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BACTERIAL DISEASES OF *DENDROBIUM*

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Cover Photo: Commercially grown *Dendrobium* on the island of Hawai'i.

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INTRODUCTION

There were few bacterial problems in commercial *Dendrobium* fields in Hawai'i for almost 20 years prior to the late 1980s. Since then, however, bacterial pathogens have become a major factor contributing to large economic losses at several orchid nurseries. Loss of leaves and complete plant destruction were especially severe during prolonged rainy periods. Today, bacterial diseases are found in all orchid production areas in the state and have become a serious threat to the industry.

In spite of these epidemics, there is still poor recognition of bacterial disease symptoms by many growers. Bacterial pathogens can destroy entire fields; thus, their importance cannot be overemphasized. This paper identifies common bacterial disease symptoms on *Dendrobium*; discusses methods by which pathogenic bacteria feed and survive; and addresses disease control methods.

HOW TO RECOGNIZE SYMPTOMS

Any part of a plant can be affected, but leaf symptoms are likely to be noticed first. Faint, irregular, olive-green areas appear at the early stages of infection. As the disease progresses, these areas develop into larger, dark green to brown, water-soaked spots (Figure 1), and eventually the entire leaf rots. Yellowish leaves or yellow margins around spots on the leaf followed by leaf drop are common symptoms (Figures 2, 3, and 4). Another leaf symptom variation, particularly in heavily diseased fields, is the formation of translucent, tan leaves (Figure 5).

The disease spreads from infected leaves into the canes. The outside of diseased canes are yellow to brown, while the insides are greenish yellow to brown. Diseased leaves and canes have a foul odor. Mature canes infected with bacteria are often soft and mushy. Eventually, diseased canes become weakened, brittle, and hollow, often breaking or bending at various points along the cane (Figure 6). Bacteria may also enter the lower parts of canes through wounds and move upward inside the cane to healthy leaves. Watery rots of leaves beginning at the stem-end of the leaf are a very good indication of bacterial infection (Figure 7). Severely infected canes die, which results in stunted plants with poor vigor. Young shoots may be destroyed within 2 weeks and many young plants die in a few months. Older (3- to 4-year-old) plants decline gradually and die in 1 to 2 years.

Rapid and severe damage to commercial *Dendrobium* fields include: a significant decrease in flower production; death of plants; or epidemics which destroy entire fields. Slow, progressive damage is less dramatic and includes: poor growth; stunted plants; few new shoots; small shoots; few, small, or incomplete spikes (floral sprays with missing flowers); and early decline in productivity of the crop.

Usually bacteria do not affect the floral sprays until

Figure 1. Bacterial leaf rot of *Dendrobium*. Dark green areas indicate water soaking of the diseased tissue.

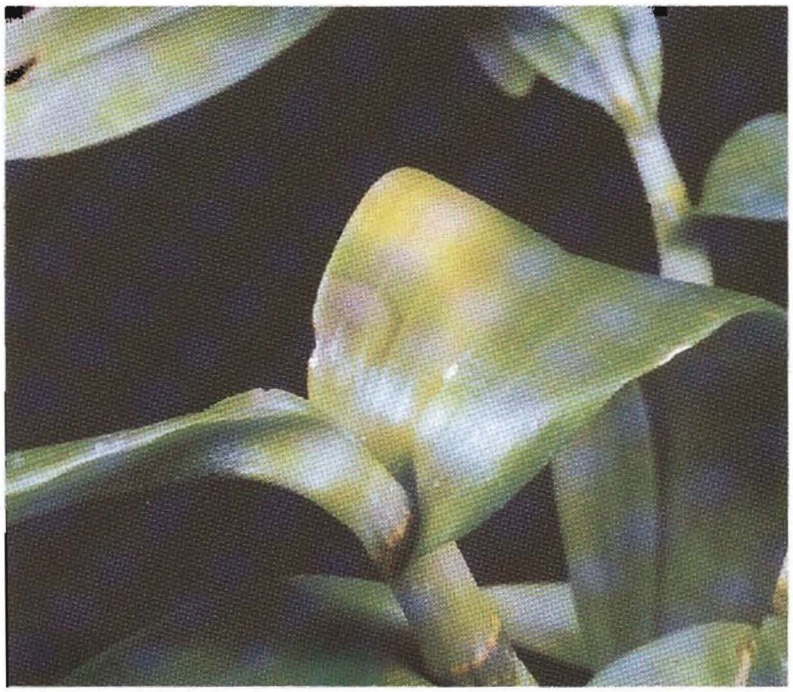

Figure 2. Yellowing around bacterial leaf spot on *Dendrobium* leaf.

Figure 3. Advanced disease of *Dendrobium* cane with circular, green and brown leaf spot. All leaves are diseased, yellow or yellowish brown, and water soaked.

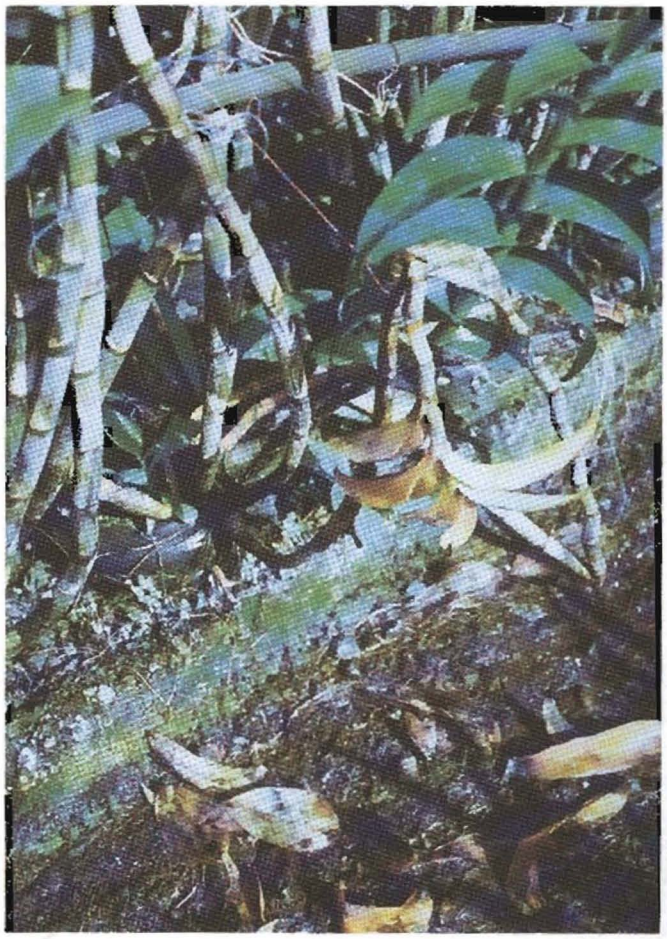

Figure 4. Leaf yellowing and defoliation of young *Dendrobium* cane caused by bacteria in a commercial field.

Figure 5. Translucent, tan to dark brown blights of *Dendrobium* leaves in a commercial field. Printed with permission: American Phytopathological Society, Uchida 1994.

Figure 6. Field-collected, diseased *Dendrobium* plant with several hollow, broken canes.

Figure 7. *Dendrobium* leaf showing water soaking of the base.

the spikes are harvested. The cut ends of spikes are quickly invaded by pathogenic bacteria which swim in the vase or bucket water. These bacteria multiply and move throughout the flower stem causing rancid rots and early wilts of the lower flowers on the spike. In some cases, the entire spike rots (Figures 8 and 9). This is a major post-harvest problem that reduces the quality of Hawai'i-grown *Dendrobium*.

THE BACTERIA AND HOW THEY CAUSE DISEASE

Two species of bacteria have been identified on diseased *Dendrobium* in Hawai'i. These are *Erwinia chrysanthemi* and *Pseudomonas gladioli* pv. *gladioli*, which cause similar diseases.

These disease-causing bacteria are simple, single-celled organisms. They must feed on organic nutrient sources to grow and multiply. They reproduce rapidly and divide every 20 to 30 minutes. This rapid rate of reproduction produces massive bacterial populations which quickly destroy host plants.

Bacteria "feed" by releasing enzymes which kill or injure plant cells, and then absorb the nutrients that become available. Poisonous by-products formed by growing bacteria also accumulate in the diseased plant to further injure or kill healthy plant cells.

DISEASE SPREAD

In an infested *Dendrobium* field, large populations of pathogenic bacteria are exuded from natural plant openings, wounds, or rotting tissue. These bacteria easily contaminate healthy plant tissue, soil or potting media, pots, tools, clothing, and other material. They are transported by splashing or moving water; contact between plants; handling of plants (transplanting, cleaning, weeding, harvesting, etc.); contaminated media and supplies; and by insects, slugs, snails, toads, and other organisms. On *Dendrobium*, both *Erwinia* and *Pseudomonas* can cause disease without wounding, but wounds are easily infected.

Wet environments and low light levels promote disease development. High moisture favors bacterial emergence, movement, infection, and multiplication. These processes are restricted in dry environments, and disease levels diminish without moisture. On rare occasions, severely infested fields recover during the dry summer months (Figure 10), only to be diseased again during the wet winter period.

Bacteria survive well in the diseased plant, in plant debris, and other organic matter. Within the plant,

Figure 8. Wilting spike produced in a suspension of pathogenic *Erwinia* after 4 days (right). Uninoculated, healthy spike (left).

Figure 9. Comparison of diseased (right) and healthy (left) stem ends of *Dendrobium* spikes.

pathogenic bacteria are protected from starvation, drying, and harmful chemicals. Large populations of bacteria contained in plant sap may also survive for a few weeks outside the plant. However, when pathogenic bacteria are separated from the protection of host tissue, they quickly die. Actively growing plant pathogenic bacteria are killed by temperatures exceeding 122°F and are also killed by direct sunlight. Bacteria are also rapidly killed when exposed to weak solutions of chlorine (1 percent solution of household bleach) or salts (sea water). Outside the host plant (e.g., in soil), food sources for pathogenic bacteria are very limited and most die within a few months.

OTHER ORCHID GENERA

Commercial *Dendrobium* growers frequently cultivate a secondary orchid crop which complements *Dendrobium* production. This maximizes space utilization by allowing use of field or greenhouse areas that are too dry, bright, small, or otherwise unsuitable for *Dendrobium*, and also serves to diversify product selection offered by the grower.

Bacterial diseases, similar to those described on *Dendrobium*, also occur on *Oncidium* and *Phalaenopsis*. *Vanda* blossoms are occasionally rotted by bacteria.

Figure 10. Field-collected, diseased *Dendrobium* plant. Older canes were defoliated during wet, disease-conducive months. New shoots were subsequently produced during a dry period.

These bacterial diseases may spread to *Dendrobium*. Thus, all plants grown at the nursery must be carefully checked for disease.

DISEASE CONTROL FOR BACTERIAL PATHOGENS

Bacterial diseases are extremely difficult to control. Rapid reproduction rates, massive population levels, and tolerance to many chemicals aid survival of plant pathogenic bacteria. The following principles for bacterial disease control must be used.

1. Exclusion

Growers must start their fields using clean plants, preferably those obtained from flasks. These plants must be carefully grown in a clean area following strict guidelines to prevent contamination by bacteria

or other pathogens. If the disease-causing bacteria are excluded or kept out of the nursery, disease will not occur.

New plants must be planted in pasteurized or sterilized potting media. For commercial fields, the soil should be fumigated if the field is prepared in areas with heavy vegetation. Gravel, cinders, or other bedding material must not have been previously used and must be free of organic matter and soil. If soil or small bits of plant debris are present, the medium must be fumigated or pasteurized to reduce common fungal root pathogens that are likely to cause decline problems as the crop matures.

New fields should not be planted in the same nursery if old fields have bacteria. Disease spread will most likely occur.

2. Elimination

Once a field is contaminated, it is very difficult, if not impossible, to completely eliminate the bacteria. As soon as a diseased plant is observed, the entire plant and those around it must be removed and destroyed. All leaves, stems, roots, and flowers from diseased plants must be gathered and removed from the nursery site. Do not replant in the spot from which the diseased plant(s) was removed for at least 8 months.

3. Moisture Control

Moisture levels must be carefully regulated to control bacterial disease. Generally, this means that fields need to be established in areas with low rainfall or that crops should be grown under solid cover. Without pathogenic bacteria, orchids will grow well in wet environments. With the presence of bacterial pathogens, however, disease levels will be very high during periods of high moisture and epidemics will become uncontrollable.

4. Sanitation

Good sanitation practices will reduce the population of bacteria. Diseased plants should be immediately removed from the field and destroyed to reduce the bacterial population. Infected leaves on otherwise healthy plants indicate bacterial contamination and the entire plant must be removed from the nursery site.

5. Pests

Pests, such as insects and slugs, can carry pathogenic bacteria. Consequently, these insects and slugs must be controlled or eliminated. The activities of birds, large lizards, and toads also spread the bacteria and their entry must be prevented.

6. Resistant Varieties

For many crops, breeding has provided resistance to bacterial diseases. It may be a long time, however, before resistance to two or three different types of bacterial diseases is bred into commercial orchid cultivars.

7. Chemical Control

Few agricultural chemicals are available for bacterial disease control and none are highly effective. Agribrom® is effective as a post-harvest treatment in controlling *Erwinia* and *Pseudomonas* on flower stems.

WHY ARE THERE NO CHEMICALS FOR BACTERIAL DISEASE CONTROL?

It is well known that diseases of orchids caused by fungi (*Botrytis*, *Phytophthora*, and others) can be effectively controlled with chemical pesticides. These fungicides destroy the disease-causing fungal pathogen, thus preventing or reducing disease. However, similar chemicals are not available for bacterial disease control.

There are several important reasons for the lack of success in using chemicals to control diseases caused by bacteria or viruses. Although both fungi and bacteria are extremely small or microscopic in size, they differ tremendously from each other. Fungi are more closely related to flowering plants than they are to bacteria.

Like plants, fungi have many membrane structures inside of them which allow them to process food, grow, reproduce, and survive. These membranes are destroyed by fungicides. Thus, many chemicals have been developed to destroy fungi by interfering with membrane functions. Low/moderate doses of these chemicals are relatively harmless to the plants they are designed to protect.

Bacterial pathogens are formidable foes. They are more "primitive" than fungi and have few structures inside their cells. They have a small amount of genetic material, as compared to fungi or plants. The membranes in the fungi that are destroyed by chemicals are not present in bacteria. Thus, spray applications of fungicides generally have no effect on diseases caused by bacteria. Dipping plants in a fungicide bath will kill fungal pathogens, but will spread bacterial pathogens

to all plants in the bath.

Few chemicals are available for use on plants to control bacterial diseases. Chlorine is useful for cleaning pots, tools, and other non-metallic surfaces. Outside the plant, the small bacterial cells are vulnerable and are quickly destroyed by chlorine. However, higher concentrations of chlorine will harm plants or animals. In the same way, Agribrom® is effective for controlling post-harvest spike rot and is generally used to clean the nursery. On other crops, some disease reduction has been observed with the use of antibiotics (streptomycin) or copper compounds (e.g., Kocide). Some orchids are sensitive to copper compounds, however. Antibiotics are costly, and the development of pathogenic bacteria resistant to them is well known.

Disease control cannot be accomplished by relying on these chemicals. In dry environments, bacteria can be reduced but not eliminated. When the environmental conditions favor disease development, bacterial diseases will recur. The most important factor is *moisture*. Prolonged periods of moisture are highly favorable to bacterial diseases and their spread. High relative humidity or frequent light showers keep the bacteria active and make it impossible to control bacterial diseases.

Since chemicals for disease control are not available, other methods of control MUST be used. These include the principles of exclusion, eradication, sanitation, moisture control, and host resistance discussed above.

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