Orchard Replant Disease: Proposed Actions to Address it in Historic Orchards in Scotland

A discussion paper by Dr Crispin W. Hayes, CW Hayes Associates

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Background

This paper collates and summarises evidence and opinions from other sources, and is not the result of primary research. It takes the evidence and opinions, and proposes various courses of action to address the issue specifically in the historic orchards of Scotland.

Disclaimer: This paper should not be considered as an authoritative source; it a brief piece of secondary research, intended to provide a basis for preliminary guidance and further discussion.

The Problem

Orchard Replant Disease (ORD) is widely acknowledged as a serious problem for various species including apple, pear, plum, cherry, and rose. It results in reduced root growth and thus reduced tree growth and reduced yield, and particularly affects young trees[1]. It is not normally fatal to young trees. A complex of root pathogens is responsible for the disease. Although there is some diversity of opinion on the detail of the pathogens, it appears that populations of particular fungi are the main actors[2], while various bacteria and nematodes[3] may also play a subsidiary role.

Symptoms

For apples the symptoms are stated[4] as:

- Stunting of the tree with short internodes,
- Small and light green rosette leaves,
- Small root systems and decayed or discoloured roots,
- Few new lateral or feeder roots are produced,
- Affected trees leaf out in the spring but often produce little or no shoot growth,
- Severe disease results in the death of young trees and entire orchards,
- Trees in orchards not killed by replant disease often bear fruit two to three years later than healthy tree and rarely attain comparable yields.

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[1] Washington State University (2012) *Specific Orchard Replant Disease. Crop Protection Guide for Tree Fruits*. webpage at [http://jenny.tfrec.wsu.edu/eb0419/web/Special_Programs/Replant_Disease]

[2] Mazzola, M. (1998), 'Elucidation of the microbial complex having a causal role in the development of apple replant disease in Washington', *Phytopathology*, 88 (9), 930-38.

[3] Ministry of Agriculture, British Colombia (2012) *Pathogenic Nematodes in Tree Fruit.* webpage at [http://www.agf.gov.bc.ca/cropprot/tfipm/nematode.htm]

[4] Ministry of Agriculture, Food and Rural Affairs, Ontaria (2012) *Apple Replant Disease.* webpage at [http://www.omafra.gov.on.ca/IPM/english/apples/diseases-and-disorders/apple-replant-disease.html]

Conventional Solutions for Commercial Orchards

For commercial orchards, the conventional solution is sterilisation by steam or soil fumigation (using toxic chemicals[5] such as methyl bromide, metam sodium, organochlorine compounds and the chemical warfare agent chloropicrin[6]). This needs to be carried out by a specialist contractor, is costly and in the context of older orchards obviously has a significant negative impact on biodiversity. It is therefore suggested here, that these conventional solutions are not appropriate for use in historic orchards.

Durability of Disease Agents

The durability of disease agents is not well established. In the context of historic orchards in Scotland, some replanting areas may not have had a fruit tree in the immediate vicinity within two decades or more. It would be useful to determine whether this is sufficient passage of time for the ORD causative agents to have diminished sufficiently to the point of having a negligible impact.

Some local opinion[7] suggests that after 14 years, ORD agents may become negligible. Other local opinion suggests that it may last for decades[8]. One example of the literature[9] states that "Rotating the site out of orchard for at least 5-8 years may reduce the severity of the disease, but tree root suckers maintain its presence, so years when root suckers are present do not count as part of the rotation". Other literature for Ontario suggests rotating out of pome fruit for 2 – 8 yrs[10].

So effective duration is undetermined but the consensus appears to be that its effects decline. This could be a very useful factor in considering historic orchards in which depopulation of trees has happened over several decades. In effect, much of the area of the historic orchards in Scotland has been fallow for several decades.

Local Advice

Soil Replacement

The replacement of "one or two barrowfulls of fresh non-orchard soil" is recommended by one leading local advisor[11] and is discussed elsewhere in the literature . However other

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[5] Smith, T.J. (1994), 'Successful management of orchard replant disease in Washington', *Acta Horticulturae*, 161-161.

[6] Washington State University (2012) *Specific Orchard Replant Disease. Crop Protection Guide for Tree Fruits*. webpage at [http://jenny.tfrec.wsu.edu/eb0419/web/Special_Programs/Replant_Disease]

[7] Personal communications with Willie Duncan.

[8] Personal communications with John Butterworth.

[9] Washington State University (2012)

[10] Ministry of Agriculture, Food and Rural Affairs, Ontaria (2012)

[11] Personal communications with John Butterworth.

literature suggests this may only be a temporary solution[12] for the first couple of years of growth, but that this brief respite will benefit growth overall[13].

It is likely to be a costly solution on larger sites, but may well be pragmatic on smaller sites where replanting closely follows previous plantings. It may be particularly suitable for walled garden orchards.

Planting Location

Replanting at least 2m from previous planting locations is suggested by several other local advisors[14]. However, previous tree roots will have spread further than this so it's effectiveness as a technique will vary on the particular situation. It is obviously a costless and pragmatic solution if it is effective.

Alternative Solutions Discussed in the Literature

Rotation

The old adage regarding 'pomes and stones' states that trees from the same group should not be replanted successively. It indicates that following stones with pomes, and vice versa will go someway to addressing the problem.

Rootstocks

A certain amount of disease resistance may be achieved in selecting a *Phytophthora* resistant rootstock. It is unclear whether newer rootstocks such as some of those in the Cornell-Geneva series[15] (i.e. CG.30, CG.6210 and CG.16) offer better resistance to fungal root diseases than the M or MM series in Scottish conditions. The literature suggests that they do for conditions in parts of north America[16]. Research and development into improving rootstocks is ongoing at north American institutions such as Cornell University, whereas in the UK it largely ceased 40 years ago. It therefore seems likely that the novel exotic rootstocks may offer some advantages.

In wet soil conditions MM104 and MM106 are more susceptible than are M9 and M26[17].

Dwarfing rootstocks are more susceptible than the more vigorous rootstocks.

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[12] Washington State University (2012)

[13] Wilson, S., P. Andrews, and TS Nair (2004), 'Non-fumigant management of apple replant disease', *Scientia horticulturae*, 102 (2), 221-31.

[14] Personal communications Willie Duncan, Andrew Lear.

[15] Ministry of Agriculture, Food and Rural Affairs, Ontaria (2012)

[16] Perry, R. (2005), The new Geneva apple rootstocks - which ones work for Michigan. Geneva Stocks Briefing, (Michigan State University). download at [http://www.hrt.msu.edu/department/Perry/Rootstock_Reports/GenevaStocksBrief.pdf]

[17] Teviotdale, B. L., and Gubler, W. D. (1995), *Phytophthora crown and root rot. UC Pest Management Guidelines, University of California Statewide Integrated Pest Management Project.* webpage at [http://www.ipm.ucdavis.edu/PMG/r4100511.html]

In traditional orchards, standard form of trees will usually be used and these are a vigorous rootstock.

Soils

The type of soil affects the severity of ORD. The disease is worse on poorer soils[18].

Sandy soils can host higher nematode numbers, than finer textured soils[19].

Trenching

Trenching is a technique to expose the planting soil in the autumn and leave it exposed over the winter period and thereby deplete the scale of disease agents. It has been shown to be quite effective[20] compared to fumigation in Washington state in the USA.

Soil Solarisation

The use of the sun to partially deplete the scale of disease agents is recommended as an alternative technique.

In one example the literature suggests the following advice: "Soil solarization can be an effective, organic-friendly alternative to fumigation, but requires taking the land out of production for a year. Soil solarization is a non-chemical technique that will control many soil-borne pathogens and pests, including nematodes, root and foliar diseases and some weeds. Solarization involves capturing the heat of the sun by covering the soil with transparent polyethylene plastic sheets during warm sunny months. The soil temperatures under the plastic increase to levels lethal to many soil-borne plant pathogens, weed seeds, seedlings, and nematodes. Soil should be tilled before solarization, and should also have a good soil moisture level. The area to be treated should be level and free of weeds, plant debris, and large clods which would raise the plastic off the ground. Cover the area with a double layer of clear polyethylene sheet, seal the edges with soil and leave it in place for 4-6 weeks during the heat of the summer (mid-June through mid-August). If possible, leave the poly in place over the winter to prevent re-contamination. Black plastic is less effective than clear plastic."

This advice is provided for British Colombia whose apple growing area is at around 51 deg N compared to our situation at 56 deg N. Average summer temperatures are higher at around 29 deg C. Nevertheless, in a good summer this technique may prove effective in Scotland.

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[18] Washington State University (2012)

[19] Ministry of Agriculture, British Colombia (2012)

[20] Granatstein, D. and M. Mazzola (2001), 'Alternatives to fumigation for control of apple replant disease in Washington State orchards', *IOBC WPRS BULLETIN*, 24 (5), 265-72.

Mycorrhizal Fungi

Work into role of beneficial fungi in addressing the excessive populations of non-beneficial fungi are in the early stages of research[21]. It suggests that higher populations of mycorrhiza fungi reduce the effects of non-beneficial fungi in *Prunus sp.* Related research[22] shows that general fruit tree health is enhanced in soils where mycorrhizal associations are active.

If nursery stock (rootstock and grafted youngstock) has been subjected to fungicide treatment, it will guarantee that mycorrhiza as well as non-beneficial fungi have been eliminated. The use of non-fungicidally treated and organic nursery stock is more likely to have mycorrhiza present.

Brassica-based Soil Additives

The USDA has been experimenting for more than a decade on adding brassica seed meals to orchard soils to facilitate biological control of ORD agents, as an alternative to fumigation. While this started off with promising results[23], the ongoing research has thus far failed to make enough progress[24] to render this technique useful in the field.

Compost-based Soil Additives

While some research[25] has indicated that the addition of compost and compost-based material in to the planting zone is ineffective in combating ORD, research in marginal conditions in South Africa has shown clear benefits[26].

Breeding Resistance to ORD

Preliminary research[27] indicates that there is a good possibility of breeding resistance to apple replant disease in *Malus* sp. Further work is required to realise this.

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[21] Veghelyi, K. (1994), 'Myccorrhizal root rot fungi and fruit trees', *Acta Horticulturae*, 175-175.

[22] Szucs, E. and K. Veghelyi (1996), 'Observation with Entoloma clypeatum mycorrhizal fungus in Hungarian orchards', *IV International Symposium on Replant Problems 477*, 123-26.

[23] Mazzola, M., et al. (2001), 'Suppression of specific apple root pathogens by Brassica napus seed meal amendment regardless of glucosinolate content', *Phytopathology*, 91 (7), 673-79.

[24] Mazzola, M. and L.M. Manici (2012), 'Apple Replant Disease: Role of Microbial Ecology in Cause and Control', *Annual Review of Phytopathology*, 50 45-65.

[25] Wilson, S., P. Andrews, and TS Nair (2004), 'Non-fumigant management of apple replant disease', *Scientia horticulturae*, 102 (2), 221-31.

[26] Van, Schoor, L., S. Denman, and NC Cook (2009), 'Characterisation of apple replant disease under South African conditions and potential biological management strategies', *Scientia Horticulturae*, 119 (2), 153-62.

[27] Isutsa, D.K. and I.A. Merwin (2000), 'Malus germplasm varies in resistance or tolerance to apple replant disease in a mixture of New York orchard soils', *HortScience*, 35 (2), 262-68.

Suggested Management Actions in Historic Orchards

The following framework is proposed as an ordered methodology to address Orchard Replant Disease in historic orchards in Scotland:

1. Assessment of residual threat. Determine the whether there have been any active roots or living trees in the planting area (diameter approx 6m) within the last 20 years. If there have not, then the area may be considered to be fallow for that period and the disease agents for ORD are likely to significantly depleted.
2. Planting location. As a matter of good practice, do not plant in the exactly the same location as the previous tree. Move at least 2m along the row, or create a new row at least 2m offset if this is not possible. When working with rig and furrow orchards this is more problematic but may still be possible if the rig is wide.
3. Rotation. If a number of species are to be planted, determine the previous species in each location, and follow the 'pome and stone' rule, so that pome does not follow pome (apple, quince, medlar, pear), and stone does not follow stone (plum, cherry, gage, apricot, peach).
4. Vigorous rootstocks. Use larger forms of tree such as standards, that have a more vigorous rootstock. If possible use a *Phytophthora* resistant rootstock particularly in wet soil conditions.
5. Soil replacement. Where, it is not possible to avoid the same planting location, or a diseased tree is known to have existed, or indeed a valuable specimen is to be planted, then soil replacement should be carried out, to a diameter of 1.2m and 0.7m deep. The smaller the area of soil replacement, the smaller the benefit. Walled gardens, against the walls, at path sides and on espalier lines are definite candidates for soil replacement. The replacement soil should be from a healthy and fertile soil from non-orchard location. However, in a rig and furrow orchard, it may be that material from the adjacent furrow is suitable.
6. Other techniques. The use of other techniques such as soil solarisation, soil trenching or mycorrhizal enhancement may well be useful in addition to the above. More experience of their use in Scotland is required.