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CAN WE VACCINATE TREES TO PROTECT AGAINST DISEASES?

PART 2: PUTTING SCIENCE INTO PRACTICE

Introduction

In the previous edition of Ontario Arborist the author spoke about the science behind the theory of boosting a trees own immune system i.e. vaccinating a tree, to protect against tree pests and diseases. In this edition the author talks about putting the science learnt into practice.

Vaccinating trees using soil amendments

Given the fact that previous research demonstrated trees defence systems could be promoted by applying amendments into the soil, and with funding secured from the TREE FUND, Hyland Johns Grant "Can Soil Amendments Reduce Disease Severity in Trees?" research at the Bartlett Tree Research Laboratory now aimed to evaluate four potentially powerful, stable and non-toxic soil amendments singly and in combination. These included, chitin, phosphites, biochar (a form of activated charcoal) and pure mulches i.e. a mulch made from a single tree species such as willow or eucalyptus. Importantly most of the products tested (biochar, chitin, mulch) are derived from waste materials that would otherwise go to landfill.

Chitin

Chitin is a naturally occurring constituent of fungal cell walls that can also be sourced from waste crustacean (crabs, lobsters, crayfish, and shrimp) shells. Application of chitin or a derivative known as chitosan, has been shown to enhance bio-control efficacy when applied to soils in combination with other bio-control fungi *(Trichoderma)* and bacteria *(Bacillus)*. Applied alone, chitin and chitosan have shown potential for the control of soil borne diseases. Chitin acts as a "food" source in soils, stimulating soil microorganisms to release chitinolytic enzymes to break down the chitin molecule. An increased level of soil chitinolytic enzymes aids in the suppression of pathogenic fungi such as *Rhizobium* and *Fusarium* root rots, while the increase in chitinolytic bacteria such as *Bacillus licheniformis*, *Stenotrophomonas maltophilia*, and *B. thuringiensis* aid in the control of Oomycetes such as *Phytophthora cactorum*. Recently, chitosan has also shown potential as an insecticide, controlling a range of aphid species and lepidopteran pests via ingestion of foliage with chitosan either applied to the leaf surface or translocated within the vascular system of a plant.

Biochar (Photograph 1)

Several articles show soil fertility and quality are improved with the addition of biochar. As well as altering the physical and chemical properties of the soil around the rhizosphere, biochar also alters the biological dynamics of a soil through several mechanisms. Biochar is initially sterile and therefore has no indigenous populations of microorganisms. Instead, the physical structure of the biochar encourages colonization by various arbuscular mycorrhizal fungi, nematodes and bacteria. Biochar adsorbs humic acid, which is used as sustenance by soil microbes, and humic acid adsorbs fertilizers, preventing them from leaching out of the soil. Roots can access this stored fertilizer. Numbers of plant-enhancing microorganisms, such as *Trichoderma*, are boosted in soils amended with biochar. Studies have shown a significant interaction between biochar and *Fusarium oxysporum* that strongly reduces disease severity. Recent research has shown that soil-applied biochar also induces resistance to the fungal diseases such as *Botrytis cinerea* (gray mold), *Leveillula taurica* (powdery mildew) as well as the insect mite pest *Polyphagotarsonemus latus*. Zwart and

Photograph 1

Photograph 2

Photograph 3

Kim (2012) identified that a 5% biochar application (by soil volume) resulted in a significantly greater stem biomass in *A. rubrum* compared with plants inoculated with *Phyophthora cinnamomi,* suggesting that biochar amendment has the potential to alleviate disease progression and physiological stress caused by *Phytophthora* canker. It has also been suggested that the beneficial microorganisms encouraged by biochar application could produce antibiotics to directly affect bacterial plant pathogens. Ultimately, biochar offers potential to be used in conjunction with other biologicals to increase treatment efficacy.

Phosphites

Inorganic phosphite salts are a family of potential plant protection agents. When applied to plants as a foliar spray or soil drench phosphites exhibit two modes of action; acting directly on the disease and indirectly by stimulating plant host defence responses, such as the accumulation of plant antibodies (phytoalexins), hypersensitive cell death, cell wall lignification and formation of lytic enzymes that in turn inhibit pathogen growth. Research has found potassium phosphite salts to be effective in the control of Oomycetes such as *Phytophthora* root rot and canker pathogens, fungal pathogens such as *Venturia inaequalis* (apple scab) and pathogenic bacteria such as *Erwinia amylovora* (apple fire blight) and *Pseudomonas syringae* pv *aesculi* (bacterial bleeding canker).

Pure Mulches

Studies have shown mulches can provide an integral cultural control method for suppressing disease development of several plant diseases. Cellulose forms part of the component of the primary cell wall of green plants acting as a structural polymer to provide plant rigidity. Following the application of a mulch to a soil surface the concomitant microbial and fungal population build-up promotes a reservoir of enzymatic activity such as cellulase and laminarinase to induce mulch decomposition. Cellulose microfibrils in *Phytophthora* cell walls are susceptible to enzymatic destruction particularly by cellulases present in mulch litter layers that cause cell wall lysis and, by default, a subsequent reduction in *Phytophthora* pathogen severity. In addition, mulches also contain a variety of soil microbes that can exert biological control over soil borne pathogens, either through resource competition or antibiosis (production of antibodies). Limited studies exist focusing on the efficacy of mulches derived solely from one tree species, defined as pure mulch on suppression of diseases. However, information available indicates the use of a pure mulch can have a powerful influence on transplant success and survival of trees. Pure mulches derived from the common hawthorn (*Crataegus monogyna* JACQ), and common cherry (*Prunus avium* L.) increased survival rates of European beech *(Fagus sylvatica* L.) from 10 to 70% following containerisation and under field conditions enhanced fruit tree crown volume and fruit yield by 53 and 100% compared to non-mulched trees. Disease suppressive effects may also relate to allelochemicals released as mulches degrade. For example allelopathetic testing of water soluble extracts of pure mulches derived from hawthorn, cherry, silver birch, English and evergreen oak positively increased pea seed germination, relative growth rate and photosynthetic efficiency of established seedlings. A pure mulch derived from willow (Salix) will


Photograph 4


Photograph 5

be the focus of attention for this study. Willow tissue is naturally high in salicylic acid a powerful stimulator of plan defence pathways. Indeed application of salicylic acid to plants has been shown to confer resistance against several plant pathogens to include early blight of potato (*Alternaria solani)*, powdery mildew *(Erysiphe cichoracearum)*, tobacco mosaic virus, fire blight *(Erwinia amylovora)*, *Sclerotinia sclerotiorum* and *Phytophthora palmivora*.

Case Study: Apple scab (Venturia inaequalis)

The trial site consisted of a 1.5 ha block of apple cv. Crown Gold (an apple scab sensitive species) with individual trees of Red Delicious and Gala as pollinators. Planting distances were based on a 3 by 3 m spacing with the trees trained as a bush shaped tree to an average height of 2.0 to 2.5 metres. Historically the trial site suffered heavily from apple scab on a annual basis. Consequently prior to the trial commencing trees were inspected the year before and only those trees rated with 50-80% of leaves affected, representing severe foliar discolouration and scab infection were used in the trial. Treatments were applied to a soil depth of 20-30 cm using an air-spade in early February *(Photograph 2)* with the exception of a pure willow bark mulch which was applied to the soil surface at a depth of 10 cm. As an industrial comparative the synthetic fungicide penconzole was applied at bud break, early flowering, 90% petal fall and early fruitlet as a foliar spray until run-off using a hand-sprayer at manufacturers recommended rate (1.0ml penconazole per litre of water):

Soil amendments (i.e. treatments used): i) Chitin (5% by soil volume i.e. 1:19 ratio), ii) Biochar, (5% by soil volume), iii) Chitin (2.5% by soil volume) + Biochar (2.5% by soil volume), iv) Willow Mulch, v) Willow Mulch + Chitin (5% by volume), vi) Willow Mulch + Biochar (5% by volume), vii) Willow Mulch + Chitin (2.5% by volume) + Biochar (2.5% by volume), viii) Non-amended soil (controls), ix) Fungicide (penconazole) spray.

Photograph 3 shows the degree of scab severity on recorded on non-treated control leaves compared with leaves on a tree where the soil was amended with biochar + chitin *(Photograph 4)* and leaves on a tree that were sprayed four times with a synthetic fungicide *(Photograph 5*) at the end of the 2016 growing season

In summary, photograph 4 shows that soil amendments that promote tree defence systems provided a significant degree of protection against apple scab, however, control generally was less effective than that achieved with four sprays of a standard fungicide (penconazole). However, results do show that these soil amendments work under field conditions and potentially offer a potential management strategy of apple scab. If, however, a zero scab policy is adopted then application with conventional synthetic fungicides would be required. Alternately with ornamental apples which are grown and planted for aesthetic reasons within town and city landscapes lower scab levels are generally acceptable as the fruit is not eaten. In addition, these soil amendments can be incorporated into an integrated control system and/or be used preventatively to bolster general plant health. In these instances the reductions in scab severity recorded in this investigation may warrant the use of soil amendments as an alternative or compliment to conventional synthetic fungicides.

Conclusions

Studies to date suggest that use of the soil amendments outlined above offers potential alternatives for help in managing a broad spectrum of economically important foliar and root fungal diseases of urban trees. Many of the products used here are waste or by-products of industry (chitin, biochar, wood chip mulch) which present a "green" environmentally benign approach to pest and disease management. It is also important to emphasise that these products should not be used as a "stand alone" treatment for pest and disease management. Management should also rely on promoting tree vitality and alleviating all forms of stress where possible. Aftercare is always critical to pest and disease management. This should include:

- Frequent inspections for health and structural issues;
- Soil de-compaction if required;
- Monitoring of soil moisture to protect against over and under irrigation;
- Prescription fertilisation for optimal tree nutrition;
- Mulching the critical root zone.

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