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Foliar Nematodes on Orchids in Hawaii

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Foliar nematodes are microscopic roundworms that parasitize many types of plants in Hawaii, including orchids. These nematodes are active swimmers and commonly move over wet plant surfaces to infect plant tissues, causing leaf rots and inhibiting growth of floral buds. This publication describes symptoms of diseases caused by foliar nematodes in orchids and recommends disease prevention and control practices.

Foliar nematodes are common in warm, moist environments. In Hawaii, many other plants besides orchids are hosts of these pests, including African violet, anthurium, bird's nest fern (*Asplenium* sp.), laua'e fern (*Polypodium* sp.), coleus, chrysanthemum, fireweed (*Erechtites hieracifolia*), strawberry, hibiscus, hydrangea, garden balsam (*Impatiens balsamina*), pentas, rice, tuberose, tree marigold (*Tithonia* sp.), and zinnia. Major commercial problems have occurred in field-grown tuberose crops and greenhouse-grown ferns. In both cases, leaf rots were the primary symptom of nematode infection.

In the orchid family, foliar nematodes have been observed in Hawaii on cattleya, cymbidium, dendrobium, oncidium, and vanda. The species of foliar nematode on vanda and *Dendrobium nobile* has been identified as *Aphelenchoides besseyi*, whereas *Aphelenchoides fragariae* has been found on oncidium. Diseases of vanda blossoms, dendrobium foliage, and oncidium have cost orchid growers thousands of dollars in unmarketable products. Because many people are not aware of these pathogens and their symptoms and control, diseases caused by foliar nematodes often remain undiagnosed for years, and losses are increased.

Disease symptoms caused by nematodes

Foliar nematodes enter plants through wounds or natural openings such as stomatal pores on leaves. The method of entry varies among host plants. Nematode feeding and movement within the plant causes damage by disturbing tissues. This damage becomes visible as tissue discoloration, formation of rots, or inhibition of growth in young buds and shoots.

On vandas, foliar nematodes infect immature buds and prevent flower formation. Diseased buds become yellow and abscise (drop off) or become blackened and adhere to the spike (flower cluster). Many buds may be killed, and the entire spike may become blackened and shriveled. Infection of developing flowers causes rots of petals and sepals, and petals become deformed when the diseased areas fail to expand and unfold normally.

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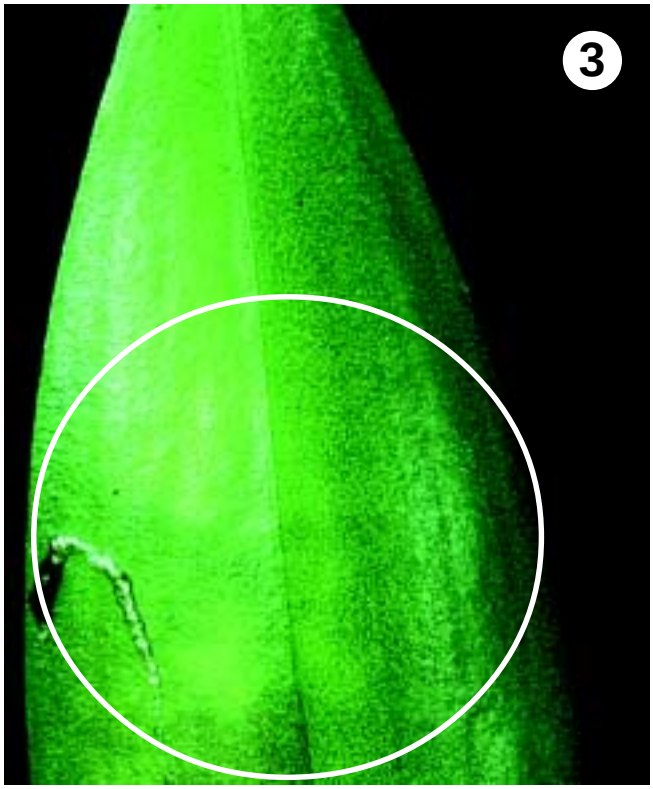
Compare the oncidium flower spikes infected with foliar nematodes (D1, D2, and D3) with a healthy spike (H). Note that the infected spikes D1 and D2 have dry sheaths and undeveloped floral buds. On infected spike D3, the sheath is slightly yellowed and separated from the stem.

This pseudobulb of an oncidium orchid infected with foliar nematodes has a long, dark streak on the base of the leaf sheath.

On oncidiums, infected buds are slightly yellow and the sheath covering the buds becomes yellow (Figure 1, D3). Eventually the buds dry and become deformed as they fail to develop (Figure 1, D1 and D2). Infected flower spikes are short and barren. Dark, elongated streaks develop on leaf sheaths covering the bulb (Figure 2). Very thin, black scar tissue forms on leaf sheaths and spikes. These scars represent areas of host tissue that have been damaged by nematode movement and feeding. The dead cells become blackened.

Commercial dendrobium cultivars are also attacked by foliar nematodes. The typical symptoms are large, irregular, slightly yellow, olive-green blotches on mature leaves (Figure 3). The blotches can occur anywhere on the leaf and become brown as the disease spreads. The epidermis (skin) of the

On this green dendrobium leaf with a blotchy discoloration, the discolored area is infected with nematodes. (The black scar and white blemish are not part of the symptom.)



This older dendrobium leaf infected with foliar nematodes has a brown, blotchy area near the tip of the leaf. (A rectangular leaf section was removed for microscopic examination.)

leaf remains smooth and unbroken, in contrast to fungal infections, which typically destroy the epidermis or cover the leaf surface with fungal spores. Leaves infected with foliar nematodes turn yellow as the brown blotches increase in size (Figure 4). These leaves then die and abscise.

Leaf symptoms of infected *Dendrobium nobile* begin with small, dark, greasy areas, frequently on the leaf edges. These areas expand into larger dark spots that eventually have a wide chlorotic (yellow) area surrounding the spot. The entire half of the leaf that is infected may become yellow. Complete leaf yellowing is followed by necrosis (leaf rot) and leaf drop.

On cymbidium leaves, foliar nematode infection is characteristized by long, dark streaks (Figures 5 and 6), whereas large, dark rots occur on cattleya leaves.

Foliar nematodes also attack the roots of many orchid plants. Plants thus infected may have reduced vigor and be stunted. These symptoms can be confused with poor nutrition or fungal diseases of the root system.

This diseased cymbidium plant has a darkened pseudobulb and prominent, dark brown leaf streaks caused by foliar nematodes.

Close-up of leaf streaks caused by foliar nematodes on cymbidium.

Foliar nematode biology

Foliar nematodes are microscopic roundworms from 0.4 to 1.2 mm long. Like other plant-parasitic nematodes, *Aphelenchoides* species have a pointed stylet (spear-like organ), which is used to puncture cell walls and feed on plant cells. They feed on cells within the plant, often moving internally between cells, and multiply by producing eggs.

When conditions are moist enough, foliar nematodes swim by undulating their long, slender bodies. This ability allows them to migrate from the root zone to floral buds at the tips of plants.

Foliar nematode spread and survival

In most potted orchids, foliar nematodes reside in the roots of the plant. They feed on root tissues and multiply within infected roots. They may also feed on fungi in the rhizosphere. On vandas, the nematodes reside between leaf sheaths and can survive long periods with little or no moisture. They may survive in dried buds and spikes for many months. During wet periods caused by rain, overhead irri-

gation, or high humidity followed by condensation, foliar nematodes emerge from diseased tissue or roots and swim in films of water on the external surface of the host plant, moving rapidly to the upper parts of the plant.

The numbers of foliar nematodes in infected plant tissue can be high. In moist weather, nematodes are commonly present on the plant surface, especially near rotted areas. Water droplets on infected vanda plants may each contain 100–200 nematodes. Nematodes are easily splashed from one plant to another. They also migrate from one plant to another if the environment is moist and plants are kept close together. Foliar nematodes can be carried in drainage water also. Most long-distance movement of foliar nematodes occurs when infected host plants, contaminated soil, or infested potting media are transported to new locations.

Foliar nematodes can remain in potted plants or in field soil for long periods. They feed on roots and fungi in the root zone. They have a wide host range and can spread to many different kinds of plants. For example, the foliar nematode *Aphelenchoides besseyi* from diseased vanda will infect chrysanthemum, African daisy, Shasta daisy, aster, cornflower (*Centaurea cyanus*), zinnia, dahlia, gloxinia, and coleus. This nematode also infects weeds in Hawaii, such as *Emilia* species and Asiatic pennywort (*Centella asiatica*).

Disease control for foliar nematodes

Control options for nematodes on orchids are limited. Chemicals that eradicate these pathogens from orchid plants or have therapeutic value are not legally available for use. Crop damage resulting from plant-parasitic nematodes on other plants is minimized or prevented by soil fumigation (e.g., pineapple), use of tissue-cultured plants (e.g., banana and anthurium), or use of resistant varieties (e.g., tomato).

Prevention

Preventing crop contamination is the key to disease control. When crops are started from clean seeds or tissue-cultured plantlets, they are generally free of pathogenic nematodes. Thereafter, contamination may originate from poor sanitation practices that allow nematode introduction. Some likely contamination sources and suggested methods of prevention include the following.

® Non-orchid plants may be diseased or infested with foliar nematodes. Growers should keep only clean orchids in the nursery.

® Other orchid plants introduced to an orchid production area or hobbyist collection may be diseased or infested. Newly acquired orchid plants should be kept in an isolated area and monitored frequently for disease symptoms for at least six months.

® Cinders that have been gathered near infected plants may be infested with nematodes. Cinders should be obtained from a cinder source with minimal vegetation.

If cinder quality is uncertain, it can be fumigated with products such as Vapam® (follow the label directions carefully). Also, exposure to high temperatures (above 40°C, 104°F) for 30 minutes kills plant-parasitic nematodes; higher temperatures require less time. When using heat to eliminate nematodes, the center of the cinder pile must reach the desired temperature for the required amount of time.

The same sanitation considerations given for cinder apply to all other ingredients of the potting

mixture, although it is not known if foliar nematodes are present in hapu'u.*

® Potting media should not be reused because it harbors many pathogens and pests that will cause plant diseases. Never save old potting media and mix it with new materials.

® The soil of the orchid field can be a source of plant-parasitic nematodes. In preparing the field for cut flower production, weeds and other vegetation should be killed and removed. Weed mats covered with a thick layer of gravel or cinders can be used to reduce contamination of the root zone. Gravel beds used to plant orchids should be raised above the ground level to prevent root growth into the soil below the gravel. Remove weeds immediately.

The field must be properly contoured to allow water to drain toward the aisles and out of the field. Water that drains across plant rows may carry plant-parasitic nematodes and fungal pathogens to healthy plants.

For growers producing potted plants for export, the crops must be grown on raised benches. If a new planting area was previously covered with vegetation, clear the ground and cover it with weed mat and a thick layer of gravel. In existing nurseries, benches with infested plants should be cleared of plants, cleaned, drenched with a 20% solution of household bleach, and allowed to dry. The ground below these benches should be covered with a thick layer of fresh gravel or cinder. Old gravel and soil should be removed from under the benches if the addition of new gravel raises the ground level and the benches become lower than quarantine regulations allow.

*The hapu'u plant (*Cibotium glaucum*) produces thick, dark, fibrous roots around a hard central stem, and its fibers are commonly used in the culture of orchids, anthuriums, and other plants.

® Pots, tags, stakes, trays, and tools should be cleaned with soap and water and surface-disinfested with a 10% solution of household bleach for 10 minutes after each use. Bleach solutions should be prepared immediately before use and should not be stored. A few drops of detergent added to the bleach will reduce air bubbles on the surface of pots that interfere with nematode kill.

® Snails, slugs, toads, frogs, mice, and other small animals can move nematodes into clean fields or onto clean benches. Prevent entry of pests such as toads and eliminate slug, snail, and insect infestations. A dry barrier of gravel without weeds or plants should surround the greenhouse to discourage entry of these pests. The barrier should be at least 5 ft wide. Weeds near the field will harbor many pests and make control difficult.

Tires of vehicles and footwear of employees may carry nematodes during moist periods, particularly if plant debris is scattered over the roadway or in aisles.

Therapeutic disease control measures

For orchid plants with existing foliar nematode problems, the following procedures are suggested.

- **Control moisture.** Keep the growing environment as dry as possible. Early morning dew can provide sufficient moisture for nematode migration. When the weather is dry, incidence of diseases caused by foliar nematodes drops to nearly zero. Migration and subsequent infection by foliar nematodes is prevented without water. Solid-covered greenhouses are strongly recommended. Air movement within the field or greenhouse should be maximized to encourage evaporation and leaf dryness. Trees and shrubs surrounding the field should be trimmed to allow for good air movement. Watering

should be conducted early in the day and not late in the afternoon. Drip irrigation is preferable to overhead systems.

- **Reduce levels of nematode inoculum.** Remove all diseased leaves, spikes, and other infected plant parts from the field. This will prevent plant-to-plant spread of the nematodes. Send infected plant parts to the county dump or incinerator. Do not pile diseased plants at the nursery, because these piles will serve as a source of nematodes that will infect healthy plants.
- **Quarantine and isolate.** If only a few potted plants are infected, remove them from the main crop. Small diseased plants should be discarded. All diseased plants will serve as a continuous source of inoculum. If plants are planted in the ground, remove infected plants and discard them from the nursery. Do not replant in the same spot for at least 6 months.
- **Keep growing areas weed-free.** The area surrounding and within the crop should be kept free of weeds and other plants. The host range of foliar nematodes is wide, and weeds may harbor the nematode.
- **Disinfest plants.** Hot-water treatment (45–50°C, 113–122°F) has been used for other crops. Heat treatment can be used to kill nematodes in some stock plants, although the effective temperature for nematode eradication in orchids such as dendrobiums is not known. In experiments with vanda cuttings, hot-water treatment for 15 minutes at 46°C (115°F) eliminated nematodes. At higher temperatures (15 minutes at 49°C, 121°F), growth of the vanda cuttings was set back for a month, but shortening the soaking time to 5–10 minutes at 49°C killed nematodes without injuring the plants. Other types of orchids need to be tested to find the effective temperature and time required to disinfest them. Plants that survive the heat treatment must be evaluated for several months to ensure that nematodes have been eliminated.
- **Use new, clean fields.** For commercial growers with large numbers of infected or suspect plants, a gradual conversion to new fields in a new location using new plants is highly recommended. This is especially important if solid-covered greenhouses are not being used to control moisture. The new crop should be grown at a different site or in a greenhouse separate from the infected plants. Clean plants placed in a separate section of an infested greenhouse generally become infected.

Education of staff

Successful disease prevention and control are highly dependent on good education. If employees understand how nematodes move and reproduce, then disease control methods become more effective. Without a good understanding of how these microorganisms spread, it is easy for a routine action, such as leaving a watering nozzle on the ground, to cause spread of nematodes. With good education, the rules of sanitation and procedures to prevent contamination will become "logical" and easier for employees to remember and follow.

Tremendous effort, commitment, and dedication are needed to develop new, clean fields. A set of guidelines can be developed for individual growers in consultation with CTAHR researchers and extension agents. Check with your local Cooperative Extension Service county agent for additional information.