Effect of Water Quality on Plant Propagation

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INTRODUCTION

Water is an essential component of all life on earth. The application of water to nursery and greenhouse plants is the most universal treatment in greenhouse and nursery culture, the most important treatment for crop success and the most discounted and neglected. It is estimated 80% of crop success is due to proper management of water and light. Water quality has a major influence on nursery and greenhouse plant nutrition, growth, and crop quality. The influence water quality imparts is most significant when dealing with young plants or propagation materials.

In woody plants, water has four important functions. First, water is an essential constituent of the plant protoplasm. The water content of plant cells ranges from 10% of dried seeds to 95% of some fruits and young leaves. Water generally represents 80% to 90% of the fresh weight of actively growing tissue. Second, water is the solvent in which gases, salts, and other solvents move in and out of cells and from organ to organ. Third, water is a major reagent in photosynthesis and in a number of other hydrolytic processes. Fourth, water is essential for the maintenance of turgidity (Kramer and Kozlowski, 1979). In plant water relations, maintenance of a sufficiently high water content and turgor to permit normal functioning of physiological and biochemical processes involved in growth is essential (Kramer and Kozlowski, 1979).

In coastal regions, the three most common problems with water for greenhouse and nursery stock irrigation are high salt content, high pH, and high alkalinity. These three are increasing in severity and becoming of major importance in certain regions. They are of concern to all producers of nursery and greenhouse material; however, for propagators they pose an even greater worry.

WHAT ARE YOU LOOKING FOR?

It is recommended that you have a water test done at least once each year. It may be good to have two water tests done the first time you are investigating your irrigation supply. The two tests should be conducted as follows: (1) in the spring, after all the rains; and, (2) in late summer, before the rains begin. The spring test will give you the best synopsis of your irrigation water and the test in late summer your worst scenario. Water quality testing should also be conducted more than once a season if any of the four following conditions apply. First, there has been an exceptionally dry or wet growing season. Second, there has been a period of abnormally high or low water usage. Third, a drought has occurred. Fourth, the irrigation water comes from various sources, including a city or municipal source.

When reviewing the results of a water analysis it is important to note excess or minimal levels first, before studying the balance of parameters measured. Presented in Table 1 are some ornamental irrigation water quality guidelines. The characteristics in set one should definitely be monitored. They are the minimum set of analyses that should be done on a regular basis. Set two characteristics are desirable but not as essential.

Table 1. Desirable ranges for specific elements in irrigation water.

Characteristic	Upper limit	Optimum range
Set 1:		
pH		5-7
EC general production	1.25 dS/m	Near zero
plugs & seedlings	0.75 dS/m	Near zero
Phosphorus (P)	0.005-5 mg $liter^{-1}$*	< 1.0 mg $liter^{-1}$
Calcium (Ca)	120 mg $liter^{-1}$	40 –120 mg $liter^{-1}$
Sulfate (SO_4)	240 mg $liter^{-1}$	24-240 mg $liter^{-1}$
Alkalinity	200 mg $liter^{-1}$	0-100 mg $liter^{-1}$
Sodium (Na)	50 mg $liter^{-1}$	0-30 mg $liter^{-1}$
Boron (B)	0.8 mg $liter^{-1}$	0.2-0.5 mg $liter^{-1}$
Fluoride (F)	1.0 mg $liter^{-1}$	0 (especially for sensitive crops, i.e. lilies, freesias
Magnesium (Mg)	24 mg $liter^{-1}$	6-24 mg $liter^{-1}$
Chloride (Cl)	140 mg $liter^{-1}$	0-50 mg $liter^{-1}$
Bicarbonate equivalent	150 mg $liter^{-1}$ **	30-50 mg $liter^{-1}$
Set 2:		
Nitrate ($N0_3$)	5 mg $liter^{-1}$	0-5 mg $liter^{-1}$
Potassium (K)	10 mg $liter^{-1}$	0.5-10 mg $liter^{-1}$
Zinc (Zn)	2.0 mg $liter^{-1}$	0.1-0.2 mg $liter^{-1}$
Molybdenum (Mo)	0.07 mg $liter^{-1}$	0.02-0.05 mg $liter^{-1}$
Iron (Fe)	5 mg $liter^{-1}$	1-2 mg $liter^{-1}$
Copper (Cu)	0.2 mg $liter^{-1}$	0.08-0.15 mg $liter^{-1}$
Aluminum (Al)	5.0 mg $liter^{-1}$	0-5.0 mg $liter^{-1}$
Sodium absorption ratio (SAR)	4 mg $liter^{-1}$	0-4 mg $liter^{-1}$

* 1 mg $liter^{-1}$ = 1 ppm

** Acidification is usually required to correct pH if bicarbonate equivalent is above 50 mg/liter

TOTAL SALTS

If you have compared your water analysis to the guidelines in Table 1 and discovered an electrical conductivity (EC) problem, you should take comfort that you are not alone. High salt content is a relatively common problem.

Salinity is the total quantity of salts dissolved in water and one way to measure it is by EC. A commonly used unit for measuring conductivity is millimhos per centimeter (mmhos cm^{-1}) which is equal to the millisiemen (mS). More recently mmhos cm^{-1} has been renamed decisiemens per meter (dS m^{-1}).

Effects on Plant Growth. The total amount of dissolved salts in a water supply constitutes its salinity. The cells of plant roots absorb water as a result of the differences in osmotic pressure between the cell contents and the surrounding soil water. Whenever salinity of the soil solution is near to or greater than that of the cell contents, plants are unable to take up sufficient water for growth and other processes. Mature plants can tolerate higher salts than young plants. Some common salt sensitive ornamental plants are *Cotoneaster horizontalis, Photinia ×fraseri, Ilex cornuta* 'Burfordii', *Vinca minor, Hibiscus rosa-sinensis* 'Brilliant', *Nandina domestica, Rhododendron* spp. (azalea spp.), *Gardenia* spp., and *Limonium perezii*, to name a few.

When evaluating salinity, it is important to note the dominant anion in the water. For water with bicarbonate as its principal anion, the salinity hazard is much lower than if the principal anion were chloride. The irrigation water constituents of greatest concern to growers of ornamental species are chloride, boron, and sodium. High sodium and bicarbonate are the two I have come across most often, to date.

Sodium. Plant roots can absorb sodium and transport it to leaf tissue where it accumulates. Sodium toxicity symptoms are similar in appearance to those of chloride toxicity, i.e., marginal scorch on older leaves.

Bicarbonate. The principle concern with bicarbonate is not that it is a toxic ion, but that it increases soil pH. Waters that contain sodium and bicarbonate as the major cation and anion can cause serious problems for plants.

Alkalinity and pH. Remember alkalinity and pH are not the same. The characteristic of water that will have a bearing on the change in medium pH is alkalinity, not pH. Alkalinity for all practical purposes, is the "buffering capacity" of the water. A buffer solution is a solution that has the capacity to resist change in pH (usually a decrease). The greater the alkalinity of water, the greater is the buffering capacity of that water and the tougher it is to acidify. Alkalinity is measured in units expressed as mg $liter^{-1}$ of calcium carbonate. As the units imply, the source of alkalinity is usually from bicarbonates (HCO_3^-) and carbonates (CO_3^{-2}). Both of these components will cause growing media to increase in pH if present in sufficient amounts.

As soils dry after having been irrigated with water high in bicarbonate, calcium and magnesium combine with the bicarbonate to form calcium and magnesium carbonates. These are insoluble salts and are not readily leached from the soil. With each irrigation, more calcium and magnesium carbonates are added to the soil. As they accumulate, they ease the soil pH upward, above pH 7. High soil pH levels make zinc, iron and manganese less available to plants. The rate and extent of pH increase will depend upon media formulation, watering practices, and fertilization practices.

Table 2. Acid injection into irrigation water.

Formula: A × B × C = ounces of acid per 1000 gal of water to adjust pH to approximately 6.4.

"A" is a factor determined by water pH.

Water pH	A	Water pH	A
6.7	0.249	7.7	0.475
6.9	0.342	7.9	0.484
7.1	0.400	8.1	0.490
7.3	0.437	8.3	0.494
7.5	0.460	8.5	0.496

"B" = the sum of bicarbonate and carbonate expressed as milliequivalents/liter (meq).

"C" = A factor determined by the type acid used.

Acid Source	C
75% phosphoric	10.60
85% phosphoric	8.74
93% sulfuric	3.72
61.4% nitric acid	15.6

Example: Water pH = 7.5, carbonate + bicarbonate = 3.4 meq

A × B × C = ounces of acid per 1000 gal.

0.460 × 3.4 × 10.6 = **16.5 ounces** of 75% Phosphoric acid per 1000 gal of water.

Source: Vaughan's Seed Company 1993

Table 3. Common antagonisms occurring in plants.

Nutrient in excess	Induced deficiency
N	K
K	N, Ca, Mg
Na	K, Ca, Mg
Ca	Mg
Mg	Ca
Ca	B
Fe	Mn
Mn	Fe
Cu	Fe
P	Cu

The most important point is "high pH does not determine the capacity of irrigation water to increase a potting medium's pH during production – it is the water's alkalinity".

Waters that contain less than 50 mg $liter^{-1}$ of bicarbonate usually do not have a serious effect on soil pH. Water containing concentrations of bicarbonate above 50 mg $liter^{-1}$ cause pH increases in growing media and need to be acidified. Work closely with a consulting laboratory if acid injection is necessary.

If you experience periodic iron or micronutrient deficiencies, total carbonates may be one of the causal factors. If your media pH values constantly run too high, the carbonate and bicarbonate levels in your water may be the cause of this problem. If certain crops that prefer a lower pH turn yellow, evaluate the total carbonates in your water. See Table 2 for additional information on acid injection.

Water quality, of course, is not the only reason you may see nutrient deficiencies. Some nutrients will interfere or promote the uptake of other nutrients. Table 3 contains a list of common antagonists.

Acids also supply plant nutrients and you may have to modify your fertility program after injection. Acid injection may also change the solubility of trace elements in your water. Analyze your water after acid injection and confirm that you have achieved the desired results. Also, one message about phosphoric acid. It is the most commonly used but probably should not be used as widely to correct alkalinity problems as it causes "stretch" in plants. It will have a definite stretching effect on primulas, petunias and impatiens. Citric acid is a much better acid for propagation materials.

SUMMARY

The take home message of this presentation was have a "Water Quality Action Plan". That "Action Plan" should contain these five steps: (1) have your irrigation water laboratory tested at least once each year; (2) compare your test results with the standards; (3) consider whether acid treatment will improve your water quality and which acid is best for your situation; (4) make adjustments to your water and fertilizer practices based on steps one to four; and, (5) always use pH and EC meters to make well-informed decisions, don't guess.

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Sticking the Knife In: Grafted Nursery Stock Production at Yorkshire Plants

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INTRODUCTION

Yorkshire Plants is a wholesale nursery located in the north of England approximately 200 miles north of London. Temperatures range from -10°C in the winter up to about 30°C in the summer. We have rainfall of about 24 inches per year. This is not totally unfamiliar to the climate of the Northwest; just not as cold nor as warm and not as wet. Winds, gales, and spring frosts are our other main climatic challenges. Our main crops (*Cotoneaster, Euonymus, Larix, Photinia, Prunus, Salix*) are top-worked patio trees on an 80- to 150-cm stem. These trees are convenient for retail sales and not too large (they cannot fit into a small family car) but not so small they can still be considered trees. We have tried to search for unusual hard-to-find trees, but with garden appeal (e.g., variegated, purple foliage, large leaves, cut leaves, or contorted forms). Conifers (*Picea, Pinus, Cedrus, Abies, Taxus*) are grafted plants with high value.

SHRUBS

We grown *Hibiscus, Syringa, Wisteria*, and *Corylus* that are propagated by grafting. The U.K. nursery stock industry has largely left this type of product to be grown by continental growers. There is no great tradition in this type of production in the U.K. Our market is retail garden centers/nurseries in the U.K. and Ireland.

GRAFTED NURSERY STOCK PRODUCTION

Grafting. Our grafting is nearly all done in the winter (December to March) using a simple side or whip graft. Only on *Aesculus* and *Gleditsia* do we use the whip and tongue method to help bind the graft union. Bottom-working of trees and shrubs is mainly done on a hot-callus-pipe system where water is heated by a small domestic