Understanding Water Quality: Part Two

The second of this two-part series will focus on water and plant nutrition.

By Bill Argo and Paul Fisher

Crop production bulletins often make very specific fertilizer recommendations, such as "use a balanced fertilizer like 20-10-20 for New Guinea impatiens." In reality, you can't choose the "best" fertilizer for your greenhouse operation until you consider the irrigation water quality. This article provides the information you need to match fertilizers to your water quality.

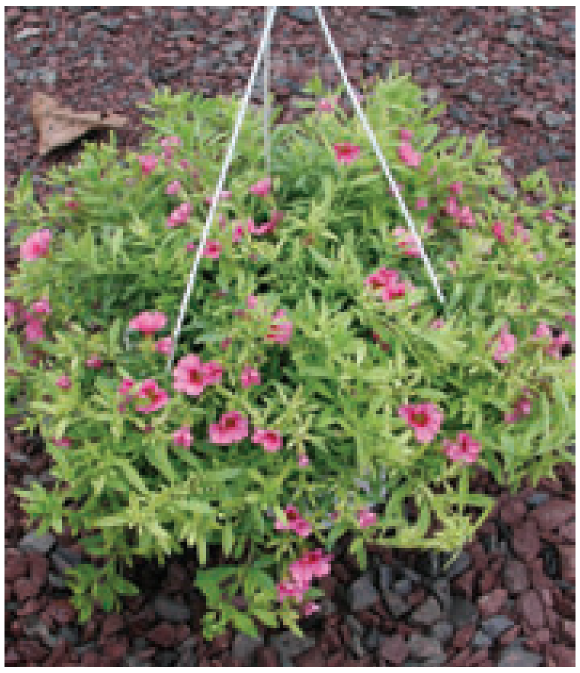

Figure 1. Iron deficiency in calibrachoa caused by high media pH (approximately 6.8). Note the yellowing of the newest growth.

Figure 2. Iron/manganese toxicity in marigold grown at low media pH (approximately 5.3). Note the yellowing or "bronzing" coloration.

Water Quality, Media pH and Plant Nutrition

Understanding the influence that irrigation water has on pH management is important because media pH influences the solubility and uptake of a number of essential plant nutrients, particularly the micronutrients iron (Fe) and manganese (Mn).

For example, iron deficiency is a common problem associated with high media pH. With iron, the solubility decreases as media pH increases. Certain species, including calibrachoa and petunias, are inefficient at taking iron out of the soil solution and therefore prone to iron deficiency when grown at a high media pH (Figure 1).

In contrast, iron/manganese toxicity is a common problem associated with low media pH. With iron and manganese, the solubility increases as media pH decreases. Certain species, including geraniums, marigolds and New Guinea impatiens, efficiently remove iron from the soil solution and, therefore, are prone to iron/manganese toxicity when grown at a low media pH (Figure 2).

One of the key factors affecting media pH is the acidic or basic reaction produced by the fertilizer solution, a combination of both the irrigation water and the fertilizer. The acidity of a fertilizer is dependent on the percentage of ammoniacal nitrogen (NH_4-N) contained in the formula. However, that acidity can be modified by the presence of water alkalinity, often thought of as the lime content of the water.

If the acidic effect produced by the fertilizer is equal to the liming effect of the alkalinity, then the media pH will remain stable. If the acidic effect produced by the fertilizer is less than the liming effect of the water, then the media pH will drift up, increasing the potential for iron deficiency problems. To avoid high media pH–related problems, you may have to either switch to a more acidic (higher ammoniacal nitrogen) fertilizer or lower water alkalinity directly by injecting acid into the irrigation water. In comparison, if the acidic effect produced by the fertilizer is more than the liming effect of the water, then the media pH will drift down, increasing the potential for iron/manganese toxicity. To avoid this low media pH–related problem, you may need to use a less acidic (lower ammoniacal nitrogen) fertilizer.

Learning to balance your water alkalinity and fertilizer (Table 1) will improve the pH management of your crops. However, sometimes pH problems are caused by other factors, such as adding too little or too much limestone to the mix. In this case, adjusting the water or fertilizer may not be sufficient to "fix" the media problem. Other times, you may experience pH-related problems with only certain crops. For example, petunias and calibrachoa may show iron deficiency at pH 6.5, but geraniums and marigolds look fine. In this case, you may want to adjust the water or fertilizer only on problem crops.

Water Can Supply Essential Plant Nutrients

Irrigation water is not a significant source of the primary macronutrients nitrogen (N), phosphorus (P) or potassium (K). However, irrigation water can contain high levels of the nutrients calcium (Ca), magnesium (Mg) and sulfur (S). And just like alkalinity, the concentration of nutrients contained in the irrigation water can vary dramatically among greenhouse operations (Table 2, page 42).

Adding mineral acids to the irrigation water to neutralize alkalinity will also add nutrients. For

Balancing Fertilizers and Alkalinity

Calcium carbonate equivalency (lbs./ton)	% Acidic Nitrogen = (ammonium + urea)/ total N	Examples	Alkalinity concentration (ppm $CaCO_3$) that provides a stable media pH
> 500 acidic	>50%	20-20-20, 25-10-10	200-300*
150-500 acidic	40%	20-10-20, 21-5-20	120-200*
150 acidic to 150 basic	20-30%	20-0-20, 17-5-17	60-120
> 150 basic	<15%	13-2-13, 14-0-14	30-60

* At these alkalinity concentrations, we recommend that you consider injecting acid into the irrigation water to lower alkalinity directly. That approach provides more flexibility in your choice of fertilizer

Table 1. Approximate guidelines to match fertilizers with water alkalinity in order to achieve a stable media pH over time. Use these values as a starting point only. It is up to the grower to make changes in media pH based on pH measurements in the crop.

example, adding enough 93 percent sulfuric acid to neutralize 150-ppm alkalinity (about 1 fluid ounce per 100 gallons) will add about 35-ppm sulfur to the fertilizer solution. Using 85 percent phosphoric acid to neutralize 150-ppm alkalinity (about 2.5 fluid ounces per 100 gallons) will add about 90-ppm phosphorous to the fertilizer solution.

Fertilizer Is Only Part of Total Nutrient Solution

The nutrients supplied by the fertilizer solution are the combination of the irrigation water, acid (if it is injected) and the water-soluble fertilizer. The term "fertilizer solution" should be used when discussing nutrient management of any crop because whenever water-soluble fertilizer is applied, it is always in conjunction with irrigation water.

Table 3 (page 42) presents examples of how to calculate the total concentration of nutrients applied to the crop by adding the concentration of nutrients supplied by the water-soluble fertilizer, the irrigation water itself and acid injected into the water source.

A grower using the fertilizer solution from example 1 in Table 3 may have problems with phosphorus deficiency, magnesium deficiency or sulfur deficiency because these nutrients are not being supplied. In example 2 in Table 3, a grower may have to worry only about phosphorus deficiency because all other nutrients are being supplied in adequate amounts. In example 3 in Table 3, all nutrients are supplied in adequate amounts. However, the grower in example 3 may observe excessive, leggy growth because the acid supplies phosphorus.

The concentration of nutrients supplied by the fertilizer solutions in Table 3 are fundamentally different from one another, even though the same 15-0-15 water-soluble fertilizer is being used, because of differences in the water quality or type of acid being used. These examples illustrate why you can not just look at the fertilizer bag to determine what concentration of nutrients are being applied to the crop and why it is important to know more about your irrigation water than just its alkalinity.

Waste Ions

Some ions contained in irrigation water are either not needed by the plant, or the plant requirement is so low that only small amounts are required. Examples of waste ions are sodium (Na) or chloride (Cl). Generally, their presence in irrigation water at high concentrations increases the risk of salt build up in the root media. Even calcium, magnesium or sulfur can be considered a waste ion if their concentration is too high or it is difficult to balance their concentration in the nutrient solution with water-soluble fertilizer.

High salt concentrations can be managed by leaching at a heavier rate than the commonly recommended 20 percent to remove any excess salt build up. If increasing leaching rate, you will also have to increase the fertilizer concentration of all nutrients supplied

Concentration Values

	Units	Average	Median	Range
pH		7.0	7.1	2.7 to 11.3
EC	mS/cm	0.6	0.4	0.01 to 9.8
Alkalinity	ppm	160	130	0 to 1120
Calcium (Ca)	ppm	52	40	0 to 560
Magnesium (Mg)	ppm	19	11	0 to 190
Sulfur (S)	ppm	27	8	0 to 750
Sodium (Na)	ppm	33	13	0 to 2500
Chloride (Cl)	ppm	33	14	0 to 1480
Boron (B)	ppm	0.2	0.02	0 to 11.7
Fluoride (F)	ppm	0.1	<0.01	0 to 8.3
Ca:Mg Ratio		5.0	3.2	0.1 to 150
SAR[1]		2.6	0.7	0 to 280

[1]Sodium-adsorption ratio, which is a formula that compares the concentration of sodium to the combined concentration of calcium and magnesium

Table 2. *Average and median values for irrigation water pH, EC and nutrient concentration in the United States. Research by Bill Argo, John Biernbaum and Darryl Warncke. (For more information, See HortTechnology 7(1):49-51).*

Three Examples

	N	P	K	Ca	Mg	S
Example #1 (Pure water source, no acid)	**Concentration, in ppm**					
Water-soluble fertilizer	100	0	85	75	0	0
Water	0	0	0	20	6	3
Acid	0	0	0	0	0	0
Total nutrient solution from #1	100	0	85	95	6	3
Example #2 (Midwest well water, sulfuric acid)						
Water-soluble fertilizer	100	0	85	75	0	0
Water	0	0	0	90	40	10
93% sulfuric acid (1.0 fl oz/100 gal)	0	0	0	0	0	35
Total nutrient solution from #2	100	0	85	165	40	45
Example #3 (Midwest well water, phosphoric acid)						
Water-soluble fertilizer	100	0	85	75	0	0
Water	0	0	0	90	40	10
85% phosphoric acid (3.1 fl oz/100 gal)	0	90	0	0	0	0
Total nutrient solution from #3	100	90	85	165	40	10

Table 3. *Fertilizer, irrigation water and acid can all contribute nutrients to the crop. The water-soluble fertilizer used in each example is 15-0-15 "dark weather special" and represents the concentration of macronutrients supplied by the 15-0-15 fertilizer at 100-ppm nitrogen. The water quality in example #1 is a pure water source, common to the East Coast. The water quality in examples #2 and #3 is a well water source common to the Midwest. In example #2, sulfuric acid is also added to neutralize 150-ppm alkalinity, and in example #3, phosphoric acid is used for alkalinity control.*

to the crop because leaching washes out all salts from the container, including nutrients.

Changing the water source may also be an option when salt concentrations are excessively high. For example, rainwater collection or a municipal water source are alternatives to well water sources. If an alternative water source is not easily available or does not have a sufficient capacity, consider water treatment. For example, reverse osmosis (RO) purification will remove most salts (except for boron), leaving very pure water.

If you change your water source, remember to re-evaluate your entire nutrition program (acidification, fertilizer, lime rate, media, etc.) to ensure that all nutrients are applied at adequate rates and media pH remains stable.

Ideal Versus Manageable Nutrient Concentrations

There is no perfect irrigation water for crop production. Each water source comes with its own set of challenges. Most problems can be overcome as long as the concentration of alkalinity, nutrients, or waste ions in the irrigation water is within a manageable range, either through proper management of alkalinity or by supplementing or balancing the nutrients contained in the water with those supplied by acid or chemical fertilizers. GPN

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