Control of *Phytophthora palmivora* in Papaya Orchards with Weekly Sprays of Chlorothalonil

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ABSTRACT

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Weekly sprays with chlorothalonil (3.4 kg a.i./ha) for control of *Phytophthora palmivora* resulted in 25–34% fewer diseased papaya trees in sprayed plots in three orchards than in unsprayed controls. A zinc ion-maneb complex sprayed weekly at 1.8 kg/ha was less effective than chlorothalonil in controlling fruit rot and preventing loss of trees. When the interval between sprays of chlorothalonil was increased from 7 to 14, 21, and 28 days, disease incidence increased by about 6% for each interval. Both chlorothalonil and zinc ion-maneb were effective only in protecting trees before trunk cankers developed. After cankers formed, trees continued to die in wet weather regardless of the fungicide used.

Fruit rot, trunk canker, and root rot of papaya (*Carica papaya* L.) caused by *Phytophthora palmivora* Butler is a major disease on the island of Hawaii where 86% of Hawaiian papayas are currently produced (2,6,7). In 1979, growers on this island lost more than 181,000 trees because of severe storms accompanied by Phytophthora outbreaks during the rainy season, which reduced the annual production by 35%. The loss of trees resulted in a slow recovery in production, and in May 1980, fresh fruit shipments were still 30% below the 1978 level.

In previous tests, orchard sprays of chlorothalonil at 1.7–3.4 kg a.i./ha controlled anthracnose and other postharvest diseases of papaya caused by *Colletotrichum gloeosporioides, Ascochyta caricae-papayae,* and *Alternaria alternata*, but field control of *P. palmivora* could not be determined because of an unusual dry period throughout the state and low field incidence of this disease (1). The results of a laboratory test developed to evaluate field sprays by inoculating detached fruits with *P. palmivora* zoospores indicated that infections were reduced 30% by chlorothalonil but 53% by zinc ion-maneb complex, compared with the control (1). Because chlorothalonil is registered for use for Phytophthora control of other crops (late blight of potato and tomato), field tests were done on papaya farms during the rainy season to determine whether orchard sprays of chlorothalonil would control natural infections by *P. palmivora.*

MATERIALS AND METHODS

Field trials were established on the island of Hawaii on farms that represented the three major papaya-growing areas of the state. Plots were established in areas with a history of heavy losses to *P. palmivora* infection of seedlings, trees, and fruit. Trees were all approximately 20 to 24 mo old and grown under standard field practices. Tests were conducted in the fall and early winter when rainfall is usually high (23–35 mm/mo) and losses to *P. palmivora* are highest.

Trees were sprayed at weekly intervals with a hand-held power spray gun, mounted on the back of a tractor. The D6 nozzle delivered 925 L/ha with a pressure of 20 kg/cm^2.

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On farm A, a 1-ha field was divided into three treatments and two replications. Each replication consisted of seven rows of trees, 50 trees per row, 2.18 m between trees, and 3.9 m between rows. Treatments were chlorothalonil, 3.4 kg a.i./ha, or zinc ion-maneb, 1.8 kg a.i./ha, applied with spreader-sticker, Triton B-1956 (15 ml/100 L). The controls were not sprayed. In preliminary field trials, the highest recommended rate of chlorothalonil gave best control of *P. palmivora* and other fungal diseases; at the lower rate (1.7 kg/ha), control was equal to that of zinc ion-maneb.

The test was replicated on farm A in a nearby 1-ha field separated from the first field by 11 rows (0.52 ha) of unsprayed papaya trees. Fields were surveyed for infected and dead trees before the first spray and at weekly intervals thereafter. The number of infected fruits was recorded and calculated as a percentage of the total number of full-sized, green to color-break fruits on each fruit column.

Infections by *P. palmivora* were easily detected by symptoms on fruit and were confirmed by isolation. Infected trees had brown discoloration on the trunk or had stem cankers that resulted in severe leaf chlorosis, a tapering growing point, defoliation, and overall loss of plant vigor. Trees that were completely defoliated were considered dead. *P. palmivora* was isolated from tree cankers.

On farms B and C, 0.4-ha and 0.8-ha plots were used, respectively, with 40 trees per replication and two replications per treatment. Trees sprayed with chlorothalonil were compared with unsprayed control trees as on farm A, but because less area was available, the zinc ion-maneb was not included in trials. Intervals of 14, 21, and 28 days between spray periods were compared on farm C.

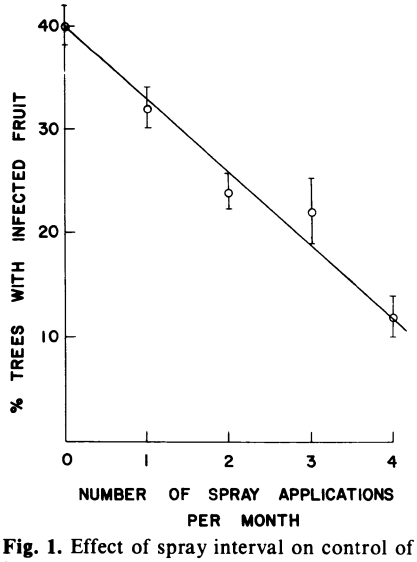

Fig. 1. Effect of spray interval on control of Phytophthora fruit rot of papaya (farm C, Opihikao, Hawaii). Brackets represent the standard error.

RESULTS AND DISCUSSION

On farm A, *P. palmivora* was present throughout the orchard at the beginning of the spray trial. Approximately 10% of the trees had infected fruits but no trunk cankers. After eight weekly sprays, no infected fruits were observed in subplots sprayed with either chlorothalonil or zinc ion-maneb, but 25% of the trees in unsprayed subplots had fruit infections. No trees had died by 17 November 1978 when sprays were discontinued.

On 15 January 1979, fruits in the center rows of each subplot were rated for disease, and the results showed that *P. palmivora* was again present in the orchard. On 12 February 1979, about 3 mo after the last spray, 30% of the trees had died in the unsprayed subplots (Table 1). Subplots sprayed with chlorothalonil had fewer infected and dead trees than those sprayed with the zinc ion-maneb complex.

In the 0.52-ha unsprayed field between the two test plots, 90% of 550 trees were dead, and the remaining 10% had trunk cankers. Disease was greater here than in the unsprayed control plot, probably because greater inoculum pressure could build up in a larger area of unsprayed trees.

On farm B, the percentage of trees with diseased fruits dropped from 85 to 14% 2 wk after the first spray with chlorothalonil, and no cankers were observed on the trees. After eight weekly sprays, no diseased fruit was detected in the treated subplots. During the 8-wk trial, controls had an average of 34% more trees with infected fruits ($P = 0.01$) than sprayed subplots did, and approximately 30% of the trees had trunk cankers and later died. This points out the need to distinguish between infected trees (with cankers) and trees with infected fruits. Decrease in the number of infected fruits suggests crop protection (infected fruits were removed or fell from trees and no new infections formed), whereas recovery of trees with cankers would have indicated eradication. Chlorothalonil did not eradicate disease from trees with trunk cankers in these tests. Overall disease levels dropped during the latter weeks because rainfall was lower.

Results were similar on farm C, where subplots receiving weekly chlorothalonil spray treatments had an average of 30% fewer diseased and dead trees than the unsprayed control subplots. When the spray interval was increased from 7 to 14, 21, and 28 days, about 6% more trees were infected at each increased 7-day interval (Fig. 1). Because a mature tree annually yields about 24 kg and 1,593 trees are planted per hectare, a 6% reduction in harvested fruit represents an annual loss of 2,337 kg/ha. This clearly justifies applications of chlorothalonil at weekly intervals during periods of high disease incidence.

More important than fruit loss is the protection of trees from trunk cankers and eventual death. Diseased fruit represent infection foci that eventually initiate trunk cankers. After trunk cankers formed, trees usually did not recover, indicating that chlorothalonil is protective rather than eradicative. If 25% of the unsprayed trees develop trunk cankers and die, production is reduced 19,104 kg/ha below the potential during the normal 2-yr productive life of the orchard. Because *P. palmivora* infections spread rapidly during periods of high rainfall (3–5), trees with trunk cankers should be rogued to prevent further aerial spread, and adjacent trees should be protected with fungicide sprays.

In field tests chlorothalonil was more effective against *P. palmivora* than had previously been suggested by laboratory assays (1). Thus, the inoculum level (10 zoospores per milliliter) and incubation time (18 hr at 100% relative humidity) used for detached fruits probably exceeded the requirements for infection in the field. Under natural conditions in papaya orchards, chlorothalonil controlled *P. palmivora* and, when used at its highest recommended rate, was somewhat more effective than zinc ion-maneb.

Table 1. Comparison of orchard sprays for control of *Phytophthora palmivora* of papaya (farm A, Nanawale, Hawaii)

Treatment	Graded fruits (no.)[x]	Infected fruits (%)[x]	Trees killed by *Phytophthora* (%)[y]	Total infected and dead trees (%)
Chlorothalonil, 3.4 kg a.i./ha	689	1.6 a[z]	6 a	38 a
Zinc ion-maneb, 1.8 kg a.i./ha	784	4.7 b	15 b	47 b
None (control)	517	4.1 b	30 c	65 c

[x] Means of two replications; 50 trees were sampled per replication in the center of each plot 15 January 1978.

[y] Means of two replications of 350 trees each. Data were recorded 12 February 1979, 3 mo after the last spray.

[z] Column means not followed by the same letter are significantly different by a Chi-square test for a 2 × R contingency table ($P = 0.05$).

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