Final Report

This is year 3 of a 3 year proposed project.

For the Washington Grape & Wine Research Program

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Project Title: Essential nematode data to enable decision-making by Washington grape growers
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Project Summary:

In two years of greenhouse evaluations of own-rooted *Vitis vinifera* varieties/clones, it was discovered that the white varieties (Chardonnay and Riesling) were better hosts for *Meloidogyne hapla*, the northern root-knot nematode, than red varieties (Syrah, Cabernet Sauvignon, Merlot). While all of the varieties/clones evaluated would be considered good hosts for *M. hapla* with reproduction factors (RF = final population/initial population) > 1, the magnitude of population increase was 4x greater on white varieties compared to red varieties. We also evaluated nine rootstocks (420A, 110R, 3309C, 101-14, Riparia Gloire, St. George, Harmony, Freedom, and Salt Creek) for host status to *M. hapla*. All of the evaluated rootstocks would be considered poor host for *M. hapla* with RF values < 1. In established wine grape vineyards in Washington we investigated the horizontal and vertical distribution of plant-parasitic nematodes. Two vineyards were sampled: a Chardonnay block on a sandy loam soil and a White Riesling block on a silt loam soil. The plant-parasitic nematodes *M. hapla*, *Pratylenchus* spp., *Xiphinema* spp., and *Paratylenchus* spp. were found at both vineyards while *Mesocriconema xenoplax* was only detected in the Chardonnay vineyard. At both vineyards, population densities of *M. hapla* were positively related to soil moisture and fine root biomass ($p \leq 0.0001$); however, these relationships were not always strong (r^2 values ranging from 0.1 to 0.5). The same trend was observed for *M. xenoplax* at the Chardonnay vineyard ($p < 0.0003$; $r^2 = 0.1$). The horizontal distribution of nematodes varied among the nematode genera with *M. hapla* and *M. xenoplax* concentrated in the row near emitters while *Pratylenchus* were aggregated at the vine row's edges. At both vineyards, *M. hapla* and *Pratylenchus* population densities were concentrated in the upper 18" of the soil profile; this was true also for *M. xenoplax* in the Chardonnay vineyard. Conversely, *Xiphinema* was found throughout the soil profile at both vineyards. These results indicate that variety/rootstock selection may be an important tool for managing *M. hapla* and that there is potential to reduce the treated area within a vineyard when targeting *M. hapla* and *M. xenoplax*. The impact of plant-parasitic nematodes on vine productivity will continue to be explored in a newly established vineyard where grape varieties are being grown in areas with and without nematodes.

Materials, Methods, and ExperimentsConducted to Meet Stated Objective(s):

1. Screen grape variety/clone combinations and rootstocks against *Meloidogyne hapla*.

   We evaluated the host status of *V. vinifera* varieties/clones and *Vitis* species rootstocks to *M. hapla* in five independent greenhouse trials. The *V. vinifera* varieties/clones evaluated were: Riesling GM239, GM198, and N90, Chardonnay 06 and 15, Syrah Phelps, 07, and Shiraz 07, Cabernet Sauvignon 04, 06, 02, and 21, and Merlot 03, 06 and 15. The rootstocks evaluated were: Salt Creek, Freedom, Harmony, St. George, Riparia Glorie, 101-14, 3309C, 110R, and 420A. All plants were inoculated with eggs of *M. hapla* (root-knot nematode) and allowed to grow for 5 to 6 months. At termination the number of eggs/g root, juveniles in soil, and total *M. hapla*/pot were determined.

2. Determine spatial dynamics of plant-parasitic nematodes in established WA vineyards.

   In 2011, we sampled a Chardonnay and Riesling vineyard to determine the horizontal distribution of plant-parasitic nematodes in a 5*x*7' area (1' intervals; depth of 18"); there were 5 plots established in each vineyard. In addition to determining plant-parasitic nematode population densities, soil moisture, fine root biomass, and AMF colonization was also determined in all or some of the samples. In 2012, we returned to the same vineyards and established 5 more sampling plots (different areas from 2011) to determine the vertical distribution of plant-parasitic nematodes. In each plot, soil cores to a depth of 36" were collected directly under emitters and 1' to the north, south, east, and west of emitters and from the alley; cores were partitioned into 6" samples. Plant-parasitic nematode population densities and soil moisture were determined for each sample.

3. Determine the impact of *M. hapla* on variety/clone establishment and productivity in a field setting.

   A field trial was established at Columbia Crest Vineyard and Winery, Patterson, WA. Main plots were fumigated with 39 gal/a Telone C-35 in August, 2012. Prior to fumigation, soil samples were collected from each plot (30' long) and the type and number of plant-parasitic nematodes was measured. In spring 2013, Cabernet Sauvignon 08, Merlot 03, Syrah 07, Chardonnay 06, Riesling N90 and Riesling 09 were planted into fumigated and non-fumigated main plots. Each variety/clone subplot is comprised of five vines. Soil samples were collected prior to planting and plant-parasitic nematode population in the samples was determined. At planting, additional eggs of *M. hapla* were added to the root zone of vines planted in non-fumigated areas. Plant vigor and plant-parasitic nematodes status was evaluated in fall 2013.

Major Research Accomplishments and Results:

1. Screen grape variety/clone combinations and rootstocks against *Meloidogyne hapla*.

Similar trends were observed across several years of greenhouse evaluations. White varieties (Chardonnay and Riesling), regardless of clone, were always better hosts for *M. hapla* than red varieties (Cabernet Sauvignon, Syrah, and Merlot) ($p < 0.001$). Average reproduction factor (RF = final population/initial population) values ranged from 27.6 to 45.1 for white varieties/clones and from 7.9 to 18.2 for red varieties/clones. While all varieties would be considered good hosts for *M. hapla*, the rate of increase of *M. hapla* on white varieties was 4x greater than on red varieties. There were few differences detected among clones within a variety (i.e. Cabernet Sauvignon 02, 04, 06, 08, and 21) as hosts for *M. hapla* ($p > 0.05$). In the rootstock evaluations, all of the rootstocks were poor hosts (RF values < 1.0) for *M. hapla* compared to own-rooted Riesling N90 (the positive control; RF value = 24.4) ($p < 0.001$).

Key Outcomes of Objective 1: Based upon our greenhouse results, we learned that, in general, own-rooted white *Vitis vinifera* varieties are better hosts for *M. hapla* (root-knot nematode) than red *Vitis vinifera* varieties. We also demonstrated rootstocks carry resistance to *M. hapla*. Combined, this data will guide growers in choosing planting materials in replant situations where *M. hapla* is of concern.

2. Determine spatial dynamics of plant-parasitic nematodes in established vineyards.

Plant-parasitic nematodes present at the Chardonnay vineyard were: northern root-knot nematode (*M. hapla)*, ring nematode (*Mesocriconema xenoplax*), dagger nematode (*Xiphinema americanum*), root-lesion nematode (*Pratylenchus* sp.), and pin nematode (*Paratylenchus* sp.); *M. xenopax* had the highest population density at this vineyard. At the Riesling vineyard, *M. hapla*, *X. americanum*, *Pratylenchus*, and *Paratylenchus* were detected with *M. hapla* having the highest population density.

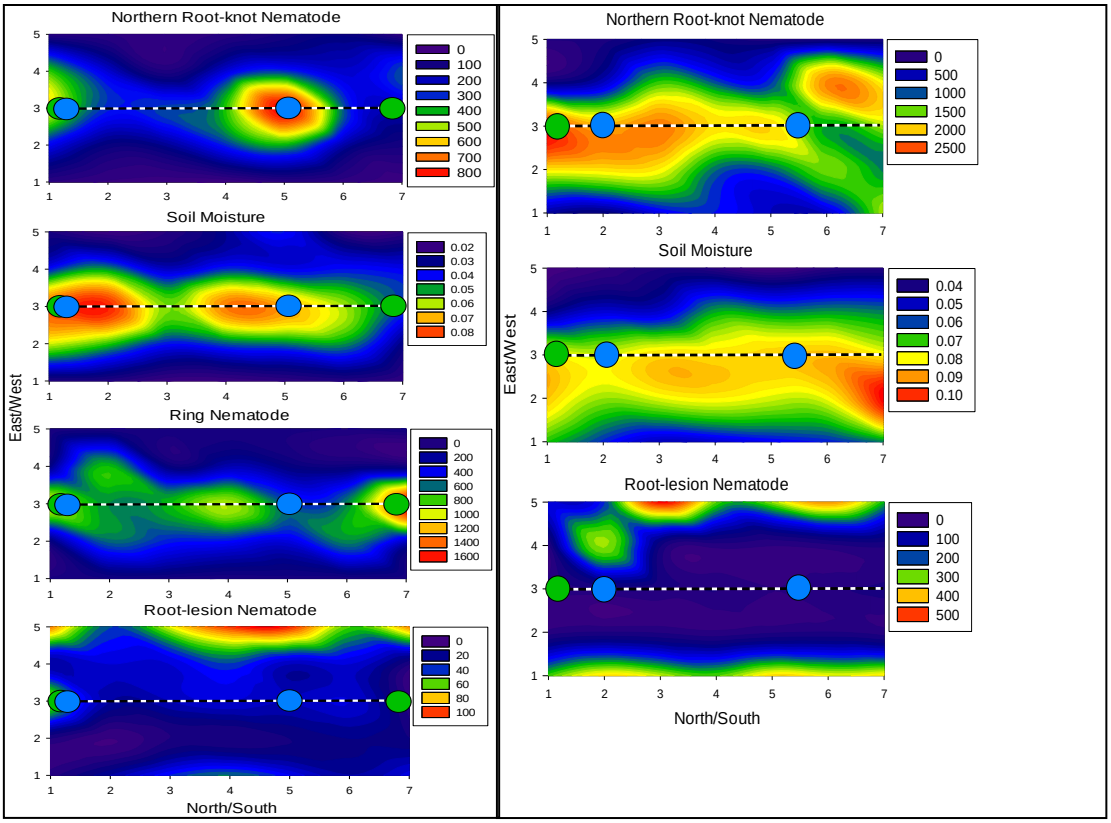
Horizontal distribution of plant-parasitic nematodes in semi-arid Washington vineyards: The relationship between plant-parasitic nematodes and soil moisture and fine root biomass at both sites was explored using regression analyses. At the Chardonnay vineyard, *M. hapla* and *M. xenoplax* population densities were positively correlated with soil moisture ($p < 0.0001$) and fine root biomass ($p < 0.0001$), however this correlation was not always strong (r^2 values ranging from 0.27 and 0.43). At the Riesling vineyard, the same trend was observed for *M. hapla* with population densities being positively correlated with soil moisture ($p < 0.0001$) and fine root biomass ($p < 0.0001$), with r^2 values of 0.45 and 0.24, respectively. At both vineyards, there was a negative correlation between *Pratylenchus* population densities and soil moisture ($p < 0.0001$) as well as fine root biomass ($p < 0.0001$). However, these relationships were weak (r^2 of 0.06 to 0.22, respectively). There were few consistent relationships between soil moisture and fine root biomass and population densities *Paratylenchus* or *X. americanum* at either vineyard.

When average plant-parasitic nematode population densities and soil moisture were mapped for each vineyard (**Figure 1**), the relationships between measured variables, or lack-there-of, became visually evident. The soil types at the two vineyards were a silt loam (Riesling vineyard) and a sandy loam (Chardonnay vineyard). The contour plots of soil moisture and *M. hapla* in the Riesling vineyard indicate that a larger area along the vine row stays moist

supporting this nematode and fine root biomass (*data not shown*). This was in contrast to the Chardonnay vineyard, where defined foci of *M. hapla* and soil moisture occurred directly beneath emitters or within close proximity. Also in this vineyard there was a definite trend for *M. xenoplax* to be concentrated within a foot of the center of the vine row. Interestingly, at both sites the *Pratylenchus* was found on the outer edge of the plots not in proximity to grape roots or moisture. There were few consistent trends at either site for the horizontal distribution of *X. americanum* and *Paratylenchus* across the sampling areas.

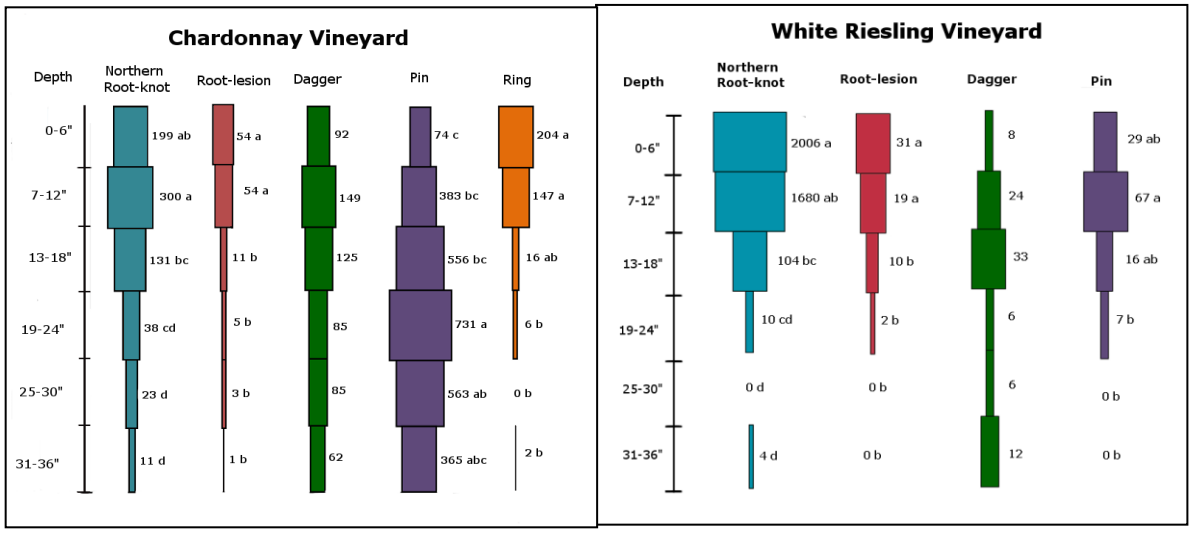
When location of soil sample relative to the emitter was considered, there was significantly less soil moisture in the alley compared to beneath the emitter or within a foot of the emitter in any direction, but only at the Chardonnay vineyard (**Figure 1**). This result is similar to results from the horizontal sampling that indicated that the wetting zone in the Chardonnay vineyard grown on a sandy loam soil is much more defined than that at the Riesling vineyard grown on the silt loam soil. This reduced moisture was related to a reduction in population densities of *M. hapla* in the alley with 7 *M. hapla*/250 g soil in the alley and 689 *M. hapla*/250 g soil directly beneath the emitter at the Chardonnay vineyard. There were no other significant differences in plant-parasitic nematode population densities in relationship to the emitter in either vineyard.

Figure 1. *Horizontal distribution of plant-parasitic nematodes and soil moisture. Left: Chardonnay vineyard grown on a sandy loam soil in Patterson, WA. Right Horizontal Riesling vineyard grown on a silt loam soil in Mattawa, WA. Values in legends for plant-parasitic nematodes are #/250 g dry soil while values for soil moisture are proportions. Green circles represent vines, blue circles represent emitters, and dashed line represents the middle of the vine row. Each x and y axis value represents 1 ft, for a total area of 5 by 7 ft sampled***.**



Vertical distribution of plant-parasitic nematodes in semi-arid Washington vineyards: At both vineyards, there was no interaction between location of sample in relationship to the emitter and depth of sample ($p > 0.05$), therefore they were considered separately. Soil moisture significantly decreased with depth ($p < 0.0001$) with a significant drop at 12". For all plant-parasitic nematodes at both vineyards, except *X. americanum*, there was a significant influence of depth on abundance (**Figure 2**). At both vineyards, *M. hapla* and *Pratylenchus* were concentrated in the top 12 to18" of soil ($p < 0.0001$); the same was true for ring nematode at the Chardonnay vineyard ($p < 0.0001$) (Figure 2). The vertical distribution of *Paratylenchus* differed between the two vineyards, with this nematode concentrated in the upper 12" in the Riesling vineyard and more abundant deeper in the soil profile (> 18") at the Chardonnay vineyard.

Figure 2. *Vertical distribution of plant-parasitic nematodes. Left: Chardonnay vineyard grown on a sandy loam soil in Patterson, WA. Right: Riesling vineyard grown on a silt loam soil in Mattawa, WA. Values next to boxes at each depth represent the average number of nematodes/250 g dry soil (N = 5). Within a nematode type, values followed by the same letter are not significantly different according to Tukey's adjustment for multiple comparisons (p < 0.05).*



Key Outcomes of Objective 2: Despite subtle difference in the distribution of moisture and plant-parasitic nematodes between the two vineyards included in the spatial study, similar trends in the spatial distribution of plant-parasitic nematodes in semi-arid Washington vineyards were observed. *M. hapla* and *M. xenoplax* (two of the major nematode parasites of grape) were closely related to wetting patterns within the vineyard and occupied very defined areas within the vine row. At both sites, *Pratylenchus* sp. population densities did not appear to be driven by the grape plant; rather, they were more commonly detected close to the alley where other hosts were growing. *Xiphinema* sp., another major parasite of grape, had no consistent distribution within the vineyards. These results will guide grape growers in where to sample for nematodes and may provide information regarding the area that needs to be treated to reduce nematode populations and minimize their impact on vine productivity.

3. <u>Determine the impact of *M. hapla* on variety/clone establishment and productivity in a field setting.</u>

Average pre-fumigation (August 2012) plant-parasitic nematode population densities in this field were: 16 *M. hapla*, 8 *M. xenoplax*, 7 *Pratylenchus*, 28 *Paratylenchus* and, 5 *X. americanum* (expressed as #/250 g soil). Plant-parasitic nematode populations across the site were low prior to planting (April 2013) with no plant-parasitic nematodes detected in fumigated main plots. Six months after planting, plant-parasitic nematode populations in soil remained low. However, *M. hapla* was only detected in plots that had been inoculated at planting and fumigated areas remained free of plant-parasitic nematodes. There was a significant ($p < 0.001$) row effect on plant vigor (shoot length) with vines in the middle of the trial area performing better than those on the edges.

Key Outcomes of Objective 3: A long-term research vineyard has been established which will allow us to provide information on the impact of plant-parasitic nematodes on establishment and productivity of a range of *V. vinifera* own-rooted varieties. It will also provide information on how long the residual impacts of soil fumigation lasts.

Results Dissemination to Grape and Wine Industry:

Industry/Extension Publications: 2014 Pest Management Guide for Grapes in WA (EB7062; WSU Extension) was updated to include new information on nematode distribution and feeding preferences. Information was also included in the *Field Guide for Integrated Pest Management for Pacific Northwest Vineyards* (PNW644; Pacific Northwest Extension).

Industry Meeting Posters: WAWGG 2013 Annual Meeting, Kennewick, WA; Spatial distribution of plant-parasitic nematodes in semi-arid vineyards

Field Days: OSU Field Scouting Workshop, Mosier, OR

Scientific Meeting Presentations: 2013 Society of Nematologists Annual Meeting, Knoxville, TN; 2013 Association of Horticultural Science Annual Meeting, Palm Springs, CA.

Funds Status:

This is the last year of this project. As of 12/31/13 there was $28,297.94 remaining on this grant. The amount remaining is due to lapsed salary of John Wilson who was originally on the project and subsequently fell sick and retired. We propose to carry this money over to support efforts in continuing to manage and monitor the vineyard established at Columbia Crest over the next three years. This managing and monitoring will be done, in part, but research technician Jensena Newhouse (supervised by Moyer).

Other Sources of Funding:

None