Exploring non-traditional products for management of postharvest anthracnose and stem end rot in avocado

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Abstract

There are many products available which may be effective in reducing postharvest fruit disease (anthracnose and stem end rot) of avocado, but which have not been rigorously tested. While some of these are fungicides registered in other crops, others are purported to be “organic” fungicides and some may not be directly fungicidal, but rely on alternative mechanisms of action on the plant or pathogen. We tested the efficacy of several products in postharvest dipping and field spray trials in avocado. ‘Hass’ fruit dipped in fungicides prochloraz (the standard practice in Australia), fludioxinil, NaturalGreen® or EcoCarb®, resulted in significantly less anthracnose developing in fruit than in water-dipped controls. Only the fungicide treatments resulted in significantly less stem end rot. In subsequent trials with ‘Hass’ and ‘Reed’ disease levels were lower and there were no significant treatment effects, however the most marketable fruit were from the fungicide and EcoCarb treatments. Field trials with ‘Hass’ showed that spray applications of mancozeb fungicide (not registered for avocado in Australia), copper + azoxystrobin (standard industry program) or “Product A”, significantly reduced anthracnose. Stem end rot was the least severe in fruit treated with standard fungicides or Product A. The most marketable fruit were from the standard industry fungicide treatments, however there were slightly more marketable fruit from mancozeb, Product A and NaturalGreen treatments compared to water and other treatments. EcoCarb, Aminogro® and Bion® field sprays were not effective. NaturalGreen had effects on skin N, Ca, K and Mg.

EXPLORANDO PRODUCTOS NO-TRADICIONALES PARA EL MANEJO POSCOSECHA DE LA ANTRACNOSIS Y PUDRICIÓN DE RAÍZ EN AGUACATES

Existen muchos productos disponibles, los cuales pueden ser eficientes para reducir enfermedades en el fruto de aguacate (antracnosis y pudrición de tallo), pero no han sido probados rigorosamente. Mientras algunos fungicidas han sido registrados en otros cultivos, otros pretenden ser ‘orgánicos’ y algunos pueden no ser fungicidas directamente, pero se basan en mecanismos de acción alternos en la planta ó patógeno. Nosotros comprobamos la eficacia de varios productos en la etapa de pos-cosecha y realizamos ensayos de riego. Los frutos de aguacate de la variedad ‘Hass’, al ser sumergidos en el fungicida prochloraz (práctica convencional en Australia), fludioxinil ó en fungicidas orgánicos NaturalGreen y EcoCarb mostraron una reducción significativamente de antracnosis en comparación con el control realizado con agua. Solo aquellos tratamientos con fungicidas mostraron menor pudrición de tallo. En ensayos subsecuentes con ‘Hass’ y ‘Reed’ se observó la disminución de la enfermedad, aunque los mejores resultados se obtuvieron a partir de los tratamientos con los fungicidas y EcoCarb. Ensayos de campo con ‘Hass’ mostraron que la aplicación del fungicida mancozeb (no esta registrado en Australia), cobre y azoxystrobin (modelo utilizado en Australia) o el producto ‘A’, disminuye significativamente la antracnosis. Los frutos de mayor mercadeo fueron aquellos en los tratamientos bajo la práctica convencional, aunque fueron solo un poco mas que aquellos tratados con mancozeb, producto ‘A’ y Natural Green en comparación con los de agua y otros tratamientos. Los tratamientos de riego con Ecocarb, Aminogro y Bion no fueron eficientes. NaturalGreen mostró efectos en la cáscara, N, Ca, K y Mg.

Introduction

One of the greatest challenges faced by producers is the control of fruit diseases to maintain the supply of high quality and robust fruit to meet the expectations of the consumer. In the Australian production system, the two major diseases of concern are anthracnose fruit rot caused by the fungal pathogens *Colletotrichum gloeosporioides* and to a lesser extent *Colletotrichum acutatum* and stem end rot caused by a range of fungal pathogens though primarily anamorphs of *Botryosphaeria* spp (Pegg et al, 2002).

There are currently a number of traditional chemicals registered for use in the control of post harvest diseases of avocado fruit that are available to Australian producers. However there is a general movement in agriculture towards products considered more environmentally friendly and 'green' to allay the fears of consumers surrounding chemical residues in both produce and their effects on the environment. With this in mind, producers are often in search for new 'greener' products that may contribute their 'green' credentials. This move has generated a new market for a range of products touted to have beneficial influences in controlling post harvest diseases often with little to no objective peer reviewed and independent scientific data to support such claims.

Trials have been conducted to test a number of 'non-traditional' products in the control of anthracnose and stem end rot diseases of avocado fruit in both preharvest spray trials and post harvest dipping trials.

Materials & methods

Postharvest dipping trials

Post harvest dipping trials were undertaken to determine the effect on the severity and incidence of anthracnose and stem end rot of dipping avocado fruit after harvest in solutions containing un-registered fungicides, organic fungicides, or products with novel modes of action, compared to fruit left untreated or dipped in the industry standard of Sportak® (prochloraz). A brief outline of the products used in the trials follows.

NaturalGreen® (naturalGreen GmbH, Germany) is composed primarily of calcium carbonate ($CaCO_3$) approx. 79%, and magnesium carbonate ($MgCO_3$) 4.6%, and is high in silicon and trace elements such as iron, copper, manganese, selenium and zinc. It's manufacturers claim a wide range of benefits, including improvement of natural resistance against plant diseases, improvement of yield and quality, and continuous supply of calcium to the plant aiding cellular stability and ionic exchange. It is certified by BioGro New Zealand for organic production as well as being listed by the Organic Materials Review Institute USA for use in organic systems (Natural Green n.d.).

EcoCarb (Organic Crop Protectants, Sydney), is registered as an organic fungicide by Australia Certified Organic and is based on activated potassium bicarbonate. It is also recognized as a fungicide by the Australian Pesticides and Veterinary Medicines Authority where it is classed as a Group Y fungicide registered for use in controlling powdery mildew in grapevines and roses. According to its makers, EcoCarb changes the pH of the leaf surface severely disrupting spores and fungal cell walls (Organic Crop Protectants 2005).

Aminogro® (Organic Crop Protectants, Sydney) is claimed to be a 'plant crop biostimulant' based on chitosan derived from prawn shells, and other marine sourced materials which are converted in a unique industrial digestion process into amino acids, polypeptides, proteins and fortified with a range of trace minerals and vitamins. The amino acids are rapidly absorbed by the plant and help the plants immune system to minimise insect and fungal attack/damage to correct minor stress and nutrient deficiencies to maximise premium quality fruit flowers and produce (Organic Crop Protectants, 2005).

Bion® (Syngenta) contains the active compound acibenzolar-S-methyl, a known plant defence activator that has been commercialised in many countries for use in specific plant/pest target systems and has been effective in some mango trials in reducing postharvest disease (eg. Zainuri, 2006).

Scholar® (Syngenta) is a fungicide containing fludioxonil registered for the control of blue and green moulds in citrus, kiwi fruit, pome and stone fruits as well as diplodia stem end rot in citrus and brown rot in stone fruit.

In 2009, post harvest dipping trials were carried out on ‘Hass’ fruit in July and repeated on ‘Reed’ fruit in December. For the ‘Hass’ trial, 640 fruit, free of obvious blemishes, were selected at harvest from bulk bins from a farm in Duranbah, northern New South Wales and divided into 32 trays with 20 fruit per tray. The following day, dipping treatments (Table 1) were imposed with four replicate trays of fruit per treatment. Once fruit had been dipped they were air dried and then re-packed into fruit boxes before been moved to a controlled environment ripening room set to 23^{o}C and 65% relative humidity. Fruit were monitored for ripeness and judged to be eating ripe based on the amount of give in the flesh when squeezed. Once eating ripe, fruit were peeled and assessed for disease severity by rating the percentage of the fruit surface affected by side rots and the percentage of fruit volume affected by stem end rots.

Fruit used in the ‘Reed’ trial in December 2009 were harvested from 40 trees on a farm at Hampton in south east Queensland, with one tray of fruit harvested per tree. Treatments were applied in the same way as for the ‘Hass’ trial, with five replicate trays per treatment. Fruit were then ripened as previously described until assessed as eating ripe. Once at eating ripe stage, fruit were assessed with the peel intact for disease severity by rating the percentage of the fruit surface affected by side rots and where stem end rots were apparent, cutting into the fruit to determine the percentage of fruit volume affected by stem end rots.

These trials were repeated in the 2010 season. Hass fruit were harvested in July 2010 from the farm at Hampton with eight trays of fruit harvested from each of five trees with one tray of fruit per tree treated with each of the treatments. Forty trays of ‘Reed’ fruit were collected from bulk bins at harvest in January 2011 and treated as previously described with five replicate trays per treatment.

Data from both seasons was analysed using GenStat 11 data analysis software (GenStat 2008) using a general analysis of variance design. Fisher’s protected least significant difference (LSD) test (P=0.05) was used for pair-wise comparisons of means.

Preharvest spray trials

Preharvest spray trials were undertaken to determine the effect on the severity and incidence of anthracnose and stem end rot of fruit harvested from trees that had received applications of various products not currently used widely by Industry (as described above), throughout the growing season compared to fruit harvested from trees that had been left untreated or treated with the standard industry fungicide regime (regular copper sprays plus one or two applications of azoxystrobin fungicide). The trials incorporated chemicals used in the dipping trials as well as the products Serenade Max®, Kasil® 2040 and Rainshield®.

Serenade® MAX (Agraquest, USA and supplied locally by Nufarm Australia), is a biocontrol agent based on a patented strain of *Bacillus subtilis* (QST 713), with claimed superior antimicrobial activity via 3 classes of antimicrobial compounds and efficacy against a broad range of bacterial pathogens, as well as activating plant defence responses. It is supposedly synergistic with fungicides (eg. strobilurins and triazoles), as cell membranes are damaged by the lipopeptide compounds giving fungicides improved access to fungal cells (AgraQuest, 2007).

Kasil 2040 (PQ Corporation, Sydney) has been shown (inconsistently) to reduce postharvest disease when applied as a trunk injection (Anderson, Pegg *et al.* 2004) however, it’s efficacy as a foliar spray with surfactant to aid penetration into leaf cells has not been adequately examined. The disease-reducing effect of silicon has been shown for many plant/pathogen systems, where it is particularly effective in annual crops (Dann and Muir 2002; Whan 2009).

Dithane Rainshield™ (Dow AgroSciences Aust. Ltd.) is a formulation of the protectant fungicide mancozeb with claimed improved rainfastness and more uniform distribution upon application. It is currently registered in mangoes and other fruit crops but not avocados.

Trials were begun in November 2009 at trial sites in the Glass House Mountains and Childers, both in Queensland. At both trial sites, five tree replicates were assigned per treatment.

At both sites trees were treated with the trial chemicals five times throughout the growing season at six to eight week intervals. Industry standard and Dithane treated trees also received an application of the fungicide Amistar at three weeks and one week prior to harvest.

Treatments at the Glass House Mountains site were applied using a vehicle mounted spray rig while those at the Childers site were applied with a motorised backpack mounted rig.

Fruit were harvested from the trials once they had reached 24% dry matter and final treatment application had been made. Twenty fruit per tree were harvested and transported to Indooroopilly Research Centre before being stored in a controlled environment room set at 22^{o}C and 70% relative humidity. Fruit were monitored for ripeness and assessed as described previously.

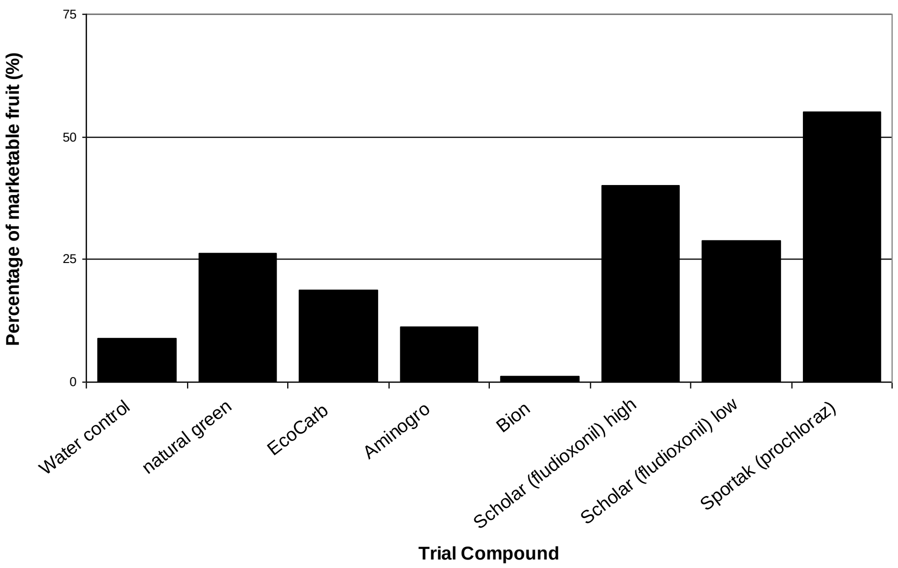
The peel of fruit from the control and NaturalGreen treated trees at both locations was also sampled for measurement of nitrogen, calcium, magnesium and potassium levels.

Results

Postharvest dipping trials

In the 2009 'Hass' trial the fungicides significantly reduced the severity and incidence of anthracnose compared to the water control. Disease levels were also reduced in fruit dipped in NaturalGreen and EcoCarb. These reductions in disease translated to a higher percentage of marketable fruit (defined as fruit which had less than 5% anthracnose, and no stem end rot). Marketability was greatest for fruit treated with Sportak being significantly greater than for fruit treated with all other products except the high rate of Scholar (Figure 1). Marketability of fruit treated with NaturalGreen and the low rate of Scholar, though significantly less than for Sportak treated fruit, were not significantly less that fruit treated with the high rate of Scholar.

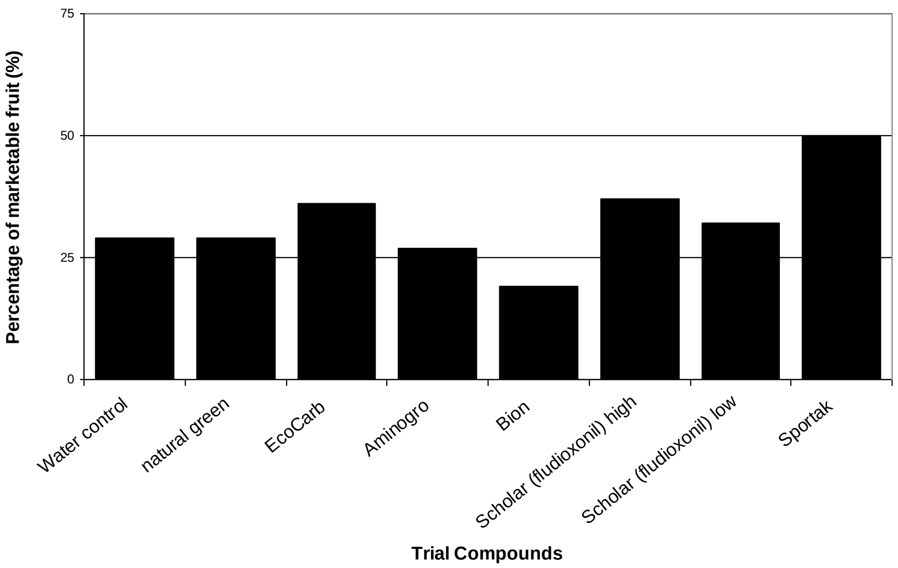
Figure 1. Marketability of 'Hass' fruit treated with trial dipping compounds in the 2009 season.



In the 2010 'Hass' trial similar results were seen with Sportak, the higher rate of Scholar, NaturalGreen and EcoCarb reducing the severity of side anthracnose compared to the water control, though not significantly. While the percentage of marketable fruit was not significantly different among the treatments, fruit treated with Sportak again had the highest percentage of marketable fruit followed by fruit treated with the high rate of Scholar, EcoCarb and the low rate of Scholar (Figure 2). In both seasons, treating fruit with Bion or Aminogro typically increased the severity and incidence of both anthracnose and stem end rot, often significantly.

Disease levels were very low in both the 2009 and 2011 'Reed' trials, with no significant differences among treatments for any of the parameters measured.

Figure 2. Marketability of 'Hass' fruit treated with trial dipping compounds in the 2010 season.



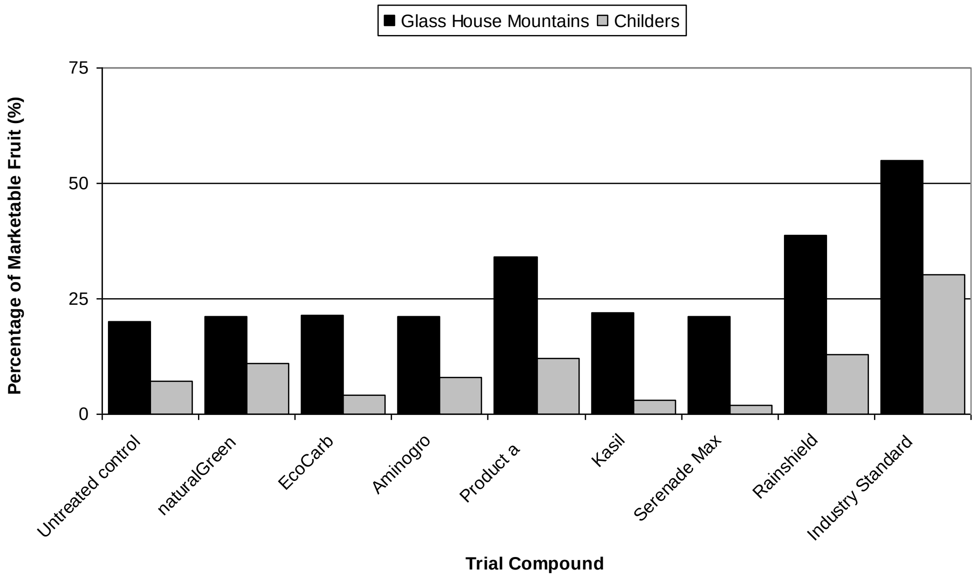
Preharvest spray trials

There were no significant differences among treatments in the severity or incidence of anthracnose or stem end rot disease in fruit from Glass House Mountains trial. Trees receiving the industry standard treatment (copper and azoxystrobin fungicides) had a significantly greater percentage of marketable fruit than most other treatments except Product A and Rainshield treated trees (Figure 3). Marketability of fruit from trees treated with Product A and Rainshield was not significantly greater than for fruit from untreated control trees.

At the Childers site, anthracnose severity in fruit from trees treated with Product A, NaturalGreen and Rainshield were significantly greater than the industry standard fungicide regime, but significantly less than for other treatments. The industry standard treatment had a significantly higher percentage of marketable fruit than all other treatments with fruit from the Product A and Rainshield treatments the next most marketable (Figure 3). Disease severity and incidence was significantly greater at the Childers site accounting for the decrease in the percentage of marketable fruit at this site compared to the Glass House Mountains site.

Peel concentrations of Ca, Mg, K and Ca:N were higher in fruit from the NaturalGreen treatment compared to the control treatment, however the difference was significant only for Mg.

Figure 3. Effect of preharvest spray treatments on marketability of 'Hass' avocado fruit harvested from Glass House Mountains and Childers.



Conclusions

A number of products were identified for use pre and post harvest with the potential to be incorporated into management strategies for the control of the primary diseases of economic importance in avocado fruit.

Although the accepted industry standard postharvest dipping treatment with Sportak (active ingredient prochloraz) produced the best results in reducing the severity and incidence of anthracnose and stem end rots, Scholar showed good potential as a post harvest dip, reducing the severity of anthracnose and stem end rots in both seasons as well as the incidence of stem end rots. Scholar, produced by Syngenta, contains the active ingredient fludioxonil, a Group 12 fungicide unrelated to any others currently used in avocado production and hence may have good potential to be incorporated into anti-resistance control strategies in avocado production. Other products trialled did not perform as well or as consistently although most did reduce anthracnose and stem end rot severity and incidence compared to the water dipped control with the exception of Bion. Although Bion, a known plant defence activator containing the active ingredient acibenzolar-S-methyl, has good efficacy in some specific plant/pest target systems, in these trials it consistently resulted in increasing severity and incidence of anthracnose and stem end rot above those levels seen in untreated fruit.

In the field spray trials, the industry standard of monthly applications of copper combined with applications of Amistar prior to harvest resulted in the lowest levels of both stem end rot and anthracnose. The fungicide Dithane Rainshield also consistently performed well at both sites, reducing the incidence and severity of both stem end rot and anthracnose. Two non-fungicidal products, Product A and NaturalGreen also had a positive effect on disease reduction. NaturalGreen, composed primarily of calcium carbonate, reduced fruit disease levels and resulted in an increase in the accumulation of calcium in the peel, the benefits of which has been well established (Willingham, Pegg *et al*. 2001). These products will be further tested in ongoing trials to determine their efficacy alone and in combination with registered fungicide (eg. Amistar) applications.

Acknowledgements

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