Soil quality and cover crops in red raspberry in the Pacific Northwest

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In 2013, Oregon and Washington produced over 33 million kg of red raspberry (*Rubus idaeus*), valued at $64 million (USDA-NASS, 2014).

93% of processed red raspberry is produced in Washington state (USDA-NASS, 2014).

Total acreage has increased in the Pacific Northwest (PNW), but crop longevity has decreased.

Much of the decline is attributed to replant disease complex.
Introduction

- Replant disease, aka replant disorder, is a combination of abiotic and biotic factors that affect the growth, development, yield, and health of new plants that have been planted in sites where older plants were recently removed.

- Factors include:
  - Pathogenic fungi
  - Bacteria
  - Plant parasitic nematodes
  - Improper pH
  - Soil nutrient deficiency

(Savory, 1966; Merwin et al., 2001)
Introduction

- Phytophthora rubi and Pratylenchus penetrans, specifically, have been shown to contribute to the reduced vigor and yield of red raspberry (McElroy, 1977; Pinkerton et al., 2009).
- *P. rubi* is the most serious known soilborne pathogen for Washington raspberry (Walters et al., 2011).
  - Causes root rot
  - Persists in the soil, making management difficult

http://whatcom.wsu.edu/ipm/manual/rasp/phytophthora.html
Introduction

- P. penetrans, or root lesion nematode (RLN), is one of the most important raspberry pests (McElroy, 1992; Walters et al., 2009; Walters et al., 2011).
  - Feeds on roots, causes reduced uptake of water and nutrients
  - Plants decline rapidly
  - Can aggravate root rot

http://extension.oregonstate.edu/umatilla/pests/rootlesionnematodes
Chemical fumigation is a common control method for both organisms. Although it does delay root rot or suppress RLN populations, it does not completely eliminate the problem (Bélair, 1991, Walters et al., 2009, Zasada et al., 2010).

Fumigants do not address the issue of declining soil quality, which is defined as “the capacity of the soil to function” (Karlen et al., 1997).
Projects

- Field Experiment 1: Cover crops and ground covers in post-plant raspberry alleyways
- Greenhouse RLN host assay using cover crops from Experiment 1
Experiment 1: Cover crops and ground covers in post-plant raspberry alleyways
Introduction

- Alleyway cover cropping is not common practice in PNW red raspberry systems.
- Alleyways are commonly kept clean by repeated cultivation and herbicides.
- Repeated cultivation can:
  - Increase soil erosion
  - Increase compaction
  - Contribute to loss of soil physical structure
  - Reduce nutrient and water holding capacity
  - Increase dust during the dry season
    - Accumulates on leaves and potentially reduces photosynthetic capacity and overall productivity of raspberry plants, as well as promotes spider mite activity.

(Magdoff & Van Es, 2009; PNW Extension, 2007)
Introduction

Cover cropping has many potential benefits:

- Increased soil organic matter (Sarrantonio, 2007)
- Weed suppression (Freyman et al., 1989, Forge et al., 2000)
- Soil structure improvement (Magdoff & Van Es, 2009; Sarrantonio, 2007)
- Pest and pathogen suppression (Mazzola & Gu, 2002)
- Promotion of beneficial soil microorganisms (Mazzola & Gu, 2002)
- Improved nutrient cycling/management (Zebarth et al., 1993)
Proper selection of cover crops is crucial because many cover crop species may serve as RLN hosts.

- White clover (Thies et al., 1995; Vrain et al., 1996)
- Barley (Vrain et al., 1996)
- Oat (Thies et al., 1995)
- Cereal rye (Thies et al., 1995)
Objectives

- Measure the effects of alleyway cover cropping in established red raspberry on:
  - Soil quality
  - Soil microbial community structure
  - Plant competition
- Evaluate suitability of annual and perennial cover crops in PNW red raspberry production system.
Experimental procedures

- Conduct Fall 2014-Fall 2016
- Established commercial ‘Meeker’ red raspberry field
- History of RLN, but no root rot
- CRD, 9 treatments, 4 reps, untreated bare soil plots will serve as control
- Treatment plots are 30 ft. x 12 ft. and span the entire alleyway on both sides of the row and a minimum of 60 ft. were maintained between plots as buffer.
Experimental procedures

- The treatments will be seeded once every fall season (twice over two years) and include:
  - Hard, red winter wheat cv. Norwest 553 (*Triticum aestivum*)
  - Soft, white winter wheat cv. Rosalyn (*T. aestivum*)
  - Winter-hardy oats cv. TAM 606 (*Avena sativa*)
  - Winter-hardy oats cv. Nora (*A. sativa*)
  - Ryegrass (*Lolium spp.*) mix that included 51.25% intermediate ryegrass cv. Tetralite and 48.24% tetraploid perennial ryegrass cv. Kentaur
  - Perennial ryegrass (*L. perenne*) mix that included 43.93% ‘Esquire’, 31.44% ‘TopHat 2’, and 22.49% ‘Tetragreen’
  - Triticale cv. Trical 103BB (*Triticosecale sp.*)
  - Triticale cv. TriMark 099 (*Triticosecale sp.*)
  - Generic cereal rye (*Secale cereale*)
## Experimental Procedures

<table>
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<tr>
<th>Variable</th>
<th>Fall 2014</th>
<th>Spring 2015</th>
<th>Summer 2015</th>
<th>Fall 2015</th>
<th>Spring 2016</th>
<th>Summer 2016</th>
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RESULTS
YEAR 1
Spring 2015 alleyway bulk density

Till Control till/cultivation
Mow Control weedy mow
R Cereal rye
G1 Ryegrass mix
G2 Perennial ryegrass mix
O1 'TAM 606' oat
O2 'Nora' oat
T1 'Trical 103BB' triticale
T2 'Trimark 099' triticale
W1 'Norwest 553' wheat
W2 'Rosalyn' wheat
Spring 2015 alleyway soil compaction at 5 in (in PSI)
Spring 2015 alleyway soil compaction at 12.5 cm (in kPa)
Spring 2015 RLN in raspberry roots
Spring 2015 RLN in cover crop roots
Summer 2015 estimated fruit yield

1 metric ton = 1.1 U.S. ton
1 hectare = 2.47 acres
Fall 2015 alleyway bulk density
Fall 2015 alleyway soil compaction at 4 in (in PSI)
Fall 2015 alleyway soil compaction at ~10 cm (in kPa)
Fall 2015 alleyway soil compaction at 5 in (in PSI)
Fall 2015 alleyway soil compaction at ~12.5 cm (in kPa)
Fall 2015 RLN in raspberry roots
Fall 2015 RLN in cover crop roots

![Bar chart showing RLN/g of root for different treatments: R, G1, G2, O1, O2, T1, T2, W1, W2. The chart displays the RLN values for each treatment, with error bars indicating variability.](image-url)
Greenhouse RLN host assay

RLN has a broad host range and cover crops should be tested for host suitability before being recommended to growers with RLN-infested fields.

Objective:
- Test the RLN host suitability of the cover crops/ground covers used in Experiment 1.
- Determine if RLN affects cover crop development and biomass production.
Experimental procedures

- CRD, 4 reps, 11 treatments
- Treatments:
  - Hard, red winter wheat cv. Norwest 553 (T. aestivum)
  - Soft, white winter wheat cv. Rosalyn (T. aestivum)
  - Winter-hardy oats cv. TAM 606 (A. sativa)
  - Winter-hardy oats cv. Nora (A. sativa)
  - Ryegrass (Lolium spp.) mix
  - Perennial ryegrass (L. perenne) mix
  - Triticale cv. Trical 103BB (Triticosecale sp.)
  - Triticale cv. TriMark 099 (Triticosecale sp.)
  - Generic cereal rye (S. cereale).
  - ‘Pacific Gold’ mustard (Brassica juncea)
  - ‘IdaGold’ mustard (Sinapis alba)
Experimental procedures

- Cone-tainers were filled with pasteurized loamy sand material.
- All cover crops were planted at 1 seed/pot.
- Cover crops were allowed to grow for ~2 weeks prior to inoculation.
- After making small holes in the soil, all pots were inoculated with 2,500 RLN in solution (both juveniles and adults) near plant roots.
- Non-inoculated controls of each cover crop were also seeded and inoculation was simulated with water.

http://www.greenhousemegastore.com/category/standard-plastic-pots
Pre-inoculation

Pre-termination (8 weeks later)
Experimental procedures

- Soil temperature sensors were placed in pots in order to calculate growing degree days.
- The host assay was terminated after ~8 weeks.
- Shoots were cut from the crown, oven dried, and weighed.
- Roots were shaken of soil, placed in a mist chamber for 7 days to extract RLN, then oven dried and weighed.
- Extracted RLN were counted.
- Soil from Cone-tainers was collected and RLN was extracted and counted.
- The host assay will be modified and repeated to verify results.
Reproductive factor (RF)

RF = # of RLN recovered/ # of initial inoculum
Initial inoculum = 2,500 RLN
Results overview

- **Spring 2015**
  - Plots seeded with ryegrass mix (G1) has the lowest bulk density.
  - Plots seeded with ‘Rosalyn’ wheat (W2) had the highest bulk density.
  - In the alleyways, the ryegrass mix had the lowest counts for RLN per gram of root, but differences were not significant.
  - Raspberry plants grown between ‘Trical 103BB’ triticale had the lowest RLN counts per gram of root, but differences were not significant.

- **Summer 2015**
  - There were no significant differences in estimated raspberry yield.
Results overview

- Fall 2015
  - No significant differences in bulk density among treatments.
  - Compaction differences seen at 4 and 5 inches.
    - Control mow, both oats, and ‘Rosalyn’ wheat had the lowest compaction.
  - Raspberry growing in plots seeded with ‘TAM 606’ oats had the lowest RLN counts per g of root.
  - Both ryegrass mixes had the lowest RLN counts per gram of root.

- Host assay
  - All crops were tested as potential hosts for RLN and were confirmed as hosts.
    - ‘Trical 103BB’ triticale was the least suitable host
Expected outcomes

- Provide the red raspberry community with valuable information regarding alternative horticulture management practices that may be more environmentally sustainable and efficacious in controlling replant disorder.

- Will give additional insight into the complex factors involved in raspberry replant disorder, as well as the intricacies of soil agroecology in this important perennial fruit cropping system.
Thank you!

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- Dr. Lisa DeVetter
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Questions?
Literature cited

Literature Cited