ISBN: 978-85-66836-20-2

# PATHOGENICITY AND MANAGEMENT OF PLANT-PARASITIC NEMATODE ASSOCIATED WITH SMALL FRUITS

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Small fruit crops (including grape, strawberry, raspberry, blueberry, cranberry, etc.) are considered high-value crops. Berry consumption globally is increasing due to the nutritive value of these fruits. Similar to other crop commodity groups, plant-parasitic nematodes are a constraint to the production of small fruits. A diversity of plant-parasitic nematodes are found in small fruit crops. In general, the following nematodes are production limiting: *Meloidogyne* spp. in grape and strawberry; *Pratylenchus* spp. in raspberry, grape and strawberry; *Tylenchulus semipenetrans* in grape; *Belonolaimus longicaudatus* in strawberry; *Paratrichodorus* in blueberry; and *Mesocriconema xenoplax* in grape. *Xiphinema* spp. are of particular importance in small fruit production because of their ability to vector *tomato ringspot virus* and *tobacco ringspot virus* to many small fruits, and *grape fanleaf virus* to grape. Each of these plant-parasitic nematodes has unique biological attributes that should be considered when developing a management program.

Historically, plant-parasitic nematodes have been managed in small fruit crops by soil fumigation; this has been possible because of the high per hectare return from this crop allowing for the additional expense of fumigation. Methyl bromide was an important part of the management of nematodes in small fruits, however, due to the global reduction in methyl bromide usage, this fumigant is no longer available for many small fruit growers. Other fumigants that are commonly used in these production systems include 1,3-dichloropropene and metam sodium. Looking forward, it is likely that soil fumigation will become more difficult for small fruit growers in most countries because of cost, availability, and regulatory restrictions. Transitioning to plant-parasitic nematode management practices that do not rely exclusively on soil fumigation will require an integrated approach coupled with an increased understanding of nematode biology and ecology. Examples from research conducted in the Pacific Northwest of the United States will highlight the need to characterize plant-parasitic biology and ecology to improve management. In this region, the plant-parasitic nematodes of interest on small fruits (primarily raspberry and grape) include *Meloidogyne hapla*, *Pratylenchus penetrans*, and members of the *Xiphinema americanum*-complex.

Research on the horizontal and vertical spatial distribution of a plant-parasitic nematodes in semi-arid winegrape vineyards in Washington state USA demonstrates that nematode distribution in soil will depend upon soil type, nematode species, and plant rooting dynamics. In winegrape vineyards, *Meloidogyne hapla* and *M. xenoplax* were aggregated under irrigation emitters in areas with abundant fine roots, usually to a depth of 45 cm. *Xiphinema* spp. was randomly distributed in the vineyard and occurred at depth (down to 1 meter) and in the alleyway. From a management perspective, based upon this data *M. hapla* and *M. xenoplax* can be reliably managed with drip-applied fumigants or other treatments targeted to the row where the majority of these nematodes reside. However, this management approach would not be effective against *Xiphinema* spp. The entire area would need to be treated with a management practices and *Xiphinema* spp. enticed to move into shallower soil depths (< 45 cm) where management practices can be consistently applied.

The initial density of a nematode population will also have a strong influence on the efficacy of some management practices. A non-bearing application of oxamyl was evaluated in three raspberry fields in Washington state that varied in initial population densities of *P. penetrans*. One of the fields was considered a high density field (> 500 *P. penetrans*/g root) and the other two moderate (100 *P. penetrans*/g root) to low (<50 *P. penetrans*/g root). A spring application of oxamyl did not significantly decrease *P. penetrans* population densities in the high density field. In the moderate density field, oxamyl initial (6 to 12 months after application) decreased *P. penetrans* population densities, but 1.5 years after application population densities were similar in treated and nontreated areas. In the low density field, oxamyl was very effective at reducing *P. penetrans* population densities up to two years after oxamyl treatment, with densities 15 times lower in treated areas. In raspberry, knowledge of initial *P. penetrans* population densities may guide a grower to apply oxamyl only when population densities are low to moderate and also to temper expectations of the potential of a management practice to suppress nematodes.

The region where winegrapes are grown in Washington state is considered a temperate climate with average high temperatures of 18.5 °C and low temperatures of 5.6 °C. Under these environmental conditions *M. hapla* would be expected to undergo few generations within a growing season; however, the population dynamics of *M. hapla* on wine grapes was unknown. Three winegrape vineyards in Washington state were intensively sampled from March 2015 to March 2017 to determine the life cycle of *M. hapla* by measuring the number of second-stage juveniles (J2) in soil, egg densities in roots, as well as the quantity of fine root tips. This information was used to model *M. hapla* J2 development based on soil growing degree days using a base

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temperature (Tb) of 0°C ($GDD_{soil}$) and a start date of March 1. Based on J2 and egg dynamics, *M. hapla* appears to have one generation per year. Juvenile populations initially declined in the spring, reaching their lowest density around 1,800 $GDD_{soil}$ (late June to early August). They subsequently increased over the remaining summer and fall, reaching a maximum density in soil over the winter (October to March), from 4,200-4,800 $GDD_{soil}$. Understanding the developmental dynamics of *M. hapla* will allow Washington winegrape growers to better time chemical or cultural management techniques.

Growers rely on diagnostic laboratories to provide them with nematode identification to genus and sometimes species. This type of information is crucial when tailoring nematode management strategies in a site specific manner. Research in small fruit production systems in the Pacific Northwest of the United States demonstrates that knowledge of nematode species composition, spatial and temporal distribution in soil, and initial population density can improve the efficacy of chemical and nonchemical nematode management strategies.