Determining the occurrence of replant disease in British Columbia orchard and vineyard soils by pasteurization1

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Experiments were conducted to determine by response to soil pasteurization what sequence of fruit trees or grapevines will grow without damage by replant disease after removing a particular fruit tree or grapevine crop. Apple seedlings developed replant disease in apple, peach, cherry, pear, and grape soils. Peach trees may be planted after any fruit tree or grapevine crop. Plums will grow normally when planted after grapes or any fruit trees except peach. Testing of orchard and vineyard soil is required for the proper diagnosis and treatment of replant disease.

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On a réalisé des experiences afin de dbterminer, en se fondant sur la reaction à la pasteurisation du sol, quelle sequence d'arbres fruitiers ou de vignes ne serait pas endommagee par la maladie de la replantation après avoir éliminé une culture particulière d'arbres fruitiers ou de vignes. Les plantules de pommiers plantées dans des sols ou l'on avait antbrieurement cultivé des pommiers, des pêchers, des cerisiers, des poiriers et des vignes ont été frappbes par la maladie de la replantation. En outre, les pêchers peuvent être plantes dans un sol ou a poussé n'importe quel arbre fruitier ou n'importe quelle vigne. Les pruniers croîtront normalements'ils sont plantés après des cultures de vignes ou d'un arbre fruitier, à l'exception du pêcher. Il est nécessaire d'analyser les sols de vergers et de vignobles afin d'établir un diagnostic exact et de determiner le traitement des plantes atteintes de la maladie de la replantation.

Introduction

Many fruit crops grow poorly when replanted into orchards where fruit crops of the same or closely related species were previously grown. This "soil sickness" has been recognized for over 200 years (Traquair 1984). Because of the cost of fruit production and the limited supply of suitable land for fruit trees in portions of the U.S., Canada, and European countries, the replant problem has become a major concern to the fruit growers in these regions.

Confusion exists over use of the term specific and non-specific replant disease. Savory (1966) coined the term "specific replant disease (SRD)" to describe the poor growth of many fruit and plantation crops when planted on land previously occupied by the same or closely related species. No leaf symptoms are evident but the roots of affected plants are weak, sparsely branched, discoloured, and necrotic (Savory 1966). Trees with SRD symptoms are usually evenly distributed in the orchard (Mai and Abawi 1981). The causal agents of SRD appear to persist in the soil for a number of years. SRD persisted in apples even after the orchard soil was cropped for at least eight years with grasses and cereals (Hoestra 1968, Savory 1967, Sewell 1979). Because of the control obtained by soil fumigation and heat treatment, the causal agents are considered to be biotic (Jaffee *et al.* 1982, Mai and Abawi 1981, Sewell 1981, Slykhuis and Li 1985, and Westcot and Beer 1986).

Non-specific replant disease refers to the poor crop of fruit trees regardless of the previous fruit crop (Mai and Abawi 1981). Symptoms include stunting and retarded shoot growth, leaf chlorosis, discolouration and necrosis of feeder roots and, in severe cases, death of the tree within two to three years of planting. Necrosis of young roots by parasitic pathogens may or may not be obvious (Mai and Abawi 1981). Affected trees have patchy distribution in the orchard. The factors responsible for non-specific replant disease are toxic plant products, nematodes, unbalanced soil nutrition, poor soil structure and drainage, low or high pH, and cold or drought stress (Mai and Abawi 1981, Patrick *et al.* 1964).

Replant disease has become a major concern to the growers in the Okanagan and Similkameen valleys of British Columbia. Slykhuis and Li (1985) tested 51 orchard soils and found that apple seedlings on all of these soils responded to pasteurization, ammonium phosphate (11-55-0) fertilizer, or both, indicating that the soils might adversely affect the growth of apple trees. It has not been determined in what sequence fruit tree species or grape vines can be planted without harm from replant disease in old orchard/vineyard soils. The following experiments were conducted with seedlings to determine such sequential effects for six fruit tree species and grapes.

Materials and methods

Soils were collected from the root zone 15 cm below the surface under standing (25-30 years old) fruit trees [Peach (Prunus *persica* L.), Apricot (*Prunus armeniaca* L.), Apple (*Malus pumila* Mill.), Cherry (*Prunus avium* L.), Plum (*Prunus domestica* L.), Pear (*Pyrus communis* L.)] and grape vines (*Vitis vinifera* L. 10-20 years old) in the Okanagan and Similkameen valleys of British Columbia. These soils were placed in polyethylene bags, tightly closed to maintain moisture, and kept in a cool place (10°C) until used. Each soil sample was mixed thoroughly to assure uniformity, and passed through a 5-mm sieve to remove stones and root fragments. Samples were removed from each bag and passed through a 2-mm sieve to remove stones and root fragments. Chemical analysis of all soils for soil analysis were done by a soil testing laboratory and are presented in Table 1.

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Table 1. Soil analysis results of various soil samples used in this experiment.

Soil Source	Chemical analysis (ranges in ppm)						
	pH	N	P	K	Mg	Ca	B
Peach	5.7 -7.6	2-152	56 - 144	142 - 364	92-610	654 - 3562	0.32 - 0.59
Apricot	6.5 -7.4	7 -65	38-210	100 - 892	354 - 700	1438 - 2982	0.36 - 0.91
Apple	6.1 -7.3	3 -80	39 - 400	160 -322	176-388	1013-1528	0.30-1.02
Cherry	5.6 -6.5	20 - 72	342 - 942	274 - 770	156 - 426	2734 - 5334	0.54 - 1.34
Plum	6.7 - 7.8	12-84	16 - 167	110-468	230 - 370	1345-8147	0.35 -0.89
Pear	5.5 -7.7	6 - 76	12-472	176 - 1526	126 - 870	858-12146	0.66-2.29
Grape	6.8 - 7.9	4-125	216-400	436 - 700	165 - 544	3120-7861	0.17-0.84

Half of the soil was pasteurized (70°C. 1 h) and the remaining half was non-treated. The soil was placed in 10-cm diameter pots. Each of the two treatments was replicated 5 times. Seeds of fruit trees were treated with Captan to control damping off and then stratified at 0-2°C in moist paper towels and sealed in plastic bags for 10 weeks. Seeds were planted in a peat-moss and perlite mixture (1:1). Germination occurred within a week at 20°C. After 7 days, seedlings were selected for uniformity. Two seedlings of fruit trees or root cuttings of grapevines were planted in each pot. Seedlings or rooted cuttings were grown in the greenhouse (20 ± 2°C) supplemented with fluorescent lighting to give a 14 h photoperiod.

To determine the presence of replant disease in various orchard/vineyard soils, seedling growth was measured after 14 weeks. An increase of 50% or more in seedling height in pasteurized soil compared to non-pasteurized soil, plus being significant at 1% level was considered as evidence of replant disease.

Results and discussion

When peach orchard soil was used, pasteurization provided a definite increase in growth of apple, cherry, plum and grape seedlings, but apricot and pear seedling growth was not increased (Table 2). This indicates a possible replant problem

Table 2. The effect of pasteurization of soil from fruit orchards and vineyards on the growth of fruit and grape seedlings in the greenhouse.

Orchard Soil	Seedlings planted						
	Peach	Apricot	Apple	Cherry	Plum	Pear	Grape
Peach	?(4)†	-(2)	+(4)	+(4)	+(2)	-(4)	+(4)
Apricot	-(4)	-(2)	-(4)	+(4)	-(2)	-(4)	+(4)
Apple	-(4)	?(2)	+(4)	-(4)	?(2)	+(4)	+(4)
Cherry	-(4)	+(2)	+(4)	+(4)	-(2)	?(4)	+(4)
Plum	-(4)	+(2)	-(4)	+(4)	-(2)	-(4)	-(4)
Pear	-(4)	?(2)	+(4)	?(4)	-(2)	?(4)	-(4)
Grape	-(4)	+(2)	+(4)	+(4)	-(2)	?(4)	?(4)

? Response to pasteurization not consistent.
+ 50% or more increase in growth after pasteurization and significant at $p = 0.01$.
- No improvement from pasteurization,
† No. of orchard soils tested for replant disease of fruit trees and grape vines.

for apple, cherry, plum and grapes but not for apricot and pear in the peach orchard chosen for the test. The response of the peach seedlings was not clear. In apricot orchard soil, only cherry and grape seedlings responded to pasteurization.

No replant problem was observed for cherry or peach seedlings planted in apple orchard soil. These results are similar to that observed by Savory (1966), Pitcher *et al.* (1966), Hoestra (1968), and Jackson (1973). In our trial, apple seedlings planted in cherry orchard soils developed replant disease. But the growth of apple in old cherry soils, fumigated or not, showed increases of 51% in the Netherlands (Hoestra 1968) and 44 and 60% in England (Pitcher *et al.* 1966). The average increase in growth response in England soils were 52%. This value is slightly above that of ours.

Apples, pears or grapes should not be planted after apples without soil treatments; however, peach and cherry soils do not need any treatment. Similar observations were made by Hoestra (1968) and Sewell (1979).

Peach was the only tree crop that was free of replant disease after any of the tree fruits or grapes. Plum was free from replant disease except after peach. These observations suggest that replant disease is not crop specific. The planning for new orchards should start at least one year before pulling out old trees. These soils should be tested to determine the presence of replant disease. These tests also indicate the best possible soil treatment to avoid replant disease. It is essential to follow the standard horticultural production procedures to obtain the best growth of young fruit trees or grapevines planted in old orchard/vineyard sites.

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