07/02/2016	0.00	
07/03/2016	0.00	
07/04/2016	0.00	← 14-day PHI Harvest
07/05/2016	0.00	
07/06/2016	0.00	
07/07/2016	0.07	
07/08/2016	0.17	
07/09/2016	0.08	
07/10/2016	0.01	
07/11/2016	0.00	← 21-day PHI Harvest

Report to the Agricultural Research Foundation
2017

Title: Supplement to SCRI grant "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"

Principal investigators: Chad Finn, USDA/ARS Geneticist, NCSFR
Nahla Bassil and Jill Bushakra, USDA/ARS National Clonal Germplasm Repository
Jungmin Lee, USDA/ARS HCRL, Parma, ID

Cooperators: *Scientists:* G. Fernandez (NC State), P. Perkins-Veazie(NC State), C. Weber (Cornell University), T. Mockler (OSU), R. Agunga (Ohio State Univ.), E. Rhoades(Ohio State Univ.), J.C. Scheerens(Ohio State Univ.), W. Yang (OSU), K. Lewers (USDA-ARS, Beltsville), J. Graham (James Hutton Institute, Scotland), F. Fernández Fernández (East Malling Research, UK), S.J. Yun (Chonbuk University).
Growers: In Oregon: Oregon Berry Packing, Riverbend, Sandy Farm, Townsend Farms; In New York- Orchard Dale; in North Carolina, SunnyRidge Farms; In Washington: Wyckoff Farms.

Objectives:
The real objective is to show support for the Specialty Crop Research Initiative Grant that we received funding for in 2011. The specific objectives for that project are:
1) Transcriptome sequencing and high throughput genomic sequencing.
2) Developing molecular markers from genomic and EST sequences.
3) Studying genotype by environment interaction in crosses involving diverse wild black raspberry germplasm.
4) Using molecular markers for mapping specific traits of interest in crosses involving diverse wild black raspberry germplasm.
5) Evaluate transferability of SSR markers developed in black raspberry to red raspberry.
6) Better understanding of consumer preferences and factors promoting black raspberry market expansion.
7) Delivering research results and training in molecular breeding to the industry, breeders, and students through a multifaceted outreach and extension program.

If you would like to see the entire proposal I would be happy to share it with you.

Take home messages:
- Aphid resistance in black raspberry is controlled by three linked but separate loci
- Existing DNA tests can identify resistant individuals irrespective of source
- One DNA test can identify ME source of R
- More research is needed to distinguish the ON from the MI sources and assist breeders in developing cultivars with durable resistance

Accomplishments

Major project goals: The overall goal of this proposal was to develop and make available genomic tools for the improvement of black raspberry and apply these tools for crop improvement using wild germplasm. These resources will significantly aid in the integration of novel traits from wild germplasm into elite cultivars and are necessary tools for molecular breeding of black raspberries and related species (e.g., red raspberry, blackberry) and to address the needs of the industry for improved cultivars. Objectives were presented as solutions to address problems in production and breeding that were identified by the industry and the USDA-ARS Small Fruits Crop Germplasm Committee. Conversations with black raspberry growers and processors over the last decade revealed disease and short planting longevity as their top production concerns. The USDA-ARS Northwest Center for Small Fruits Research (an academic/commercial industry partnership) and the Oregon Raspberry and Blackberry Commission have identified cultivar improvement as a number one research priority for the commercial raspberry industry.

Obj. 1: Transcriptome sequencing and high-throughput genomic sequencing: We completed the sequencing and assembly of the genome of a black raspberry individual using the facilities at Oregon State University, Corvallis, OR and The Donald Danforth Center, St. Louis, MO. We also obtained transcriptome sequence information from a variety of plant tissue types to better understand the genes that are expressed in each tissue. We used the expressed gene data to identify gene locations on our genome sequence. The genome of black raspberry (*Rubus occidentalis*) accepted and published in The Plant Journal on line May 12, 2016.

Obj. 2: Developing molecular markers from EST and genomic sequences: We mined the genome sequence for Simple Sequence Repeat (SSR) markers not previously available in black raspberry. We completed the high-throughput sequencing of our two mapping populations and a third population to identify specific differences within a single population and among the three populations.We used this information to develop targeted SSR and genome-wide SNP molecular markers and have placed these markers on a genetic linkage map. We are in the process of constructing a linkage map for our second mapping population of 192 progeny.

Obj. 3: Studying genotype by environment interaction on specific traits of interest in crosses involving diverse wild black raspberry germplasm: Interest in black raspberry production has expanded far beyond upstate New York and the Ohio River Valley where production was once concentrated; however, the industry today is reliant on cultivars developed for this region. The extent to which they are adapted to other production regions is not well understood. Studying the performance of seedling populations segregating for adaptation and other important traits in four production regions, Oregon, New York, Ohio, and North Carolina will provide valuable information on relative performance for these traits and effectiveness of selection for them in very different locations with strong small fruits industries and an interest in improved black raspberry cultivars. We successfully completed three years of data collection to conduct this analysis. Preliminary results using a subset of data indicate that an individual's performance is influenced by the environment in some cases. This analysis will be completed this year.

Obj. 4: Using molecular markers for mapping specific traits of interest in crosses involving diverse wild black raspberry germplasm: We constructed a genetic linkage map for one mapping population. We are in the process of developing the linkage map for the second mapping population. Genetic linkage maps provide a framework of how the chromosomes of black raspberry are assembled and which regions are inherited together and will be used for identifying the regions of the genome involved in the expression of traits of interest. Next we plan to map loci involved in disease and insect resistance, vigor, phenology, fruit chemistry properties, and quality traits across locations as well as specific to each production region. The resulting linkage maps and QTL association will be used for the development of marker-based tests for important traits.

Obj. 5: Evaluate transferability of SSR markers developed in black raspberry to red raspberry: The completion of the first genetic linkage map for black raspberry will provide us with the means to address this objective as we are prioritizing evaluating transferability of markers mapped in black raspberry to red raspberry to allow comparative mapping in both crops. To date, 37 SSR markers are polymorphic in both species and 14 of these markers are located on the linkage map for ORUS 4305 with 1 to 4 markers per linkage group. These and other markers are useful as anchor markers for comparing maps between red and black raspberry and other Rose Family crops.

Obj. 6: Better understanding of consumer preferences and factors promoting black raspberry market expansion: We managed a replicated planting of advanced black raspberry selections for use in sensory evaluation. Fruit harvested from all fruiting plants commenced on 28 June and continued to 10 July. Fresh fruit harvested from these plots were submitted to an 11-member trained sensory panel for quantitative descriptive analysis (QDA) of appearance, aroma, flavor and texture characteristics. QDA panelists were exposed to 3 or 4 entries per test; each genotype was evaluated twice. There were significant differences among genotype means for many fruit characteristics. Oregon-grown fruit of the same selections and standards were machine-harvested and processed into puree by the Oregon State University (OSU) Department of Food Science and Technology. Purees were randomly assigned to two groups of four purees. Groups were subjected to consumer preference analysis at the OSU Sensory Science Laboratory on August 6th and 7th and on September 17th and 18th using 109-member and 115-member consumer panels, respectively. Purees will be analyzed by the QDA panel in mid-Oct. 2014. We are also exploring messaging techniques to improve black raspberry market share. Survey instruments and protocols to ascertain purchasing incentives of larger buyers (processors, retail grocery chains, etc.) have also been developed. We have also explored several analytical techniques for extracting and evaluating flavor compounds present in these fruit and have developed an analytical library of over 30 flavor compound standards. This information will provide us with consumer acceptance targets when selecting germplasm for breeding. Additional work is on-going at the Ohio State University.

A survey instrument entitled "Opportunities and Challenges Facing Black Raspberry Producers" was developed to delineate current production and marketing strategies and to outline important grower needs/concerns for future expansion of acreage. This instrument was presented at the 2014 Oregon Raspberry and Blackberry Commission (ORBC) Annual Growers Meeting, December 17 at the Wellspring Conference Center, in Woodburn, Oregon and at the North American Raspberry & Blackberry Association (NARBA) Conference, February 24-27, 2015 in Fayetteville, Arkansas. An on-line version was made available and was promoted by ORBC, NARBA and the Ohio Produce Growers & Marketers Association (OPGMA). The survey revealed that most black raspberry producers (68%) farm less than 100 acres and 32% of respondents reported to grow less than 5 acres of this crop and realized gross receipts of less than $50,000 annually. They tend to grow a mixture of berry crops. They sell through farm stands, farmers markets, pick your own, wholesale and retail. Responding growers indicated that production costs, product perishability and shipping constraints, disease and insect problems, consumer unfamiliarity with the product (often confused with blackberries), and the lack of cultivar diversity to be major impediments to industry growth. Varietal characteristics most highly desired by producers included excellent pest resistance and fruit quality characteristics, thornlessness, season extension capacity and the primocane fruiting habit.

Obj. 7: Delivering research results and training in molecular breeding to the industry, breeders, and students through a multifaceted outreach and extension program: Over the course of the project we have presented our research at more than 20 different conferences and field days and have nine peer-reviewed publications. We hired and trained high school students and trained volunteers in North Carolina and Oregon in field and molecular components of the project. Research was also highlighted on several social media sites. We conducted training in germplasm assesment and characterization, molecular breeding, and applied use of molecular tools in breeding at the 2015 American Society for Horticultural Science Annual Conference in New Orleans, LA.

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PROGRESS REPORT TO OREGON RASPBERRY AND BLACKBERRY COMMISSION 2017

TITLE: Development of New Raspberry Cultivars for the Pacific Northwest

PROJECT LEADER: Patrick P. Moore, Professor
Wendy Hoashi-Erhardt, Scientific Assistant
WSU Puyallup Research and Extension Center

PROJECT STATUS: Continuing (indefinite)

FUNDING: USDA/ARS Northwest Center for Small Fruits Research
Amount Awarded $32,299 for 2017-2018 for both raspberry and strawberry breeding

Washington Red Raspberry Commission
Amount Awarded $70,000 for 2017 "Development of New Raspberry Cultivars for the Pacific Northwest"

Washington Red Raspberry Commission
Amount Awarded $3,748 for 2017 "Evaluation of Raspberry Bushy Dwarf Virus strains"

OBJECTIVES:
Develop summer fruiting red raspberry cultivars with improved yields and fruit quality, and resistance to root rot and raspberry bushy dwarf virus. Selections adapted to machine harvesting or fresh marketing will be identified and tested further.

Potential release. WSU 2166 has been recommended for release by the Cultivar Release Machine Committee and is waiting for the recommendation by the Agriculture Research Center. WSU 2166 is an early season selection with large, firm, good flavored fruit that machine harvests very easily. It is not immune to root rot, but appears to have good levels of tolerance.

Crosses/selections. Fifty-eight crosses were made in 2017 for floricane breeding with emphasis on parents that are machine harvestable and root rot resistant. Forty of the 58 crosses had at least one parent that has root rot resistance in its background. All of the crosses had at least one parent with good machine harvestability. An additional 12 crosses were made for primocane breeding. Twenty-two selections were made in 2017 from seedlings planted 2014 and 2015.

Selection Trial Puyallup. The 2014 and 2015 replicated plantings at Puyallup were hand harvested in 2017. In the 2014 selection trial, 'Cascade Harvest' had the highest two year total yield (**Table 1**) followed by WSU 2001, WSU 2188 and WSU 2200. WSU 2166, which performed very well in machine harvesting trials and grower trials, had the lowest yield in the selection trial although there were few statistically significant differences. It appears that this selection did not establish very well at this location and produced few canes. The yield per cane did not differ from the highest yielding selections. WSU 2001 and 2088 had the highest yields in 2017 in the 2015 planting with very good firmness (**Table 2**). The 2015 and 2016 plantings will be harvested in 2018.

Machine Harvesting Trials. A new machine harvesting trial was planted in Lynden with 40 WSU selections, 8 BC selections, 6 ORUS selections and 'Cascade Harvest', 'Meeker' and 'Willamette' for reference. This planting will be harvested in 2019 and 2020.
The 2014 and 2015 planted machine harvesting trials were harvested in 2017. Yield was determined for each harvest date for the 2014 planting and total yield calculated (Table 3). Two year yield for WSU 2166 was greater than that of 'Willamette' and 'Meeker'. WSU 2166 had a production curve almost identical to 'Willamette' (Figure 1)..

Grower trials

Four WSU selections were planted in Grower Trials in 2014 with WSU 1980, WSU 2122, WSU 2166 and WSU 2188. All of these selections appeared very promising in small plots in previous Machine Harvesting Trials in grower fields in the Lynden area. In the Grower Trials, one grower field has a history of very high levels of root rot and WSU 1980 and WSU 2122 did not perform well on this site. WSU 2188 had significant root rot damage. WSU 2166 did not show any damage in 2014-16 and slight damage in 2017. Three selections were planted in Grower Trials in 2017 and three additional selections will be planted in Grower Trials in 2018.

Publications/Presentations

Machine Harvesting Field Day Lynden, WA July 19, 2017

Summary

This project will develop new raspberry cultivars using conventional breeding methods. Controlled pollinations will be made, seedlings grown, selections made among the seedlings and these selections evaluated. The primary goal of the program is to develop new summer fruiting red raspberry cultivars with improved yields and fruit quality, and resistance to root rot. Selections adapted to machine harvesting or fresh marketing will be identified and tested further. The most promising selections will be tested in grower trials and evaluated for possible release.

Several raspberry selections tested in machine harvesting trials appear very promising: machine harvesting well, productive, with good fruit integrity, good flavor and some with probable root rot tolerance. WSU 2166 has been recommended for release by the Cultivar Release Committee and is waiting for the recommendation by the Agriculture Research Center. The proposed name is 'Cascade Premier'.

Table 1. 2016-17 harvest of 2014 planted raspberries, Puyallup, WA

	Yield (t/a)			Fruit weight (g)		Fruit firmness (g)		Fruit rot (%)		Midpoint of Harvest	
	2016	2017	Total	2016	2017	2016	2017	2016	2017	2016	2017
C Harvest	11.0 a	7.0 ab	18.0 a	4.16 ab	3.54 bc	90 a-c	106 d-f	9.8 a-c	14.5 ab	6/23 d-f	7/11 b-d
WSU 2001	7.8 a-c	8.1 a	15.8 ab	3.86 a-c	3.84 ab	87 a-d	147 a-e	14.3 a	12.7 a-c	6/30 a	7/17 a
WSU 2188	8.1 ab	7.2 ab	15.3 a-c	4.41 a	4.05 a	102 a	168 a-c	7.8 bc	5.7 de	6/27 a-d	7/13 ab
WSU 2200	6.8 a-c	8.1 a	14.8 a-c	2.49 f	2.57 e	59 e	94 f	6.4 bc	6.3 de	6/22 ef	7/8 d-f
Willamette	7.8 a-c	6.3 ab	14.2 a-d	3.06 d-f	3.37 bc	74 b-e	122 c-f	7.2 bc	6.6 de	6/19 fg	7/5 f
WSU 1985	6.7 a-c	6.8 ab	13.5 a-d	3.43 b-d	3.80 ab	64 de	180 ab	9.2 a-c	6.5 de	6/27 a-c	7/13 ab
Meeker	6.8 a-c	6.5 ab	13.4 a-d	3.10 de	3.19 cd	74 c-e	107 d-f	11.4 ab	10.6 a-d	6/28 ab	7/9 b-f
WSU 2122	6.9 a-c	5.7 ab	12.6 a-d	3.64 bc	3.18 cd	88 a-d	158 a-d	12.0 ab	9.7 b-e	6/26 b-e	7/12 bc
WSU 0836	5.4 bc	7.0 ab	12.4 b-d	2.92 ef	2.71 de	63 de	95 ef	12.4 ab	16.0 a	6/17 g	7/7 ef
WSU 2133	4.4 bc	7.6 a	12.0 b-d	2.93 ef	2.53 e	60 e	95 ef	6.3 bc	4.8 e	6/23 c-f	7/10 b-e
WSU 2205	6.2 bc	5.8 ab	12.0 b-d	3.16 de	3.26 c	74 b-e	110 d-f	4.2 c	5.2 de	6/17 g	7/7 ef
WSU 2082	4.0 bc	6.1 ab	10.1 cd	4.27 a	4.16 a	100 ab	195 a	9.4 a-c	8.0 c-e	6/23 c-f	7/13 ab
WSU 2166	3.7 c	5.1 b	8.7 d	4.30 a	3.84 ab	101 a	137 b-f	4.4 c	5.4 de	6/19 fg	7/8 c-f
	6.6	6.7	13.3	3.5	3.4	80	132	8.8	8.6	6/23	7/10

Table2. 2017 harvest of 2015 planted raspberries, Puyallup, WA

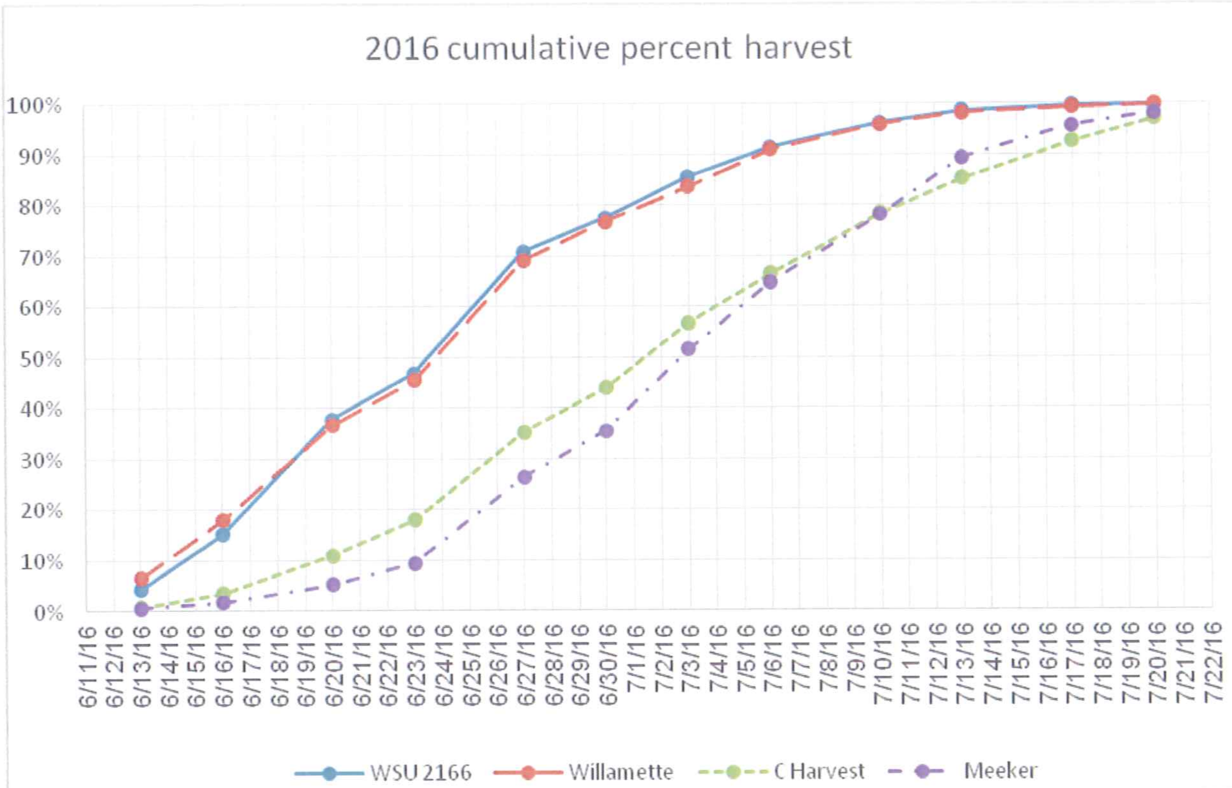
	Yield (t/a)		Fruit weight (g)		Fruit firmness (g)		Fruit Rot (%)		Midpoint of Harvest	
WSU 2001	10.0	a	3.44	a	132	b	7.9	b	7/16	a
WSU 2088	9.1	ab	3.37	a	182	a	4.3	b	7/15	a
WSU 2133	7.3	bc	2.27	c	73	d	5.7	b	7/11	b
C. Harvest	7.2	bc	3.69	a	109	bc	14.6	a	7/10	b
Meeker	7.1	bc	2.88	b	86	cd	7.2	b	7/10	b
WSU 2299	7.1	bc	2.33	c	60	d	9.7	ab	7/8	b
Willamette	5.6	c	3.33	ab	112	bc	7.9	b	7/5	c
	7.6		3.04		107		8.2		7/10	

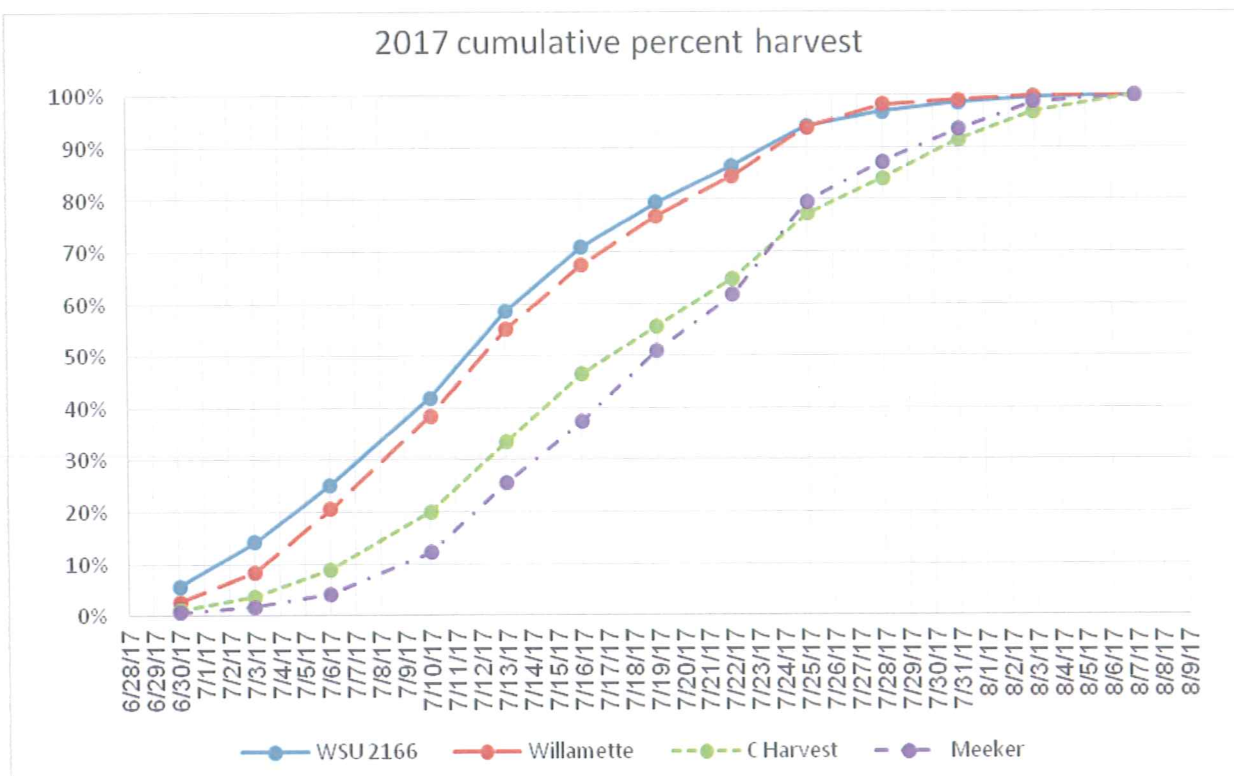
Table 3. Yield of machine harvested raspberries, 2014 planting, Lynden, WA

plot #	clone	2016 lb/plot	2017 lb/plot	2016-17 Total lb/plot
1.30	WSU 2087	90.4	68.0	158.4
1.16	**C Harvest**	**85.7**	**68.5**	**154.2**
1.14	WSU 2001	82.6	58.7	141.4
1.06	WSU 2188	75.9	54.9	130.8
1.01	WSU 2425	67.0	62.2	129.1
1.39	WSU 2088	65.0	63.7	128.6
1.17	**WSU 2166**	**73.9**	**53.7**	**127.6**
1.31	WSU 2385	71.1	55.1	126.2
1.19	WSU 2441	73.8	50.4	124.2
1.36	**Meeker**	**56.2**	**66.7**	**122.9**
1.15	WSU 2402	62.5	58.6	121.1
1.03	WSU 2133	69.8	48.6	118.3
1.28	WSU 2431	66.6	51.6	118.2
1.11	WSU 2205	62.5	54.2	116.7
1.40	**Willamette**	**58.5**	**53.3**	**111.7**
1.18	WSU 1985	79.0	30.9	109.9
1.27	WSU 2123	72.6	36.9	109.5
	Average	71.4	55.1	126.4

Planting included 40 WSU selections and 3 cultivars. After the 2016 harvest, 26 WSU selections were discarded because of low yield or fruit quality.

Figure 1. Cumulative percent yield of 2014 planted raspberries, Lynden WA.


2016 cumulative percent harvest
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
WSU 2166
Willamette
C Harvest
Meeker


2017 cumulative percent harvest
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90%
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60%
50%
40%
30%
20%
10%
0%
WSU 2166
Willamette
C Harvest
Meeker

The Northwest Berry Foundation
5261 North Princeton Street, Portland OR
97203-5263
503-285-0908~info@nwberries.org
www.nwberryfoundation.org

Small Fruit Update Progress Report

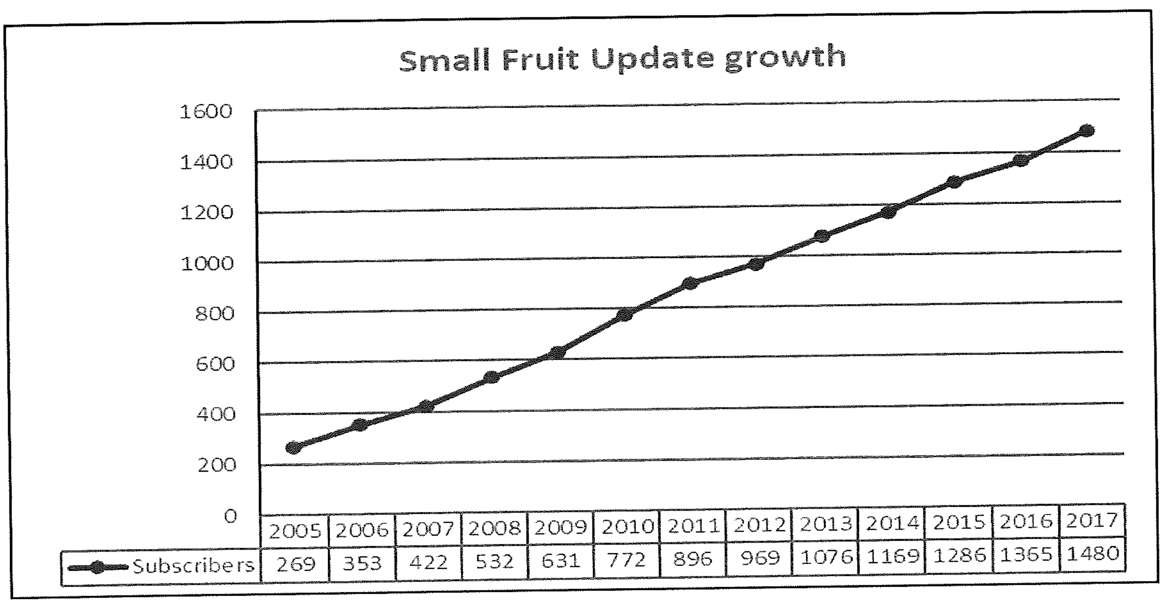
As of November 27, 2017

Objectives:

- Increase industry communication.
- Increase grower knowledge of IPM strategies.
- Accelerate the dissemination of pesticide information. such as label changes to growers.
- Facilitate real time pest alerts to growers throughout the growing season.
- Inform industry personnel of upcoming meetings as well as other relevant commission news such as elections, seat vacancies and/or legislative activities.

Overview

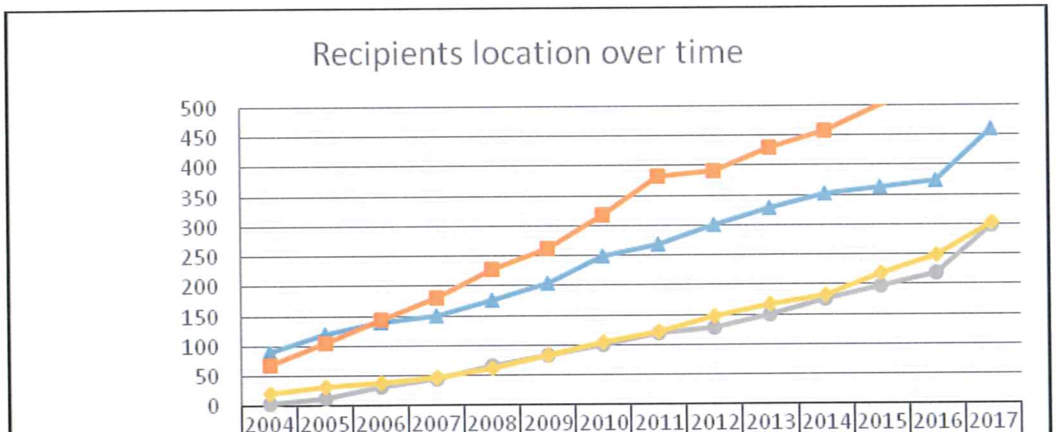
Peerbolt Crop Management has been providing a weekly emailed Small Fruit Update to an increasing number of growers, industry personnel, and researchers since February 2000. At the time of this report, the email list grew by 115 addresses (from 1365 addresses in 2016, to 1480 addresses in 2017). As several recipients regularly pass it on to others, we estimate the total number receiving the Update to be well over 1,500 people.



20167Profile of the Small Fruit Update

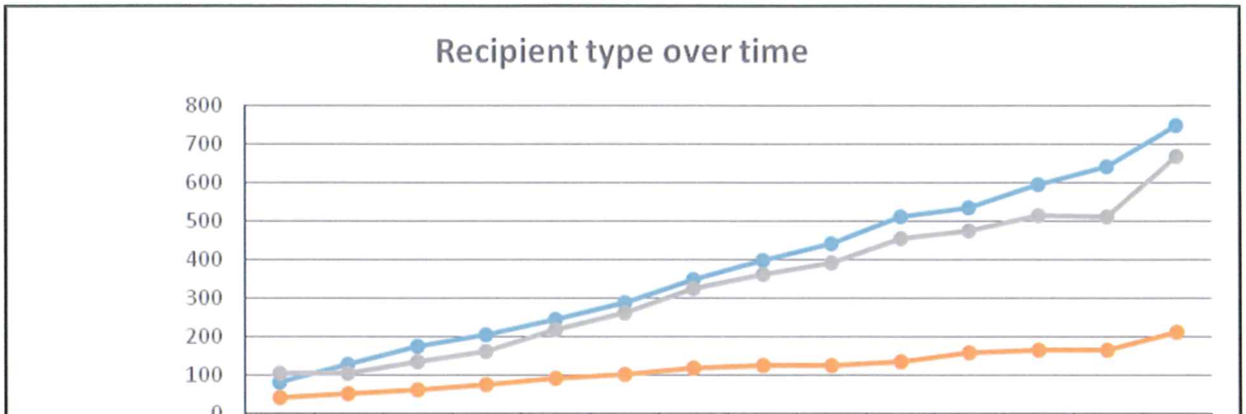
The following charts illustrate the profile of the Small Fruit Update recipients in our database as of the date of this report.

We make every effort to provide you with accurate information. We don't mandate those who sign up for the Update to give us any information beyond their email address, name, address, and phone number. We also request that growers note what crops they grow. Sometimes they do, and sometimes they do not. This means that our annual demographic reports often change previous report's numbers. Also note that each year we lose a certain number of recipients (this year there were 36 unsubscribes). Some drop out because of a job change, but there are always a few dropped simply because their email address no longer works and we are unable to rectify the situation after attempting to contact them. However, you can see that even with these individuals dropped, the overall trend for the SFU is an *increase* in recipients across all locations.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Washington	91	119	140	150	175	203	249	269	301	329	352	363	373	460
Oregon	69	106	143	180	227	261	318	383	392	430	458	501	528	674
Out of Area	4	12	31	45	67	84	101	121	129	150	176	197	219	298
BC	22	32	39	47	63	83	104	123	147	167	182	220	250	302

In 2017, there has been a subscriber increase of 52 recipients in BC, 146 in Oregon and 87 in Washington. The remaining recipients are located throughout the U.S., Canada, and the rest of the world. That segment increased by 79 subscribers. We screen new subscribers from potentially competitive markets until such time that the funding entities decide that is not necessary.



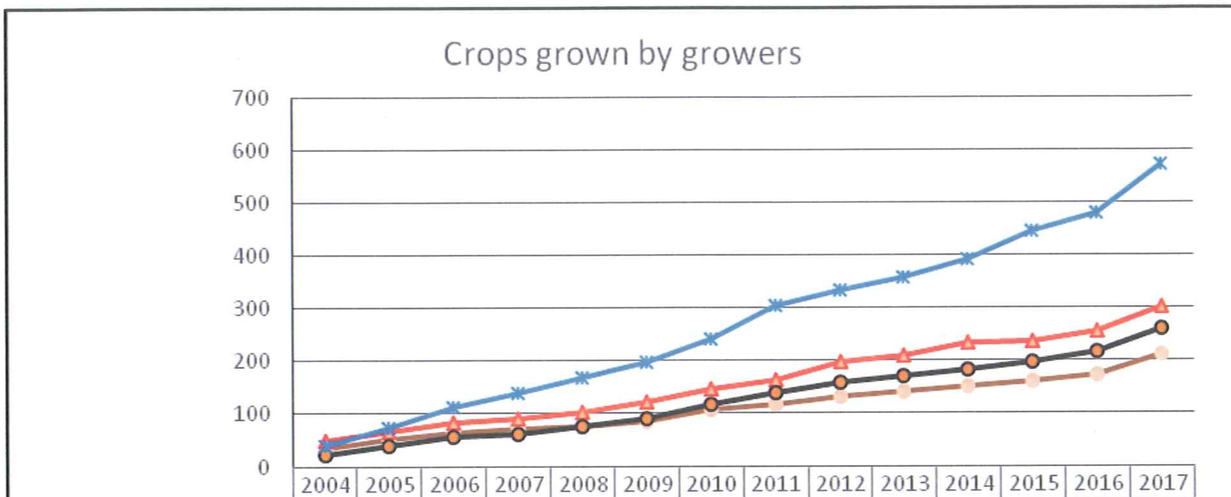
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Growers	83	130	175	205	244	289	349	399	443	513	536	596	641	747
Researchers	42	53	63	74	92	103	118	125	127	134	158	166	165	211
Industy	104	104	135	163	217	262	325	362	391	455	474	516	513	669

The "Growers" category increased by 17% -- individual subscribers going from 641 in 2016 to 747 in 2017.

The "Researchers" category includes anyone associated with USDA, ARS, a college, or university, as well as state or federal departments of agriculture, and others who work for public agencies. Over the past year, researchers receiving the Small Fruit Update increased by 46 individuals.

The category "Industry" includes suppliers, newspaper reporters, propagators, processors, nurseries, fruit buyers, manufacturers, sales reps, and even bankers. This year the number of industry recipients increased by 156 individuals.

Our signup form encourages those wanting the Update to give us demographic information. The crop data reflects the fact that some growers do not indicate what crop they grow and some growers are harvesting more than one small fruit.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Strawberry	35	52	64	70	75	85	108	117	131	141	152	161	172	212
Raspberry	49	65	82	90	103	121	147	163	198	210	233	237	255	301
Blackberry	23	39	56	62	76	91	116	139	158	171	183	196	217	261
Blueberry	40	73	113	139	167	197	242	303	333	358	392	444	480	572

In general, the trend over the past 10 years is that strawberry recipients have grown at a slow rate, Although, this year they increased by 23%. Blackberry and raspberry growers have been growing steadily, and blueberry producers have been rising exponentially. In 2017, the number of recipients identifying themselves as blackberry growers increased 20%, and blueberry growers increased by 19%, while raspberry growers increased by 18%.

As noted at the start of this report the Small Fruit Update continues to expand its recipient list and the quality and quantity of the information provided. In 2004 our list comprised the addresses of 186 individuals. We have added 1,294 addresses since that time. All this is due to your continued sponsorship.

Progress Report to the Oregon Raspberry & Blackberry Commission

November 30, 2017

Project Title: Coordinated Regional on-farm Trials of Advanced Blackberry & Raspberry Selections (Fifth year 2017)

Principal Investigator:
Thomas Peerbolt –Peerbolt Crop Management Inc, Portland, OR
Co PIs
Chad E. Finn – USDA-ARS-HCRU, Corvallis, OR
Patrick Moore – Washington State University, Puyallup, WA

Justification

The Northwest blackberry and raspberry breeding programs have been a cornerstone of the industry's success. Their ability to produce cultivars of commercial value is crucial to continued success. Global competition is increasing and public funding for these programs at our land grant institutions is under increasing budget constraints. Accelerating the commercialization of the cultivars produced by these programs is of great economic value to the northwest caneberry industry.

Previous objectives (2013-2017) now completed

First funded in 2013 it has taken these four growing seasons to complete the establishment phase of this project. There is now in place a viable onfarm testing program for advanced caneberry selections. The elements that are now in place:

- Communication links and agreed upon timelines with the three Northwest public caneberry breeding programs (USDA/ARS & OSU; WSU; and the British Columbia Program) for deciding which advanced selections should be included in the trials each year.
- A set of protocols with the wholesale commercial propagators (North American Plants, Northwest Plants and Sakuma/NorCal) to be able to supply viable, quality plant material to the growers at the appropriate time and in the needed quantities.
- Informal protocols for spreading out regional costs between the three Northwest industry commissions/councils (ORBC, the Washington Red Raspberry Commission & the B.C. Raspberry Development Council) for onfarm trials throughout the western Oregon, Washington and British Columbia.
- A network of cooperating growers.
- Realistic cost estimates for viable budget projections and fiscal planning.
- An information dissemination network that includes use of the Small Fruit Update newsletter, grower meeting presentations, one-to-one grower communication and production of information factsheets.

Previous objective (2013-2017) needing further investment

- Onfarm trial site evaluation protocols:
- The format and forms needed for site visits has been developed.
- Not enough resources have been allocated during the season. That will be addressed in the 2018 proposal by increasing the time committed to the site visits.

Yearly Calendar of On-Farm Caneberry Trials

Mid-November: Propagator and wholesale nursery meeting.

This took place on November 16, 2017 for this coming year.

- Decide on selections for following season in collaboration with plant breeders & nurseries.
- Edit list of promising candidate selections for trials 2-3 years in the future.
- Coordinate with wholesale nurseries to decide on plant source and date needed to deliver on farms.

December- March: Winter meetings, production of factsheets, submit reports and funding proposals, web postings.

- Disseminate information to stakeholders through newsletters, meeting presentations, factsheets and websites.
- Coordinate with on farm trials in Washington and British Columbia.
- Collect stakeholder feedback on selections, independent selection trials and commercially planted cultivars.
- Recruit grower cooperators for the coming season.

April-May: Getting new trials planted. First check on ongoing trials.

- Coordinate deliveries with propagators and growers.
- Expedite memorandums of understanding paperwork for growers.
- Evaluate trials in the ground for winter damage, cane vigor, bud break, and any other pest symptoms that might be visible in the early season. (Could be either site visit or a phone interview with grower.)

June-August: Harvest Season

- Site visits during harvest to evaluate: Fruit quality; yield potential; machine harvestability; fruit disease susceptibility…
- Second site visit during third to fourth week of harvest to evaluate: late season fruit quality; revise yield potential; machine harvestability; length of harvest; disease harvestability, etc.
- Visit trials in Washington and British Columbia at least once during the season.

August-October: Post harvest

- Phone interviews with growers for comments on train-ability, pruning methods, etc.
- Determine which plantings should be removed and/or continued.

Compilation of all Caneberry Selections/Cultivars included in ORBC-funded onfarm trials to date 2013-2017

Progress Report to the Agricultural Research Foundation
2017-2018

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 Vance Faculty Research Assistants NWREC
Mary Peterson, USDA/ARS Technicians

Cooperators: Pat Moore, WSU, Puyallup
Michael Dossett; Agriculture and Agri-Foods Canada
Brian Yorgey, 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, blackberry, and strawberry 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 a bit 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', 'Metolius', 'Newberry', and 'Onyx', have been released to provide different options for the blackberry fresh market. 'Columbia Star' in its first years of plant sales was 2nd only to 'Black Diamond' in sales. 'Columbia Sunrise', the earliest ripening thornless blackberry we are aware of was released last year. This year 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 plan to release the semi-erect ORUS 4370-1 in 2018. 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 'Cascade Harvest' as well as the release of 'Saanich', 'Cascade Bounty', and 'Cascade Gold'. We have several selections in machine harvest trials in northern Washington and a few of these are promising. The relatively recent primocane fruiting release 'Vintage' is performing well for some growers and 'Kokanee' was released last year. 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.

In 2017, we evaluated about 6,000 blackberry and red and black raspberry and black raspberry seedlings. We made 31 red raspberry (18 floricane, 13 primocane), 18 **black raspberry**, and 17 blackberry (11 trailing and 6 primocane fruiters) selections. Below are the highlights of the genotypes at various stages of evaluation.

Blackberry

Cultivar Releases

'Hall's Beauty' trailing blackberry released and patent application filed in 2017

A thornless trailing blackberry with high yields of medium-large, firm fruit with excellent flavor that typically ripen earlier than 'Columbia Star' but later than 'Columbia Giant'. In small scale grower trials has worked very well for local fresh sales. Machine harvestable. Also has giant, attractive flowers with many petals so suitable for ornamental market.

'Eclipse' and 'Galaxy' semi-erect blackberry released and patent application filed in 2017

These are the 1st semi-erect releases developed within our program. They are a cross of ('Navaho' x ORUS 1122-1 ['Olallie' x ORUS 728-3]) x 'Triple Crown' and so are ¾ eastern blackberry germplasm and ¼ western. Earlier ripening than 'Triple Crown' and 'Chester Thornless'. 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'.

'Columbia Sunrise' trailing blackberry released and patent application filed in 2016

'Columbia Sunrise' is thornless and very early ripening, 10 d before 'Black Diamond' and 14 d sooner than 'Marion'. The fruit size is larger than 'Marion' or 'Black Diamond' while its yield is comparable to 'Marion' and less than 'Black Diamond'. Fruit quality as a fresh or processed fruit is outstanding. What has set it apart is that it is early ripening, very sweet and has good ripening uniformity. Earlier ripening is one way to potentially reduce (through avoidance) spotted winged drosophila damage. Has done well with growers.

Slated for release. Need names, patent data or plant propagation.

- **ORUS 4370-1** is an early ripening (10d<Triple Crown) thornless that is ¾ eastern blackberry and ¼ western blackberry. Outstanding fruit quality, particularly skin toughness and a pleasant firmness along with large attractive fruit. Yield was comparable to 'Chester Thornless' in 2/3 years tested.

Grower trials

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

- ORUS 4024-3 has 'Willamette' 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 want it after 1st look.
- ORUS 4057-3. Thornless that produces high yields of high quality fruit 7-10 d ahead of 'Black Diamond' and ahead of Metolius/Obsidian in some seasons.
- ORUS 4222-1 is thornless and very high yielding, comparable to 'Black Diamond', with fruit size comparable to 'Marion'. Excellent quality for processing

2013 Trailing Planting (Tables BLK1 and BLK8)

- Nothing is better than current standards

2014 Trailing Planting (Tables BLK2 and BLK8)

- The newly named 'Hall's Beauty performed well, especially as early season berry with excellent firmness and flavor

2014 Trailing Planting (Tables BLK3 and BLK8)

- Nothing appears better than current standards in 1st harvest season

2013, 2014, and 2015 Semi-erect trials (Tables BLK4, BLK5, BLK6 and BLK8)

- ORUS 4370-1 performed well and will be released (see above).
- The recent release 'Eclipse' continues its steady performance. While it's yields are not as big as 'Chester Thornless' or 'Triple Crown', it is 2.5 weeks earlier than 'Chester' and 2 weeks ahead of 'Triple Crown' with very good fruit quality especially firmness, skin toughness and flavor.
- 'Von' had excellent fruit quality early in the season, and ripened about 2 weeks ahead of 'Triple Crown' and 'Chester Thornless'.
- None of the new selections planted in 2014 were impressive

2014 Planted Primocane-fruiting trials (Table BLK7 and BLK8)

- ORUS 4545-2 looked promising for trial due to medium berry size, yield higher than 'Prime-Ark® 45' and it was about 1 week ahead of 'Prime-Ark® 45'
- While lower yielding than the standards, ORUS 4546-1 was firm with superior fruit quality.
- In trying to assess commercial viability of our selections asked a colleague who has looked at a lot of these for a late season assessment: "ORUS 4545-1 is earlier and appears to have good yield relative to 'Prime-Ark® 45' but I'm concerned about small fruit and an apparent susceptibility to heat leading to poor set. ORUS 4545-2 looks better with regard to fruit quality and I like its more compact habit. Not sure how much earlier it is. Of the bunch my

fav is ORUS 4546-1 which I think has good size and a good growth habit and fruit presentation. I think this one shows promise. Would like to see yield and season though."

***Blackberry phenotyping RosBREED completed* (Yin, M. Clark, Bassil, Zurn, J.R. Clark, Finn)**

Populations were established in both locations and phenotyped for numerous vegetative and fruiting traits. Melinda Yin has taken the lead on this. The populations will be genotyped in the Bassil lab.

Winter hardiness and machine harvestability evaluation

Since 2001, over 250 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 ORUS 4370-1 were scored as similar to, or much better than, 'Marion' for cold hardiness in comparable years in Lynden.

Seedlings, germplasm/cultivar development

- In 2017, we made 41 crosses (26 trailing, 7 semi-erect/erect, and 8 PF), made 11 trailing and 6 primocane fruiting blackberry selections; and planted ~2500 seedlings.

Red Raspberry

Named

- 'Kokanee' (ORUS 4090-1) is primocane fruiting with very large fruit, excellent fruit quality and yields comparable to or better than 'Heritage'. Shipping quality is excellent. Since as late as 'Heritage' may need tunnels in Oregon to have sufficient yield. It is root rot susceptible but not horribly so. Did very well in commercial fresh market trial in Mexican/Spanish fresh market production systems.

Being propagated for Grower Trial

- ORUS 4089-2, Primocane or floricane fresh. Looked very good in Lynden and at NWREC. Bright firm and attractive as PF
- ORUS 4291-1, Primocane, fresh. Very early! 18-21 d < Heritage
- ORUS 4373-1, Floricane processed. Good yield. Good fruit quality. Excellent root rot resistance at WSU-Puyallup
- ORUS 4487-1, Primocane, fresh. Very early! 10d < Heritage
- ORUS 4600-2, Floricane processed. Promising in MH in Lynden. 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 Enfield.
- ORUS 4716-1, Primocane fresh. Group would like to trial in Cal/Mexico. Initial yield and quality look good
- ORUS 4725-1, Primocane fresh. Group would like to trial in Cal/Mexico. Initial yield and quality look good

2014 Floricane Fruiting Trial (Tables RY1 and RY7)

- All harvested with Littau harvester
- Statistically similar yields for all.
- WSU 2166 performed well. Excellent yield, large high quality fruit and machine harvests. It will be named.

2015 Floricane Fruiting Trial (Tables RY2 and RY7)

- All harvested with Littau harvester
- Although yields were statistically similar ORUYS 4607-2, ORUS 4600-2 and ORUS 4600-3 looked very promising for yield, machine harvestability. In addition they looked good in machine harvest trials in Lynden, WA.

WRRC supported machine harvest trials planted in 2015 and 2016 (Table RY3)

- ORUS 4600-3, promising in our trials, had yields greater than 'Meeker' and 'Cascade Harvest' over two years and greater than 'Wake®field' in the 2nd harvest season. It was also midway in firmness between 'Meeker' and 'Wake®field'. ORUS 4600-1 also looked promising especially for firmness and yield in the Lynden trials. We will see it for the first time next year at NWREC.
- ORUS 4692-1 looked very good in initial trials with machine harvestable yields greater than 'Meeker' and 'Cascade Harvest' but less than 'Wake®field'.

2014 Primocane Fruiting Trial (Tables RY4 and RY8)

- Nothing looked outstanding for trial.

2014 Primocane Fruiting Trial (Tables RY5 and RY8)

- Root rot was a problem in this field, some selections and 'Kokanee' suffered from it.
- ORUS 4716-1 and ORUS 4725-1 had good yields and outstanding fruit quality, especially for firmness. They will be propagated for rep trial and grower trial. As soon as possible due to their potential.
- BP-1 (Amira) did not do well for us

2016 Primocane Fruiting Trial (Tables RY6 and RY8)

- Rose stem girdler unbeknownst to us infected our planting. A couple selections, particularly ORUS 4864-1 looked decent but it may simply have been that they were really early and ripened more of their crop before their canes were girdled. The standard 'Heritage', along with 'Imara', 'Kweli' and 'Kwanza' did not look good but the trial was probably not fair due to RSG!

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 2017, we made 40 crosses (22 floricane, 18 primocane), made 31 selections (18 floricane, 13 primocane), and planted ~3,000 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 now further refining the markers for aphid resistance and did use the markers to screen seedlings for aphid resitance. We now have selections that have mulitple sources of aphid resistance.

Grower Trial

- Major setback on ORUS 3735-3 as every plant that came from the nursery was crumbly in 2015 and it was not due to RBDV; suspect a mutation in propagation. We have started over with plants from original stock. Excellent root rot tolerance in WSU-Puyallup trials
- ORUS 3013-1 Processing. High yields of fruit that appear to machine harvest well. Not the long-lived replacement we want for 'Munger' but may be better for the short-run.
- 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 3038-1. Processing. High yields of very tasty fruit. May have root rot problem.
- ORUS 3217-1. Processing. High yields of fruit that appear to machine harvest well. 'Munger' size not sure color is dark enough. Not the long-lived replacement we want for 'Munger' but may be better for the short-run.
- 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
- ORUS 3409-1 is a primocane fruiting black raspberry that is somewhat similar to 'Niwot' but seems to be more reliably productive. 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

2014 Planted Trials (Tables BLKRY1 and BLKRY3).

- Harvested the entire field with Littau machine.
- ORUS 4412-2 and ORUS 4499-1 high yields, relatively large fruit, machine harvested well and had excellent fruit quality.

2015 Planted Trials (Tables BLKRY2 and BLKRY3).

- Harvested the entire field with Littau machine.
- A few had yields higher than Munger with similar berry size excellent fruit quality.
- Very excited but need more data!

- ORUS 3381-3 has yields, season, and fruit size similar to MacBlack

Seedlings, Germplasm/Cultivar development
In 2017, we made 22 crosses, 18 selections, and planted ~900 seedlings.

Table BLK1. Fruit size and yield in 2015-17 for trailing blackberry genotypes at OSU-NWREC. Planted in 2013. All thornless except 'Marion'.

	Berry size (g)	Yield (tons·a^{-1})			
Genotype	2015-17	2015	2016	2017	2015-17
2015	5.9 b[z]				3.41 b
2016	6.5 a				5.48 a
2017	6.6 a				5.88 a
Replicated					
Columbia Star	**6.6 b**	**3.33 a**	**5.73 ab**	**7.11 a**	**5.39 a**
Black Diamond	**6.2 c**	**2.55 a**	**6.07 a**	**6.12 ab**	**4.92 a**
Marion	**5.1 d**	**3.87 a**	**4.82 c**	**5.67 ab**	**4.79 a**
ORUS 4344-2	7.4 a	3.87 a	5.28 bc	4.61 b	4.58 a
Nonreplicated					
Hall's Beauty (ORUS 3453-2)	6.5	2.51	4.72	5.68	4.30

[z] Mean separation within columns by LSD, p≤0.05.

Table BLK2. Fruit size and yield in 2016-17 for thornless trailing blackberry genotypes and 'Marion' at OSU-NWREC[z]. Planted in 2014.

	Berry size (g)	Yield (tons·a^{-1})		
Genotype	2016-17	2016	2017	2016-17
2016	6.2 b			6.47 a
2017	6.9 a			6.04 a
Replicated				
Columbia Star	**6.9 a**	**7.24 a**	**6.92 a**	**7.08 a**
Hall's Beauty (ORUS 3453-2)	**6.9 a**	**7.40 a**	**6.21 a**	**6.81 a**
Black Diamond	**6.6 a**	**6.73 a**	**6.32 a**	**6.53 a**
Marion	**5.7 b**	**4.50 b**	**4.72 a**	**4.61 b**
Nonreplicated				
ORUS 4430-1	6.8	8.39	5.34	6.86

[z] Mean separation within columns by LSD, p≤0.05.

Table BLK3. Fruit size and yield in 2017 for trailing blackberry genotypes at OSU-NWREC. Planted in 2015

Genotype	Thornless or thorny [y]	Berry size (g)[z]	Yield $(tons \cdot a^{-1})$
Replicated			
Columbia Star	**Thls**	**7.1 a**	**4.28 a**
Marion	**Thorny**	**5.3 c**	**3.59 a**
Black Diamond	**Thls**	**6.4 ab**	

RESEARCH REPORT
TO THE
OREGON RASPBERRY AND BLACKBERRY COMMISSION
AND THE
AGRICULTURAL RESEARCH FOUNDATION
2016-2017

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

Investigator: Brian Yorgey, 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, 2016, through June 30, 2017

ORBC Funding for 2016-2017: $ 8236

Results:

Caneberry varieties and selections from plots at the North Willamette Research and Extension Center were sent to the OSU Food Science Pilot Plant for analysis and processing from May 31 to September 13, 2016. During the 2016 season the following numbers of genotypes were processed and analyzed:

Blackberries – 6 processing cultivars, 12 ORUS processing selections, 4 fresh market floricane fruiting cultivars, 16 ORUS fresh market floricane fruiting selections, 3 fresh market primocane fruiting cultivars, 7 ORUS fresh market primocane fruiting selections
Red raspberries – 4 processing cultivars, 21 ORUS processing selections, 16 WSU processing selections, 3 primocane/fall fruiting cultivars, 12 ORUS primocane/fall fruiting selections
Black raspberries - 2 cultivars, 33 ORUS selections

Chemistry data (°brix, pH, and TA) are shown in Tables 1 through 6. Included are data for individual harvest dates and weighted data for each genotype over the entire harvest period for blackberries, red raspberries and black raspberries.

Samples were displayed at the Research Evaluation at OSU in December, 2016, at the ORBC Commission Research meeting two days later (also December, 2016), and at the Northwest Food Processors Association meeting in January, 2017.

Black Raspberry Puree Evaluation:

In March 2017, I presented purees of seven black raspberry selections from our breeding program along with Munger as the standard to growers, processors, and researchers in a blind evaluaton. Forty five people participated. The results are shown in Figue 1.

Results:

<u>Overall Quality</u>
Four selections scored in the highest tier: ORUS 4412-2, ORUS 4306-1, ORUS 3902-2, and ORUS 4410-1. Munger and ORUS 4399-1 scored the lowest.

<u>Aroma</u>
Two ORUS selections, ORUS 3902-2 and ORUS 4412-2, scored statistically higher than one selection, ORUS 4399-1. All other selections and Munger were rated equivalently.

<u>Color</u>
Munger and all the selections were rated as equivalent.

<u>Flavor</u>
The four highest rated selections were ORUS 4306-1, ORUS 4412-2, ORUS 3902-2, and ORUS 4410-1. Munger was rated statistically lower than all of these and had the lowest mean score of all eight.

Discussion:

Looks to me like we've got some very promising germplasm in ORUS 4412-2, ORUS 4306-1, ORUS 3902-2, and ORUS 4410-1. Yes, we need to line up these results with the field data but I'm excited.

Table 1: 2016 Blackberry Chemistry - by Harvest Date

Variety/Selection	Field Year	Harvest Date	°brix	pH	TA (g citric/kg)
Black Diamond	2012	6/15/16	9.82	3.40	9.32
		6/21/16	9.71	3.20	15.80
	2013	6/15/16	10.81	3.40	11.45
		6/21/16	10.59	3.29	14.82
	2014	6/7/16	10.23	3.56	12.89
		6/14/16	9.11	3.52	10.26
		6/21/16	9.59	3.39	14.39
Chester Thornless	2012	7/12/16	11.17	3.16	10.30
		8/2/16	11.86	3.51	9.68
	2013	7/19/16	11.79	3.30	10.65
	2014	7/26/16	11.90	3.29	10.60
		8/2/16	11.82	3.50	10.32
Columbia Star	2013	6/7/16	14.60	3.44	14.74
		6/15/16	11.39	3.24	13.00
		6/21/16	12.64	3.23	14.17
	2014	6/7/16	13.10	3.40	15.45
		6/14/16	11.44	3.27	13.94
		6/21/16	11.45	3.34	13.60
Columbia Sunrise	2012	6/7/16	13.32	3.78	8.42
		6/15/16	12.53	3.89	5.89
Hall's Beauty	2013	6/15/16	12.72	3.41	11.55
	2014	6/14/16	10.76	3.33	12.00
		6/21/16	11.15	3.49	12.07
Marion	2012	6/15/16	12.53	3.12	15.59
		6/21/16	12.56	3.21	16.32
	2013	6/15/16	12.57	3.12	14.53
		6/21/16	12.56	3.27	15.14
	2014	6/14/16	12.25	3.10	15.65
		6/21/16	12.43	3.32	13.65
Osage	2012	6/28/16	10.11	3.30	12.74
Triple Crown	2013	7/19/16	13.63	3.27	12.71
		8/2/16	14.22	3.60	8.54
	2014	7/26/16	13.89	3.61	10.53
		8/2/16	14.10	3.55	9.50
Von	2013	7/5/16	11.67	3.45	8.16
		7/26/16	12.81	3.49	8.10
ORUS 2711-1	demo	7/19/16	10.30	3.34	11.16

Variety/Selection	Field Year	Harvest Date	°brix	pH	TA (g citric/kg)
ORUS 2816-4	2013	7/5/16	12.67	3.57	8.65
ORUS 2867-2	2014	7/12/16	15.26	3.32	10.93
		7/19/16	16.71	3.34	10.88
ORUS 2867-3	2014	7/26/16	12.35	3.36	8.91
		8/2/16	12.68	3.49	8.35
ORUS 3172-1	2013	6/28/16	16.18	3.20	19.92
		7/5/16	14.85	3.15	17.86
ORUS 3636-1	2014	6/7/16	12.90	3.58	16.73
		6/14/16	11.97	3.49	12.18
ORUS 4057-2	2012	6/15/16	10.56	3.42	11.28
ORUS 4057-3	2012	6/7/16	12.75	3.66	14.08
		6/21/16	10.96	3.49	12.14
		6/28/16	11.18	3.31	12.80
ORUS 4066-2	2012	7/5/16	15.18	3.63	7.56
		7/21/16	11.80	3.37	9.18
ORUS 4200-1	2012	7/5/16	13.27	3.26	16.15
ORUS 4222-1	2012	6/15/16	12.47	3.55	11.32
		6/21/16	11.51	3.36	13.52
		6/28/16	12.71	3.19	15.81
ORUS 4235-2	2013	6/15/16	12.73	3.38	12.10
		6/21/16	13.06	3.18	15.57
		6/28/16	13.47	3.26	13.69
ORUS 4239-1	2012	7/5/16	12.45	3.99	7.09
		7/12/16	11.72	3.45	8.86
ORUS 4248-1	2012	1/7/00	12.47	-	-
ORUS 4266-1	2012	7/5/16	12.83	3.67	8.23
ORUS 4266-2	2012	6/28/16	13.50	3.78	6.91
		7/5/16	14.50	4.35	4.80
ORUS 4273-2	2012	6/28/16	12.77	3.39	10.03
		7/5/16	12.73	3.62	8.06
ORUS 4278-2	2012	7/21/16	13.43	3.52	6.88
		8/2/16	12.95	3.70	7.25
ORUS 4344-2	2013	6/21/16	15.32	3.44	12.10
		6/28/16	13.70	3.43	13.00
		7/5/16	13.64	3.47	11.91
ORUS 4344-3	2013	6/15/16	11.79	3.72	7.24
		6/28/16	12.87	3.63	7.80
ORUS 4358-3	2013	6/28/16	10.18	3.23	15.23

Variety/Selection	Field Year	Harvest Date	°brix	pH	TA (g citric/kg)
ORUS 4370-1	2013	7/5/16	13.58	3.66	7.40
		7/19/16	11.87	3.28	10.39
ORUS 4370-2	2013	7/19/16	13.84	3.40	8.62
		7/26/16	13.59	3.37	10.10
ORUS 4424-1	2014	6/14/16	11.79	3.12	16.96
		6/21/16	12.30	3.27	17.03
		6/28/16	12.76	3.35	16.20
ORUS 4425-1	2014	5/31/16	12.30	3.26	13.83
		6/7/16	14.10	3.69	13.26
ORUS 4426-1	2014	6/21/16	10.88	3.60	12.76
		6/28/16	11.50	3.73	12.11
ORUS 4430-1	2014	6/14/16	13.58	3.29	17.34
		6/21/16	12.19	3.37	15.51
ORUS 4430-2	2014	6/21/16	14.54	3.44	15.54
		6/28/16	14.82	3.44	14.87
ORUS 4437-1	2014	6/14/16	12.35	3.34	13.14
ORUS 4453-1	2014	7/5/16	14.87	3.55	9.79
		7/21/16	12.21	3.26	12.16
ORUS 4453-2	2014	6/28/16	11.00	3.22	14.22
		7/5/16	12.02	3.40	10.40

Table 2: 2016 Blackberry Chemistry - Weighted Means

Variety/Selection	Field Year	Wt'd °brix	Wt'd pH	Wt'd TA (g citric/L)
Black Diamond	2012	9.77	3.31	12.23
	2013	10.67	3.33	13.60
	2014	9.48	3.46	12.64
Chester Thornless	2012	11.66	3.41	9.86
	2013	11.79	3.30	10.65
	2014	11.85	3.42	10.42
Columbia Star	2013	12.21	3.25	13.71
	2014	11.54	3.31	13.83
Columbia Sunrise	2012	12.77	3.86	6.65
Hall's Beauty	2013	12.72	3.41	11.55
	2014	10.99	3.42	12.04
Marion	2012	12.55	3.18	16.08
	2013	12.56	3.22	14.95
	2014	12.38	3.25	14.21
Osage	2012	10.11	3.30	12.74
Triple Crown	2013	14.08	3.52	9.53
	2014	14.01	3.57	9.93
Von	2013	11.99	3.46	8.15
ORUS 2711-1	demo	10.30	3.34	11.16
ORUS 2816-4	2013	12.67	3.57	8.65
ORUS 2867-2	2014	15.92	3.32	10.91
ORUS 2867-3	2014	12.53	3.43	8.60
ORUS 3172-1	2013	15.38	3.17	18.68
ORUS 3636-1	2014	12.32	3.52	13.89
ORUS 4057-2	2012	10.56	3.42	11.28
ORUS 4057-3	2012	11.25	3.40	12.70
ORUS 4066-2	2012	12.65	3.43	8.77
ORUS 4200-1	2012	13.27	3.26	16.15
ORUS 4222-1	2012	12.38	3.32	14.05
ORUS 4235-2	2013	13.16	3.25	14.02
ORUS 4239-1	2012	12.11	3.74	7.92
ORUS 4248-1	2012	12.47	-	-
ORUS 4266-1	2012	12.83	3.67	8.23
ORUS 4266-2	2012	14.05	4.09	5.75
ORUS 4273-2	2012	12.74	3.54	8.77
ORUS 4278-2	2012	13.21	3.60	7.05
ORUS 4344-2	2013	13.85	3.45	12.26

Variety/Selection	Field Year	Wt'd °brix	Wt'd pH	Wt'd TA (g citric/L)
ORUS 4344-3	2013	12.42	3.66	7.57
ORUS 4358-3	2013	10.18	3.23	15.23
ORUS 4370-1	2013	12.44	3.41	9.39
ORUS 4370-2	2013	13.70	3.38	9.48
ORUS 4424-1	2014	12.32	3.26	16.81
ORUS 4425-1	2014	12.75	3.36	13.69
ORUS 4426-1	2014	11.07	3.64	12.56
ORUS 4430-1	2014	12.50	3.35	15.93
ORUS 4430-2	2014	14.63	3.44	15.32
ORUS 4437-1	2014	12.35	3.34	13.14
ORUS 4453-1	2014	14.14	3.47	10.44
ORUS 4453-2	2014	11.57	3.32	12.07

Table 3: 2016 Red Raspberry Chemistry - by Harvest Date

Variety/Selection	Year	Harvest Date	°brix	pH	TA (g citric/L)
Cascade Gold	2014	6/7/16	7.61	3.44	16.15
Heritage	2013	8/9/16	11.90	3.02	20.86
		8/16/16	11.79	3.15	20.82
	2014	8/9/16	12.34	3.07	18.70
		8/23/16	11.37	3.11	19.70
	2015	8/23/16	15.33	3.24	20.17
Kokanee	2015	8/16/16	11.63	3.19	17.34
		8/23/16	14.29	3.52	15.45
Lewis	2014	6/14/16	10.36	3.18	15.59
		6/21/16	11.15	3.26	16.99
		6/28/16	9.32	3.20	17.60
Meeker	2013	5/31/16	11.95	3.24	14.38
		6/7/16	13.28	3.49	13.80
		6/14/16	11.08	3.36	12.70
		6/21/16	12.58	3.43	13.61
	2014	6/7/16	12.01	3.46	13.27
		6/14/16	10.71	3.33	13.49
		6/21/16	11.00	3.46	13.65
Vintage	2014	8/2/16	13.14	3.58	11.36
	2015	8/9/16	13.75	3.41	11.58
		8/16/16	13.34	3.36	11.08
		8/23/16	13.83	3.47	12.35
Wakefield	demo	6/14/16	9.14	3.34	14.52
ORUS 3702-3	2013	5/31/16	10.34	3.06	18.23
		6/14/16	9.57	3.28	14.17
ORUS 3713-1	2014	6/14/16	10.95	3.23	14.80
		6/21/16	10.20	3.32	14.52
		6/28/16	11.55	3.46	12.86
ORUS 3722-1	2013	6/7/16	9.46	3.52	11.39
		6/14/16	8.87	3.39	10.28
ORUS 3767-3	2014	6/7/16	11.66	3.47	10.44
		6/14/16	10.60	3.18	15.14
		6/21/16	-	3.23	18.93
ORUS 3959-3	2014	6/14/16	10.12	3.35	13.57
ORUS 4090-1	2014	8/23/16	12.17	3.27	14.94
ORUS 4371-3	2013	6/14/16	11.27	3.71	8.38

Variety/Selection	Year	Harvest Date	°brix	pH	TA (g citric/L)
ORUS 4371-4	2013	6/7/16	11.50	3.31	16.17
		6/14/16	10.26	3.24	15.65
		6/21/16	12.12	3.19	18.75
ORUS 4373-1	2013	6/14/16	10.67	3.26	12.25
		6/21/16	11.85	3.41	14.30
		6/28/16	12.31	6.61	9.80
ORUS 4380-3	2013	6/14/16	8.48	3.10	18.89
ORUS 4462-1	2014	6/14/16	9.44	3.39	14.28
ORUS 4462-2	2014	6/14/16	11.19	3.35	11.56
		6/21/16	11.17	3.29	14.87
ORUS 4463-1	2014	6/21/16	10.75	3.04	24.50
		6/28/16	9.93	2.69	27.41
ORUS 4465-1	2013	6/14/16	9.42	3.13	15.34
ORUS 4465-2	2014	6/7/16	10.05	3.40	16.37
		6/14/16	9.39	3.29	15.81
		6/21/16	10.12	3.21	18.41
ORUS 4465-3	2014	6/7/16	10.84	3.61	14.28
		6/14/16	9.66	3.37	13.44
		6/21/16	9.07	3.41	15.71
ORUS 4473-3	2014	6/14/16	8.94	3.24	14.46
		6/21/16	8.25	3.19	17.23
ORUS 4482-3	2014	6/14/16	8.63	3.23	16.21
		6/21/16	9.84	3.25	18.63
ORUS 4487-1	2013	8/9/16	13.10	3.37	12.90
		8/23/16	15.27	3.42	13.62
ORUS 4493-1	2014	7/12/16	10.12	3.07	18.97
		7/19/16	9.99	3.13	18.67
		7/26/16	10.22	3.24	17.69
		8/23/16	10.73	3.54	11.96
ORUS 4494-2	2013	7/26/16	11.64	3.33	14.86
ORUS 4599-1	2014	6/14/16	11.51	3.30	12.98
ORUS 4599-3	2014	6/14/16	9.53	2.99	18.49
		6/21/16	9.97	3.24	16.77
		7/5/16	10.73	3.17	19.03
ORUS 4619-1	2014	6/7/16	11.68	3.32	16.52
ORUS 4622-2	2015	8/16/16	11.32	3.14	19.30
		8/23/16	13.03	3.21	19.84
ORUS 4716-1	2015	8/16/16	12.55	3.08	18.86

Variety/Selection	Year	Harvest Date	°brix	pH	TA (g citric/L)
ORUS 4719-1	2015	8/9/16	12.28	3.26	14.76
		8/23/16	13.79	3.38	16.33
WSU 1914	2013	6/7/16	10.05	3.10	22.49
		6/14/16	8.41	3.11	14.94
WSU 1956	2014	6/14/16	11.12	3.22	12.96
		6/21/16	11.31	3.29	14.35
		6/28/16	9.99	3.10	16.20
		7/5/16	10.52	3.21	17.15
WSU 1980	2014	6/14/16	10.96	3.35	15.00
		6/21/16	12.05	3.35	17.60
		6/28/16	10.96	3.58	16.92
WSU 1985	2014	6/14/16	9.91	3.36	14.34
		6/21/16	9.84	3.19	17.59
		6/28/16	9.96	3.13	20.95
WSU 2001	2014	6/14/16	10.60	3.40	16.35
		6/21/16	11.32	3.09	15.79
		6/28/16	9.72	3.27	16.43
WSU 2010	2013	6/14/16	9.63	3.33	12.71
	2014	6/7/16	11.37	3.46	13.71
		6/14/16	9.86	3.25	14.10
		6/21/16	10.81	3.34	15.01
WSU 2068	2014	6/7/16	10.59	3.48	14.38
		6/14/16	10.58	3.22	14.24
		6/21/16	12.23	3.10	17.25
WSU 2075	2014	6/7/16	10.94	3.56	16.25
		6/14/16	8.46	3.54	13.92
		6/21/16	12.15	3.30	16.73
WSU 2122	2014	6/7/16	11.22	3.45	18.05
		6/14/16	10.51	3.32	16.54
		6/21/16	10.82	3.13	17.78
		6/28/16	10.66	3.20	18.37
		7/5/16	10.87	3.18	20.81
WSU 2130	2014	6/7/16	10.97	3.45	18.52
		6/14/16	10.14	3.15	16.94
		6/21/16	-	3.21	21.24
WSU 2133	2014	6/7/16	14.00	3.38	18.86
		6/14/16	11.75	3.33	14.14
		6/21/16	12.05	3.13	18.75

Variety/Selection	Year	Harvest Date	°brix	pH	TA (g citric/L)
WSU 2166	2014	6/7/16	10.75	3.54	19.45
		6/14/16	10.33	3.01	20.07
		6/21/16	10.11	3.14	20.41
		6/28/16	11.18	2.98	20.58
WSU 2188	2014	6/14/16	11.49	3.14	18.23
		6/21/16	11.18	3.13	21.17
		6/28/16	12.24	3.17	18.83
		7/5/16	12.62	3.15	19.87
WSU 2200	2014	6/14/16	9.53	3.32	14.56
		6/21/16	10.57	3.26	15.90
WSU 2205	2014	6/7/16	11.31	3.58	19.00
		6/14/16	10.46	3.22	16.26

Table 4: 2016 Red Raspberry Chemistry - Weighted Means

Variety/Selection	Year	Wt'd °brix	Wt'd pH	Wt'd TA (g citric/L)
Cascade Gold	2014	7.61	3.44	16.15
Heritage	2013	11.82	3.11	20.83
	2014	12.13	3.08	18.92
	2015	15.33	3.24	20.17
Kokanee	2015	13.03	3.36	16.35
Lewis	2014	10.22	3.22	17.05
Meeker	2013	12.22	3.40	13.44
	2014	11.03	3.41	13.54
Vintage	2014	13.14	3.58	11.36
	2015	13.67	3.42	11.70
Wakefield	demo	9.14	3.34	14.52
ORUS 3702-3	2013	9.76	3.22	15.18
ORUS 3713-1	2014	10.65	3.33	14.21
ORUS 3722-1	2013	9.05	3.43	10.61
ORUS 3767-3	2014	11.03	3.28	14.82
ORUS 3959-3	2014	10.12	3.35	13.57
ORUS 4090-1	2014	12.17	3.27	14.94
ORUS 4371-3	2013	11.27	3.71	8.38
ORUS 4371-4	2013	11.08	3.24	16.67
ORUS 4373-1	2013	11.67	4.51	12.08
ORUS 4380-3	2013	8.48	3.10	18.89
ORUS 4462-1	2014	9.44	3.39	14.28
ORUS 4462-2	2014	11.18	3.31	13.55
ORUS 4463-1	2014	10.36	2.87	25.88
ORUS 4465-1	2013	9.42	3.13	15.34
ORUS 4465-2	2014	9.81	3.30	16.69
ORUS 4465-3	2014	9.56	3.41	14.39
ORUS 4473-3	2014	8.44	3.20	16.45
ORUS 4482-3	2014	9.29	3.24	17.53
ORUS 4487-1	2013	13.82	3.38	13.14
ORUS 4493-1	2014	10.24	3.23	17.10
ORUS 4494-2	2013	11.64	3.33	14.86
ORUS 4599-1	2014	11.51	3.30	12.98
ORUS 4599-3	2014	9.95	3.14	17.75
ORUS 4619-1	2014	11.68	3.32	16.52
ORUS 4622-2	2015	12.08	3.17	19.54
ORUS 4716-1	2015	12.55	3.08	18.86

Variety/Selection	Year	Wt'd °brix	Wt'd pH	Wt'd TA (g citric/L)
ORUS 4719-1	2015	12.75	3.30	15.25
WSU 1914	2013	9.15	3.11	18.35
WSU 1956	2014	10.72	3.20	15.20
WSU 1980	2014	11.34	3.47	16.89
WSU 1985	2014	9.90	3.23	17.45
WSU 2001	2014	10.53	3.25	16.19
WSU 2010	2013	9.63	3.33	12.71
	2014	10.63	3.34	14.36
WSU 2068	2014	11.06	3.28	15.15
WSU 2075	2014	10.33	3.46	15.44
WSU 2122	2014	10.74	3.23	17.98
WSU 2130	2014	10.58	3.27	19.19
WSU 2133	2014	12.41	3.27	16.86
WSU 2166	2014	10.44	3.13	20.14
WSU 2188	2014	11.67	3.14	19.55
WSU 2200	2014	10.03	3.29	15.21
WSU 2205	2014	10.79	3.36	17.31

Table 5: 2016 Black Raspberry Chemistry - by Harvest Date

Variety/Selection	Field Year	Harvest Date	°brix	pH	TA (g citric/kg)
MacBlack	2014	6/28/16	13.55	3.54	13.27
		7/5/16	11.57	3.70	11.62
Munger	2013	6/14/16	11.76	3.74	9.84
		6/21/16	-	4.05	8.44
	2014	6/13/16	11.91	3.80	10.28
		6/21/16	16.63	4.13	7.40
ORUS 3219-2	2012	6/14/16	11.50	3.71	10.70
ORUS 3381-3	2014	6/21/16	14.99	3.88	8.47
		6/28/16	13.63	3.68	9.37
ORUS 3412-1	2012	6/14/16	10.64	3.61	10.13
		6/28/16	15.81	3.88	9.85
ORUS 3808-2	2014	6/13/16	-	3.65	12.52
		6/21/16	-	4.02	10.63
ORUS 3835-1	2014	6/13/16	13.37	4.11	6.52
		6/21/16	15.04	4.26	6.52
ORUS 3843-1	2014	6/13/16	14.67	3.92	11.25
ORUS 3891-1	2014	6/13/16	13.71	4.04	7.87
		6/21/16	15.51	4.11	7.47
ORUS 3896-1	2014	6/13/16	13.41	3.96	10.46
		6/21/16	15.26	4.16	7.49
ORUS 3902-2	2014	6/13/16	12.64	4.05	7.82
		6/21/16	16.25	4.16	6.77
ORUS 4124-1	2014	6/21/16	13.63	4.54	4.77
ORUS 4154-1	2014	6/13/16	11.01	3.92	9.16
		6/21/16	12.62	3.94	8.37
ORUS 4306-1	2013	6/14/16	13.93	4.02	8.27
		6/21/16	-	4.28	5.48
ORUS 4310-1	2013	6/14/16	12.68	3.64	10.02
		6/21/16	-	3.77	10.31
ORUS 4310-2	2013	6/14/16	13.02	3.97	7.30
ORUS 4311-1	2013	6/14/16	14.06	4.17	7.34
ORUS 4395-1	2013	6/14/16	12.48	3.90	7.75
	2014	6/13/16	11.05	3.96	7.79
		6/21/16	13.45	4.03	7.26
ORUS 4396-1	2013	6/14/16	11.13	3.69	9.64
ORUS 4396-2	2013	6/14/16	11.41	3.57	10.57

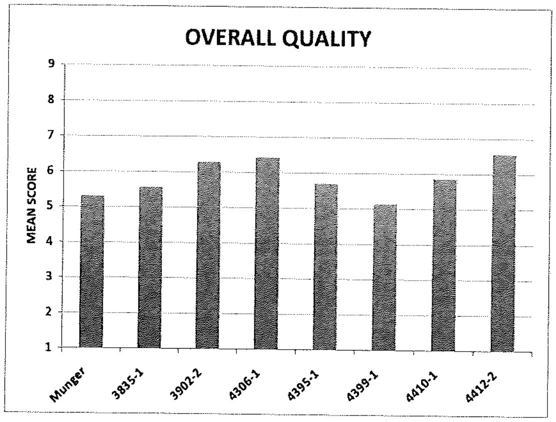
Variety/Selection	Field Year	Harvest Date	°brix	pH	TA (g citric/kg)
ORUS 4399-1	2014	6/13/16	11.28	4.05	6.75
		6/21/16	13.23	4.41	5.02
ORUS 4401-1	2013	6/21/16	16.02	4.24	8.15
ORUS 4409-2	2014	6/13/16	11.85	3.90	9.57
		6/21/16	13.82	4.05	7.63
ORUS 4410-1	2014	6/13/16	11.66	3.80	8.23
		6/21/16	13.78	4.01	7.62
ORUS 4411-1	2014	6/13/16	13.54	4.25	9.05
ORUS 4411-2	2014	6/13/16	12.25	4.05	8.32
		6/21/16	13.90	4.12	6.84
ORUS 4411-3	2014	6/13/16	12.33	3.92	9.33
		6/21/16	13.73	4.12	6.57
ORUS 4412-1	2014	6/13/16	12.81	4.23	6.78
		6/21/16	14.98	4.19	6.38
ORUS 4412-2	2014	6/13/16	11.64	3.88	7.62
		6/21/16	12.91	3.97	7.10
ORUS 4412-3	2014	6/13/16	11.08	4.13	7.51
ORUS 4412-4	2014	6/13/16	-	3.96	7.46
ORUS 4497-1	2014	6/13/16	11.37	3.72	9.50
ORUS 4498-2	2014	6/13/16	13.46	4.10	8.16
		6/21/16	-	4.10	7.76
ORUS 4499-1	2014	6/13/16	11.58	3.77	9.79
		6/21/16	13.59	3.97	7.91
ORUS 4499-3	2014	6/13/16	13.08	4.14	9.60

Table 6: 2016 Black Raspberry Chemistry - Weighted Means

Variety/Selection	Field Year	Wt'd °brix	Wt'd pH	Wt'd TA (g citric/kg)
MacBlack	2014	12.69	3.60	12.56
Munger	2013	11.76	3.93	8.98
Munger	2014	14.39	3.97	8.77
ORUS 3219-2	2012	11.50	3.71	10.70
ORUS 3381-3	2014	14.08	3.74	9.07
ORUS 3412-1	2012	13.52	3.76	9.97
ORUS 3808-2	2014	-	3.88	11.35
ORUS 3835-1	2014	14.12	4.18	6.52
ORUS 3843-1	2014	14.67	3.92	11.25
ORUS 3891-1	2014	14.29	4.06	7.74
ORUS 3896-1	2014	14.11	4.03	9.33
ORUS 3902-2	2014	14.10	4.09	7.39
ORUS 4124-1	2014	13.63	4.54	4.77
ORUS 4154-1	2014	11.74	3.93	8.81
ORUS 4306-1	2013	13.93	4.17	6.64
ORUS 4310-1	2013	12.68	3.71	10.18
ORUS 4310-2	2013	13.02	3.97	7.30
ORUS 4311-1	2013	14.06	4.17	7.34
ORUS 4395-1	2013	12.48	3.90	7.75
ORUS 4395-1	2014	12.14	3.99	7.55
ORUS 4396-1	2013	11.13	3.69	9.64
ORUS 4396-2	2013	11.41	3.57	10.57
ORUS 4399-1	2014	12.48	4.27	5.69
ORUS 4401-1	2013	16.02	4.24	8.15
ORUS 4409-2	2014	12.66	3.96	8.78
ORUS 4410-1	2014	12.62	3.89	7.95
ORUS 4411-1	2014	13.54	4.25	9.05
ORUS 4411-2	2014	12.83	4.07	7.79
ORUS 4411-3	2014	12.86	3.99	8.30
ORUS 4412-1	2014	13.43	4.22	6.66
ORUS 4412-2	2014	12.18	3.92	7.40
ORUS 4412-3	2014	11.08	4.13	7.51
ORUS 4412-4	2014	-	3.96	7.46
ORUS 4497-1	2014	11.37	3.72	9.50
ORUS 4498-2	2014	13.46	4.10	7.93
ORUS 4499-1	2014	12.27	3.84	9.15
ORUS 4499-3	2014	13.08	4.14	9.60

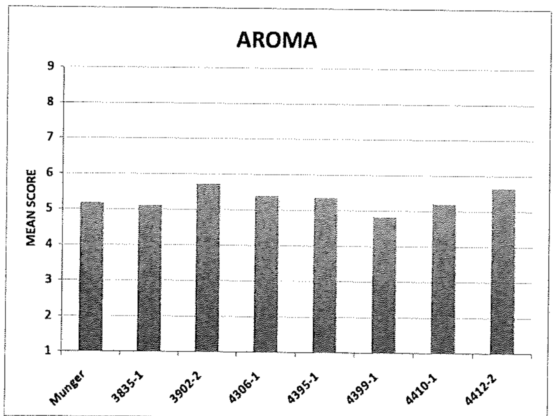
Variety/Selection	Field Year	Wt'd °brix	Wt'd pH	Wt'd TA (g citric/kg)
ORUS 4499-1	2014	12.27	3.84	9.15
ORUS 4499-3	2014	13.08	4.14	9.60

Figure 1. 2016 Black Raspberry Puree Evaluation Results



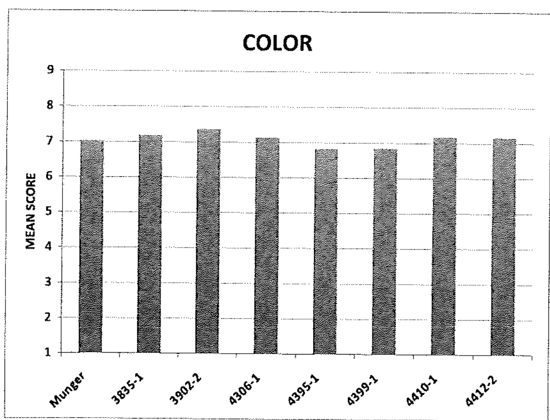
OVERALL QUALITY
ANOVA Mean Score
Tukey's HSD = 0.76
Values followed by the same letter are not statistically different.

ORUS 4412-2	6.6	a
ORUS 4306-1	6.4	ab
ORUS 3902-2	6.3	abc
ORUS 4410-1	5.9	abcd
ORUS 4395-1	5.7	bcd
ORUS 3835-1	5.6	cd
Munger	5.3	d
ORUS 4399-1	5.1	d



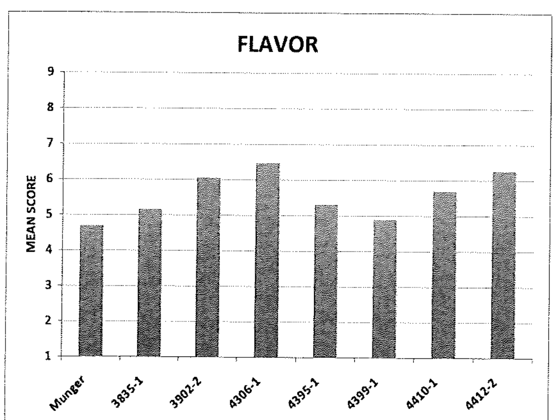
AROMA
ANOVA Mean Score
Tukey's HSD = 0.79
Values followed by the same letter are not statistically different.

ORUS 3902-2	5.7	a
ORUS 4412-2	5.6	a
ORUS 4306-1	5.4	ab
ORUS 4395-1	5.4	ab
ORUS 4410-1	5.2	ab
Munger	5.2	ab
ORUS 3835-1	5.1	ab
ORUS 4399-1	4.8	b



COLOR
ANOVA Mean Score
Tukey's HSD = 0.59
Values followed by the same letter are not statistically different.

ORUS 3902-2	7.4	a
ORUS 3835-1	7.2	a
ORUS 4410-1	7.2	a
ORUS 4412-2	7.2	a
ORUS 4306-1	7.1	a
Munger	7.0	a
ORUS 4399-1	6.8	a
ORUS 4395-1	6.8	a



FLAVOR
ANOVA Mean Score
Tukey's HSD = 0.92
Values followed by the same letter are not statistically different.

ORUS 4306-1	6.5	a
ORUS 4412-2	6.3	a
ORUS 3902-2	6.0	ab
ORUS 4410-1	5.7	abc
ORUS 4395-1	5.3	bcd
ORUS 3835-1	5.2	bcd
ORUS 4399-1	4.9	cd
Munger	4.7	d