CAN WE VACCINATE TREES TO PROTECT AGAINST DISEASE?

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INTRODUCTION

During their life cycle, urban trees are susceptible to many pathogenic fungi and bacteria that, if uncontrolled, can result in high mortality rates.

PEST AND DISEASES WITHIN THE UK: INCREASED SEVERITY

NEW PEST AND DISEASE THREATS

EVER INCREASING THREATS

- Conventional control relies heavily on repeat fungicide spray applications.
- Increased tolerance to commercial fungicides.
- Failure of many fungicides to adequately control diseases once a tree is infected and
- Increased legislative restrictions regarding the use and application of fungicides means new techniques of disease control are now of environmental and economic importance.

P.RAMORUM 3,000,000 LARCH TREES FELLED….NO EFFECT ON SPREAD

IS THERE ANOTHER APPROACH?

SPECTATOR | 10 NOVEMBER 2012 | WWW.SPECTATOR

INDUCED RESISTANCE

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

INTRODUCTION

Induced resistance (IR) is the phenomenon whereby a plant's own defence mechanisms (accumulation of phytoalexins, hypersensitive cell death, increased lignification and cell wall fortification, enhanced lytic enzyme formation) are induced by prior treatment with either a biological or chemical agent.

Developments in plant protection technology have led to the formulation of a range of commercially available IR agents.

Messenger (a.i. Harpin protein) in the US.

Bion (BTH) in Europe.

Agri-Fos (a.i. Potassium phosphite) in Australia and the US .

Rigel (a.i. Salicylic acid analog) in the UK

Oryzemate (a.i. Probenazole) Japan.

- Several studies have found these IR agents are effective in controlling:

- Fire blight (*Erwinia carotovora*)
- *Phytophthora* root rot (*P. palmivora*)
- 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 unlike conventional fungicides a "one-off" IR application has been shown to provide growing season protection.

Aims of this study are to investigate the efficacy of a range of commercially available IR agents on controlling apple scab (*Venturia inaequalis*) a foliar pathogen

APPLE SCAB

The apple trial site consisted of a 1.5 ha block of apple cv. Crown Gold interspersed with individual trees of Red Delicious and Gala as pollinators.

Planting distances were based on a 2 by 2 m spacing.

Trees were planted in 1979 and trained under a central-leader system to an average height of 2 m ± 0.2 m with mean butt diameters of 33 cm ± 5cm.

TRIAL SITE

RESEARCH PLAN

Four IR agents and a water control were applied at bud break, green cluster and early fruitlet formation.

RESISTIM (a.i. Betaine): 10ml (0.3 fl oz) per litre (0.26 gal) of water

Messanger (a.i. Harpin protein): 4.0g (0.15 oz) per 100 m2 (1111 sq ft)

Agri-Fos (a.i. Potassium phosphite): 3ml (0.09 fl oz) per litre (0.26 gal) of water

Rigel-G (a.i. Salicylic acid): 3ml (0.09 fl oz) per litre (0.26 gal) of water

In addition a comparative evaluation of a conventional fungicide spray programme (penconazole): 1.0ml (0.03 fl oz) per litre (0.26 gal) of water used within the UK for apple scab control was conducted.

TREE HEALTH MEASUREMENTS

- Visual indexing technique using a 1-6 scab severity scale.
- Leaf photosynthetic efficiency using chlorophyll fluorescence
- Leaf chlorophyll content using hand held SPAD meters
- Girth increments
- Foliar nutrient content

TREE RESISTANCE MEASUREMENTS

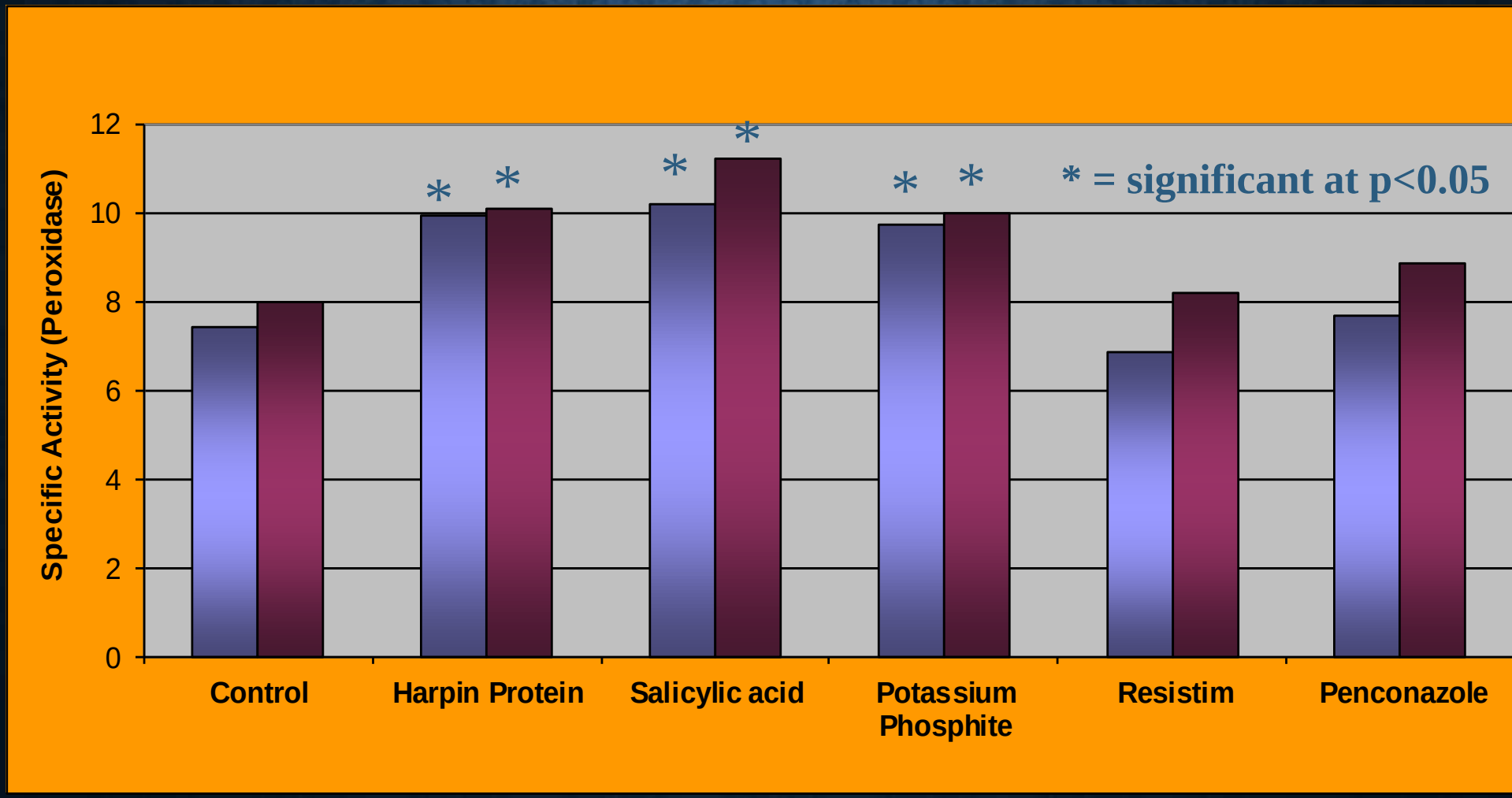
Increases in leaf defensive and stress enzymes:

Superoxide dismutase: Catalyse the first step in the detoxification of active oxygen to H_2O_2.

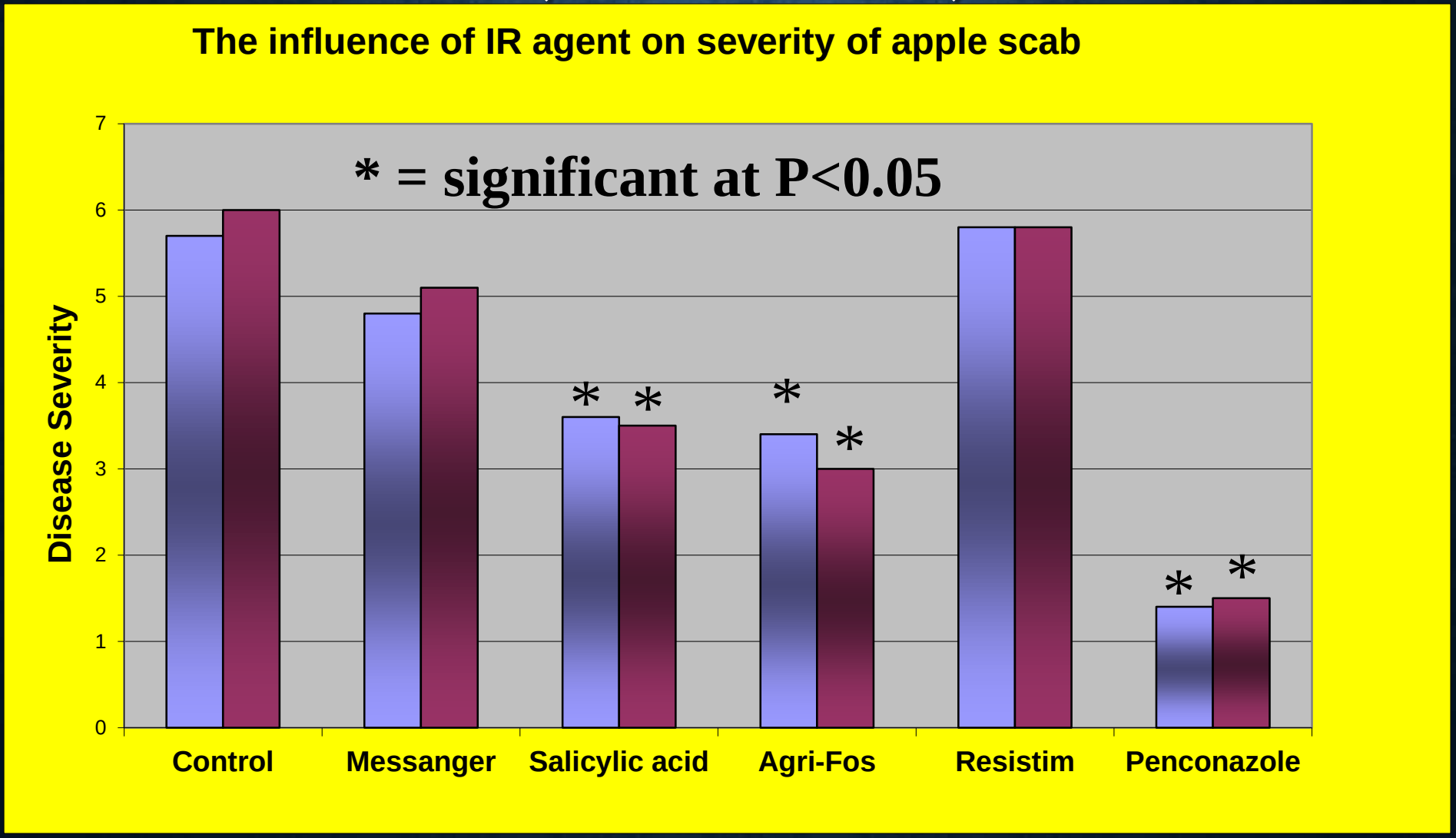
Peroxidase: Involved with the leaf lignification process at the site of fungal penetration.

B-1,3-glucanase: A fungal cell wall dissolving enzyme.

LEAF PEROXIDASE ACTIVITY AT DAY 15 AFTER FINAL IR SPRAY



DISEASE ASSESSMENT MADE AT THE CESSATION OF THE GROWING SEASON (SEPTEMBER)




Control


Penconazole


Messanger

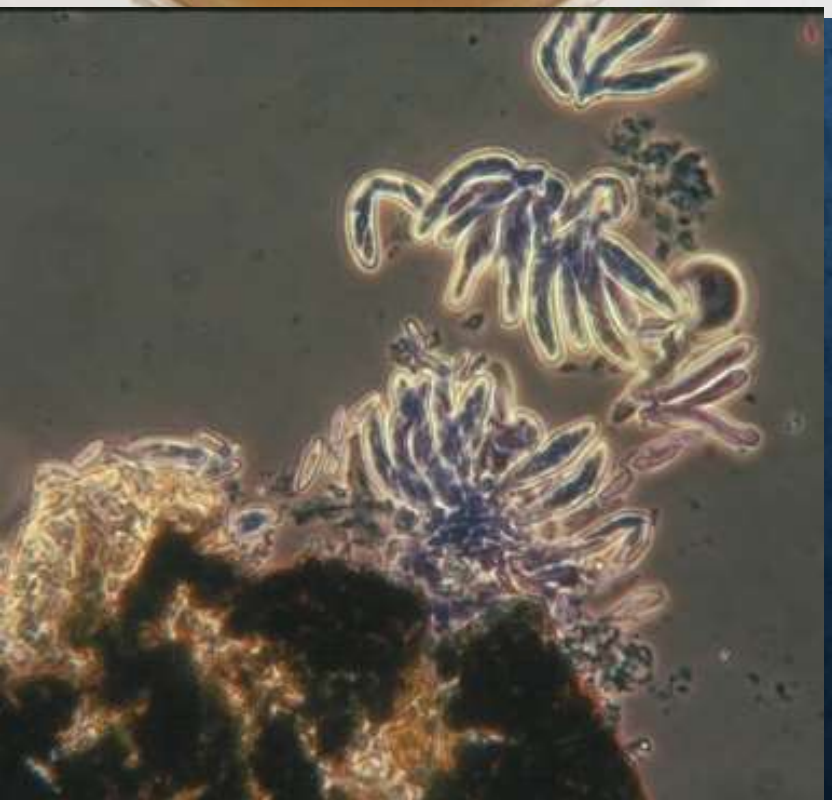

Control


Penconazole

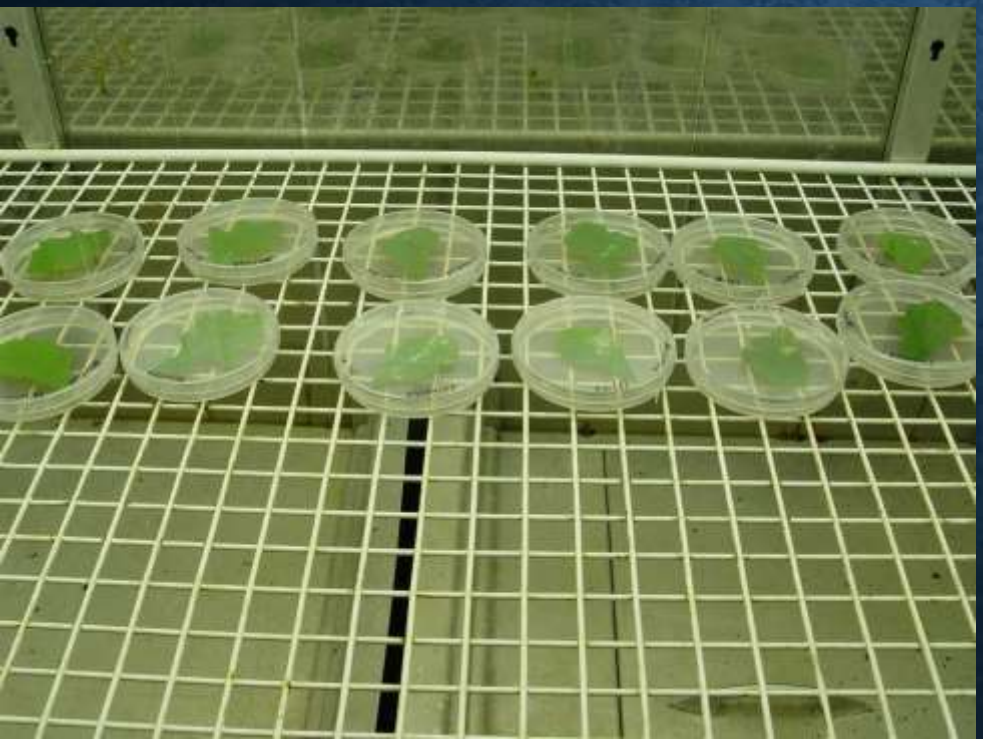

Messanger

DETACHED LEAF BIOASSAY (YEPES AND ALDWINCKLE (1993) PLANT SCIENCE. 93:211-216

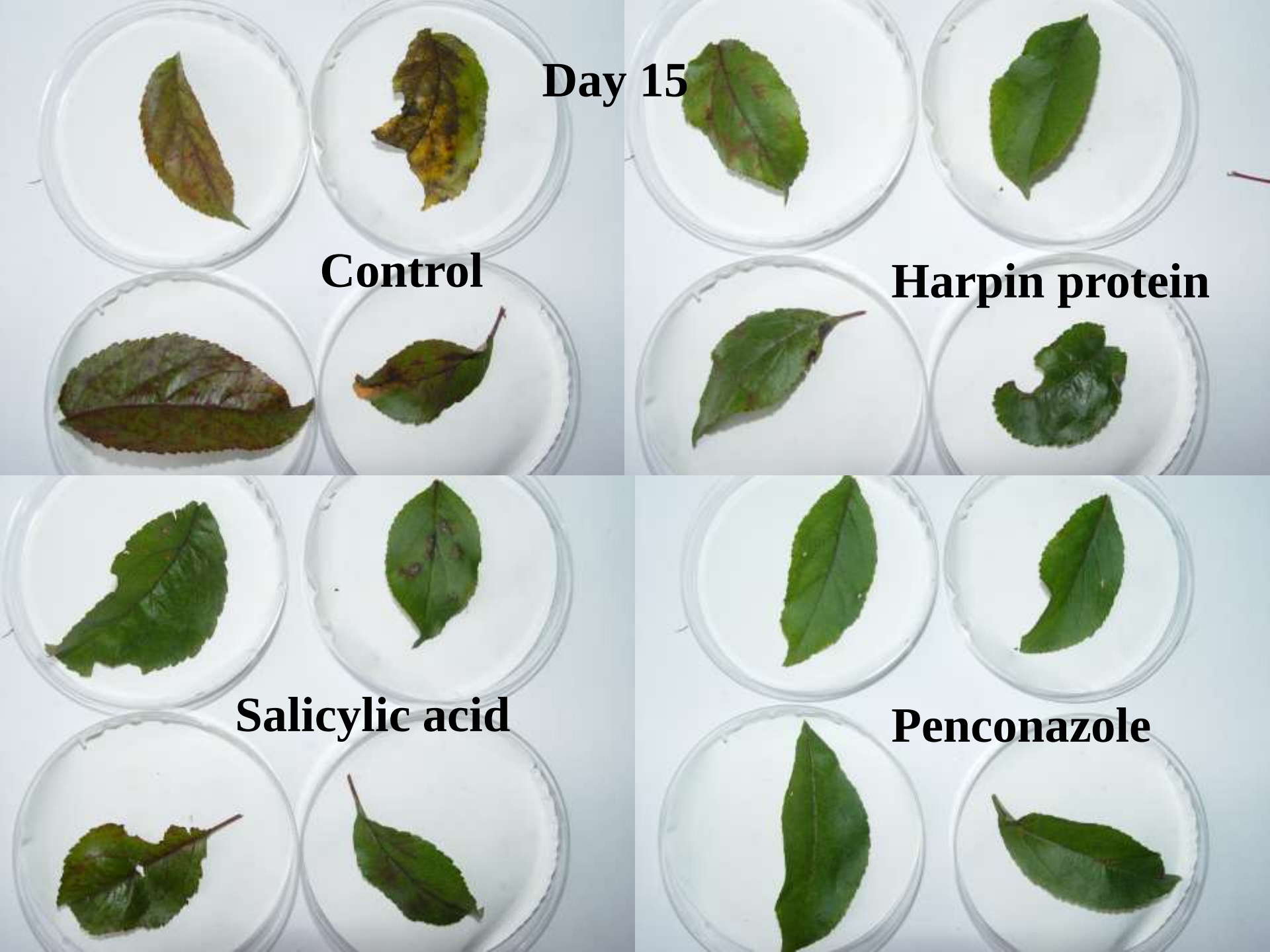
Detach healthy leaves (i.e. no signs of scab development) of a susceptible *Malus* cultivar (cv. Floribunda) and surface sterilize (Tween 20).



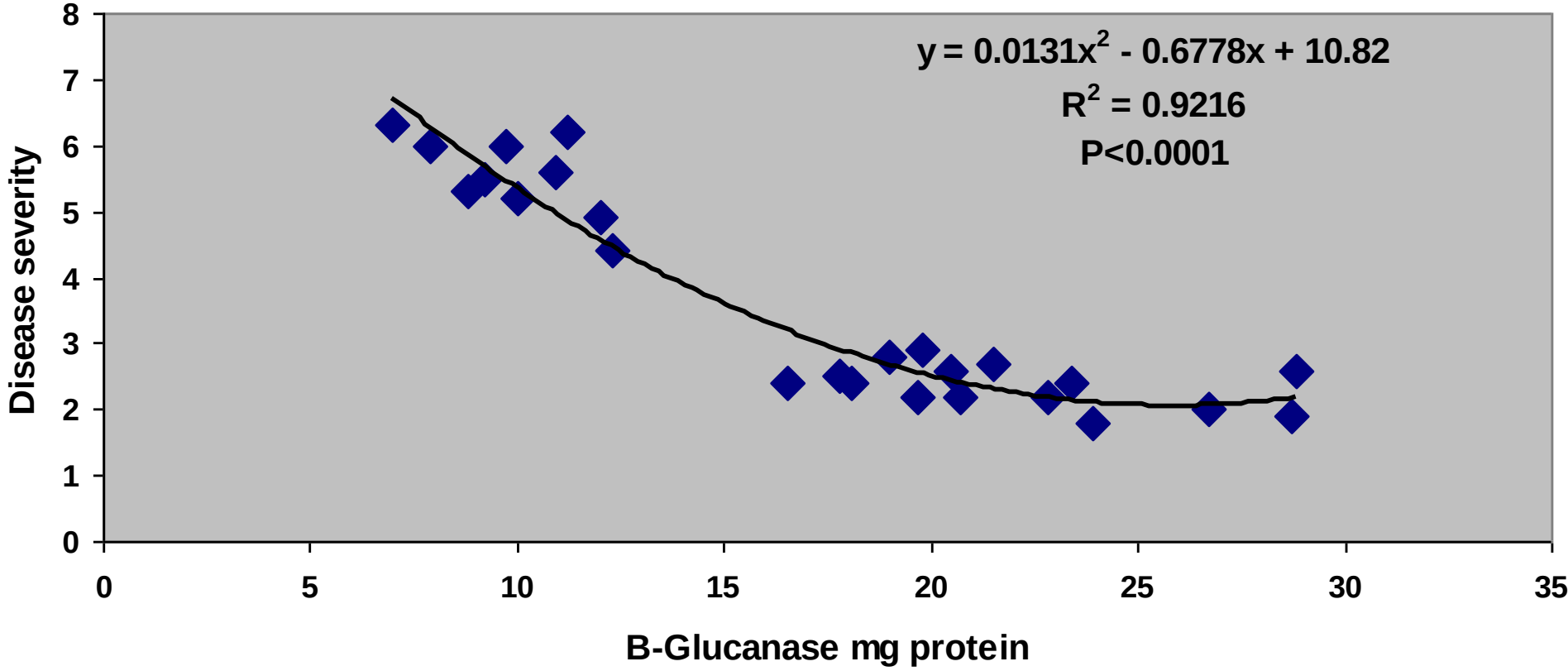
Pippette a spore suspension (10^6 ml) from cultures of apple scab onto the detached leaf previously treated with a IR agent.



- Incubate the detached leaf (19°C (66°F), 16h photoperiod).


Day 15
Control
Harpin protein
Salicylic acid
Penconazole

ACTIVITY OF B-1,3 GLUCANASE AND SCAB SEVERITY OF DETACHED LEAF TISSUE AT DAY 15



Conclusion of early work

Results of early studies provide evidence that potassium phosphite, salicylic acid derivative and harpin protein could potentially play a useful role as an alternative and/or supplementary method of apple and pear scab management under field conditions providing at least three sprays are applied during bud break to early fruitlet formation.

Percival, G.C; Noviss, K; Haynes I. (2009). Field Evaluation of Systemic Inducing Resistance Chemicals at Different Growth Stages for the Control of Apple (*Venturia inaequalis*) and Pear (*V.pirina*) Scab. *Crop Protection*. **28:** 629-633.

Percival, G C. (2009). Effect of Systemic Inducing Resistance and Biostimulant Materials on Apple Scab Using a Detached Leaf Bioassay. *Arboriculture and Urban Forestry*. **36(1):** 41-46.

- A small but significant step.
- **Trees responses can be induced by applying IR agents 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 trees in urban landscapes.**

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?

COMMERCIAL CHITIN/CHITOSAN PRODUCTS

INAPPROPRIATE SPECIES PLANTING. HEAVY APPLE SCAB INFECTION

Established Street Planting.
London, UK

CHITIN/CHITOSAN PRODUCTS

1 = Crab meal 2.0kg per tree based on MRR 0.5-1.0kg per 2.5cm trunk diameter

2 = Pure chitin (120g sq m) 360 g per tree applied

3 = Pure chitosan (120g sq m) 360 g per tree applied

4 = Liquid Chitosan 1ml into 5 litres. Apply once a week for 3 weeks and then once a month

5 = Horti feeds 0.8g per litre. Rate applied = 2.0g per tree. Apply every 2 weeks

6= Topas (Penconazole) applied as a spray

Application by vertical mulching

RESEARCH PLAN

All treatments were applied preventatively in late March 2017 i.e. no visible symptoms of apple scab on any tree tested. Trees were assessed in September 2017 and 2018. Increases in tree resistance were assessed by recording disease severity on a 0-5 scale (0 = no leaf scab observed, 5 = >75% leaf area covered by scab).

Trial site (Sept 2017) 7-8 months after treatment

Pure Chitin

Liquid Chitosan Control

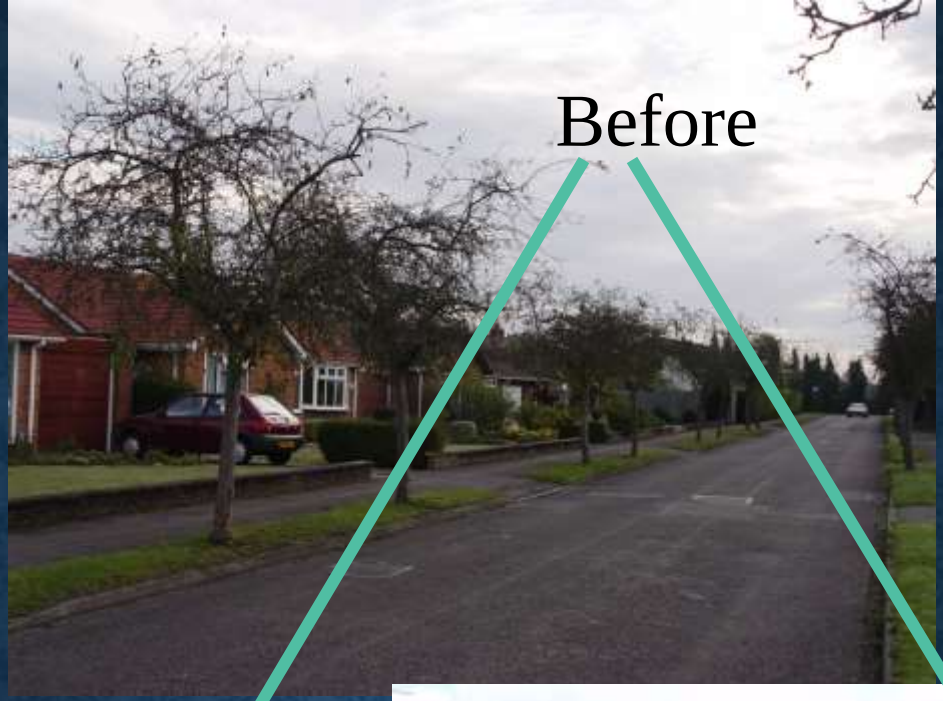
Penconazole


September 2017


Penconazole
Pure Chitosan


Crab Meal


Pure Chitin

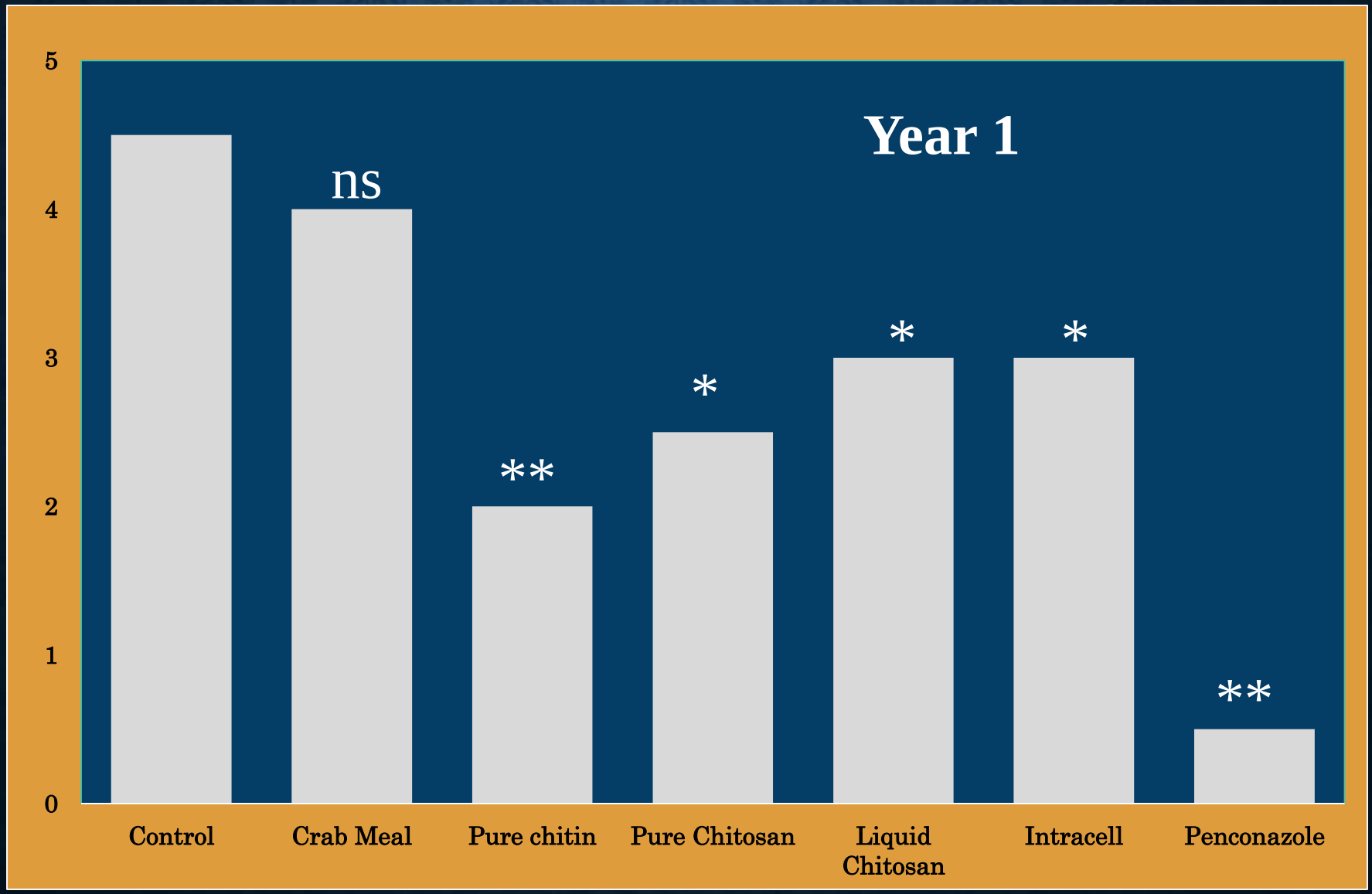

Before


After

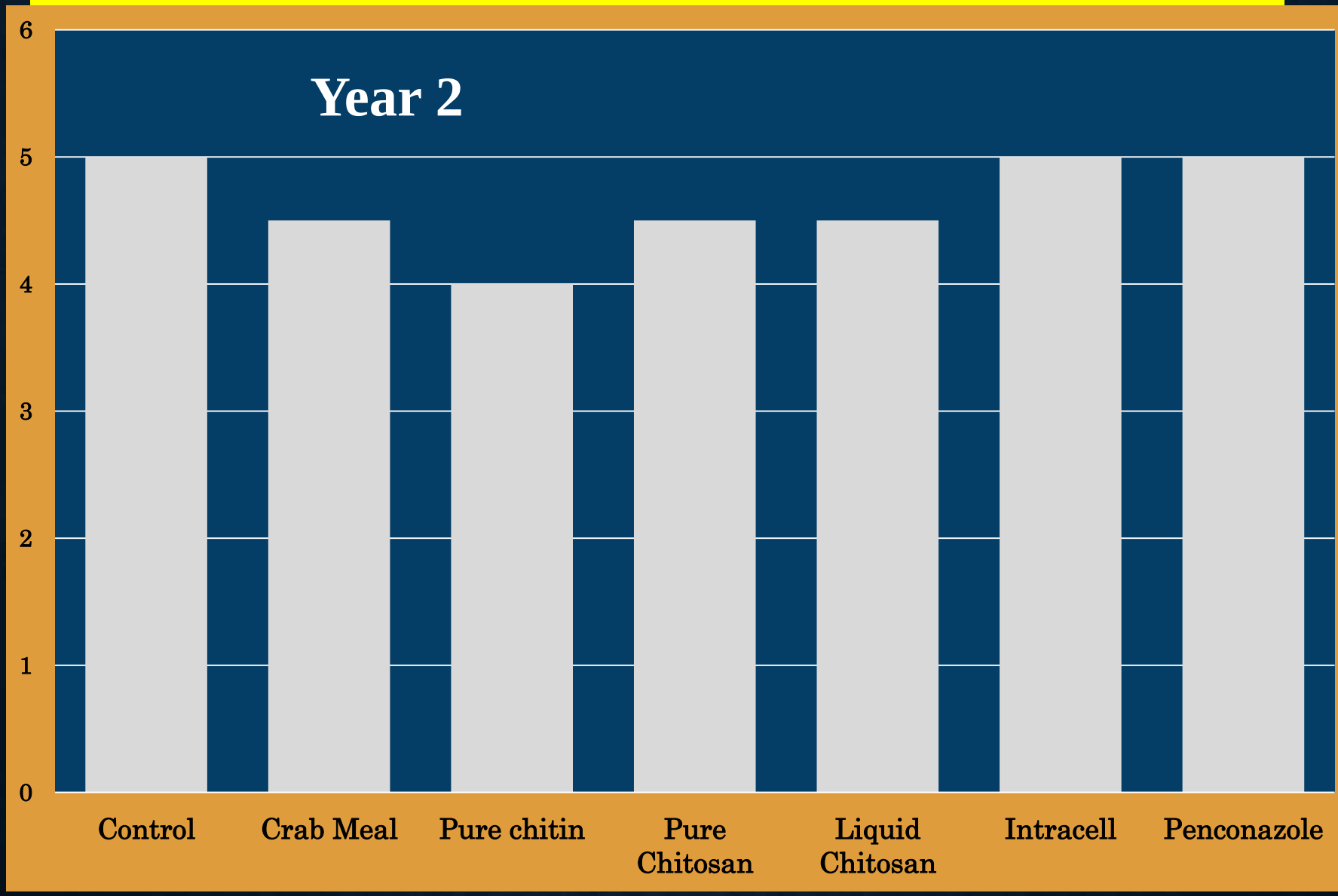

After

Year 2 Sept 2018:
No Significant Difference

THE INFLUENCE OF CHITIN BASED IR AGENTS ON APPLE SCAB SEVERITY



THE INFLUENCE OF CHITIN BASED IR AGENTS ON APPLE SCAB SEVERITY

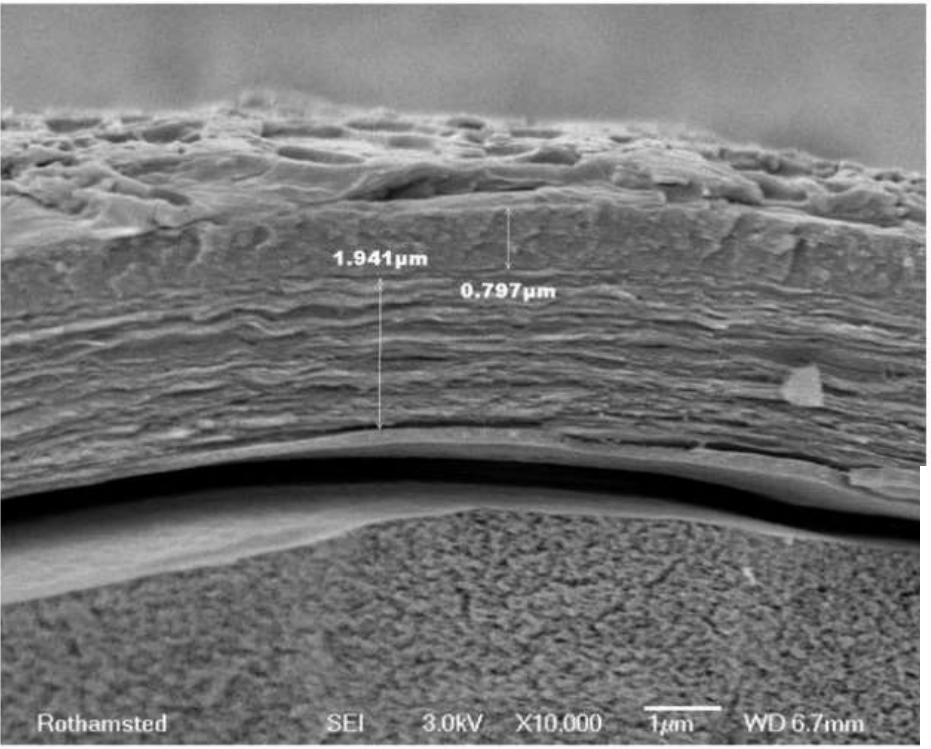


APPLE SCAB TRIAL SITE (2019)

Control

Chitin

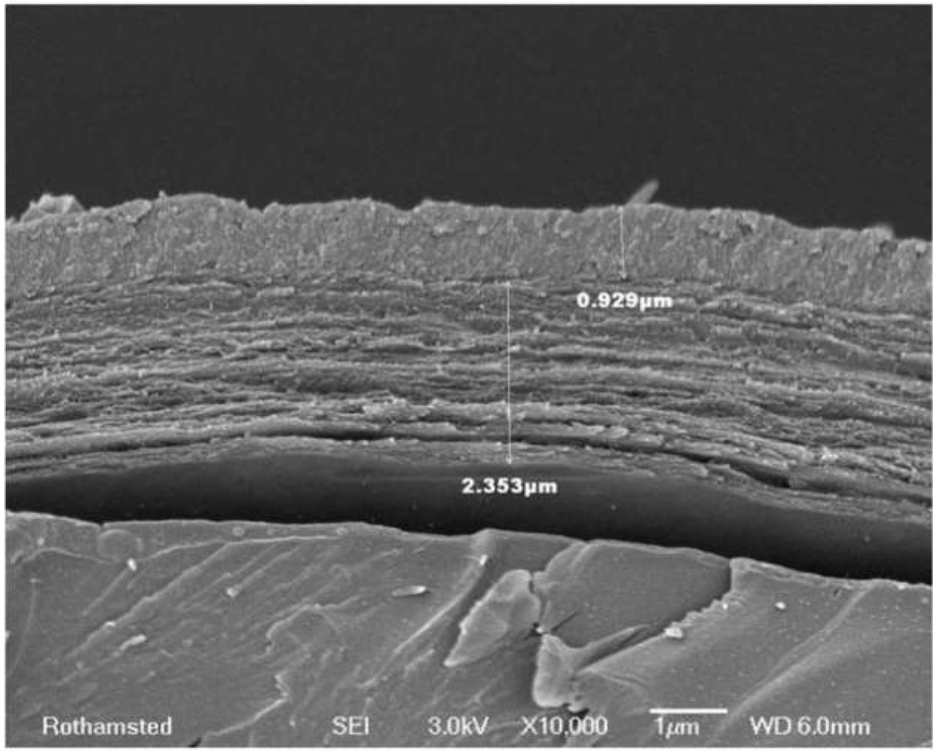
Thicker leaves



treatment 0.25% fracture 050.tif

Control

Biochar + Chitin



CONCLUSIONS

A reduction in scab severity was recorded at the end of the first growing season indicating application of chitin as a soil amendment offer potential for scab management.

None of the chitin/chitosan treatments provided any form of control against the fungal pathogen apple scab in the second growing season. This indicates that these products need to be applied annually.

Pure chitin and chitosan resulted in the greatest reduction in scab severity.

A SLIGHTLY DIFFERENT APPROACH

Research findings to date show that all of the IR agents tested are generally less effective than standard synthetic fungicides for pathogen control.

Perhaps a more appropriate role for these IR agents would be in combination with a reduced dose of synthetic fungicide to achieve control comparable or significantly higher than stand-alone applications of fungicides at full dose?

PEAR SCAB TRIAL

IR + FUNGICIDE

The pear trial site consisted of a 0.90 ha (2.3 A) block of *Pyrus communis* 'Williams' Bon Chrétien' interspersed with individual trees of *Pyrus communis* Beth and Concorde. *Pyrus communis* 'Williams' Bon Chrétien' was chosen for experimental purposes due to its sensitivity to pear scab infection. Planting distances were based on 2 by 2 m (6.6 x 6.6 ft) spacing. The trees were planted in 2003 and trained under the central-leader system to an average height of 2.5 m ± 0.25 m (8.25 ± 0.83 ft) with mean trunk diameters of 12 cm ± 1.4 cm (0.4 ± 0.05 ft) at 45 cm (1.5 ft) above the soil level.

IR + FUNGICIDE

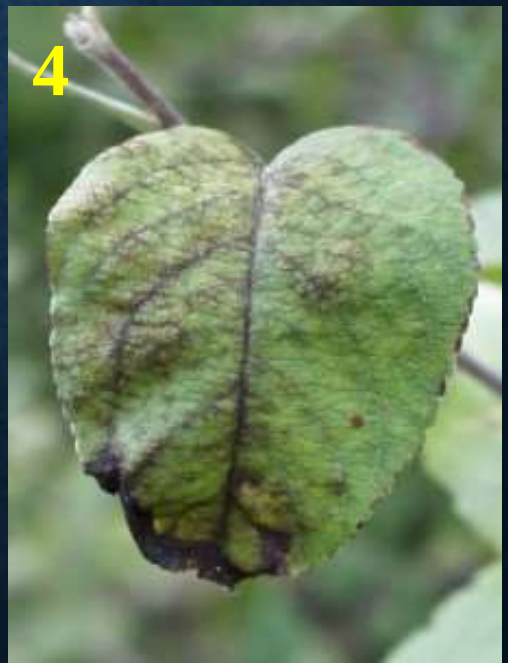
IR agent and fungicide treatments were applied at four growth stages or combinations of stages identified as key spraying times for scab control under field conditions, namely:

Bud break (March 11, 2018)
Green cluster (April 2, 2018)
90% petal fall (May 13, 2018)
Early fruitlet (June 6, 2018).

Rigel-G (a.i. Salicylic acid): 3ml (0.09 fl oz) per litre (0.26 gal) of water

Signum (a.i. 7% pyraclostrobin + 27% boscalid): 0.9g l^{-1} of water

SCAB SEVERITY SCALE - LEAF



SCAB SEVERITY SCALE - FRUIT

IR + FUNGICIDE COMBINATION

Treatment		
	Leaf Scab Severity	Fruit Scab Severity
Water (control)	3.5d	2.2e
Rigel-G (SA)	1.9bc	1.3cd
Signum FS	1.0ab	0.2ab
Signum FS + SA	0.5a	0.0a
Signum 66% + SA	1.2abc	0.8bc
Signum 33% + SA	2.0c	1.8de

Comparison of Signum + SA applied as four foliar sprays for the control of Pear Scab on *Pyrus communis* 'Williams' Bon Chrétien'

IR + FUNGICIDE COMBINATION

Treatment		
	SPAD	Fruit Yield
Water (control)	26.8a	10.1a
Rigel-G (SA)	33.2ab	11.8abc
Signum FS	42.4cd	13.6bc
Signum FS + SA	44.5d	14.0c
Signum 66% + SA	40.8bcd	12.9bc
Signum 33% + SA	35.0bc	11.5ab

Comparison of Signum + SA applied as four foliar sprays for the control of Pear Scab on *Pyrus communis* 'Williams' Bon Chrétien'

IR + FUNGICIDE

Treatment	Black Spot Leaf Severity	
	2014	2015
Water (control)	3.6c	3.3d
SA	1.5b	1.8c
Topas FS	0.8ab	0.5ab
Topas FS + SA	0.3a	0.0a
Topas 66% + SA	0.8ab	0.7ab
Topas 33% + SA	1.2ab	1.2bc

Comparison of Topas (Penconazole) + Rigel-G (SA) applied as four foliar sprays for the control of black spot (*Diplocarpon rosae*) on Rosa 'The Fairy'

CONCLUSIONS

In all pot and field studies to date application of a fungicide at two third strength plus IR agent provided the same degree of pathogen control as a fungicide at full strength.

Application of a fungicide at one third strength plus IR agent provided a reasonable degree of pathogen control but not to the same degree as that of a fungicide applied at full strength.

COMBINATIONS OF IR AGENTS ONGOING

Chitin + Willow Mulch

Preliminary results are promising

ACKNOWLEDGEMENTS

TREE FUND (HYLAND R. JOHNS GRANT)

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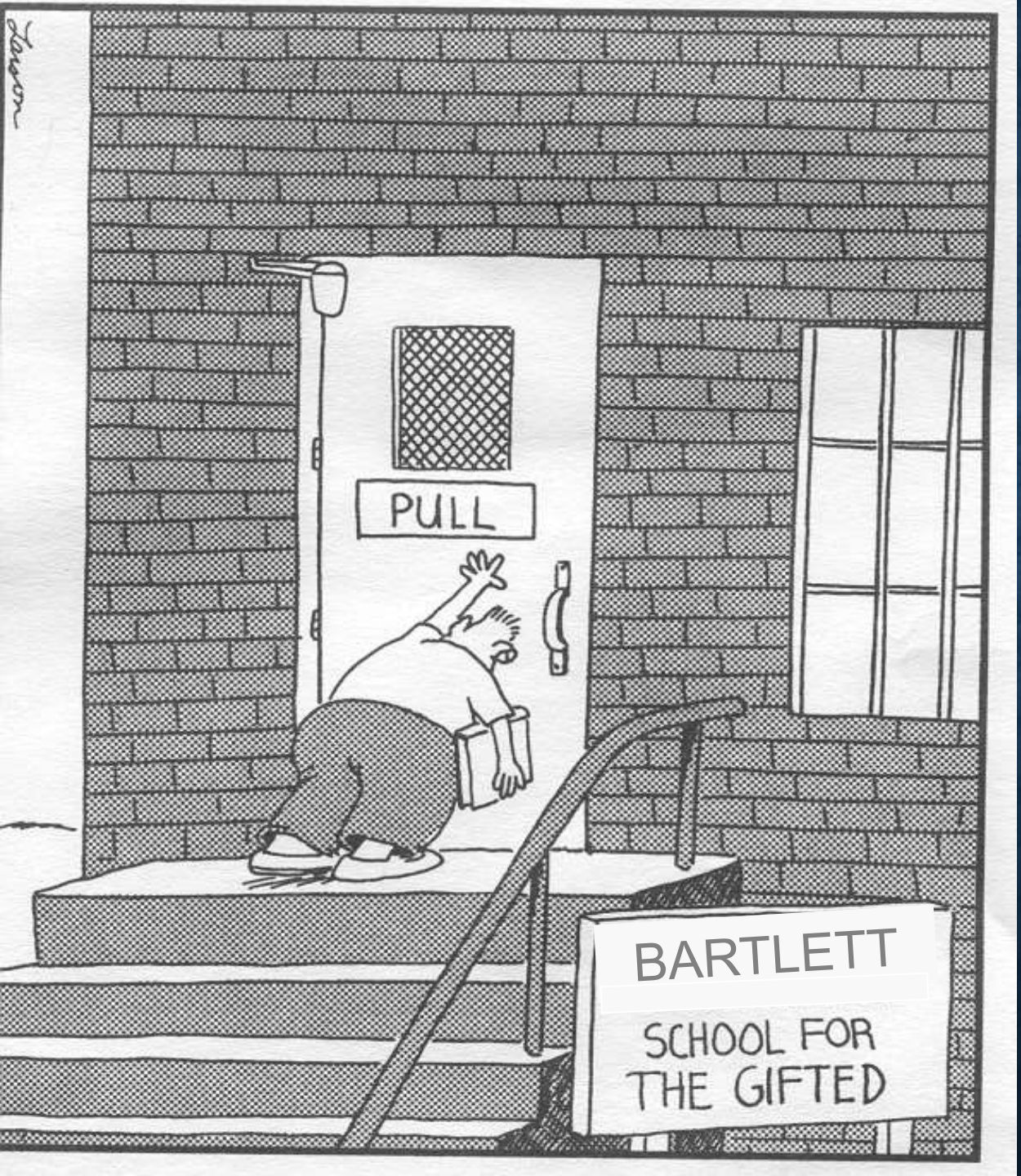

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