

Importance of Water Quality in Container Plant Production

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Abstract: High substrate pH is a major problem for producers of container-grown plants and seedlings. The primary cause of high substrate pH is irrigation water with high alkalinity. Alkalinity is defined as the capacity of water to neutralize acids. Some alkalinity in irrigation water is beneficial as it serves as a buffer to large swings in pH levels, but high alkalinity in the water often leads to micronutrient deficiencies. Alkalinity of irrigation water should be monitored for changes on a regular basis. Be sure to check with the laboratory being used to determine if they test for alkalinity, carbonates and bicarbonates, or water hardness. Guidelines and suggestions for dealing with alkalinity in irrigation waters are given.

Keywords: alkalinity, bicarbonates, carbonates, hardness, pH

Introduction

High quality water is essential to the production of plants grown in container nurseries. Production time can be increased and quality of seedlings decreased when water quality and quantity are not managed properly. For further information and a general review of water quality issues focusing on container-grown tree seedlings, see Landis (1989) and Moorhead and Ruter (1999).

The Importance of pH

During production of container-grown trees, the pH of the growing substrate needs to be monitored and adjusted as needed. pH is the measurement of the hydrogen ion concentration of a solution, or how acidic or basic a solution is. Values of pH can range from 0 (very acidic), to 14 (very basic or alkaline), with 7.0 being neutral. Lemon juice for example has a pH of 2.2-2.4, while baking soda has a pH near 8.0. Pure water would have a pH of 7.0. The pH scale is logarithmic, which means that each unit increase or decrease is a 10 fold difference in the acidic or basic nature of a solution. As an example, coffee at pH 5.0 is 100 times less acidic than orange juice at pH 3.0.

The ideal pH for soilless substrates used in nursery production is in the range of 5.2 to 6.2, while most conifers grow best around pH 5.5 (Landis 1989). Once familiar with the pH of the nursery's irrigation water and crop substrate, growers can begin to manage production practices to prevent pH related problems. One factor where pH plays an important role in plant nutrition is how it influences the availability of plant nutrients. In general, metal micronutrients (Cu, Fe, Mn, Ni, and Zn) are most available at a pH of below 5.5, whereas nutrients such as calcium and magnesium are most available above a pH of 6.5 (Reed 1996). Based on 35 years of experience, iron deficiency is by far the most common cause of foliar yellowing in different species of pines both in California (Ruter 1986) and in the eastern United States. Chelated products such as Sprint 330 (useful up to pH 7.5) and Sprint 138 (useful up to pH 9.0 or above) can be used with alkaline irrigation water to help manage iron deficiency issues.

Table 1. Acidic, Neutral, or Basic reactions of common fertilizer products.

Acidic	Neutral	Basic
Ammonium nitrate	Monocalcium phosphate	Calcium nitrate
Ammonium sulfate	Monopotassium phosphate	Magnesium nitrate
Diammonium phosphate	Treble superphosphate	Sodium nitrate
Monoammonium phosphate	Potassium sulfate	Potassium nitrate
Nitric Acid	Superphosphate	-
Phosphoric Acid	-	-
Sulfuric Acid	-	-
Urea	-	-
20-20-20	-	-
21-7-7	-	-

Factors that influence substrate pH include 1) substrate components, 2) incorporated fertilizers, 3) fertilizers used during production, and 4) irrigation water quality. While pine bark and peat moss are acidic substrate components, hardwood bark and some types of vermiculite often have a pH above 7.0. An example of an acidic-forming fertilizer is ammonium sulfate, while potassium nitrate would be basic. A further list is shown in Table 1.

What is Alkalinity and Why is it Important

Alkalinity is a measure of the capacity of water to neutralize acids, whereas alkaline describes a pH measurement above 7.0. Although not the same, alkalinity is related to pH. Alkalinity establishes the buffer capacity of water. Since alkalinity is the main cause of buffering, it influences how much acid is required to change the pH of a given water source. In a study looking at the chemical characteristics of water used for the production of cranberries, there was a general increase in alkalinity as pH increased but the authors noted that several samples with a pH above 7.0 had relatively low levels of alkalinity (Hanson and others 2000).

Dissolved bicarbonates and carbonates are the major ions causing alkalinity in irrigation water. Bicarbonates are generally present at a pH below 8.3 whereas carbonates are the main ions above pH 8.3. As water evaporates, carbonates and bicarbonates are left behind. These ions then neutralize hydrogen ions in the water, thus increasing pH.

Water with low alkalinity is not very buffered and the pH can be quickly changed depending on the type of fertilizer used. In areas with moderate to high alkalinity in the irrigation water low rates of dolomitic limestone are recommended (5.0 lbs. per cubic yard or less) whereas in areas with low alkalinity higher rates are recommended for incorporation into the substrate so that the pH does not drop too low.

How is Alkalinity Measured

In the laboratory, alkalinity of a water sample is measured as the amount of acid required to bring the pH of a water sample to a known endpoint. Alkalinity is expressed in terms of milligrams per liter of calcium carbonate equivalents (mg/l CaCO_3) or milliequivalents per liter of calcium carbonate equivalents (me/l CaCO_3). The two measurements can be compared using the following:

$$1 \text{ me/l } \text{CaCO}_3 = 50.04 \text{ mg/l } \text{CaCO}_3$$

A water source alkalinity of 2.5 me/l CaCO_3 or less is considered ideal for the long term production of nursery crops while 1.3 me/l CaCO_3 is preferred for plugs or seedling production.

Not all testing laboratories report alkalinity with a standard water test. A water sample sent to The University of Georgia Soil Testing lab would come back with a report of water hardness, whereas other labs might report alkalinity or carbonates plus bicarbonates. Similar to pH, water hardness is related to alkalinity but is not the same. The hardness of water is calculated as:

$$\text{Hardness} = (\text{mg/l Ca} \times 2.5) + (\text{mg/l Mg} \times 4.1)$$

Water with a hardness rating of 0-75 is considered soft, 75-150 is moderate, 150-300 is hard, and >300 is very hard. Water quality for five locations in Alabama and Georgia is shown in Table 2. In a survey of greenhouse irrigation water from around the country Argo and others (1997) found the average alkalinity from 4306 samples to be 3.19 me/l CaCO_3 .

Countering Alkalinity

The battle against alkalinity can be won by 1) acid injection into the irrigation water, 2) application of acidic amendments, or 3) the use of acidic fertilizers. Sulfuric acid is often preferred for injection into irrigation systems for safety reasons, though some growers may utilize nitric or phosphoric acids. See Reed (1996) for further information. To acidify a substrate, iron sulfate or elemental sulfur can be used. The rate of pH change in the substrate will be moderate for iron sulfate compared to slow for sulfur. See Table 1 for acidic-forming fertilizers. Peters Excel pHLow is a new water-soluble line of fertilizers designed to correct water alkalinity while being safer than using acids for injection (Hulme 2012).

Table 2. Ground water characteristics from five locations in Alabama and Georgia. Data given in mg/l.

	Auburn, AL	Blairsville, GA	Cairo, GA	Dearing, GA	Tifton, GA
Alkalinity	32	64	-	-	190
Hardness	41	51	327	27	146
Calcium	13	17	75	5	47
Magnesium	2	2	33	3	7

An online alkalinity calculator known as “ALKCALC” is available at: Extension.unh.edu/Agric/AGGHFL/Alkcalc.cfm

This application allows growers to enter the alkalinity and pH of their irrigation water, select an acidifying agent, and determine the amount needed to reach a determined target alkalinity or pH.

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