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Soil treatments against replant pests and diseases

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Introduction

Fruit trees, being a perennial, remain in the orchard soil for one or more decades prior to being removed and replanted. This means that there is an extremely long period of time, while the trees are in the orchard, for the build up and distribution of pests and disease that live on the roots of the trees. While these root pests and diseases usually only have a minor impact on mature trees, in young, rapidly growing orchards this is not the case. In newly planted orchards root pests and disease adversely affect the tree resulting in slow growth. This delays the first significant harvest of fruit by a more than a year and it may take greater than 10 years for the trees to reach their full potential. An example of this can be seen in figure 1, where after the first 7 years of the orchard life apple replant disease reduced cumulative yield from 306 tonnes to 215 tonnes representing a $182,000 loss of income per hectare in the 7 year period. This can have a devastating effect on the economic viability of a young high density orchard and this needs to be avoided. The cost of proper orchard preparation prior to planting is minor compared to the lost income.

Unfortunately there is no simple, quick and inexpensive test that can be conducted to verify if replant problems exists in a particular orchard. One of the problems here is that there is often more than one organism involved and it is the total ecosystem that is of interest. If there is sufficient time then a biological test could be conducted in the season prior to removing the orchard. This is conducted by growing trees in pots filled with orchard soil (plus 25% perlite to make them more suited to the pot environment) where half the pots have soil that has been sterilised (eg. moist soil at 60°C for several days). You will need a minimum of ten trees in individual pots in untreated and ten in sterilised soil and this should be set up in the winter, prior to bud burst in spring. Growth needs to be studied at the end of the following season as cyclic shoot growth can give incorrect answers if growth is studied too early. If this can not be performed then it is best to assume that replant problems are in your orchard soil and to take corrective steps prior to replanting.

This article will focus on the treatments that may be used to help overcome the many replant pests and disease in both pome and stone fruit orchards.

Environmentally friendly treatments

Environmentally friendly treatments rely on the removal of potential host plants, dramatic changes in the soil environment, addition of helpful microflora, the production of toxic materials from plant or animal sources or planting of resistant rootstocks. Environmentally friendly treatments often utilize one or more of these processes and the effectiveness tends to be unpredictable.

Removal of host plants
In order to survive tree root pests and disease need a supply of food. If their preferred food, tree roots, is not available, then they need to find an alternative host or rely on long term resting bodies to survive until the next tree root becomes available. Hence it is important when removing an orchard to try and remove as much root material as possible in an attempt to remove both the pests and diseases and their food supply. After this is done it is important to plant a crop which does not support the same root pests and diseases and to keep this crop weed free (many weed roots can maintain tree root pests and diseases). Grass crops are useful here and the foliage can be used as animal fodder or incorporated as a green manure crop.

Dramatic changes in the soil environment
By rapidly changing the soil environment it is possible to destroy many root pests and diseases or at least change the microflora composition in favour of less aggressive species. Common ways of changing the soil conditions include heat, UV radiation and soil pH.

Heat: In field crops the usual way of heating the soil is through a process called solarisation. This is where a clear plastic film is placed over the soil surface to create a glasshouse effect. For this to work effectively it is important that the heat penetrates deep into the soil so it is important that the soil remains moist. If the temperatures get high enough even the resting bodies of root pests and diseases can be controlled and with this method the treatment depth can extend below the ploughable layer of soil. Attempts have been made to inject heat into the soil but this has proved to be an expensive operation.

UV radiation: This is an extremely effective method of destroying soil pests and diseases and the sun provides a ready form of cheap intense UV radiation. In order to utilize this it is important to 'turn the soil over' on a regular basis, possibly weekly, during the summer months as it is only the top surface of the soil that is exposed to the treatment at any one point in time. This also helps to eliminate alternative host roots (including perennial weeds) as well as exposing much of the soil to extreme temperatures and dryness which aids in pest and disease control. Obviously the down side of this treatment is that soil structure is downgraded, soil organic matter is reduced and there is risk of significant erosion.

pH: Depending on location it is not uncommon for soils in orchards to become acidic and the soil microflora that live in these soils will be dominated by acid tolerant species. As a result it is common to have to lime the soil prior to replanting. If this is done with significant quantities of hydrated lime, more than required for pH correction alone, then the soil pH will move temporarily to a very alkaline condition and this can be enough to modify the microflora composition of the soil. In a trial in Tasmania it was found that yield of fruit from this treatment was close to that of soil fumigation (Figure 1).

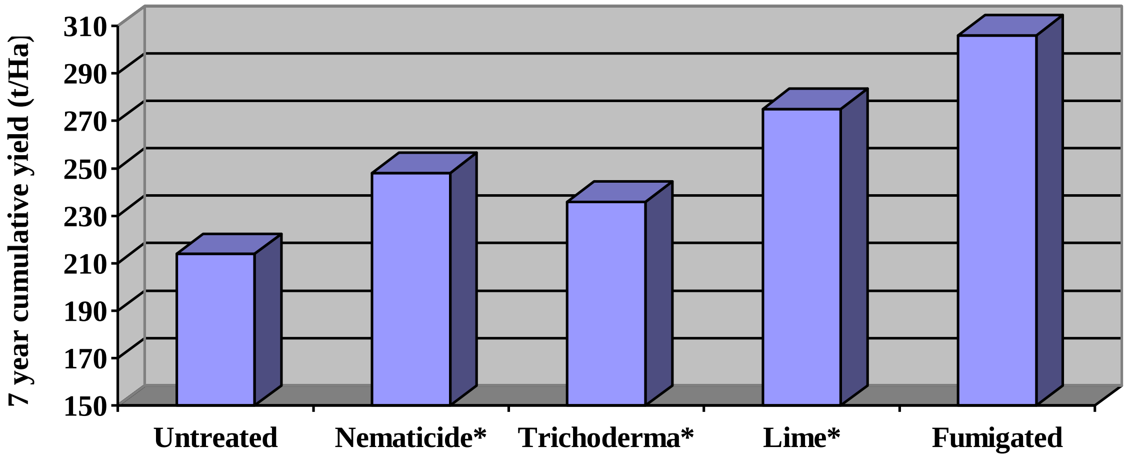

Figure 1. The impact of apple replant disease on cumulative yield of 'Smoothie' Golden Delicious for the first 7 years of the orchard life. * treatments all received a nematicide. 5% LSD = 55. HAL project AP97005.

Addition of helpful microflora

Helpful microflora that can be added to the soil include organisms that predate on soil pests and disease, such as predatory nematodes often found in chicken manure, and organisms that can physically occupy space on the root and do not allow for access to the root by the pathogens, such as mycorrhiza. The market for these organisms is rapidly changing with the introduction of new products and the withdrawal of other products. Results against tree root pests and diseases have been variable and two points about these materials must be remembered. Firstly they are living organisms so they have a short use by date. Ensure the product is fresh when it is purchased and it should not be stored in a spray shed for any length of time as the control organisms will die. Preferably store these materials in a fridge. Secondly many of these organisms, such as mycorrhiza and trichoderma, survive on the root from the sugars within the root. This means that they can also reduce tree growth in the absence of replant problems (figure 1 - trichoderma).

Production of toxic materials from plant or animal sources

The two most common toxic materials from plant or animal sources which are effective against tree root pests and diseases are ammonia from chicken manure and glycoasinolates from Brassica crops. With the use of Brassica crops care has to be taken as the active material against soil pests and diseases is found in the leaf while the roots are very good hosts for nematodes. Hence, by growing this crop nematode numbers in the soil can actually increase. As the active material is generated within a few hours after the leaf is crushed it is essential to incorporate the leaf material into the soil quickly. Direct and deep rotary hoeing is excellent but if the crop needs to be slashed prior to incorporation it is wise to have two tractors operating, one slashing and one incorporating. Another essential for maximum effectiveness of the Brassica crop is that the active material, MITC, moves through the soil in the soil water, its distribution in the soil is markedly improved if incorporation occurs to moist soil, the soil is compacted after incorporation and possibly irrigation should then be considered. This treatment can be very effective (figure 2). Wrightson Seeds sell a product, BQMulch(r), which is a mixture of high glucoasinolate brassicas specially for this purpose. Of interest is that in the trials conducted in Tasmania the BQMulch(r) product provided close to 100% control of the weeds indicating a potential further advantage of this crop. Alternatively, Organic Crop Protectants market a mustard and neem meal (Fumafert(r)) which may also provide a source of glucoasinolates without the need to grow the crop although this product needs research to verify its effectiveness.

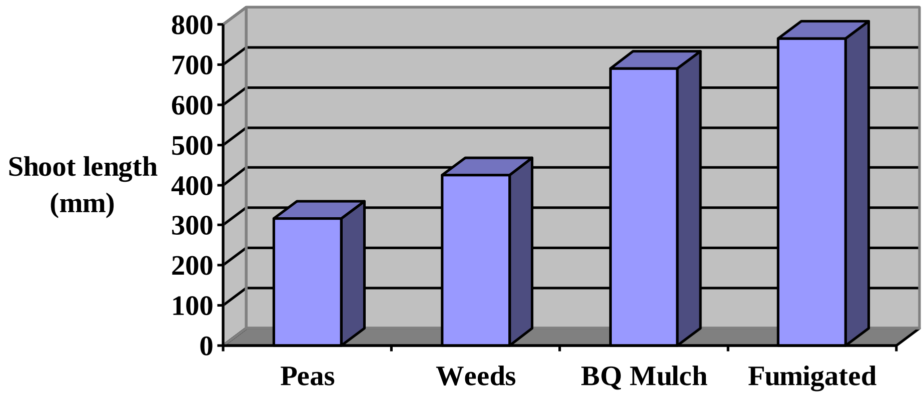

Figure 2. The impact of cover crop in the season prior to planting on apple tree shoot length in the following season. BQ mulch is a high glucoasinolate Brassica. 5% LSD = 291. HAL project AP05015.

Planting of resistant rootstocks

While there is a large impact of rootstock on the expression of apple replant disease this aspect has been poorly studied. In 1975 Ryan, in New Zealand, reported on the tolerance of 5 vigorous rootstocks to ARD. Here it was found that ‘MM115’, ‘MM106’ and ‘M12’ are not tolerant of replant disease and ‘M793’ and ‘Northern Spy’ are moderately tolerant. Unfortunately these rootstocks are too vigorous to contemplate using in modern high density orchard situations, however, working more recently on dwarfing rootstocks suited to high density plantings, Foot et al (2001), again from New Zealand, found that Mark and M9 rootstocks were more tolerant of replant disease than M26 although even for Mark and M9 soil fumigation led to a 40% increase in tree vigour indicating that these two rootstocks are not resistant to replant disease. From studies in the United States Leinfelder and Merwin (2006), working with 'M26', 'M7', 'G16', 'CG6210', and 'G30' concluded that trees on 'CG6210' and 'G30' grew better and yielded more than those on other rootstocks grown in replant affected soil. No other research concerning the relative tolerance of apple rootstocks to ARD can be found. These findings, however, indicate the potential to select a replant resistant rootstock.

Commercial chemical treatments

Chloropicrin

Chloropicrin is an old material that has been successfully used as a soil fumigant for many years. It is registered against nematodes, weeds, soil insects, fungi and bacteria and even against rabbits. It is delivered as a liquid in a pressurised bottle and rapidly becomes a gas in the soil where it is able to penetrate and distribute itself in the soil profile. The product is registered for use at 15 to 30ml/m^2 in field applications and to 50ml/m^2 for soil heaps covered in plastic. In field trials conducted in Tasmania in 1997 its effectiveness, at 50ml/m^2, against apple replant disease was superior to that of methyl bromide at one of the two sites. Its effectiveness at lower rates of application is not known.

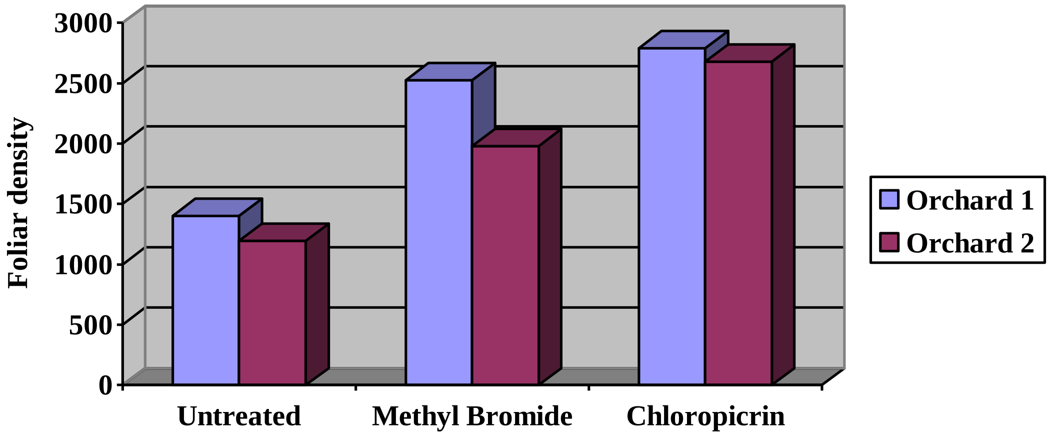

Figure 3. The efficacy of Chloropicrin (50ml/m^2) compared to Methyl Bromide against apple replant disease. Foliar density after the first season of growth was determined from the cross sectional area of the trees using photography and image analysis. Both materials were significantly different to the untreated and chloropicrin was significantly superior to methyl bromide at site 2 (p=0.05). Funding Hansen Orchards and Clements and Marshall P/L.

Telone(r)

The active in Telone(r) is only effective at controlling nematodes. As weeds, fungi and bacteria are often also involved in replant problems with tree fruit the use of this material by itself should be avoided.

Telone C-35(r)

This product incorporates chloropicrin into Telone to assist in Telone's control of pests, diseases and weeds. The use rate for fruit and nut crops is 35 to 70ml/m^2 although against apple replant disease the label recommends 50 to 70ml/m^2. This gives a rate of chloropicrin application of 18 to 25 ml/m^2, less than that for chloropicrin alone.

Metham Sodium

Like Chloropicrin metham sodium has been available to growers for a long time and this product controls weeds, nematodes and fungal root diseases. This is a highly toxic liquid material which converts to MITC in the soil (the same active as Brassica crops). MITC is active in the water in the soil so the soil needs to be damp at application and the material needs to be extremely well incorporated to ensure even treatment of the soil profile. Sealing to stop the escape of the material is by rolling or overhead watering rather than plastic covers and this is an advantage of this material. The registered rate of application for field application to beds or rows is 40 to 80ml/m^2.

Basamid$^{(r)}$

This material is a relatively non toxic powder which, when combined with water in the soil, converts to MITC as per Brassica crops and metham sodium. The attraction of this material is the increased applicator safety and the fact that the material can be applied using simple seeding / fertilizer application equipment followed by rotary hoeing. As for metham sodium the soil needs to be moist at application and the material needs to be very well incorporated into the soil. The surface is sealed by rolling and / or watering and plastic covers are not necessary. Label rates of application are 50 to 70g/m^2. In trials conducted in Tasmania this material has been shown to be very effective against apple replant disease (figure 4).

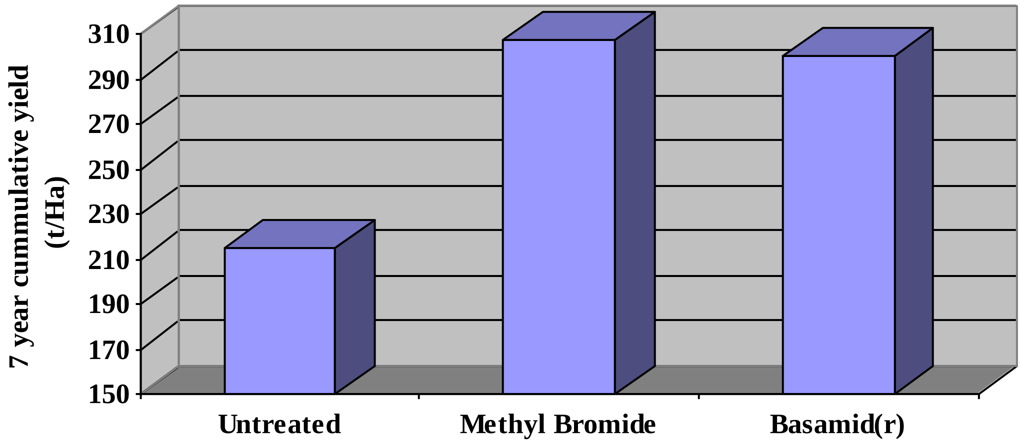

Figure 4. The efficacy of Basamid(r) compared to Methyl Bromide against apple replant disease. 5% LSD = 55. HAL project AP97005.

Conclusion

Replant disease is a disease that affects pome and stone fruit trees. Replanting an apple orchard with a stone fruit crop does not overcome this problem. In one of the trials reported here it was found that apple replant disease led to a $182,000/Ha loss of income in the first 7 years of the orchard life. In comparison the cost of treatment is small.

As with most pest and disease control strategies reliance on one treatment is risky. Soil chemicals tend to be applied in strips down the tree row leaving the untreated area, between the rows, close and within easy reach of re-infection. Further, often the treatment does not go as planned with blocked injectors or slight deviations from the intended path so usually there are some trees planted in untreated soil leading to an uneven crop.

While it is tempting to plant a tree on a more vigorous rootstock in an attempt to overcome replant disease this leads to two problems, predicting how much growth retardation will occur and unfortunately replant disease is rarely even across an orchard or indeed from tree to tree within a row so this approach leads to uncertain tree performance and an uneven crop. Until more is known about rootstock tolerances this approach should also be avoided.

One possible practical system to controlling replant disease is to remove trees using an excavator to pluck the trees out of the moist soil in early winter removing most of the roots with the trees. The soil should be turned over several times to expose it to UV radiation and to remove as many old roots as possible and terminate and prevent weed growth. Towards the end of winter a Brassica crop can be planted. If cabbage white butterflies become a problem these should be controlled as it is essential to maximise the vegetative matter to be incorporated into the soil. Just prior to the crop running up to seed it should be irrigated and then rotary hoed in followed by rolling and more irrigation to activate and seal in the bioactive material. After a few more weeks the soil can be turned over again a few times to expose it to late summer UV radiation and remove any more roots that appear. If the site is in a summer dominant rainfall area erosion considerations may be necessary. If the soil is acidic then this would be a good time to apply substantial quantities of lime. Studies to date indicate a minimum of 5t/Ha of hydrated lime ($CaOH_2$). It is important to ensure no weeds grow during these operations as these will potentially supply the tree pests and pathogens with an alternate host. In Autumn the base fertilizer could be applied and beds formed up. This should be followed by one of the chemical treatments while the soil is still warm. For organic growers the mustard / neem meal treatment may be useful here. Trees can then be planted in winter, after germination tests show that all fumigant activity has ceased.