

How The Pest Was Won

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Lesson from History - *Xylella fastidiosa*

We have a lot of “defense free space” within UK urban landscapes

- ▶ ‘Bloodgood’ London Plane
- ▶ 2000 Trees Planted 1989-90



1995

1993 Leaf Scorch Confirmed 1996 Tree Mortality Begins



2001: Infection Rate-75%
Mortality Rate- 25%



What are the Options?



Tree Removal



What are the Options



A Different Approach

Western medicine dictates that prevention of infectious diseases (typhoid, diphtheria, measles, hepatitis, small pox) is primarily via vaccination. In such circumstances the human body is injected with a weakened or attenuated strain of a disease. This in turn stimulates the body to produce antibodies against that specific disease which in turn confers immunity. Importantly a “one-off” vaccination can confer immunity for many years (at least 10) and in some cases last an entire life time.



Can we use these vaccination principles for trees?

The answer is yes. Vaccinating plants against pests and diseases is not a new concept; the idea of inducing resistance in response to plant diseases was recognised in the early 20th century when heat or cold treated *Botrytis cinerea* (grey mould) when exposed to *Begonia* plants instead of causing infection as expected, resulted in the plants developing resistance.



- ▶ Several studies have found that “vaccinating” trees to be effective in controlling:
- ▶ Fire blight (*Erwinia carotovora*)
- ▶ *Phytophthora* root rot.
- ▶ Powdery mildew (*Sphaerotheca pannosa* var. *rosa*, *Phyllactinia* sp and *Uncinula necator*)
- ▶ Wilt disease of spruce (*Ceratocystis polonica*)
- ▶ Importantly, the level of disease control achieved was comparable with currently used agrochemicals and a “one-off” vaccination has been shown to provide growing season protection.



- ▶ Interestingly tree defence responses are superior to that of humans!
- ▶ An injection against typhoid would only confer immunity against typhoid. Further separate injections would be required if immunity against diphtheria or measles was required.
- ▶ In trees, however, a single vaccination causes alterations to several plant biochemical and physiological processes.
- ▶ Accumulation of antimicrobial proteins, fungi-toxic enzymes, phenolics and terpenoids within leaves, stems and roots.
- ▶ Leaves become thicker and more lignified.
- ▶ Enhanced resin production, production of phenolics and initiation of a wound periderm occurs.
- ▶ Importantly, because multiple defence mechanisms are switched on it is highly unlikely that pests and diseases can develop resistance to this measure.
- ▶ In addition, a single vaccination has been shown to provide resistance against biologically different pathogens (fungal, bacterial, virus) over a growing season

► A small but significant step.

- Trees can be vaccinated by applying products as a root drench! (Percival G.C and Banks J M (2015). *Arboricultural Journal*: 37(1): 7-20
- Applying products via the roots opens up opportunities to manage tree pest and diseases without the need to spray i.e. by soil amendments applied at the time of planting or around the base of established trees.



Vertical mulching



► So what soil amendments can we use to vaccinate trees?

► 1. A pure mulch.



Willow mulch



No mulch



Willow mulch



Biochar

Provides a suitable soil environment for root growth and mycorrhizal associations.



Slide courtesy Drs D Zwart/K Fite

Phytophthora Management

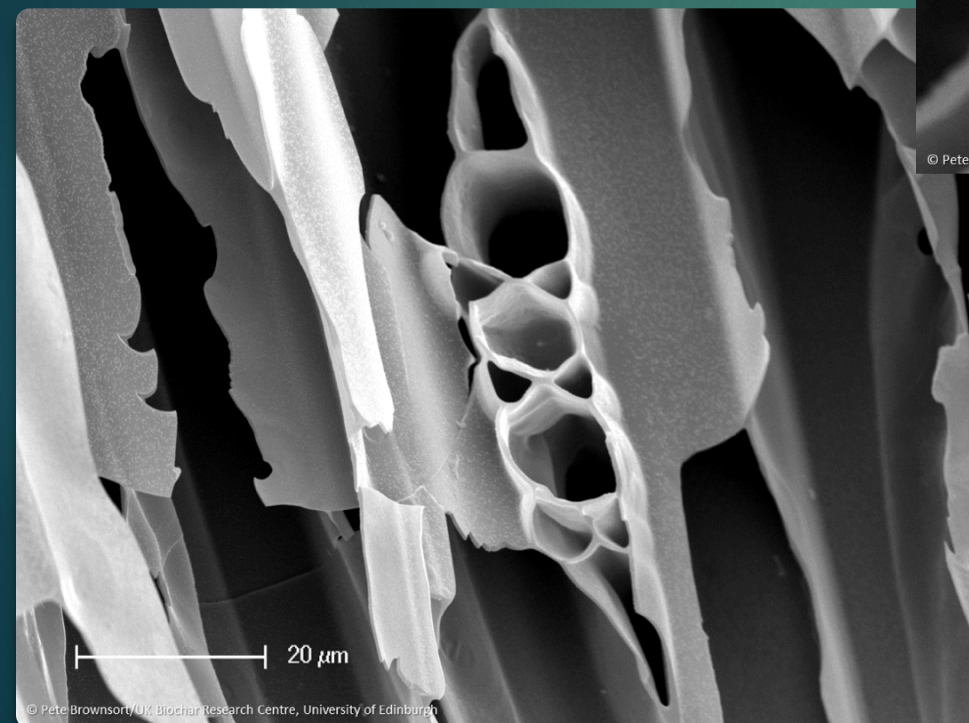
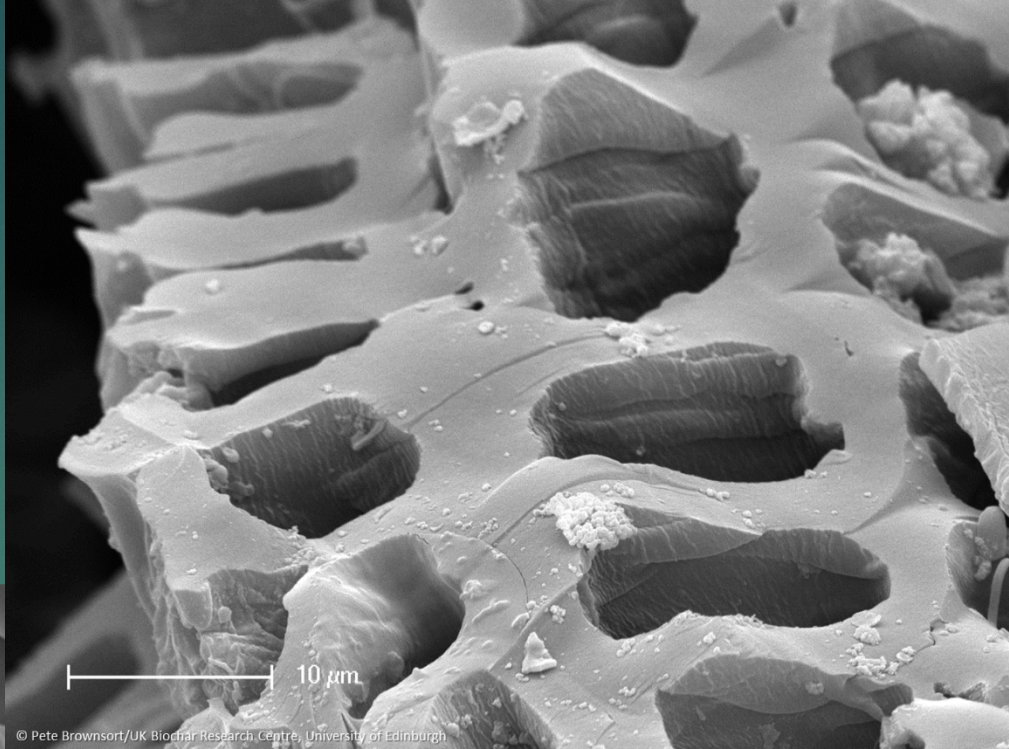
Vinca and Gardenia inoculated with *Phytophthora*

Control

Compost

Biochar





© Pete Brownsort/UK Biochar Research
Centre ,University of Edinburgh

Biochar effect on leaf blotch and leaf miner severity



**Biochar
0.25kg m²**



Control



Biochar 0.50kg m²

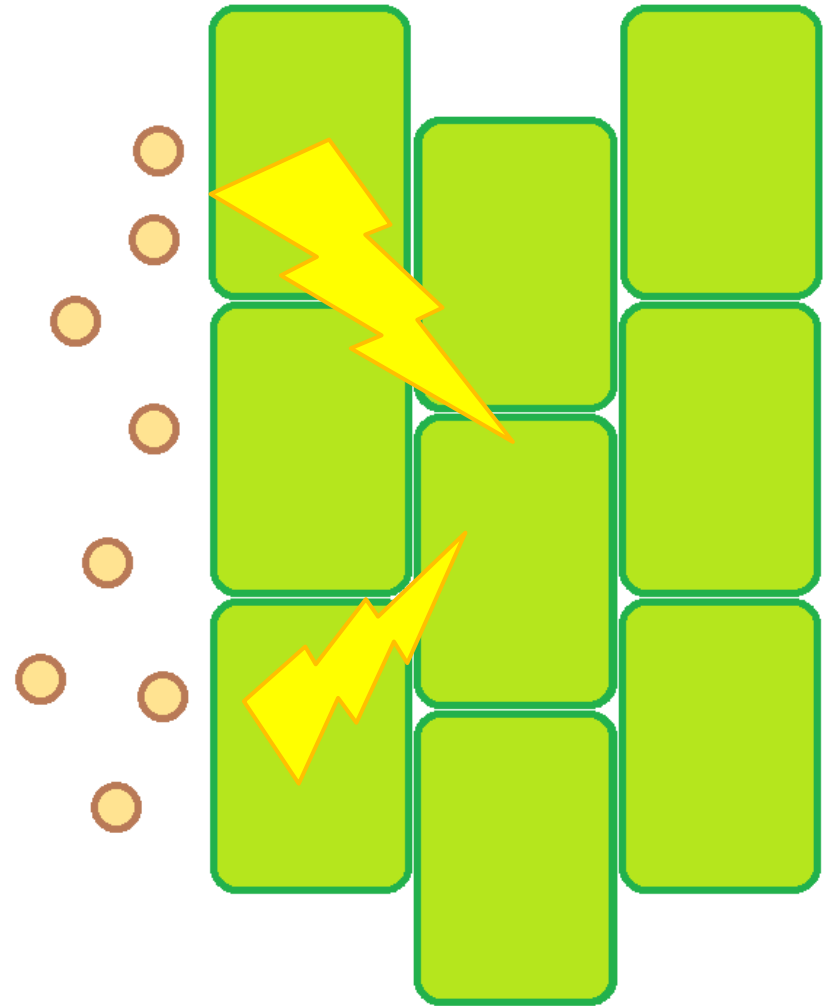
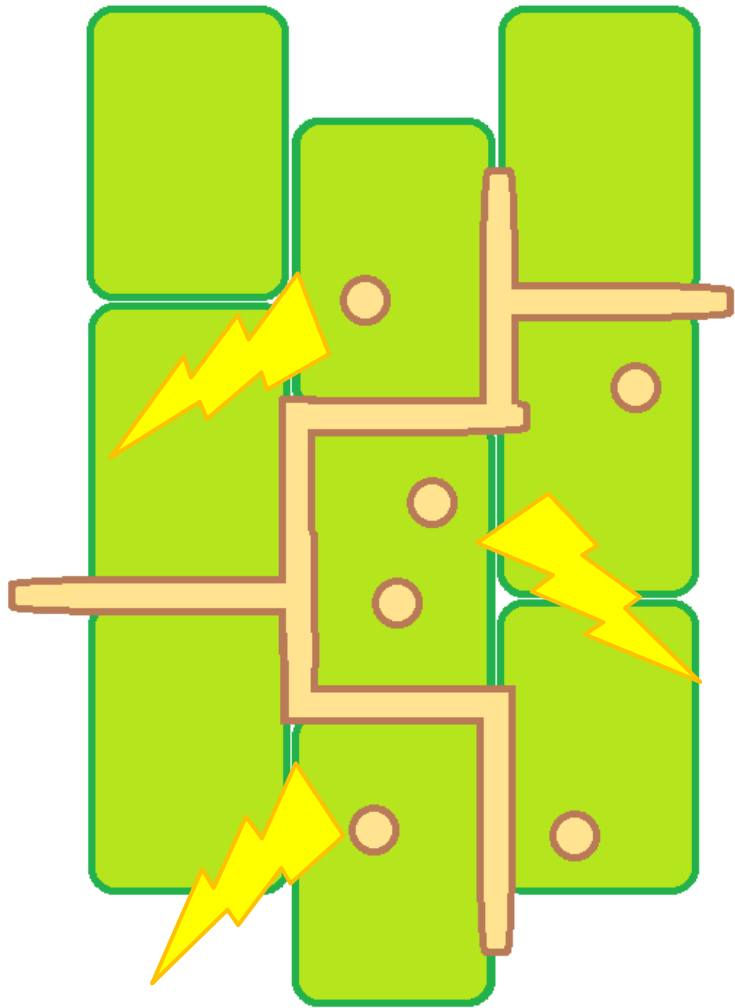
Phosphites



Chitin – What is it?

- ▶ 2nd most widespread natural polymer
- ▶ Forms structure of:
 - ▶ Fungi cell walls
 - ▶ Insect exoskeletons
 - ▶ Crustacean exoskeletons
- ▶ Insoluble!
 - ▶ Derivatives soluble... and more effective?





Chitin mimics fungal attack

Apple scab trial site



R&D Trials Over the Past 2 Years

Looking at these four products singly and in combination

i.e. Biochar

Biochar + Chitin

Biochar + Pure Mulch

Biochar + Phosphites

Biochar + Chitin + Pure Mulch etc.

Importantly Biochar,
Mulch, Chitin are waste
products.



Woodland/Forest



Business Park



► 2000 trees in an urban landscape setting

Barnet Council Trial Month 4 After Planting Street Plantings



Parkland/Ornamental Gardens



Each Site has a
unique set of pests
and diseases



Honey Fungus



Ash Die-back





Scab and Blister Mites

Is it Working? Rust Disease



Control

B+PM+C+Pi

HCLM and Pseudomonas Bleeding Canker

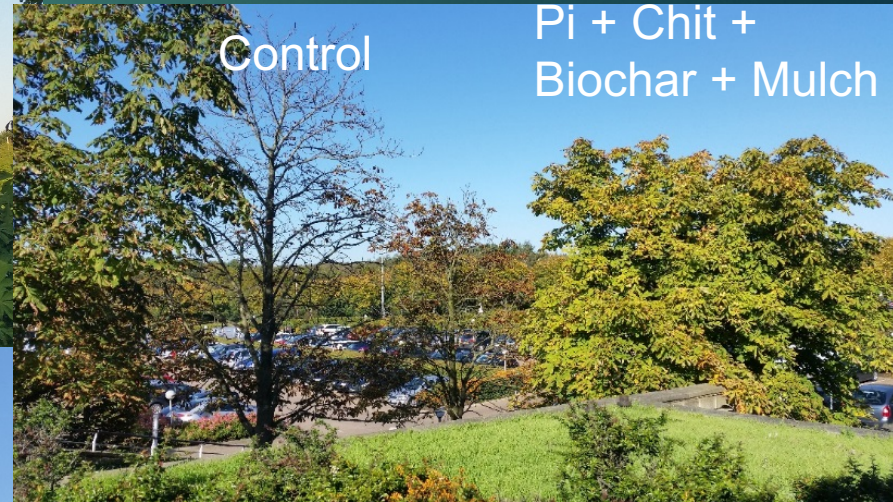
Pi + Chit +
Biochar

Control



Control

Pi + Chit +
Biochar + Mulch



Pi + Chit +
Biochar + Mulch

Control



Scab



Biochar + Phosphites

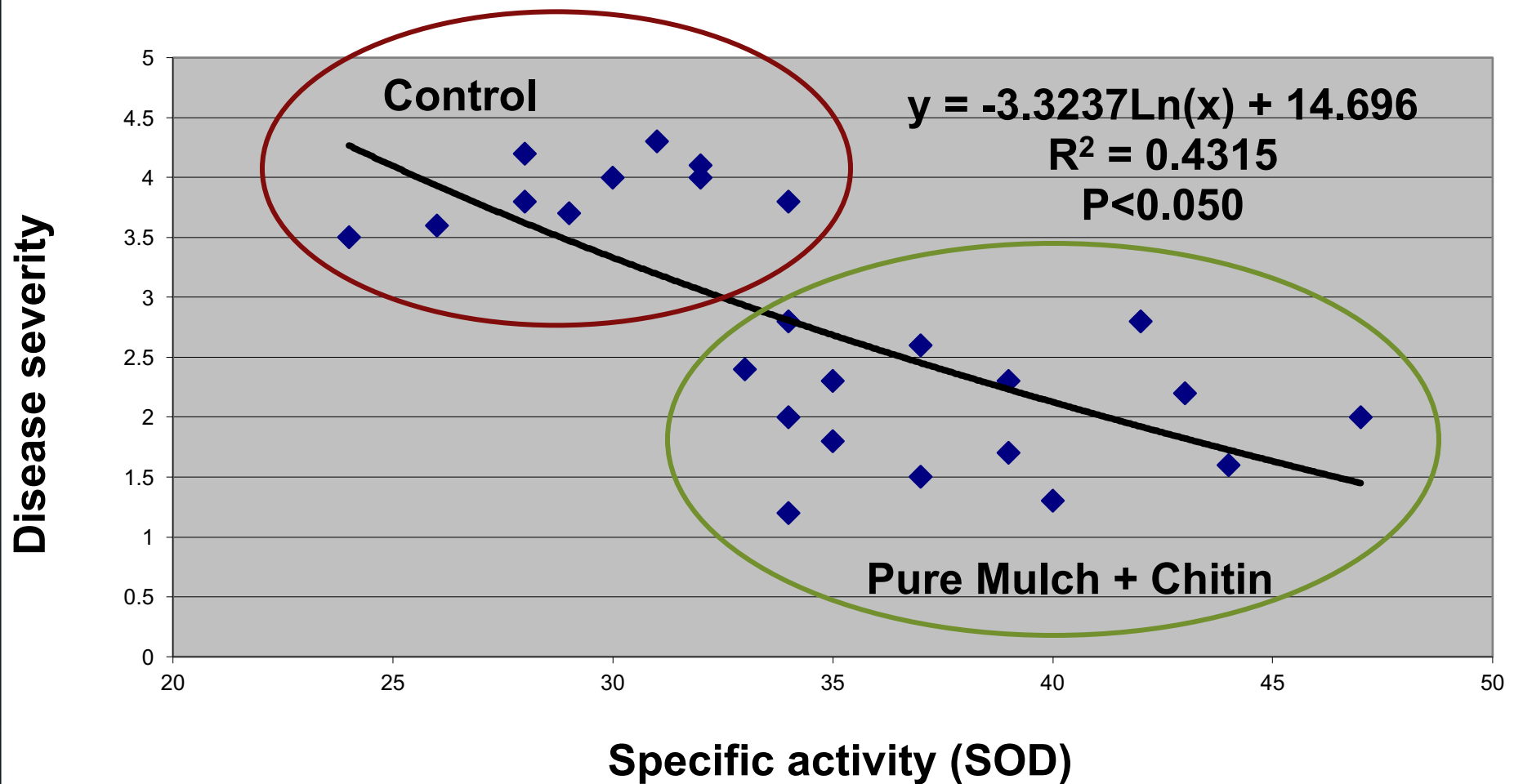


Control

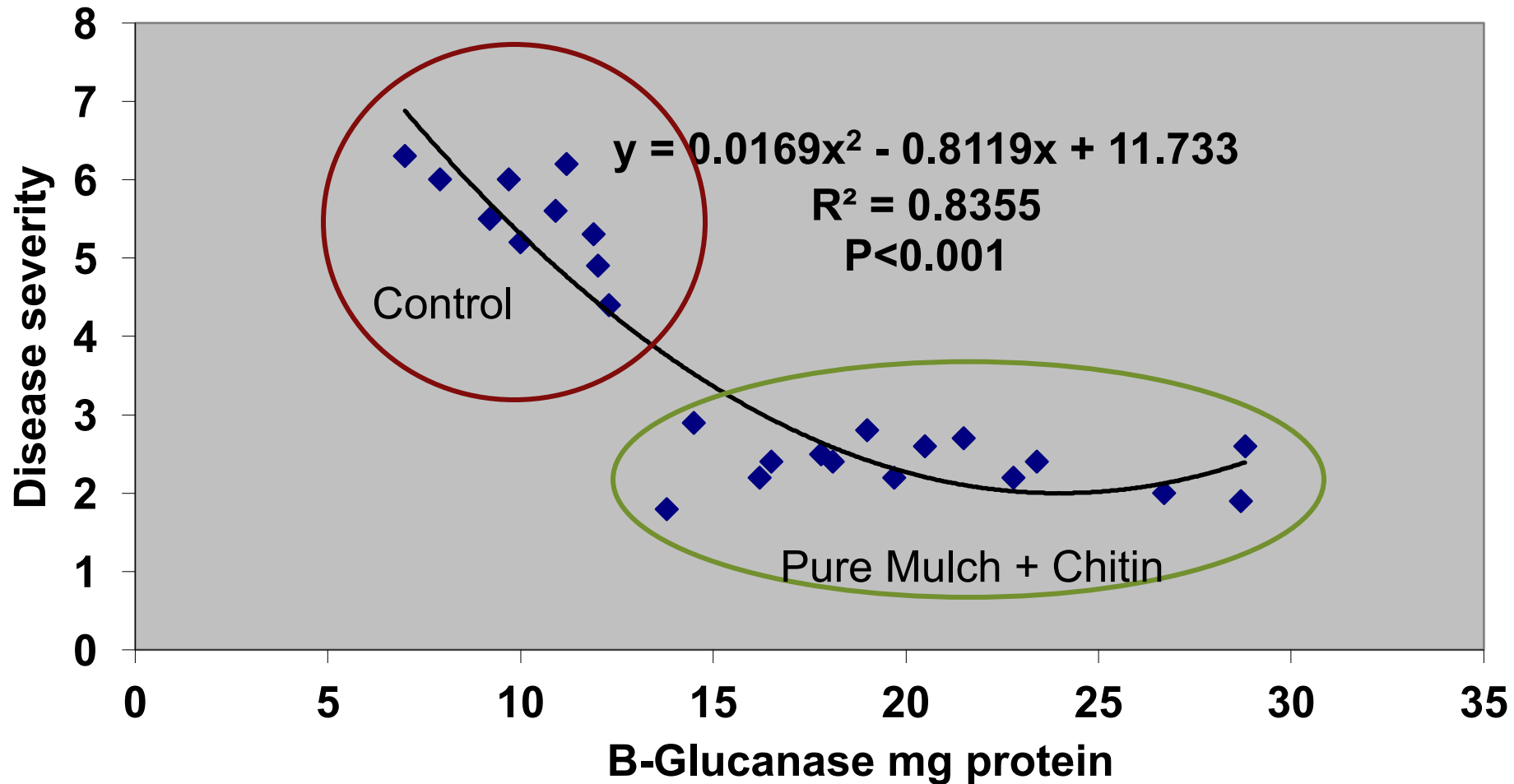
Defoliating beetles



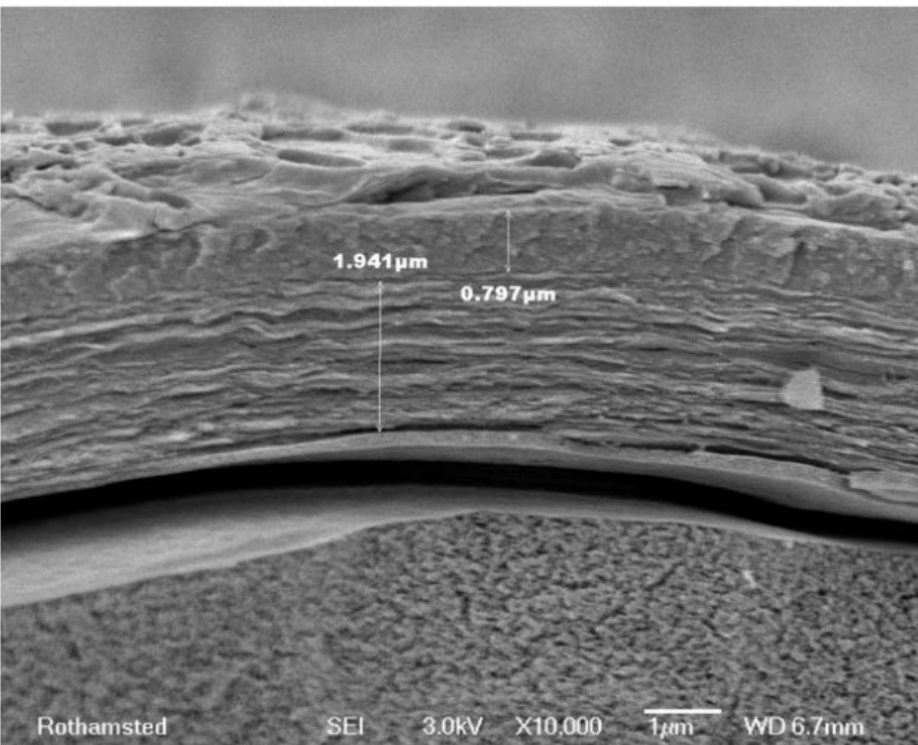
Specific activity of defensive root enzymatic activity Vs ARMILLARIA severity



Specific activity of defensive root enzymatic activity Vs ARMILLARIA severity



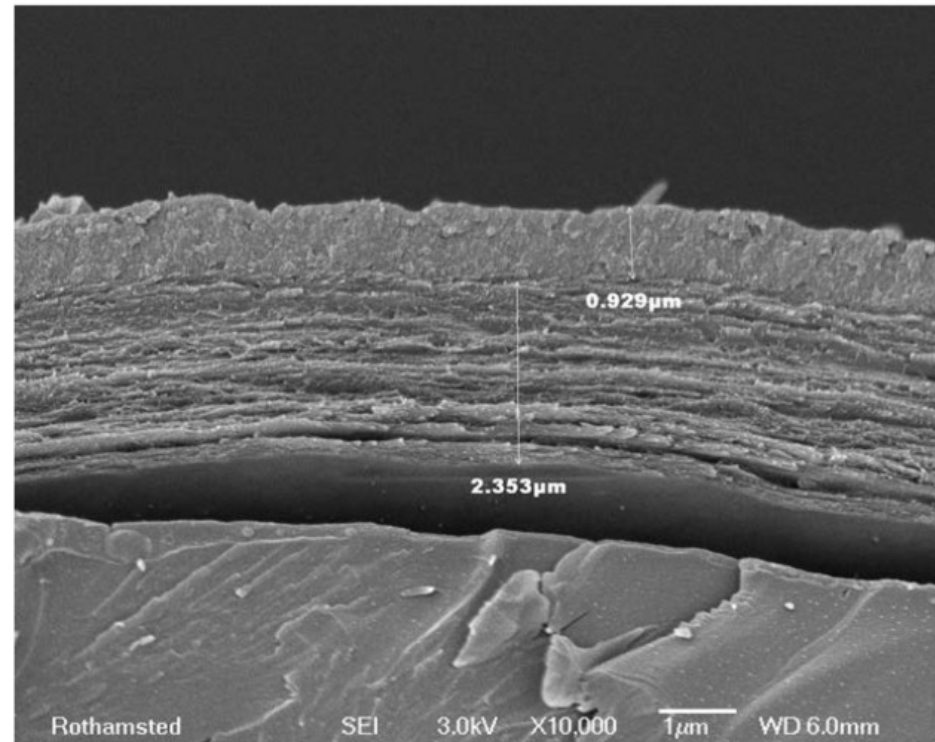
Thicker leaves



treatment 0.25% fracture 050.tif

Control

Biochar + Chitin



► Summary

- Use of biochar, pure mulch, chitin and phosphites do:
 - 1. Cause enhancement of defensive enzymes in leaves and roots (SOD, Peroxidase, Beta Glucanase)
 - 2. Leaves become thicker and more lignified.
 - 3. Highly likely many more defense enzymes/metabolites enhanced that we haven't analysed for.
 - 4. 15-20% reduction in growth

- ▶ But it's not perfect
- ▶ Using this system can provide reductions of disease/pest severity ranging from 30-70%.
- ▶ Using conventional plant protection products can provide 100% reductions.



► For the future: Willow species



► For the future; Chitin and/or Chitosan



► For the future; Biochar

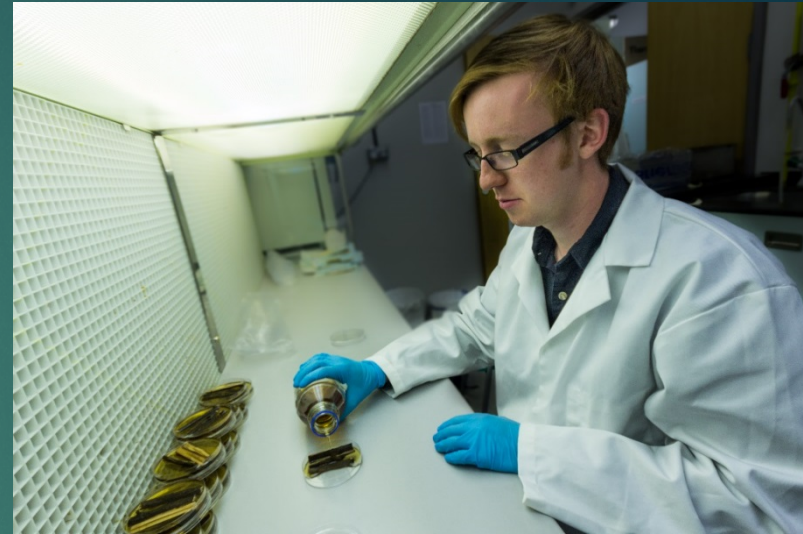


► Practical Guidelines:

- **Mulch: Willow; 5-10 cm deep, mulch area under crown + 1 metre beyond**
- **Chitin: 120g per square metre**
- **Phosphites: 1.5 litres per 100 litres of water**
- **Biochar: 5% by soil volume i.e. for every 19 litres of soil add 1 litre of biochar.**
- **How long does the**
- **induced response last?**
- **?????**



- ▶ Sadly I do not have time to talk about
- ▶ The importance of endophytes and bacteriophages in conferring disease resistance.



- ▶ Acknowledgements
- ▶ All my PhD Students
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- ▶ Stockley Park
- ▶ Woodland Trust
- ▶ **Thank You!**

