Learn an easy way to calculate the amount of water-soluble fertilizer needed for stock solutions.

By Thomas Boyle

The principal method used for fertilizing greenhouse crops is to apply completely soluble fertilizers with a fertilizer injector (or proportioner). Fertilizer injectors “inject” a small quantity of concentrated fertilizer solution (stock solution) into irrigation water to supply plants with the appropriate concentration of fertilizer. For fertilizer injectors to operate properly, the fertilizers must be completely soluble in water, which means they must not contain precipitates or insoluble material. Completely soluble fertilizers are manufactured from technical-grade fertilizers that are more refined than fertilizer-grade fertilizers, which are used predominantly for field-grown crops.

Previously, many growers formulated their own water-soluble fertilizers by mixing two or more fertilizer salts such as ammonium nitrate, calcium nitrate, potassium nitrate, monoammonium phosphate or diammonium phosphate. Today, most growers purchase bags of pre-mixed, water-soluble fertilizers. Pre-mixed fertilizers typically supply nitrogen, phosphorus, and potassium and include six micronutrients: boron, copper, iron, manganese, molybdenum and zinc. Some pre-mixed fertilizers also contain secondary major elements such as magnesium and/or sulfur. Primarily, three numbers, such as 20-20-20 or 15-16-17, distinguish fertilizers. The first, second and third numbers indicate the percentages of elemental nitrogen, phosphorus in the oxide form and potassium in the oxide form, respectively.

Mixing Stock Solutions

Fertilizer stock solutions are mixed according to the fertilizer injector ratio: each injector will deliver a certain amount of stock solution for each increment of irrigation water that passes through the injector. For example, a 1:100 injector will deliver 100 gals. of diluted fertilizer solution for each gallon of stock solution. The 100 gals. of diluted fertilizer solution is composed of 99 gals. of water plus 1 gal. of stock solution. A 1:200 injector will deliver 200 gals. of diluted fertilizer for each gallon of concentrated stock solution (or 100 gals. of diluted solution per one-half gal. of stock). If both injectors were to deliver 150 ppm of nitrogen from the same fertilizer, the stock solution for the 1:200 injector would have to be twice as concentrated as the one for the 1:100 injector.

Growers need to determine the amount of fertilizer needed to mix stock solutions. Manufacturers of pre-mixed fertilizers and fertilizer injectors provide information sheets to aid in preparing stock solutions. Many fertilizer manufacturers also print this information on the fertilizer bags. Sometimes, however, the information provided does not apply to a particular grower’s situation. For example, the recommendations are limited to the common injector ratios (1:100 and 1:200) or the diluted fertilizer solutions listed are not those that are desired. Without recourse to tables or bags, growers can easily calculate the amount of fertilizer required for preparing stock solutions using the following formula:

\[
\text{Amount of fertilizer to make 1 gal. or liter of stock solution} = \frac{\text{Desired concentration in parts per million} \times \text{Dilution factor}}{\text{Percent of element in fertilizer} \times \text{Conversion constant}}
\]

The dilution factor is the larger number of the fertilizer injector ratio, and the conversion constant is determined by the desired units for the answer (Figure 1, below). Conversion constants are provided for ounces or pounds per gallon. Also, for those brave few that have become familiar with the metric system, a conversion constant is provided for grams of fertilizer per liter of stock.

Calculate Fertilizer Amounts

The formula allows you to calculate the amount of fertilizer needed to mix stock solutions. The advantage of this formula is that it can be used with any injector ratio, any desired concentration of diluted fertilizer solution and all common units of measurement.

**Example 1.** You have an injector with a 1:200 ratio and a fertilizer with an analysis of 17-5-24. You want to apply 150-ppm nitrogen as a constant feed.

1. List all the variables:
   - Desired concentration = 150 ppm
   - Injector ratio = 1:200; dilution factor = 200
   - Fertilizer analysis = 17-5-24 (17-percent nitrogen)
   - Ounces of fertilizer to make 1 gal. of stock solution = X (unknown)
   - Units: ounces per gallon. Use 75 as the conversion constant.

2. Perform calculation:
   \[
   X = \text{150-ppm nitrogen} \times \text{200} = \frac{30,000}{23.53} = \text{roughly 1291 oz. per gal.}
   \]

3. Answer:
   - Add 23 oz. of 17-5-24 to a stock solution bucket and fill to the 1-gal. mark.

**Example 2.** You have an injector set to a 1:128 ratio and a fertilizer with an analysis of 20-9-20. You want to apply 200-ppm nitrogen at each 1-gal. mark.

4. List all the variables:
   - Desired concentration = 200 ppm
   - Injector ratio = 1:128; dilution factor = 128
   - Fertilizer analysis = 20-9-20
   - Ounces of fertilizer to make 1 gal. of stock solution = X (unknown)
   - Units: ounces per gallon. Use 75 as the conversion constant.

5. Perform calculation:
   \[
   X = \text{200-ppm nitrogen} \times \text{128} = \frac{25,600}{23.53} = \text{roughly 1,090 oz. per gal.}
   \]

6. Answer:
   - Add 23 oz. of 20-9-20 to a stock solution bucket and fill to the 1-gal. mark.
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watering. How many ounces of fertilizer would you have to weigh out to make 1 gal. of stock solution?

1. List all the variables:
   - Desired concentration = 200 ppm
   - Injector ratio = 1:128; dilution factor = 128
   - Fertilizer analysis = 20-9-20 (20-percent nitrogen)
   - Ounces of fertilizer to make 1 gal. of stock solution = X (unknown)
   - Units: ounces per gallon. Use 75 as the conversion constant.

2. Perform calculation:
   \[
   X = \frac{200-ppm \text{ nitrogen} \times 128}{20-\text{percent nitrogen} \times 75} = \frac{25,600}{1,500} = 17.07 \text{ or roughly } 17 \text{ oz. per gal.}
   \]

3. Answer:
   - Add 17 oz. of 20-9-20 to a stock solution bucket and fill to the 1-gal. mark.

To Weigh Or Not?

After calculating the amount of fertilizer, a grower will usually weigh out the fertilizer and mix the stock solution. However, weighing fertilizers may be unnecessary in some cases. Since many commercially formulated, water-soluble fertilizers are packaged in 25-lb. bags, it is easy to determine how many gallons of stock solution to mix from a single bag of fertilizer:

1. Convert 25 lbs. to the equivalent number of dry ounces:
   - 25 lbs. per bag \( \times \) 16 oz. per lb. = 400 oz. per bag

2. Using the information in Example 1, we then divide 400 by 23 oz. per gal. to determine the number of gallons of stock we can prepare from one bag of fertilizer:
   - 400 oz. per bag \( \div \) 23 oz. per gal. = 17.02 or roughly 17 gals. per bag

Thus, one 25-lb. bag of 17-5-24 fertilizer will make 17 gals. of stock for a 150-ppm nitrogen solution when using a 1:200 injector. All that is needed is a stock tank with the appropriate capacity and 1-gal. markings.

For the example given above, it is important to remember the final volume of stock solution should be 17 gals., and this means we add the fertilizer first and then sufficient water (warm or hot water works best) to obtain 17 gals. Adding the bag of fertilizer to 17 gals. of water will give us more than 17 gals. of stock solution due to displacement by the fertilizer. The net result is that you’ll end up with a more diluted stock solution than desired if the fertilizer is added to 17 gals. of water.

Example 3. You have an injector with a 1:100 ratio and a fertilizer with an analysis of 15-16-17. You want to apply 300-ppm nitrogen to a crop as a 1-time application. How many pounds of fertilizer would you have to weigh out to make 10 gals. of stock?

1. List all the variables:
   - Desired concentration = 300 ppm
   - Injector ratio = 1:100; dilution factor = 100
   - Fertilizer analysis = 15-16-17 (15-percent nitrogen)
   - Pounds of fertilizer to make 1 gal. of stock solution = X (unknown)
   - Units: pounds per gallon. Use 1,200 as the conversion constant.
   - 10 gals. of concentrate are needed.

2. Perform calculation for 1 gal. of concentrate:
   \[
   X = \frac{300-ppm \text{ nitrogen} \times 100}{15-\text{percent nitrogen} \times 1,200} = \frac{30,000}{18,000} = 1.67 \text{ lbs. per gal.}
   \]

3. Solve the problem for 10 gals. of concentrate:
   - 1.67 lbs. per gal. \( \times \) 10 gals. = 16.7 lbs.

4. Answer:
   - Add 16.7 lbs. of 15-16-17 to a stock solution bucket and fill to the 10-gal. mark.

In Example 3, I used two steps to calculate the number of pounds of fertilizer needed for 10 gals. of stock. With a slight modification to the original formula, we can calculate the amount of fertilizer needed for multiple gallons (or liters) of stock in only one step:

\[
\text{Amount of fertilizer to make the desired volume of stock solution} = \frac{\text{Desired concentration in parts per million} \times \text{Dilution factor}}{\text{Percent of element in fertilizer} \times \text{Conversion constant}}
\]

- Percent of element in fertilizer
- Total gallons or liters

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Example 4. You want to prepare 50 gals. of stock solution using 16-4-12 fertilizer. The injector has a 1:150 ratio, and the desired concentration in the diluted solution is 125-ppm nitrogen. How many pounds of fertilizer would you have to weigh out to make 10 gals. of stock?

1. List all the variables:
   - Desired concentration = 125 ppm
   - Injector ratio = 1:150; dilution factor = 150
   - Fertilizer analysis = 16-4-12 (16-percent nitrogen)
   - Units: pounds per gallon. Use 1,200 as the conversion constant.
   - 50 gals. of stock are needed.
   - Pounds of fertilizer to make 50 gals. of stock = X (unknown)

2. Perform calculation:

   \[ X = \frac{125 \text{ ppm nitrogen} \times 150 \times 50 \text{ gals.}}{16\text{-percent nitrogen} \times 1,200} = 937,500 = 48.8 \text{ lbs. of fertilizer} \]

3. Answer:
   - Add 48.8 lbs. of 16-4-12 to a stock solution tank and fill to the 50-gal. mark.

The Injector Ratio

Like other mechanical devices, fertilizer injectors experience wear over time, so the injector ratio is subject to change. Therefore, it is important to check the injector periodically to determine the current ratio. Knowing the actual injector ratio is necessary to ensure the desired concentration of diluted fertilizer is being delivered to the plants. Injector ratios should be checked once or twice a year. The next example shows how to determine the injector ratio:

Example 5. You have a fertilizer injector but do not know the injector ratio. To determine the ratio, you put the injector dip tube in a “stock” container with exactly 1 qt. (one-fourth gal.) of water. You then turn on the faucet and the “diluted” solution coming out of the hose is collected in a large-volume tank with 1-gal. markings. You turn off the faucet just when the one-fourth gal. of water is emptied from the stock container, and approximately 28 gals. of diluted solution have been collected in the tank. What is the fertilizer injector ratio?

1. List all the variables:
   - One-fourth gal. of “stock” solution yielded 28 gals. of “diluted” solution.
   - Injector ratio is unknown.

2. Set up a proportion, cross-multiply and solve for X:

   \[ \frac{.25\text{-gal. stock}}{1\text{-gal. stock}} = \frac{28\text{ gals. dilute}}{X\text{ gals. dilute}} \]

   \[ .25X = 28 \]

   \[ X = 112 \]

3. Answer:
   - The injector ratio is 1:112.

Summary

With the aid of a calculator, you can easily determine the injector ratio or the correct amount of fertilizer for making stock solutions. Remember, always recheck your calculations to ensure they are correct; errors can be very costly!

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