# Genomic and phenomic technologies for assessing root lesion nematode (*Pratylenchus penetrans*) resistance in red raspberry

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## Objectives

- ❖ Characterize root lesion nematode (RLN; *Pratylenchus penetrans)* resistance and tolerance phenotypes in a diverse population of 270 red raspberry breeding lines and cultivars and 10 mapping populations
- ❖ Determine the effectiveness of drone-collected spectral imaging data for assessing RLN damage
- ❖ Conduct genome-wide association study of RLN resistance using phenotypic and genotypic information
- ❖ Develop and evaluate genomic prediction models for improved selection of RLN resistance

## Introduction

Management of root lesion nematode, *Pratylenchus penetrans*, (RLN; Fig. 1) is an important production goal for the profitable red raspberry industry in the unique climate of the Pacific Northwest (Figs. 2 & 3; Rudolph & DeVetter, 2015; Walters et al., 2017). Developing economical and sustainable control methods are a priority. Resistant cultivars are an effective control method; however, there is currently limited understanding of the genetics involved in host resistance. Furthermore, phenotypic evaluation of nematode resistance is an intensive and destructive process, which has hindered research into the genetics of RLN resistance. This project is currently evaluating newer technologies such as genomic prediction and high-throughput imaging, which may accelerate screening and improve a breeder's ability to select for resistance. This project leverages the combined diversity of raspberry germplasm from breeding programs at Washington State University (WSU), British Columbia Berry Cultivar Development Inc. (BCBCDI), the United States Department of Agriculture (USDA)/Oregon State University (OSU), and germplasm at the National Clonal Germplasm Repository (NCGR) for assessment of RLN resistance.

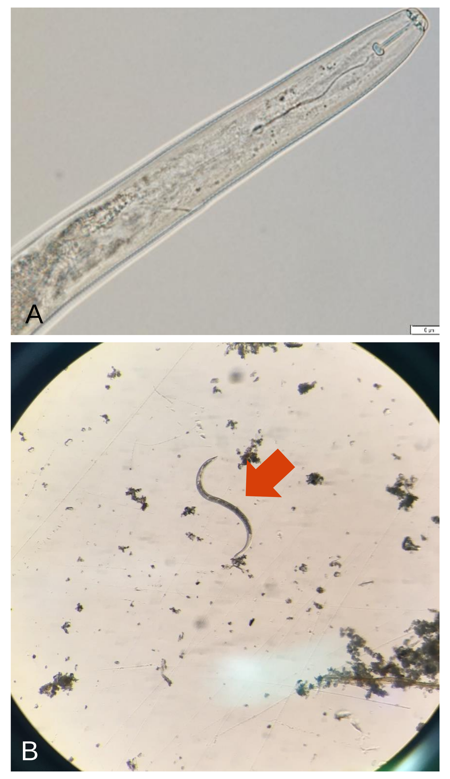


**Figure 1**: **A)** Head region of *Pratylenchus penetrans*. Photo by Inga Zasada. **B)** *Pratylenchus* spp. under a microscope from an inoculated raspberry plant. Photo by Savannah Phipps.

**Figure 2**: A red raspberry field in Northwestern Washington. Photo by Inga Zasada.

**Figure 3**: Red raspberry 'Willamette' in a field with **A)** nonfumigated and **B)** fumigated plants with *Pratylenchus penetrans* present. Photos by Inga Zasada

Figure 4: Year 1 panoramic photo of plants in field at Mt. Vernon, WA. Photo by Savannah Phipps.

## Methods

### Plant Materials

- ❖ 270 red raspberry genotypes from the WSU Small Fruits breeding program, BCBCDI, USDA/OSU breeding program, and NCGR
- ❖ 296 individual seedlings from 10 mapping populations derived from a susceptible by resistant cross made by the BCBCDI

### Field Experimental Design

- ❖ Paired non-inoculated and RLN inoculated plants randomized across 3 replications (Figs. 4 & 5)
- ❖ Non-replicated seedlings from 10 mapping population planted alongside diversity panel (Fig. 4)

**Figure 5**: Examples of morphological diversity seen in field. **A)** 'Dorman Red' **B)** 'Jokgal' **C)** WSU 1478 **D)** 'Meeker'. Photos by Savannah Phipps.

**Figure 6 (above)**: **A)** Harvesting of aboveground biomass in year 1. **B)** Weighing and recording of aboveground biomass in year 1. **C)** Weighing and recording of aboveground biomass in year 2. Photos by Savannah Phipps.

### Phenotypic Data Collection

- ❖ Collected yearly
- ❖ Root sampling for nematode quantification
- ❖ Fresh weight aboveground biomass sampling (Fig. 6) for plant nematode stress response
- ❖ Spectral data collection via drone fly-overs and smart devices for plant nematode stress response (Fig. 7)

### Genotypic Data Collection

- ❖ Genotyping-by-Sequencing following the protocol outlined in Bushakra et al. (2015)

### GWAS Analysis

- ❖ FarmCPU in R with GAPIT (Lipka et al., 2012)

### Genomic Prediction

- ❖ Develop single and multi-year data models

**Figure 7 (right)**: Examples of ground-based and aerial imaging in action. **A)** Stitched red-green-blue aerial orthomosaic of field trial from May 5, 2023. Photo by Alexander Gregory. **B)** AgBOT mk 1 Quadcopter equipped with MicaSense RedEdge-MX multispectral sensor. Photo by Savannah Phipps. **C)** Savannah Phipps imaging in the AgerPoint Capture app with iPhone 14 Pro Max. Photo by Hannah Baker.

## Progress to Date

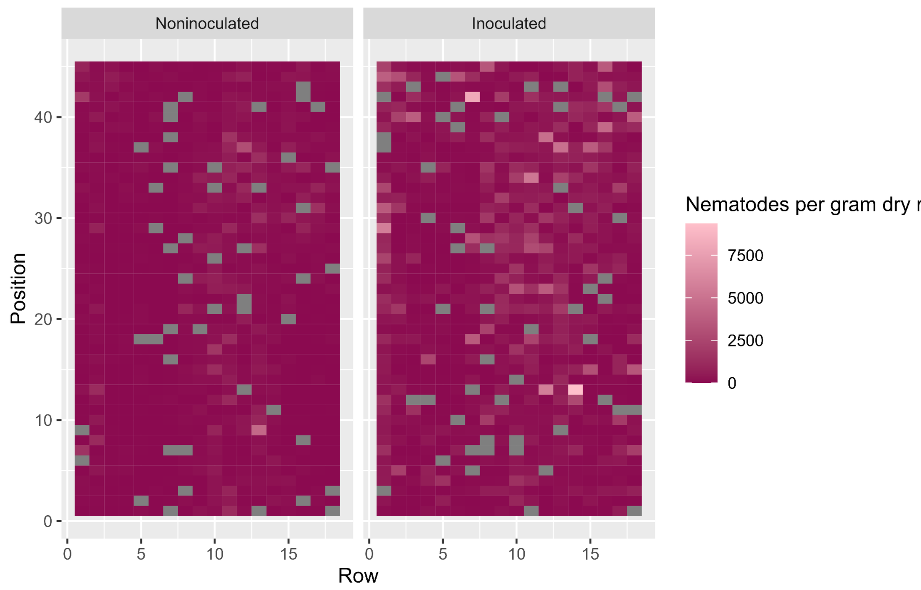
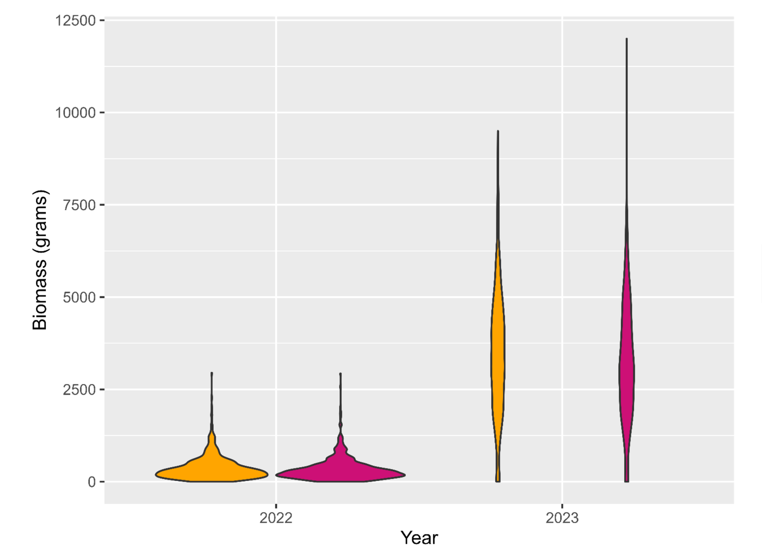



**Figure 8 (left)**: Heatmap of RLN densities per gram of dry root in non-inoculated (left) and inoculated treatments (right) from 2023. Gray boxes indicate missing data. Heatmap has been organized to reflect field arrangement. Graph by Savannah Phipps.

**Figure 9 (right)**: Distribution of fresh weight aboveground biomass between RLN non-inoculated and inoculated treatments across trial years. Graph by Savannah Phipps.




- ❖ 1st year nematode quantification conducted (Fig. 8)
- ❖ 1st and 2nd year aboveground biomass measurements collected (Fig. 9)
- ❖ 1st year aerial and ground-based imaging conducted
- ❖ Initial data exploration and analysis ongoing
- ❖ Processing of image data ongoing

## Future Work

- ❖ Final year of data collection
- ❖ Evaluate multi-year models for correlations between spectral data and biomass and nematode count data
- ❖ Conduct genome-wide association study with phenotypic and genomic data
- ❖ Evaluate genomic prediction models for multi-year data
- ❖ Publish results

### Collaborations and Affiliations

Photo by Alexander Gregory

WASHINGTON STATE UNIVERSITY · Oregon State University · BCBCDI · USDA · agerpoint

### Funding

Northwest Center for Small Fruits Research · NARBA North American Raspberry & Blackberry Association

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