INNOVATIVE FARMERS

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Using willow woodchip mulch to manage apple scab

Final report

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Summary

A number of trials were instigated at orchards through-out the UK to evaluate the potential of a willow wood chip mulch applied around the base of trees on reducing disease severity of apple and pear scab, as well as document any influences on leaf nutrient and fruit sugar content. The trial commenced in February 21 and concluded on October 22, 2019. In addition the salicylic acid (SA) content of ten willow species commonly planted in the UK was quantified so growers would be aware of which species provides the highest SA content. Indeed, a wide variation in the SA content of ten willow species (0.2 (S.alba) to 3.21 (S. daphnoides) mg/g FW) was recorded. Results, based on pooled data from all trial sites, show that apple scab severity of leaves and fruit was lower than that of non-mulched controls. However, these differences were not statistically significant. Similarly, fruit sugar content was higher than that of non-mulched controls but not statistically significantly so. No detrimental or positive influences of applying a willow wood chip mulch on leaf nutrient content (Nitrogen, Sulphur, Phosphorous, Potassium, Calcium, Magnesium, Manganese, Iron, Copper, Zinc, Boron) was recorded. Only fungicide spray treatments significantly reduced leaf and fruit scab severity but had no significant effect on foliar nutrient and fruit sugar content. Recommendations for future research are suggested.

1 Field lab aims

The aim of this field lab was to assess the efficacy of single species woodchip mulches, applied to the base of the tree, against apple scab severity. Specifically, it:

1.1 Determined the salicylic acid content of commonly used willow species
1.2 Assessed the efficacy of applying single species willow wood chip as a mulch for the control of apple scab in apple and pear orchards
1.3 Assessed the efficacy of willow wood chip as plant growth and development stimulant in apple and pear trees by quantifying i) foliar nutrient content and ii) fruit sugar content (brix analysis).

2 Background

Apple scab caused by the fungal pathogen Venturia inaequalis can be devastating to apples (Malus spp.) reducing fruit quality, marketable yield, and aesthetics. As a consequence, the economics of fruit production require frequent application of synthetic fungicides throughout the growing season. Increased pathogen insensitivity to synthetic fungicides coupled with public demands to reduce use, stimulated by greater awareness of environmental and health issues has placed emphasis on the development of alternative control strategies. From a grower's perspective, the restrictions placed on the use of some fungicides, in particular Dodine which is widely used in conventional, are causing concern and the need to find alternative approaches is becoming increasingly urgent.

Induced resistance (IR) is the phenomenon whereby a plant's own defense mechanisms are induced by treatment with a biological (i.e., weakened or attenuated fungal pathogen) or chemical agent such as salicylic acid (SA). Importantly, IR is characterized by a restriction of pathogen growth and a suppression of disease symptoms compared to non-induced plants infected with the same pathogen. In addition, willow (Salix species) have been shown to be inherently high in SA.

Mulching as a means of reducing soil moisture stress, suppressing weeds and fertilising have been used in arboricultural, agricultural, fruit and ornamental crops production systems for decades. The use of a mulch made solely from willow wood chip applied around a fruit tree

offers a unique potential for the management of apple scab in that as the wood chip is degraded by soil and surface micro-organisms the release of SA into the soil may result in an IR response.

3 Methodology and data collection

SA Analysis

Samples of the ten most commonly planted willow species through-out the UK were collected from the Royal Botanic Gardens Kew and the SA content of each species determined using liquid chromatography at the University of Reading, Chemistry Department.

Field Lab Locations

Full participant details and site locations of each trial is provided in Appendix 1. A summation of sites and apple/pear varieties used in his study is shown below (Table 1).

Table 1. Site locations and apple varieties used

SITE	**Variety**
Buckinghamshire	Cox, Black Dabinett
Thatchers (Somerset)	Cox
Aston Manor (Hereford)	Prince William
G T Thompson (Harwich)	Braeburn
Heineken (Hereford)	Mitchell
Pencoed	Fiesta, Spartan, Rubinette
Kempley Barn (Ross on Wye)	Helens early*
Tom The Apple Man (Oswestry)	Hereford, Ashmead, Blenheim
Sheppys (Somerset)	Katy

* Pear variety

Tree selection

As tree size differed between locations then tree selection should be based on areas within an orchard with trees of similar age and size uniformity. Five trees should be used per treatment (mulched, non-mulched (controls), sprayed) with ideally two guard trees between treatments to minimise interactions and potential overlapping of impact.

Willow woodchip and application

Woodchip was sourced from a stand of willow of various species at Bristol University's Fenswood Farm, the site of the former Long Aston Research Station. Trees of the following species were harvested: Salix daphnoides, S. alba (Chermasina) S. fragilis. One grower (George Thompson Ltd), used chip from their own S. alba. Where possible wood chip was produced from young growth (>7cm in diameter) due to a naturally inherent SA content. Ideally 5Kg woodchip should be used per tree with the size of the chips 5 – 10 mm as chips of this size degraded during the course of the season. Fresh woodchip (Harvested on 14 February 2019) i.e. non-composted should be used.

Directions: Circa 5kg woodchip mulch should be applied to the area under the crown in a band 0.5 m either side of the tree leaving a few inches from the base of the trunk free of mulch to allow air flow around the root collar. Mulch should be applied to a depth of 5-10cm.

Mulches should be applied in January/February (early March at the latest) to allow SA to leach in the soil (4-6 weeks) and affect the trees. Ideally application should be timed to coincide with bud break

Scab severity assessment

The incidence and severity of apple scab on fruit and leaves (5-10 leaves per tree) was assessed on each of the 10-15 trees (5 mulch treated, 5 controls, 5 sprayed) in September 2019 using the scale below:

Index	Description
0	No scab observed
1	Less than 5% of leaves affected and no aesthetic impact
2	5–20% of leaves affected with some yellowing but little or no defoliation
3	21–50% of leaves affected, significant defoliation and/or leaf yellowing
4	51–80% of leaves affected, severe foliar discoloration
5	81–100% of foliage affected with 90–100% defoliation

A pictorial guide of scab severity assessment is provided in Appendix 2.

Foliar nutrient content

The influence of treatment on foliar nutrient content was assessed on fifteen leaves per tree - 5 from the top third of the canopy, 5 from the middle third and 5 from the bottom third, and from each side of the tree by selecting leaves at random from within each third. Nutrients analysed included: Nitrogen, Sulphur, Phosphorous, Potassium, Calcium, Magnesium, Manganese, Iron, Copper, Zinc, Boron.

Sugar content of fruit

Five fruits were sampled per tree. Fruit was collected from both sides of the tree as per the leaf sampling. Sugar content was analysed using a brix analysis. A brix analysis uses a small hand held piece of equipment known as a refractometer which measures the refractive index of extracted apple or pear juice which in turn is a measure of the specific gravity or sugar content of fruit.

4 Results and discussions

Please note no single location results deviated significantly from data presented within this report based on combined data from all locations used in the IF trial. Consequently, for reasons of clarity, this report is based on all data combined for all locations with one exception, the Bulmers site in Herefordshire (Heineken) where data is shown graphically within this report. Appendices 1-5 provides each IF participant with a detailed breakdown of results for their individual location.

Table 2. Salicylic Acid content of the 10 most common UK willow species

Scientific name	Common Name(s)	Salicylic Acid (mg/g FW)
S. daphnoides	European violet willow	3.21
S. matsudana tortuosa	Chinese Willow, Corkscrew	2.33
S. caprea	Pussy Willow, Goat Willow, Great	1.95
S. fragilis	Crack willow, Brittle willow	1.65
S. alba 'Chermesina'		1.62
S. pentandra	Bay Willow	0.81
S. triandra	Almond willow; Almond leaf	0.60
S. erythrotoflexuosa		0.38
S. viminalis	Basket willow/ common osier	0.21
S. alba	White Willow	0.20

Results of Table 2 show that the SA content of willow species varies considerably from 0.2 (S.alba) to 3.21 (S. daphnoides) mg/g FW.

Table 3. The influence of willow wood chip mulch versus non-mulched and sprayed trees for apple scab management

Parameter	Control	Mulched	Spray
Leaf Scab Severity	1.4a	1.2	0.6b
Fruit Scab Severity	09.a	0.8a	0.7a
Brix	10.8a	11.0a	12.2a
Nitrogen	2.31a	2.49a	2.39a
Sulphur	0.14a	0.15a	0.14a
Phosphorous	0.28a	0.30a	0.28a
Potassium	1.19a	1.41ab	1.56b
Calcium	1.68a	1.84a	1.70a
Magnesium	0.27a	0.31a	0.29a
Manganese	43.5a	49.3a	46.3a
Iron	99.1a	111.1a	101.3a
Copper	8.24a	8.59a	7.80a
Zinc	21.1a	23.2a	19.5a
Boron	29.7a	31.7a	29.2a

Data is derived from pooled means of all trial sites. Values varied between sites. Full data for each site is presented in Appendices 3, 4 and 5.

All data were analyzed using ANOVA and the differences between means were determined using Tukey w procedure (P = 0.05) using the Genstat for Windows program. This experimental design was adopted in line with Official Recognition of Efficacy Testing Organisations in the United Kingdom guidelines for product efficacy testing and analysed as a randomized complete block design.

Lower case letters indicate significant differences between means for each evaluation date by Tukey highly significance test (P = 0.05) i.e. values with the same letter are not significantly different from each other. For example fruit scab severity of non-mulched controls, mulched and spray treated trees were 0.9a, 0.8a and 0.7a respectively. This means there was no significant difference between non-mulched controls, mulched and sprayed trees (all values had the letter "a"). However, leaf scab severity of non-mulched controls, mulched and spray treated trees were 1.4a, 1.2a and 0.6b. This means there was no significant difference between non-mulched

controls and mulched trees (both have the letter “a”) but sprayed trees had significantly lower scab severity hence the letter “b”.

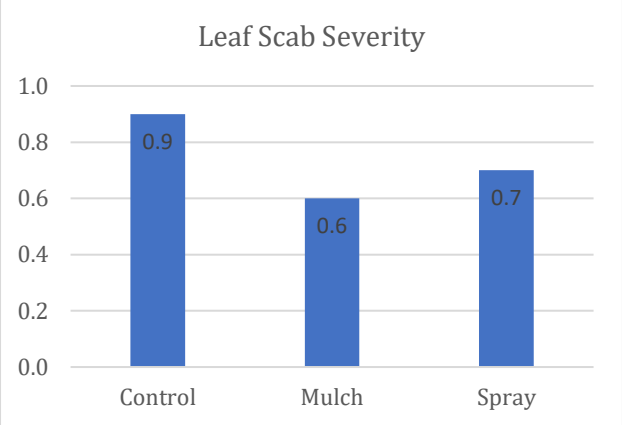
Results show that when data from all trial sites is pooled there was no statistically significant influence of willow wood chip on leaf and fruit apple scab severity. However, applying willow wood chip did significantly reduce scab severity on some orchards/trial sites (Appendix 3) i.e. Aston Manor (var. Prince William), Pencoed (var. Rubinette), Heineken (var. Mitchell; Graphs 1 and 2) and Sheppys (var. Katy). Similarly where a willow mulch was applied scab severity values were always lower compared to non-mulched trees indicating a “trend” towards lower apple scab severity on willow mulched trees. Only spraying with a conventional fungicide significantly reduced apple scab severity*.

*data derived from three trial sites only.

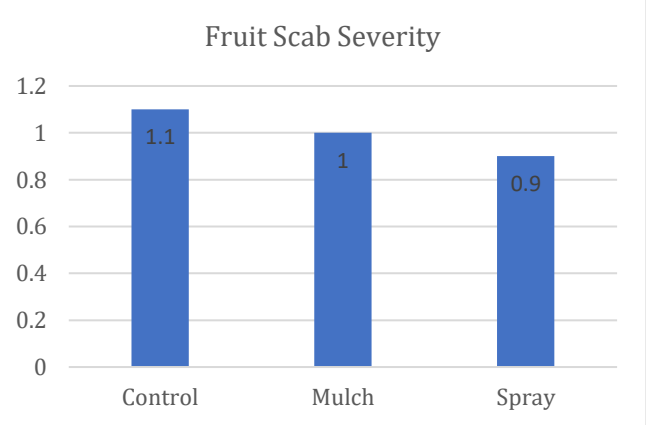
There was no significant influence of willow wood chip or fungicide sprays on fruit sugar content compared to non-mulched controls. Although willow mulched trees in general had a higher fruit sugar content these values were not significantly different from non-mulched controls (Graph 4, Appendix 4).

Pooled data for all trial sites shows there was no significant influence of a willow mulch or fungicide sprays on leaf nutrient content (Appendix 5). Again, however, applying a willow wood chip did enhance leaf nutrient content i.e. Nitrogen (Graph 3), Sulphur, Phosphorous, Potassium, Calcium, Magnesium, Manganese, Iron, Copper, Zinc, Boron compared to non-mulched control trees indicating a trend towards a higher leaf nutrient content on willow mulched trees.

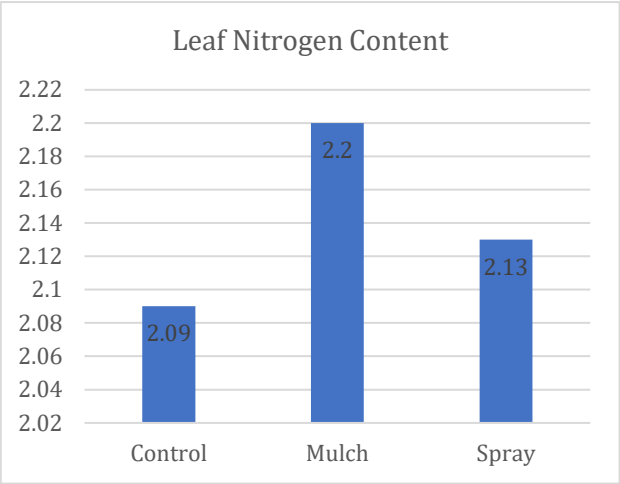
Graphs 1-4 The influence of willow wood chip mulch, non-mulched and fungicide sprayed trees on leaf (Graph 1) and fruit (Graph) scab severity, leaf nitrogen content (Graph 3) and fruit sugar content (brix; Graph 4) on apple var ‘Mitchell’ at Bulmers Orchard, Herefordshire.



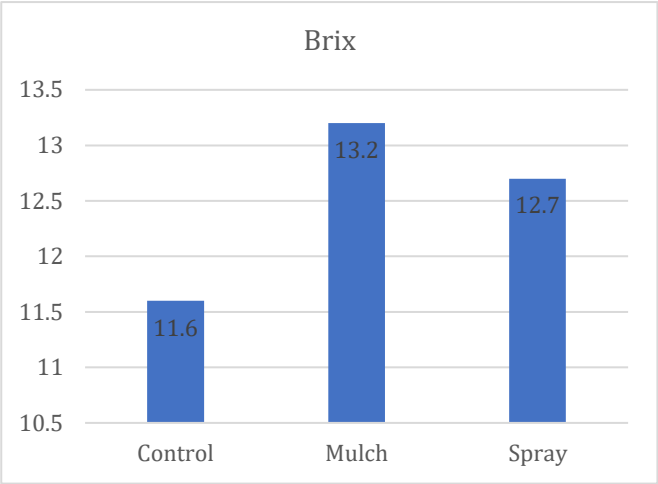
Graph 1.



Graph 2.



Graph 3.



Graph 4.

5 Conclusions and recommendations

Results consistently show a "trend" across all trial sites (Appendix 5) towards lower leaf and fruit scab severity and higher leaf nutrient content following application of a willow mulch around the base of fruit trees. Trial sites were treated with mulches made from primarily white willow species (*S.alba, S.alba 'Chermasina, S.fragalis*), which a later analysis was shown to be the lowest SA containing willow species. This does raise the possibility that treating with a different willow species i.e. *S. daphnoides* or *S. matsudana tortuosa* with an inherently higher SA content would result in even lower scab severity and higher leaf nutrient content. In support of this *S.daphnoides* was used at the Aston Manor site where significantly lower scab levels were recorded.

At some of the sites visited the amount of willow mulch applied was far lower than that recommended (5kg per tree) while the size of the tree was quite large (4-6 metres). This raises the possibility that the overall amount of SA provided to the tree was insufficient to induce any resistance response. Photograph 1 and 2 shows the authors mulch trial and amount applied compared to what was frequently seen at some of the trial locations (Photographs 3 and 4). Consequently it could be argued that had a greater amount of mulch been applied then a lower scab severity and higher leaf nutrient content may have been recorded.

Photographs 1-2. Author's trial site

Photographs 3-4. Two different trial sites.

Recommendations

1 Further research has shown that SA is primarily concentrated within willow bark. Consequently the use of a willow bark mulch (a by-product of basket weaving) would be superior to that of a mulch made from willow wood and offers possibilities for future research.

2 Some of the apple varieties tested were highly scab sensitive. A willow wood mulch may offer greater possibilities when used with intermediate and resilient apple species.

3 Likewise, use of a commercial SA sprays (Rigel-G) in combination with willow mulches, especially those with a low SA content, offers potential as a viable scab management option.

4 For future work species with the highest SA content should be selected for mulching/scab management purposes.

6 Further reading

[References and useful literature]

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