

Limitations of Hot Water Treatment in the Control of *Phytophthora* Fruit Rot of Papaya

M. ARAGAKI, Plant Pathologist, W. S. KIMOTO, Research Assistant, and J. Y. UCHIDA, Research Associate, Department of Plant Pathology, University of Hawaii, Honolulu 96822

ABSTRACT

Aragaki, M., Kimoto, W. S., and Uchida, J. Y. 1981. Limitations of hot water treatment in the control of *Phytophthora* fruit rot of papaya. *Plant Disease* 65:744-745.

A destructive epidemic of *Phytophthora* blight of papaya occurred in Hawaii in the spring of 1979. Fruit rots, which were usually controlled by field fungicide applications and postharvest hot water treatment, developed in large numbers. Possible causes for the failure to control fruit rots were tested experimentally and discounted, including failure to maintain minimum specifications for temperature and time of hot water treatment; development of a strain of *Phytophthora palmivora* tolerant to high temperature; and introduction of *P. parasitica* or *P. capsici*, species tolerant to high temperature. Infections 24 hr old were effectively controlled by the standard hot water treatment, but about 30% of the infections 48 hr old survived and developed into rots.

Additional key words: *Carica papaya* L.

Fruit rots become a serious problem during outbreaks of *Phytophthora* blight of papaya (*Carica papaya* L.), but they can be controlled by regular applications of mancozeb (3). Developing rots appear as water-soaked, circular spots 5–10 mm in diameter, which expand in 2–3 days into white, circular to elliptic rots 70 mm or more in diameter. Fruit rots are easy to recognize at this stage, making the culling process quite efficient. Although young infections are difficult to recognize and frequently escape culling, they are efficiently eradicated by the standard hot

water (48 C for 20 min) treatment (1). Culling and hot water treatment have effectively controlled postharvest *Phytophthora* fruit rots, and the disease is insignificant in transit, on market shelves, and to the consumer.

In January–April of 1979, Hawaii papaya growers experienced probably the most destructive epidemic of *Phytophthora* blight of papaya since the beginning of commercial production. Nearly 200,000 trees, or the equivalent of 325 acres of planted papaya, were destroyed by the disease during this period. Further, trees that became infected were killed during the following months, ultimately resulting in a loss of about 20% of the industry's producing trees.

Phytophthora fruit rot also developed on 10–20% of the fruit, despite processing through the standard hot water treatment. At first, researchers suspected that the treatment had been incorrectly applied, but growers were certain that this had not happened; further, the problem occurred

throughout the industry, not with a single grower. When researchers collected fruit from diseased fields and treated it with hot water under controlled laboratory conditions, rots developed as they had after treatment by growers.

Papaya fruit rots can be caused by *Phytophthora capsici* Leonian and *P. parasitica* Dast. (2), both of which have higher temperature maxima for growth than *P. palmivora* (Butl.) Butl. (5). Rots caused by either or both of these organisms may be able to tolerate the standard hot water treatment. A strain of *P. palmivora* tolerant to heat may also have caused the failure of the hot water treatment. In the absence of experimental evidence, we began an investigation into the problem.

MATERIALS AND METHODS

A grower gave us 10 papaya fruit with developing *Phytophthora* rot that had been treated with hot water. We washed 10 pieces of tissue, each from a different lesion, in tap water and placed them on water agar. Single hyphal tips were transferred aseptically to V-8 juice agar (10% Campbell's V-8 juice, 0.2% CaCO₃, and 1.8% agar) and incubated at 24 C with continuous cool white fluorescent irradiation (about 2,200 lux) for 4 days to allow fungal colonies to grow.

We tested the sensitivity of the fruit-rotting *Phytophthora* to hot water by placing 15 disks of naturally infected fruit tissue (5 mm diam × 10 mm deep, including rind and pulp) in water at 48 C for 20 min, and then plating them on water agar.

Mature papaya fruit (cultivar Kapoho

Journal Series 2552 of the Hawaii Institute of Tropical Agriculture and Human Resources.

Accepted for publication 7 January 1981.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "advertisement" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

0191-2917/81/09074402/\$03.00/0

©1981 American Phytopathological Society

Solo, at the breaking yellow stage) was used for laboratory inoculation with a hyphal tip culture of *P. palmivora* isolate P 268 from papaya. Sporangia were produced and zoospore inocula were prepared as previously described (2); inoculum concentration was adjusted to 5×10^4 zoospores per milliliter. Three sterilized disks of filter paper (12.5 mm diam) were dipped momentarily into the zoospore suspension and placed singly at separate loci on each papaya. The fruit was incubated in moist chambers for 24 or 48 hr at 24 C, then immersed in water at 48 C for 20 min, cooled in tap water, and stored at about 24 C for 3 days. In four tests, 37 papayas had a total of 111 inoculation loci for each of the two incubation periods.

RESULTS AND DISCUSSION

P. palmivora was the only fungus isolated from rotted papaya fruit and from naturally infected fruit treated with hot water. It was thus a significant factor in the 1979 epidemic. However, results from this limited number of isolations cannot rule out the possibility that *P. capsici* or *P. parasitica* was involved. No fungus grew from fruit rot disks that were subjected to the standard hot water treatment, which suggests that the

pathogen was sensitive to the treatment but may have escaped in deep-seated infections because the heat failed to penetrate the large fruit mass.

Rots did not develop on papayas that were treated with hot water 24 hr after inoculation; however, about 30% of the papayas that were incubated for 48 hr before hot water treatment developed rots 3 days later. The differences in numbers of fruit rots between the 24- and 48-hr incubation periods in each of the four tests were highly significant, according to chi-square analysis. Hot water treatment eradicated young *P. palmivora* infections but was ineffective on 2-day-old infections. Because papayas with rots more than 2 days old are easily culled, they are not postharvest problems.

Before 1979, when the incidence of Phytophthora fruit rot was low, hot water was an adequate complementary treatment to eliminate the disease. The unusually high disease incidence in 1979 resulted in many 2-day-old infections that were not controlled by hot water.

When the fruit rot problem was first called to our attention, *P. capsici* and *P. parasitica* were suspected as causal organisms. Both fungi have recently been implicated in papaya fruit rots on Maui and Molokai (2), but not in Puna, Hawaii, the main papaya production

area. Because both fungi grow well at 35 C (5), which is above the temperature maximum for *P. palmivora*, higher thermal death points were hypothesized. However, only *P. palmivora* was isolated from rotted fruit, and all isolates were sensitive to the hot water treatment.

These results illustrate the effectiveness of the hot water treatment as well as its limitations. Klotz and DeWolfe (4) reported that Phytophthora brown rot of lemon is controlled when treated with water at 48.3 C for 4 min, providing the infected fruit is incubated for not longer than 24 hr at 24–30 C before treatment.

LITERATURE CITED

1. Akamine, E. K., and Arisumi, T. 1953. Control of postharvest storage decay of fruits of papaya (*Carica papaya* L.) with special reference to the effect of hot water. Proc. Am. Soc. Hortic. Sci. 61:270-274.
2. Aragaki, M., and Uchida, J. Y. 1978. A new papaya fruit rot in Hawaii caused by *Phytophthora capsici*. Plant Dis. Rep. 62:765-768.
3. Hunter, J. E., and Buddenhagen, I. W. 1969. Field biology and control of *Phytophthora parasitica* on papaya (*Carica papaya*) in Hawaii. Ann. Appl. Biol. 63:53-60.
4. Klotz, L. J., and DeWolfe, T. A. 1961. Limitations of the hot water immersion treatment for the control of Phytophthora brown rot of lemons. Plant Dis. Rep. 45:264-267.
5. Tucker, C. M. 1931. Taxonomy of the genus *Phytophthora* de Bary. Mo. Agric. Exp. Stn. Res. Bull. 153. 208 pp.