POTATO EARLY DYING COMPLEX

Understanding biology and symptoms of early dying and control options for growers.

based on presentations on February 2nd & 3rd, 2018 by Dr. Mario Tenuta, University of Manitoba

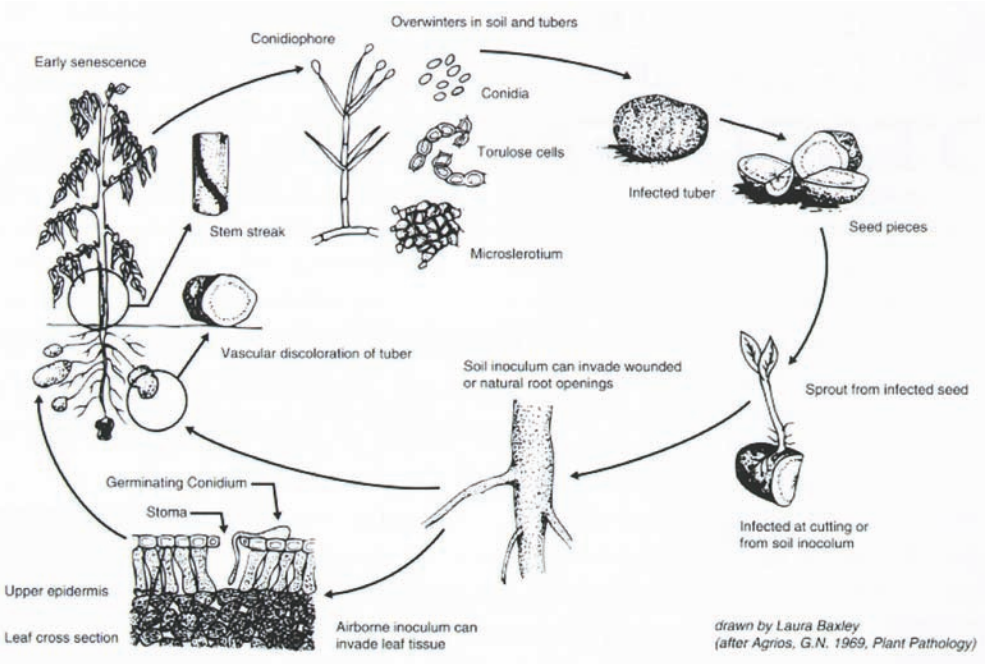
A major cause of potato yield reduction in Prince Edward Island is Early Dying Complex. The name of the complex is very apt, as the major symptom is the premature wilting and senescence of the potato plant late in the season by the disease, Verticillium Wilt, limiting the opportunity for tuber bulking. This results in lower marketable yield and a smaller size profile of resultant tubers. Early dying is called a complex because there is more than one micro-organism involved.

Potato plant displaying symptoms of Verticillium Wilt. Photo courtesy OMAFRA.

Pathogen Biology:

Early dying complex can consist of a number of opportunistic and synergistic organisms, but the two primary causal agents in Prince Edward Island are species of the soil-borne *Verticillium* fungi and root lesion nematodes. The two primary *Verticillium* species causing early dying in Prince Edward Island are *Verticillium dahliae* and *Verticillium albo-atrum*, with *V. dahliae* noted as particularly aggressive and more common on potato crops. The primary nematode of concern is a species of root lesion nematode, *Pratylenchus penetrans*, although there are other root lesion nematode species present in PEI that is part of the early dying complex.

Verticillium infects plants by entering the roots and then subsequently moving through the vascular tissue, forming dispersal structures called conidia. In fighting the infestation of *Verticillium*, the infected plant acts to choke off infected tissues, leading to chlorosis and wilting of foliage. There is some indication from past studies that *V. dahliae* can produce a toxin and enzymes to help spread through the vascular system. The result is a disease called Verticillium Wilt, that can often be identified by wilting on one side of the leaf or plant, as well as browning of stems (vascular tissue). In some cases, *Verticillium*-infected plants can also display "flagging," where the stem stands stiff and upright despite wilting of the majority of leaves. *Verticillium* infection can also lead to tuber discoloration in some cases and usually browning



Life cycle of *Verticillium* fungi. Reprinted from University of Maine Cooperative Extension.

of the cross-section of the base of the plant stem.

As infected plants senesce, small "black pepper-like" structures called microsclerotia are formed in the dying tissues. These microsclerotia are released into the soil as the plant debris decomposes. When a growing root encounters microsclerotia in the soil, root exudates encourage the microsclerotia to activate, germinate to produce thread-like structures called hyphae that infect the root of potato, restarting the life cycle once again.

Root lesion nematodes live free in the soil, feeding on the roots of plants and entering into those roots. The root lesion nematode species, *P. penetrans*, accelerates the rate of infection of the plant from *V. dahliae*, as the two micro-organisms appear to act in a synergistic fashion. High populations of *P. penetrans* and other species of root lesion nematodes alone can limit yields in potatoes, but presence of *Verticillium* at the same time will increase the severity of yield loss.

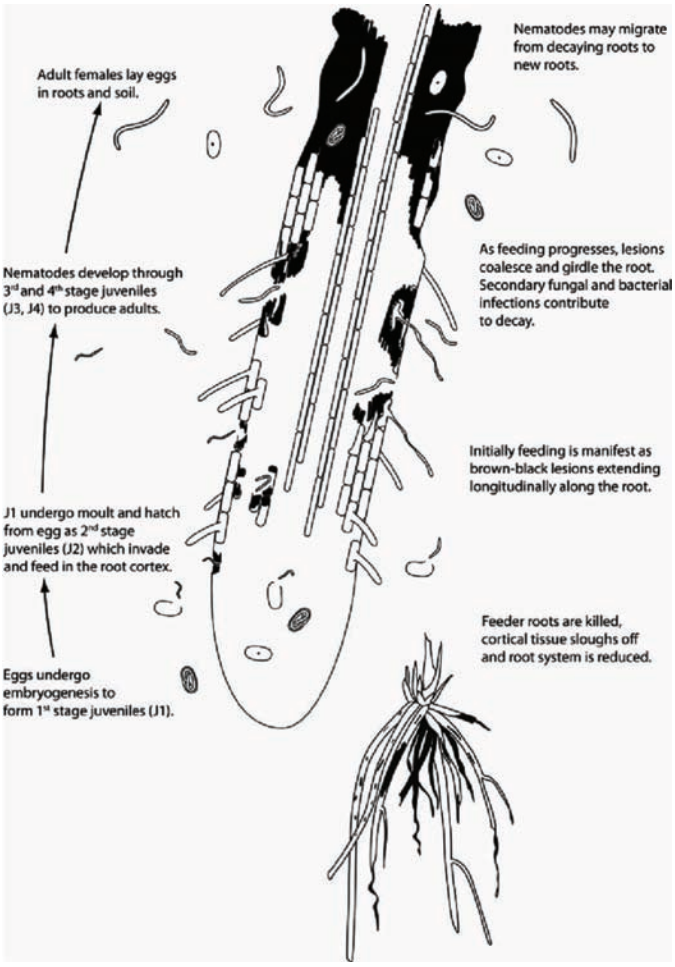
Recent studies have confirmed the presence of high populations of *Verticillium* and root lesion nematodes in Prince Edward Island soils. A study from 2014 to 2016 investigating within-field variability found that out of 180 samples taken from a total of 45 fields, 156 samples had very high populations of *V. dahliae* (3 on a 0 to 3 severity scale). In the same study, 142 samples had root lesion nematode numbers greater than 2,500 per kg of soil, the threshold limit established by Joe Kimpinski of AAFC for damage in the Superior cultivar without the presence of *V. dahliae*. An additional survey of fields in rotation with potatoes in 2017 by the PEI Potato Board and AAFC found root lesion nematodes in 100% of fields, with an average level of 2,700 per kg of soil in spring samples.

Host species:

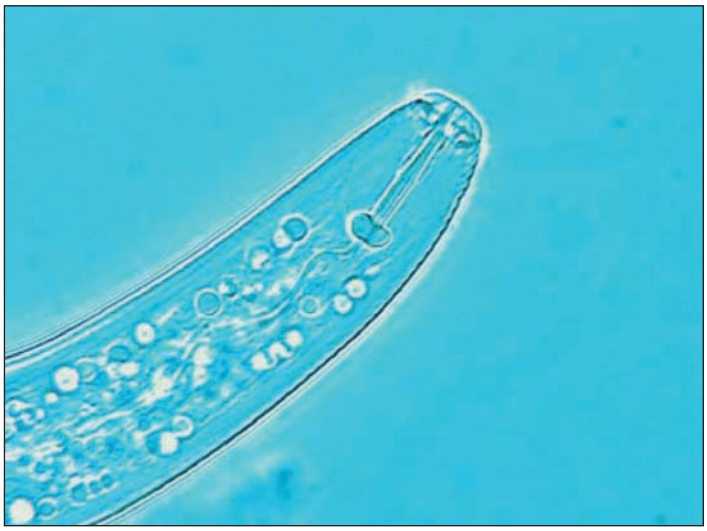
Almost all dicotyledon (broadleaf) plants are susceptible to *Verticillium*. This includes potato, clover, alfalfa, cabbage, radish, tomato, soybean, and more. Cereal crops, such as barley, oats, and wheat, as well as forage grasses are not thought to be hosts of *Verticillium*.

Root lesion nematodes have a very wide host range. Grasses, cereals, a variety of field and vegetable crops, and many weeds all host root lesion nematodes. Preferred hosts include corn, carrot, vetch, strawberry, soybean, and potato. Some non-host crops include pearl millet, sudangrass, and onions.

Verticillium microsclerotia can remain viable in soil for many years. A succession of crops that host *Verticillium* will allow populations to grow over time, as crop residues decompose and return increased loads of micro-



Life cycle of root lesion nematodes. Reprinted from Pethybridge et. al., 2008. Diseases of Pyrethrum in Tasmania: Challenges and Prospects for Management. Journal of Plant Science.



Microscopic view of *Pratylenchus penetrans*, the root lesion nematode. Reprinted from Wikipedia

sclerotia to the soil. Root lesion nematodes require host crops to feed on and proliferate. Population numbers will generally decrease overwinter but will not be controlled completely by frost. Even in the absence of susceptible host crops, *Verticillium* and root lesion nematode levels can be sustained by weeds or volunteer crops. Thus, good weed control is important.

Control Options:

In a number of US states and Canadian provinces, chemical fumigation of soil has proven effective at controlling both *Verticillium* and root lesion nematodes. Metam sodium (Vapam/Busan) or chloropicrin (Pic Plus) have been employed commercially as fall-applied soil fumigants. Neither product is currently permitted for use in Prince Edward Island. In addition, research has shown that the effects of soil fumigation are temporary, with *Verticillium* populations recovering quickly following use of a host crop like potatoes. This requires the continued use of fumigation before growing potatoes. Nonetheless, fumigation products have proven effective in fields with very high *Verticillium* and nematode number; conversely, effects may be less cost-effective in healthier soils with lower levels of inoculum. Improved yields of 75-100 cwt with fumigation, depending on costs and potato value, are required for the practice to be economically viable.

Research by Dr. Mario Tenuta from the University of Manitoba has indicated that soils with higher levels of soil organic matter suffer less from early dying symptoms and yield loss than fields with low soil organic matter percentages. Additional studies have shown that additional of compost can also reduce the occurrence of early dying in potatoes.

Biofumigant crops, such as brown or white mustard, have been shown to reduce populations of *Verticillium* and nematodes. This is due to the breakdown of glucosinolates in the presence of water to gases similar to chemical fumigants. For optimum effect, mustard crops should be incorporated first before peak flowering before seed set when biomass is at maximum volume and the concentration of glucosinolates is also at peak levels in the green biomass. This is normally 45-60 days after planting, depending on planting date and time of year. Biofumigant crops should always be incorporated in the presence of significant soil moisture to ensure activation of the biofumigation process. Rolling soil is also helpful to increase concentration of the biofumigation products.

Incorporating mustard as a biofumigant crop.
Photo by Ryan Barrett, PEI Potato Board.

Sorghum sudangrass.
Photo by Ryan Barrett, PEI Potato Board.

There is also evidence that the incorporation of other green manure crops the year before potatoes can also have a positive impact on potato yields and a decrease in foliar symptoms of early dying. Generally, these green manure crops don't significantly decrease *Verticillium* or nematode levels. More research is needed to better understand how the incorporation of these crops improve soil health and crop yields. Examples of green manure crops are sorghum sudangrass, buckwheat, and oilseed radish as well as crop mixes of cereals/grasses and legume crops, such as oats and peas or timothy and alfalfa. Green manure crops incorporated in the summer (for maximum beneficial effect) should ideally be followed by a cover crop to prevent soil erosion, reduce soil nitrates, and promote improved soil health and soil structure.

Certain crops have been shown to have a direct effect on reducing populations of these soil-borne pathogens. Sorghum sudangrass is a high-biomass forage crop that activates *Verticillium* microsclerotia but doesn't allow them to colonize the roots and reproduce, thereby decreasing levels of *Verticillium* in the soil. Multiple

cuttings of sorghum sudangrass in a season will substantially increase the volume of root mass. *Verticillium* soil levels decrease with years of continuous cropping of sorghum sudangrass. Past studies indicate three successive crops of sorghum sudangrass is required to dramatically reduce *Verticillium* levels in soil. Sorghum sudangrass is a warm season plant and should not be planted until soil and air temperatures are sufficiently warm, ideally after the first week of June in Prince Edward Island.

Pearl millet has been demonstrated in a number of studies, including work in potato conducted in Quebec, to reduce root lesion nematode populations, thereby increasing marketable yield of potatoes. A particular cultivar, Canada Forage Pearl Millet (CFPM) 101, has been specifically bred in Canada for this purpose. Pearl millet is also a warm season grass crop similar to sorghum sudangrass and should be managed in a similar fashion. Both sorghum sudangrass and pearl millet can be harvested as silage for cattle feed or can be mulched on the field.

Lengthening rotation has also been associated with improved marketable yields, as a reduced frequency of potato crops results in less build-up of *Verticillium* and root lesion nematode populations, provided that other crops in rotation are not also preferred host crops for either pathogen. Longer crop rotations with increased use of perennial crops and cover crops are also generally associated with higher soil organic matter and improved soil structure.

Recently, two new crop protection products have been approved for use in potatoes. Aprovia™ (solatenol), marketed by Syngenta, is approved for in-furrow control of *Rhizoctonia* and silver scurf as well as suppression of Verticillium Wilt. Velum® Prime (fluopyram), marketed by Bayer Crop Science, has been approved for in-furrow suppression of root lesion nematodes in potato. Velum® Prime is also an approved product for suppression of early blight and control of powdery mildew. Both products are applied as in-furrow liquid products and have MRLs for approved usage. Evaluation of both products in Prince Edward Island is being performed at present.

Potato cultivars vary in susceptibility to Verticillium Wilt. Growers can thus select cultivars to suit disease pressure of fields. The cultivars Superior, Kennebec, Russet Norkotah, Shepody and Sangre are susceptible. Ranger Russet and Atlantic cultivars are resistant. Russet Burbank is moderately susceptible.

Take Home Messages:

- **Verticillium dahliae and root lesion nematode numbers are high** in Prince Edward Island potato fields at present.
- Both causal agents have a **wide range of host crops** and are multiplied significantly by tight rotations of potatoes.
- **Testing services** for both Verticillium and root lesion nematodes is available from the Potato Quality Institute in Charlottetown.
- **Extending rotations with non-preferred or non-host crops** is one method to reduce impact of early dying complex.
- Use of **green manure and/or biofumigant crops** has been shown to reduce the impact of early dying complex.
- **New crop protection products** (ie. Aprovia™, Velum® Prime) have recently been registered for use in Canada on suppressing either Verticillium or root lesion nematodes. Evaluation of these products in PEI conditions is currently underway.
- Different **cultivars have differing levels of resistance** to Verticillium Wilt.

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