**College of Tropical Agriculture and Human Resources**
University of Hawai'i at Mānoa

**Plant Disease**
**July 2012**
**PD-89**

# Potassium Deficiency of Palms in Hawai'i

Scot Nelson and Erik Patnude
Department of Plant and Environmental Sciences

Of the more than one thousand palm species, many play important cultural, aesthetic, medicinal, and culinary roles in indigenous and contemporary societies. Among the leading agricultural palms, *Cocos nucifera* (coconut palm) has fruits valued at more than US$6 billion annually. Coconut oil accounts for US$2.9 billion of that amount, and processed fresh coconuts, desiccated coconuts, husk material, and kernel or shell products are worth US$3.1 billion (Smith et al. 2009).

A key to growing healthy palms in nurseries, on farms, and in landscapes is to ensure that they receive adequate nutrition. Palms in Hawai'i commonly display symptoms of deficiencies of a number of essential elements, including nitrogen, magnesium, boron, and potassium. Various factors may cause these deficiencies, such as insufficient fertilizer applications, heavy rainfall, nutrient-poor soils, bad horticultural practices, and drought or insufficient irrigation.

**Scorched tips of leaflets on the lower leaves of this Sabal palmetto (cabbage palm) are diagnostic symptoms of potassium deficiency.**

Deficiency diseases are not infectious, but unless managed properly the symptoms can mar landscapes, prevent the sale of potted palms, reduce coconut yield, and eventually cause plant death. Here we discuss a common nutrient deficiency disease of palms in Hawai'i: the lack of potassium. We illustrate the typical symptoms of this disease and suggest practices that may be combined to prevent or treat it.

## Potassium

Potassium is one of the key elements necessary for palm health and is required in relatively large amounts. Potassium facilitates many functions in plants, including photosynthesis, enzyme activation, and osmoregulation. It aids in the production of adenosine triphosphate (ATP), which affects the rate of photosynthesis, and acts as a catalyst for over 60 enzymatic processes related to plant growth (Armstrong 2012). Osmoregulation affects the pressure within a plant cell: potassium controls the opening and closing of stomata, the small openings in leaves that regulate gas exchange, plant cooling, and transpiration (Johnston 2010); thus, if potassium levels are low, plant leaves develop symptoms of water stress (Armstrong 2012). Palms may also become more susceptible to disease if important elements, including potassium, nitrogen, boron, and magnesium, are out of balance in soils.

Potassium occurs in soils in several forms. Minerals such as feldspar and mica contain much natural potassium, but it is not available to plants until released. However, soils high in potassium-rich minerals tend to have more available potassium than soils low in these minerals. Mineralized potassium is gradually changed to the plant-available state, the potassium ion ($K^+$). The potassium ion is attached to soil particles based on the cation exchange capacity (CEC) of the soil. When $K^+$ is

Published by the College of Tropical Agriculture and Human Resources (CTAHR) and issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, under the Director/Dean, Cooperative Extension Service/CTAHR, University of Hawai'i at Mānoa, Honolulu, Hawai'i 96822.

**Chlorotic and necrotic speckling occur on coconut leaflets with potassium deficiency.**

**Scorched leaf tips, brown necrotic lesions, and chlorosis on this Pritchardia palm are easily identifiable traits of $K^+$ deficiency.**

released from soil particles, it is available to plants and can be taken up by their roots.

The soil orders in the Hawaiian island chain vary in their natural potassium content. In high-rainfall areas of the state, soils tend to have less available potassium than in areas of low to moderate rainfall. Also, highly weathered soils in Hawai‘i have a low CEC and low available potassium. Knowing the soil type in an area and the amount of yearly rainfall can help growers design fertilizer practices to avoid potassium deficiencies.

## Symptoms of Potassium Deficiency

Potassium deficiency symptoms occur on older, lower leaves first. However, new and emerging leaves may also show symptoms as the deficiency becomes more severe (Broschat 1990). There are two primary symptoms: light-colored or brown necrotic speckling of the leaves and scorching of the leaf tips or margins. The extent of the speckling and scorching depends on the severity of the $K^+$ deficiency, the host species, and the stage of the disease.

Symptoms of potassium deficiency differ in appearance and severity among palm genera. Some species may develop translucent orange and yellow spots, while others develop necrotic spots or yellowing of the leaves. The amount of leaf necrosis varies (Broschat 2005), ranging from inconspicuous to severe.

Advanced symptoms include a reduced canopy size and smaller trunk diameter, also known as pencil-pointing. New leaves may be small, frizzled, and chlorotic (Broschat 1990). Plant death is possible.

$K^+$ deficiency affects all species of palms, some more severely than others. Severe symptoms in Florida occur on *Washingtonia robusta* (Mexican fan palm), *Syagrus romanzoffiana* (queen palm), *Phoenix dactylifera* (date palm) and date palm hybrids, *Dypsis lutescens* (areca palm), and *Hyophorbe verschaffeltii* (spindle palms). In the landscapes and commercial plant nurseries of Hawai‘i, the palm species that commonly show severe symptoms of potassium deficiency include *Roystonea elata* (royal palm), *C. nucifera* (coconut palm), *D. lutescens*, *H. verschaffeltii*, *Caryota mitis* (fishtail palm), *Pritchardia* spp. (Pritchardia palm), *Howea forsteriana* (Kentia palm), and *Sabal palmetto* (cabbage palm). Less susceptible species in Hawai‘i include *Bismarkia nobilis* (silver Bismarck palm) and *Adonidia merrillii* (Manila palm).

Palms in Hawai‘i may suffer from multiple nutrient deficiencies, leading to additional symptoms. The elements most commonly lacking are boron, magnesium, and nitrogen.

## Causes

$K^+$ deficiency diseases are due to one or more of the following causes:

- Soil is infertile and inherently low in $K^+$.
- Potassium in the soil is tightly bound by arid condi-

**Chlorotic and necrotic speckling and mosaic occur on the leaflets of a fishtail palm with early symptoms of potassium deficiency in a Hawai'i landscape. The symptoms can progress to a more severe stage, resulting in leaf spots, distortion, and necrosis.**

**In advanced stages of severe potassium deficiency, leaves of Pritchardia palm have scorched tips and chlorotic speckling.**

tions, making the $K^+$ less available to plants.
- Potassium in the soil is leached from the profile by high rainfall.
- There is an unbalanced ratio of nitrogen to potassium in the soil.
- Large plants, such as palms, have a particularly high need for $K^+$.
- Root pathogens, including nematodes, can attack the roots and reduce the uptake of $K^+$.
- Poor planting site (e.g., adjacent to a parking lot or surrounded by sidewalk) leads to poor root growth and development.
- There may be improper fertilization practices, including too little potassium or too much calcium and magnesium. The latter, depending on the soil CEC, compete with potassium ions for position on soil particles.
- Soil is poorly aerated and impedes the uptake of $K^+$.
- Soil is acidic and has aluminum or manganese toxicity that inhibits root growth.

## Diagnosis

$K^+$ deficiency may be diagnosed by observing the following combination of symptoms, especially in the lower third of the palm canopy:

- Chlorotic speckling of leaves and leaflets (divisions or sections of a leaf)
- Necrotic spots on leaves and leaflets
- Marginal or tip necrosis of leaves or leaflets.

If you are uncertain of the diagnosis, take a sample from an affected palm leaf to the College of Tropical Agriculture and Human Resources, Agricultural Diagnostic Service Center (UH-CTAHR ADSC). The amount of potassium measured in the sample can be compared to normal ranges for some of the palms grown in Hawai'i (Plant Nutrient Management in Hawaii Soils 2000) (see Table 1).

If the normal range of potassium for a palm is unknown, compare the values for tissue from an affected leaf with those of a healthy (asymptomatic) leaf. Be sure to collect leaves for evaluation from a similar position on the plants and from plants that are of the same or similar age. This will make comparison of the $K^+$ levels more precise and accurate.

## Prevention

Prevent potassium deficiency by following these guidelines:

- Select a site for palm cultivation with fertile soil that is relatively rich in potassium, or identify the soil type in order to estimate the risk for developing a potassium deficiency (Table 2).
- Ensure that soils are well drained and have a balance of all nutrients. Well-drained soil contains oxygen

**Table 1. Acceptable potassium levels for selected healthy palm species.**

| Palm Species | Percent Potassium | Origin of Sample |
|---|---|---|
| Areca | 0.7–4.0% | Middle leaflets of most recently matured leaf |
| Seifritzii | 1.6–2.8% | Middle leaflets of most recently matured leaf |
| Rhapis | 1.5–2.5% | Middle leaflets of most recently matured leaf |
| Manila | 0.81% | Midsection of most recently matured leaf |

**Brown, yellow, and orange speckling of leaves is common on palms growing throughout Hawai‘i.**

**Table 2. Soil orders in Hawai‘i and their relative risk for development of potassium (K) deficiency in cultivated palms.[1]**

| Soil Orders in Hawai‘i | Potassium | Risk for $K^+$ Deficiency in Palms |
|---|---|---|
| Andisols | Andisols in areas with <60 inches of rainfall annually are some of the most fertile and productive soils of Hawai‘i.<br><br>In areas with higher rainfall, K leaches from the soil. | Low risk<br><br>High risk |
| Histosols | Histosols in areas of moderate rainfall (40–60 inches) are well supplied with K.<br><br>Histosols in high-rainfall areas (90 to >150 inches) have depleted K due to extensive leaching. | Low risk<br><br>High risk (East Hawai‘i, S. Kona, N. Kona) |
| Oxisols | Infertile soils due to extensive weathering | High risk |
| Mollisols | Fertile soils, rich in K | Low risk |
| Inceptisols | Infertile soils, deficient in K | High risk (East Hawai‘i, S. Kona, N. Kona) |
| Ultisols | Infertile soils, deficient in K | High risk |
| Aridisols | Dryness of these soils limits plant growth. | High risk |
| Entisols | If close to shoreline, deficient in K. | High risk |
| Vertisols | Fertile, but have poor physical properties | Low risk |
| Spodosols | Not used for agriculture | High risk |

[1]Information in this table is derived from UH-CTAHR’s publication “Soils of Hawai‘i” (http://www.ctahr.hawaii.edu/oc/freepubs/pdf/SCM-20.pdf). Refer to it for the maps showing locations of the soil orders in the Hawaiian Islands and for more details.

**Symptoms of potassium deficiency of coconut include brown and yellow discoloration and drooping of older, lower leaves.**

**A potassium-deficient palm has scorched leaves in the lower canopy.**

that is required by plants to take up potassium. Soil samples may be submitted to the UH-CTAHR ADSC for nutrient analysis.

- Apply a slow-release fertilizer formulated for palms every four months. Palm fertilizers usually appear in Nitrogen-Phosphorus-Potassium (N-P-K) ratios such as 3:1:2, 2:1:3, or 3:1:3. For small palms (i.e., pygmy date palms, European fan palms, etc.), use ½–2 lbs (0.22–0.9 kg) per application. For medium palms (true date palms, queen palms, etc.), use 3–4 lbs (1.4–1.8 kg) per application. For large palms (i.e., royal palms, reclinata hybrids), use 5–7 lbs (2.3–3.2 kg) per application. Apply the fertilizer to the soil surface in a band at the interface between the root ball and existing soil or at the drip line. Slow-release fertilizer works best when scratched into the soil surface. Fertilizers containing micronutrients can stain concrete, so use caution when applying them. Products for organic growers include Espoma's "Organic Palm Tone," Jobe's Palm Fertilizer Spikes, EnviroWise Foliar Spray, and Fertilome Palm Tree Food.
- Apply well-rotted compost to soil around palms.
- Plant palm species tolerant of low soil potassium levels. Some of the more tolerant palm species are alexandra (*Archontophoenix alexandrae*), spiny fiber (*Trithrinax acanthocoma*), maya (*Gaussia maya*), and thatch (*Thrinax* & *Cocothrinax*) (Garofalo 1999).
- Avoid planting intolerant palms beside asphalt parking lots or in locations that restrict root growth and aeration. When palms are planted in moist, low-lying areas or in soils with poor drainage, $K^+$ can be leached out of the root zone, or root rots can develop.
- Avoid transplanting root-bound palm seedlings into landscapes.
- Avoid planting palms too deeply. Oxygen needed for potassium uptake decreases with soil depth.
- Before planting, add lime to acidic soils to improve

**Chlorotic and necrotic speckling and mosaic on leaflets of Kentia palm with potassium deficiency at an export nursery in Hawai'i.**

**Chlorotic speckling and scorched leaf tips are characteristic symptoms of potassium deficiency for palms, which often is combined with magnesium deficiency (marginal chlorosis of leaves) in Hawai'i.**

potassium uptake. Aluminum and manganese toxicities in acidic soils cause poor root development and hinder potassium uptake by plants. When acidic soils are limed, exchangeable $K^+$ increases due to the increase in cation exchange capacity.

- Avoid over-fertilization with calcium and magnesium. Calcium and magnesium ions compete with potassium ions for binding sites on soil particles.

## Treatment

Palms in a tropical environment generally produce one or two leaves per month throughout the year. At this rate, a medium-sized palm will need more than one year to replace its canopy.

- If $K^+$-deficient plants have root rot caused by a plant pathogen, treat the plants with appropriate pesticides, improve soil drainage and aeration, or both. Healthy, vigorous root growth will improve plant uptake of available potassium.
- Do not remove leaves with deficiency symptoms. Plants can reallocate the potassium in these living leaves to other tissues (Garofalo 1999), possibly slowing the development of symptoms (Garofolo 1999). Continual removal of older, potassium-deficient leaves can accelerate the rate of decline (new leaves get smaller and smaller) and may result in either premature death or the need to remove the declining plant from the landscape.
- Apply one of the potassium fertilizers indicated below. Symptoms will lessen within the first 4 to 6 months, but more than a year may elapse before a plant can produce a healthy canopy (Broschat 2005). Because high levels of $K^+$ can induce magnesium deficiencies, use a corrective fertilizer that contains both elements, such as K-Mag® or Lutz potassium spikes.
    - Muriate of potash (0-0-60), or potassium chloride (KCl), is highly soluble in water.
    - Potassium sulfate ($K_2SO_4$) (0-0-50) is a dry, crystalline material. It is a specialty fertilizer used either for direct application or in blended fertilizers. Use sulfur-coated (slow-release) potassium sulfate in granular form. Apply between 3 and 8 pounds of sulfur-coated potassium sulfate per palm, depending on the severity of the symptoms and size of the plant. Apply one-third as much magnesium sulfate to balance the added potassium. Repeat the application every 3 months.
    - Potassium nitrate ($KNO_3$) (13-0-45) is a dry, crystalline material used as a specialty fertilizer for direct application and in blended fertilizers.
    - Potassium hydroxide (KOH) (0-0-70) is a crystalline material usually used in liquid starter fertilizers.
    - Sulfate of potash magnesia (Sul-Po-Mag® or K-Mag®) (0-0-22) is a crystalline material made

**Early or mild symptoms of potassium deficiency of Pritchardia palm (left) include slightly scorched leaf tips. More severe symptoms of potassium deficiency of Pritchardia palm (right) include leaves with chlorotic speckling, pronounced necrosis, and unthrifty growth.**

from langbeinite that contains 22% potassium, 22% sulfur, and 11% magnesium.

- Lutz potassium spikes are a convenient delivery system for soluble potash, magnesium, sulfur, and nitrogen: http://www.lutzcorp.com/p-15-potassium-spike.aspx.

## Acknowledgements

The authors thank Fred Brooks and Ty McDonald of UH-CTAHR for their thoughtful reviews of this manuscript.

## References

Armstrong, DL. 1998. Functions of potassium in plants. *Better Crops With Plant Food* 82(3):4–5.

Broschat, TK. 1990. Potassium deficiency of palms in south Florida. *Principes* 34:151–155.

Broschat, TK. 1992. Palm Nutrition Guide. Cooperative Extension Service. Institute of Food and Agricultural Sciences, University of Florida Pub. SS-ORH-02.

Broschat, TK. 1994.Removing potassium-deficient leaves accelerates the rate of decline in pygmy date palms. *HortScience* 29:823.

Broschat, TK. 2005. Potassium Deficiency in Palms. University of Florida: IFAS Extension. Pub. ENH-1017.

Deenik, J and McClellan, AT. 2007. Soils of Hawai'i. SCM-20. http://www.ctahr.hawaii.edu/oc/freepubs/pdf/SCM-20.pdf

Garofalo, J and Fehrman, A. 1999. Potassium Deficiency of Palms. University of Florida: IFAS Extension.

Johnston, J. 2010. The Importance of Potassium in Soils and Plants. Rothamsted Research. http://www.fertilizer-assoc.ie/publications/Spring%20Meeting%202010/Fertiliser%20Association%20of%20Ireland%20-%20Johnston.pdf (accessed 6/8/2012).

Silva, JA, and Uchida, RS, editors. 2000. Plant nutrient management in Hawaii's soils: Approaches for tropical and subtropical agriculture. Honolulu (HI): University of Hawai'i.

Smith, N, Ha, NM, Cuong, VK, Dong, HTT, Son, ST, Baulch, B, and Thuy, NTL. 2009. Coconuts in the Mekong Delta: An Assessment of Competitiveness and Industry Potential. Prosperity Initiative. http://prosperityinitiative.org/images/stories/Coconuts_in_the_Mekong_Delta.pdf (accessed 6/8/2012).