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# Boron Deficiency of Palms in Hawai'i

Erik Patnude and Scot Nelson
Department of Plant and Environmental Protection Sciences

Palms are key plants in tropical environments. Coconut palms (*Cocos nucifera*), for example, are valued ornamental plants in landscapes and yield edible nuts, a staple food in many Pacific Island communities. Coconuts are also important ingredients in cooked and processed foods globally. Other parts of palms that are used include the stem xylem of some species in furniture or baskets; the edible heart of palm, a vegetable harvested from the inner core of certain palms; palm sap, which is fermented to make palm wine; and coconut husks, comprised of fibers (coir) used to manufacture brushes, ropes, nets, furniture upholstery, and plant growth media.

**Severe twisting and bending of coconut palm foliage caused by a boron deficiency.**

Most palm species grow naturally in tropical and subtropical climates. They have come to symbolize the tropics, adding grandeur and prestige to private and public landscapes. From the native forests, botanical gardens, and sandy beaches of Hawai'i to business offices in temperate zones, palms beautify our world.

In Hawai'i, palms commonly suffer from deficiencies of one or more elements required for plant growth, including potassium, magnesium, and boron. The symptoms of deficiencies of each elemental nutrient are distinct and recognizable, allowing growers to identify and correct them with applications of the appropriate fertilizer or nutrient. These deficiency diseases can arise when palms grow in stressful environments or where they receive insufficient care. For example, when palms grow near asphalt parking lots or in nutrient-poor soils, characteristic symptoms can develop and become increasingly severe over time.

One of the most common palm deficiencies in Hawai'i is insufficient boron. A deficiency in boron limits and distorts the foliar growth of many palm species. In this paper we describe the typical symptoms of boron deficiency and describe how to prevent and correct the problem.

## Boron

Boron is a ubiquitous element in rocks, soil, and water. Boron naturally occurs in soils ranging from about 2 to 100 ppm (Woods 1994). In basaltic rocks such as are found in Hawai'i, boron comprises about 5 ppm (Woods 1994). Some boron within soils is replenished by decomposing organic matter, but in areas of heavy rainfall, boron may be leached from the soil. This occurs most often in sandy and rocky soils. During rainy or wet periods, plants may encounter long periods of low boron levels, resulting in boron-deficiency symptoms. Chronic boron deficiencies can occur in perpetually dry soils or in soils with high pH levels. These conditions are common in deserts and seasonally arid areas where boron is tightly bound within drying soils, restricting its uptake by plants.

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**“Accordion leaf” occurs when tissues fail to open and expand normally. Left: Mild “accordion leaf” symptoms can indicate a palm in the early stages of boron deficiency. Middle: Moderate symptoms. Right: Severe “accordion leaf” on the foliage of a boron-deficient coconut seedling.**

Boron is an essential element involved in plant metabolism and cannot be replaced by or interchanged with any other element. Boron plays important roles in nitrogen metabolism, protein formation, cell division, and cell wall formation. These functions help plants to maintain a proper balance between sugars and starches in their tissues. Boron also plays a vital role in pollination and seed production (Gupta et al. 1985). Boron assists the transport of potassium to the guard cells of leaf stomata. Guard cells help regulate transpiration and tissue hydration (Cakmak 1997).

Palms and other plants may die if they lack all of the necessary micro- and macronutrients, although death may be gradual and take many years. Although boron is a micronutrient and thus is needed by plants in very small quantities, as opposed to macronutrients such as nitrogen, it still plays a vital role in the health of palms. Only small quantities of boron must be available to satisfy the requirements of plant cell wall formation, but these quantities are necessary. Palms need a healthy mix of all trace elements, including zinc, iron, manganese, and copper, to avoid other growth defects and disease symptoms.

## Symptoms

Severe boron deficiencies cause several diagnostic symptoms. They are most evident in fully grown, mature palms. Recognizing and treating early, less severe symptoms can preserve the natural beauty of palms before severe foliar distortion occurs.

Unlike nitrogen, boron in not readily transported thoughout plants. For this reason, boron deficiency characteristically damages the shoot apical meristem of palms, where the leaf primordia develop within the apical bud. When new growth emerges it is often deformed (Shorrocks 1997).

These deformations include twists or bends in the stems, failure of apical meristems to fully open and expand, and leaf wrinkling or crumpling known as “accordion leaf.” Such deformities can range from subtle to gross, the latter associated with severe disease. Chronic boron deficiency will cause spear leaves to emerge unopened at the apex of the canopy. This apical damage can also cause twisting of the petioles and leaves, or wrinkles in the leaf tissue.

There may be chlorosis (yellowing) in young leaves, shortening of terminal internodes, or “scorched” leaf tips.

**Left: Characteristic twisting and deformity of the apical growth of a palm affected by boron deficiency in the Puna district on the island of Hawai‘i. This diseased spike failed to open and now exhibits the “accordion leaf” symptom. The plant’s health was restored a few months afterwards by applying a drench of boron fertilizer to the root system. Middle: Boron-deficient *Pritchardia* leaves fail to open and expand; are stunted; display “accordion leaves”; and have brown, necrotic margins. Right: The leaflet tips of this boron-deficient Queen palm show a hook-leaf symptom, an accordion-like distortion.**

Boron deficiency may also cause a functional failure in pollen tubes, the effects of which are evident in the flowers or fruits. Fruits may abort prematurely as a result of severe boron deficiency (Broshat 2012). In certain palm species, such as *Dypsis lutescens* and *Syagrus romanzoffiana*, transverse, translucent streaking occurs (Broshat 2012). In some cases, necrotic truncation of the leaves may result in an inverted V shape (Broshat 2011).

Spatially, boron deficiency can be very patchy in a landscape, with symptomatic plants growing next to healthy plants.

Palms with feather-shaped fronds may be more susceptible to boron deficency than palms with palmate leaves (Caldwell 1997).

## Diagnosis

Symptoms of boron deficiency in palms are diagnostic for the disease: A grower can diagnose this problem accurately by symptoms alone. In early stages, boron deficiency appears as subtle leaf wrinkling. In later stages, look for “accordion leaf” and twisting of petioles or leaf midribs, deformation of leaves, or abnormal bending of stems at the stem apex. The photographs in this article illustrate these diagnostic symptoms.

To identify a boron deficiency, collect samples from both healthy and diseased palm tissue and compare the results of symptomatic versus healthy samples.

Avoid confusing boron deficiency symptoms with those of other palm diseases. Some species of palms may display symptoms that appear similar to “lethal yellowing” disease (currently not present in Hawai‘i), but the symptoms can be differentiated by observing the fruit. “Lethal yellowing” will cause the calyx end of a coconut to become blackened, but a boron deficiency will not (Broshat 2011). A boron deficiency is sometimes confused with a manganese deficiency, which can cause necrotic truncation of leaves. In contrast, however, boron deficiencies will normally cause necrosis only at the tips of palm leaves (Broshat 2012). However, in coconut palm, boron deficiency can appear as an inverted V-shaped truncation or trimming at the tips of leaves.

## Prevention

- **Apply fertilizer.** Feed palms at least twice per year with fertilizers designed for palms that contain all minor elements, including boron. However, even if palm fertilizers containing boron are applied regularly, symptoms of boron deficiency may still develop.
- **Irrigate fertilized plants.** Ensure that in areas of low rainfall, fertilized palms are irrigated in order to bring the elements into aqueous solution or suspension in the rhizosphere, thereby making them available for uptake by palm roots.
- **Site selection.** Recognize that boron deficiency is more common in very wet or very dry areas, or in sandy or rocky soils, and these areas may require more frequent boron applications as a preventive measure. For example, according to the Board of Water Supply of the City and County of Honolulu, annual rainfall amounts range from 48 to 98 inches per year along the Ko‘olau Mountain Range at elevations between 150 and 3,000 feet above sea level. Many cities located on the windward coast of O‘ahu receive over 100 inches of rain per year. Most of the high-rainfall areas are on the windward side of this mountain range, but others are on the leeward side of the Ko‘olau mountains. For example, Mānoa Valley, Moanalua, and Nu‘uanu record high annual rainfalls (Board of Water Supply 2004).

## Treatment

Apply a boron drench to the root systems of symptomatic plants. Solubor®, a water-soluble boron solution, is such a boron-containing product; it should be used with care, as should all boron fertilizers. Other products for increasing boron levels can be found in most nurseries. They include Granubor®, borax, soluble trace element mix (S.T.E.M.), and boric acid solutions (Broshat 2011). These products vary in the solubility of the boron they contain. For example, when mixing borax, agitate the suspension regularly, as the product does not dissolve readily in water and will settle to the bottom of the container.

Carefully read and follow the instructions for products containing micronutrients. Too much boron can severely damage or kill a plant, yet too little boron will not resolve the problem (Gupta et al. 1985).

**Palms with symptoms of boron deficiency usually have a scattered or patchy distribution. Here, a coconut palm with a boron deficiency grows between two healthy palms. The affected leaves are erect and not fully open.**

**The stems of palms affected by boron deficiency may bend at the apex. Such deficiencies can be patchy in a landscape and be mistaken for wind damage.**

For a medium- to large-sized palm, a mixture of 2 to 4 ounces of Solubor® in 4 to 5 gallons of water can be applied to the root zone of deficient plants (Broshat 2011). However, the Solubor® label recommends using a foliar spray of the product for commercial or large-scale practices. Such foliar spray applications of boron can correct a boron deficiency more rapidly than root (soil drench) applications, but they may require elevated booms or high-pressure sprayers to reach very tall palm canopies.

The desired amount of boron to apply will vary with the type of palm and severity of deficiency. Do not reapply boron to a treated palm for at least 4 to 6 months, as this much time may be required to see the effects of the first treatment.

To help prevent or treat boron deficiencies, trim the inflorescences. Removing these nutrient sinks (flowers and fruits) reduces the amount of boron needed by palm foliage.

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**In coconut palm, boron deficiency can appear as an inverted V-shaped truncation or trimming at the tips of leaves.**

**The apical meristem of a boron-deficient *Pritchardia* is erect and fails to open.**

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