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FUNGICIDE EVALUATION FOR DISEASE CONTROL IN PAPAYA

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Anthracnose (*Colletotrichum gloeosporioides*) is an important postharvest disease of papaya. Growers can currently use mancozeb (and maneb), copper hydroxide, copper sulfate, chlorothalonil, azoxystrobin, copper oxide, copper sulfate, and neem oil. Of these, mancozeb and copper sulfate are probably the main fungicides used for general disease control. Chlorothalonil may be used, but only for the local market, because the hot water dip or vapor heat for quarantine treatment of fruit flies can result in a phytotoxic response on the skin of fruits. Azoxystrobin might also be used sparingly because of its higher cost, and its propensity to induce disease resistance.

New fungicides should be evaluated for their efficacy and as alternatives to existing registered products. Therefore, the purpose of this work was to evaluate certain fungicide products (not currently registered for use in papaya) for anthracnose and other disease control in papaya.

Materials & Methods

Test 1

Papaya (cv. Rainbow) trees were selected from a grower's field in Kea`au, Hawai`i Island (Puna District). Five (5) treatments, each treatment with 5 trees, were established (Table 1). A total of 5 applications were made at approximately 14-day intervals using a backpack mistblower. Fungicides were sprayed in 100 gal acre⁻¹ with the addition of a spreader-sticker (Latron B-1956) at 16 oz 100 gal⁻¹.

Fruits were harvested approximately weekly, at the color break stage, and after sprays had dried after an application was made. Fruits were placed in plastic bags while harvesting, and subsequently taken to the headhouse at Waiakea Experiment station, where they were left in the plastic bags with the open end folded under (but not sealed) on a cart for approximately 7 days to allow any diseases to develop.

Visual ratings for disease severity were recorded at approximately 7 days after harvesting. Ratings were taken for stem end rots, blossom end rots, body rots, and other diseases. The following rating scale was used, relating to the severity of the particular disease evaluated: 0 = no symptoms; 1 = trace ($\leq 2\%$); 2 = slight (3-10%); 3 = moderate (11-25%); and 4 = severe ($\geq 25\%$).

Table 1.

TRT#	Common Name	Trade Name	Rate ^{1, 2}
1	untreated control	-	-
2	fenamidone	Reason	0.267 lb ai acre ⁻¹
3	famoxadone + cymoxanil	Tanos	0.625 lb product acre ⁻¹
4	cyprodinil + fludioxonil	Switch	0.875 lb product acre ⁻¹
5	mancozeb (=industry std)	Manzate	1.874 lb ai acre ⁻¹

¹ Application dates: April 10, 24, May 8, 21, and June 5, 2007.

² Fruit sampling dates: April 24, May 2, 8, 15, 23, 29, June 5, and 12.

Test 2

Fruits at the color break stage which had not been treated with fungicide for approximately 6 weeks were harvested and separated into 2 batches. One batch was the untreated control, and fruits from the second batch were individually dipped into a solution of cyprodinil + fludioxonil (Switch) at a concentration of 0.875 lb product 100 gal⁻¹. The fungicide solution was allowed to dry, and fruits were placed in plastic bags and allowed to remain at ambient temperature until 100% ripe (approximately 7 days); at which time they were visually rated for disease using the same rating scale described above.

Test 3

Colletotrichum gloeosporioides isolates were obtained and cultured from papaya and mango. Agar media were mixed with various fungicides to obtain concentrations that were equivalent to maximum field labeled rates applied in either 75 or 100 gallons acre⁻¹.

TREATMENTS	RATE	VOLUME (gallons acre ⁻¹)
pyraclostrobin (Cabrio)	0.2 lb ai acre ⁻¹	75
pyraclostrobin + boscalid (Pristine)	0.45 lb ai acre ⁻¹	75
cyprodinil + fludioxonil (Switch)	0.875 lb product acre ⁻¹	75
cymoxanil + famoxadone (Tanos)	0.5 lb product acre ⁻¹	75
azoxystrobin (Amistar)	0.2 lb ai acre ⁻¹	75
pyraclostrobin (Cabrio)	0.2 lb ai acre ⁻¹	150
pyraclostrobin + boscalid (Pristine)	0.45 lb ai acre ⁻¹	150
cyprodinil + fludioxonil (Switch)	0.875 lb product acre ⁻¹	150
cymoxanil + famoxadone (Tanos)	0.5 lb product acre ⁻¹	150
azoxystrobin (Amistar)	0.2 lb ai acre ⁻¹	150
untreated control	-	-

Test dishes were inoculated with an agar plug and visually evaluated at 3 and 6 days after inoculation.

Results & Discussion

Test 1

Visual rating data from all dates were pooled for the statistical analyses because fruits at the color-break stage of ripeness were not always present from each tree and in sufficient number at each sampling date. Consistent with past results, demonstrating efficacy of fungicides against anthracnose in papaya is difficult, because it is a latent infection. If sprays were not timed correctly, and fruits were infected prior to fungicide application, efficacy would not be apparent. However, it appears that cyprodinil+fludioxonil (Switch) may be effective against *Colletotrichum* (stem end rot) (Table 2). Stem end rot caused by *Colletotrichum* was the disease that most consistently appeared in the sampled fruits, because the wound at the stem end made it easy for *Colletotrichum* to infect the fruit. The body rot caused by *Colletotrichum*, typically called anthracnose or chocolate spot, were not prevalent; perhaps the inoculum levels were low due to the drought.

Efficacy of Switch against *Colletotrichum* is supported by results obtained in a laboratory test we conducted in which agar plugs with *Colletotrichum* mycelia, were placed on agar growth media which contained Switch. Switch completely inhibited mycelial growth of *Colletotrichum* isolates obtained from papaya and mango. Mycelial growth was also inhibited on the inoculation plug. Switch appears to be a good candidate for anthracnose control in papaya.

Table 2. Visual Ratings ^{1,2}

Treatments ³	Phyto	Colle-SE	Colle-BR	Asper-BR	Ppalm-BR	Other-BR	Colle-BE	Lasio-BE	Ppalm-BE
Untreated control	0 ns	1.18 a	0.13 ns	0.29 ab	0.26 ns	0 ns	0 ns	0.13 ns	0.11 ns
Fenamidone	0 ns	0.68 ab	0 ns	0.13 b	0.13 ns	0.15 ns	0 ns	0 ns	0.17 ns
Famoxadone+cymoxanil	0 ns	1.39 a	0.11 ns	0.18 ab	0 ns	0 ns	0.21 ns	0 ns	0.14 ns
Cyprodinil+fludioxonil	0 ns	0.21 b	0 ns	0.41 a	0 ns	0 ns	0.03 ns	0 ns	0 ns
Mancozeb	0 ns	0.96 ab	0 ns	0.30 ab	0 ns	0 ns	0 ns	0.02 ns	0 ns

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- 1 Phyto = phytotoxicity; Colle-SE = *Colletotrichum*-stem end rot; Colle-BR = *Colletotrichum*-body rot; Asper-BR = *Asperisporium*-body rot; Ppalm-BR = *Phytophthora*-body rot; Other-BR = Unknown disease-body rot; Colle-BE = *Colletotrichum*-blossom end rot; Lasio-BE = *Lasiodiplodia*-blossom end rot; Ppalm-BE = *Phytophthora*-blossom end rot.
- 2 Means within a column followed by the same letter are not significantly different at $\alpha=0.05$ using Tukey's Studentized Range Test.
- 3 Fenamidone = Reason; famoxadone+cymoxanil = Tanos; cyprodinil+fludioxonil = Switch; mancozeb = Manzate.

Test 2

Stem end rot caused by *Colletotrichum* was controlled by dipping fruit into a Switch solution at the field rate (Table 3); providing additional evidence that Switch can control *Colletotrichum*.

Table 3. Visual Ratings ^{1,2}

Treatment ³	Colle-SE	Colle-BR	Asper-BR
Untreated control	1.93 a	1.07 ns ³	1.08 ns
Cyprodinil+fludioxonil	0 b	0.31 ns	1.07 ns

- ¹ Colle-SE = *Colletotrichum*-stem end rot; Colle-BR = *Colletotrichum*-body rot; Asper-BR = *Asperisporium*-body rot.
- ² Means within a column followed by the same letter are not significantly different at $P < 0.05$.
- ³ $P = 0.13$

Test 3

It appears that the anthracnose isolate cultured from papaya, has some tolerance to azoxystrobin; and, there also may be some cross-resistance with Cabrio, Pristine, and Tanos. Although Tanos is not indicated to control anthracnose, there appeared to be activity against the isolate cultured from mango. The mango isolate appeared sensitive to all fungicides. Few, if any fungicides are used in mango, so the contrast in fungicide sensitivity between the mango and papaya isolates is interesting because papaya is more intensively managed with fungicides and it appears that the papaya isolate is expressing some resistance to strobilurins.

Table 4. Petri Dish Efficacy Test Summary

TREATMENTS ¹	GROWTH ON AGAR ²	GROWTH ON MYCELIAL INOCULATION PLUG ²
PAPAYA ISOLATE		
pyraclostrobin (Cabrio)	-	+
pyraclostrobin + boscalid (Pristine)	-	+
cyprodinil + fludioxonil (Switch)	-	-
cymoxanil + famoxadone (Tanos)	+	+
azoxystrobin (Amistar)	+	+
untreated control	+	+
MANGO ISOLATE		
pyraclostrobin (Cabrio)	-	-
pyraclostrobin + boscalid (Pristine)	-	-
cyprodinil + fludioxonil (Switch)	-	-
cymoxanil + famoxadone (Tanos)	-	+ (slight inhibition)
azoxystrobin (Amistar)	-	-
untreated control	+	+

¹ Overall visual results 6 days after inoculation, with no apparent differences between the 75 and 150 gallons acre⁻¹ concentrations.

² "+" = mycelial growth; "-" = no mycelial growth