e-GRO Alert

Food Crops

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Three methods to check fertilizer compatibility

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Mixing concentrated stock solutions is common practice in fertilization of controlled environment agriculture (CEA) crops. The concentrated stock solutions are then dispensed using injectors which dilute the fertilizer down to the concentration it is used by the crop. However, at the concentration mixed in the stock tank some fertilizer salts are incompatible. This article addresses three ways to check fertilizer compatibility.

Why concentrated stock tanks?

The advent of fertilizer injectors (Figure 1) to accurately dilute and dispense water soluble fertilizers was a large advantage in greenhouse production. No longer did fertilizers need to be mixed in large reservoirs at the dilute concentration used by plants. Fertilizer injectors ratios vary, frequently these are between 1:64-1:200. The most used injector ratio, 1:100, makes the math easy. A 1:100 ratio means that a fertilizer is mixed in a stock tank at a 100-fold higher concentration than what the plants receive. The injector then picks up 1 part of concentrated fertilizer and dilutes it down with 99 parts of tap water resulting in the final concentration needed by the crop.

Figure 1. Two fertilizer injectors, each with a concentrated stock tank, connected in series to dispense a 2-part fertilizer. Photo: N. Mattson, Cornell University.

Why is compatibility an issue?

Some fertilizer salts are incompatible at higher concentrations and thus they cannot be mixed in the same stock tank. If they are mixed together, they react to form insoluble compounds (precipitates) which can appear cloudy or as a sludge. This causes two major issues: 1) the nutrients are tied up and not available for the plant and 2) the sludge can clog injector/drip lines. Unfortunately, the precipitation is irreversible. No amount of stirring will make the sludge soluble again in water (Figure 2).

Figure 2. Testing compatibility of 2 different fertilizers using the jar test. The left photos represent the fertilizers mixed at the dilute concentration received by plants (200 ppm N), the subsequent photos L to R represent the two fertilizers mixed at 16x, 100x, and 200x concentration showing they are incompatible in the same stock tank. Photo by N. Mattson, Cornell University.

Ultimately it is important to understand whether the fertilizers you plan to mix in the same stock tank are compatible (i.e. able to be mixed together at a 100x or higher concentration). The issue with fertilizer compatibility is especially common in growing food crops. Because food crops tend to have a higher need for calcium than ornamental crops it is common to use calcium nitrate fertilizer. However, calcium is incompatible with fertilizer salts that contain phosphates (such as monopotassium phosphate) or sulfates (such as magnesium sulfate). In these examples, the fertilizer salts will chemically recombine to form calcium phosphate or calcium sulfate (gypsum) both of which are not soluble enough to remain in solution. If fertilizers are incompatible, they will need to be mixed in separate stock tanks and then you will need to use two injectors (connected in series) (Figure 2). Each injector dilutes the fertilizer stock solution down before the solutions combine. At the dilute concentration the plant receives there are not compatibility issues. Most commonly growers producing food crops will need 2-3 injectors. Three is ideal: one stock tank/injector contains calcium nitrate and compatible fertilizers; a second stock tank contains everything not compatible with calcium; and a third stock tank is used for pH control (most commonly containing an acid, but sometimes with pure water sources may contain a base instead)

So how do you know if the fertilizers you plan to use are incompatible with either other in a concentrated stock tank? Here are three methods to follow, ideally you'll use two or more be sure your fertilizers are compatible **before mixing**..

1.) Check with your fertilizer supplier or cooperative extension specialist. These technical support specialists are always happy to assist. This might be your quickest way to get an answer! A word of caution, some fertilizers products have the same N-P-K numbers (ex. 20-10-20) but are formulated by different manufacturers and thus may have different fertilizer salts. Thus it's always helpful to share the specific fertilizer brand and label when asking questions.

2.) Read the fertilizer label to check for compatibility issues. The fertilizer label will list the fertilizer salts it is derived from. You can then check a fertilizer compatibility table (Table 1). It these ingredients are incompatible with another fertilizer then they will need to be mixed in separate stock tanks and with separate injectors connected in parallel.

Let's look at an example, let's say you want to use Jack's 5-12-26 as your base hydroponic fertilizer but you also need to add calcium nitrate (15-0-0). Are these two compatible? First let's look at the 5-12-26-label, note the fertilizer ingredients listed in the "Derived from" section (Figure 3). Let's see if anything listed there is incompatible with calcium nitrate looking at the compatibility chart (Table 1). Indeed, there are two compatibility issues: magnesium sulfate and monopotassium phosphate are each incompatible with calcium nitrate. Thus, we will need to mix these two fertilizers in separate stock tanks. And indeed, the manufacturer lists clear instructions on the full label for doing so.

Table 1. Compatibility of common fertilizer salts used in concentrated stock tanks for fertigation.
C = Compatible, I = Incompatible, R = Reduced Solubility

	Urea	Ammonium Nitrate	Ammonium Sulfate	Calcium Nitrate	Potassium Nitrate	Potassium Chloride	Potassium Sulfate	Ammonium Phosphate	Fe, Zn, Cu, Mn Sulfate	Fe, Zn, Cu, Mn Chelate	Magnesium Sulfate	Phosphoric Acid	Sulfuric Acid	Nitric Acid
Urea	C													
Ammonium Nitrate	C	C												
Ammonium Sulfate	C	C	C											
Calcium Nitrate	C	C	I	C										
Potassium Nitrate	C	C	C	C	C									
Potassium Chloride	C	C	C	C	C	C								
Potassium Sulfate	C	C	R	I	C	R	C							
Ammonium Phosphate	C	C	C	I	C	C	C	C						
Fe, Zn, Cu, Mn Sulfate	C	C	C	I	C	C	R	I	C					
Fe, Zn, Cu, Mn Chelate	C	C	C	R	C	C	C	R	C	C				
Magnesium Sulfate	C	C	C	I	C	C	R	I	C	C	C			
Phosphoric Acid	C	C	C	I	C	C	C	C	C	R	C	C		
Sulfuric Acid	C	C	C	I	C	C	R	C	C	C	C	C	C	
Nitric Acid	C	C	C	C	C	C	C	C	C	I	C	C	C	C

Adapted from: Smart Fertilizer Management

Figure 3. Fertilizer ingredients listed on the label for Jack's 5-12-26 Part A fertilizer. Note the fertilizer contains monopotassium phosphate and magnesium sulfate, which are not compatible with calcium nitrate. Thus, calcium nitrate will need to be mixed in a separate stock tank.

Derived from: Monoammonium phosphate, monopotassium phosphate, potassium nitrate, magnesium sulfate, boric acid, iron EDTA, manganese EDTA, zinc EDTA, copper EDTA, ammonium molybdate.

3) Conduct the jar test to directly test for compatibility issues. In the jar test you will test compatibility in a small jar before mixing a large batch of blended fertilizers. E-Gro's own beloved professors Garrett Owen and Brian Whipker have a great bulletin on this topic here. The brief instructions are as follows:

- Based on the fertilizer label and your target concentration, calculate the amount of each fertilizer you would need for a 1-quart (or 1-liter) stock solution using your injector ratio.
- Obtain a clean 1-quarter (or 1-liter) jar.
- Add water to close to the top.
- Add fertilizers and dissolve.
- Cap the jar and shake it up to dissolve. Let stand for 12-24 hours. (Note it is best to wait at least 12 hours to observe as some chemical reactions take time).
- Observe the jar for cloudiness, precipitation, or sludge. If observed the fertilizers are incompatible.

The jar test is a great last check to verify that fertilizers are compatible/incompatible before you mix up a large batch.

Summary

Any time you are planning to use new fertilizer products always verify compatibility before mixing. Once incompatible fertilizers have formed a sludge, there is no going back, resulting in wasted product and time. As Benjamin Franklin famously noted, no doubt talking about fertilizer mixing himself*, "an ounce of prevention is worth a pound of cure".

*Fact check: Benjamin Franklin coined this phrase in 1735 to promote fire-prevention practices in Philadelphia.

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