



Washington Red Raspberry Commission

2025 Research Reports

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Plant Breeding



Project: 13C-3755-5641

TITLE: Red Raspberry Breeding, Genetics, and Clone Evaluation

Reporting Period: 2025

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Objectives: Achieve next stages in developing new summer-fruiting red raspberry cultivars with excellent yields and fruit quality and resistance to economically important diseases; conduct on-farm and disease evaluations to identify important germplasm; accelerate the release of advanced selections adapted to machine harvesting.

Accomplishments:

Cultivars and prospective cultivars. **WSU 2087** is a high-performing advanced selection that is in the cultivar release stage. It has excellent traits of machine harvestability, productivity, firm dark fruit, high soluble solids, low pH, and moderate levels of root rot tolerance for the Pacific Northwest processing industry. **WSU 2188** ('Cascade Legacy') received a complete plant patent. Information about 'Cascade Legacy' was published in the academic journal, *HortScience*. It is being propagated under a nonexclusive license with several regional nurseries. **WSU 2029** ('Cascade Prize') received Plant Variety Protection in 2025. It is being propagated under a nonexclusive license. **WSU 1605** ('Cascade Gem') received Plant Variety Protection in 2025. It is being propagated under exclusive license in North America. 'Cascade Gem' is a fresh cultivar with large fruit size, high yields, and excellent fruit quality that is well suited to long-cane production.

Crosses, seedlings, and selections. New crosses were performed in 2025 between parents with traits of excellent machine-harvested yield, berry firmness, and root rot tolerance. Thirty-seven crosses were successful out of 46. The seeds were germinated in vitro and transferred to the greenhouse to grow into 4,000 nursery plugs to plant with a grower-cooperator in Lynden in 2026. Three seedling fields are currently being managed and evaluated:

- 3600 seedlings planted 2023 with Lynden cooperator, 400 at WSU PREC, evaluated 2025-26.
- 1,739 seedlings planted 2024 with Lynden cooperator, managed and evaluated 2026-27
- 4,263 seedlings planted 2025 with Lynden cooperator, managed for 2027-28 evaluation

Machine Harvesting (MH) Trials - Observational. Three established machine harvesting trials were managed for production, and one new trial was planted in 2025 at Rader Farms. The 2022 MH trial was evaluated for the second time in 2025. Several selections stood out for outstanding qualities of plant durability, yield, and fruit quality. The cultivar 'Meeker' yielded 5.4 T/A, 'Wakefield' had 4.5 T/A, and 'Willamette' had 7.0 T/A average per year for two years. WSU 2731, WSU 2775, and WSU 2802 had excellent yield potential with good fruit quality. They are being propagated for further testing in a replicated field and fruit quality will be evaluated. Selections will be used for crosses in

2026 or 2027. WSU 2778, WSU 2776, and WSU 2726 averaged over 7.0 T/A per year for two years and will be used as parents in 2026 or 2027. Most other selections will be dropped from further evaluation.

The 2023 MH trial was evaluated for the first time in 2025. Several selections stood out for outstanding qualities of plant durability, yield, and fruit quality (Fig 2). WSU 2666 had good quality fruit in the mid-late season and over 13 tons per acre in harvested fruit. A second harvest evaluation is planned for 2026. Four MH trials were managed and evaluated in 2025:

- 2022 MH, 75 WSU, 14 ORUS selections, 3 cultivars, managed for evaluation 2024-2025.
- 2023 MH, 39 selections, 3 cultivars, managed for evaluation 2025-2026.
- 2024 MH, 46 selections, 3 cultivars, managed for evaluation 2026-2027.
- 2025 MH, 37 WSU, 6 ORUS selections, 3 cultivars; planted, managed for evaluation 2027-28.

Yield and Fruit Quality Evaluations (selection trials). Three established replicated trials were managed for production, and one new trial was planted in 2025 at Rader Farms:

- 2022 ST, 8 selections, 3 cultivars, 3 replicates, managed for evaluation 2024-2025.
- 2023 ST, 3 selections, 3 cultivars, 3 replicates, managed for evaluation 2025-2026.
- 2024 ST, 3 selections, 3 cultivars, 3 replicates, managed for evaluation 2026-2027.
- 2025 ST, 9 selections, 3 cultivars, 3 replicates; planted, managed for evaluation 2027-28.

The 2022 Selection Trial was harvested 3 times weekly in 2025 and evaluated for qualitative fruit quality. Fruit firmness was measured on a select number of selections and cultivars throughout the harvest season. WSU 2268 had yields comparable to ‘Willamette’ and ‘Cascade Harvest’ over two years (Table 1). WSU 2268 was noted for having large fruit with balanced flavor. WSU 2268 was similar in firmness to ‘Meeker’, which will need to be evaluated in future trials (data not shown).

Table 1. Yield of 8 WSU selections and 3 cultivars planted in 3 replicates in 2022 and harvested by machine in 2024 and 2025 in Lynden, WA.

Clone	2024		2025		2024-2025	
Meeker	5.3	a ^z	7.7	ab	13.0	a
WSU 2268	4.6	abc	8.3	a	12.9	a
Willamette	3.4	bcde	8.3	a	11.7	ab
Cascade Harvest	4.7	ab	6.8	abc	11.5	ab
WSU 2654	4.6	abcd	4.9	cd	9.5	bc
WSU 2188	2.9	e	5.9	bcd	8.8	c
WSU 2563	3.5	bcde	5.3	cd	8.8	c
WSU 2653	3.1	de	5.0	cd	8.1	cd
WSU 2088	3.2	bcde	4.6	de	7.8	cd
WSU 2585	3.0	e	4.2	de	7.2	cd
WSU 2575	3.2	cde	2.7	e	5.9	d

^zmeans in a column with the same letter are not statistically different at p=0.05 by Tukey's HSD.

The 2023 Selection Trial was harvested every 2 days during the season in 2025 and evaluated for qualitative fruit quality. Fruit firmness and size were measured on the selections twice during the

season. WSU 2205 had very high yields that were statistically similar to ‘Willamette’ and ‘Cascade Harvest’ (Table 2). WSU 2205 had berry size and firmness similar to cultivars ‘Meeker’ and ‘Cascade Harvest’ (data not shown). This planting will be evaluated for a second season in 2026.

Table 2. Yield of 3 WSU selections and 3 standard cultivars planted in replicated plots in 2023 and harvested by machine in 2025.

Clone	Yield (tons/A)
WSU2205	9.56 a ²
Willamette	8.36 ab
WSU2234	8.22 ab
CascHarv	7.94 ab
Meeker	6.78 bc
WSU2407	5.10 c

²means in a column with the same letter are not statistically different at p=0.05 by Tukey's HSD.

Grower Trials. Four advanced selections were evaluated in grower trial in 2025 and had results.

- **WSU 2130.** Data from 2025 show that WSU 2130 is not adapted to processing production in Washington. It has had very high, early yields and excellent fruit quality in Puyallup and the North Willamette valley over several harvest seasons and may potential in Oregon only.
- **WSU 2068** had good yields but overall soft fruit quality and will not be evaluated further.
- **WSU 2069** had good yields but overall soft fruit quality and will not be evaluated further.
- **WSU 2088** had good yields, mid-late season, dark color, and root rot symptoms. This selection will no longer be evaluated except at one site by request of the grower.

Root rot evaluations. Farm 5 at PREC has documented high levels of Phytophthora root rot and is an ideal site to screen selections for tolerance. Selections WSU 2268, WSU 2557, WSU 2653, WSU 2298, WSU 2376, WSU 2472, and WSU 2372 were noted for having high root rot tolerance over four years in a site with heavy disease pressure, similar to the standard ‘Cascade Bounty’. In the 2023 trial, several ORUS selections showed disease tolerance over three years, and WSU 2407 was also tolerant. WSU 2205 appears susceptible. In the planting established last year, WSU 2492 and WSU 2767 had high ratings. Four different root rot field screenings are being managed and evaluated in 2025, representing 124 total WSU, ORUS, and BC selections and several cultivars.

Collaborative genetic research. A fourth year of evaluation was accomplished on a project to study genomic selection for tolerance to root lesion nematode (RLN) and other traits in red raspberry. This project leverages investment by the WRRRC in raspberry plant breeding to contribute genetic resources and methods to evaluate a unique replicated panel of 270 raspberry clones representing the combined diversity of germplasm from WSU, British Columbia Berry Cultivar Development Inc., United States Department of Agriculture/Oregon State University, and the National Clonal Germplasm Repository. Genotyping-by-sequencing information was generated to conduct a genome-wide association study for RLN resistance in 2024, with results forthcoming. This is impactful work that has the potential to generate parents and useful markers for nematode resistance for cultivar development.

Select Publications

- Fincham, A., Makonya, G.M., Kiraga, S., Peters, T., Galinato, S.P., Gallardo, K., Hoashi-Erhardt, W., Benedict, C., Zamora Re, M.I., Bryla, D.R., & DeVetter, L.W. 2025. Heat Mitigation in Raspberries and Blackberries in the Pacific Northwest. WSU Extension Whitepaper. [Additional Information | Beat the Heat | Washington State University](#)
- Phipps, S.N., Bassil, N.V., DeLong, J.A., Hoashi-Erhardt, W., Lee, J., Vining, K.J., Weiland, J.E., Zasada, I.A., & Hardigan, M.A. 2025. Breeding for Resistance to Significant Disease and Insect Pests of Red and Black Raspberry (*Rubus idaeus* and *R. occidentalis*) in the Pacific Northwest. *HortScience*, 60(7), 1180–1199. <https://doi.org/10.21273/HORTSCI18571-25>.
- Davis, A., Hardigan, M.A., Lukas, S., Jones, P., Hoashi-Erhardt, W., & DeVetter, L.W. 2025. Raspberry cultivars for the Pacific Northwest. *Pacific Northwest Extension Publishing*, 655, 1–14. <https://extension.oregonstate.edu/catalog/pnw-655-raspberry-cultivars-pacific-northwest>.
- Hoashi-Erhardt, W., Moore, P.P., Hardigan MA, Peterson M., Lukas SB, Jones P, & Dossett, M. 2025. ‘WSU 2188’ (Cascade Legacy™) Red Raspberry. *HortScience*, 60(6):899–903. <https://doi.org/10.21273/HORTSCI18510-25>.
- Hoashi-Erhardt, W. Small Fruit Plant Breeding in Washington. In T. Kabaluk, L. Frey, and R. Sarte (eds.), *Horticultural Growers’ Short Course 2025 Proceedings*. Lower Mainland Horticultural Improvement Association.
- Makonya, G.M., D.R. Bryla, M.A. Hardigan, W. Hoashi-Erhardt, and L.W. DeVetter. 2025. Biostimulants with glycine betaine or kelp extract alleviate heat stress in red raspberry (*Rubus idaeus*). *Scientific Reports*, 15:2251 <https://doi.org/10.1038/s41598-024-83955-7>.

Title: On-farm trials of Advanced Raspberry Selections

Personnel: Thomas Walters, Walters Ag Research (PI). Co-PI's: Julie Pond, Michael Hardigan, Wendy Hoashi-Erhardt, Julie Enfield. Cooperators: Eric Gerbrandt, Rob Dhaliwal, John Clark

Reporting Period: 2025

Accomplishments: Evaluated five advanced selections from the WSU raspberry breeding program in trials at four locations, in comparison with Wakehaven, Kulshan and Cascade Premier

Results: We scouted and evaluated plants and fruit at four locations:

- A 2020-planted small plot trial on Bob Hall Road. Field variety Wakehaven, plots of WSU 2188, WSU 2088, WSU 2087 and WSU 2130.
- A 2020-planted small plot trial on Havemann Road. Field variety Cascade Premier, plots of ORUS 4607-2 (discarded), WSU 2130, WSU 2088.
- Block trial on Van Dyk road of Kulshan, WSU 2088, WSU 2069
- Block trial on Noon road of WSU 2188; single row WSU 2087 present

Cascade Legacy (WSU 2188)

- Long fruiting laterals break, especially in the first harvest year. Manage vigor.
- Flowering laterals were damaged by harvesters. They are very long at harvest, and can bend/break over training wires. Harvesters need to be set up for this variety, similar to Kulshan. At one location, primocanes were also damaged.
- Harvest start comparable to Kulshan, but does not continue as long
- Outstanding fruit quality, excellent for IQF processing. Fruit slips off easily, so first pick needs to happen before fruit falls off the plants
- Fruit is long and conic. Firm, but soft following a rain.
- Winter Hardiness better than WakeHaven® but not as good as

Cascade Premier

- Moderately susceptible to cane botrytis. Relatively few fruits/lateral (10-14) compared with other new varieties, so be sure to protect every bud with dormant sprays.
- Susceptible to Spur Blight.
- A few RBDV positive plants in year 3
- Yield potential good, provided that harvesters are set up to minimize lateral breakage, especially in the first year.
- Harvest starts and ends later than Wakehaven
- Moderately fewer mites than in neighboring WakeHaven rows.
- Very good root rot resistance.
- Some susceptibility to sunburn, at least compared with WSU 2087 and WSU 2088.



WSU 2069

- High-yielding, firm, early fruiting selection.
- Slender primocanes are abundant. May require different timing for caneburning.
- Harvest begins with Cascade Premier and Kulshan. Harvest ends with Kulshan.
- Fruit size initially large, but drops off significantly in second half of

harvest.

- Winter hardy
- Moderate to good root rot resistance
- Druplets on some plants are irregular and rough-looking
- Susceptible to Cane Botrytis, similar to Cascade Premier.
- Notably susceptible to mites.
- Low incidence of Cane Blight in a planting where other selections were notably affected.
- Probable drop



WSU 2088

- Excellent yield potential at some locations, 24+ fruits/lateral.
- Fruit rounded, firm, large, heavy. Uniform, attractive on harvester
- Laterals more compact than Cascade Legacy and less likely to be damaged. Haven't seen that reflected in high yields, though.
- Harvest begins later than Wakehaven, similar to Cascade Legacy. Continues well past Wakehaven, up to 2 weeks after Cascade Legacy.
- Slightly less winter hardy than 2087

- Less cane Botrytis than Cascade Premier or Wakehaven
- Much less cane blight than Kulshan
- Thick canopy, notable fruit Botrytis
- Purplish color to fruit
- More susceptible to root rot than most WSU selections. Not on par with Cascade Legacy or WakeHaven.
- Failed to perform well at one location-cause unknown.
- Possible drop, but grower likes this one, so maybe not...



WSU 2087

- Mid-season, a few days behind WakeHaven. Very good early yield potential, 15-20 fruits/lateral. Looks better in third harvest than in the first two.
- Vigorous plants, thick primocanes. More compact than Cascade Legacy. Laterals shorter than Legacy, but more fruits per lateral. Laterals not damaged by harvesters.
- Fruit large, rounded, consistent size. Possibly softer than Wakehaven. Fruit can sunburn, similar to Wakehaven. Fruit purplish when overripe

- Fruit rot following rain.
- Less Cane Botrytis than Cascade Premier or WSU 2188, but still susceptible.
- Harvester damage minimal, notably less than WSU 2188.
- Mite response good, comparable to Cascade Legacy
- Root rot resistance excellent so far, but only planted in two locations
- May be released; has been exceptionally reliable and productive



WSU 2130

- Compact plants, fruit presented outside canopy
- Variable yield potential, 15-25 fruits/lateral some years, 12-14 others.
- Fruit relatively small, conic, uniform, releases easily.
- Winter hardy
- Harvest begins and ends just after Wakehaven.
- Laterals extend past canopy, presenting fruit outside.
- Moderate root rot resistance. Did not perform well under heavy root rot pressure.
- Sunburns somewhat, but less so than Wakehaven.
- Less cane Botrytis than Cascade Premier, but more than most other WSU selections. Will require cane Botrytis management.
- Spur blight susceptible.
- Does very well in Oregon. May be released for that market

Table 1. Root Rot ratings (1=poor, 5=best) at two trial locations, 2025. Ratings shown are averages over four dates 19 June through 22 July 2025.

	Location 1	Location 2
WakeHaven	3.6	
Cascade Legacy	3.8	4.8
WSU 2088	2.3	3.4
WSU 2087	4.4	5.0
WSU 2130	1.8	
Kulshan		4.3
WSU 2069		4.1

Table 2. Percent leaves with visible mites or mite eggs in block trials at Location 1, 2025. Ratings shown are based upon evaluations at four locations/plot, five leaves/location.

	Mites %	Eggs %
WakeHaven	25	30
Cascade Legacy	20	20
WSU 2087	30	40
WSU 2088	20	40
Kulshan	25	30
WSU 2069	60	75

Publications:

- Comments shared at Mechanical Harvesting Field Day, July 2024
- Note in Small Fruit Update (submitted, to publish winter 2025-2026)

Washington Red Raspberry Commission Progress Report

Title: Red raspberry cultivar development

Personnel:

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Reporting Period: 2023-2025

Accomplishments:

- Established ~11,000 seedlings in the field
- Established a new machine-harvest yield trials (283 genotypes, replicated)
- Harvested and evaluated seedlings (~18,000 genotypes)
- Made 239 new selections for further evaluation
- Harvested and evaluated yield-trials (2020, 2021, 2022 and 2023 plantings)

Results:

Yield trial evaluations have helped us to identify a number of standout selections. They have also resulted in the decision to drop some selections from further consideration. Based on trial results, BC 10-71-27 has been put on hold and will not be considered further. It is quite early ripening and has generally machine-harvested well, but only looked really good at one trial site. At the Clearbrook station, it has been an adequate producer but not a great producer, while plant health and canopy cover was average. While it had a large yield at one grower site, in other trial sites plants just generally looked tired and not strong and we suspect that it probably has something to do with grower inputs and management. BC 10-71-27 has potential as a parent but does not have the consistent performance across locations that we are looking for. Similarly, BC 10-79-33 is also being put on hold. While it has continued to have good yields and has yet to become infected with RBDV, the fruit has been slightly soft and machine-harvest quality has been a bit more inconsistent than desired. Moreover, BC 1855.14 ripens in the same season and has shown similar or higher yields with vastly superior fruit quality as compared to BC 10-79-33.

Standout selections from yield trial plots evaluated in this period:

BC 1653.7 – This is an early ripening selection that has consistently shown strong growth and yield. It is slightly early (similar season to Cascade Premier) and has stiff, erect canes. Machine-harvest quality has been OK except during periods of heat in 2024 and 2025 where softening was observed. At this time, we are not recommending further trials of BC 1653.7 except as an early fresh-market variety.

BC 1855.11 – This selection has been a standout because of its outstanding firmness and fruit quality. It has been consistently the firmest selection we have observed, while the fruit machine picks beautifully. It is a little later ripening than desired and tends to have long, somewhat weepy laterals. In spite of this, we have not observed lateral breakage or problems with machine harvesting, though the potential is there, especially for high vigor fields. We are planning to name and release BC 1855.11 as a dual-purpose variety some time in 2026, with the expectation that it will likely be of more interest to fresh growers than processed growers because its sibling, BC 1855.14 is likely a better machine-pick processing berry. Yields of BC 1855.11 have been very good, ranging between ~6 and ~8 tons/acre in various trials while the plants are very

vigorous and strong growing. Some growers may need to adjust their management and inputs to reduce vigor slightly for optimal results.

BC 1855.14 – This selection is very likely to be named and released in the next few years. In trials to date, it has been consistently very high yielding (7-11 tons/acre), picking very easily and cleanly, with very firm berries ripening a few days after Meeker. BC 1855.14 is likely to be a better choice than BC 1855.11 for processing growers because of the plant growth habit and higher yields with similar firmness and machine-harvestability. It is a strong grower but has shorter internodes than BC 1855.11 and as a result has more fruiting laterals on each cane. Laterals are held at a slightly upward angle and are strong and stiff rather than weepy as in BC 1855.11.

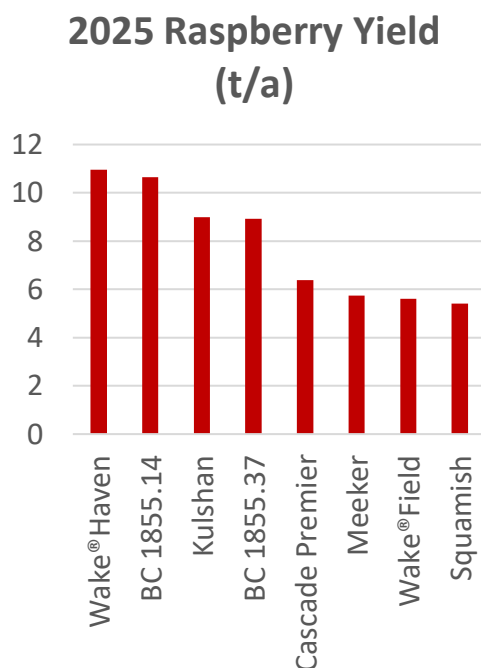
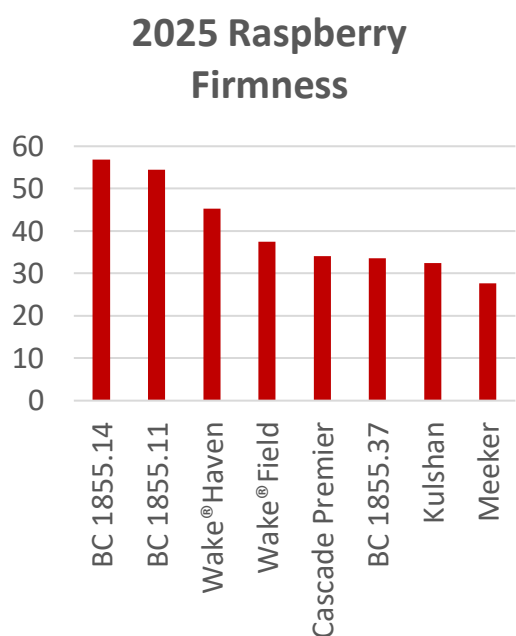
BC 1855.37 – This is the softest of the BC 1855.## siblings, while also being the earliest ripening and having the nicest flavor. Trial data on this one is very preliminary so far, but it appears to have similar season, yield, and firmness as Kulshan.

WSU 2087 – This was a standout performer in the 2020 planting with good yield and excellent firm fruit quality, starting a few days before Chemainus. Yields have been similar to or slightly better than Chemainus.

BC 1747.32: Good quality, strong yields and relatively early. May advance to grower trial pending evaluations in 2026.

BC 1750.56: Good quality, strong yields and relatively early. May advance to grower trial pending evaluations in 2026.

BC 1855.11 and BC 1855.14 have significantly raised the bar for firmness and there's a long list of selections that might be considered of further trials if not for the fact that the quality of BC 1855.11 and BC 1855.14 are a level above everything else. The first selections with these two as parents are starting coming down the pipeline and we are seeing some of this come through to the next generation so I expect that in the coming years we will see a significant number of these selections advancing.





Closeup of machine-harvested fruit of BC 1855.14

Washington Red Raspberry Commission Progress Report Format for 2025 Projects

Project No:

Title: Cooperative raspberry testing and cultivar development program

Personnel: Michael Hardigan, USDA-ARS-HCPGIRU
Wendy Hoashi-Erhardt, Program Lead, WSU Puyallup REC
Scott Lukas, Berry Crops Research Leader, OSU-NWREC

Reporting Period: 2025

Accomplishments:

- Contributed to release of new raspberry cultivar WSU 2188, A.K.A., ‘Cascade Legacy™’ with pending patent.
- Continued generating trial data for WSU 2130 (Table Ry-FL 2) an elite selection with potential for cultivar release. Selection WSU 2130 showed excellent plant health, was higher yielding than other replicated selection, and produced berries of high quality that withstood machine harvest. The excellent fruit quality of WSU 2130 was notable due to exposure to several days of excessive heat during its harvest season. Susceptible to RBDV.
- Continued generating trial data for ORUS 4715-2, available at North American Plants, a selection with potential for production in central Washington. Showed excellent heat tolerance during 2021 “heat dome” and withstand excessive heat and machine harvest in early July 2024. We tested ORUS 4715-2 in a trial as part of a heat tolerance study with by Lisa DeVetter, where it showed superior post-harvest quality compared to ‘Meeker’, ‘Wakefield’, and WSU selections and was able to achieve good quality under high temperatures.
- Observed WSU 2087 to possess elite IQF quality in terms of fruit durability and leakage, with essentially no leakage or crumbling in IQF samples

Results:

We continued to test USDA and WSU raspberry selections to assess their performance including yield and machine-harvested fruit quality in the northern Oregon trials at OSU-NWREC (Aurora, OR). Results from replicated field trials showed that WSU red raspberry selection WSU 2130 was the top performing red raspberry in Oregon, with excellent early season yields and machine harvested quality. When evaluated by growers and stakeholders at the ORBC annual meeting, acceptance of WSU 2130 IQF fruit quality was on par with ‘Meeker’ and greater than ‘Wakefield’. Additional USDA selection ORUS 4715-2 showed excellent performance with regard to heat tolerance in central Washington (WSU-IAREC; Prosser, WA), and was among the top yielding genotypes in both the 2022 and 2023 planted NWREC field trials evaluated in 2025. ORUS 4715-2 has entered grower trials in Oregon. These will be made available for grower trial at PNW nurseries. We identified newer primocane-fruited types with fresh market and season-

extension potential including recent cultivar release 'Finnberry' and new selection ORUS 5209-1 that improves on 'Finnberry' yields with larger size and sturdier, more erect canes.

Publications:

- 'WSU 2188' Red Raspberry

Appendix I: Current and Pending Support Table

Current & Pending Support					
Name (List PI #1 first)	Supporting Agency and Project #	Total \$ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
Current:					
Peterson, Simons, Kubota, Ramirez, Francis, Teegarden, Hardigan , Luby, Bassil	Foundation for Food & Agriculture Research	\$1,800,000	09/2023-09/2026	10%	Advancement of Strawberries for Indoor Environments: Mapping Chemical Compositions, Genetics, and Growing Conditions for Premium Flavor
DeVetter, Bryla, Hardigan , Hoashi-Erhardt	USDA Specialty Crop Multi-State Program	\$1,000,000	09/2023/09/2026	10%	Beat the Heat - Mitigating Heat Damage in Caneberry
Hoashi-Erhardt, Hardigan	WSDA	\$ 178,000	01/2025-12/2027	10%	Novel and Valuable Raspberry Plant Breeding Datasets Leading to New Cultivars and Molecular Breeding Tools
Pending:					

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Appendix II: Tables

Table Ry-FL 1. Fruit size and yield of florican-fruited red raspberry genotypes tested in OSU-NWREC 2022 trial planting, harvested from 2024-2025. Yield measurements are based on twice-weekly machine harvest using an Oxbo 7450 Harvester.

Berry Size (g)		Yield (tons·a-1)		
<i>Annual Mean</i>				
2024	3.37	3.82		
2025	3.20	3.73		
Genotype	2024-25	2024	2025	2024-25
<i>Replicated</i>				
WSU 2130	2.88	5.67	4.99	5.33
ORUS 5198-1	2.70	3.10	2.66	2.88
Meeker	2.28	3.80	1.77	2.79
WSU 2082	2.40	0.94	2.04	1.49
<i>Nonreplicated</i>				
WSU 2564	3.10	6.42	7.68	7.05
ORUS 5444-3	3.65	5.18	6.39	5.79
WSU 2622	4.55	6.34	5.01	5.68
*ORUS 4715-2	3.10	4.62	6.61	5.61
ORUS 5439-2	3.65	6.24	4.75	5.50
WSU 2737	3.55	4.88	5.16	5.02
ORUS 5442-4	3.25	3.83	5.63	4.73
ORUS 5443-2	3.50	4.77	4.46	4.61
WSU 2561	2.55	4.15	4.33	4.24
WSU 2613	2.85	2.76	5.49	4.12
Wakefield	2.55	3.76	4.06	3.91
ORUS 5442-5	3.95	4.35	2.79	3.57
WSU 2571	2.95	3.61	3.17	3.39
Csc. Premier	3.80	2.90	3.76	3.33
Csc. Gem	4.00	3.75	2.76	3.25
*ORUS 4089-2	3.20	1.59	4.76	3.18
ORUS 4371-4	3.15	4.19	1.74	2.97
ORUS 5434-1	3.55	3.79	2.10	2.95
WSU 2366	3.00	1.90	3.72	2.81
WSU 2641	2.65	3.35	2.11	2.73
*ORUS 4607-2	2.95	3.95	1.41	2.68

ORUS 5432-3	3.90	3.09	2.08	2.59
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*Nursery list – Available at nurseries for trial by request (breeder contact; michael.hardigan@usda.gov)

Table Ry-FL 2. Fruit size and yield of floricane-fruited red raspberry genotypes tested in OSU-NWREC 2023 trial planting, harvested from 2025. Yield measurements are based on twice-weekly machine harvest using an Oxbo 7450 Harvester.

	Berry Size (g)	Yield (tons·a-1)
<i>Annual Mean</i>		
2025	2.87	4.18
Genotype	2025	2025
<i>Replicated</i>		
ORUS 5108-3	2.60	4.62
ORUS 5533-2	2.97	4.31
ORUS 5107-1	2.13	3.91
*ORUS 4974-1	2.50	3.78
Meeker	2.30	3.02
<i>Nonreplicated</i>		
Wakefield	2.90	6.81
ORUS 5539-3	2.50	6.07
*ORUS 4715-2	2.50	5.63
ORUS 5533-3	3.10	4.80
ORUS 5543-2	2.50	4.73
WSU 2622	3.10	4.67
ORUS 4600-3	2.90	4.66
Wakehaven	2.70	4.66
ORUS 5102-2	2.90	4.54
ORUS 5537-1	2.50	4.51
ORUS 4961-1	3.20	4.45
Csc. Harvest	3.20	4.43
ORUS 5534-1	2.70	4.17
ORUS 4371-4	3.40	4.15
ORUS 5536-1	2.60	3.85
ORUS 5533-1	2.50	3.85
ORUS 5536-3	3.00	3.76
ORUS 5543-4	2.90	3.26
ORUS 5431-2	2.80	3.24

ORUS 5532-5	3.80	2.98
ORUS 5532-3	3.30	2.84
ORUS 5532-4	3.60	2.75

*Nursery list – Available at nurseries for trial by request (breeder contact; michael.hardigan@usda.gov)

Table Ry-PF 1. Fruit size and yield of primocane-fruiting red raspberry genotypes tested in OSU-NWREC 2024 trial planting, harvested from 2025. **2023 harvest skipped due to low plant health.*

	Berry Size (g)	Yield (tons·a-1)
<i><u>Annual Mean</u></i>		
2025	1.78	1.12
Genotype	2025	2025
<i><u>Replicated</u></i>		
*ORUS 5209-1	2.80	2.41
Heritage	0.43	0.81
ORUS 4858-2	1.67	0.52
<i><u>Nonreplicated</u></i>		
Polka	2.40	2.06
ORUS 5248-1	2.70	1.32
ORUS 5118-1	2.00	1.19
ORUS 5467-1	2.00	0.76
ORUS 5451-1	0.90	0.61
ORUS 5559-1	1.10	0.45

*Nursery list – Available at nurseries for trial by request (breeder contact; michael.hardigan@usda.gov)

Washington Red Raspberry Commission Progress Report Format for 2025 Projects

Project No:

Title: Virus testing of PNW public raspberry breeding programs.

Personnel: Michael Hardigan, USDA-ARS-HCPGIRU
Wendy Hoashi-Erhardt, Program Lead, WSU Puyallup REC

Reporting Period: 2025

Accomplishments:

- Verified virus infection status of three common viruses, RBDV, SNSV, and ToRSV, in breeding program field plots and propagation facilities
- Identified several selections that may be either virus resistant or have delayed onset of virus infection, used to develop new families for evaluation in subsequent years.

Results:

In 2025 at Lewis Brown Farm, red raspberry RBDV infection rates were approximately 15% of plots, and SNSV infection rates were approximately 10% of plots. ELISA screening continues to assist in prevention of the spread of virus through crossing or distribution of infected plant material. The majority of RBDV and SNSV infected plants were removed and we have used support from this grant to create a virus quarantine field at an adjacent farm where progeny from infected parents can be observed for RBDV/SNSV tolerance without risk of infecting the main breeding population. ToRSV appears to pose the lowest risk of infection at the moment with no observed cases of infection. Raspberry selections that have remained virus-free for 6 or more years will be used as parents to develop new selections that are slow to develop infection. **ORUS 5083-1 is a hybrid derived from the Korean black raspberry and appears to be a potential source of resistance or delayed infection from both RBDV and SNSV, able to persist without infection in a seven-year-old field.** This selection was successfully used to develop new crosses for both red and black raspberry. **RBDV: 2023 (OSU-NWREC)** - Approximately 25% of red raspberries were infected. Notable selections that remained free of infection (5+ years): Cascade Harvest, Finnberry, Heritage, Kokanee, Meeker, ORUS 4487-1, ORUS 4858-2, ORUS 4978-3, ORUS 5114-1, Vintage, and Wakefield. **2024 (OSU-LBF)** - Approximately 5-10% of red raspberries were infected at OSU-LBF. No new selections with low susceptibility detected. **2025 (OSU-LBF)** – Approximately 15% of raspberries were infected at OSU-LBF. **SNSV: 2023 (OSU-NWREC)** - Approximately 35% of red raspberries were infected. Notable selections that remained free of infection (5+ years): ORUS 4858-2, ORUS 4961-1, ORUS 4965-3, ORUS 4974-1, ORUS 4978-3, ORUS 5106-1, ORUS 5114-1, ORUS 5250-1, Polka, Wakefield, and Wakehaven. **2024 (OSU-LBF)** - Approximately 50% of red raspberries were infected. All selections in 5+ year old plots) were infected with the exception of ORUS 5114-1, a primocane fruiting selection with some promise for late summer production. **2025 (OSU-LBF)** - Approximately 10% of raspberries were infected at OSU-LBF.

Publications:

None.

Appendix II: Tables

Table 1. Confirmed susceptibility (S) for relevant cultivars and nursery list selections tested at OSU-NWREC in 2023 and OSU-LBF in 2024 for RBDV, SNSV, and ToRSV. Clean status does not indicate resistance, only that the tested plants did not contain virus.

<u>Red Raspberry</u>	Oldest Plot	RBDV	SNSV	ToRSV
Cascade Harvest	2018	-	-	-
Crimson Treasure	2021	-	S	-
Finnberry	2020	-	S	-
Heritage	2018	-	-	-
Kokanee	2018	-	S	-
Meeker	2018	-	S	-
ORUS 4487-1	2018	S	S	-
ORUS 4600-1	2020	S	S	-
ORUS 4715-2	2019	S	S	S
ORUS 4725-1	2019	-	S	-
ORUS 4858-2	2019	-	-	-
ORUS 4974-1	2018	S	-	-
ORUS 5106-1	2019	S	S	-
ORUS 5209-1	2019	-	S	-
ORUS 5250-1	2019	-	S	-
Polka	2018	-	S	-
Vintage	2018	-	S	-
Wakefield	2018	-	-	-
Wakehaven	2018	-	-	-
WSU 2069	2020	S	-	-
WSU 2087	2020	S	S	-
WSU 2088	2019	S	S	-
WSU 2130	2022	-	-	-
WSU 2277	2019	S	-	-
WSU 2376	2018	-	-	-
WSU 2425	2020	-	S	-
WSU 2472	2020	-	S	-
WSU 2481	2019	S	S	-
WSU 2605	2019	-	S	-

Entomology



A Report to the Washington Red Raspberry Commission

Title: Two-Spotted Spider Mite and Thrips Control in Raspberry

Year Initiated: 2024 Current Year: 2024 Terminating Year: 2025

Principal Investigator:

Alan Schreiber, 2621 Ringold Road, Eltopia, WA 99301, aschreb@centurytel.net

Tom Walters, Walters Ag Research, 2117 Meadows Ln, Anacortes WA 98221

waltersagresearch@frontier.com, 360-420-2776.

Justification and Background:

Two-Spotted Spider Mites (TSSM)

Historically, two-spotted spider mites (TSSM) have been a moderately important but manageable pest of raspberries. Red raspberries are naturally susceptible to mites. During harvest, picking machines travel through fields every 24 to 36 hours. Tractors applying pesticides twice a week and other field activities create a great deal of dust that exacerbate mite outbreaks. Growers spray for primocane suppression two to three times per season which forces mites living on weeds to move up into the canopy.

Recently, Washington red raspberry growers have had increased difficulty controlling two-spotted spider mites in commercial fields. The increased difficulty in controlling mites is thought to be due to one or two reasons. First, the “recent” movement of spotted wing drosophila (SWD) into raspberry fields has resulted in an increased number of insecticides applied during the 40 or so days of harvest. This pest is particularly challenging for growers of individually quick-frozen (IQF) fruit which has zero tolerance for SWD. This problem is even more acute for growers exporting fruit as maximum residue limits (MRLs) restrict products they can use. Some of the products that are considered essential to SWD control include pyrethroid insecticides which likely are fomenting mite outbreaks by disrupting the natural controls of mites. Second, the standard miticide available for use during harvest is Acramite (bifenazate). Growers and crop advisors believe that due to heavy reliance on this product mites have developed resistance and control is failing.

There are several miticides registered for use on raspberries, but they have use restrictions that limit or prevent their use. Abamectin cannot be used near or during harvest due to the 7 day preharvest interval. Vendex and Savey have MRL restrictions that limit their use to early season. Zeal can be used, but only once and it targets eggs only, so it is used in early season when mite nymph and adult numbers are low. Kanemite is considered ineffective. Current mite programs will use Vendex or Savey early in the season followed by two applications of Acramite and one application of Zeal in mid-season and abamectin postharvest. However, growers feel that Acramite has become ineffective. Some growers insist that TSSM have developed resistance to Acramite (bifenazate). A molecular marker for bifenazate resistance in mites has been identified making detection of resistance straightforward. Six populations of TSSM from Whatcom County raspberry fields were screened for bifenazate resistance as part of this project and all tested positive for presence of resistance to the miticide. This means that reliance on bifenazate should be immediately reduced. New miticides have been registered for raspberry but lack the necessary MRLs to allow for export.

Challenges associated with mites have increased so much that the WRRC has made this one of their top research priorities. The industry is interested in finding miticides that have new modes of action with 1-day preharvest intervals and a high level of efficacy. Ideally, new application programs will have longer periods of residual control and be translaminar (products move into the leaf where a reservoir of active ingredient remains for a period of time providing longer control). And more ideally, the products can obtain MRLs in key export markets.

Thrips. Based on feedback from the industry, there is an interest in an efficacy trial targeting thrips. There is an expectation that there will be a related proposal from Washington State University focusing on thrips biology and identification. Thrips have not historically been considered a pest of consequence in raspberry in Washington. However, we assume that the primary thrips involved is western flower thrips, *Frankliniella occidentalis*, or at least in the genus *Frankliniella*. The damage in 2023 was widespread in northwest Washington and was of great concern to growers and processors of raspberry. Adult thrips are small (about 1-2 mm long at maturity), slender insects with fringed wings. They are generally white when young but brown or black when mature. The larvae are very tiny and difficult to distinguish without magnification. They feed by puncturing plant material, often blossoms, and sucking out the cell contents. Injured blossoms often turn into distorted fruit. When feeding on flowers, affected petals appear stippled or are scarred with brown streaks or spots. When unusually abundant in spring, thrips have been reported to cause blossom blasting. Fruit may be misshapen or distorted. Controls are most effective when applied at flowering; field control is not practical in eliminating thrips present at harvest. Applications at flowering has the additional challenge of applying insecticides that are safe to pollinators. *The picture to the right shows feeding damage of thrips on the fruit during 2023.* We propose to screen existing registered insecticides and additional unregistered products for efficacy against thrips. An additional complication is that in order to control thrips, applications will be required during bloom time limiting early season to products that are a low risk to pollinators. Many traditional thrip insecticides are not safe to use around bees.



Materials and Methods

In 2025, Agriculture Development Group, Inc. conducted two insecticidal trials to investigate the efficacy of different insecticides for control of two-spotted spider mite (TSSM) (trial 1) and thrips (trial 2) in raspberry. All trials were conducted in a commercial raspberry field in northwest WA near Everson. The experimental design for both trials was RCB with 4 replications and plot sizes of 10ft x 25ft. Applications were made with an over-the-row sprayer calibrated to apply treatment sprays at 85 gallons per acre (Photo 1).

Trial 1 (TSSM) has 19 treatments (Table 1), and three applications which were made on 7/22 (A), 7/29 (B), and 8/5 (C). To assess the mite population, 20 random leaves per plot were collected and at 0, 7, 14, 21, and 28 days after application A (DAA), and the mites on the leaves assessed using a magnifier (Photo 2 and 3). Cumulative number of total thrips was calculated by summing the number from 7 to 28 DAA for each plot.

For the trial 2 (thrips) has 16 treatments (Table 2), and three applications which were made 7/24 (A), 7/31 (B), and 8/7 (C). Beat sheet method (Photo 4) was used to assess both sides of the raspberry row (2 samplings per plot) (Photo 3) at 0, 7, 14, and 21 days after application A (DAA) for number of thrips. Cumulative number of total thrips was calculated by summing the number from 7 to 21 DAA for each plot.

Table 1. Treatment list for the TSSM trial.

Trt No.	Treatment Name	Rate RateUnit	Appl Code	Appl Description
1	Untreated Check			A: first detection
2	Fujimite SC	2pt/a	AB	ABC at 7 days interval
3	Kanemite 15 SC	31fl oz/a	AB	
4	Savey 50 DF	6oz/a	AB	
5	Acramite 4sc	16fl oz/a	AB	
6	Brigade 2 EC	6.4fl oz/a	AB	
7	Danitol 2.4 EC	16fl oz/a	AB	
8	Nealta	13.7fl oz/a	AB	
9	Zeal	3oz/a	AB	
10	Miteus	2pt/a	AB	
11	Magister	36fl oz/a	AB	
12	Bexar	27fl oz/a	AB	
13	Plinazolin	1.6fl oz/a	AB	
14	Bioshot	32fl oz/a	AB	
	Prolux	5fl oz/100 gal		
15	CinnAcar	32fl oz/a	ABC	
	Prolux	5fl oz/100 gal		
16	Bioshot	32fl oz/a	ABC	
	CinnAcar	32fl oz/a		
	Prolux	5fl oz/100 gal	ABC	
17	Rango	0.3% v/v	ABC	
18	Rango	0.6% v/v	ABC	
19	Rango	1.2% v/v	ABC	

Tabel 2. Treatment list for the thrips trial.

Trt No.	Treatment Name	Rate RateUnit	Appl Code	Appl Description
1	Untreated Check			A: first detection; B=7D after A
2	Aza-Direct	1.5pt/a	AB	CC applied 7d after B if needed
	Pyganic	1qt/a	ABC	
3	Rango	0.3% v/v	ABC	
4	Rango	0.6% v/v	ABC	
5	Rango	1.2% v/v	ABC	
6	Assail 30SG	5.3oz/a	ABC	
7	Verdepryn	11fl oz/a	ABC	
8	Malathion 8F	2pt/a	ABC	
9	Delegate WG	6oz/a	ABC	
10	Success	6fl oz/a	ABC	
11	Sivanto	14fl oz/a	AB	
12	CinnAcar	32fl oz/a	ABC	
13	Plinazolin	3fl oz/a	ABC	
14	Beleaf	2.8oz/a	ABC	
15	Bioshot	32fl oz/a	ABC	
16	Bioshot	32fl oz/a	ABC	
	CinnAcar	32fl oz/a	ABC	
	Prolux	5fl oz/100 gal	ABC	

Results and Discussion

Two-Spotted Spider Mite Efficacy-Trial 1

No phytotoxicity was observed for all treatments at any point of the trial.

Trial site had excellent mite population in 2025, and treatments did not show significant treatment effect under such heavy pressure at 7 DAA and 14 DAA (7 days after B, 7 DAB). However, some of the treatments showed obviously lower mite counts than the untreated check's 174 mites per 20 leaves at 14 DAA (7 DAB). For example, Kanemite and Acramite had around 139 mites per 20 leaves, Bioshot (+adjuvant Prolux), Rango at high rate, Zeal, and Plinazolin had around 120 mite counts. Further, Bioshot tank mixing with CinnAcar (+adjuvant Prolux) and Magister had only around 106 mite counts per 20 leaves.

By 21 DAA (14 DAB or 7 days after C=7 DAC), data showed significant control from certain treatments. Brigade, Acramite, Miteus, Zeal, Magister and Plinazolin with 2 applications A + B, or Rango high rate (1.2% v/v) with 3 applications A + B +C resulted in only 71 to 113 TSSM per 20 leaves, which were statistically 40% to 62% lower than untreated check's 187 TSSM per 20 leaves (Table 3 column 4).

Although all treatments lost their significant residual effect by 28 DAA (14 DAC), the dataset showed similar distribution of the mite counts among treatments as the 21 DAA dataset. As a result, cumulative dataset in Table 3 column 6 showed a trend correlated to the combined effect from 14, 21 and 28 DAA datasets.

While untreated plots had in a total of 716 mite counts per 20 leaves, Plinazolin, Magister, Bioshot + CinnAcar, Zeal, Rango high rate, and Miteus showed the best control with only 425 to 501 total mites, suggesting 30% to 41% overall control over untreated. Bioshot, Acramite, Brigade, Kanemite, Fujimite, Nealta, Bexar, and Rango low rate also had significantly lower total mite counts than untreated control with 522 to 577 total mites, which are still 19% to 27% overall control (Table 3 column 6). Interestingly, the Rango medium rate had reduced control with a total 610 mites, indicating less differentiation among the low and medium rates, but more confirmative control effect from its high rate.

Table 3. ANOVA table for the mean separation of TSSM counts for different treatments for trial 1.

Rating Date					7/22/2025	7/29/2025	8/5/2025	8/12/2025	8/19/2025		
Rating Unit					#	#	#	#	#	total # (no 0 day)	
Sample Size					20 leaves	20 leaves	20 leaves	20 leaves	20 leaves	20 leaves	
Reporting Basis					1 plot	1 plot	1 plot	1 plot	1 plot	1 plot	
Days After First/Last Appl.					0, 0	7, 7	14, 7	21, 7	28, 14		
Trt	Treatment	Rate	Unit	Appl	1	2	3	4	5	6	
No.	Name	Rate	Unit	Code							
1	Untreated Check				92.5 a	139.5 a	174 a	187 a	215.3 a	715.8 a	
15	CinnAcar	32 fl oz/a		ABC	103.8 a	117.3 a	164.5 a	161 abc	225.8 a	668.5 ab	
	Prolux	5 fl oz/100 gal									
7	Danitol 2.4 EC	16 fl oz/a		AB	110 a	116.8 a	232 a	138 a-d	137.5 a	624.3 abc	
18	Rango	0.6 % v/v		ABC	97.5 a	116.5 a	156.3 a	163.5 ab	173.3 a	609.5 a-d	
4	Savey 50 DF	6 oz/a		AB	91.3 a	100 a	160 a	171.3 ab	157.3 a	588.5 a-e	
17	Rango	0.3 % v/v		ABC	100 a	109.3 a	128 a	156.5 abc	183.3 a	577 b-e	
12	Bexar	27 fl oz/a		AB	117.5 a	119.8 a	156 a	140.3 a-d	154 a	570 b-e	
8	Nalta	13.7 fl oz/a		AB	95 a	111.3 a	143.5 a	129.3 a-f	173.3 a	557.3 b-f	
2	Fujimite SC	2 pt/a		AB	82.5 a	85 a	162.3 a	158.8 abc	147.8 a	553.8 b-f	
3	Kanemite 15 SC	31 fl oz/a		AB	98.8 a	73 a	138.3 a	132 a-e	209.8 a	553 b-f	
6	Brigade 2 EC	6.4 fl oz/a		AB	97.5 a	105.8 a	155.5 a	103.5 c-f	177.8 a	542.5 b-f	
5	Acramite 4sc	16 fl oz/a		AB	75 a	74 a	139.8 a	102.3 c-f	206.3 a	522.3 c-f	
14	Bioshot	32 fl oz/a		AB	93.8 a	101.3 a	121.3 a	149.5 abc	149.5 a	521.5 c-f	
	Prolux	5 fl oz/100 gal									
10	Miteus	2 pt/a		AB	91.3 a	80.3 a	144.5 a	113.3 b-f	163 a	501 c-f	
19	Rango	1.2 % v/v		ABC	117.5 a	116 a	117.3 a	87.8 def	179 a	500 c-f	
9	Zeal	3 oz/a		AB	96.3 a	113.8 a	124.3 a	75.8 ef	163.3 a	477 def	
16	Bioshot	32 fl oz/a		ABC	113.8 a	105.8 a	106.8 a	145.8 a-d	117.8 a	476 ef	
	CinnAcar	32 fl oz/a									
	Prolux	5 fl oz/100 gal		ABC							
11	Magister	36 fl oz/a		AB	68.8 a	96.5 a	106 a	113 b-f	144.8 a	460.3 ef	
13	Plinazolin	1.6 fl oz/a		AB	147.5 a	112.5 a	123.8 a	70.8 f	118 a	425 f	
LSD P=.10					56.83	56.94	63.36	59.03	93.8	132.81	
Treatment Prob(F)					0.9375	0.9449	0.3088	0.0582	0.886	0.0767	

Thrips Efficacy-Trial 2

No phytotoxicity was observed for all treatments at any point of the thrips trial as well.

We identified western flower thrips as the pest in this trial and 2025 trial had much better thrips pressure than 2024 trial, with the population started at 39 thrips per sampling (1 side of the row) at 0 DAA and quickly reached 121 per sampling at 7 DAA in untreated plots. Significant treatment effect was observed at 7 DAA, where all 15 tested treatments had statistically lower thrips counts than untreated check. Plinazolin did the best control with only 3 thrips per sampling, almost 98% control over untreated; followed by Delegate at 14 thrips, Assail at 32 thrips, Malathion at 38 thrips, Bioshot + CinnAcar at 42 thrips, Beleaf at 44 thrips, and Sivanto at 49 thrips, where the rest treatments had a range of 56 to 93 thrips (Table 4 column 2).

Similar treatment control efficacy was observed at 14 DAA (7 DAB), and 21 DAA (7 DAC).

Overall, Plinazolin showed the superior control on thrips over other treatments with only 4.5 total thrips, which was 98% lower than untreated check's 284.3 total thrips; followed by Delegate at 30.5, Malathion at 66.3, Beleaf at 70.3, Assail at 87.3, Bioshot + CinnAcar at 91.3, and Bioshot alone at 95.8 total thrips, suggesting 66% to 89% thrips reduction; while Sivanto, Rango at 3 different rates, Aza-Direct + Pyganic, Verdepryn, and Success had 136 to 220.8 total thrips, also 22% to 52% significantly lower than untreated check (Table 4 column 5).

Rango, CinnAcar and Bioshot are exempt from tolerance so their use is exempt from maximum residue limits so there may be value in their use for raspberry products that are destined for export.

Table 4. ANOVA table for the mean separation of thrips counts for different treatments for trial 2.

Rating Date					7/24	7/31	8/7	8/14		
Rating Unit					#	#	#	#	Total # (no 0 day)	
Sample Size					2 sides	2 sides	2 sides	2 sides	2 sides	
Reporting Basis					1 plot	1 plot	1 plot	1 plot	1 plot	
Days After First/Last Appl.					0, 0	7, 7	14, 7	21, 7		
Trt	Treatment		Rate	Appl	1	2	3	4	5	
No.	Name	Rate	Unit	Code						
1	Untreated Check				38.8 a	121.3 a	127.5 ab	35.5 a	284.3 a	
12	CinnAcar	32	fl oz/a	ABC	42.5 a	93.0 b	146.3 a	24.8 b	264.0 ab	
4	Rango	0.6	% v/v	ABC	47.0 a	78.5 bcd	121.0 abc	21.3 b	220.8 bc	
10	Success	6	fl oz/a	ABC	42.0 a	91.8 bc	85.8 cde	37.3 a	214.8 bc	
3	Rango	0.3	% v/v	ABC	42.5 a	71.5 b-e	109.5 a-d	24.8 b	205.8 bc	
7	Verdepryn	11	fl oz/a	ABC	26.3 a	65.8 c-f	98.8 b-e	26.0 b	190.5 cd	
2	Aza-Direct	1.5	pt/a	ABC	34.8 a	93.0 b	79.0 d-g	5.0 c	177.0 cd	
	Pyganic	1	qt/a	ABC						
5	Rango	1.2	% v/v	ABC	47.8 a	76.8 bcd	84.3 c-f	8.8 c	169.8 cd	
11	Sivanto	14	fl oz/a	AB	31.3 a	49.0 efg	65.3 e-h	21.8 b	136.0 de	
15	Bioshot	32	fl oz/a	ABC	32.0 a	56.0 d-g	36.5 hij	3.3 c	95.8 ef	
16	Bioshot	32	fl oz/a	ABC	35.0 a	41.5 fg	44.0 ghi	5.8 c	91.3 ef	
	CinnAcar	32	fl oz/a	ABC						
	Prolux	5	fl oz/100	ABC						
6	Assail 30SG	5.3	oz/a	ABC	35.0 a	31.8 gh	47.5 f-i	8.0 c	87.3 efg	
14	Beleaf	2.8	oz/a	ABC	42.3 a	44.0 fg	23.8 ij	2.5 c	70.3 fg	
8	Malathion 8F	2	pt/a	ABC	41.0 a	38.0 gh	26.3 ij	2.0 c	66.3 fg	
9	Delegate WG	6	oz/a	ABC	42.8 a	13.8 hi	16.3 ij	0.5 c	30.5 gh	
13	Plinazolin	3	fl oz/a	ABC	32.0 a	3.0 i	0.8 j	0.8 c	4.5 h	
LSD P=.10					17.56	26.2	37.63	9.25	58.75	
Treatment Prob(F)					0.7809	0.0001	0.0001	1E-04	0.0001	

Photo 1. Over-the-row sprayer used for applications.



Photo 2 an3. Mite assessment in the lab (left) and TSSM found on the leaf (right).



Photo 4. Beat sheet method for the thrips assessment.



WRRC Progress Report 2025

Project Title: Spotted Wing Drosophila Control with Sterile Insect Releases (SIR)

Research PI: Louis Nottingham, Washington State University, NWREC, Mount Vernon, WA.

In 2025, the Nottingham lab in Mount Vernon, Washington, in collaboration with two other universities (Michigan State and University of Minnesota), performed trials testing sterile insect releases (SIR) to control spotted wing drosophila (SWD) (the SIR product is referred to as ‘Knockout’, Fig 1.). Additionally, lab examinations tested the robustness of sterile males after shipment. Field releases occurred at the NWREC in a three-year-old blueberry planting with ripening fruit. One section of the field was used for releases of ‘Knockout’ SIR flies, and the other was the untreated control (over 100 m from the SIR release site). Releases occurred weekly from early August through the end of September. We trapped SWD adults with lure-baited traps throughout both plots to monitor populations and evaluated SWD damage by collecting fruit from both release and untreated control plots, and incubating berries in the lab until SWD adults emerged. Separate lab evaluations were conducted to measure emergence of SIR flies from shipments. Boxes were kept in cages until sterile males emerged. Males exiting the box vs dead pupae and males dead in the box were compared.



Results: Both Washington and the Midwest sites showed impressive control of SWD with ‘Knockout’. The Washington site (NWREC) had **less than 1% infestation in ‘Knockout’ treated plots, while the untreated control block had infestation levels ranging from 50-100% (Fig. 2)**. Similar results were seen in a 2025 Michigan State cherry trial with the same methods. Lab trials showed approximately 70% of sterile males emerging from ‘knockout’ release boxes, but with significant variability (30-95% emergence per box). This suggests that while emergence is generally good, there is room for improved consistency in the delivery process.

Discussion: While data is still limited, these trends are promising, especially considering similar results seen in Michigan. We will continue testing SIR of SWD with ‘Knockout’ over the three years if funding continues. We also plan to expand to include a replicated greenhouse trial, in which we will evaluate release ratios of sterile males to wild-type females to gain a better understanding of future commercial release densities. Finally, we will continue to facilitate discussions and site visits from Agragene to ensure their production pathway realistically aligns with commercial berry growing practices.

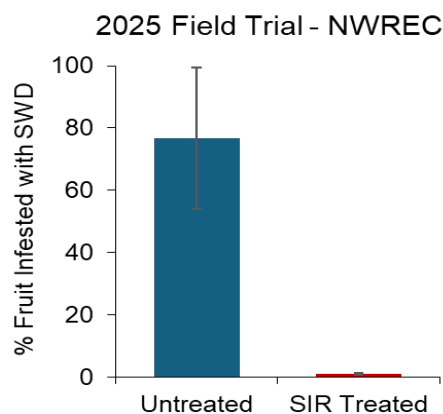


Fig. 2. 2025 field trial. ‘Knockout’ (SIR) treated plot had nearly 100% control of SWD infested fruit compared. The untreated plot became heavily infested, with 78% of berries infested with SWD maggots.

Washington Red Raspberry Commission Research Report

Title: Monitoring Raspberry SWD Populations for Insecticide Resistance

Principal Investigator:

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Cooperator:

Louis Nottingham, Ph.D., WSU Mt Vernon Research and Extension Center, Mt. Vernon.

Justification and Background:

Spotted wing Drosophila (SWD) appeared in Washington in 2009 and quickly became the most critical pest of berries. Initially the pest swamped the ability of growers to control the pest. Eventually growers learned to control the pest through the heretofore unheard levels of insecticide applications to blueberry and raspberry. A typical conventional SWD program will have six applications of insecticides. The specter of resistance looms larger in raspberry due to the more susceptible nature of the pest and the few insecticides registered for use on the crop.

There is zero tolerance for the presence of SWD in raspberry fruit. A single detection can result in a semi load of the crop being rejected. Raspberry growers producing for the export market face tremendous pressure to have no SWD in their fruit. Additionally, growers of berries destined for the export market have very limited selections of products to use due to maximum residue limits (MRLs). Raspberry growers producing for the export markets rely on a limited number of insecticides. Widespread resistance in SWD to spinosad and malathion has been reported in California (Gress and Zalon 2019, Gress and Zalon in review) and to Exirel and deltamethrin in Italy (Civolani et al. 2021). Anecdotal information exists for resistance to Mustang Maxx and other insecticides in berries in California including raspberries.

A national effort exists to screen SWD for resistance to insecticides which has screened SWD populations in California, Florida, Georgia, Maine, Maryland, Michigan, New Jersey, and North Carolina. Washington and Oregon are not included in the survey. A recent effort to screen SWD for insecticide resistance in Washington berries by WSU's Elizabeth Beers was not successful.

A group of small fruit entomologists have developed a standard protocol for monitoring insecticide resistance in SWD. The method is called Rapid Assessment Protocol for Identification of resistance in SWD (RAPID). It uses a single discriminating dose that can easily and quickly test field populations for the presence of resistance genes. The discriminating dose for malathion, methomyl (Lannate), spinetoram (Delegate), spinosad and zeta-cypermethrin (Mustang Maxx) have been developed for use in the test. This method provides results in 24 hours. This effort originated out of a Specialty Crop Research Initiative that seeks to advance the development of sustainable, integrated management strategies for spotted wing drosophila, SWD, based on biology. Schreiber is on the advisory board for the grant. Additionally, Schreiber used a very similar method for monitoring resistance in field populations of insect pests for his Ph.D. dissertation.

WSU's Louis Nottingham and Alan Schreiber successfully proposed to continue to screen organic and conventionally managed SWD populations for insecticide resistance in eastern and western Washington blueberry farms. No one is screening SWD populations in raspberries for resistance. Schreiber proposes to screen SWD populations in raspberry fields from fruit ranches that have the most insecticidally intense programs, at locations with the highest risk for resistance. There is some reason to believe that raspberry populations may be at high risk for development of SWD resistance. First, SWDs prefer or can develop easier on raspberry than blueberry. Second, raspberries have access to fewer insecticides than do blueberries and strawberries.

In the first year of the blueberry project, Nottingham and Schreiber had some challenges discerning how to conduct the resistance screenings and did not survey as many farms as planned. The “bugs” have been worked out of the system and we expect to be able to significantly increase the number of farms that we can sample. In the second year of the blueberry projects, Schreiber's project found that 97% of SWD flies collected from 15 organic blueberry fields were considered susceptible by the bioassays.

Methods and Materials. In this project we followed what is called the Michigan protocol for the RAPID test. The 20 ml scintillation vials were treated with 1 ml each of five formulated insecticides Malathion 8F, Lannate 2.4LV, Delegate, Entrust 22.5SC and Mustang Maxx 0.8EC.



Imidan, and Exirel were included in the screen but no discriminating has been developed for these active ingredients so the dose was estimated (2x the high labeled rate). Schreiber and Nottingham used the same products provided by Schreiber. To prepare for treating the vials, insecticides were dissolved in acetone for malathion, methomyl, and zeta-cypermethrin, or if they did not dissolve in this solvent, we used water with 1% v/v Induce spray adjuvant, for spinetoram and spinosad. Adult *D. suzukii* flies from a single population were placed in each vial and re-sealed with the cap. Wherever possible flies were

loaded in a humid environment, ideally >50% relative humidity, to reduce mortality. The number of flies that are alive, moribund, or dead were counted. Vials were used for no longer than two weeks.

A discriminating dose, in this situation, describes a dose of an insecticide that is high enough to kill 100% or close to 100% of a pest population that is susceptible to an insecticide. Any significant survivorship of a discriminating dose would indicate the presence of insecticidally resistant members of the pest population.

Flies were collected from Scentry traps baited with sugar yeast water bait that has been placed in blueberry fields and left over night. Traps were put in a refrigerator or a cooler

until flies were immobilized by low temperatures. They were aspirated out and placed in the treated vials.

2025 Results. A total of 11 bioassays from 9 raspberry fields and five bioassays from one blackberry field were completed. All raspberry fields were in Whatcom County, and the one blackberry field (1 acre) was a research plot in Franklin County which is used by Schreiber to



screen insecticides for SWD efficacy. A total of 1,301 flies were screened against seven insecticides. The results were unexpected with survivorship far exceeding what was expected. It was assumed, based on industry satisfaction with outcomes of competent SWD management programs that the fly population would be rated as susceptible. In a discriminating dose bioassay, such as used in this project, survivorship above 5% would be cause for evidence of resistance.

Overall survivorship for SWD adults collected from Whatcom County raspberry fields were Delegate at 31%, Entrust at 68%, Exirel at 37%, Imidan at 30%, Lannate at 31%, Malathion at 47%, and Mustang Max at 37%. The untreated check had 77% survivorship. More information is presented in the Table 1 below with data arranged for all sixteen bioassays and totals for all trials and for raspberry only bioassays. One could argue that the conditions in Whatcom County fields are at

higher risk for elevated levels of resistance based upon the aforementioned risk factors. These results would indicate the presence of resistance.

However, there are trends in the data that give this research some concern about the results. First, control mortality is higher than expected. Overall, all control mortality is 18%, while control mortality for Whatcom County bioassays was at 23%. This is higher than is desired and is a likely sign of overdue hardship during handling of the flies in the bioassay process. There were two handling methods for Whatcom County (short-term holding in a freezer) and eastern Washington (cooler with blue ice) which may explain the difference in control mortality by location.

Further, the high level of survivorship across all insecticides with five different modes of action, particularly for Delegate and Entrust, which are not commonly used in raspberry, creates in the mind of this researcher some question about these results. Initially, fields were selected based on a history of high insecticide use and therefore would be expected to be at the highest risk of elevated resistance. Once high level of survivorship in bioassays was noted, two fields (Bench Road, Central Road) with minimal use of insecticide inputs were selected for three bioassays. There was significant survivorship in these three bioassays as well. One would expect a lower level of survivorship in these fields. In the parallel study in blueberries, one conventionally managed field was subjected to three bioassays using the same techniques and insecticides. These three bioassays had similar outcomes as the raspberry bioassays. The eastern Washington blackberry bioassays had 0 control mortality but overall had roughly analogous outcomes in terms of survivorship. Unless resistance is widespread and highly entrenched in a population, one would not expect to see such widespread resistance. For the above reasons, it is my opinion that it is premature to consider these results to indicate resistance.

This researcher believes a thorough examination of protocol process and techniques are warranted and the bioassays should be repeated and expanded.

Table 1. 16 SWD Insecticide Resistance Bioassay Results from Caneberries, 2025

Location	Bioassay	Status	Control	Delegate	Entrust	Exirel	Imidan	Lannate	Malathion	Mustang Max
Bench Road 1	1	dead	2	0	2	15	12	20	2	6
	1	alive	12	10	16	4	12	0	20	20
Bench Road 2	2	dead	2	12	1	2	10			13
	2	alive	12	0	17	17	0			13
Central Road	3	dead	3	8	14	13	10	12	9	12
	3	alive	12	0	0	0	0	0	3	2
Loomis 1	4	dead	1	18	10	10	13	14	15	8
	4	alive	7	3		3	3	0	2	3
Bartlett 1	5	dead	8	15		14	10	8	6	6
	5	alive	3	0		0	1	0	2	0
Haverstick 1	6	dead	3	8	8	10	11	7	8	6
	6	alive	2	2	0	3	1	0	0	1
Loomis 2	7	dead	2	1	3	4	7	1	0	0
	7	alive	3	12	13	13	4	13	0	0
Bartlett 2	8	dead	0	2	3	8	7	11	12	14
	8	alive	5	10	10	0	1	4	6	4
Haverstick 2	9	dead	0			9		5	5	8
	9	alive	5			0		3	4	4
Wilkely Lake	10	dead	2			10			10	5
	10	alive	3			1			10	8
Van Dyck	11	dead	0	20		0	0	0	0	14
	11	alive	14	0		14	13	15	12	0
Eastern WA 1	12	dead	0	6		7	6	7	6	6
	12	alive	6	6		6	5	7	3	6
Eastern Wa 2	13	dead	0	5		4	5	6	5	4
	13	alive	3	5		4	3	6	4	4
Eastern WA 3	14	dead	0	6		5	6	6	6	6
	14	alive	4	6		5	3	6	3	5
Eastern WA 4	15	dead	0	5		5	5	5	5	5
	15	alive	3	4		4	2	5	4	5
Eastern WA 5	16	dead	0	8	0	3	10	12	10	7
	16	alive	10	0	7	0	2	0	0	3
Total		dead	23	114	41	119	112	114	99	120
Total		alive	104	58	63	74	50	59	73	78
		% dead	0.18	0.66	0.39	0.62	0.69	0.66	0.58	0.61
Western WA		dead	23	84	41	95	80	78	67	92
Western WA		alive	78	37	56	55	35	35	59	55
Western WA		% dead	0.23	0.69	0.42	0.63	0.70	0.69	0.53	0.63

Weeds



Washington Red Raspberry Commission Research Report

Title: Management of weeds in the Polygonaceae family in red raspberries

Year Initiated: 2025 **Current Year:** 2025 **Terminating Year:** 2026

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Take Home Message

- Pre-harvest applications of rimsulfuron showed the best suppression of wild buckwheat, but did not control ladysthumb.
- The combination of flumioxazin and paraquat showed the best suppression of wild buckwheat and ladysthumb post-harvest, but all treatments (regardless of their effectiveness) did not prevent viable seed production.
- All three application timings (2-, 3-, 4-leaf) of paraquat provided similar, effective control of wild buckwheat.

Background

Red raspberries in Northwest Washington are largely grown in one county and represent the far majority (~90%) of US processed raspberry fruit. Weeds compete with raspberries for water, nutrients, space, and light, causing yield reductions and indirectly degrading fruit quality. Weeds are largely managed through the application of pre- and post-emergent herbicides applied as a broadcast over the entire raspberry hill or along hill edges ("skirting"). The industry typically grows one of six varieties, all of which are floricanes fruiting types. Because of this, growers must manage both the fruiting (floricanes, 2-year-old wood) and vegetative (primocanes, 1-year-old wood) canes in a given growing season. The first flush of primocanes is typically chemically removed ("cane burning"), but the second flush is allowed to grow up into the canopy alongside the floricanes. During this time, herbicides cannot be used as they would have a negative impact on the growing primocanes. This period is also a time when air and soil temperatures are increasing, and weed emergence and growth are rapid. Additionally, most raspberry harvest occurs over a ~six-week period when most growers also do not typically apply herbicides.

Over the past decade, growers have reported an increase in three polygonum species (*Persicaria maculosa*, *Polygonum aviculare*, *Fallopia convolvulus*). Two of these weeds have prostrate or trailing growth habits that can intertwine within the raspberry plant canopy. Even with post-emergent herbicides applied, the plant may continue to mature and shed seed. As a result, growers need better information on when to apply currently registered herbicides so that their impact on these weeds will be most effective.

Objectives:

1. Evaluate the effectiveness of herbicides currently registered for raspberries to manage weeds in the Polygonaceae family.
2. Evaluate the effectiveness of different application timings of paraquat on wild buckwheat.

Methods

Herbicide Efficacy (Obj. 1)

Trial 1 Pre-harvest

One field in Whatcom County with a high population of ladysthumb, prostrate knotweed, and wild buckwheat was utilized. In 2024, the location of individual plants was noted using a centimeter-accurate GPS (Trimble, Westminster, CO). Plots were 4'X30', contained at least one target weed, and each treatment was replicated four times and set up in a randomized complete block design. Herbicides were broadcast centered over rows using a CO₂ sprayer (22 PSI, 52 GPA) ([Table 1](#)). Additionally, a hand-weeded, weed-free control was included to monitor the overall populations of the three targeted weeds in this field (all hand-weeded data not included in the report). Before treatment applications, the commercial collaborator applied carfentrazone (2 oz/A) and paraquat (1 pt/A) on 2/15/25. Visual weed control and red raspberry damage were assessed beginning at 14 days (4/28/25) after the first applications and continued through 6/17/25, within 2 weeks of the start of harvest activities.

Trial 2 Post-harvest (Obj. 1)

Utilizing the same field, but different rows from Trial 1, plots (4'X30') were set up similarly (four replications, completely randomized block design) after harvest operations were finished. Weed populations were mapped at the plot level to ensure the presence of at least one problematic weed (listed above), but in almost all cases, weed densities exceeded five per plot. Herbicides were broadcast centered over rows using a CO₂ sprayer (22 PSI, 52 GPA). Nine treatments ([Table 2](#)) consisted of varying rates of selected products applied to plots on 8/27/25, with four replications per treatment in a completely randomized block design. Visual weed control and red raspberry damage were assessed beginning at eight days (9/4/25) after applications.

Herbicide Timing (Obj. 2)

This trial focused on the timing of post-emergent herbicide applications (paraquat at 4 pts/A per application) and their impact on wild buckwheat ([Table 3](#)). Applications occurred at the 2- (5/7/25), 3- (5/22/25), and 4-leaf (5/30/25) stages of wild buckwheat. Herbicides were broadcast centered over rows using a CO₂ sprayer (22 PSI, 52 GPA). Plots (4'X30') were replicated three times and setup in a completely randomized block design. A non-treated control was included to monitor wild buckwheat phenological development ([Fig. 1](#)). Visual weed control and red raspberry damage were assessed beginning at seven days (5/14/25) after the first application and periodically (6/6/25, 6/17/25, 6/25/25) before harvest.

Results

Herbicide Efficacy (Obj. 1)

Trial 1 Pre-harvest

On the first assessment date of 4/28/25, all applied treatments showed good to excellent suppression of wild buckwheat, but the rimsulfuron treatment did not suppress ladysthumb ([Table 1](#)). The addition of paraquat in the sulfentrazone treatments led to the suppression of wild buckwheat. The noted primocane crop injury on 5/21/25 was expected in the paraquat treatment, as no other primocane burn application occurred in these plots (it should be noted it was short-lived). By early June (6/6/25), the sulfentrazone treatments suppression was below acceptable thresholds, and rimsulfuron treatments maintained moderate suppression (71-75%). On the last assessment date (6/17/25) before harvest,

weeds broke through treatments, with moderate wild buckwheat suppression at the full rate of rimsulfuron and paraquat.

Trial 2 Post-harvest

There was minor (<5%) injury observed in some of the plots, but it was not treatment-specific (data not included for brevity). Wild buckwheat and ladythumb were evenly present throughout the plots, which allowed for visual assessment to identify the weaknesses of each treatment (Fig. 2). The addition of paraquat with flumioxazin significantly increased control of both species at eight days after application and provided the best suppression of the treatments in this time frame. The remaining treatments did not provide adequate control at eight days after application. These plots will be monitored next spring to look for crop injury during budbreak and shoot elongation.

Herbicide Timing (Obj. 2)

All treatments had only a single application, with applications occurring on 5/7/25 (2-leaf), 5/22/25(3-leaf), 5/30/25(4-leaf). In a similar trial in blueberries in an adjacent field, the 2-leaf treatment required three applications by 6/16/25. This difference was driven by cane burning application that occurred on 4/5/25 in red raspberries. Because of the treatments, a second primocane burn application did not occur on top of the treatments. All treatments showed similar control at all assessment dates (5/14/25, 6/6/25, and 6/25/25) prior to harvest (Fig. 3).

Conclusion and Additional Thoughts

Mature wild buckwheat seed has been shown to become 100% non-viable within six years of burial, with reductions of 15% in just three years¹. Prostrate knotweed follows a similar pattern, with <20% reduction in buried viable seed within three years, but the authors noted that burial depth is a factor, with seed buried deeper having higher survival¹. Ladythumb, unlike the other two already mentioned, can survive for decades in undisturbed soil, but it has also been shown to survive at much shorter intervals in regularly tilled soils². So, if seed production is eliminated or dramatically suppressed, populations can be effectively reduced in a relatively short time for most of these species.

Red raspberries have several tools registered to suppress these weeds that cause minimal damage to red raspberry plants. Results from these three trials have identified several strategies to reduce populations and, subsequently, seed production, using well-timed applications of existing labelled herbicides. This project also identified weaknesses of specific herbicides to provide season-long suppression.

Future field trials should focus on a program approach using pre- and post-emergence herbicides, with tank mixes of both to evaluate their impact on these weeds. Specifically, the period after cane burning and during harvest is a notable window of weakness, as most herbicide applications are suspended to allow remaining primocanes to grow. This work has found this to be an opportune time for these weeds, specifically wild buckwheat, to emerge and become established. This fact is significant for wild buckwheat, as once the plant grows large enough to reach the red raspberry canopy, it can continue to mature and shed seed even after being sprayed with a post-emergent contact herbicide before or after harvest.

References:

1. Conn, J. S., Beattie, K. L. & Blanchard, A. Seed viability and dormancy of 17 weed species after 19.7 years of burial in Alaska. *Weed Sci.* **54**, 464–470 (2006).
2. Mohler, C. L., Teasdale, J. R. & DiTommaso, A. *Manage Weeds on Your Farm: A Guide to Ecological Strategies*. (University of Maryland Printing Services).

Table 1. Treatment list, herbicide rates, application timings, and visual ratings (red raspberry injury, wild buckwheat, and ladythumb control), in pre-harvest herbicide trials, Whatcom County, WA 2025.

Treatment	Rate	Appl Code	Appl Date	Rating Date	4/28/25	4/28/25	4/28/25	5/21/25	5/21/25	5/21/25	6/6/25	6/6/25	6/6/25	6/17/25	6/17/25
				% injury	% weed control	% weed control	% injury	% weed control	% weed control	% weed control	% weed contr	% injury	% weed control	% weed control	
				Blueberry	POLCO	POLPE	Blueberry	POLCO	POLPE	POLCO	POLPE	Blueberry	POLCO	POLPE	
					<i>F.convolvulus</i>	<i>P. maculosa</i>		<i>F.convolvulus</i>	<i>P. maculosa</i>	<i>F.convolvulus</i>	<i>P. maculosa</i>		<i>F.convolvulus</i>	<i>P. maculosa</i>	
					Wild buckwheat	Ladysthumb		Wild buckwheat	Ladysthumb	Wild buckwheat	Ladysthumb		Wild buckwheat	Ladysthumb	
Days after first/last				14, 14 ^a	14, 14	14, 14	37, 14	37, 14	37, 14	53, 30	53, 30	53, 30	64, 41	64, 41	
sulfentrazone	6 fl oz/a	A	4/14/25	21.3 a ^b	96.3	96.3 a	0.6 b	73.8	75.0 b	61.3	57.5 b	0.6 b	55.0	28.8 b	
paraquat	2.5 pt/a	A													
NIS	2 pt/100 gal	A													
sulfentrazone	12 fl oz/a	A	4/14/25	18.8 a	96.3	96.3 a	0.0 b	78.8	76.3 b	65.0	60.0 b	0.0 b	51.7	31.3 b	
paraquat	2.5 pt/a	A													
NIS	2 pt/100 gal	A													
rimsulfuron	2 oz wt/a	A	4/14/25	5.0 b	83.8	0.0 b	0.6 b	77.5	0.0 c	77.5	0.0 c	0.6 b	75.0	0.0 c	
AMS	8 lb/100 gal	A													
rimsulfuron	4 oz wt/a	A	4/14/25	7.5 b	85.0	0.0 b	0.0 b	76.3	0.0 c	71.3	0.0 c	0.0 b	65.3	0.0 c	
AMS	8 lb/100 gal	A													
paraquat	2.5 pt/a	B	5/7/25				65.2 a	98.0	94.8 a	94.5	77.5 a	3.5 a	71.0	47.5 a	
NIS	2 pt/100 gal	B													

^ADays after first/last herbicide application

^BMeans followed by different letters within the same column are considered statistically different (LSD p<0.05). Those columns with no letters were not considered statistically different.

Table 2. Treatment list, herbicide rates, and application timings in a pre-harvest herbicide trial evaluating the impact of paraquat timing on wild buckwheat, Whatcom County, WA 2025.

Trt	Treatment	Rate	Appl Code	Appl Date
1	flumioxazin	3 fl oz/a	A	8/27/25
	NIS	0.3 % v/v	A	
2	flumioxazin	6 fl oz/a	A	8/27/25
	NIS	0.3 % v/v	A	
3	flumioxazin	3 fl oz/a	A	8/27/25
	paraquat	5 pt/a	A	
	NIS	0.3 % v/v	A	
4	flumioxazin	6 fl oz/a	A	8/27/25
	paraquat	5 pt/a	A	
	NIS	0.3 % v/v	A	
5	quinclorac	13 fl oz/a	A	8/27/25
	COC	1 % v/v	A	
6	quinclorac	13 fl oz/a	A	8/27/25
	COC	1 % v/v	A	
7	rimsulfuron	4 oz wt/a	A	8/27/25
	COC	1 % v/v	A	
8	pendimethalin	6.3 qt/a	A	8/27/25
9	quinclorac	13 fl oz/a	A	8/27/25
	rimsulfuron	4 oz wt/a	A	
	COC	1 % v/v	A	

Table 3. Treatment list, herbicide rates, application timings in post-harvest herbicide trials, Whatcom County, WA 2025.

Trt	Treatment	Rate	Appl Code	Appl Timing	Appl Date
1	paraquat	2.5 pt/a	A	POST 2-LEAF	5/7/25
	NIS	2 pt/100 gal	A	POST 2-LEAF	
2	paraquat	2.5 pt/a	B	POST 3-LEAF	5/22/25
	NIS	2 pt/100 gal	B	POST 3-LEAF	
3	paraquat	2.5 pt/a	C	POST 4-LEAF	5/30/25
	NIS	2 pt/100 gal	C	POST 4-LEAF	

Figure 1. Phenological development of unmanaged wild buckwheat plants in a ‘Meeker’ red raspberry field, Whatcom County, WA 2025.

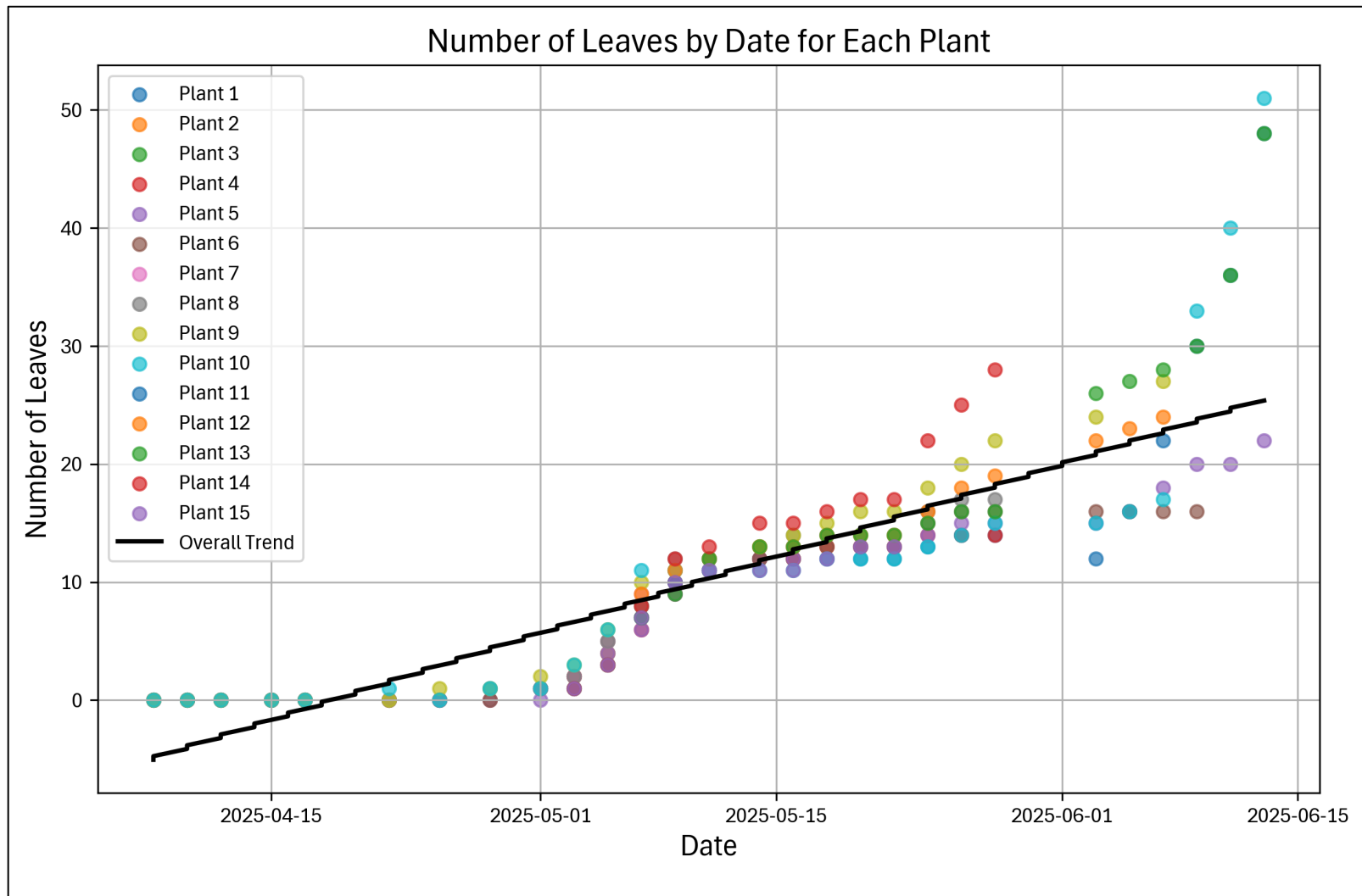


Figure 2. Wild buckwheat and ladysthumb post-harvest control in red raspberries, 2025.

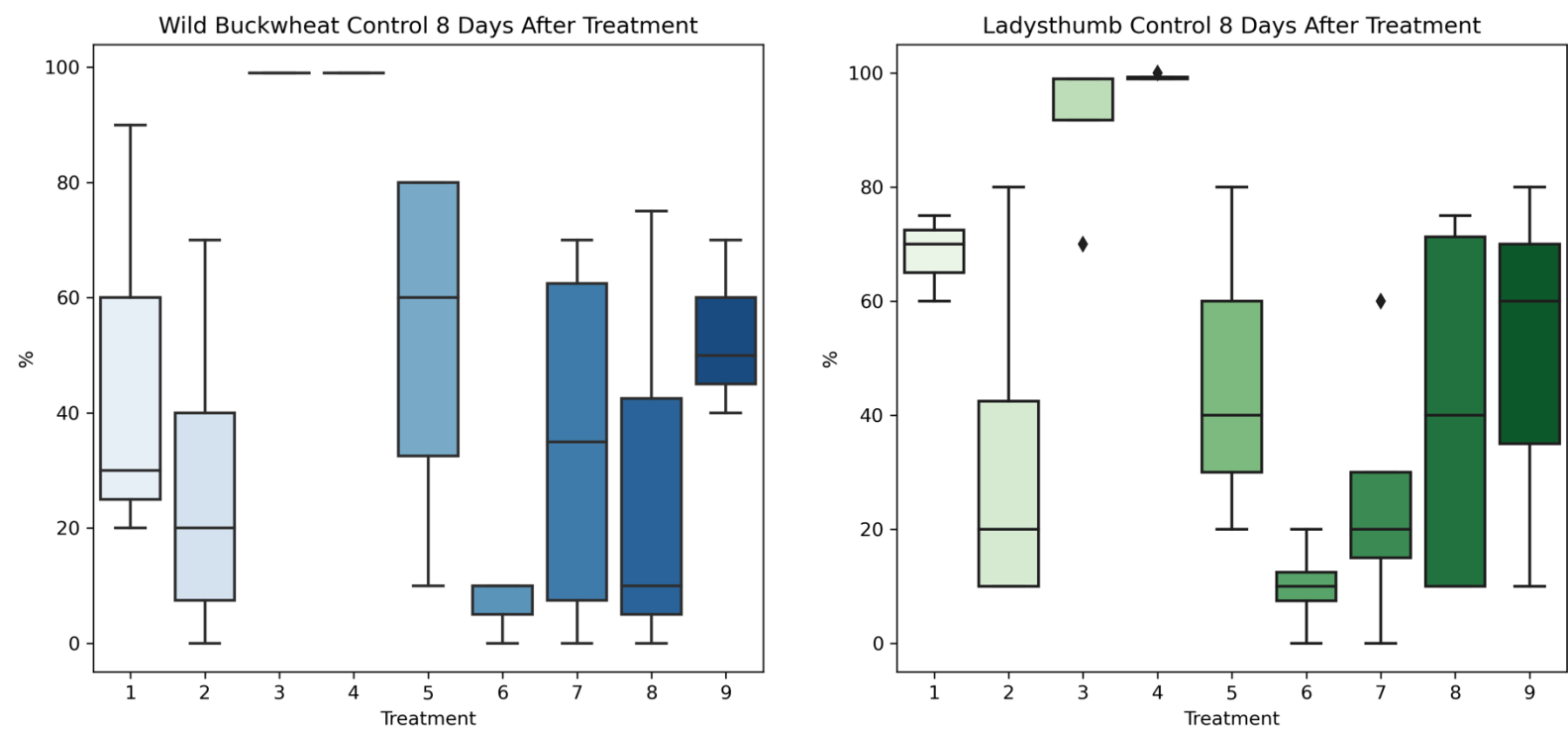
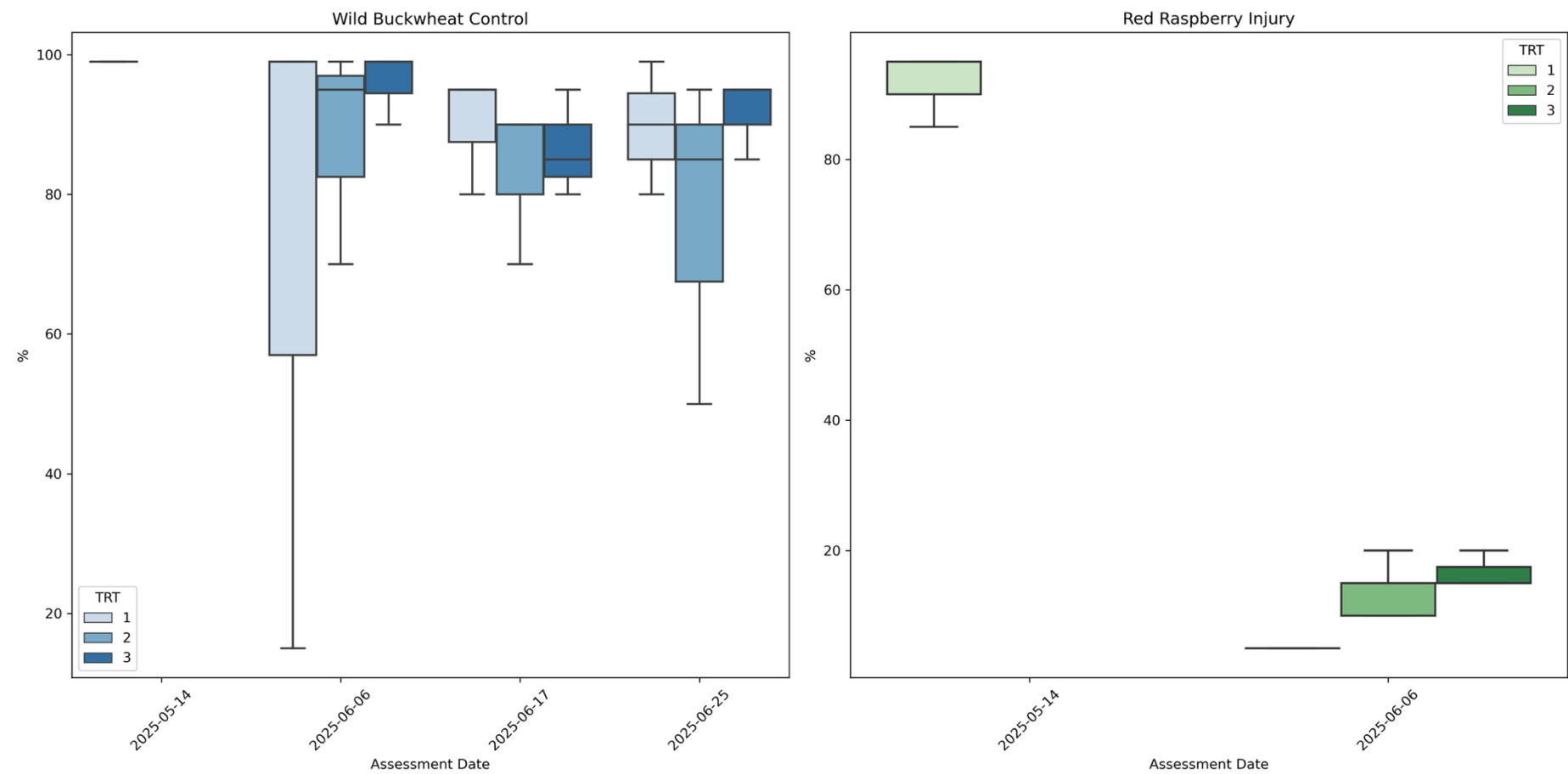


Figure 3. Wild buckwheat control using paraquat at 2-, 3-, and 4-leaf stages in red raspberries, 2025.



A Report to the Washington Red Raspberry Commission

Title: Management of Common Weeds in Raspberry

Year Initiated: 2024 **Current Year:** 2025 **Terminating Year:** 2025

Principal Investigator:

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Materials and Methods

Research staff at Agriculture Development Group, Inc. conducted the 2nd-year herbicidal study in raspberry. There were 2 sub-trials for this study, one focused on the efficacy of quinclorac applied as early or late postemergence or both timings for control of common field weeds, and the 2nd trial evaluated the efficacy of multiple pre- and postemergence herbicides with focus on grass weeds. Trials were conducted on a commercial raspberry farm located 5 miles northeast of Lynden, WA (Whatcom County) thus treatments were limited to low phytotoxicity risk products (Table 1 and 2). The experimental design for this trial was a RCB with 4 replications and plot sizes of 3ft x 25ft. For trial 1 (common weeds), two applications were made on Apr-2 (A) and May-14 (B); for trial 2, three applications were made on Mar-25 (A), Apr-10 (B), and Jun-11 (C). The plots were rated for % coverage (area) of individual weed species at pre-application, 7 days after application A (DAA), 7 days after application B (DAB), and 36 DAB for trial 1; at 10 DAA and 7 DAB for trial 2, where the impact on raspberry primocane was also rated for trial 2 by measuring the primocane height from the crown and side at 7 DAB, and again at 98 days after application C (DAC) (Photo 1).

Table 1. Treatment list for trial 1.

Trt No.	Treatment Name	Rate	Appl Code
1	Untreated		
2	Quinclorac 40% SC	12.6fl oz/a	A
	COC	2pt/a	A
3	Quinclorac 40% SC	12.6fl oz/a	B
	COC	2pt/a	B
4	Quinclorac 40% SC	12.6fl oz/a	AB
	COC	2pt/a	AB

Table 2. Treatment list for trial 2.

Trt No.	Treatment Name	Rate	Appl Code
1	Untreated		
2	Prowl H2O	3pt/a	A
3	Chateau	6oz/a	A
4	Poast	2.5pt/a	BC
	COC	2pt/a	BC
5	Dakota	8fl oz/a	BC
	COC	0.5% v/v	BC
6	Fusilade DX	24fl oz/a	BC
	COC	1% v/v	BC
7	Zeus xc	7.7fl oz/a	AB
	NIS	0.25% v/v	B
8	Sandea	1oz/a	A
	NIS	0.25% v/v	B
9	Dakota	8fl oz/a	B
	Poast	2.5pt/a	C

Results and Discussion

Trial 1-Common Field Weeds

This trial focused on testing the efficacy of quinclorac (40% SC) applied at different postemergence timings: early (A), late (B), and both (A + B). We observed 6 different weed species before the application: wild buckwheat, chickweed, dandelion, an unidentified broadleaf species, horseradish, and crabgrass. Although no statistical differences were observed among treatments and untreated check, we did observe relatively better control of wild buckwheat at 36 DAB by Treatment 2 (with early application A) and Treatment 4 (2 applications at A and B) with 10.88% and 3.38% coverage which were only 4.63% and 0% increases compared to their pre-study wild buckwheat coverage (Table 3 column 19*), indicating good suppression of the spreading of this weed. Meanwhile, the untreated check and late-post Treatment 3 had increased wild buckwheat coverage from 7.45% to 28.75%, and from 5.25% to 21.75%, respectively. Based on these results, we cannot recommend use of quinclorac for control of wild buckwheat.

Trial 2-Grass Weeds

We observed 4 different weed species in this trial: Californian thistle, dandelion, annual bluegrass, and red-veined dock.

At 10 DAA, the pre-emergence application A of Prowl, Chateau, and Sandea led to significant control of Californian thistle with 0 to 0.5% coverage. Chateau was also able to significantly suppress the annual bluegrass down at 0.3% coverage (Table 4 column 1*). By 7 DAB, all treatments appeared to hold lower California thistle coverage than untreated check, numerically (Table 4 column 5*).

It is important to mention that Chateau, Zeus, and Sandea caused stunt effect on young primocanes with <3 inches of growth from the crown and <2 inches from the side by 7 DAB, which is statistically lower than untreated check's 4.75 inches (from crown) and 3.75 inches (from side) (Table 4 columns 9* and 10*). However, by 98 DAC, no negative treatment impact on the primocane height was observed.

Photo 1. Assessing the primocane height.



Table 3. ANOVA table for the mean separation of % weed coverage for trial 1.

Rating Type				% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage		
Pest Name				Wild buckwheat	Chickweed	Dandelion	Unclear Broadleaf	Horseradish	Crabgrass	Wild buckwheat	Chickweed	Dandelion	Unclear Broadleaf	Horseradish	Crabgrass	Wild buckwheat	Chickweed	Dandelion	Unclear Broadleaf	Horseradish	Crabgrass	Wild buckwheat	Chickweed	Dandelion	Unclear Broadleaf	Horseradish	Crabgrass	
Treatment Appl. Interval				0 DA-A	0 DA-A	0 DA-A	0 DA-A	0 DA-A	0 DA-A	7 DA-A	7 DA-A	7 DA-A	7 DA-A	7 DA-A	7 DA-A	7 DA-B	7 DA-B	7 DA-B	7 DA-B	7 DA-B	7 DA-B	36 DA-B	36 DA-B	36 DA-B	36 DA-B	36 DA-B	36 DA-B	
Trt	Treatment	Rate	App	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*	17*	18*	19*	20*	21*	22*	23*	24*	
No.	Name	Rate	Unit	Cod																								
1	Untreated				7.25 -	18.00 -	2.63 -	2.50 b	2.63 -	0.75 -	12.50 -	22.00 -	4.30 -	5.30 -	3.88 -	1.80 -	8.00 -	3.50 -	0.80 -	0.00 na	1.30 -	0.00 na	28.75 -	2.30 -	1.50 a	5.25 -	2.00 -	0.30 -
2	Quinclorac 40% COC	12.6 fl oz/ A	2 pt/a	A	6.25 -	19.50 -	2.25 -	1.80 b	0.75 -	1.75 -	14.13 -	27.50 -	2.50 -	2.80 -	0.75 -	2.30 -	3.00 -	2.50 -	0.00 -	0.00 na	1.00 -	0.00 na	10.88 -	2.30 -	0.00 b	1.50 -	0.50 -	0.00 -
3	Quinclorac 40% COC	12.6 fl oz/ B	2 pt/a	B	5.25 -	30.80 -	1.50 -	2.00 b	1.25 -	1.38 -	12.50 -	38.80 -	2.50 -	3.80 -	1.75 -	2.00 -	6.30 -	5.00 -	0.30 -	0.00 na	1.30 -	0.00 na	21.75 -	8.00 -	0.50 b	0.88 -	3.00 -	0.00 -
4	Quinclorac 40% COC	12.6 fl oz/ AB	2 pt/a	AB	3.38 -	16.30 -	3.25 -	4.00 a	0.50 -	3.75 -	4.50 -	22.00 -	4.50 -	6.30 -	0.38 -	5.80 -	3.00 -	5.80 -	0.00 -	0.00 na	0.00 -	0.00 na	3.38 -	6.00 -	0.00 b	4.00 -	0.00 -	0.00 -
LSD P=.10					9.718	16.37	1.945	1.4	2.729	2.172	15.392	24.87	2.47	2.8	4.095	4.58	7.03	5.64	1.06		1.54		26.815	9.68	0.53	4.831	3.69	0.32
Treatment Prob(F)					0.8975	0.4069	0.4565	0.0644	0.5187	0.1358	0.6704	0.5873	0.331	0.1744	0.4413	0.385	0.5056	0.7223	0.5493	NaN	0.4363	NaN	0.3682	0.6387	0.0017	0.3551	0.4617	0.4363

Table 4. ANOVA table for the mean separation of % weed coverage and primocane height ratings for trial 2.

Rating Type					% Coverage		% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	% Coverage	Primocane Height		Primocane Height	Primocane Height
Pest Name					Californian thistle	Dandelion	Annual bluegrass	Red-veined dock	Californian thistle	Dandelion	Annual bluegrass	Red-veined dock	From Crown (inches)	From Side (inches)	From Top (inches)			
Treatment Appl. Interval					10 DA-A	10 DA-A	10 DA-A	10 DA-A	7 DA-B	7 DA-B	7 DA-B	7 DA-B	7 DA-B	7 DA-B	7 DA-B			
Trt	Treatment	Rate		Appl	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*			
No.	Name	Rate		Code														
1	Untreated				2 a	0.5 -	1.8 a	0.13 -	3.13 -	0.75 -	1 -	0 -	4.75 ab	3.75 ab	104 -			
2	Prowl H2O	3 pt/a	A		0 b	0.75 -	1 abc	0 -	0.25 -	0.25 -	1.25 -	0 -	4.75 ab	3.75 ab	106.3 -			
3	Chateau	6 oz/a	A		0 b	0.13 -	0.3 bc	0 -	0 -	0.25 -	0.5 -	0.13 -	2.13 c	1.63 d	95.3 -			
4	Poast	2.5 pt/a	BC		0 b	0.75 -	0.3 bc	0.13 -	0.25 -	0.38 -	0.25 -	0 -	4.75 ab	4 a	110.8 -			
	COC	2 pt/a	BC															
5	Dakota	8 fl oz/a	BC		0.13 b	1 -	0 c	0 -	0.13 -	0.5 -	0.13 -	0 -	4.75 ab	3.88 ab	108.8 -			
	COC	0.5 % v/v	BC															
6	Fusilade DX	24 fl oz/a	BC		0 b	0.75 -	0 c	0 -	0 -	0.5 -	0 -	0 -	4.38 b	3.38 b	101.8 -			
	COC	1 % v/v	BC															
7	Zeus xc	7.7 fl oz/a	AB		0 b	0.5 -	1.3 ab	0 -	0.25 -	1 -	0.5 -	0 -	2.25 c	1.63 d	105.8 -			
	NIS	0.25 % v/v	B															
8	Sandea	1 oz/a	A		0.5 b	0.75 -	0.8 abc	0 -	0.75 -	0.63 -	0.5 -	0 -	2.63 c	2.25 c	108.3 -			
	NIS	0.25 % v/v	B															
9	Dakota	8 fl oz/a	B		0.75 b	0.5 -	1.8 a	0 -	1.75 -	0.25 -	1.5 -	0 -	5.5 a	3.75 ab	97.5 -			
	Poast	2.5 pt/a	C															
LSD P=.10					1.082	0.905	1.19	0.146	2.262	0.708	1.09	0.101	0.96	0.541	15.29			
Treatment Prob(F)					0.0618	0.8809	0.0852	0.5774	0.3031	0.6269	0.2866	0.4613	0.0001	0.0001	0.7037			

Physiology



Washington Red Raspberry Commission Final Report

Project No: 146041

Title: Determining leaf nutrient sufficiency standards for red raspberry in Washington

Personnel:

- PI: Lisa DeVetter, Professor of Horticulture at WSU, Mount Vernon, WA
- Co-PI: Dave Bryla, Research Horticulturist at USDA-ARS, Corvallis, OR

Reporting Period: 2025

Project Objectives:

1. Determine leaf macro- and micro-nutrient sufficiency standards for traditional and new florican-fruiting raspberry cultivars grown in northwest Washington.
2. Disseminate findings to stakeholders and develop a new raspberry nutrient management guide for the region.

Rationale:

Current sufficiency standards are outdated and have not been evaluated for new, machine-harvestable cultivars being widely adopted by the processed raspberry industry in northwest Washington. Moreover, current sufficiency standards originated from data collected in Oregon (Hart et al., 2006; Strik and Bryla, 2015) or, in the case of several nutrients, in northeastern United States (Bushway et al., 2008). Therefore, results from this project will provide cultivar-specific, regionally relevant standards for the northwest Washington raspberry industry.

Procedures:

To accomplish the first objective, newly expanded primocane leaf tissue samples were collected every two weeks from mid-June through mid-September in 2024 and 2025. Samples were collected from productive, commercially representative fields of ‘Meeker,’ ‘WakeHaven,’ ‘WakeField,’ and ‘Kulshan’ within the Lynden area and included three fields per cultivar (12 fields total). Each field had four transects (rows), with a minimum of 50 leaves collected from each transect during every sampling round. Leaf samples were dried, sent to Brookside Labs, and analyzed for macro- and micronutrients. Fall soil samples were also collected and sent to Brookside Labs each year. Composite soil samples were prepared from 12 cores collected on both sides of each transect, with sampling to a depth of 12 inches within the raspberry row. Regarding the second objective, preliminary results were shared in 2024 and again in 2025 at the Lynden Ag Show.

Accomplishments:

- A total of 672 leaf samples were collected and analyzed for nitrogen (% N), phosphorous (% P), magnesium (% Mg), potassium (% K), calcium (% Ca), sulfur (% S), boron (ppm, B), iron (ppm, Fe), manganese (ppm, Mn), copper (ppm, Cu), and zinc (ppm, Zn). This amounts to 7,139 data points.
- A total of 48 fall soil samples were also collected and analyzed for Total Exchange Capacity (meq/100 g), pH, organic matter (%), S (ppm), P (Bray-1 in ppm), Ca (mg/kg and %), Mg (mg/kg and %), K (mg/kg and %), Na (mg/kg and %), Ca (mg/kg and %), hydrogen (%), B

(mg/kg), Fe (mg/kg), Mn (mg/kg), Cu (mg/kg), Zn (mg/kg), and other bases. This amounts to 1,056 data points.

- Initial data analysis has been used to identify potential oversupply of certain nutrients based on soil tests, the most stable period(s) for leaf sampling, and the sufficiency ranges for each tissue nutrient (see Results section).
- Preliminary results for this project were shared twice at the 2024 and 2025 Lynden Ag Show/Washington Small Fruit Conference.
- A newsletter article summarizing project findings is being prepared for publication in the *WSU Whatcom Ag Monthly*, with a target release by March 2026. The article will also be jointly published in the *Northwest Berry Foundation Small Fruit Update*.
- Results will be used to update the regional extension guide titled “Nutrient management of raspberries and blackberries in Oregon and Washington” by Davis et al. (2024).

Results: Soil and tissue nutrients from 2024 and 2025 have undergone preliminary analyses with results presented below in bullet-point format to enhance conciseness and readability. Tables and figures are provided in the appendix.

Soil Test Results:

- Mean, standard deviation, and recommended ranges of key soil variables for floricanefruiting raspberry in the Pacific Northwest are presented in **Table 1**. The data represent averages across all 12 fields sampled in 2024 and 2025.
- Most sites were within the recommended pH range of 5.6-6.5. Sites outside of this range should focus on pH management to promote the availability of nutrients.
- Soil P levels were notably high. While the recommended range is >20-40 ppm, the mean concentration was 194 ± 90 ppm. Excess P can reduce micronutrient availability, particularly Zn, by forming insoluble compounds that contribute to deficiencies. It also reduces root colonization by beneficial mycorrhizal fungi. These results suggest growers may be oversupplying fertilizer P and should consider soil and tissue testing to determine if P levels are sufficient before adding additional fertilizer P.
- Soil B levels were also high, averaging $1.3 (\pm 0.4)$ ppm, whereas the recommended range is 0.5-1.0 ppm. While B is typically depleted from soil due to winter rains, soil test results suggest there may be an oversupply of fertilizer B in many fields. Growers are advised to evaluate soil B in conjunction with leaf tissue tests before applying additional fertilizer B to avoid the risk of reduced yields and toxicity from excess B. Foliar applications of B in the fall or spring prior to bloom are effective at elevating tissue B levels if plants indicate deficiency.
- Soil Ca was also high relative to Mg and K at $2,419 (\pm 602)$ ppm. Results indicate most soils have sufficient Ca, so additional fertilizer applications may not be warranted and may also interfere with Mg and K uptake. Growers are advised to monitor leaf and soil Ca, Mg, and K before applying additional fertilizer Ca to the soil to avoid imbalances with these nutrients. Additionally, other experiments led by DeVetter and Bryla show application of soil or foliar fertilizer Ca does not improve raspberry yield and fruit quality attributes, including firmness, even when applied during Ca uptake windows (Dias Da Silva et al., 2023; Rojas-Barros et al., 2025). Moreover, Ca concentrations in receptacles were $\approx 165\%$ higher than in drupelets, with no variation in fruit Ca levels across fertilizer treatments (Rojas-Barros et al., 2025).

This indicates that isolation events restrict the transfer of fertilizer-derived Ca from receptacles to drupelets.

- Soil Mn levels averaged 17.1 (± 4.8) ppm, which is slightly below the recommended range of 20-60 ppm. Low soil Mn levels were associated with sites that had higher pH ranges, underscoring the importance of pH management to ensure nutrient availability.
- All other soil variables were within recommended ranges and are not further detailed in this report.

Leaf Tissue Results [Note: OSU sufficiency levels were referenced from Davis et al. (2024)]:

- Preliminary results indicate that the period of nutrient stability extends later into August, leading to the recommendation that leaf tissue sampling can extend from mid-July through late August. However, to ensure consistency and enable robust comparisons over time, growers should still aim to be consistent across years with their sampling time.
- Nitrogen tissue concentrations were sometimes outside the OSU recommended range of 2.0-3.0%, particularly for new, high-vigor cultivars (**Fig. 1**). This indicates thresholds for newer cultivars should be modified. The new proposed range is 2.0-3.3% N.
- Potassium concentrations were often outside the OSU range of 1.0-1.8%, indicating the threshold should be slightly elevated to 1.0-2.0% K (**Fig. 2**).
- Despite high soil Ca, tissue Ca concentrations were often below the OSU range of 0.6-1.5%, suggesting the threshold may be lowered to 0.4-1.5% (**Fig. 3**).
- Concentrations of S in 2024 were often above the OSU range of 0.10-0.20%, especially in 'Kulshan' fields (**Fig. 4**). Tissue S thresholds can be modified to 0.10-0.25%.
- Tissue B exceeded 100 ppm in several fields, which is outside the OSU range of 30-80 ppm (**Fig. 5**). Combined with the soil test results, the data indicate growers are likely oversupplying B fertilizer. The proposed range for tissue B remains at 30-80 ppm to avoid toxicity over time.
- Tissue Fe concentrations were generally within the OSU range of 70-300 ppm, although they trended on the lower end of the threshold (**Fig. 6**). The new proposed range is 60-300 ppm. Levels exceeding 600 ppm were observed but attributed to traces of soil dust on the leaves, which is very high in Fe.
- Copper levels were often outside the OSU sufficiency range of 3-10 ppm (**Fig. 7**). Levels outside this range in the late fall are attributed to fungicide applications. The proposed threshold for WA samples is 3-20 ppm.
- Concentrations of Zn were sometimes outside the OSU range of 15-40 ppm, with a few outliers observed due to micronutrient or fungicide applications in 2024 (**Fig. 8**). The proposed threshold for Washington raspberry is expanded to 20-50 ppm.
- Results for P, Mg, and Mn indicate the OSU sufficiency ranges are acceptable for these nutrients and no modification is required (**Figs. 9, 10, and 11**, respectively). Boron sufficiency ranges were also found to be sufficient (**Fig. 5**).
- A table of original and proposed ranges is provided in **Table 2**. DeVetter will meet with growers and crop consultants in December 2025 to gather feedback on these ranges and soil test results before publishing.

Appendix

Publications:

One extension publication has been co-authored by the collaborating scientists (see below). This guideline will be updated, and new guidelines will be published as a WSU Extension publication at the end of this project.

Davis, A., S. Lukas, B. Strik, A. Moore, L.W. DeVetter, D. Bryla, and E. Dixon. 2024. Nutrient management of raspberries and blackberries in Oregon and Washington. PNW Extension Publication. Pp. 35. PNW 780. [Available online for free.](#)

Table 1. Mean, standard deviation ($\pm$ SD), and recommended ranges of key soil variables for floricane-fruited raspberry in the Pacific Northwest. Samples were collected from within raspberry rows in Lynden, Washington, with four composite samples per field in October 2024 and 2025. Analyses were conducted by Brookside Labs, and values represent averages across 12 fields.

Variable	Mean ($\pm$ SD)	Recommended range ^z
pH (1:1; tested in water)	6.5 ($\pm$ 0.5)	5.6-6.5
OM (%)	6.4 ($\pm$ 1.3)	---
CEC (meq/100 g)	16.6 ($\pm$ 3.8)	---
Bray I P (ppm)	194 ($\pm$ 90)	>20-40
Potassium (ppm)	300 ($\pm$ 95)	150-350
Calcium (ppm)	2,419 ($\pm$ 602)	>1,000
Magnesium (ppm)	151 ($\pm$ 49)	>120
Manganese (ppm)	17.1 ($\pm$ 4.8)	20-60
Boron (ppm)	1.3 ($\pm$ 0.4)	0.5-1.0

^zRecommended ranges from *Nutrient management of raspberries and blackberries in Oregon and Washington* (PNW 780).

Table 2. Proposed tissue nutrient sufficiency ranges relative to original sufficiency ranges for floricane raspberry grown in northwest Washington. Changes are noted in red font.

Nutrient	Oregon ^z	Washington (<i>proposed</i>)
Nitrogen (%)	2.0-3.0	2.0-3.3^y
Phosphorus (%)	0.20-0.40	0.20-0.40
Potassium (%)	1.0-1.8	1.0-2.0
Calcium (%)	0.6-1.5	0.4-1.0
Magnesium (%)	0.25-0.50	0.25-0.50
Sulfur (%)	0.10-0.20	0.10-0.25
Boron (ppm)	30-80	30-80
Iron (ppm)	70-300	60-300
Manganese (ppm)	50-300	50-300
Zinc (ppm)	15-40	20-50
Copper (ppm)	3-10	3-20

^zRecommended ranges from *Nutrient management of raspberries and blackberries in Oregon and Washington* (PNW 780).

^yTissue levels of 2.0-3.0% N adequate for traditional cultivars like ‘Meeker’, but higher-vigor and yielding cultivars proposed range is 2.0-3.3%.

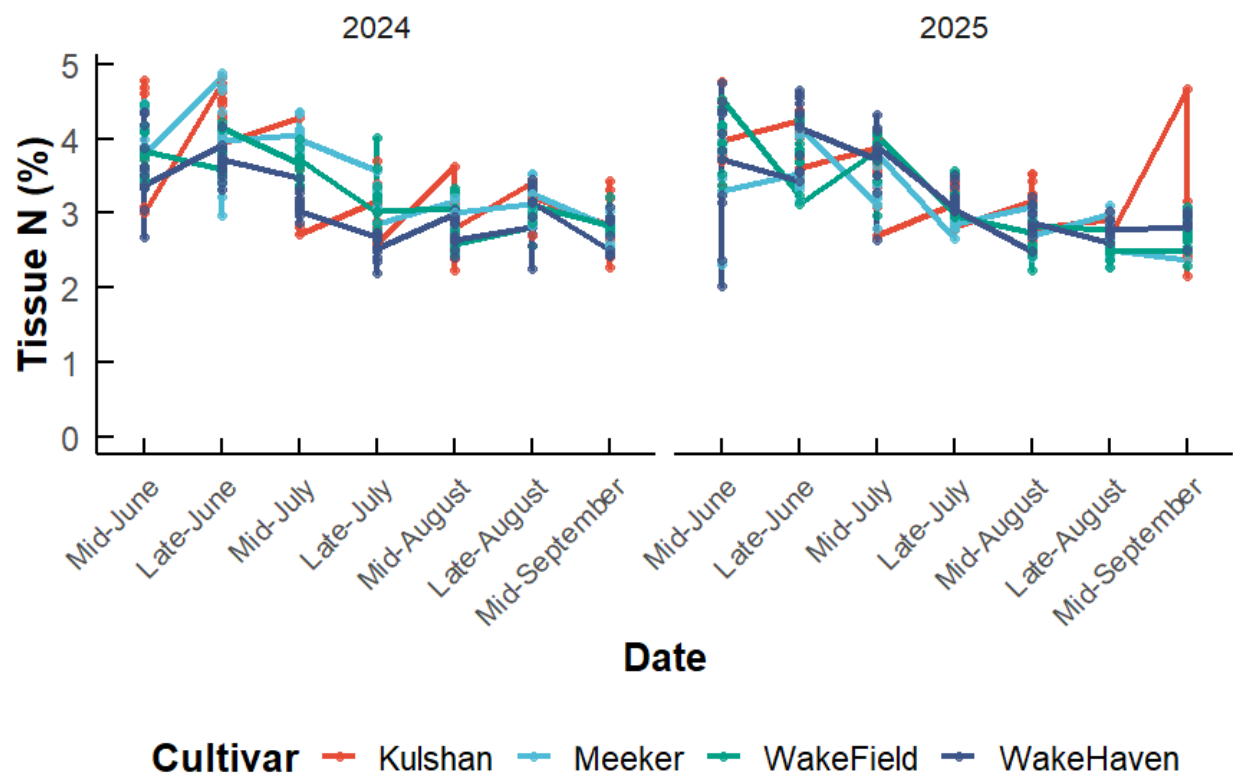


Fig 1. Concentrations of leaf nitrogen (N%) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ florican raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

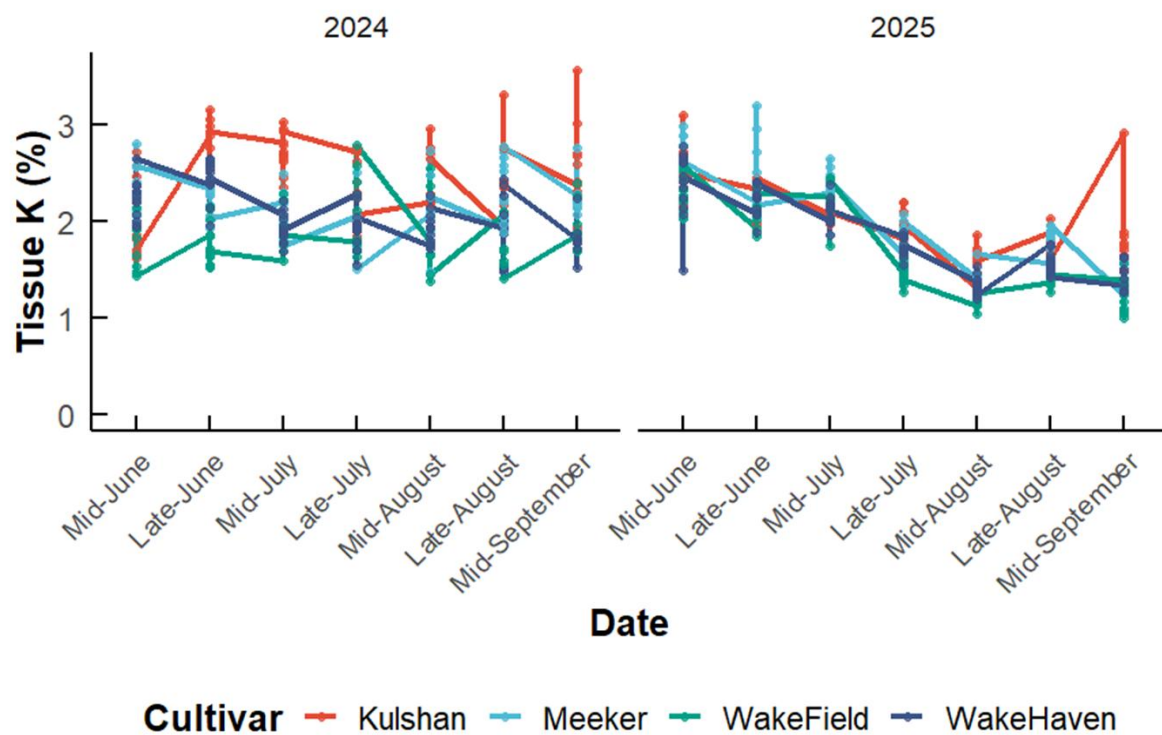


Fig 2. Concentrations of leaf potassium (K%) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ floricane raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

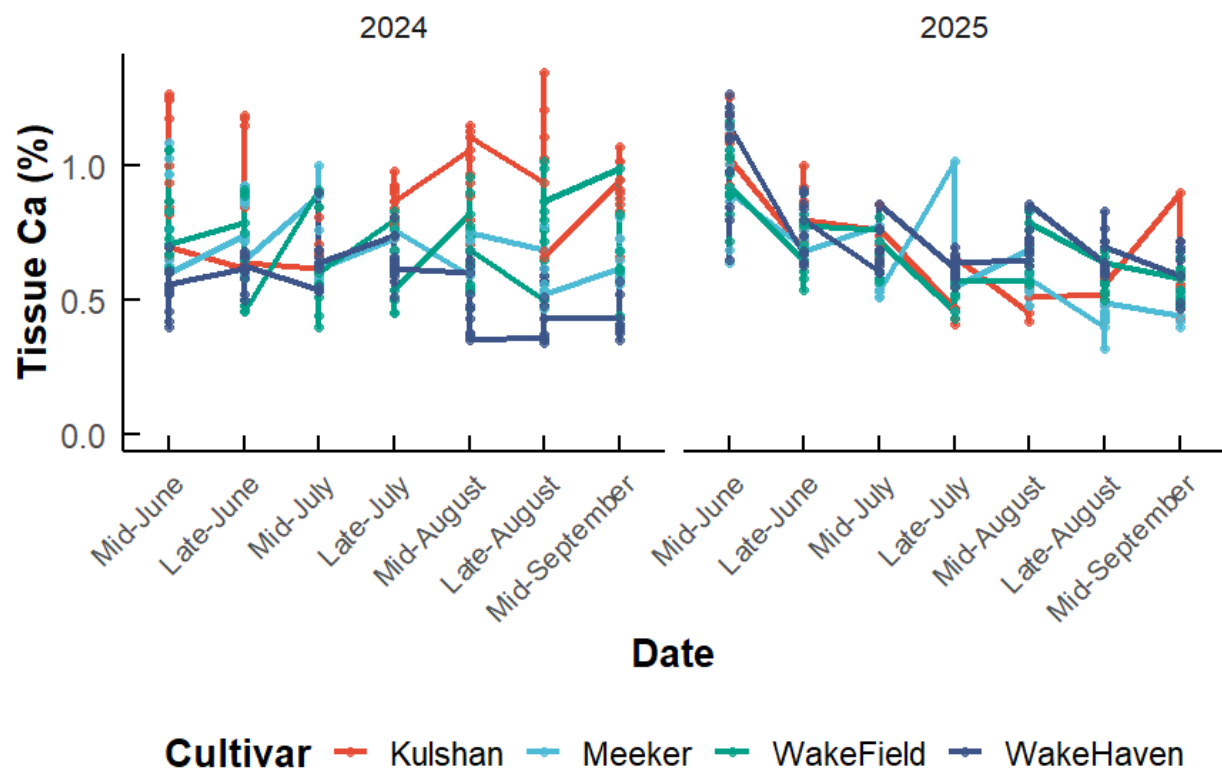


Fig 3. Concentrations of leaf calcium (Ca%) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ floricane raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

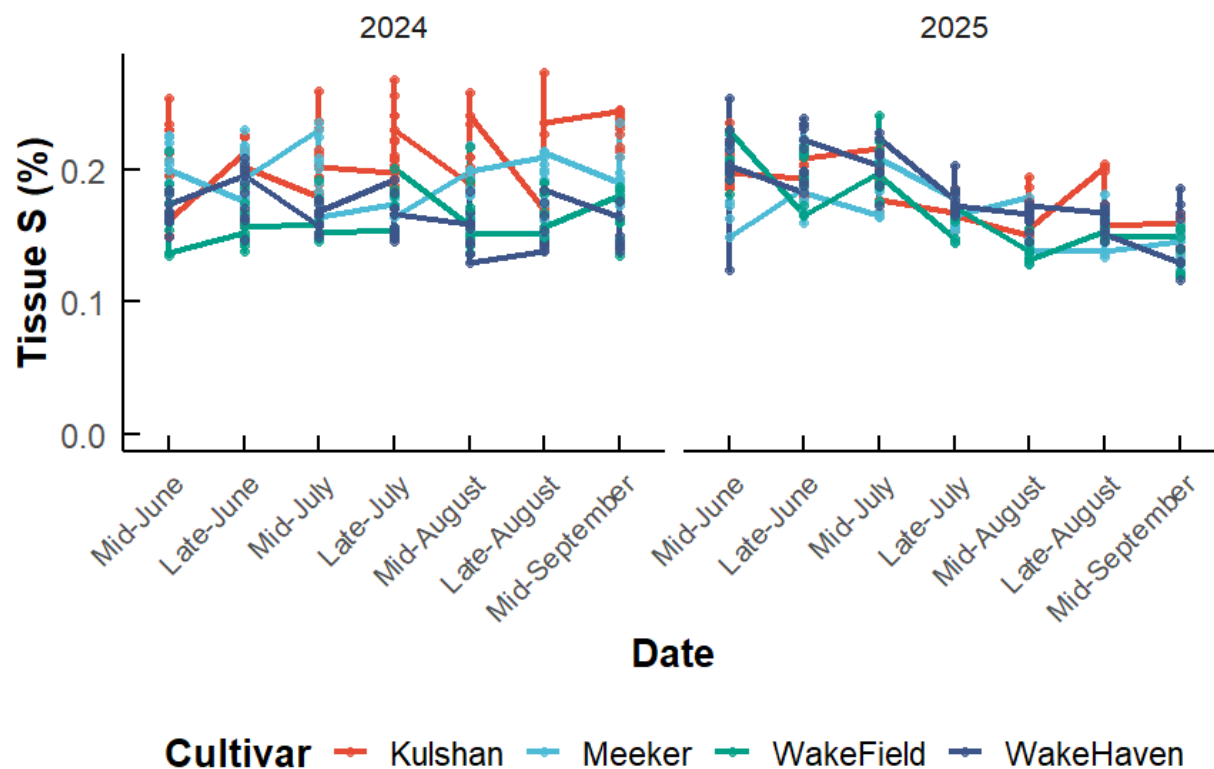


Fig 4. Concentrations of leaf sulfur (S%) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ florican raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

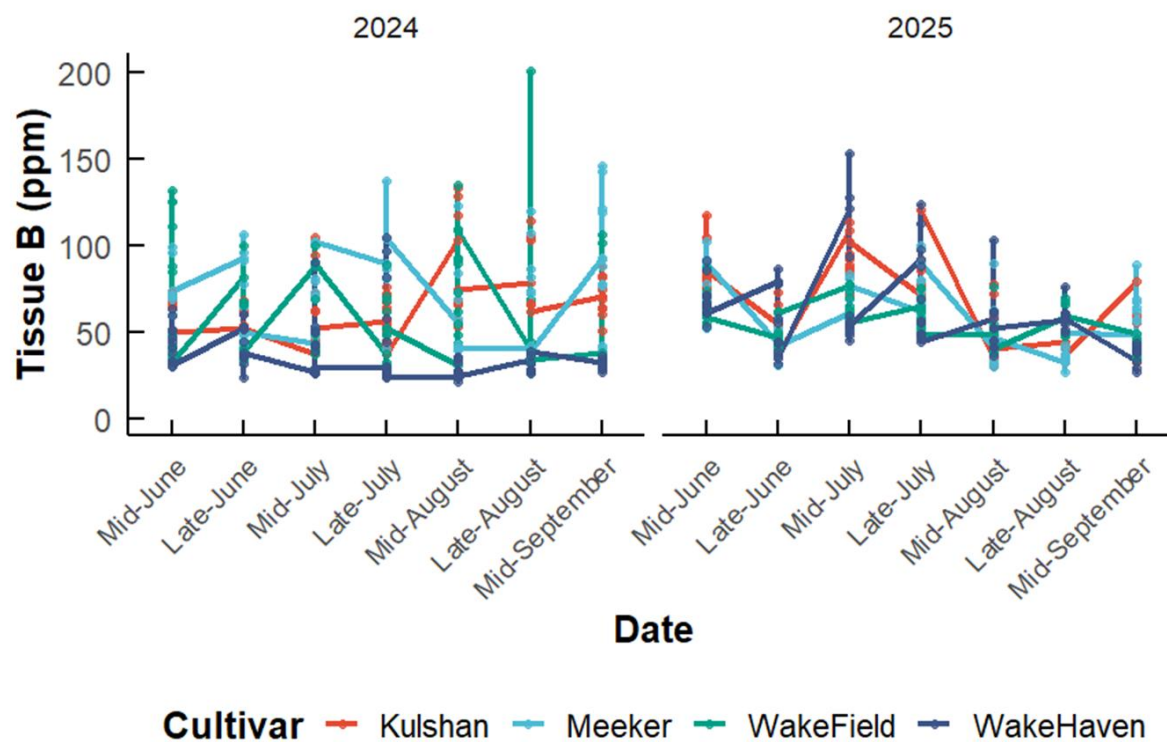


Fig 5. Concentrations of leaf boron (B, ppm) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ florican raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

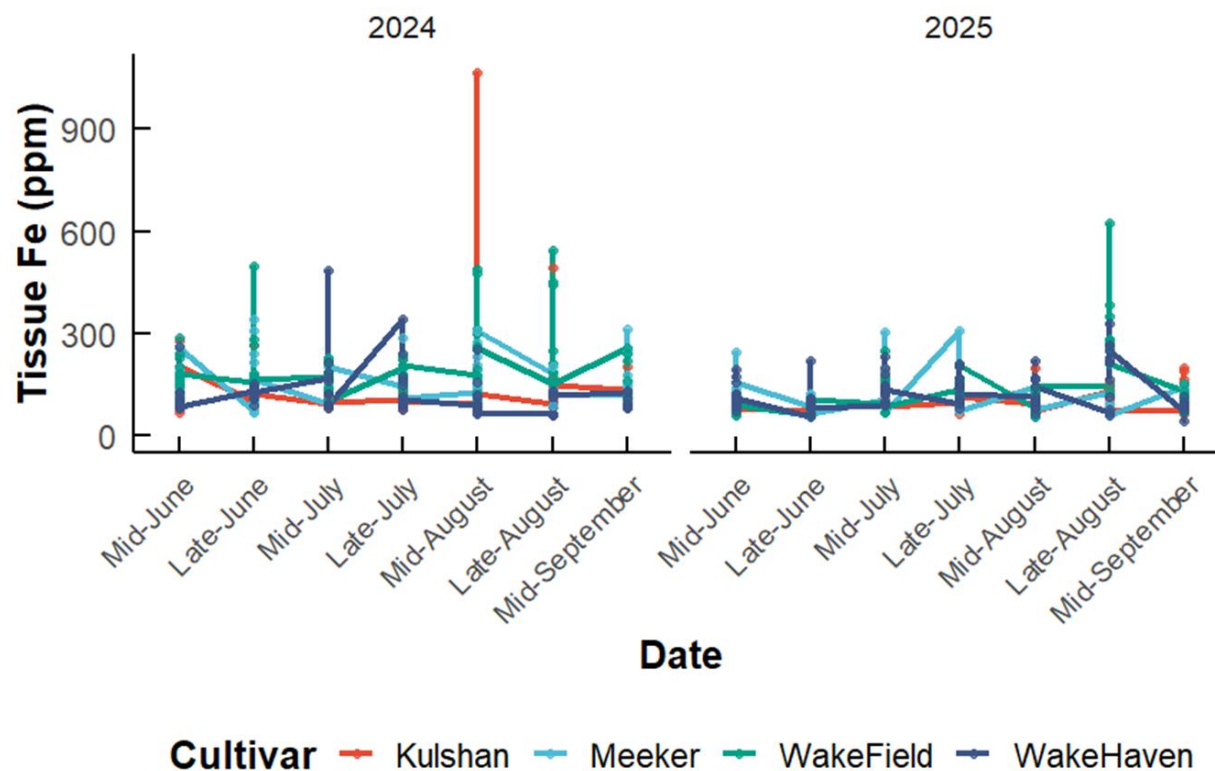


Fig 6. Concentrations of leaf iron (Fe, ppm) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ florican raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

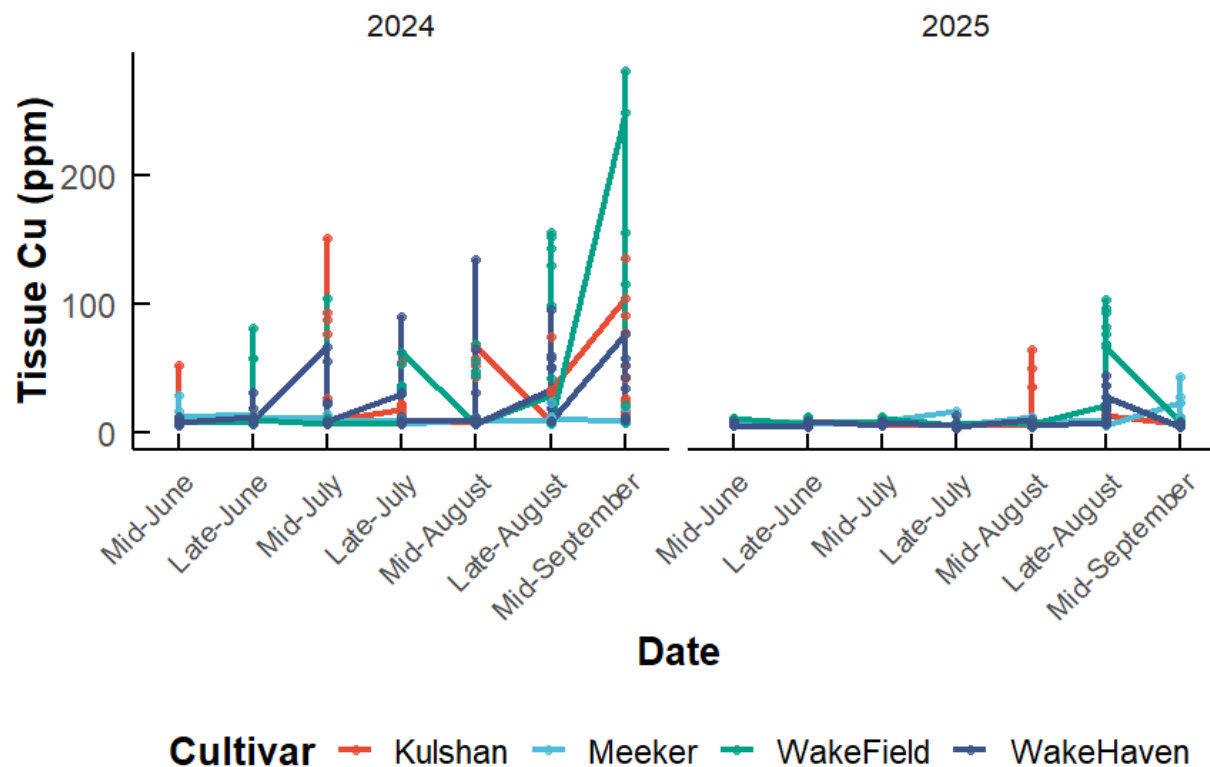


Fig 7. Concentrations of leaf copper (Cu, ppm) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ floricane raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

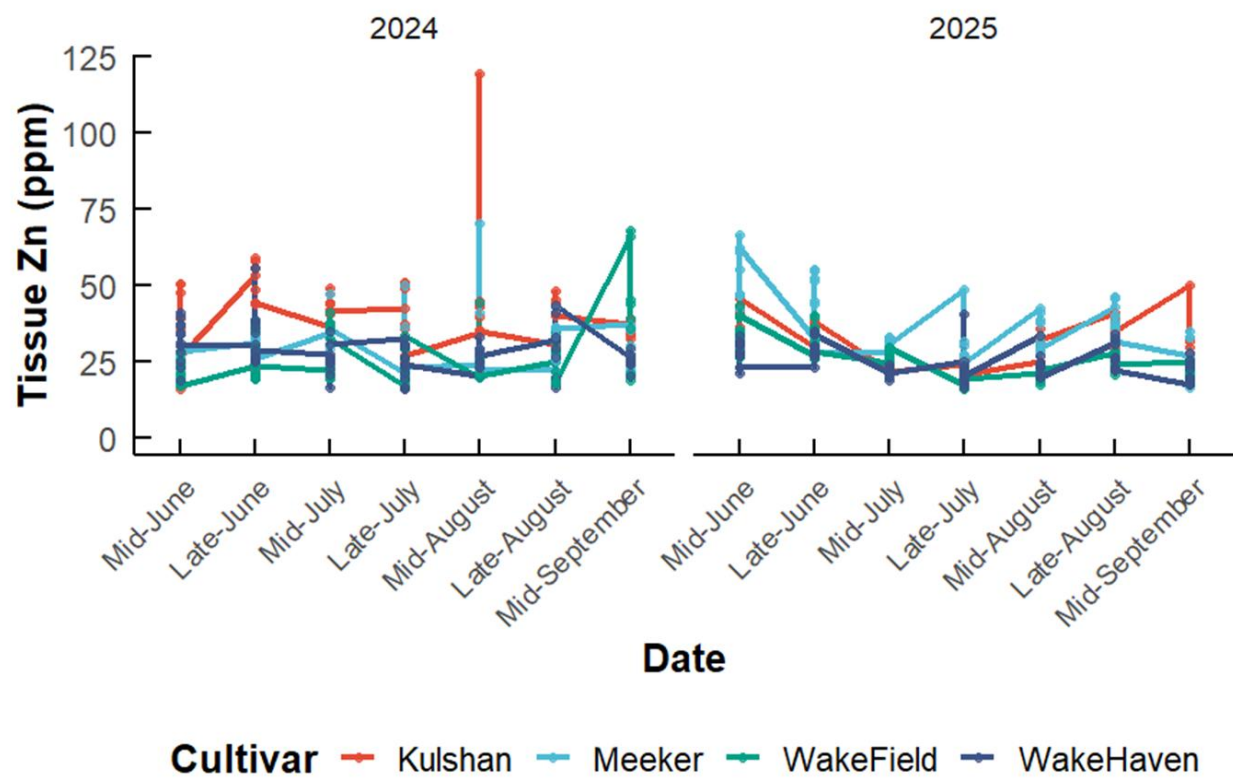


Fig 8. Concentrations of leaf zinc (Zn, ppm) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ floricane raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

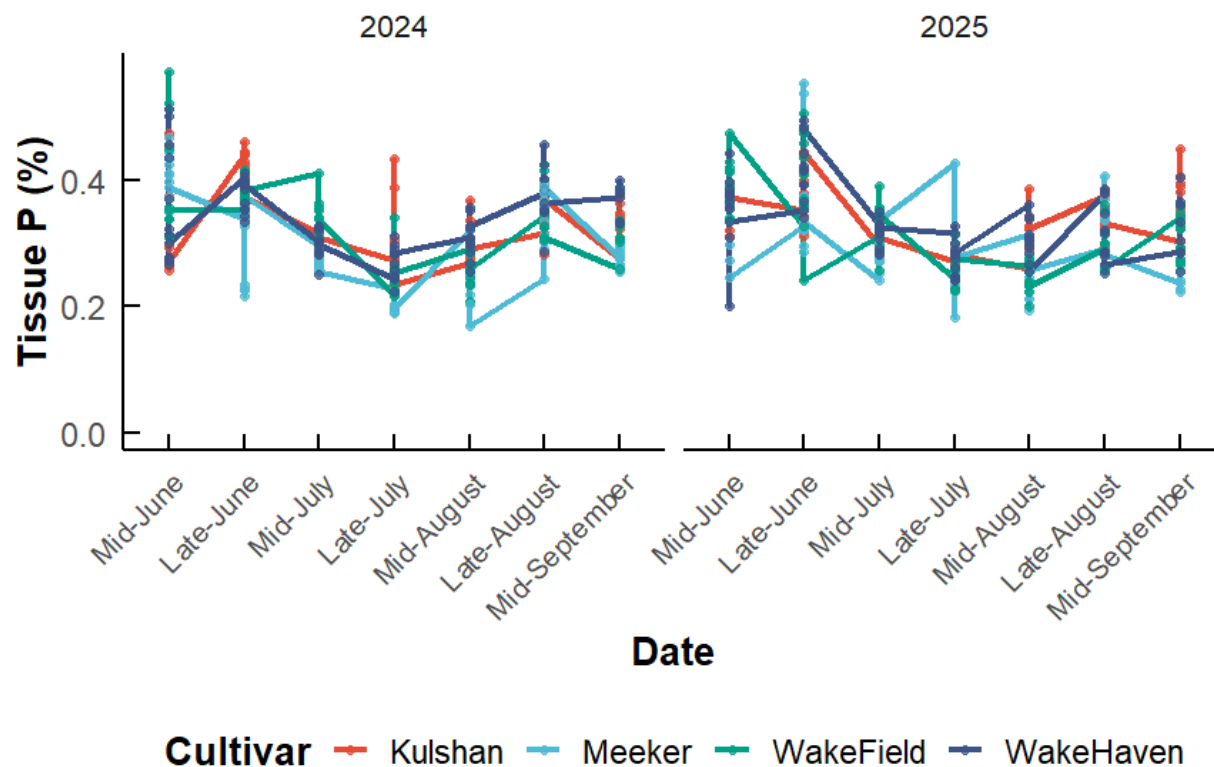


Fig 9. Concentrations of leaf phosphorus (P, %) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ florican raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

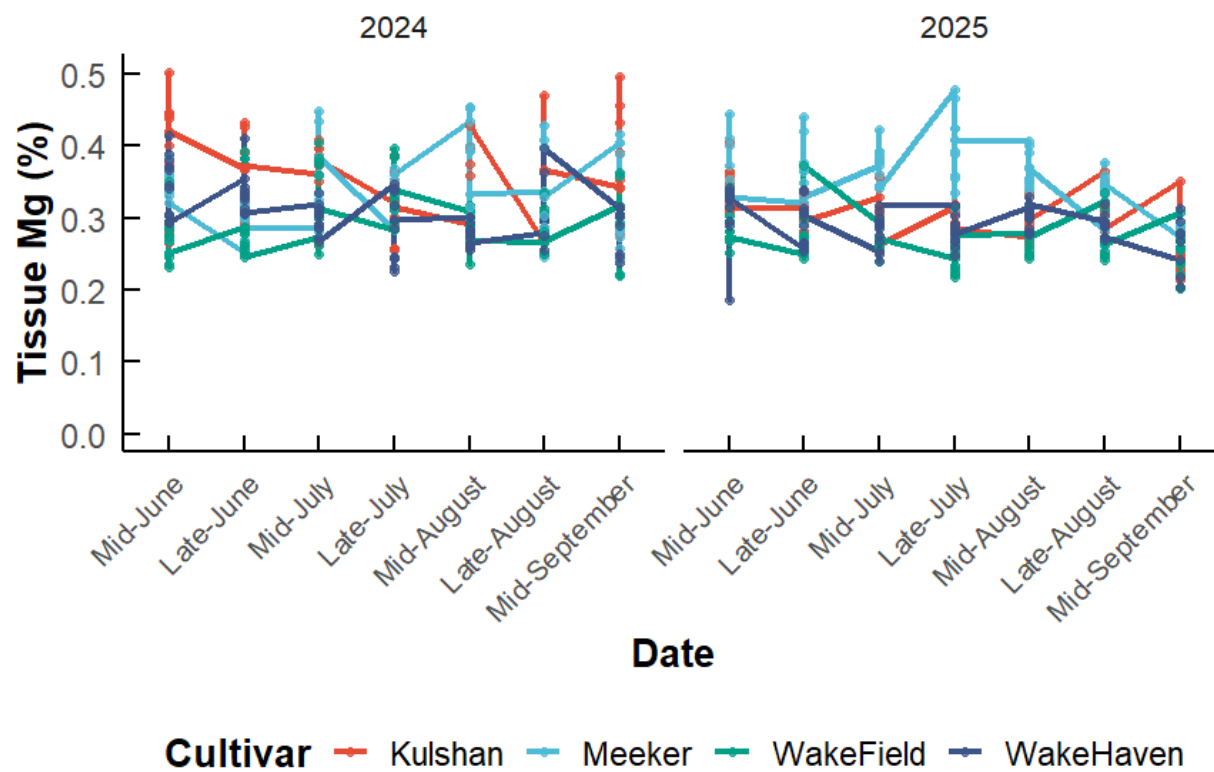


Fig 10. Concentrations of leaf magnesium (Mg, %) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ floricane raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

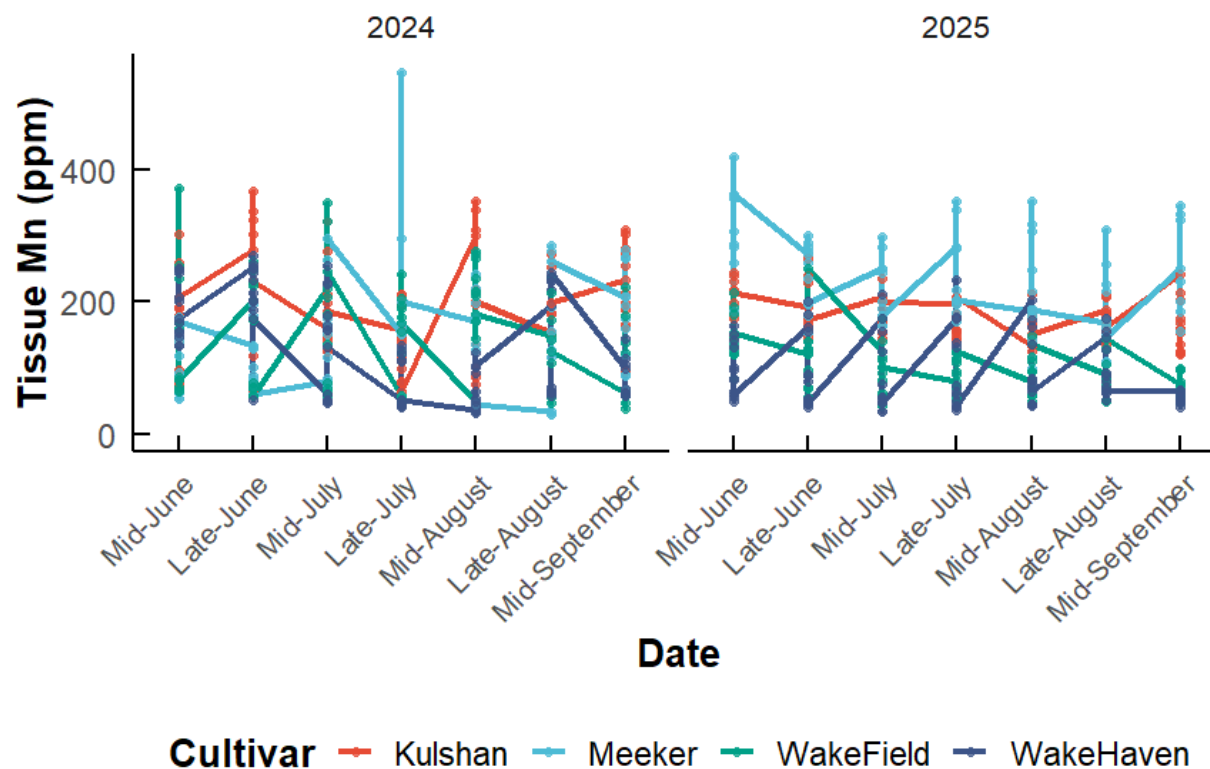


Fig 11. Concentrations of leaf manganese (Mn, ppm) in newly expanded primocane leaves of ‘Kulshan,’ ‘Meeker,’ ‘WakeField,’ and ‘WakeHaven’ florican raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September in 2024 and 2025 in three commercial fields of each cultivar within the Lynden area.

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Pathology



A Report to the Washington State Red Raspberry Commission

Title: Control of Cane Blight in Raspberry

Year Initiated: 2024 Current Year: 2025 Terminating Year: 2026

Principal Investigator:

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Justification and Background: Cane blight, which is caused by the fungus *Kalmusia coniothyrium*, occurs on a wide range of crops including raspberry, blackberry, and roses, and was only recently recognized as a major pest on Washington red raspberries. Cane blight infection requires a wound, such as those that occur during machine harvest, to infect a plant. Infections commonly originate on primocanes during summer. Shortly after infection the fungus colonizes vascular tissue. The fungus will produce small black pimple-like spore producing bodies in the fall and overwinter on the cane. The fungus will continue to grow in the spring and it will slowly girdle the cane. The girdled cane will start to wilt and collapse during early fruit development. Symptoms will develop quicker during hot and dry weather. Uninfected canes and roots are not affected. The fungus can also live on the dead tissue such as cane stubble or debris in the soil. Cane blight rarely is a problem in hand-harvested fields. Rain or overhead irrigation during harvest has increased disease incidence because spores are disseminated in splashing water. Young canes are more rapidly infected while older canes of raspberry are more resistant to infection in the fall.

Northwest Plant Company cultivars (WakeField, WakeHaven), Driscoll's cultivars and Chemainus appear to have a comparatively high level of sensitivity to this disease. In 2015, older WakeField plantings where cane blight had not been managed had up to 40% yield losses. WakeField represents about 30% of Washington's raspberry acreage and up to 50% of the state production. There are non-chemical control options that can reduce infections including pruning out infected canes, avoiding excess nitrogen, adjusting harvester catcher plates to reduce wounding, leaving cane stubble as short as possible and minimizing humidity during infection periods. However, despite the use of these tactics the disease has become a worsening problem. The primary means of controlling the disease is expected to be fungicides. Currently, the products recommended for control of cane blight are Tanos (famoxadone (Group 11), cymoxanil (Group 27)) and QuiltXcel (propiconazole (Group 3) and azoxystrobin (Group 11)), although cane blight is not on either label. Tanos requires rotation with fungicides containing different modes of action. The only products registered on caneberries that have cane blight on the label are copper and lime sulfur products (14 total products between the two types of products.) However, lime sulfur cannot be applied in season and copper is not thought to be very effective.

One Washington raspberry grower found that alternating Tanos with Switch (Group 9 and 12) and Pristine (Group 7 and 11) seemed to reduce cane blight.

Lisa Jones, a Ph.D. plant pathologist with Pacific Berries, has carried out field and laboratory investigations on cane blight including the first identification of the disease on Wakefield raspberry in 2015. She has conducted lab bioassays screening selected fungicides against cane blight and found that Switch and Pristine were the most effective, with Kenja (isofetamid (Group 7)) and Tanos being intermediate in effectiveness and Decree (fenhexamid (Group 17)) and PhD (polyoxin D) were relatively ineffective. A concern with applications of these products is that they occur during timings for *Botrytis*. Applications of products like Switch and Pristine have implications for resistance management. Drs. Jones, Walters and Schreiber propose to screen various fungicide use patterns for their ability to control cane blight in bearing raspberries in addition to collecting biological information on this disease. In 2021, this effort was expanded to include efficacy of Velum Prime against root lesion nematodes. This will be expanded in 2024. This is the only research being conducted against this disease on raspberries in the Pacific Northwest.

New Developments in Cane Blight Management. Possible Game Changer. However, recent research out of the southeastern U.S. on cane blight indicates that the approach Schreiber took, which is the use of *Botrytis* fungicides and Tanos applied during harvest, was probably not the best approach. The logic was applying products during harvest when entry points for the disease created by harvesters occurred was assumed to be the most effective means of control. Based on caneberry research in the southeastern U.S., the new recommendations for cane blight are to start applications much earlier, more often, and use some different fungicides than were previously used. The new recommendations have applications start at delayed dormant (not at prebloom as before), then apply at 6 inch shoot length and again before prebloom, early bloom, full bloom, petal fall, and cover sprays through harvest. This program is probably ten applications as opposed the previous approach of six applications. The products recommended by southeastern caneberry pathologists are Abound, Cabrios, Pristine, and Quilt Xcel. Captan was described as having fair efficacy. Since this product is commonly used in blueberries, and should be included, as well as Miravas Prime and Luna Tranquility.

Lisa Jones, a Ph.D. plant pathologist with Pacific Berries, has carried out field and laboratory investigations on cane blight including the first identification of the disease on Wakefield raspberry. Enfield Farms and Dr. Jones have agreed to be cooperators on the project.

Materials and Methods

This is year two of a 3-year trial. This raspberry cane blight trial was conducted by Agricultural Development Group, Inc. at the adjacent field of the 2024 trial, about 6 miles south of Lynden, WA to evaluate the effect of different fungicides on raspberry cane blight. The experimental design was a RCB with 4 replications with the plot size of 10 ft x 30 ft. The treatments were the

same as 2024 trial. Applications were made on July 3, July 12, July 22, and August 3, 2025. The applications for this trial were made by an over the row sprayer to apply treatment spray at 85 gallons/acre. Both sides of each plot's raspberries were simultaneously sprayed to ensure complete coverage with the experimental products used. The rows of raspberries established for this trial were not treated with any maintenance fungicides to prevent the possibility of interfering with the existing trial's objectives. There were two raspberry varieties tested in this trial, one is Wakefield, and the other is Kulshan.

The disease incidence was calculated for both varieties by using the number of diseased canes divided by the total canes per plot on January 26, 2026.

Results and Discussion

The results for Kulshan showed that Pristine, Quilt Xcel, Captan 80 WDG, and Miravis Prime had 2.4%, 4.6%, 3.3%, and 3.8% less cane blight incidence compared to untreated check, respectively. The results for Wakefield, however, only showed that Captan 80 WDG had 1% less cane blight incidence compared to untreated check. The disease pressure is low especially for Wakefield.

Table 1. Treatment list and application timings.

Trt No.	Treatment Type	Treatment Name	Form Type	Rate	Unit	Appl Code
1	CHK	Untreated check				
2	FUNG	Abound	L	10.75fl oz/a		ABCDE
3	FUNG	Cabrio	SG	14oz/a		ABCDE
4	FUNG	Pristine	SG	20.75oz/a		ABCDE
5	FUNG	Quilt Xcel	L	17.5fl oz/a		ABCDE
6	FUNG	Captan 80 WDG	SG	2.5lb/a		ABCDE
7	FUNG	Miravis Prime	L	11.8fl oz/a		ABCDE
8	FUNG	Luna Tranquility	L	21fl oz/a		ABCDE

Table 2. ANOVA table for Kulshan and Wakefield raspberry cane blight incidence.

Rating Date					Jan-26-2026	Jan-26-2026
Rating Type					Kulshan cane	Wakefield cane
Rating Unit					blight incidence	blight incidence
Rating Min/Max/Interval					%	%
					0, 100, -	0, 100, -
Trt	Treatment	Rate	Appl		1	2
No.	Name	Rate	Unit	Code		
1	Untreated check				11.7a	1.8a
2	Abound	10.75fl oz/a		ABCDEFGHI	12.7a	2.1a
3	Cabrio	14oz/a		ABCDEFGHI	11.8a	4.0a
4	Pristine	20.75oz/a		ABCDEFGHI	9.3a	3.9a
5	Quilt Xcel	17.5fl oz/a		ABCDEFGHI	7.1a	2.1a
6	Captan 80 WDG	2.5lb/a		ABCDEFGHI	8.4a	0.8a
7	Miravis Prime	11.8fl oz/a		ABCDEFGHI	7.9a	4.8a
8	Luna Tranquility	21fl oz/a		ABCDEFGHI	15.0a	2.5a
LSD P=.05					6.88	2.80
Standard Deviation					4.68	1.91
CV					44.51	69.32
Grand Mean					10.50	2.75
Levene's F^					3.27*	1.03
Levene's Prob(F)					0.014*	0.436
Rank X2					.	.
P(Rank X2)					.	.
Shapiro-Wilk^					0.9508	0.9726
P(Shapiro-Wilk)^					0.1517	0.5727
Skewness^					0.2821	0.2885
P(Skewness)^					0.5011	0.4915
Kurtosis^					-0.9449	-0.2976
P(Kurtosis)^					0.2519	0.7156
Replicate F					0.411	10.017
Replicate Prob(F)					0.7471	0.0003
Treatment F					1.353	1.963
Treatment Prob(F)					0.2759	0.1095

Rating Unit
%, 0, 100, = percent

Means followed by same letter or symbol do not significantly differ (P=.10, LSD).

Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

^Calculated from residual.

Figure 1. Effect of fungicides on Kulshan raspberry cane blight.

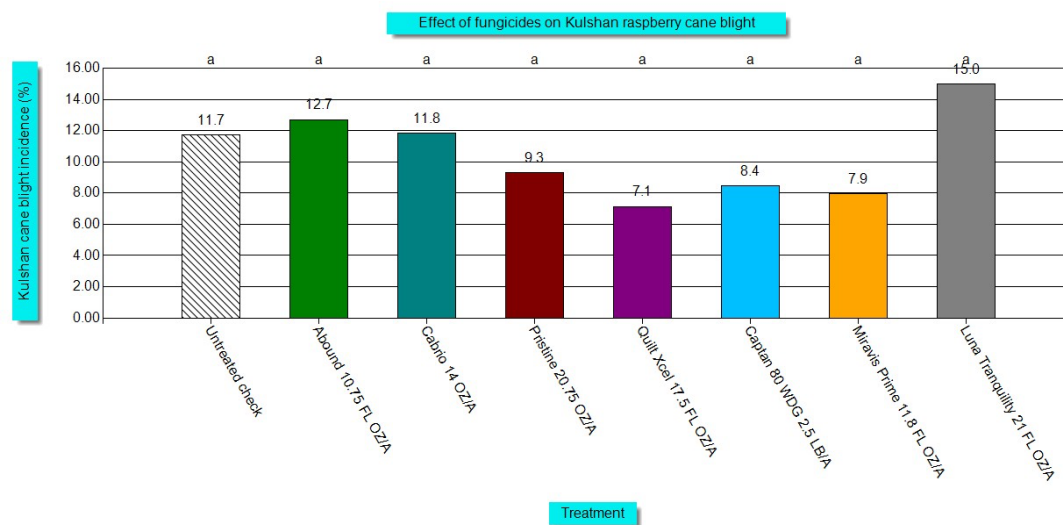


Figure 2. Effect of fungicides on Wakefield raspberry cane blight.

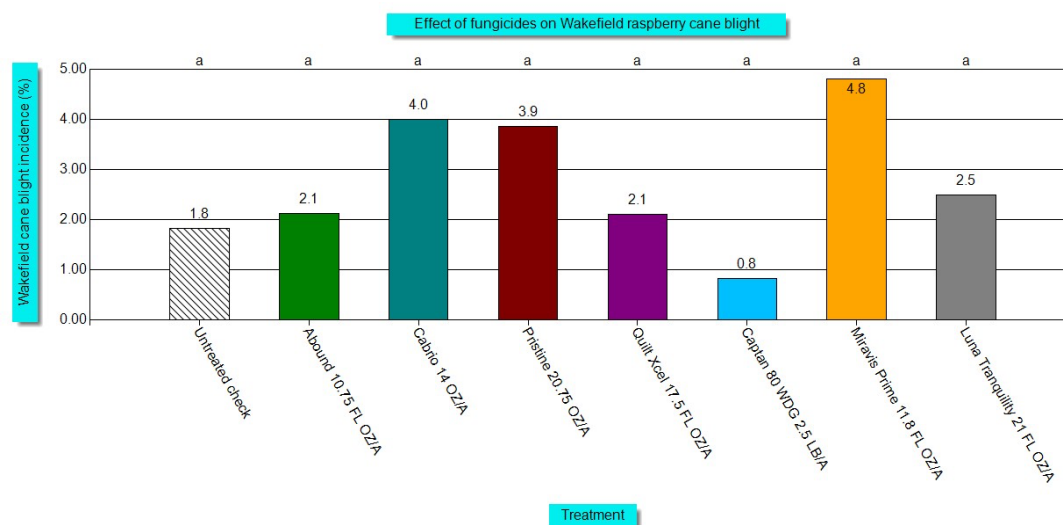


Photo 1. Representative foliar application photos using over the row sprayer.



Photo 2. Representative photo for raspberry plot.



Photo 3. Representative photo for raspberry primocane damage.



A report to Washington Red Raspberry Commission

Project Title: Cane Botrytis of Raspberry

Year Initiated: 2025 **Current Year:** 2025 **Terminating Year:** 2027

Justification and Background: Botrytis cane blight, *Botrytis cinera*, caused by the same pathogen that rots fruits, is common in Washington raspberries. Lesions can weaken or kill lateral buds and laterals. Some varieties, such as Cascade Premier, Chemainus, Kulshan, and WakeHaven have experienced serious yield reduction due to this disease, when many of the fruiting laterals fail to develop. Furthermore, Botrytis cane blight produces inocula capable of infecting growing tissues and developing fruit the following year contributing to fruit rot losses. Cane botrytis was a more severe problem in 2024 than any year in memory. There are at least three potential reasons for this.



First, certain new raspberry varieties appear to be more susceptible to the disease than traditional varieties such as Meeker. It is not clear if the increased problems associated with variety is due to genetically based susceptibility or the physical structure of the plant that foments disease development. Second, environmental conditions were more conducive for development of cane botrytis in 2024. Two inches of rainfall in a short period in August and in general late summer and fall of 2024 was extremely wet and promoted disease development. A third possibility is the widespread development of fungicide resistance in botrytis infecting berries.

Investigations into fungicide resistance in Botrytis, Drs. Mattupalli (WSU) and DeLong (USDA) have recently shown there is widespread resistance to fungicides in FRAC groups 7, 9, 11, and 12 in blueberries and raspberries. This dangerous situation will seriously constrain fungicide programs for Botrytis fruit rot, especially in years when conditions favor disease. It is critical that botrytis cane blight management not exacerbate fungicide resistance in Botrytis.

Botrytis cane blight lesions typically start to appear late in July. Lesions continue to develop and expand through late summer and fall, when overwintering structures (sclerotia) develop. The sclerotia produce conidia throughout the winter and spring, spreading the fungus to new tissues. We propose to evaluate interventions at all of these stages.

Lesion initiation: We will evaluate the ability of numerous treatments (Jet Ag, OSO, PhD, Cueva, and biologicals) to prevent lesions when applied during harvest.

Lesion expansion: We will evaluate effect of pruning and training time (Mid-August or December) on botrytis lesion expansion. Hypothesis is that early pruning will expose canes to sun and dry air, thus reducing lesion expansion.

Re-infection of new growth: We will evaluate numerous treatments (Lime sulfur, Jet Ag, OSO, PhD, Cueva, and biologicals) to protect new tissue from dormancy to bloom.

Objectives: Generate data on fungicide efficacy against cane botrytis.

Trial 1. Raspberry Cane Botrytis Trial in Everson, WA

Materials and Methods

A raspberry fungicide trial was initiated in May, 2025 near Everson, WA, in Whatcom County to evaluate the efficacy of different fungicides on raspberry cane Botrytis. The variety is Cascade Legacy. The experimental design was a RCB with 4 replications with the plot size of 10 ft x 25 ft. Applications for this trial were made by an over the row sprayer to apply treatment spray at 84 gallons/acre. Both sides of each plot's bushes were simultaneously sprayed to ensure complete coverage with the experimental products used. The raspberries used for this trial were not treated with any other fungicides to prevent the possibility of interfering with the existing trial's objective.

The treatment applications were applied on May 30, June 9, June 19, July 1, and July 10, 2025. The Botrytis number (fruit with Botrytis symptoms by 4 people counting 45 seconds in each plot) was evaluated on July 18, 2025. The number of lesions and total length of all lesions on canes per plot were evaluation for both raspberry spur blight and raspberry cane Botrytis on September 19, 2025. The Botrytis pressure in this trial was low while spur blight pressure was high.

Table 1. Treatment list with application codes.

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code
1	Untreated check			
2	Miravis Prime	13.4fl oz/a	ABCDE	
	Jet Ag	1% v/v	E	
	SB-56	0.05% v/v	ABCDE	
3	Switich	14oz/a	ABCDE	
	PhD	6.2oz/a	E	
	SB-56	0.05% v/v	ABCDE	
4	Luna Tranquility	18fl oz/a	AB	
	Switch	14oz/a	CD	
	Fontelis	20fl oz/a	E	
	Captan	2lb/a	E	
	SB-56	0.05% v/v	ABCDE	

Results and Discussion

No treatments showed efficacy of Botrytis control in raspberries. At $p=0.1$ level, treatment of Miravis Prime+Jet Ag showed 56% significantly lower number of spur blight and 56% significantly less total spur blight lesion length compared to untreated check, respectively (Columns 2 and 3 in ANOVA table; Graphs 1 and 2). Although not statistically different, treatment of Miravis Prime+Jet Ag, Switch+PhD, and Luna Tranquility+Switch+Fontelis+Captan showed 73%, 71%, and 63% numerically less number of cane Botrytis, and 4%, 45%, and 19% numerically shorter total cane Botrytis lesion length, compared to untreated check, respectively (Columns 4 and 5 in ANOVA table; Graph 4 and 5).

The treatment of Miravis Prime+Jet Ag can suppress spur blight in raspberries. Treatments of Miravis Prime+Jet Ag, Switch+PhD, Luna Tranquility+Switch+Fontelis+Captan have potential for reducing cane Botrytis in raspberries.

Table 2. ANOVA table for the mean separation for different fungicide treatments.

Rating Date						Jul-18-2025	Aug-28-2025	Aug-28-2025	Aug-28-2025	Aug-28-2025
Rating Type						Botrytis	Spur blight	Spur bli le	Cane Botryt	Can Botr le
Rating Unit						#	#/plot	inch	#/plot	inch
Number of Subsamples						1	1	1	1	1
Days After First/Last Appl.						49, 8	90, 49	90, 49	90, 49	90, 49
Treatment Appl. Interval						49 DA-A	90 DA-A	90 DA-A	90 DA-A	90 DA-A
Trt	Treatment	Rate	Other	Other	Appl	1	2	3	4	5
No.	Name	Rate	Unit	Rate	Rate Unit	Code				
1	Untreated check						5.5a	20.3a	45.5a	20.3a
2	Miravis Prime	13.4fl oz/a		0.349lb ai/a		ABCDE	8.5a	9.0b	20.0b	5.5a
	Jet Ag	1% v/v				E				
	SB-56	0.05% v/v		0.05% v/v		ABCDE				
3	Switch	14oz/a				ABCDE	7.3a	15.3ab	39.0a	5.8a
	PhD	6.2oz/a				E				
	SB-56	0.05% v/v		0.05% v/v		ABCDE				
4	Luna Tranquility	18fl oz/a				AB	8.3a	20.0a	46.3a	7.5a
	Switch	14oz/a				CD				
	Fontelis	20fl oz/a				E				
	Captan	2lb/a				E				
	SB-56	0.05% v/v				ABCDE				
LSD $P=$.10							5.52	7.30	18.61	13.64
Standard Deviation							4.26	5.63	14.36	10.52
CV							57.75	34.91	38.1	107.9
Grand Mean							7.38	16.13	37.69	9.75
Levene's $F^{\wedge}$							1.333	1.164	0.533	0.48
Levene's Prob(F)							0.31	0.364	0.668	0.702
Rank X2							.	.	.	.
P(Rank X2)							.	.	.	.
Shapiro-Wilk $^{\wedge}$							0.9579	0.9384	0.9578	0.8432*
P(Shapiro-Wilk) $^{\wedge}$							0.6234	0.3297	0.6223	0.0108*
Skewness $^{\wedge}$							-0.0215	-0.5492	-0.4082	1.3552*
P(Skewness) $^{\wedge}$							0.9726	0.3867	0.5175	0.0439*
Kurtosis $^{\wedge}$							-0.9334	0.7107	-0.0292	3.5656*
P(Kurtosis) $^{\wedge}$							0.4452	0.5594	0.9808	0.0091*
Replicate F							0.446	2.926	4.086	0.462
Replicate Prob(F)							0.7263	0.0923	0.0437	0.7155
Treatment F							0.409	3.515	2.902	1.800
Treatment Prob(F)							0.7505	0.0622	0.0939	0.2172
										0.4170

Figure 1. Effect of fungicides on raspberry spur blight number.

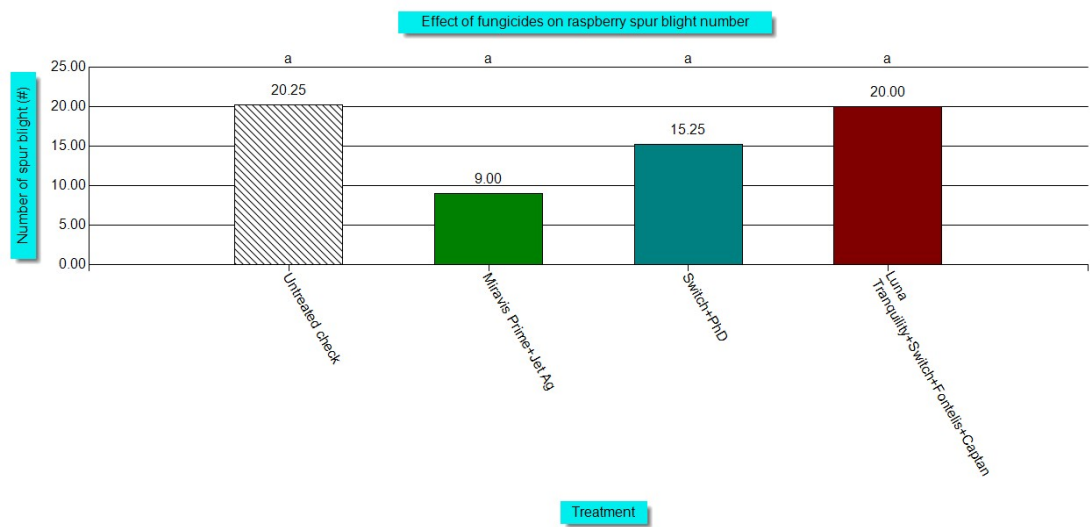


Figure 2. Effect of fungicides on raspberry spur blight lesion length.

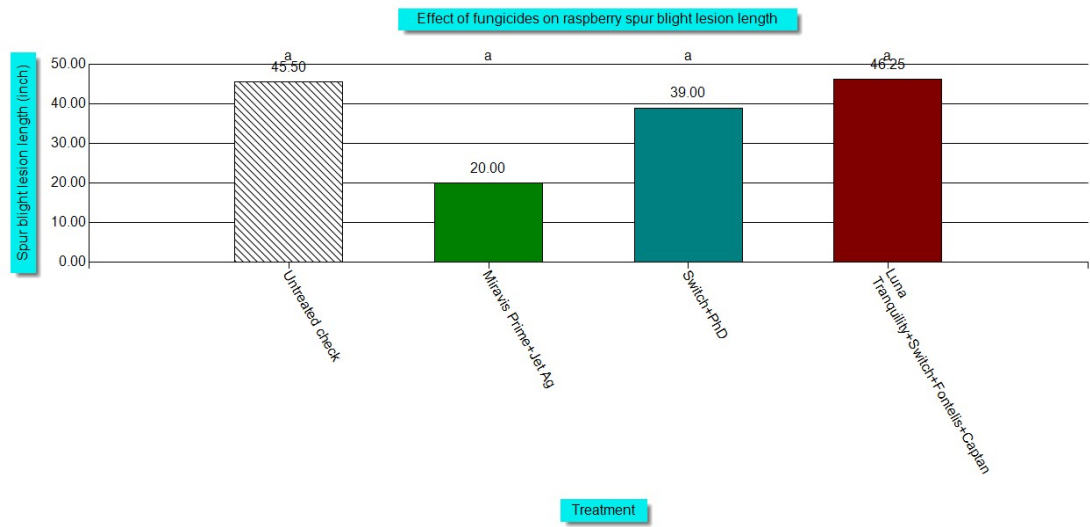


Figure 3. Effect of fungicides on raspberry cane Botrytis number.

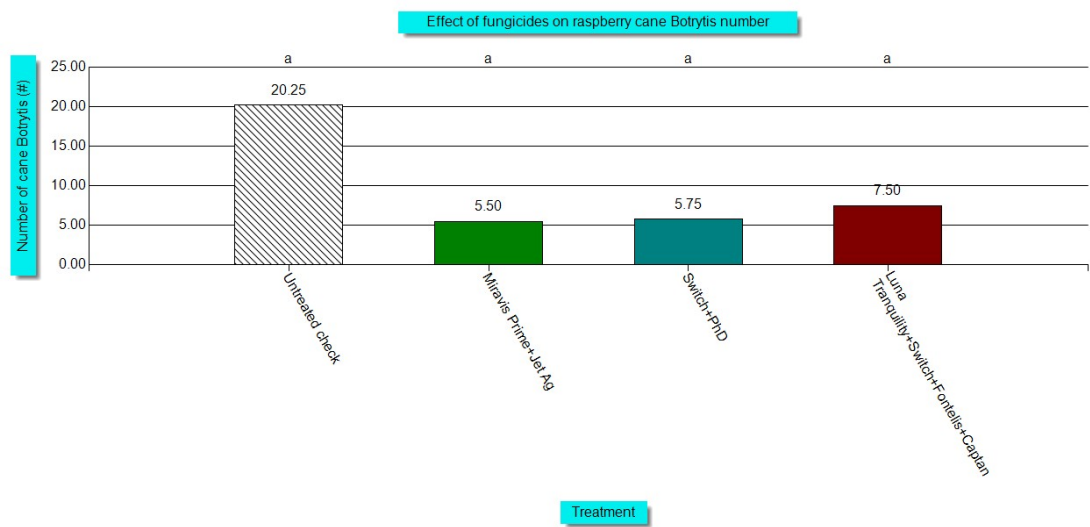


Figure 4. Effect of fungicides on raspberry cane Botrytis lesion length.

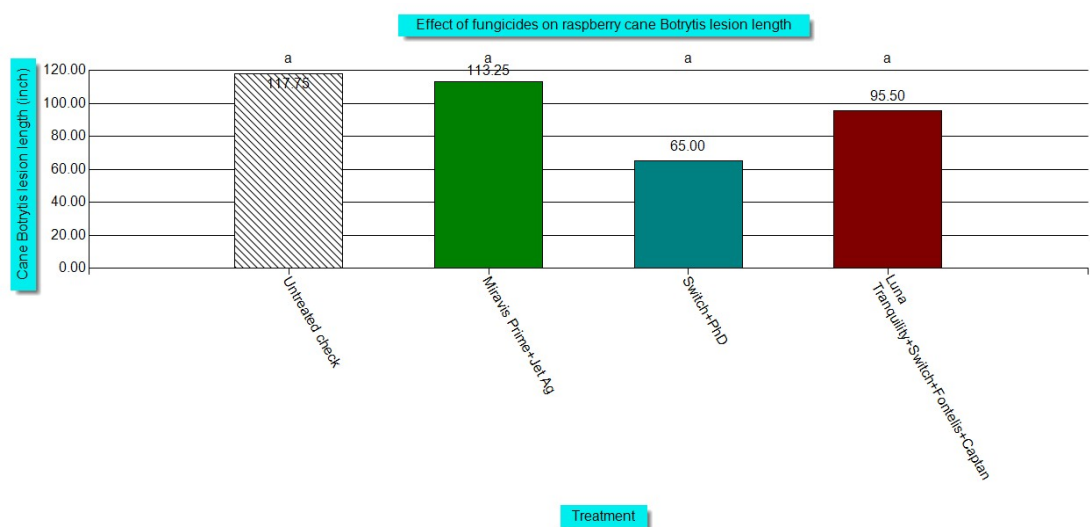


Photo 1. Trial overall photo showing the trial site. The photo was taken on May 30, 2025.



Photo 2. Applications using over-the-row sprayer. The photos were taken on June 9 (left) and June 19 (left), 2025.



Photo 3. Representative photos showing cane Botrytis (left), Botrytis on fruit (middle), and closeup photo of Botrytis (right).



Botrytis Trial 2. Raspberry Cane Botrytis Trial in Everson, WA

Materials and Methods

A raspberry fungicide trial was initiated in May, 2025 near Everson, WA, in Whatcom County to evaluate the efficacy of different fungicides on raspberry Botrytis. The variety is Cascade Legacy. The experimental design was a RCB with 4 replications with the plot size of 10 ft x 25 ft. Applications for this trial were made by an over the row sprayer to apply treatment spray at 84 gallons/acre. Both sides of each plot's bushes were simultaneously sprayed to ensure complete coverage with the experimental products used. The raspberries used for this trial were not treated with any other fungicides to prevent the possibility of interfering with the existing trial's objective.

The treatment applications were applied on May 30, June 9, June 19, July 1, and July 10, 2025. The number of lesions and total length of all lesions on canes per plot were evaluation for both raspberry spur blight and raspberry cane Botrytis on September 25, 2025.

Table 1. Treatment list with application codes.

Trt No.	Type	Treatment Name	Form Type	Rate	Unit	Appl Code
1	CHK	Untreated Check				
2	FUNG	Jet Ag	L	1% v/v		AB
	STD	Luna Tranquility	L	18fl oz/a		B
	STD	Switch	SG	14oz/a		CD
	STD	Fontelis	L	20fl oz/a		E
3	FUNG	Captan	SG	2lb/a		AB
	STD	Luna Tranquility	L	18fl oz/a		B
	STD	Switch	SG	14oz/a		CD
	STD	Fontelis	L	20fl oz/a		E
4	FUNG	PhD	SG	6.2oz/a		AB
	STD	Luna Tranquility	L	18fl oz/a		B
	STD	Switch	SG	14oz/a		CD
	STD	Fontelis	L	20fl oz/a		E

Results and Discussion

No statistical differences were noticed among treatments for any parameters tested. Treatments of Jet Ag+Luna Tranquility+Switch+Fontelis and PhD+Luna Tranquility+Switch+Fontelis showed 20% and 3% numerically lower number of spur blight, comparing to the untreated check, respectively (Column 1 in ANOVA table, Graph 1). Treatment of Jet Ag+Luna Tranquility+Switch+Fontelis showed 22% numerically shorter total spur blight lesion comparing to the untreated check (Column 2 in ANOVA table, Graph 2). Treatments of Jet Ag+Luna Tranquility+Switch+Fontelis and Captan+Luna Tranquility+Switch+Fontelis showed 18% and 38% numerically lower number of cane Botrytis, comparing to the untreated check, respectively (Column 3 in ANOVA table, Graph 3). Treatments of Jet Ag+Luna Tranquility+Switch+Fontelis, Captan+Luna Tranquility+Switch+Fontelis, and PhD+Luna Tranquility+Switch+Fontelis showed 46%, 48%, and 11% numerically shorter total cane Botrytis lesion, comparing to the untreated check, respectively (Column 4 in ANOVA table,

Graph 4).

The results indicated that adding Jet Ag or Captan for the first two applications with the program of Luna Tranquility+Switch+Fontelis have the potential for reducing cane Botrytis in raspberries, and efficacy of Jet Ag or Captan is better than PhD.

Table 2. ANOVA table for the mean separation for different fungicide treatments.

Rating Date				Sep-25-2025	Sep-25-2025	Sep-25-2025	Sep-25-2025
Rating Type				Spur blight	Spur blight	Cane Botrytis	Cane Botrytis
Rating Unit				#/plot	inch	#/plot	inch
Number of Subsamples				1	1	1	1
Trt No.	Treatment Name	Rate	Unit	1	2	3	4
			Code				
1	Untreated check			18.8a	48.5a	8.5a	115.8a
2	Jet Ag	1% v/v	AB	15.0a	37.8a	7.0a	62.0a
	Luna Tranquility	18fl oz/a	B				
	Switch	14oz/a	CD				
	Fontelis	20fl oz/a	E				
3	Captan	2lb/a	AB	21.8a	66.0a	5.3a	60.0a
	Luna Tranquility	18fl oz/a	B				
	Switch	14oz/a	CD				
	Fontelis	20fl oz/a	E				
4	PhD	6.2oz/a	AB	18.3a	54.0a	8.5a	102.5a
	Luna Tranquility	18fl oz/a	B				
	Switch	14oz/a	CD				
	Fontelis	20fl oz/a	E				
LSD P=.05				12.21	42.54	5.48	93.00
Standard Deviation				7.63	26.60	3.42	58.14
CV				41.39	51.58	46.83	68.35
Grand Mean				18.44	51.56	7.31	85.06
Levene's F^				2.539	1.606	1.485	0.741
Levene's Prob(F)				0.106	0.24	0.268	0.548
Rank X2				.	.	.	.
P(Rank X2)				.	.	.	.
Shapiro-Wilk^				0.9647	0.9571	0.9486	0.9417
P(Shapiro-Wilk)^				0.7471	0.6103	0.4686	0.371
Skewness^				0.0014	0.2948	-0.1081	0.8894
P(Skewness)^				0.9982	0.6391	0.8631	0.1693
Kurtosis^				-0.9658	-0.9031	1.5878	1.2166
P(Kurtosis)^				0.4299	0.4599	0.2022	0.323
Replicate F				3.024	2.707	0.773	0.624
Replicate Prob(F)				0.0863	0.1079	0.5379	0.6173
Treatment F				0.525	0.781	0.815	0.949
Treatment Prob(F)				0.6760	0.5336	0.5171	0.4572

Figure 1. Effect of fungicides on raspberry spur blight number.

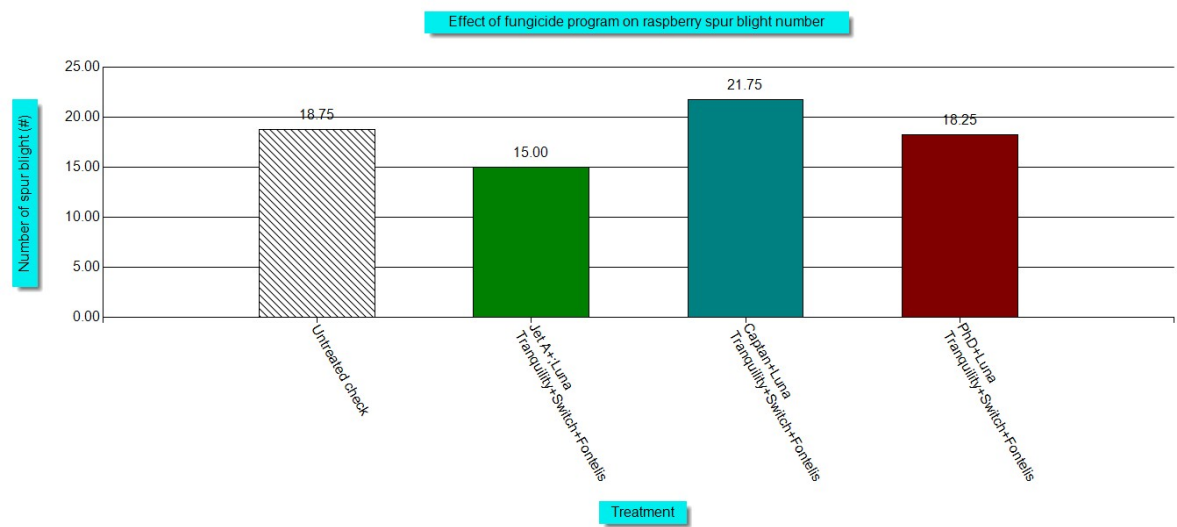


Figure 2. Effect of fungicides on raspberry spur blight lesion length.

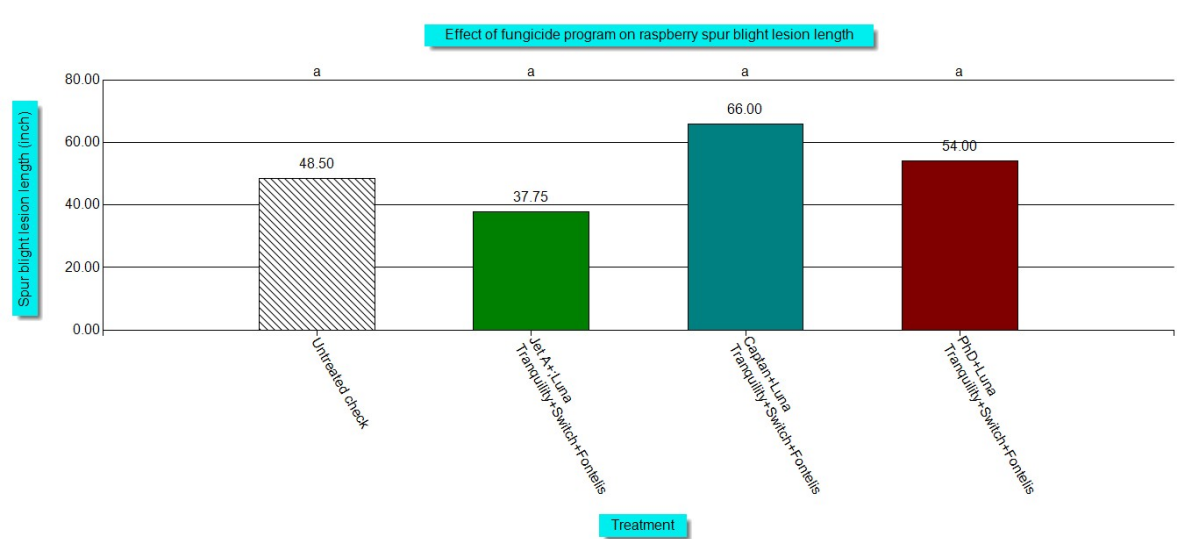


Figure 3. Effect of fungicides on raspberry cane Botrytis number.

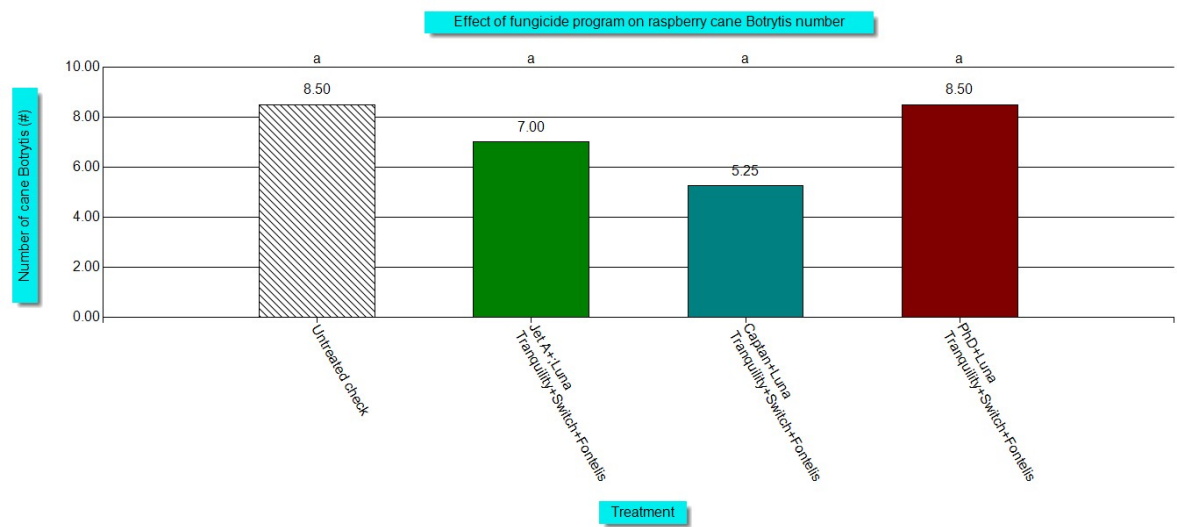
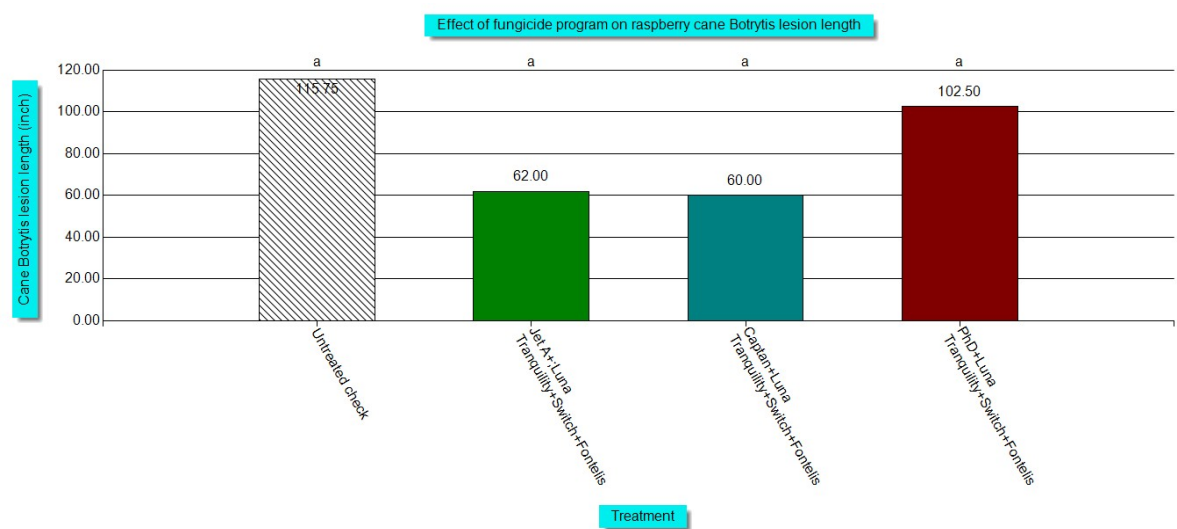


Figure 4. Effect of fungicides on raspberry cane Botrytis lesion length.



Botrytis Trial 3. Raspberry Cane Botrytis pruning trial in Everson

Materials and Methods

A raspberry pruning trial was initiated in August, 2025 near Everson, WA, in Whatcom County to evaluate the efficacy of different pruning methods on raspberry Botrytis. The variety is Cascade Legacy. The experimental design was a RCB with 4 replications with the plot size of 10 ft x 25 ft. The grower had pruning for all field on August 29, 2025. The raspberries used for this trial were not treated with any fungicides to prevent the possibility of interfering with the existing trial's objective. Frequency and size of cane Botrytis lesions will be evaluated at the end of harvest.

Treatment list is as below.

1. Untreated Check
2. Removing floricanes shortly after harvest, tie primocanes to wire and apply sanitizing agent such as Jet-Ag or a protectant such as Captan
3. Removing floricanes as above, but delay tying primocanes until dormancy
4. Cut middle sections out of floricanes shortly after harvest, remove tops and tie primocanes when dormant
5. Remove floricanes and tie primocanes when dormant.

The evaluation will be at the end of year or in January next year. A final report will be provided once these evaluations are completed.

Soils



Title: Extending the lifetime of plantings with novel post-plant nematicides

Personnel: Thomas Walters, Walters Ag Research; Inga Zasada, (formerly USDA-ARS HCRL now NemaSolutions)

Reporting Period: 2024-2025

Accomplishments:

- In three trials in 2024, found that Evaluated fluopyram (Velum Prime) was not effective on dagger nematode (*Xiphinema americanum*, *Xiphinema bakeri*).
- Fluazindolazine (Salibro, Reklamel) reduced *Xiphinema* numbers by about half. This effect was significant in two of the three 2024 trials.
- In 2025, Fluandolazine did not control dagger nematodes in two follow-up trials.

Results: Two fields with significant *Xiphinema* populations were identified in fall 2023. Pretreatment samples were collected from these June 2024. A third field was added August 2024; no pretreatment samples were collected at this location. Plots were laid out with four replicate plots/treatment and each plot 10 x 30 ft long. Application dates and rates are indicated in Table 1 below. Products were applied through drip line, applying approximately 0.25-0.5 inches of water to the beds.

Soil samples were collected June (pretreatment), August 20, and September 27. They were processed in the Zasada lab at USDA-HCRL. In Trial 1, August *Xiphinema* numbers were significantly reduced by July Salibro and Velum+Salibro treatments, but not by Velum Prime alone (Figure 1).

Similarly, in Trial 2, September *Xiphinema* numbers were numerically lower in August Salibro and Velum+Salibro treatments, but this effect was not significant. However, when treatments were grouped by Salibro treatment, those plots treated with Salibro had significantly fewer *Xiphinema* than plots not treated with Salibro (Figure 2).

Salibro-treated plots had numerically fewer nematodes than plots not treated with Salibro in trial 3, but these differences were not statistically significant.

In 2025, two follow-up trials were established in a raspberry field with *Xiphinema*. Preliminary samples to identify plots with *Xiphinema* were collected Jun 26. Samples were collected Aug 7, Sept 9 and Oct 6. Plots were laid out similarly to 2024 trials, with four replications and three treatments (Untreated, Salibro once, Salibro twice) in each trial. 61.5 fl oz Salibro/a was applied Aug 18 and Sept 9. *Xiphinema* were not controlled by one or two Salibro applications in either of the 2025 trials (Figure 4).

It is not clear why Salibro was consistently effective on *Xiphinema* in 2024 but not in the 2025 trials. The 2025 application dates were later than 2024 trials 1 and 3, but were similar to the Trial 2 dates. Application rates and methods were similar, as were sampling methods. The baseline population densities in the 2025 trials were lower than in the 2024 trials, and it is possible that some other factor was suppressing *Xiphinema* at the 2025 trial sites.

Publications:

- Managing Dagger Nematodes in Raspberry. Oral presentations, Small Fruit Conference, Lynden WA, Dec 5, 2024 and Dec 4, 2025
- Note in Small Fruit Update (planned, winter 2025-2026)

Table 1. Treatments, rates and application dates for 2024 (Trials 1-3) and 2025 (Trials 4, 5)

Product and rate	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Untreated Check	7/19	8/19	7/20	8/18	8/18
Salibro SC 61.5 fl oz/a	7/19	8/19	7/20	8/18	8/18
Salibro SC 61.5 fl oz/a			7/20, 8/20	8/18, 9/9	8/18, 9/9
Salibro SC 61.5 fl oz/a + Velum Prime, 6.84 fl oz/a	7/19	8/19	7/20, 8/20		
Velum Prime, 6.84 fl oz/a	7/19	8/19	7/20		
Velum Prime, 6.84 fl oz/a			7/20, 8/20		

nematicide trials.

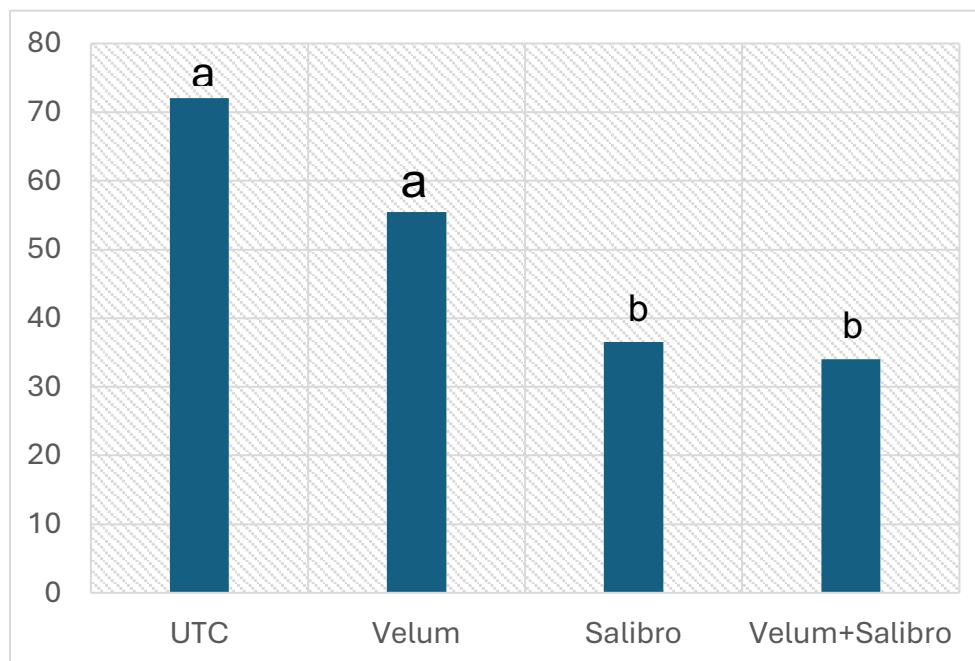


Figure 1. August *Xiphinema* readings, Trial 1

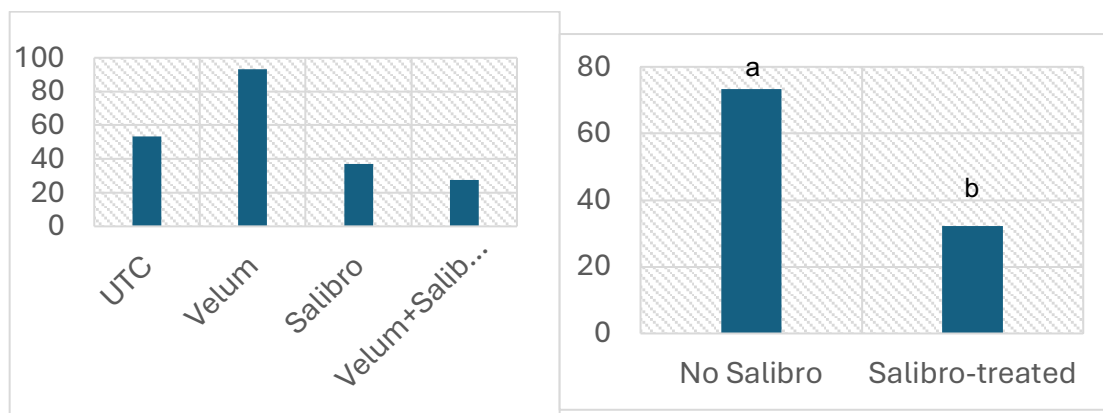


Figure 2. September *Xiphinema* readings, Trial 2. Individual treatments shown on left, grouped treatments shown on right.

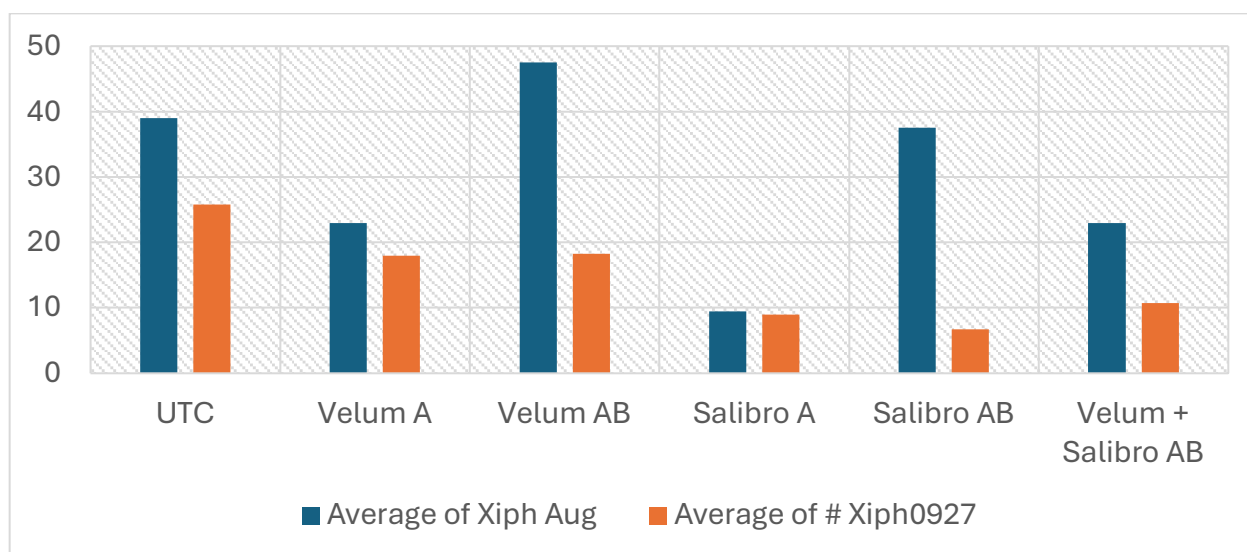


Figure 3. August and September *Xiphinema* readings, Trial 3.

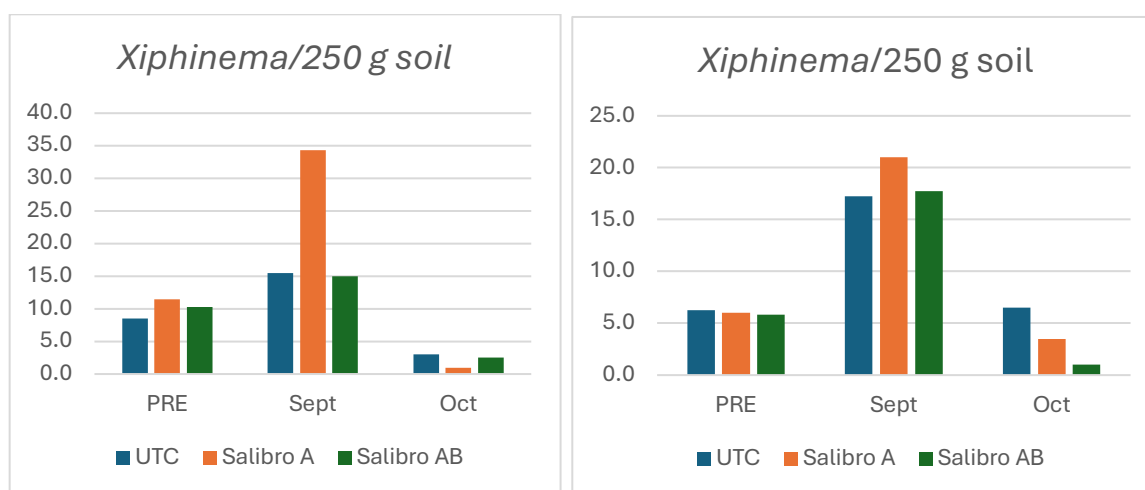


Figure 4. Pre-treatment, September and October *Xiphinema* population densities for Trials 4 (left) and 5 (right), 2025.