

Research Report Identifying Nutrient Deficiencies in Waterlilies

By Dr. Martin Staines and Kathy Sassoon

Visible signs of poor nutrition expressed by plants have long been used in agriculture to help identify nutritional disorders. Visible signs include unusual color patterns and/or burns in leaves, distortion of individual plant parts, and, in extreme cases, stunting. Symptoms are often sufficiently characteristic to be useful for diagnostic purposes, although in commercial crops a diagnosis is often confirmed by chemical analysis of representative leaves for the essential plant minerals.

Numerous publications describing visual symptoms of nutrient disorders for many agriculturally important crops are available, in print and/or online. To our knowledge this unfortunately does not extend to waterlilies.

To minimize the chance that nutrient deficiencies will arise in their plants, many waterlily growers take the approach of luxury feeding, often with slow-release fertilizers. In our case, we grow tropical waterlilies on a commercial broad-acre scale specifically for the cut-flower trade. We do produce some plants for sale to local nurseries, but this is a side line for us. We have found that slow-release fertilizers are not able to provide the level of nutrition required in our plants, and so rely heavily on frequent application of conventional fertilizers directly to soils, as well as the use of foliar application.

Our soils in Western Australia are very low in nutrients by world standards due to their geological origin and great age. Avoiding and correcting nutrient deficiencies is a constant challenge for us, made harder by the lack of published quantitative information on nutrient requirements and nutrient responses in waterlilies.

Over the past 17 years we have built up experience with the identification of nutrient deficiencies in tropical waterlilies that are summarized here. We started by using information on other ornamental plants, as found in publications such as Cresswell & Weir 1997 (*Plant Nutrient Disorders 5 – Ornamental Plants and Shrubs*, Inkata Press, Australia). We draw on material published there for this article, but have adjusted and refined this to be specific to tropical waterlilies, based on our own long-term program of chemical analysis of waterlily plants with and without a range of apparent nutritional disorders.

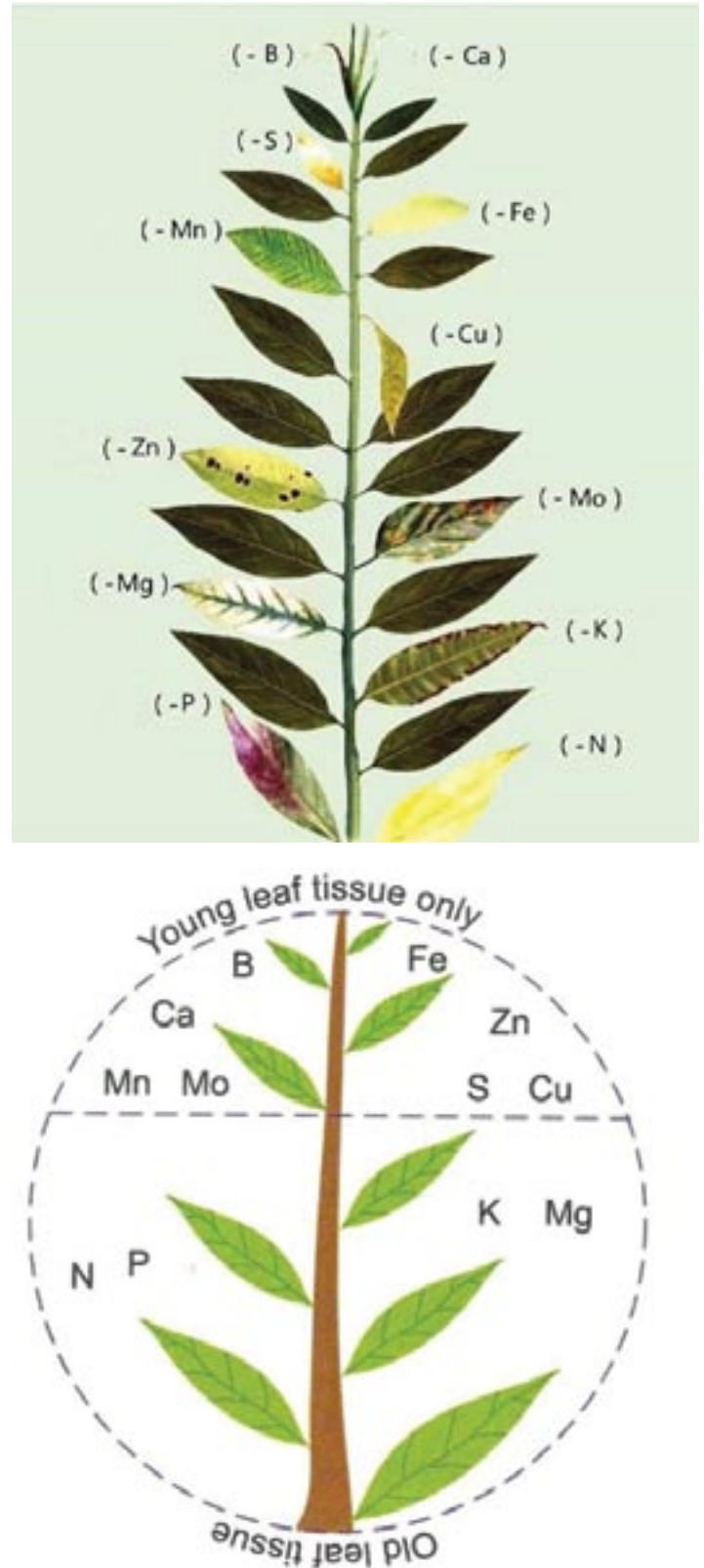


Figure 1: Generalized diagrams to identify nutrient deficiency symptoms in plants. Note some of the symptoms shown here appear to be expressed in a different manner in waterlilies
Top image courtesy University of Arizona Cooperative Extension via Pinterest.
Bottom image courtesy of the 4R Plant Nutrition Manual, IPNI 2012.

Table 1: Proposed nutrient deficiency symptoms in tropical waterlilies, with suggested minimum leaf concentrations for each element (in youngest fully developed leaves, expressed on dry matter basis), Staines and Sassoon 2020.

Symptoms first seen in older leaves

- Nitrogen (N): Pale green to yellow leaves, even over the whole leaf.

Commences at concentrations below 25 g/kg (2.5%)

- Phosphorus (P): See photo 1. Distinct reddish margins to older leaves, narrow for minor deficiencies, wider for more severe deficiencies. Poor growth.

Commences at concentrations below 2.5 g/kg (0.25%)

- Potassium (K): See photo 2. Dry scorching of margins of leaf, which often becomes cupped.

Commences at concentrations below 20 g/kg (2.0%).

- Magnesium (Mg): See photo 3. Patchy yellowing starting from leaf margins with area around leaf stalk last affected.

Severe deficiency leads to significant leaf distortion and Y-shaped newly emerging leaves which have difficulty unfurling.

Commences at concentrations below 2.0 g/kg (0.2%)

Symptoms first seen in young leaves

- Sulphur (S): Youngest leaves uniformly chlorotic (abnormally yellow color of leaves, resulting from partial failure to develop chlorophyll). Can be hard to distinguish from iron deficiency

Commences at concentrations below 2.0 g/kg (0.2%)

- Copper (Cu): See photo 4. Distortion of young leaves resulting in corrugated appearance. When severe it causes stunting, small flowers and plant death.

Commences at concentrations below 12 mg/kg

- Zinc (Zn): See photo 5. Distorted young leaves, in particular half leaves develop, producing a sickle or C shape. Plants stunted when severe.

Commences at concentrations below 40 mg/kg

- Iron (Fe): Severe loss of green between veins, leaving a faint green skeleton of veins on the leaf.

Commences at concentrations below 100 mg/kg

- Molybdenum (Mo): Stunted growth, pale and burn around leaf margins or tips. Applying nitrogen will usually accentuate this.

Commences at concentrations below 1.0 mg/kg

Symptoms first seen in young leaves and flowers:

- Calcium (Ca): Death of growing point and/or margin of young leaves. Flowers opening under water.

Commences at concentrations below 4.0 g/kg (0.4%)

- Boron (B): See photo 6. Causes pinching of youngest leaves as they expand. Sometimes a water-soaked necrosis from tip of leaf. Tissue brittle and prone to cracking and corkiness. Buds abort. Flowers small and deformed. Internodes shorten. Terminal shoot dies and leads to multiple side shoots ('witches broom').

Commences at concentrations below 40 mg/kg

Symptoms seen in leaves of any age

- Manganese (Mn): Leaves develop small pale green to yellow patches between veins. Similar to iron deficiency but plants accumulate nitrate.

Commences at concentrations below 40 mg/kg

How to Start?

Symptoms of nutritional deficiencies rarely develop uniformly over a plant. They can first appear in leaves or in flowers or even elsewhere such as roots. With leaf symptoms, the location of first appearance is important as a diagnostic. This is illustrated in Figure 1.

The highly mobile elements—nitrogen, phosphorus, potassium, and magnesium—are moved about in the plant with relative ease to support actively growing tissues. For this reason, deficiencies in these elements first show up in older leaves.

Other elements move less readily from older to younger leaves and tend to accumulate in older leaves. This includes calcium, sulphur, boron, zinc, copper, iron, and molybdenum. For this reason, deficiencies in these elements first show up in newer leaves and/or in developing flowers. Even short-term shortages in supply can severely restrict or distort the growth of young tissues.

Note that by the time visual symptoms appear, the nutrient disorder is already quite advanced and remedial action may not restore production losses. Also, visual symptoms become less reliable for diagnosis when more than one element is involved. In such cases, plant chemical analysis becomes the tool of choice.

For this article, we have compiled a table of proposed nutrient deficiency symptoms in tropical waterlilies, which draws on our observations and program of plant chemical analysis referred to earlier, while also taking into consideration information published for other ornamental plant

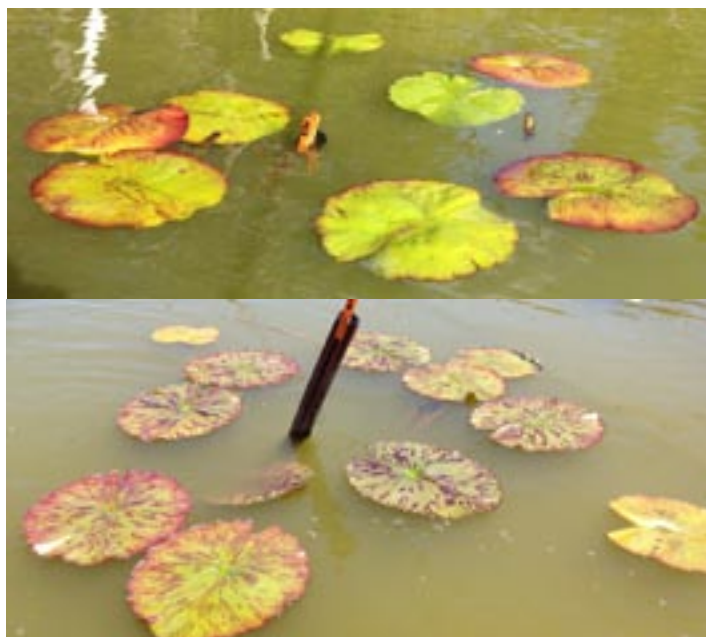


Photo 1: Characteristic symptoms that we propose are indicative of phosphorus deficiency in waterlilies. Note how older leaves are most affected.

species (Table 1). Note that symptoms vary significantly depending on the severity of a given nutrient deficiency. Given the general lack of information in this space for waterlilies, we suggest that our table may be useful for both tropical and hardy waterlilies, and we hope that this will be relevant for commercial waterlily growers and breeders as well as folk growing waterlilies in their home ponds.

Testing Your Diagnosis

Once we have identified a nutritional deficiency the next step is of course to attempt to correct it as much as pos-

Table 2: Characteristics of disorders on plant leaves - nutritional vs non-nutritional origin

Criterion	Nutritional origin	Non-nutritional origin (pathogens, herbicides)
Which leaves are affected	Seen in either young, or old, or intermediate age leaves	First seen in leaves of random ages
Where do symptoms show up first	Symptoms develop first in tissues most distant from the major veins of the leaf such as tips and margins of the leaf blade	Symptoms develop first in much more random parts of the leaf
Speed of change	Changes in leaf colour and/or tissue death develop slowly	Changes develop quickly
Patterns on leaves	Patterns are symmetrical and closely related to leaf venation	Patterns asymmetrical and not related to venation
Patterns on leaves	Boundaries between green and chlorotic areas on an affected leaf tend to be diffuse	Strong definite boundaries between green and chlorotic areas
Patterns on leaves	Leaf patterns are rarely blocky or angular	Leaf patterns are commonly blocky or angular
Mechanical damage to leaf surface	Damage to the surface of an affected leaf is unusual. Nutritional problems impair cell function but rarely cause mechanical disruption of the cuticle	Mechanical damage to surface of leaf often seen



Photo 2: Characteristic symptoms that we propose are indicative of potassium deficiency in waterlilies. Note how older leaves are most affected.

sible. Ideally, this involves a trial treatment of affected plants with an appropriate fertilizer, but leaving some plants untreated so that effectiveness of the treatment can be assessed.

Providing the appropriate fertilizer may only be part of the answer. Clay and loam soils commonly used for waterlily cultivation vary enormously in their inherent nutrient capacity. In commercial farming, fertilizer programs are tailored specifically to take soil nutrient status into account. However, in waterlily cultivation such quantitative information is simply not available.

With our particular soils and our fertilizer program, we rarely observe deficiencies of nitrogen, sulphur, and iron, but have to be constantly vigilant to prevent or correct deficiency symptoms for phosphorus, magnesium, calcium, copper, zinc, and boron.

Preventing or correcting nutrient deficiencies requires fertilizing in an aquatic environment, which brings challenges specific to the growing of waterlily flowers. Different fertilizer compounds have individual properties that may affect water quality and variously affect root uptake in the anaerobic submerged soil environment of waterlilies. Although overfeeding is rarely a direct problem for waterlilies, it may lead to excessive leaching of nutrients into pond water (in particular nitrogen and phosphorus), which can lead to algal growth. This in turn can severely perturb water pH which has a negative effect on waterlily growth.

There is of course also the possibility that abnormalities in your waterlily plants may not be caused by nutritional factors, but by other factors such as pathogens or herbicide damage. Table 2 (after Cresswell and Weir 1997) helps to distinguish between nutritional and other factors.



Photo 3a,b,c: Characteristic symptoms that we propose are indicative of various degrees of magnesium deficiency in waterlilies.



Photo 4: Characteristic symptoms that we propose are indicative of copper deficiency in waterlilies.



Photo 5a: Characteristic symptoms that we propose are indicative of various degrees of zinc deficiency in waterlilies.



Photo 5b: Characteristic symptoms that we propose are indicative of various degrees of zinc deficiency in waterlilies.



Photo 6a and b: Characteristic symptoms in very young waterlily leaves and newly forming flower buds that we propose are indicative of boron deficiency in waterlilies.

Concluding Remarks

While our waterlily farm is managed as a commercial farming operation, we have always included various research activities. Over the years, we have built up an archive of nutritional data that has formed the basis for much of the information presented here. However, we recognize that systematic research with waterlilies is required to confirm these observations. We are currently in discussion with the University of Western Australia to develop a formal research project on key aspects of waterlily nutrition, to test our data and hopefully provide a firm basis for the farming of waterlily flowers for the future.

About the Author

Dr. Martin Staines BSc MSc PhD and Kathy Sassoon operate Leuca Creek Waterlilies in Western Australia, as the principal supplier of tropical waterlily flowers for the cut flower trade in Australia. Martin has worked as an agricultural research scientist for 30+ years. He also provides an animal/plant nutritional consulting service in Australia and internationally.

