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Heart and Root Rots of Pineapple

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Heart and root rots of pineapple (*Ananas comosus* L.) in Hawai'i are caused by several species of the plant-pathogenic water molds *Pythium* and *Phytophthora*. These soil-borne organisms cause severe diseases of many crops worldwide, including pineapple. Heart rot affects the basal leaf tissues and can rot fruit as well, while root rot causes root necrosis that, if left unaddressed, may lead to reduced crop yields and total crop failure. The infection process and intensity of these diseases depend on variables such as topography, drainage, rainfall, and soil pH. In Hawai'i, pineapple heart and root rots are most severe in high-rainfall areas and irrigated soils with poor soil drainage. Root rots may increase in severity after nematode infections of roots.

This publication discusses pineapple production in Hawai'i, heart and root rots caused by *Pythium* and *Phytophthora*, and useful practices for management and prevention of the diseases. *Pythium* and *Phytophthora* are now considered to be "fungus-like" organisms and not technically fungi. However, pesticides for their suppression are referred to as fungicides. There are several fungicides registered for use on pineapple as well as a number of non-chemical options.

Host

Pineapples are members of the genus *Ananas* and part of the botanical family Bromeliaceae (Bartholomew 2002). Bromeliads, popular ornamental plants, are members of the same Bromeliaceae family and are therefore closely related. The pineapple plant is a short, perennial, herbaceous monocot about 1 m (3.3 ft.) in height. The plant has a peduncle (stem) on which the fruit develops. The fruit resembles a pinecone, hence its name. Pineapple is native to South America, but its exact origin is unknown. Extensive cultivar diversity exists north of the Amazon River basin, which suggests an origin nearby (Bartholomew 2003). Pineapple was well received by many cultures when introduced and is now cultivated throughout the tropics and subtropics. Though many pineapple cultivars exist throughout the world, 'Smooth Cayenne' dominates the industry. 'Smooth Cayenne' is also commonly referred to as 'Maipuri', 'Kew', 'Giant Kew', 'Champaka', and 'Sarawak' (Bartholomew 2003).

Heart rot of pineapple is caused by *Phytophthora* spp.

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Pineapple in Hawai'i. Pineapple has long been an important crop in Hawai'i. The first record of pineapple being grown in the Islands is 1813, but the exact date of introduction is unknown. In 1820, American missionaries found pineapple growing wild and also being cultivated in home gardens (Bartholomew 2012). Once growing began on a commercial scale, canning of pineapple was required to ship large quantities of fruit around the world and also to prevent spoilage. The development of the cannery industry in Hawai'i fostered the economic importance of pineapple as an export commodity. The potential to expand the Hawai'i industry's global market share and need for more desirable cultivars that could be grown in the area led to the creation of the non-profit organization Pineapple Research Institute (PRI). PRI was tasked with developing new, improved varieties of pineapple, including those with resistance to *Phytophthora*.

Pineapple was once the top agricultural crop in Hawai'i; later it was second only to sugarcane. Development of foreign markets with lower labor and resource costs led to the decline of the industry. In 2007, the last pineapple cannery closed on the island of Maui, marking the end of the cannery era in Hawaiian agriculture. Pineapple is still grown in Hawai'i as a fresh fruit commodity. The Dole Food Company, Inc. on the island of O'ahu and Maui Gold Pineapple Company on the island of Maui cultivate and market large quantities of fresh pineapple fruit. In addition, the advent of the sustainability movement has enticed many backyard growers to become more industrious in their agricultural endeavors. The ease of pineapple propagation has prompted many to plant the "crowns" saved from pineapples purchased at the market or received from a friend. There are also niche markets established for growers on O'ahu and other islands who grow specialty or low-acid varieties.

The Pathogens

The so-called water molds known as *Pythium* and *Phytophthora* infect the basal leaf tssues and roots of pineapple plants. These pathogens thrive is wet soils where free water commonly occurs. They are devastating plant pathogens worldwide and cause root rot of many species besides pineapple. The genus *Phytophthora* is one of the most destructive and common plant pathogens. *Pythium* and *Phytophthora* are now commonly classified as Stramenopiles, members of a phylum in the Kingdom Chromista (Agrios 2005). The Stramenopiles are similar to fungi but have several important differences. The most common of these species on pineapple in Hawai'i are *Pythium arrhenomanes*, *Phytophthora cinnamomi*, and *Phytophthora parasitica* (Bartholomew 2003).

Disease Cycle and Epidemiology

Though the life cycles of *Pythium* and *Phytophthora* differ, they bear many similarities. In this article we focus on the similarities.

- **Dissemination.** *Pythium* and *Phytophthora* may form zoospores, swimming spores with whip-like tails called flagella. Attracted by root exudates,

Pineapple heart rot caused by *Phytophthora* spp.

Pineapple heart rot caused by *Phytophthora cinnamomi*.

they navigate through water in the soil towards the roots of the pineapple plant. Other pathogen propagules (chlamydospores, mycelia, oospores) may be disseminated by draining soil water in soils attached to tools, footwear, and vehicle tires. These may be splashed up into pineapple crowns to cause heart rot in the basal white tissues.

- **Inoculation and Penetration.** Zoospores make contact with the leaf or root surface, germinate, and then enter the plant tissues.
- **Infection and Pathogen Development.** A fungus-like mycelium begins to grow in the basal white tissues of the crown or in the root within hours of penetration. As the mycelium develops, it spreads throughout the crown or root system.
- **Pathogen Reproduction.** The primary mode of reproduction is asexual. Fruiting bodies called sporangia develop from the mycelium and produce zoospores. Less commonly, the mycelia of two different mating types can produce sexual structures called oogonia (female) and antheridia (male). When these structures combine, they produce sexual spores called oospores.
- **Pathogen Survival.** The oospores and chlamydospores formed by *Pythium* and *Phytophthora* can remain dormant and survive in the soil for years.
- **Conditions Favoring Disease Development.** The germination and movement of zoospores is limited to wet soil with poor drainage and low temperatures. According to Rohrbach and Apt (1986), *P. cinnamomi* is prevalent in the cool, wet soil at upper elevations, whereas *P. parasitica* is found in a wider range of soil conditions.

Disease Symptoms

- **Heart Rot Symptoms**. These include soft rotting of the basal white tissues of the youngest leaves at the heart of the apical meristem. Infected leaves may be pulled from the plant readily, and as disease progresses sufficiently, plants die. On fruit-bearing plants of susceptible varieties, the infection can move up through the fruit peduncle and rot the fruit.
- **Aboveground Root Rot Symptoms.** A slow plant growth rate may be an initial indication of root rot. Other symptoms include chlorosis (yellowing), browning, or anthocyanescence (reddish or purplish coloring) of the leaves, which may then eventually curl and die. Stem and leaf rot develop after the leaves have become discolored due to the roots' destruction (Sideris 1930).
- **Root Symptoms.** Root necrosis is another good indicator of the disease. To check for root necrosis, grasp the crown and tug. Healthy plants will remain firmly anchored in the ground. Plants affected with root necrosis may be easily pulled

Pineapple heart rot caused by *Phytophthora parasitica* causes soft rotting of the basal white leaf tissues.

Pineapple heart rot caused by *Phytophthora parasitica* (left) contrasted with unaffected basal white leaf tissues.

from the soil. Care should be taken when removing a sample suspected of disease from the field, in order to minimize the spread of the disease to other areas. For pineapple root rots caused by *Pythium* and *Phytophthora* spp., the rotting of the roots can manifest as soft and translucent necrosis, typical of *Pythium*, or blackened necrosis, typical of *Phytophthora*. The root cortex may be easily stripped off of pineapple plants with Phytophthora root rot.

Management Practices

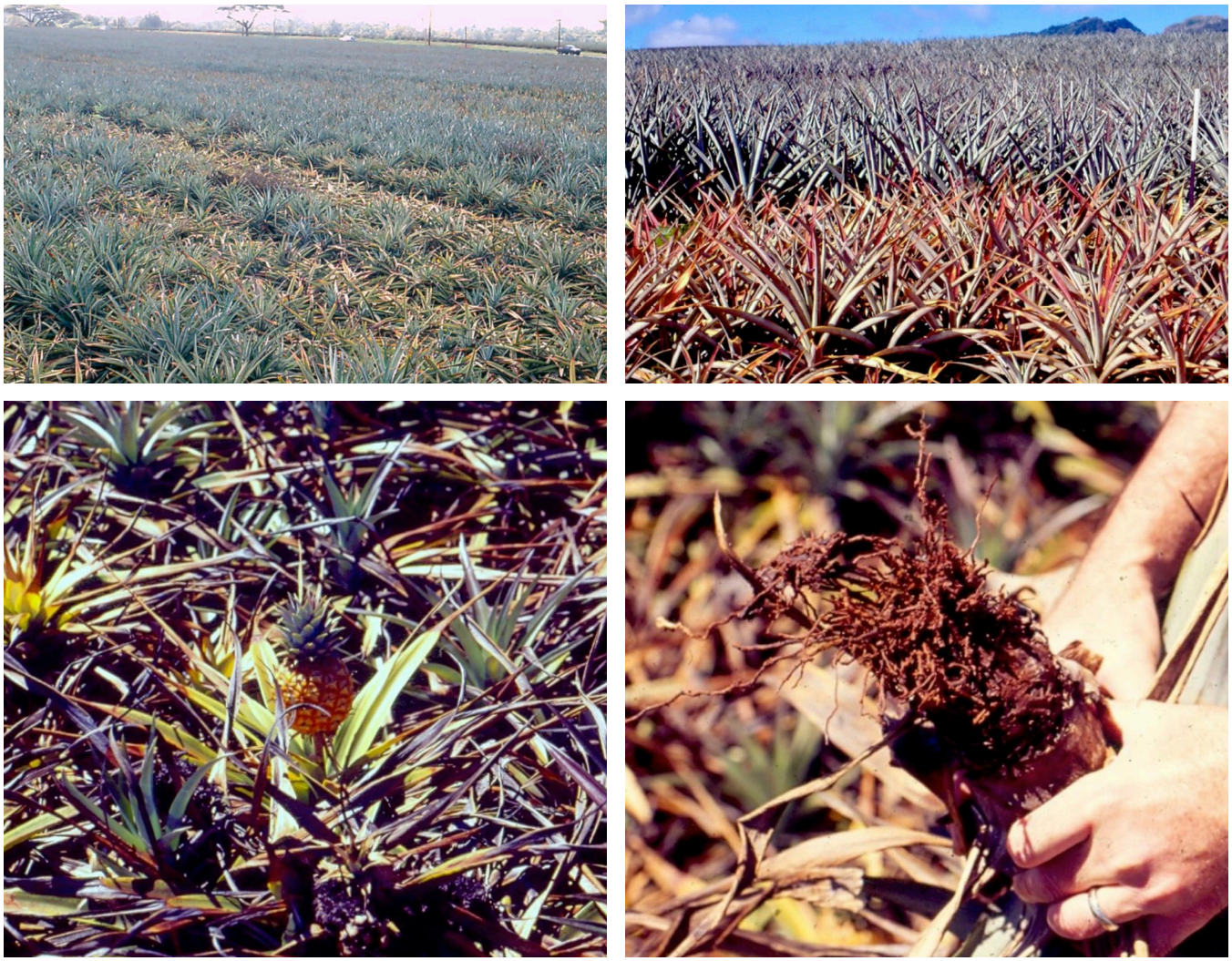
Effective management of root and crown rots of pineapple includes an integration of regulatory, cultural, chemical, and biological practices.

Pythium and *Phytophthora* are soil-borne pathogens found in soils on all the Hawaiian Islands. These pathogens have been a major issue for pineapple growers since the beginning of pineapple cultivation, but their importance declined with the use of appropriate fungicides. For organic growers, however, or those not

Pineapple heart rot can move up the peduncle to rot the fruit of susceptible varieties.

Table 1. Registered Systemic Pesticides for Pineapple Root and Heart Rot

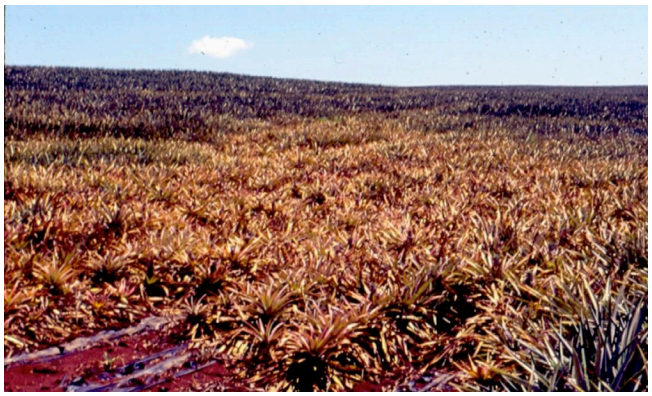
	Active Chemical(s)	Product name	Company name	Labels	EPA reg. #
Mefenoxam-based systemic fungicides	Mefenoxam	RidomilGold® SL	Syngenta	http://www2.hawaii.gov//hdoa/labels/9226.455_2017.pdf	100-1202
	Mefenoxam, Chlorothalonil	RidomilGold® Bravo® SC	Syngenta	http://www2.hawaii.gov//hdoa/labels/9226.454_2017.pdf	100-1221
Phosphonate-based systemic fungicides	Mono- and dipotassium salts of phosphorous acid	Fosphite®	JH Biotech Inc.	http://www2.hawaii.gov//hdoa/labels/8205.3_2015.pdf	68573-2
	Aluminum tris (O-ethyl phosphonate)	Fosetyl – Al 80 WDG	Quali-Pro	http://www2.hawaii.gov//hdoa/labels/8275.36_2015.pdf	66222-161
	Aluminum tris (O-ethyl phosphonate)	Aliette® WDG	Bayer	http://www2.hawaii.gov//hdoa/labels/9529.111_2016.pdf	264-516



Phytophthora root rot of pineapple caused by the pathogen *Phytophthora cinnamomi* causes rotting of roots and anthocyanescence (reddening or purplish coloration) of foliage.

wishing to use fungicides, proper management practices including the following should be used to prevent serious outbreaks.

- **Site selection.** In Hawai'i, pineapple root rot occurs most frequently in high-rainfall areas with poor soil drainage. Drier areas with good soil drainage are preferred because of the reduced chance of root rot caused by either *Pythium* or *Phytophthora*, or by anaerobic soil conditions. Acidic soils are preferred to alkaline soils for inhibiting water molds. (Bartholomew 2003).
- **Exclusion, sanitation.** An important part of plant disease prevention is to avoid the introduction of pathogen inoculum to an uninfested area. Tools, farming machinery, containers, media, or planting material contaminated with soil from off-site should be cleaned and disinfested before use.
- **Field scouting and sanitation.** Remove infected plant material from the field whenever practical and take care not to move infested soil into uninfested areas.
- **Cropping systems.** Limiting soil compaction and increasing soil aeration by tilling will stimulate root growth and limit water retention, thus helping to prevent root rot. Crop rotation will benefit pineapple production by reducing levels of inoculum



Root rot of pineapple caused by *Phytophthora parasitica* in Del Monte fields in Kunia, Hawai'i.

Root rot of pineapple caused by *Phytophthora parasitica.*

(from oospores and chlamydospores), but benefits may be limited because of the wide host range of *Pythium* and *Phytophthora*. Raised beds or mounds may increase production cost but may lead to better drainage and reduce the chances of infection (Sideris 1930). On a slope, terraces can be built to mimic the effect of raised beds or mounds.

- **Biological control.** Existing bacteria, fungi, and other microorganisms in the soil will compete with *Pythium* and *Phytophthora*. Application of beneficial microorganisms using indigenous microorganisms (IMOs) and actively aerated compost teas (AACTs) may be beneficial, depending on the site used and the cost of such practices. Though existing microorganisms compete with *Pythium* and *Phytophthora*, the efficacy of methods such as IMOs and AACTs in the soil against water molds has not been well studied.
- **Resistant varieties.** To date, no superior pineapple varieties with acceptable resistance to water molds are available. 'MD-2', a hybrid of predominantly 'Smooth Cayenne' parentage, exhibits the greatest resistance when environmental conditions favor plant growth, but not when conditions favor the pathogen.
- **Disease-free planting material.** Do not transplant pineapple plants displaying symptoms of root or heart rot.
- **Pesticides.** Fungicides, while effective, represent increased production costs and should only be used when necessary. When applying fungicides after planting, important considerations include environmental conditions like high rainfall and fields that have a history of disease. Pre-plant dips, foliar applications, and soil drenches of systemic fungicides are the most effective means of preventing or reducing crop disease (Rohrbach 1985). With the exception of a pre-plant dip, fungicides are rarely applied before planting, and then only if necessary. The crown is then dipped in a fungicide before planting in the field. Two common systemic fungicides used against *Pythium* and *Phytophthora* are Ridomil (mefenoxam) and Fosphite (phosphonate). The State of Hawai'i Department of Agriculture licenses a number of these products. Always read the label before applying these or any other pesticides.

Further Pesticide Information

If you have questions about pesticide use in Hawai'i, contact the Hawai'i Department of Agriculture's Pesticides Branch at (808) 973-9409 or 973-9424 for O'ahu, Kaua'i, Maui, Lana'i, and Moloka'i, and (808) 974-4143 for Hawai'i.

Pesticides Disclaimer

Reference to a commercial product does not imply approval or recommendation by the College of Tropical Agriculture and Human Resources, Cooperative Extension Service, nor does it imply its recommendation to the exclusion of other products that may be suitable.

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