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Blueberry Rust

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Several years ago, blueberry (*Vaccinium* spp.) seemed to be a diversified crop with some promise for Hawai'i. Exceptional yield potentials were found at a trial planting of six southern highbush blueberry varieties (*Vaccinium darrowi*) at CTAHR's Mealani Research Station near Waimea on the island of Hawai'i (Zee et al. 2006). Initially, there did not seem to be any significant pest and disease problems for blueberry at the site (Hummer et al. 2007).

This changed in 2007 when a fungal disease known as blueberry rust occurred and caused great damage to the experimental crop, despite fungicide applications. The epidemic was so severe that USDA's Pacific Basin Agricultural Research Center terminated its involvement with the blueberry trials, citing the rust as one of the principal factors (F. Zee, personal communication).

Blueberry rust is the most serious disease threat to blueberry in Hawai'i, and a plan for its management should be the highest priority of anyone considering growing this crop.

This publication discusses blueberry rust, the options we have for managing the disease, and what could be done in the future to realize the promise that blueberries initially presented.

The host

Blueberry is one of around 450 *Vaccinium* species (family Ericaceae) distributed worldwide. The most genetic diversity in *Vaccinium* occurs in North America (Canada and the United States). *Vaccinium* species are usually found in acidic soils that may be sandy or peaty or composed of other organic matter such as leaf litter, especially that from pine trees. A few subtropical and neotropical species are loosely epiphytic.

The pathogen

The rust fungus is *Naohidemyces vaccinii* (Wint.) Sato, Katsuya and Hiratsuka; it had previously been named *Pucciniastrum vaccinii* (Wint.) Joerst. and *P. myrtilli* Arthur, and much of the literature about it still refers to it as *Pucciniastrum vaccinii*. The pathogen was first collected in Hawai'i in 1921.

N. vaccinii is heteroecious (having two hosts in its life cycle). Hemlock (*Tsuga* sp.) is the alternate host. The pathogen is also considered a "species complex" that occurs on many eriaceaous hosts and has two forms in North America (an eastern form and a western form).

Hosts of the pathogen include *Vaccinium* spp. (including blueberry, cranberry, huckleberry, and our native 'ōhelo, *V. reticulatum*), *Gaylussacia* (huckleberry), *Tsuga* (hemlock, hemlock spruce), *Rhododendron* (including azalea), *Lyonia*, *Menziesia* (mock azalea), *Pernettya*, *Hugeria*, *Pieris*, *Leucothoe*, and *Oxycoccus*.

The disease has been reported in Australia, Europe, Argentina, Asia, Mexico, Canada, and the USA.

Typical yellowish orange rust pustules with urediniа and urediniospores on the lower surface of southern highbush blueberry variety 'Misty'. All photos by S. Nelson

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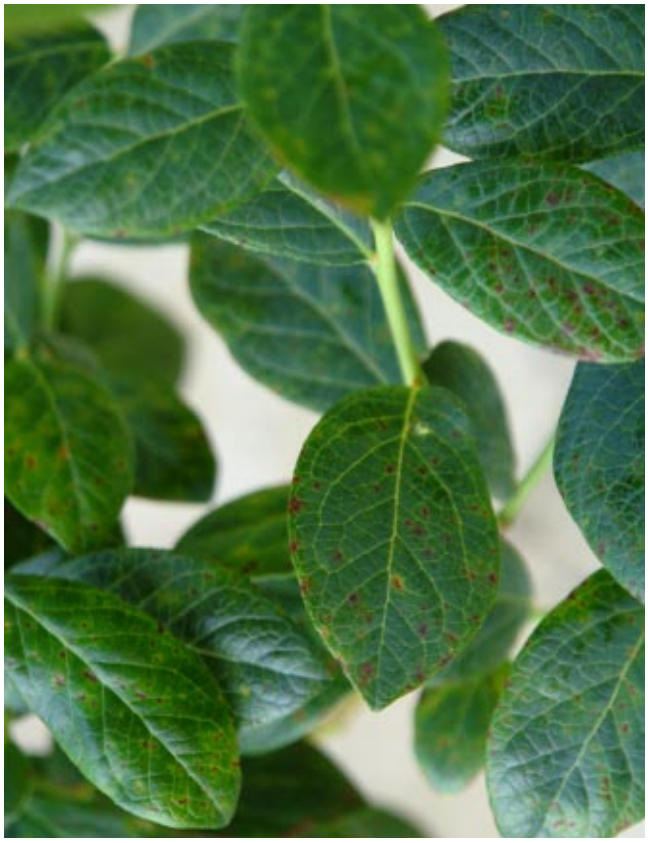

Initial symptoms: about 10 days after inoculation, the disease first appears as tiny yellow spots on the upper surface of young blueberry leaves. Spots later turn reddish brown and may be surrounded by a slight yellow halo.

Heavily rusted southern highbush blueberry foliage

Foliar yellowing and defoliation in a blueberry nursery at Mealani Research Station on the island of Hawai‘i.

Disease cycle

In the Northern United States and Canada, where hemlock (*Tsuga* sp.) exists, the rust has a *macrocyclic* life cycle, with the following different spore stages:

- Airborne aeciospores infect young blueberry leaves in spring or early summer.
- Uredinial pustules develop on the lower leaf surfaces of blueberry. Urediniospores form within these pustules. The urediniospores can continually re-infect the host throughout the season.
- Telia form on lower surface of blueberry leaves late in the season (fall–winter).
- In early spring, the teliospores germinate, forming basidia and basidiospores. Basidiospores are released from the blueberry leaves and infect hemlock needles, upon which pyncia develop.

There may be significant anthocyanescence (reddening) of affected leaves.

As lesions expand, they can coalesce to form large, brown areas of leaf blight.

Prematurely fallen leaves at a nursery due to blueberry rust.

Mature leaf spots on a lower leaf surface have developed distinct, brown margins.

- Aecia develop on hemlock needles in early summer. Aeciospores are released to infect blueberry, starting the yearly disease cycle over again.

In Hawai‘i and the southern United States, where hemlock is not present, the rust is presumed to be principally *microcyclic,* having mainly one spore stage, the urediniospores, and epidemics of the disease are driven exclusively by these spores. Experimental plantings of two hemlock species, western hemlock (*Tsuga heterophylla*) and mountain hemlock (*Tsuga mertensiana*) were installed in the early 1930s at the Honualua and Pōhakuloa Forest Reserves on Mauna Kea on Hawai‘i, but there is no evidence that these plants still survive. Therefore, urediniospores probably drive the blueberry epidemics exclusively in Hawai‘i, and the fungus over-seasons on living *Vaccinium* species.

Disease symptoms

About 10 days after a young blueberry leaf is inoculated with urediniospores, the disease appears as tiny, chlorotic (yellow) spots on the upper leaf surface. These

Leaves may turn brown, curl up, and drop from heavily diseased plants. Note the whitish fungicide residue on the leaves.

Mature leaf spots, suppressed by fungicides, developed distinct, dark colored margins.

spots later turn reddish brown and may be surrounded by a slight chlorotic halo. Uredinia are produced on the lower leaf surface, appearing as pustules that produce yellow-orange urediniospores. Yellowish orange rust pustules soon become visible scattered over the lower leaf surfaces. There may be anthocyanescence (reddening) of affected leaves. On heavily diseased plants, the leaves can turn brown, curl up, and drop. This defoliation is the principal direct cause of harm to the plant, depriving it of its photosynthetic surfaces. The indirect effect of leaf loss is reduced plant vigor and poor fruit production.

Integrated pest management

Choice of blueberry variety

The best way to control blueberry rust is to plant a resistant variety, but one has not yet been identified for Hawai'i. The six southern highbush varieties tested so far were all susceptible to blueberry rust at two locations (Lalamilo and Mealani), although they were less affected at the warmer, drier location (Lalamilo).

Sources of resistance to blueberry rust do exist among *northern* highbush varieties, but many of these varieties probably are not well suited for most of Hawai'i's subtropical environments, save perhaps for some high-elevation locations, and none of them have yet been evaluated in Hawai'i. It is possible that through plant breeding a rust-resistant southern highbush blueberry variety suited for Hawai'i could be developed.

An online Cornell University publication on blueberry rust (Heidenreich et al., n.d.) indicates the following host reactions for northern highbush varieties:

- *Resistant:* Bluecrop, Burlington, Collins, Dixi, Earliblue, Gem, Ivanhoe, Olympia, Stanley, Weymouth
- *Moderately susceptible:* Jersey, Herbert, Berkeley, Blueray, Pacific
- *Susceptible:* Coville, Pemberton, Washington, Altlantic

Table 1. Average air temperatures and total annual rainfall at the UH-CTAHR Lalamilo and Mealani Research Stations on the island of Hawai'i.

	Lalamilo (elev. 2500 ft)			Mealani (elev. 2800 ft)		
	Temperature (°F)		Rainfall	Temperature (°F)		Rainfall
Year	Maximum	Minimum	(inches)	Maximum	Minimum	(inches)
1997	74.92	57.39	32.60	71.82	55.88	57.57
1998	72.88	55.84	32.09	68.93	54.83	72.36
1999	73.47	56.78	19.78	69.67	54.63	48.65
2000	73.60	56.79	16.63	71.65	54.28	37.41
2001	73.63	57.58	23.49	72.07	54.41	48.58
2002	74.00	58.08	33.71	73.25	54.64	68.51
2003	74.74	57.69	21.62	73.84	54.13	42.59
2004	75.72	59.09	49.41	74.97	54.93	83.09
2005	75.43	58.69	28.60	73.69	54.38	47.44
2006	75.23	58.72	22.60	73.11	54.42	51.60
2007	75.60	58.85	24.08	73.16	53.65	34.53
Average	74.48	57.77	27.69	72.38	54.56	53.85

Table provided by Mary Kaheiki (UH-CTAHR).

Table 2. Fungicides registered for control of blueberry rust in Hawai'i.

Product name	***Active ingredient(s)***	***Formulation***
Cabrio	Pyraclostrobin (20%)	Water dispersable granules
Pristine	Pyraclostrobin (12.8%) Boscalid (25.2%)	Water dispersable granules
Tilt	Propiconazole (41.8%)	Emulisifiable concentrate

Source: HPIRS (Hawai'i Pesticide Information Retrieval System) and Dr. Mike Kawate, UH-CTAHR.
Labels are available at the following links:
http://www.ctahr.Hawai'i.edu/nelsons/Blueberry/9131%5B1%5D.91_2010(cabrio).pdf
http://www.ctahr.Hawai'i.edu/nelsons/Blueberry/9131%5B1%5D.102_2009(pristine).pdf
http://www.ctahr.Hawai'i.edu/nelsons/Blueberry/9226%5B1%5D.126_2007(tilt).pdf

Choice of planting location

Choice of planting location could be a key to growing blueberry efficiently in Hawai'i. Locations with relatively cool and wet climate should be avoided. In 2007, the blueberry rust epidemic at Lalamilo was markedly less severe than it was in the planting of the same varieties at Mealani (R. Hamasaki, personal communication). Climate data for the two research stations is given in Table 1.

Start with disease-free planting material

It is essential that new fields not be planted with blueberry plants that carry the rust. Do not purchase or plant any blueberry plants that have rust symptoms.

Use of fungicides

Only a few fungicides are available in Hawai'i for blueberry rust management, and the experience with them so far indicates either that are not very effective in suppressing the disease or that there are phytotoxicity issues associated with their use.

Choice of production system

Our experience indicates that growing blueberries as a row crop in fields, out in the open, can lead to the development of severe epidemics that cannot be controlled effectively using existing fungicide or other management tactics. It is probably much better to grow blueberries in

more controlled environments such as hoop houses or greenhouses, similar to the way many tomato farmers cultivate tomatoes in Hawai'i. Polycropping systems that include non-hosts of the pathogen can provide physical barriers restricting spore dispersal among plants.

Quarantine

Blueberry rust is regarded as a serious quarantine pest in some locations (Australia, for example). Because the blueberry rust pathogen is reported to be genetically variable worldwide, it might be important to prevent the introduction of new forms or strains of the pathogen into Hawai'i on blueberry or other hosts.

Fungicides

In environments that are very conducive for blueberry rust disease, frequent applications of fungicides will be necessary to successfully grow monocrops of blueberry in Hawai'i. Even with frequent fungicide sprays, this disease may still prove too difficult to manage. Also, there may be phytotoxicity of some fungicide products to blueberry leaves (test them first and avoid tank mixes of incompatible products).

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