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NEW STRATEGIES FOR THE INTEGRATED CONTROL OF AVOCADO FRUIT DISEASES

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SUMMARY

Silicon has been useful in protecting agronomically important crops against diseases. As the avocado industry looks towards using less fungicides we investigated the possible use of silicon for the control of postharvest anthracnose of 'Hass' avocado. We found injecting soluble silicon into trees prior to harvest significantly decreased the severity and incidence of anthracnose. A combination of soluble silicon and phosphorous acid was not effective for control of anthracnose.

Key words: anthracnose, silicon, postharvest, 'Hass'

INTRODUCTION

Effective disease control in plants is rarely achieved by using a single control method. Anthracnose (caused by the fungus *Colletotrichum gloeosporioides*) control in avocado relies on the combination of a number of practices including; pre-and postharvest fungicide use, crop hygiene, canopy management and controlled atmosphere ripening and storage. Recent additions to the suite of control measures are rootstock selection and nutrition management (Willingham *et al.,* 2001). Despite all of these measures, the emphasis is still on fungicide applications (both pre-and postharvest) for disease control.

All plants have their own systems of defence against pathogens (such as fungi, bacteria and viruses). If they did not then they would succumb to an even greater number of diseases. When a pathogen comes into contact with a plant, the plant responds by setting off a cascade of signalling which leads to the induction of defence responses. Some defences may be structural (such as cell wall thickening or tyloses), others are biochemical (such as phenolics or phytoalexins which are toxic to plant pathogens, or enzymes such as glucanases or chitinases which break down fungal cell walls) (Agrios, 1988, Guest & Brown, 1997). When defenses are not induced quickly enough then disease may develop.

Interestingly, phosphorous acid which is used for the control of Phytophthora root rot in avocado induces plant defences. At high concentrations phosphorous acid acts like a fungicide by inhibiting fungal growth and disrupting lipid and phosphorus metabolism. At low concentrations it acts like a defence elicitor by inducing hypersensitive cell death (to

prevent spread of the pathogen), lignification and causing phytoalexin accumulation (Guest *et al*, 1995).

Silicon has long been associated with disease resistance in plants. Due to the way in which silicon (as silica) is deposited in cell walls, it was thought that silicon provided protection against fungal diseases by strengthening cell walls thus making it more difficult for the fungi to penetrate and colonise the plant (Fawe *et al*., 2001). Early studies also showed silica accumulating at sites near pathogen entry points (Fawe *et al*., 2001). These observations led researchers to believe that silicon acted against pathogens by increasing the mechanical resistance of plants. However, recent work has shown that silicon also induces defence responses. For example, Dann and Muir (2002) found that growing pea plants in silicon amended potting mix increased the production of defence proteins (chitinase and glucanase). The treated pea plants also developed significantly less disease than the untreated controls (Dann and Muir, 2002).

Combining silicon treatments and fungicides for disease control has also been investigated. Fawe *et al*. (2001) and Datnoff *et al.* (2001) report that by combining silicon treatments with fungicide applications, the number of applications needed to control disease was reduced.

With all the data showing the benefit of silicon in disease control the question which we wanted to answer was “Would treating avocado trees with silicon decrease the development of postharvest anthracnose?”.

In the 2003/2004 avocado season we found ‘Hass’ fruit from trees injected with soluble silicon (containing 1000ppm soluble silicon) 8 and 12 weeks prior to harvest had significantly less anthracnose than untreated control trees (Anderson *et al.*, 2004). There was a 50% reduction in the number of fruit affected with anthracnose 8 weeks after treatment with soluble silicon.

The aim of the work presented in this paper was to examine the effect of timing of injections and rates of silicon applied on the development of anthracnose. Since trunk injection with phosphorous acid is already used to control Phytophthora root rot we also wanted to examine the effect of injecting with a mixture of phosphorous acid and soluble silicon.

MATERIAL AND METHODS

Treatments. The trial was conducted on ‘Hass’ grafted to either clonal ‘Velvick’ or ‘Edranol’ trees at Duranbah, northern New South Wales (NSW) in the 2004/2005 avocado season.

Each treatment (Table 1) was applied to 3 single replicate trees for each rootstock (‘Edranol’ and clonal ‘Velvick’). Trees were treated in November 2004 (time of greatest cell division in fruit) and/or March 2005 (12 weeks prior to harvest). Trees were treated with solutions containing 1000ppm soluble silicon, 2000ppm soluble silicon or 1000ppm soluble silicon mixed with 20% phosphorous acid (H_2PO_3).

Silicon was applied using the trunk injection method developed for application of phosphorous acid for the control of Phytophthora root rot. Around 15mL of solution per cubic metre of canopy was applied to each tree.

Fruit were snap harvested in late June 2005. At the time of harvest fruit were tested for percentage dry matter (an indicator of maturity). Fruit were packed into commercial count 20 trays and brought back to the laboratory for ripening and assessment.

Table 1. Treatments applied to control of anthracnose using silicon trial at Duranbah, 2004/2005 'Hass' season.

Treat. no.	Treatment
1	Untreated control
2	1000ppm soluble silicon in November 04
3	2000ppm soluble silicon in November 04
4	1000ppm soluble silicon in March 05
5	2000ppm soluble silicon in March 05
6	1000ppm soluble silicon in November 04 and in March 05
7	20% phosphorous acid + 1000ppm soluble silicon in November 05 and in March 05

Ripening and assessment Trays of fruit were ripened at 23ºC and 65% relative humidity to encourage the development of anthracnose. At the eating ripe stage fruit were peeled and assessed for the development of anthracnose. The shelf life of the fruit was recorded as the number of days from harvest to the eating soft stage. Anthracnose was recorded as the percentage of surface area affected (severity) and the percentage of fruit affected (incidence). Stem-end rot was recorded as the volume of flesh of each fruit affected (severity). The incidence of stem-end rot was the percentage of fruit affected. Isolations from diseased tissue were made onto streptomycin amended potato dextrose agar to determine the causal organism of stem-end rot. Data was compared using analysis of variance (Genstat 6th Ed).

RESULTS AND DISCUSSION

Silicon treatments tended to be variable with 1000ppm in November 2004 and 2000ppm in March 2004 being highly effective. Generally treating with silicon decreased the severity (Figure 1) and incidence (Figure 2) of anthracnose. However, some treatments were not statistically different to the untreated control (Figures 1 & 2).

Treatments had no effect on fruit maturity (range of 22-30% dry matter with an average of 26%) or shelf life (data not shown). Severity and incidence of stem-end rot and percentage of marketable fruit was not affected by treatment (data not shown).

The phosphorous acid/silicon treatment did not decrease the incidence or severity of anthracnose. The pH of the phosphorous acid/silicon solution used in this study was 6.3. In their review of the chemistry of silicon, Knight *et al.* (2001) indicate that as the pH of the solution falls below 9 the amount of silicic acid in solution decreases. In our work, due to the low pH of the phosphorous acid/silicon solution very little soluble silicon would have been available to the avocado tree. This probably explains why there were no differences in disease levels between the untreated and the phosphorous acid/silicon treated trees.

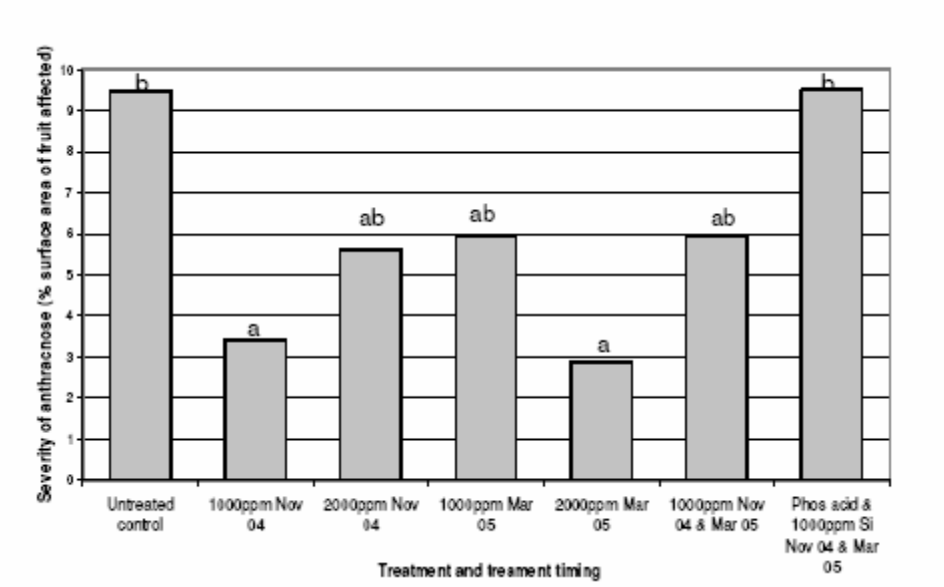

Figure 1. The effect of silicon application rate and timing on the severity of postharvest anthracnose of 'Hass' avocado.

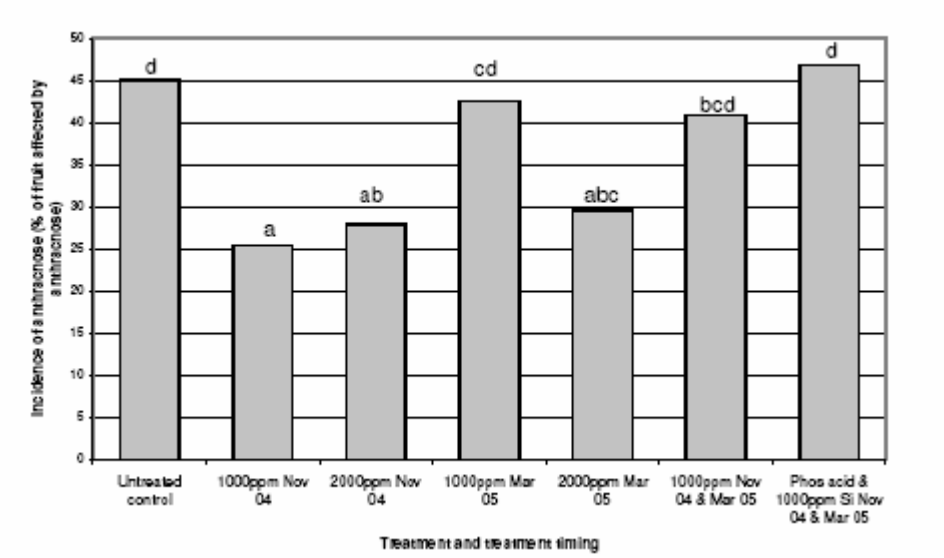

Figure 2. The effect of silicon application rate and timing on the incidence of postharvest anthracnose of 'Hass' avocado.

Now that we have shown that silicon can control anthracnose through trunk injections, future research will examine the effect of applying the silicon through fertigation. Once absorbed by roots silicic acid solution moves to the canopy by following the transpiration stream where it eventually forms insoluble deposits (polymerizes) in the extra-cellular spaces and walls of epidermal cells at sites of strong evapotranspiration as well as in basal cells of trichomes (Ghanmi *et al.*, 2004). The precise mechanisms by which silicon reduces disease are not fully understood. There is some evidence to indicate that silicon must be in the soluble form to induce defence reactions (Fawe *et al.*, 2001). However, once deposited silicon may also be acting as a physical barrier to penetration

by the pathogen.

We do know that avocados are able to absorb silicon from the soil solution because insoluble deposits (phytoliths) have been found in avocado leaves. Similar deposits have also been found in pineapple and banana (Sangster *et al*, 2001).

CONCLUSIONS

Injections of soluble silicon can reduce the severity and incidence of postharvest anthracnose. Further studies will investigate the most appropriate application method for the industry. Unfortunately, at this stage, phosphorous acid and soluble silicon mixtures do not provide control of anthracnose. Foliar applications are likely to be ineffective. We do not yet know whether the avocado tree has the capacity to absorb sufficient soluble silicon through the feeder roots to give similar control to applications by injections. This is because plants vary considerably in their ability to absorb silicon from the soil solution.

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