Irrigation Water Quality for Container-grown Plants

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Water is an important resource for growing plants. Plants, by weight, are comprised of 90 to 95 percent water. Chemicals in irrigation water can impact the growth of plants, especially container-grown plants, due to their restricted root growth and the high potential for change of soilless media with relatively low buffering capacities.

This fact sheet provides target ranges of elements for growing most greenhouse and nursery crops, growth concerns, and interpretation of test results and suggestions for correcting irrigation water problems (Table 1). The source of irrigation water can affect the quality of the water. Irrigation water quality is determined by measuring the level of dissolved elements it contains.

Water Sources

Water quality can vary from source to source. Three sources of water are commonly used by growers: well water, municipal water, and pond water.

Well water frequently contains high levels of dissolved elements, especially calcium (Ca) and magnesium (Mg), which can lead to high alkalinity. It is common in areas with limestone bedrock. The chemical composition of well water also varies with well depth, due to the water being pumped from different aquifers.

Municipal water obtained from rivers or lakes commonly has a lower level of dissolved chemicals than well water. Due to chemical purification to meet drinking water quality standards, however, excessively high levels of chloride (Cl) or fluoride (F) may be present and cause a leaf margin necrosis. By law, water treatment plants must monitor the chemical quality of their water. Contact the local water treatment plant to obtain test results.

Pond water is used by some greenhouse and nursery operations. Its advantage is that it usually contains lower levels of dissolved chemicals. Growers should be aware of the chemical composition of their pond water to ensure that they are providing adequate levels of Ca and Mg.

Chemical Components

Growth of plants in containers is most frequently limited by imbalances in electrical conductivity (EC), alkalinity, sodium (Na), and boron (B). High EC levels inhibit the germination of seeds, the rooting of cuttings, and root growth of some established crops. Alkalinity directly influences the pH of the root medium; as alkalinity in irrigation water increases, so does root medium pH. High levels of Na can antagonize the uptake of potassium (K), Ca, and Mg. Leaf necrosis occurs when high levels of B are present in irrigation water.

Levels of nitrate nitrogen (NO_3-N), phosphorus (P), K, Ca, Mg, sulfur (S), copper (Cu), iron (Fe), manganese (Mn), Cl, F, and zinc (Zn) are rarely a problem.

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Table 1. Desirable ranges, growth concerns, and corrective measures for elements in irrigation water used for container-grown plants.

Parameter	Target Range	Growth Concern	Corrective Measure
pH	5.8 to 6.5	A measure of acidity or basicity. The pH of irrigation water can influence the pH of the root medium over time, especially in soilless media, which in turn affects nutrient availability. Even though the water pH is important, the primary factor in how quickly irrigation water influences pH is the alkalinity of the water (see alkalinity below). If the root medium pH falls below 5.5 to 5.7, iron (Fe) and manganese (Mn) become more readily available. Fe and Mn toxicity is common in seed geraniums when root medium pH falls below 5.5.	**Basic pH irrigation water** (see alkalinity below). **Acidic pH irrigation water** • Use a basic fertilizer or add potassium bicarbonate. • Start with the initial root medium pH in the 6.5 to 7.0 range to allow for it to gradually decrease to pH 5.8 to 6.3. Periodically monitor the root medium pH.
Alkalinity	***Varies with pot size.*** **Plugs/seedlings** 1.0 to 1.3 meq/L **Bedding plants** 1.6 to 2 meq/L **6 in. pots and long-term crops** 2 to 2.6 meq/L	Alkalinity is the main characteristic of irrigation water that influences a root medium's pH, not the water pH. As the alkalinity level increases, the greater the influence the irrigation water will have on increasing the root medium's pH. Alkalinity is the measure of a water's capacity to neutralize acids (consume proteins or H^+ ions). The greater the alkalinity level, the harder it is to modify the pH of the water. **Conversion Factors** 1 meq/L Alkalinity = 50 ppm $CaCO_3$ or 61 ppm HCO_3^-	**For neutralizing 0 to 2 meq/L of alkalinity** • Consider using an acid type fertilizer. *Note:* acid type fertilizers often rely on high amounts of ammonium nitrogen (NH_4-N) or urea. To avoid NH_4-N toxicity, use a NO_3-N to NH_4-N (plus urea) ratio above 3:1. • Phosphoric acid addition. Modify fertilization program to account for the additional P. **For neutralizing > 2 meq/L of alkalinity** • Addition of nitric or sulfuric acid. Modify your fertilization program to account for the added N or S. • Use pond water for irrigation.
Electrical Conductivity (EC)	***Varies with age and type of plant.*** **Germinating seeds or rooting cuttings** ≤ 0.6 mS/cm **Acceptable** ≤ 1.2 to 1.5 mS/cm **Suspect** > 1.5 mS/cm **Unacceptable** > 2.0 mS/cm	EC is the measure of the total dissolved salts in the irrigation water. The most common salts contributing to EC are calcium (Ca), magnesium (Mg), bicarbonate (HCO_3^-), or sodium (Na). The EC measures the amount of salts present but not the concentration of any individual element. Symptoms of high EC include slow growth, limited root development, and plants that appear stunted. Symptoms of toxic EC levels often begin on the lower leaves as leaf chlorosis and progress to necrotic leaf tip margins. Sensitive crops: African violets, gloxinias, primulas. The addition of fertilizers to the irrigation water further increases EC. Total EC levels of fertilizer solutions should be < 3 mS/cm.	• Blend with or switch to other irrigation water sources with low EC (pond, rain, or municipal). • Invest in a reverse osmosis water purification system. • Avoid growing EC-sensitive crops. •Use low EC irrigation water to leach root medium if root medium EC values are high.
Nitrate Nitrogen (NO_3-N)	< 5 ppm	High NO_3-N in well water is an indication of environmental contamination. Potential sources of NO_3-N are leaching from agricultural fields or greenhouses, fertilizer storage tanks, or animal waste. Levels > 10 ppm of NO_3-N are considered unsafe for human consumption, especially for infants.	• No economically feasible corrective measures available. • If NO_3-N levels are > 25 ppm, account for the N in your fertilizer program.

Table 1. Continued.

Parameter	Target Range	Growth Concern	Corrective Measure
Ammonium Nitrogen (NH_4-N)	< 5 ppm	High levels indicate environmental contamination.	• No economically feasible corrective measures available.
Phosphorus (P)	< 5 ppm	High levels indicate surface water or septic tank drainage contamination. Avoid using for human consumption if P levels are > 5 ppm.	• No economically feasible corrective measures available. • Plants require < 20 ppm of P in the fertilizer solution. Adjust fertilizer program if needed to account for additional P.
Potassium (K)	< 10 ppm	K is a required element used by plants. Fertilization rates of 200 to 300 ppm of K are commonly applied to greenhouse crops. Generally high K levels are indicative of environmental contamination.	• If levels are high, adjust the fertilizer program to account for the added nutrients.
Calcium (Ca)	50 to 120 ppm	Ca naturally occurs in well water and is a required element used by plants. Fertilization rates of 100 ppm of Ca are commonly applied to plants.	• Adjust fertilizer program to account for irrigation water Ca levels. The recommended K:Ca:Mg ratio is 4:2:1.
Magnesium (Mg)	25 to 50 ppm	Mg naturally occurs in well water and is a required element of plants. Fertilization rates of 25 to 50 ppm are commonly applied to plants.	• Adjust fertilizer program to account for irrigation water Mg levels. The recommended K:Ca:Mg ratio is 4:2:1.
Sulfate (SO_4^{-2}) or Sulfur (S)	SO_4^{-2} < 240 ppm S < 100 ppm	The rotten egg smell is most readily associated with high sulfate levels. S is an element readily used by plants and rates of up to 64 ppm of S coupled with lower N levels of 128 ppm have been documented in poinsettias.[1]	• Avoid human consumption if SO_4^{-2} levels are > 250 ppm. • Adjust fertilizer program to account for irrigation water S levels.
Sodium (Na)	< 50 ppm	Na is **not** an essential plant nutrient. High levels of Na can antagonize the uptake by roots of K, Ca, and Mg. This is especially true if K, Ca, or Mg fertilization levels are low. High levels of Na may cause marginal burning of leaves. Easter lilies and impatiens are less tolerant of Na.	• Leach root medium if Na levels accumulate. • Maintain a balanced fertilization program of K, Ca, and Mg. • Blend or switch to other irrigation water sources with low Na. • Invest in a reverse osmosis water purification system.
Manganese (Mn)	< 1 ppm	High levels of Mn in the irrigation water are responsible for the brown or black deposits that develop on leaves or equipment. It is not thought to be toxic except at high levels or when the root medium pH is ≤ 5.5.	• Maintain root medium pH > 5.8. • Use of oxidation/sedimentation tanks or ponds. • Injection of chelating compounds so the Mn is resistant to oxidation-induced precipitation. • Filtration.

Table 1. Continued

Parameter	Target Range	Growth Concern	Corrective Measure
Iron (Fe)	< 5 ppm	High levels of Fe in the irrigation water are responsible for the red or orange deposits that develop on leaves or equipment. It is not thought to be toxic except at high levels or when the root medium pH is ≤ 5.5.	• Maintain root medium pH > 5.8. • Use of oxidation/sedimentation tanks or ponds. • Injection of chelating compounds so the Fe is resistant to oxidation-induced precipitation. • Filtration.
Boron (B)	< 0.3 to 0.5 ppm	B is a required nutrient of plants but only at low concentrations. Symptoms of B toxicity usually appear on the older leaves as a leaf margin necrosis. Poinsettias, *Draceana* species, Easter lily, other lilies, jade plants, and sea lavender are sensitive to high boron levels (> 0.25 ppm).	• Maintain root medium pH at > 6.0 and adequate calcium levels. Use fertilizers containing low levels of B. • Use of a reverse osmosis system.
Copper (Cu)	< 0.2 ppm	Copper is required in low levels, but toxicity is uncommon.	• Blend or switch to other irrigation water sources with lower Cu levels. • Use of a reverse osmosis system.
Zinc (Zn)	< 0.5 ppm	Zinc is required in low levels, but toxicity is uncommon.	• Blend or switch to other irrigation water sources with lower Zn levels. • Use of a reverse osmosis system.
Chloride (Cl^-)	< 50 ppm	High Cl^- in well water may be an indication of contamination from road salt. Most crops are not affected by Cl^-, except carnations, azaleas, camellias, roses, rhododendrons, and cucumbers. Symptoms of high Cl^- include marginal leaf scorch and leaf abscission.	• Blend or switch to other irrigation water sources with lower Cl^- levels. • Use of a reverse osmosis system.
Fluoride (F^-)	< 1 ppm	Fluoridated water is common in most municipalities. Crops sensitive to high F^- include Easter lilies, *Dracaena* species, and spider plants. Bract edge burn was shown to increase significantly when poinsettias were grown with 5 ppm of F^-.[2] Toxicity symptoms include a tip or marginal leaf necrosis.	• Blend or switch to other irrigation water sources with lower F^- levels. • Maintain root medium pH at 6.0 to 6.5 and provide adequate levels of Ca. Ca and F^- form a precipitate that results in F^- not being available for plant uptake.

[1]Paparozzi, E. T., P. O. Darrow, D. E. McCallister, and W. W. Stroup. 1994. Effect of varying the nitrogen and sulfur supply on the flowering of poinsettia. *J. Plant Nutrition* 17:593–606.
[2]Eddy, R. T. 1994. Interpreting poinsettia bract disorders. Unpublished MS Thesis, Purdue Univ., West Lafayette, IN.

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