RESEARCH ON REPLANTING APPLES WITHOUT MeBr IN TASMANIA, AUSTRALIA

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Introduction

Tasmania is an island state of Australia located between latitudes 41 and 43°S. The island has a land area of 68,331 km^2 and a population of close to 500,000. The climate is moist, with greater than 800mm rainfall per year, and mild, with an average summer maximum temperature of around 18°C and a winter minimum of 0°C. The dominant fruit crop in the state is apples with over 1,500,000 trees producing 47,000 tonnes of fruit. Each year approximately 60 Ha of orchard is replanted and of this 35 Ha is treated with methyl bromide prior to planting. This represents about 30 to 50% of orchard methyl bromide use in Australia.

Extent and severity of apple replant disease in Tasmania

In 1996/97 a pot experiment was conducted to estimate the frequency of apple replant syndrome in the state (Table 1). Eleven soils were tested of which soil 1 was not from an apple replant situation.

Table 1. Effect of apple replant disease on shoot growth (mm) of tissue cultured mm26 apple rootstocks after 3 months of growth.

Soil Number	1	2	3	4	5	6	7	8	9	10	11
Sterile (Heat)	275 a	491 a	483 a	415 a	242 a	489 a	214 a	521 a	570 a	441 a	286 a
Untreated	312 a	131 b	145 b	129 b	78 b	186 b	90 b	223 b	266 b	244 b	199 b
% growth reduction	-13	73	70	69	68	62	58	57	53	45	30

Means in the same column with the same letter considered not different (LSD *p*=0.05)

Of the soils tested only the soil from a non orchard situation (soil 1) showed a growth reduction with soil sterilisation. All the other soils, which were from old orchard sites to be replanted, showed an improvement in growth with soil sterilisation. The severity of the disease varied between the sites with most displaying greater than 50% reduction in growth due to the disease.

Apple replant disease and fruit yield

During 1997 two field trials were established. Their foliar area was measured at the end of the following season and fruit yield measured in the second season, 46 months after planting (Table 2).

Table 2. Effect of apple replant disease on foliar area and yield of 'Fuji' apple trees.

Site	1		2	
Parameter	Foliar area	Yield	Foliar area	Yield
Methyl bromide	2524 a	13.4 a	1978 a	7.61 a
Untreated	1402 b	10 a	1195 b	5.47 a
% reduction	44	25	40	28

Means in the same column with the same letter considered not different (LSD *p*=0.05)

At both sites foliar growth was reduced by about 40% due to growth in non sterile soil. This large reduction in growth was not reflected, however, in the data for fruit yield where the yields, although being 25% lower, were not statistically different from the methyl bromide treatment.

The role of nematodes in apple replant disease in Tasmania

In the pot trial utilizing 11 soils, discussed above, Nemacur was tested for its effect on apple replant disease in order to indicate the importance of nematodes with this problem in Tasmania (Table 3).

Table 3. Effect of Nemacur on tissue cultured mm26 apple rootstocks after 3 months of growth.

	Growth (mm)	Growth reduction (%)
Sterile	402 a	
Untreated	182 c	55
Nemacur	201 b	50

Means in the same column with the same letter considered not different (LSD *p*=0.05)

While there was some measurable improvement in growth with the use of Nemacur, the improvement was small. Further, studying the data for the individual soils it was found that the treatment was effective in only 4 of the orchard soils (data not presented). Hence this data suggests that nematodes are not the principle cause of replant disease in Tasmania.

The role of fungi in apple replant disease in Tasmania

Four trials were conducted which included fungicides to indicate the role of fungi in replant disease in Tasmania (Table 4). Fungicides tested include Shirlan, (in the trial with 11 soils), Ridomil (a separate trial with 2 soils) and Thiram (in the two field trials).

Table 4. Effect of fungicides on apple replant disease in Tasmania.

Trial	11 soils – pot trials		2 soils – pot trials		Field trial 1		Field trial 2	
Parameter	Growth (mm)	Growth reduction (%)	Growth Rate (mm/week)	Growth rate reduction (%)	Foliar area (cm^2)	Foliar reduction (%)	Foliar area (cm^2)	Foliar reduction (%)
Treated (sterile)*	402 a		44 a		2524 a		1978 a	
Untreated	182 b	55	9 b	80	1402 b	44	1195 b	40
Fungicide**	192 b	52	8 b	81	1108 b	56	1152 b	42

Means in the same column with the same letter considered not different (LSD *p*=0.05).
* Sterilised by heat (trial 1), antibiotic (trial 2) and Methyl Bromide (trials 3 and 4).
** Fungicides Shirlan (Trial 1), Ridomil (Trial 2) and Thiram (Trials 3 and 4).

None of the fungicides tested had an impact on apple replant disease in Tasmanian soils indicating that fungi are not responsible for this problem in this location.

The role of bacteria in apple replant disease in Tasmania

The role of bacteria in apple replant disease in Tasmanian soils was examined by the incorporation of streptomycin into two sets of pot trials (table 5).

Table 5. The effect of streptomycin on apple replant disease in two pot trials conducted with Tasmanian apple soils.

Trial	Pot Trials – 5 soils		Pot trials – 2 soils	
Parameter	Growth (mm)	Growth reduction (%)	Growth rate (mm/week)	Growth rate reduction (%)
Sterile	295 a		21 b	
Untreated	117 c	60	9 c	59
Streptomycin	238 b	19	44 a	-107

Means in the same column with the same letter considered not different (LSD *p*=0.05).

In both sets of trials the application of streptomycin (1 g/L) to the soil prior to planting significantly improved growth of the young plants. The poor results for the heat treatment in the second set of pot trials was possibly due to the use of older tissue cultured plants which may have been infected with replant disease prior to planting. These results strongly suggest that a bacteria, or another organism sensitive to streptomycin, is the primary cause of apple replant disease in Tasmania.

Potential biological control of apple replant disease in Tasmania

Trichopel (selected strains of Trichederma spp.) and Vaminoc (selected strains of Glomus) from Agrimm Technologies, New Zealand, were tested in a pot trial for their effect on apple replant disease (Table 6).

Table 6. The effect of Vaminoc (glomus spp.) and Trichopel (trichoderma spp.) on apple replant disease in Tasmania

	Growth rate (mm/week)	Growth rate reduction (%)
Streptomycin	44 a	
Untreated	9 bc	80
Trichopel	18 b	60
Vaminoc	0 c	100

Means in the same column with the same letter considered not different (LSD *p*=0.05).

While the growth rate of the Vaminoc and Trichopel treatments were not different to the untreated controls there was a trend in the data that indicated that Trichopel may help apple trees to overcome replant disease. The poor results for the Vaminoc indicate that this material, applied at planting time, is of little assistance in overcoming apple replant disease. This material may be useful, however, if applied prior to planting to allow for mycorrhiza establishment before exposing the trees to the disease. Field trials have been established to study this further.

Calcium hydroxide and its effect on apple replant disease in Tasmania

Calcium hydroxide at 45 g/L of soil was added to 3 replant soils in 2 trials to study the effect of this material on apple replant disease in Tasmania (Table 7).

Table 7. The effect of calcium hydroxide at 45 g/L on growth of tissue cultured mm26 rootstocks in Tasmanian apple replant soil.

	Pot trial 1 - 1 soil Growth (mm)	Pot Trial 2 - 2 soils Growth (mm)
Heat	425 ab	355 a
Untreated	325 bc	95 b
$Ca(OH)_2$	444 a	151 b
Heat + $Ca(OH)_2$	226 c	305 a

Means in the same column with the same letter considered not different (LSD p=0.05).

The first pot trial was conducted on a very acidic apple soil (pH 4.5) where apple replant disease was not severe. In this soil the addition of calcium hydroxide eliminated the growth retarding effect of apple replant disease. While the same trend was in the data for the second trial the results were not statistically significant. This may have been due to the higher starting pH of these soils (pH 5.5) or due to the severe nature of replant disease encountered in these soils (73% growth reduction). This treatment is being studied further in recently established field trials.

Irrigation and its effects on apple replant disease in Tasmania

A pot trial was established using 5 orchard soils with differing levels of water application (Table 8).

Table 8. The effect of level of water application on growth of tissue cultured mm26 rootstocks in Tasmanian apple replant soil.

	Growth (mm)
Heat + water stress	265 b
Heat + no water stress	402 a
Untreated + water stressed	160 c

Untreated + no water stress	163 c

Means in the same column with the same letter considered not different (LSD p=0.05).

While the level of watering had a major impact on the growth of trees growing in sterile soil there was no effect of watering level on trees growing in apple replant affected soil. These results highlight that apple replant disease cannot be overcome in Tasmania by the use of extra irrigation water.

Nutrients and their effect on apple replant disease in Tasmania

The effect of mono ammonium phosphate (MAP @ 1.5 g/L soil) fertilizer was studied in pot trials using 2 orchard soils (Table 9).

Table 9. The effect of level of mono ammonium phosphate on growth of tissue cultured mm26 rootstocks in Tasmanian apple replant soil.

	Growth (mm)
Heat	595 b
Untreated	176 d
Heated + MAP	718 a
Untreated + MAP	386 c

Means in the same column with the same letter considered not different (LSD p=0.05).

It was found that adding MAP to sterile soil increased shoot length by 123 mm representing a 20% increase in shoot growth while in non sterile soil the addition of MAP resulted in a 210 mm or 120% increase in shoot length. These results suggest that the addition of MAP fertilizer to non sterile soil resulted in a shoot growth response greater than that expected by nutrition alone.

Summary of results

This study has revealed that fungicides and irrigation cannot be used to control apple replant disease in Tasmanian orchard soils (Table 10). The results for mycorrhiza were disappointing, however, as these beneficial fungi are slow growing it is felt that there is a need to study fungi by infecting trees in the nursery beds rather than just prior to planting. The use of netmaticides appears to be important in approximately 40% of Tasmanian Orchards. While this pest is not primarily responsible for apple replant disease in Tasmania its control in affected soils is necessary if a selective control of apple replant disease is commercialised. The results for Trichoderma, calcium hydroxide and MAP fertilizer are encouraging and further field studies are currently underway with these materials. The use of soil applied streptomycin has been found to be the most reliable treatment to control apple replant disease in Tasmanian apple orchards. This product is not approved for use in agricultural crops in Australia, however, such that this is not a practical alternative at this point in time.

Table 10. Summary of treatments for their effect on apple replant disease in Tasmanian apple replant soils.

Treatment	Effects on apple replant disease
Fungicides	No effects.
Irrigation	No effects.
VA Mycorrhiza	No effects. Need to study infection prior to exposure to replant disease.
Nematicides	Some effect on some soils.
Trichoderma	Some effect. More work needed.
Calcium hydroxide	Some effect. More work needed.
MAP fertilizer	Some effect. More work needed.
Streptomycin	Effective. Registration and cost aspects need to be studied.

Acknowledgement

The author wishes to thank the Horticultural Research and Development Corporation for their financial support of this project.