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Foliarly Applied Aliette® and Prophyt® on Avocado (*Persea americana*) Trees Is Not Phytotoxic

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The phytophthora root rot pathogen (*Phytophthora cinnamomi*) (PRR) is ubiquitous in the soils of southern Florida and is the most economically important disease following exposure of avocado tree roots to flooded soil conditions. Research has demonstrated that properly timed foliar applications of phosphonates are effective in preventing avocado tree decline or death due to phytophthora root rot. However, there are concerns that combined foliar applications of phosphonates in conjunction with copper fungicide would be phytotoxic to leaves and fruit. To answer these concerns, field and container demonstrations were initiated to assess the risk for phytoxicity following foliar applications of phosphonate (Prophyt® or Aliette®) and copper. A grove of grafted, 3-year-old 'Simmonds', 'Donnie', and 'Monroe' trees was sprayed with four foliar applications of Prophyt® or Aliette® at 28- to 53-day intervals followed with foliarly applied copper 1–20 days later. No phytotoxicity to leaves, stems, or fruit was observed. Economic analysis found Prophyt® applications to be 55% less expensive than Aliette® applications.

The phytophthora root rot pathogen (*Phytophthora cinnamomi*) (PRR) is ubiquitous in the soils of the southern Florida and is the major disease problem following exposure of avocado tree roots to excessively wet or flooded soil conditions (Menge and Ploetz, 2003; Pegg et al., 2002). Historically this disease has caused the loss of tens of thousands of trees in southern Florida since the 1960s (Ploetz and Parrado, 1987, 1988). Based on topography and historical information, we estimate that nearly 40% of the current avocado acreage (≈7300 acres valued at ~$13 million annually in gross sales) in southern Florida is at risk of excessively wet or flooded soil conditions during the wet season, and thus susceptible to phytophthora root rot (Graham et al., 1997; Ploetz and Parrado, 1988). The potential for flooding or saturated soil conditions in southern Florida is a constant concern during the wet season (May–October). This is due to the high water table throughout the production area and the potential for numerous high rainfall events (i.e., tropical storms, hurricanes, and severe thunderstorms).

Overt symptoms of phytophthora root rot may include decay and destruction of the fibrous root system, leaf wilting, chlorosis, necrosis, and abscission, stem and shoot dieback, fruit shriveling and drop, and tree death. Symptom expression and disease progression increases with the duration of soil wetness and increasing soil and ambient temperatures. Previous research has clearly demonstrated that saturated/flooded soil conditions in the presence of phytophthora causes an immediate (synergistic) decline or death of avocado trees. Other research has demonstrated that applications of foliarly applied phosphonates are effective in controlling or preventing avocado tree decline or death (Guest and Grant, 1991; Pegg et al., 1985, 2002).

Although several fungicides are available to treat phytophthora root rot, such as mefenoxam and aluminum-tris-phosphonate, their high cost preclude them from being incorporated into growers' current practices. More importantly, there are some environmental issues surrounding the use of these chemicals. Hence, no fungicide treatment is currently used to prevent phytophthora root rot and trees under stress are rarely treated because of cost constraints.

Phosphonates (phosphorous acid) are listed under EPA's Biopesticide Active Ingredients list and have been approved for use by the EPA Biopesticide and Pollution Prevention Division (EPA–Anonymous, 2000; EPA–Anonymous, 2005). Applying three to four correctly timed prophylactic foliar treatments with phosphonates prior to flooded soil conditions have been shown to provide protection against phytophthora root rot for up to 42 d under field conditions (Schutte et al., 1991). In order to be effective in protecting a tree from phytophthora root rot, foliar applications of phosphonates must be made when leaves are recently matured (Whiley et al., 1995).

Typically, avocado trees in Florida have two flushes of vegetative growth per year: during the flowering period in late winter and during summer. However, growers have concerns that phosphonates could result in phytotoxicity to fruit and leaves when applied just prior to, during, or post copper fungicide applications used to control scab (*Oidium mangiferae*) and anthracnose (*Colletotrichum gloeosporioides*). Phytotoxicity to leaves and fruit is caused by the low pH of some phosphonate solutions and their interaction with copper applied for scab and anthracnose control (Aliette®WDG label). With this in mind a field demonstration was established to show the safe use of foliar phosphonate applications along with pre- and post-copper applications.

Demonstration Materials and Methods

A 1.8-acre orchard of 3-year-old 'Simmonds', 'Donnie', and 'Monroe' trees was used to demonstrate the proper use of foliarly applied phosphonate and copper, and demonstrate that sequential applications of these materials does not cause phytotoxicity to

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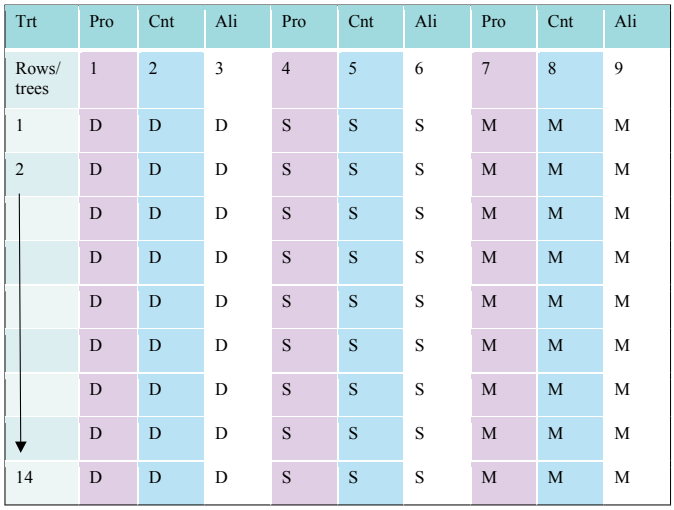

Fig. 1. Field plot layout for demonstrating the effect of Aliette®WDG, Helena® Prophyt®, and Kocide®2000 foliar applications to 'Donnie' (**D**), 'Simmonds' (**S**), and 'Monroe' (**M**) avocado trees, Homestead, FL. Trt: treatment; Pro: Prophyt® ; Ali: Aliette® WDG.

Table 1. Foliar rates of phosphonates (Aliette®WDG + KCO_3 and Helena®Prophyt®) and copper (Kocide®2000) applied to 'Simmonds', 'Donnie', and 'Monroe' avocado trees.

Foliar treatments	Material rate per 100 gal water
Aliette®WDG + KCO_3	5 lb + 3 lb
Helena®Prophyt®	64 oz
Kocide®2000	9 lb

Table 2. Dates of foliar phosphonate and copper applications applied to 'Simmonds', 'Donnie', and 'Monroe' avocado trees.

Treatments	Application dates
Aliette®WDG + KCO_3	27 May 2008, 24 June 2008, 24 July 2008, 15 Sept. 2008[z]
Helena®Prophyt®	27 May 2008, 24 June 2008, 24 July 2008, 15 Sept. 2008[z]
Kocide®2000	2 June 2008, 25 June 2008, 22 July 2008, 31 July 2008, 25 Aug. 2008, 15 Sept. 2008[z], 7 Oct. 2008
Control	Only cooper applications were made to the control trees.

[z]Mixtures of [Aliette®WDG + KCO_3 plus Kocide®2000] or [Helena® Prophyt® plus Kocide®2000] were made on this date.

avocado leaves and fruit (Fig. 1). There were 14 trees per row and one row of 'Simmonds', 'Donnie', and 'Monroe' trees each was sprayed four times with either Aliette®WDG (aluminum tris-phosphonate; Bayer CropScience, Research Triangle Park, NC), Helena®Prophyt® (potassium phosphate; Collierville, TN), or non-sprayed control (Table 1). The adjuvant Cohere® (Helena Holding Co., Collierville, TN) was mixed with all treatment solutions. All trees were sprayed seven times with copper fungicide (Kocide®2000, copper hydroxide, DuPont Crop Protection, Wilmington, DE) 2 d before and up to 23 d after Aliette®WDG and Helena®Prophyt® applications were made (Table 2).

Aliette®WDG and Helena®Prophyt® solution pH were measured prior to applications and signs of phytotoxicity were monitored closely after all applications. Cost analysis was made of the various phosphonate applications in an effort to determine a cost/benefit of applying these materials to prevent phytophthora root rot.

Table 3. Effect of Aliette®WDG + KCO_3 and Helena®Prophyt® and mixtures of Aliette®WDG + KCO_3 or Helena®Prophyt® with Kocide®2000 on spray solution pH.[z]

Treatment	Range in solution pH
Aliette®WDG + KCO_3	6.0–7.5
Helena®Prophyt®	6.0–6.5
Aliette®WDG + KCO_3 plus Kocide 2000[y]	8.0–8.5
Helena®Prophyt® plus Kocide®2000[y]	6.3–6.5

[z]Well-water pH ranged from 7.0 to 7.5 and Aliette®WDG solution alone, 4.0–5.0. All sprays included Cohere® at 8 oz/100 gal.
[y]Mixtures of [Aliette®WDG + KCO_3 plus Kocide®2000] or [Helena® Prophyt® plus Kocide®2000].

Results of the Demonstration

The pH of the well-water ranged from 7.0 to 7.5 and the various solution pHs ranged from 6.0 to 8.5 (Table 3). The pH of Aliette®WDG alone is between 4.0 and 4.5; however, after addition of potassium carbonate the pH was 6.0 to 7.5 (Table 3).

After the first Aliette®WDG, Helena®Prophyt®, and Kocide®2000 applications, some yellowing and browning of a few old leaves that had not fallen off during the bloom period were noted. However, recently matured leaves and set fruit showed no signs of phytotoxicity (Fig. 2). Furthermore, we did not observe any phytotoxicity when Aliette®WDG or Helena®Prophyt® were mixed with Kocide®2000 and sprayed onto the leaves or fruit (application number 4).

A comparison between Aliette®WDG and Helena®Prophyt® applications suggested Helena®Prophyt® to be far more cost effective (Table 4). Compared with an annual cost of $298 per acre in the case of Aliette®WDG, the cost for Helena®Prophyt® applications was $136 per acre, implying savings of $136 per acre or about 54%. The results further suggest that it makes sense for growers to apply Helena®Prophyt® as a prophylactic treatment since the annual cost incurred in reducing the risk of death by phytophtora is less than half of a percent of the estimated value of tree (Table 4).

Foliar applications of Aliette®WDG and Helena®Prophyt® applied pre- or post-Kocide®2000 applications to 'Donnie', 'Simmonds', and 'Monroe' avocado trees were not phytotoxic for both avocado leaves and fruit. We therefore recommend that in those avocado groves or sections of groves susceptible to flooding and phytophthora root rot, three to four foliar applications of either Aliette®WDG and Helena®Prophyt® be made beginning in the late spring or after leaves have matured.

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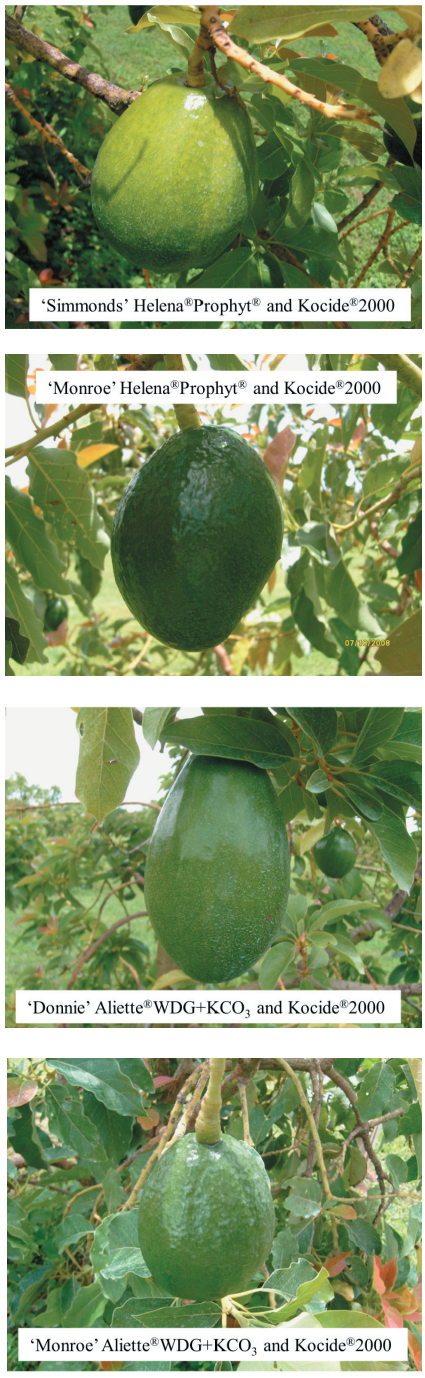

Fig. 2. Fruit peel symptoms of 'Donnie', 'Simmonds', and 'Monroe' avocado fruit after two applications of Aliette®WDG+KCO_3 and Helena®Prophyt® and Kocide®2000.

Table 4. Cost analysis of four applications of either Aliette®WDG or Helena®Prophyt® per acre of avocado trees.[z]

Foliar treatment	Costs ($/application/acre)			Applications per acre/year
	Material	Fuel and labor	Total	(no.)
Aliette®WDG	62.50	12.00	74.50	4
Helena®Prophyt®	21.95	12.00	33.95	4
	Total cost			Cost as a %
	($/acre/year)	($/tree/year)		of tree value
Aliette®WDG	298.00	4.31		1.1
Helena®Prophyt®	135.80	1.97		0.5

[z]Assumptions: Cost of Aliette®WDG, $12.50/lb (no charge for KCO_3) and Helena®Prophyt®, $43.89/gal. Rates, Aliette®WDG, 5 lb/acre; Helena®Prophyt®, 0.5 gal/acre. Number of trees per acre is 69. Replacement value of a mature avocado tree is $400.00, i.e., the cost to plant, grow, and maintain an avocado tree for about 7 years.

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