Replant disease
Why you need to control it

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Background of replant disease

Replant disease is a debilitating soil problem affecting most orchards when they are replanted. Symptoms normally affect the entire orchard and include slow, uneven growth and poor tree performance. Due to the general nature of replant disease, it is easy to be unaware that it is present, or to blame the rootstock or nursery for poor tree performance. Replant disease affects most fruit crops including both Pome and Stone fruit. In Glasshouse trials, using soils from 10 Tasmanian apple orchards, it was found that they all had replant disease, which resulted in a 30-73% reduction in growth of young trees. Hence, this problem is extremely widespread and not isolated to individual orchards.

The ramifications of replant disease need to be considered in light of the modern trend of rapid orchard replacement. Twenty years ago orchards were replanted every 20 - 50 years, with a tree density of around 600 trees per Ha or less. Modern orchards are potentially being replaced every 10 - 15 years, with up to 3000 trees per Ha. Considering the cost of replanting is between $40,000 and $60,000 per Ha, it is essential to have high early returns for the economic viability of the orchard and replant disease makes this task more difficult.

This article concentrates on apples, although many of the aspects discussed will be equally relevant to the stone fruit industry, which also encounters replant diseases.

It is commonly accepted that there are two forms of replant disease; specific and non-specific. Specific apple replant disease only affects apples when they are planted after apples. Non-specific replant disease affects apples that are replacing other fruit crops, such as stonefruit or vice versa. Non-specific replant disease is often associated with nematode activity although fungi can also be involved. Using a nematicide in pot tests it was identified that 40% of Tasmanian orchards have both specific and non-specific replant disease and the potential impact of nematodes should not be under estimated. This means that changing from one crop type to another is no guarantee of avoiding replant problems.

Unfortunately, the exact cause of apple replant disease has not been identified and is probably a complex of organisms interacting with each other with a different complex in different orchards and regions. These replant disease ecosystems may include a mixture of nematodes, Actinomycetes (filamentous bacteria), bacteria and fungi such as *Rhizoctinia, Pythium* and *Phytophthora*. This has lead to no specific treatments that can be reliably applied to target and control this disease with minimal impact on desirable soil organisms. In Tasmania, when nematodes have been specifically controlled, fungicides have not been effective against replant disease. However, soil applications of the antibiotic streptomycin has been extremely effective, indicating that in this region, a bacteria, is involved in the replant disease ecosystem. It must be noted that antibiotics are not registered for horticultural application in Australia and are not likely to be registered in the future.

Chemical control of replant disease

Due to the inability to identify the exact cause of replant disease, the use of soil sterilisation products to totally destroy the existing soil ecosystem prior to planting, has been the only reliable method of

commercially guaranteeing excellent orchard performance after replanting. Other methods of avoiding replant disease such as fallow and cover crops have to date, proved unreliable for the control of this disease.

During the 1990's, apple replant disease was commonly controlled using methyl bromide soil fumigation before planting. However, under the Montreal Protocol on Substances that Deplete the Ozone Layer, which was developed in 1987, methyl bromide has been phased out and is no longer available for this use in Australia. In Australia, we have two alternative soil sterilants for apple replant disease that are both effective and registered.

Chloropicrin is a fumigant and has been shown in numerous trials in Tasmania to be effective when used at the highest label rate (Figure 1). Unfortunately, commercial experience is that it is not effective at the lower label rates (15 – 30ml/m^2) and the concentration in Telone C35 appears to be ineffective for specific apple replant disease. The disadvantages of chloropicrin, is the need for specialised application equipment, covering with plastic and the associated cost of plastic removal and disposal.

The alternative registered pesticides are the products that produce MITC for their sterilant activity (figure 2). There are two basic groups of materials that produce MITC, Basamid® which is a relatively safe and user friendly powder, and Metham Sodium, a dangerous liquid material (Schedual 6) which is substantially cheaper than Basamid®. I have used Basamid® regularly because of its relative safety, ease of use and ability to treat small areas and it is extremely effective against replant disease. Although plastic is not always required for MITC compounds the disadvantage is that they need to be incredibly well incorporated into the soil, with multiple rotary hoeing immediately after application, and a high soil moisture content is required for MITC to be generated in sufficient concentration after application. Application to a dry soil is extremely ineffective and a total waste of money.

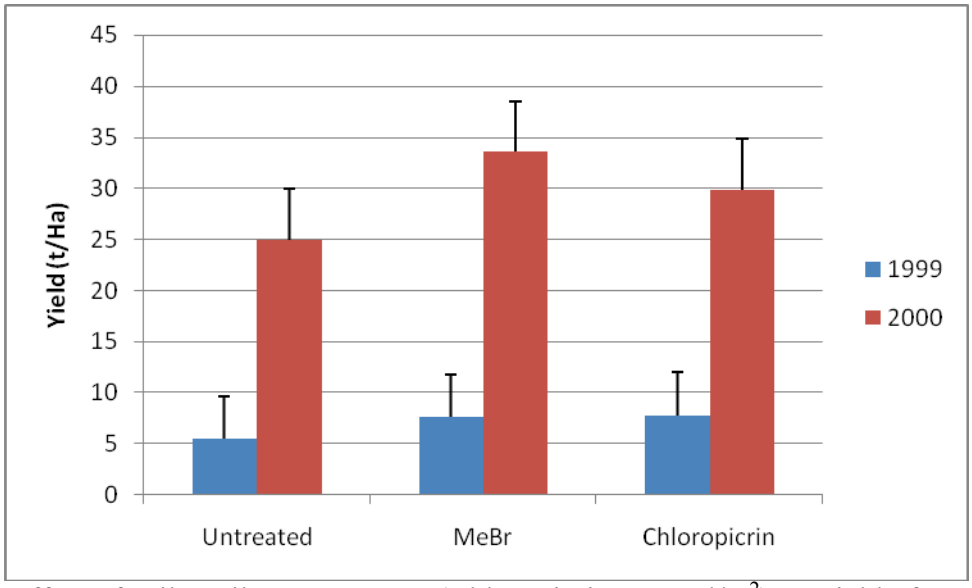

Figure 1. The effect of soil sterilant treatments (Chloropicrin at 50ml/m^2) on yield of 'Fuji' apples 2 and 3 years after planting. Bars = 5% LSD value from split plot analysis of variance. Funding from TIAR, Hansen Orchards and Clements and Marshall.

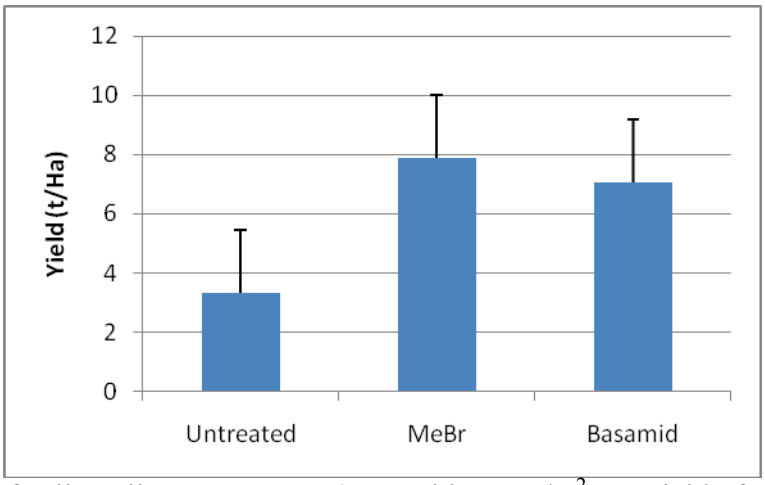

Figure 2. The effect of soil sterilant treatments (Basamid at 60g/m^2) on yield of 'Sundowner' apples 2 years after planting. Bars = 5% LSD. Funding from BASF and Duggan orchards.

Hydrated lime and replant disease

As a result of the finding that antibiotics control replant disease indicating the involvement of a bacteria in apple replant disease, a pot trial was established to determine the effect of increasing soil pH on replant disease, as bacteria tend to prefer acid environments. This treatment has the potential to provide an environmentally friendly solution to this replanting problem. The trial revealed that if the pH was adjusted sufficiently then the effects of replant disease could be totally overcome (figure 3).

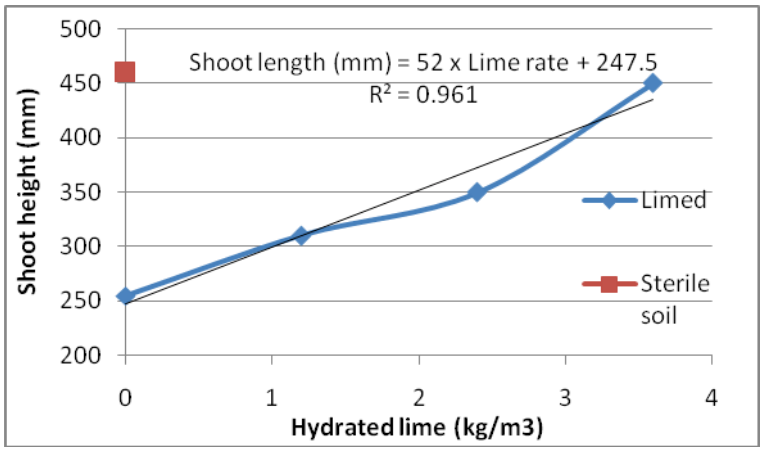

Figure 3. The shoot growth of apple trees after 10 weeks of growth in pots with orchard soil with varying rates of added hydrated lime ($Ca(OH)_2$). Soil pH ranged from 5.8 to 7.3 at the time of planting. Shoot height of tree growing in sterile soil without lime = 460mm. Funding from HAL project AP97005.

The effect of lime addition to the soil, on replant disease in the pot trials, indicated a need for a field trial to be established to test this treatment in an orchard environment. This field trial was established in 1999 and the tree performance over the past 10 years has been monitored (figure 4). In the first few years of this trial it was found that the lime treatment increased the yield of fruit to a level just below the Basamid® treatment, although the yields were not quite as high as the methyl bromide treatment. By years five to seven, however, the yields of the nematicide and nematicide plus lime treatment were approaching those of the two sterilant treatments. By nine years the annual yields of these treatments

were equivalent to those of the sterilants and these treatments had caught up with the soil fumigation treatments for their annual yields of fruit.

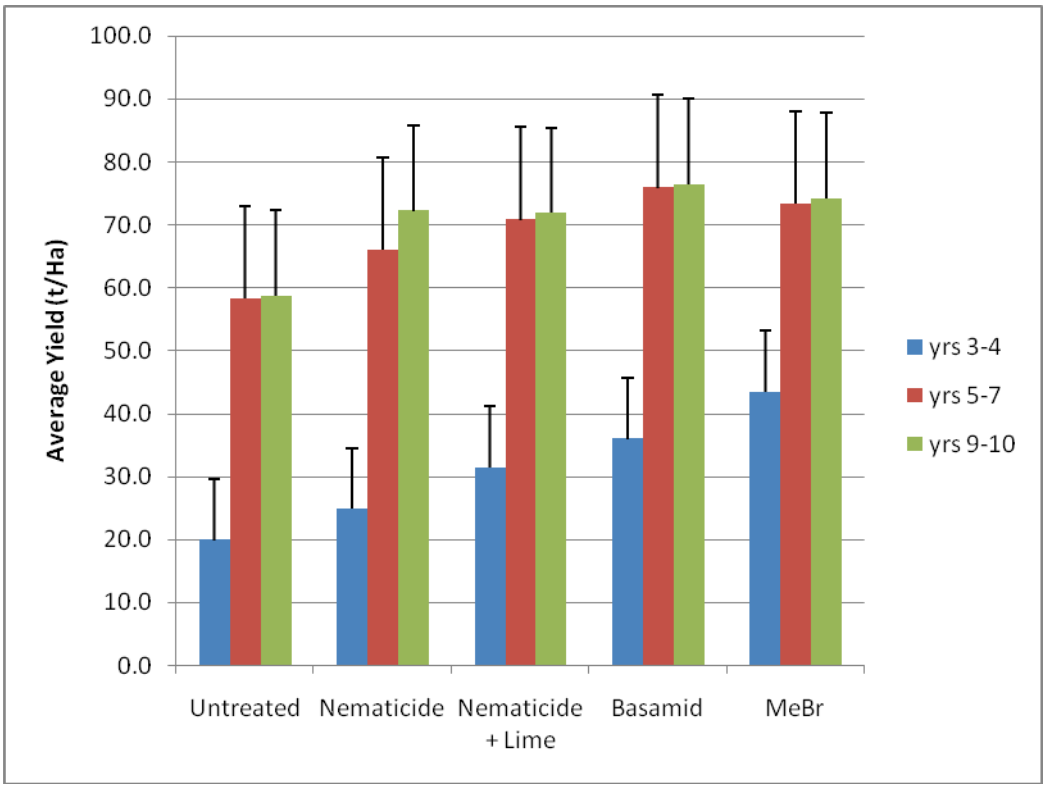

Figure 4. The average yield of 'Golden Delicious' fruit with soil preplant treatment. Nematicide = Mocap® at 11g/m^2, Lime = 1kg/m^2, Basamid® = 60g/m^2 MeBr = 50g/m^2. Bars = 5% LSD values. There was a severe frost in year 8 and no fruit remained on the trees. Funding from HAL project AP97005, AP05015, Hansen Orchards and Scientific Horticulture.

In order to determine the economic impact of these treatments it is necessary to study the cumulative yield of fruit over the ten years of orchard life (figure 5). Assuming a return of $2/kg for the fruit, at this trial site, failure to treat for apple replant disease caused a $250,000 reduction in gross income over the 10 year life of this orchard. The Basamid® treatment provided a similar level of income to the methyl bromide and the nematicide plus lime treatment resulted in a $185,000/Ha increase in gross income. The nematicide treatment alone also increased tree performance, with a $120,000 increase in gross income in this orchard over the 10 years to 2009. In Figure 5, the base line starts at $250,000 as this is approximately the cost of orchard establishment and operation over the 10 year period, such that the bars visually represent the 'profit' for the orchard. This suggests that 'profit' is increased from $400,000 to $600,000 per Hectare for the 10 years as a result of treating for apple replant disease. These findings demonstrate that while some of the treatments for replant disease appear expensive, there is an excellent return on their investment.

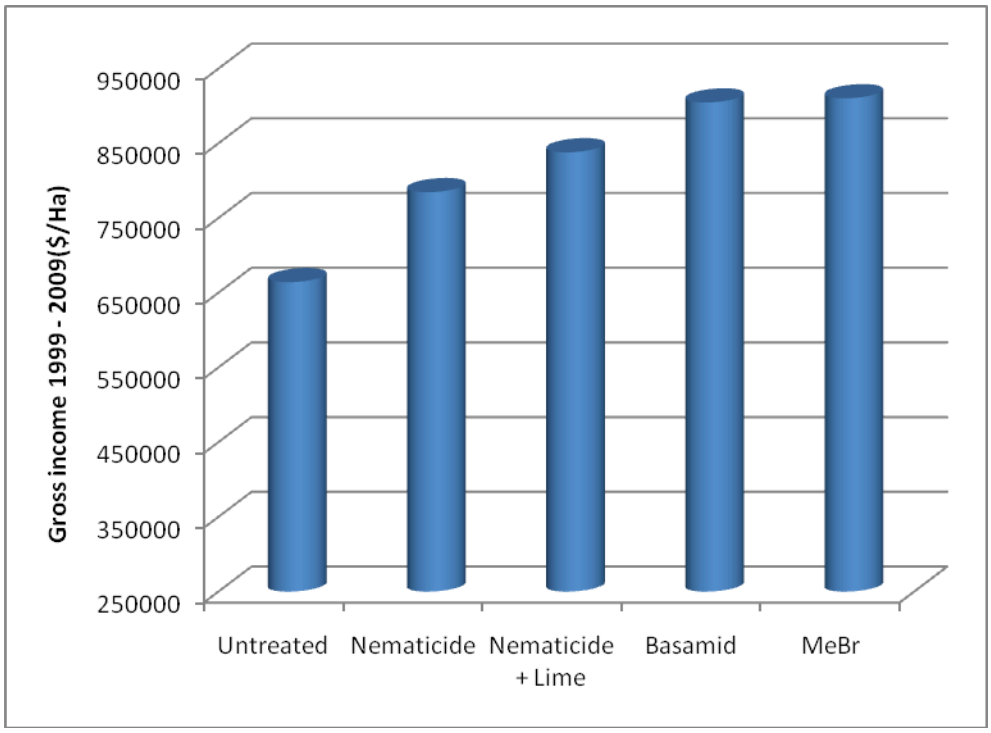

Figure 5. Gross income per Ha for 10 years of orchard life with preplant soil treatment. Based on fruit value of $2/kg. 5% LSD = $150,000. Funding from HAL project AP97005, AP05015, Hansen Orchards and Scientific Horticulture.

In order to confirm the effect of preplant lime application on replant disease and to determine the optimal application rate, a second field trial, on a different orchard, was established in 2006. At the time of planting the soil pH ranged from 6.4 for the untreated, to 7.6 for the treatment where 10t/Ha of hydrated lime was added to the soil. Unfortunately a frost occurred in the spring of 2008 causing uneven fruit set, so all fruit were removed from the trees preventing the measurement of actual fruit yield in 2009. Instead the trunk cross sectional area provided a good indication of the tree performance and this measurement is directly related to the potential yield of these trees (figure 6).

As for other replant sites, apple replant disease was present at this site, as can be seen with reduced tree growth for the untreated plots compared with the Basamid® treatment, although replant disease was not severe at this site. In the pot trial it was found that increasing the rate of hydrated lime application was associated with improved tree growth rate. This trial confirmed the results of the earlier field trial and showed that the application of 10 t/Ha of hydrated lime caused the trees to grow at a similar rate to the Basamid® treatment. The trial also identified that lower rates of application in the field are not as effective at reducing apple replant disease, suggesting that if this approach was used then lower rates of application should be avoided. If adopting this approach, it should also be noted that these results are for two sites in Tasmania only. There is no guarantee that the treatment will work at other sites, so it is suggested that orchardists interested in this treatment should apply hydrated lime to a single row in any new orchard to be replanted and fumigate the other rows normally. These results also raise the question as to what is the optimal pH for growing apple trees?

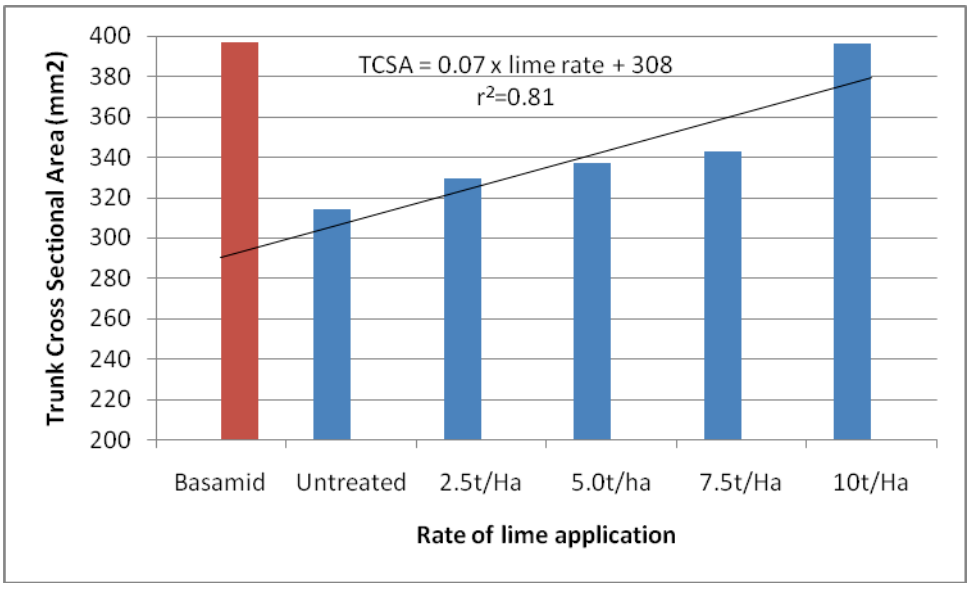

Figure 6. The impact of preplant hydrated lime ($Ca(OH)_2$) application rate on 'Pink Lady' / MM106 tree size at the end of the third season after planting. 5% LSD = $87mm^{2.}$ Funding from HAL project AP05015 and Tahune Nursery.

Summary

Replant disease of orchards is an important issue which potentially has a major impact on the farm income. There are two types of replant disease, specific and non specific which means that changing from pome fruit to stone fruit (and visa versa) is no guarantee of avoiding the disease. As there is no diagnostic test commercially available, it is wise to assume that an orchard to be replanted has a replant disease problem which needs to be treated. Commercially there are soil sterilants available that are effective against this disease. If it is not desired to use these chemicals then other practices such as fallow, cover crops and other treatments should be considered. This article is not comprehensive, however, it does indicate that hydrated lime treatment may be an economic, easy to use and environmentally friendly treatment. This treatment also has potential to be applied close to planting without damaging the trees.

Acknowledgements

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