Potato Early Dying Complex: Key Factors Related to Disease Development

Nandita Selvanathan, Soils and Crops Branch, Manitoba Agriculture, Food and Rural Initiatives, Box 1149, Carman, MB R0G 0J0 E-mail: nselvanath@gov.mb.ca

The Disease

The potato is subject to several diseases caused by fungi, bacteria, viruses and nematodes. In the arid and semiarid regions of the world, potato early dying is a common limiting factor in potato production (Rowe et al. 1987) and is endemic in many potato production areas of North America.

Economic Importance

When disease develops throughout a field midway through the growing season and then becomes severe during the period of maximum tuber bulking, a significant reduction in tuber size and total marketable yield can result (Rowe and Powelson 2002). In North America, yield reduction in moderately diseased fields can easily be 10 to 15 % and in severely diseased fields it can be as high as 30-50% (Powelson and Rowe 1993). The economic impact of Potato Early Dying across the Potato industry is significant because of the direct losses resulting from low yields (Rowe, Davis, Powelson and Rouse 1987). Early Dying complex of potato is a major issue in Manitoba.

Symptoms

Symptoms of Potato Early Dying are difficult to distinguish from normal senescence, other diseases or physiological problems as reduced growth may be the only apparent symptom. Difficulties may occur in the diagnosis of Potato Early Dying as the symptoms are highly variable and also may be associated with other disease or physiological problems. Early foliar symptoms may appear as uneven chlorosis of lower leaves on a few plants. Later, some wilting of leaflets may occur, but more typical is uneven death of lower leaflets. Leaf yellowing and death then proceed up the stems which often remain erect. A light brown vascular discolouration is often visible at the stem base when sliced. Advanced symptoms usually do not occur until after flowering and may consist of a decline of isolated plants or in severe cases, the entire crop may mature early. (Davis 1981; Krikun and Orion 1979; Mace et al. 1981 and Rowe 1983).

Causes

A major contributor to this syndrome is the wilt fungus *Verticillium dahliae* (MacGuidwin and Rouse 1990). The fungus is favored by moderate to high temperatures and is restricted to temperate climates (Joaquim and Rowe 1990). *Verticillium dahliae* survives from season to season as microsclerotia in the soil, either free or embedded in the plant debris, or as mycelium in the vascular ring of the tuber (Rowe and Powelson 2002).These microsclerotia are stimulated to germinate in response to root exudates (Mace et al. 1981).

Studies have shown that *Verticillium dahliae* and root lesion nematodes (*Pratylenchus* spp.) can interact synergistically, together they cause severe symptom development and significant yield reduction at population levels that have little or no effect when each organism is present individually. Kotcon et al (1985) found the effects of root lesion nematode in combination with *V. dahliae* on symptom expression were additive.

Severity of potato early dying and associated yield loss are also influenced by seasonal temperature as well as management factors such as irrigation and fertilization (Cappaert et al. 1992). Many factors have been reported to influence the yield loss associated with the disease e.g., climatic conditions (Martin et al. 1982 ; Stevenson et al. 1976), soil type (Martin et al. 1981) potato cultivar (Bernard and Laughlin 1976; Bird 1981 and Burpee and Bloom 1978) and soil fertility (Bird 1981).

Management Strategies

Selection of control strategies for potato early dying must be based on an understanding of the biology of the pathogens and the effects of various agricultural practices (Rowe et al. 1987). Management practices are aimed at reducing the population of these pathogens in soil or changing the susceptibility of the host. No single practice will control potato early dying. Therefore, integrated management systems are emphasized in which several decisions are implemented throughout multiple-year rotational cropping programs. Potential components of integrated systems are cultural methods like crop rotation, green manures, fertilization, irrigation and vine removal along with host resistance and biological controls (Rangahau 2003). Management practices that modify the rate of stem colonization by *Verticillium dahliae* or increase the host's tolerance to colonization, may also be useful control measures for this disease (Rowe 1987).

Crop Rotation - Crop rotation has long been considered an important part of the disease management strategies employed for potato early dying. Although, 2 to 3 year rotation practices do not result in effective control of the disease, they are useful in the total management scheme. In Idaho, the minimum time to effectively reduce inoculum with grain rotation in moderately infested land is 5-10 years (Davis 1981; Davis and McDole 1979).

Irrigation – Maintaining plant vigor with careful irrigation and fertility practices is the best management strategy for controlling this disease. Amount and timing of irrigation have been used as a management tool to suppress the disease. Where potatoes are grown under irrigation, the amount of applied water can be reduced early in the season (before tuber initiation) to minimize water use by the crop without sacrificing tuber yield or quality (Rangahau 2003). Severity of potato early dying was greater throughout each season when plants grown in infested soil were irrigated excessively compared to those receiving deficit irrigation (Cappaert et al. 1992).

Soil Fertility - Researchers in the US demonstrated that adding nitrogen and phosphorus into soil to attain plants that were optimally fertilized, rather than nitrogen and phosphorus deficient suppressed potato early dying (wilt incidence and colonization) and also reduced the rate of increase of soilborne inoculum of *Verticillium dahliae.*
(Rangahau 2003).

Host resistance – Planting resistant cultivars is the most efficient, effective economical and environmentally sound means of managing potato early dying disease. US studies have shown that growing highly resistant cultivars for five seasons can reduce pathogen levels by 60- 70 % compared with growing only susceptible cultivars. Unfortunately, many commercial cultivars do not possess any resistance to potato early dying and even the most resistant cultivars will develop symptoms of the disease under favourable environmental conditions and when the soil inoculum levels are very high (Ranghau 2003). Some commercial potato cultivars do exhibit varying degrees of tolerance to early dying, which can lessen long term pathogen survival.

Times change, as do the challenges faced and the strategies required to manage potato early dying both effectively and economically. Successful management will involve five key areas : suppression of soilborne inoculum, new plant protection chemicals, clean planting stock, enhanced host resistance and improved pathogen monitoring tools (Rowe and Powelson 2002).

Work done in Manitoba

Extensive field studies were done in 2002 and 2003 to identify biological and environmental factors responsible for disease development and subsequent yield loss in Manitoba. These studies will help in developing possible long term management plans for this disease complex. A total of 27 commercial potato fields in Manitoba were selected in 2002 and 2003 (4 fields in 2002 and 23 in 2003). Soil samples

were collected and tested for soil fertility, physical and chemical properties. *Verticillium dahliae* microsclerotia and the number of root lesion nematodes (*Pratylenchus* sp.) were counted by suitable techniques. Wilt/disease assessment was based on visual observations of the plants. Data were also collected for yield and field history for each field. The data is being analyzed and the factors that may have involvement in the early dying complex in Manitoba, will be identified.

References

Bernard, E.C. and Laughlin, C.W. 1976 Relative susceptibility of selected cultivars of potato to *Pratylenchus penetrans*. J. Nematol 8 : 239- 242

Bird, G. W. 1981 Management of plant parasitic nematodes in potato production. Pages 223-243 in : Advances in potato pest management. J.H. Lashomb and R. Casagrande, eds. Hutchinson Ross Publishing Company, Strondsburg, PA. 288 pp.

Birpee, L.L. and Bloom, J.R. 1978. The influence of *Pratylenchus penetrans* on the incidence and severity of Verticillium wilt of potato. J. Nematol. 10 : 95-99

Cappaert, M.R. Powelson, M.L., Christensen, N.W. and Crowe, F.J. 1992. Influence of irrigation on severity of potato early dying and tuber yield. Phytopathology 82 : 1448- 1453

Davis, J. R. 1981. Verticillium wilt of potato in southeastern Idaho. Univ. Idaho Curr.Inf. Ser. 564

Davis, J.R. and McDole R.E. 1979 Influence of cropping sequences on soilborne populations of *Verticillium dahliae* and *Rhizoctonia solani*. Pages 399-405 in Soil – Borne Plant Pathogens. B. Schippers and W. Gams, eds. Academic Press, New York 685 pp.

Joaquim, T.R. and Rowe, R.C. 1990. Reassessment of Vegetative Compatibility Relationships Among Strains of *Verticillium dahliae* using Nitrate - Nonutilizing mutants Phytopathology 80 : 1160-1166

Kotcon, J.J. and Rouse, D.J. and Mitchell, J.E. 1985. Interactions of *Verticillium dahliae*, *Colletotrichum coccodes*, *Rhizoctonia solani* and *Pratylenchus penetrans* in the Early dying syndrome of Russet Burbank potatoes. Phytopathology 75 : 68-74

Krikun, J. and Orio, D. 1979 Verticillium wilt of potato : Importance and control. Phytoparasitica 7 : 107-116

Mace, M.E., Bell A. A. and Beckman, C.H. eds. 1981. Fungal wilt diseases of plants. Academic Press. New York. 640 pp.

Martin, M. J. Riedel, R.M. and Rowe, R.C. 1981. *Pratylenchus penetrans* and *Verticillium dahliae* : Causal agents of Early Dying in *Solanum tuberosum* cv. Superior, in Ohio (Abstr.) J. Nematol 13: 449

Powelson, M.L. and Rowe, R.C. 1993. Biology and Management of early dying of potatoes. Annu. Rev. Phytopathol. 31 : 111-126

Rangahau, M.K. Potato Early Dying (Verticillium wilt) – Strategies for control. Crop and Food Research (Broad sheet) number 126 http://www.crop.cri.nz/psp/books/broadsheets. HTM

Rowe, R.C. 1983 Early Dying – east and west. Am. Veg. Grow. 31 (3) : 8-10

Rowe, R.C. and Powelson, M.R. 2002 Potato Early Dying : Management challenges in a changing production environment. Plant Disease 86 (11) : 1184 – 1193

Stevenson, W.R., Green, R.J. and Bergeson, G.B. 1976. Occurrence and Control of potato black dot root rot in Indiana. Plant Disease Reporter 60: 248-251