Jar Test: Determining Fertilizer Solubility and Compatibility

Not all fertilizers are compatible when mixed to formulate stock solutions. Using the jar test will help determine fertilizer compatibility and unpredicted chemical reactions.

Water-soluble fertilizers are blends of highly soluble ‘greenhouse grade’ salts (Fig. 1). Commercial fertilizer manufacturers blend constituent salts together to produce customized water-soluble fertilizer formulations. Greenhouse operations can blend their own water-soluble fertilizers but must determine if the savings outweighs the effort or if a specialty formulation is beneficial to the crop or required for water quality issues. Many hydroponic food crop (Fig. 2A) and cut flower (Fig. 2B) operations, ranging from moderate to commercial scale, typically formulate their own water-soluble fertilizers, and bedding plant greenhouse operations can easily do it too.

Blending constituent fertilizer salts is a science. Growers must be aware of solubility limits. Solubility limits essentially refers to the maximum concentration of a particular fertilizer salt (solute) that may be dissolved in water (solvent) to form a nutrient solution. When the appropriate concentration of a fertilizer salt is added to water, the ions will dissolve and form an unsaturated solution. However, when a high concentration...
of a fertilizer salt is added to water, a saturated solution is formed, and excess solute is present which is observed as solids at the bottom of a fertilizer stock container. In addition, solution temperature will also dictate solubility. Increased solubility will typically occur at warmer than cooler solution temperatures.

Growers must be knowledgeable of constituent fertilizer salt compatibility. If a combination of fertilizer salts that are not compatible are dissolved together, precipitation or formation of a solid will occur. The perfect example, but most common mistake is mixing magnesium sulfate (Epsom salt) and calcium nitrate together. The most common precipitation incompatibilities occur between sulfates and calcium but can also occur with phosphates and calcium and phosphates and iron. Precipitations between calcium and sulfates is why Cal-Mag fertilizer formulations do not supply sulfur to the plant due to the magnesium source being changed from magnesium sulfate to magnesium nitrate. Not only should growers be aware of incompatibility between fertilizer salts, but some acids used to neutralize irrigation water alkalinity when placed in stock solution can also form participates.

Mixing incompatible fertilizers or other additives together in a stock solution can be harmful to injector equipment and crop nutrient status. This is the primary reason for implementing an A-B tank or multi-head injection system. Figure 3 illustrates common fertilizer salts and acids that are compatible, incompatible, or have reduced solubility when mixed in a stock solution.
The Jar Test

Growers can implement the jar test to determine fertilizer compatibility and unpredicted chemical reactions from other water-soluble additives, minerals, pesticides, and water treatments. Before conducting a jar test (Fig. 4), one will need to gather clear 1-quart jars or containers. To perform a jar test, follow these simple steps to determine fertilizer compatibility:

1. Calculate desire concentrations of fertilizer to be dissolve in 1 to 2 quarts of water.
2. Obtain clear jar.
3. Add water.
4. Add fertilizers and dissolve.
5. Mix and cap jar. Let stand for 12- to 24-hours.
6. Observe the jar for any cloudiness or if precipitation or solids formed

By following these steps, one will be able to determine fertilizer compatibility and unpredicted chemical reactions before they occur and mitigate the likelihood nutritional disorders or equipment damage.

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**Figure 3. Solubility and compatibility of common fertilizer salt constituents. Figure by: W. Garrett Owen.**

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<th>Urea</th>
<th>Ammonium nitrate</th>
<th>Ammonium phosphate</th>
<th>Ammonium sulfate</th>
<th>Calcium nitrate</th>
<th>Potassium nitrate</th>
<th>Potassium chloride</th>
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<th>Diammonium phosphate</th>
<th>Magnesium sulfate</th>
<th>Trace Element Chelates</th>
<th>Trace Element Sulfates</th>
<th>Nitric Acid</th>
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Figure 4. The jar test can help determine fertilizer compatibility and unpredicted chemical reactions from other water-soluble additives, minerals, pesticides, and water treatments. Photos by: W. Garrett Owen.
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