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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 manufactures 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



Figure 1. Water-soluble fertilizers are blends of highly soluble 'greenhouse grade' salts. Photo by: Brian Whipker.

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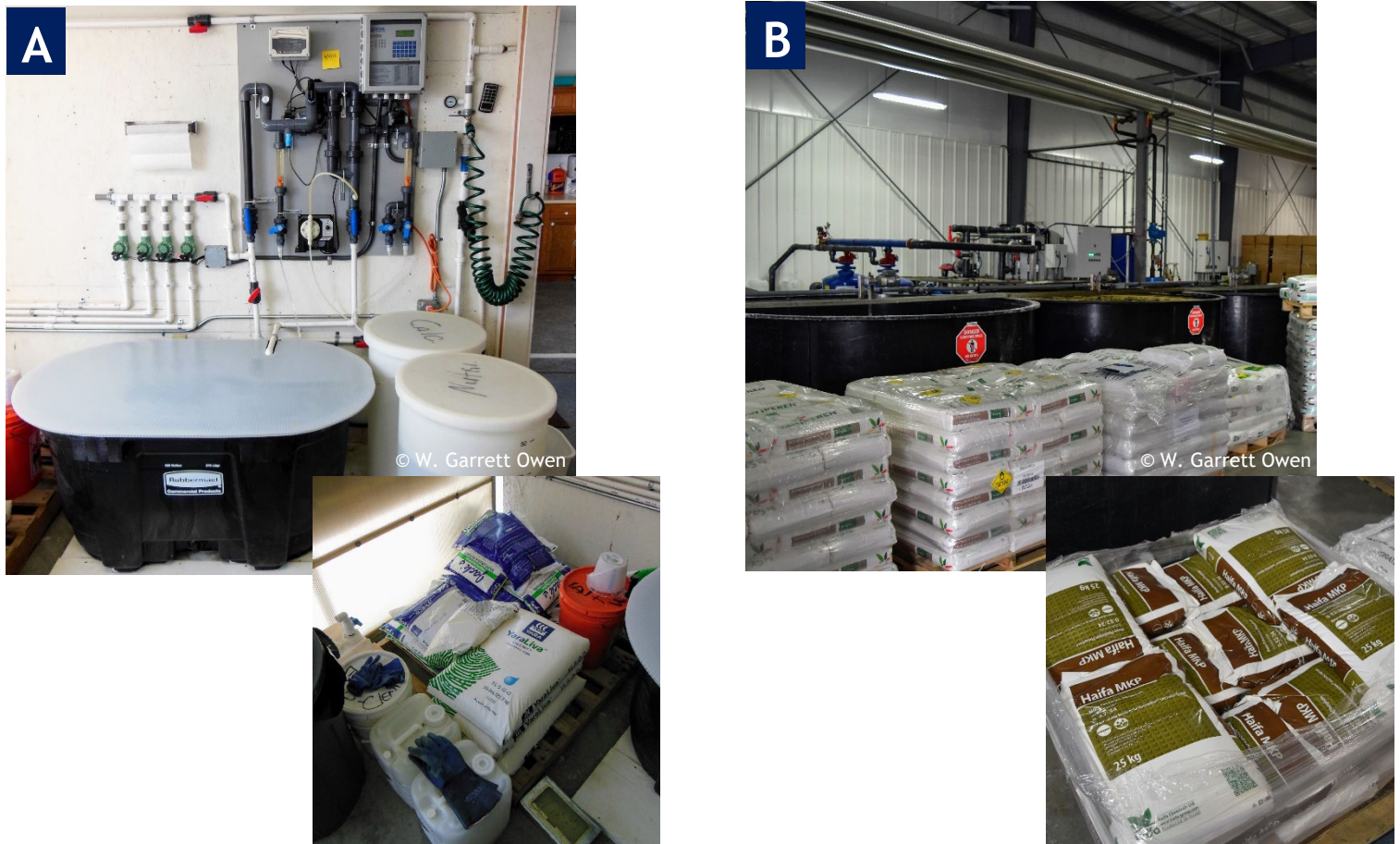


Figure 2. (A) A hydroponic leafy greens grower and (B) a cut gerbera grower both formulate water-soluble fertilizers in-house using various 'greenhouse grade' salts. Photos by: W. Garrett Owen.

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 precipitates.

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.



	Urea	Ammonium nitrate	Ammonium phosphate	Ammonium sulfate	Calcium nitrate	Potassium nitrate	Potassium chloride	Potassium sulfate	Monopotassium phosphate	Diammonium phosphate	Magnesium sulfate	Trace Element Chelates	Trace Element Sulfates	Nitric Acid	Phosphoric Acid	Sulfuric Acid
Urea	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Ammonium nitrate	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Ammonium phosphate	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Ammonium sulfate	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Calcium nitrate	Compatible	Compatible	Compatible	Compatible	Not Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Potassium nitrate	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Potassium chloride	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Potassium sulfate	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Reduced Solubility	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Monopotassium phosphate	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Diammonium phosphate	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Magnesium sulfate	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Reduced Solubility	Compatible	Compatible	Compatible	Compatible	Compatible
Trace Element Chelates	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Trace Element Sulfates	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Nitric Acid	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Not Compatible	Compatible	Compatible
Phosphoric Acid	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Sulfuric Acid	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Reduced Solubility	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible

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

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 desired concentrations of fertilizer to be dissolved 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 of nutritional disorders or equipment damage.











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Jar Test: Determining Fertilizer Compatibility

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- 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.

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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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