Fertilizer Calculations – Parts Per Million

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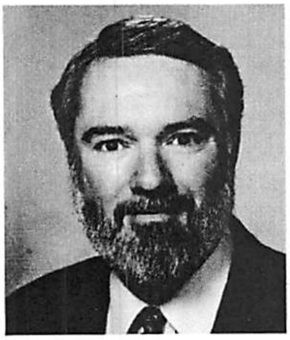

Soluble fertilizers for liquid application to greenhouse crops may be placed in one of two broad categories; *commercial fertilizers* or *tank mixes*.

Commercially available, pre-mixed fertilizers are combinations of fertilizer salts called *fertilizer carriers*. A portion of fertilizer carriers are essential nutrients for plant growth while the rest are non- nutritive. Commercial fertilizers used in greenhouse production come in a wide variety of formulations. Complete fertilizers contain the three primary macronutrients, nitrogen, phosphorus, and potassium in various proportions, e.g. 20-10-20. Fertilizer packages are labeled with three numbers. The first indicates the percent actual nitrogen (N), the second, the oxide form of phosphorus (P_2O_5), and the third, the oxide form of potassium (K_2O). Other commercial fertilizer formulations may be absent one of the three primary macronutrients, most commonly phosphorus, e.g. 15-0-15. Micronutrients may or may not be included as part of commercial fertilizers.

Tank mixes refer to liquid fertilizers formulated by growers using individual fertilizer carriers packaged and purchased separately and mixed together in a stock tank. Large greenhouse operations often find it more cost effective to mix their own liquid fertilizers compared to purchasing commercial fertilizers. Tank mixes have the added advantage of making possible a wider range of nutrient combinations and concentrations providing a great deal of flexibility in adjusting the nutrient status of crops. However, tank mixes require greater skill in determining which carriers to use and how much of each to mix. Most tank mixes are formulated from two to eight individual carriers (Table 1). Tank mixes may also include commercially-available, soluble micronutrient formulations.

In the greenhouse businesses, high-analysis fertilizer carriers are dissolved in water to make concentrated solutions which are diluted and applied to crops using a fertilizer injector or proportioner. These machines siphon the concentrated fertilizer solution from a stock tank and injects the solution into the greenhouse water line at the final concentration desired for crop application. The injector delivers the fertilizer concentrate into the water line at a preset, injection ratio. The injection ratio varies depending on the manufacturer, the capacity of the injector, and the setting for a particular unit. An injection ratio of 1:100 means that one gallon of fertilizer concentrate is injected into every 100 gallons of water passing through the water line. The dilute fertilizer in the water line is then delivered to the crops using manual or automatic irrigation systems.

Fertilizer recommendation found in greenhouse related literature may be reported in parts per million (ppm) of a specific fertilizer nutrient or in pounds and ounces (weight basis) of a fertilizer formulation per 100 gallons of water. These recommendations are final concentrations for crop application and do not specify how much fertilizer to mix for a given stock tank size or injection ratio. Recommendations reported as weight of a fertilizer formulation per 100 gallons in final solution are easy to prepare as long as the stock tank size and injection ratio are accounted for. However, before beginning fertilizer calculations, gather the following information:

a. Determine the recommended rate of fertilizer application. Example: 8 ounces per 100 gal or 200 ppm nitrogen.

b. Determine which fertilizer formulation to use and its analysis. Example: 20-10-20.

c. Determine the injection ratio for the injector to be used. Example: 1:100.

d. Determine the size of the stock tank in gallons. Example: 25 gallons.

Also have on hand these "Useful Conversions"

K_2O = 83% actual potassium
P_2O_5 = 44% actual phosphorus
1 gal = 3.78 liters
1 oz = 28.35 grams
1 tablespoon = 3 teaspoons
1 ounce = 3 tablespoons (dry)
1 ounce = 9 teaspoons (dry)
1 pound = 16 ounces (dry)

Table 1. Fertilizer Carrier Sources Commonly used to Formulate Tank Mixes.

Material Name	Analysis(N, P_2O_5, K_2O)
Ammonium Nitrate	33.5-0-0
Ammonium sulfate	21-0-0
Calcium Nitrate	15.5-0-0
Urea	45-0-0
Potassium Nitrate	13-0-44
Potassium chloride	0-0-62
Monoammonium phosphate	12-62-0
Diammonium phosphate	21-53-0

Weight Basis:

Example: Technical literature on chrysanthemum production recommends that a 20-20-20 fertilizer formulation be applied at a final concentration of 16 ounces per 100 gallons of water. How much fertilizer should be mixed in a 25 gallon stock tank if an injector with a 1:30 injection ratio will be used?

Step 1: Adjust the rate for the stock tank size using the following general equation:

Equation 1

$$\frac{\text{oz per 100 gal}}{\text{100 / Stock Tank Size (gal)}} = \text{oz per fertilizer stock tank}$$

$$\frac{\text{16.0 oz per 100 gal}}{\text{100 / 25 gal}} = \underline{\text{4.0 oz 20-20-20 per 25 gal}}$$

Step 2: Adjust the rate for the injection ratio. Because the injector will proportion one gallon of fertilizer concentrate into every 100 gallons of water passing through the water line, the stock solution must be 100 times more concentrate to achieve the desired concentration at the end of the hose as follows:

Equation 2

$$\text{oz per stock tank} \times \text{injection ratio} = \text{oz per stock tank using injector}$$

$$\text{4.0 oz per 25 gal} \times 30 = \underline{\text{120.0 oz per 25 gal using a 1:30 injection ratio}}$$

One problem with recommendations on a weight basis is that the concentration of a specific fertilizer nutrient is not readily provided. Therefore, comparisons between fertilizer recommendations or utilizing different fertilizer formulations for the same recommendation is difficult. For example, which fertilizer solution contains the most nitrogen, one with 6 pounds 20-10-20 per 100 gallons or one with 8 pounds 15-15-15 per 100 gallons? The answer is not readily apparent for the rate given on a weight basis.

Recommendations based on parts per million specify the exact concentration of a specific fertilizer nutrient to apply. Preparing and applying fertilizer on a parts per million basis has one advantage over using a weight basis. Fertilizer preparation based on parts per million takes into account that different fertilizers have different quantities of nitrogen, phosphorus, and potassium. Therefore, 200 ppm nitrogen may be applied using either a 20-10-20 or a 15-15-15 formulation.

Increasingly, fertilizer recommendations found in greenhouse literature are reported on a parts per million basis. However, using parts per million recommendations does present one problem. How many pounds or ounces of a fertilizer must be added to the stock tank at a given injection ratio? The answer to this question involves converting parts per million to a weight per 100 gallon basis, then adjusting the rate for the stock tank size and the injection ratio.

Commercial Fertilizer (ppm)

Example: A greenhouse magazine article recommends the application of 150 ppm nitrogen using a 20-10-20 to Gloxinias. How much fertilizer must be mixed in a 25 gallon stock tank using a 1:100 injector?

Step 1: Convert the ppm recommendation to a weight basis starting with the following equation:

Equation 3:

$$\frac{\text{Desired ppm}}{\text{Percent of fertilizer nutrient} \times 0.75} = \text{oz of Fertilizer per 100 gal}$$

$$\frac{\text{150 ppm}}{20\% \times 0.75} = \underline{\text{10.0 oz 20-10-20 per 100 gal}} \text{ (final solution)}$$

Step 2: Use equation 1 to adjust for a stock tank size of 25 gallons:

$$\frac{\text{10.0 oz per 100 gal}}{\text{100 / 25 gal}} = \underline{\text{2.5 oz 20-10-20 per 25 gal}}$$

Step 3: Use equation 2 to adjust the rate for a 1:100 injection ratio:

2.5 oz per 25 gal × 100 = <u>250.0 oz per 25 gal</u> using a 1:100 injection ratio

Step 4: At this point, it may be more useful to convert ounces to pounds and ounces where:

16 Ounces = 1 pound (dry) ∴ 250.0 oz per 25 gal / 16 oz =

<u>15 lbs 10 oz 20-10-20 per 25 gal for 150 ppm N</u>

It is often of interest at this point to determine how many parts per million of actual phosphorus and potassium will be applied with the 150 ppm N from the 20-10-20. The equation for this is simply an algebraic re-arrangement of equation 3. Use the following procedure:

***Equation 4*:**

oz fertilizer per 100 gal × 0.75 × percent fertilizer nutrient = ppm desired nutrient

Phosphorus: 10.0 oz per 100 gal × 0.75 × 10% P_2O_5 = 75 ppm P_2O_5

For actual phosphorus: P_2O_5 is 44% elemental phosphorus

75 ppm P_2O_5 × 0.44 = <u>33 ppm actual phosphorus</u>

Potassium: 10.0 oz per 100 gal × 0.75 × 20% K_2O = 150 ppm K_2O

For actual potassium: K_2O is 83% elemental potassium

150 ppm K_2O × 0.83 = <u>124.5 ppm actual potassium</u>

Final analysis: **150 ppm N: 33 ppm P: 124.5 ppm K**

Tank Mix:

When combining two or more fertilizer carriers to formulate a tank mix, it is usually easiest to start with a carrier containing two plant nutrients of interest, usually phosphorus or potassium, and perform the calculation for nitrogen last.

<u>Example</u>: A grower wants to prepare a tank mix containing 200 ppm actual nitrogen and 200 ppm actual potassium using calcium nitrate (15.5-0-0) and potassium nitrate (13-0-44). How much of each carrier must be added to a 50 gallon stock tank for delivery through a 1:100 injector?

Start with the potassium nitrate because it contains both nitrogen and potassium. Since potassium nitrate contains 13% actual nitrogen and 44% K_2O, first calculate the amount of potassium nitrate to add to 100 gallons to get 200 ppm <u>actual</u> potassium. However, the 44% is not actual potassium, it is K_2O.

Step 1: Convert 44% K_2O to actual K. K_2O contains 83% actual potassium, therefore:

44% K_2O potassium nitrate × 0.83 = <u>36.52% actual potassium</u>

Step 2: Determine ounces per 100 gallons of potassium nitrate for 200 ppm actual potassium using equation 3.

$$\frac{200 \text{ ppm}}{36.52\% \times 0.75} = \underline{7.3 \text{ oz } 13\text{-}0\text{-}44 \text{ per } 100 \text{ gal}} \text{ (final solution)}$$

Step 3: But wait . . . how much nitrogen was add? Calculate how much nitrogen is being provided by mixing 7.3 ounces of potassium nitrate in 100 gallons of water. This requires using equation 4:

7.3 oz per 100 gal × 0.75 × 13% N = <u>71.175 ppm actual nitrogen</u>

So, a solution containing 7.3 ounces potassium nitrate per 100 gallons is 200 ppm potassium and 71.175 ppm nitrogen. Now adjust the amount of potassium nitrate for the stock tank size and injector ratio.

Step 4: Use equation 1 to adjust for a stock tank size of 50 gallons:

$$\frac{7.3 \text{ oz per } 100 \text{ gal}}{100 / 50 \text{ gal}} = \underline{3.65 \text{ oz } 13\text{-}0\text{-}44 \text{ per } 50 \text{ gal}}$$

Step 5: Use equation 2 to adjust the rate for a 1:100 injection ratio:

$$3.65 \text{ oz per } 50 \text{ gal} \times 100 = \underline{365.0 \text{ oz per } 50 \text{ gal}} \text{ using a } 1{:}100 \text{ injection ratio}$$

Step 6: Convert ounces to pounds and ounces:

$$365.0 \text{ oz per } 50 \text{ gal} / 16 \text{ oz} = \underline{22 \text{ lbs } 13 \text{ oz } 13\text{-}0\text{-}44 \text{ per } 50 \text{ gal for } 200 \text{ ppm K}}$$

Step 7: Calcium nitrate (15.5-0-0) contains 15.5% nitrogen and 200 ppm total nitrogen is required. However, the potassium nitrate supplied 71.175 ppm N. Therefore, subtract 71.175 from 200 and apply equation 3 as follows:

$$\frac{200 - 71.175 \text{ ppm}}{15.5\% \times 0.75} = \underline{11.1 \text{ oz } 15.5\text{-}0\text{-}0 \text{ per } 100 \text{ gal}} \text{ (final solution)}$$

A solution containing 11.1 ounces calcium nitrate and 7.3 ounces potassium nitrate per 100 gallons is 200 ppm nitrogen. Now adjust the amount of calcium nitrate for the stock tank size and injector ratio using equation 2:

Step 8: Use equation 1 to adjust for a stock tank size of 50 gallons:

$$\frac{11.1 \text{ oz per } 100 \text{ gal}}{100 / 50 \text{ gal}} = \underline{5.55 \text{ oz } 15.5\text{-}0\text{-}0 \text{ per } 50 \text{ gal}}$$

Step 9: Use equation 2 to adjust the rate for a 1:100 injection ratio:

$$5.55 \text{ oz per } 50 \text{ gal} \times 100 = \underline{555.0 \text{ oz per } 50 \text{ gal}} \text{ using a } 1{:}100 \text{ injection ratio}$$

Step 10: Convert ounces to pounds and ounces:

$$555.0 \text{ oz per } 50 \text{ gal} / 16 \text{ oz} = \underline{34 \text{ lbs } 11 \text{ oz } 15.5\text{-}0\text{-}0 \text{ per } 50 \text{ gal for } 200 \text{ ppm N}}$$

These calculations indicate that 7.3 ounces potassium nitrate and 11.1 ounces calcium nitrate in 100 gallon of water results in a solution that is 200 ppm nitrogen and 200 ppm potassium. A grower with a 50 gallon stock tank and a 1:100 injector ratio would require 22 pound 13 ounces potassium nitrate and 34 pounds 11 ounces calcium nitrate.

Using the above methodologies, almost any combinations of N-P-K can be calculated and mixed within reasonable concentration ranges and available fertilizer carriers. However, a few tips:

a. Fertilizer carriers containing calcium and those containing phosphorus can form an insoluble precipitate and, therefore do not mix well.

b. Check your calculations, lay them aside and check them later, then have a coworker check your calculations

c. Keep records of fertilizer calculations for future reference. When in doubt....call your Coorpeative Extension Office....We'll be happy to help!