Hydroponics Systems: Calculating Nutrient Solution Concentrations Using the Two Basic Equations

Calculating the amount of fertilizer to add to nutrient solutions is part of successful hydroponic production. Calculations only use multiplication, division, and subtraction; no advanced math skills are required.

Once you have mastered the general process, making nutrient solutions and adjusting nutrient levels is straightforward.

Hydroponic fertilizer recipes are almost always provided in ppm (in long form: parts per million). This can be different than fertilizer recommendations for vegetable and fruit production in the field, which are generally provided in lb/acre (pounds per acre).

The first thing you will need to do is convert ppm to mg/l (milligrams per liter) using this conversion factor: 1 ppm = 1 mg/l (1 part per million equals 1 milligram per liter). For example, if a recipe calls for 150 ppm nitrogen, what we really want is 150 mg/l or 150 milligrams nitrogen in 1 liter of irrigation water.

Nutrient solution tanks in the United States are usually measured in gal (gallons). When we convert ppm to mg/l, we are working with liters. In order to convert liters to gallons, use the conversion factor of 3.78 l = 1 gal (3.78 liter equals 1 gallon).

Depending on the scale you use to weigh fertilizers, you may find it useful to convert milligrams to grams: 1,000 mg = 1 g (1,000 milligrams equals 1 gram). If your scale measures in pounds, you will want to use this conversion: 1 lb = 454 g (1 pound = 454 grams).

Let's summarize these givens:

- 3.78 l = 1 gal
- 1000 mg = 1 g
- 454 g = 1 lb

Now we have all the givens we need. Let’s look at an example.

How do you determine how much 20-10-20 fertilizer is needed to supply 150 ppm N with a 5-gal stock tank and a fertilizer injector set to a 100:1 concentration?

Start by writing down the concentration you know you want to end up with. In this case, 150 ppm of N or 150 mg N/l.

Let's review the given we have so far:

- 1 ppm = 1 mg/l
- \( P_2O_5 = 43\% \) P
- \( K_2O = 83\% \) K

Nutrient solution tanks in the United States are usually measured in gal (gallons). When we convert ppm to mg/l, we are working with liters. In order to convert liters to gallons, use the conversion factor of 3.78 l = 1 gal (3.78 liter equals 1 gallon).

Depending on the scale you use to weigh fertilizers, you may find it useful to convert milligrams to grams: 1,000 mg = 1 g (1,000 milligrams equals 1 gram). If your scale measures in pounds, you will want to use this conversion: 1 lb = 454 g (1 pound = 454 grams).

Let's summarize these givens:

- 3.78 l = 1 gal
- 1000 mg = 1 g
- 454 g = 1 lb

Now we have all the givens we need. Let’s look at an example.

How do you determine how much 20-10-20 fertilizer is needed to supply 150 ppm N with a 5-gal stock tank and a fertilizer injector set to a 100:1 concentration?

Start by writing down the concentration you know you want to end up with. In this case, 150 ppm of N or 150 mg N/l.

Let’s review the given we have so far:

- 1 ppm = 1 mg/l
- \( P_2O_5 = 43\% \) P
- \( K_2O = 83\% \) K

Nutrient solution tanks in the United States are usually measured in gal (gallons). When we convert ppm to mg/l, we are working with liters. In order to convert liters to gallons, use the conversion factor of 3.78 l = 1 gal (3.78 liter equals 1 gallon).

Depending on the scale you use to weigh fertilizers, you may find it useful to convert milligrams to grams: 1,000 mg = 1 g (1,000 milligrams equals 1 gram). If your scale measures in pounds, you will want to use this conversion: 1 lb = 454 g (1 pound = 454 grams).

Let’s review the given we have so far:

- 3.78 l = 1 gal
- 1000 mg = 1 g
- 454 g = 1 lb

Now we have all the givens we need. Let’s look at an example.

How do you determine how much 20-10-20 fertilizer is needed to supply 150 ppm N with a 5-gal stock tank and a fertilizer injector set to a 100:1 concentration?

Start by writing down the concentration you know you want to end up with. In this case, 150 ppm of N or 150 mg N/l.

Let’s summarize these givens:

- 3.78 l = 1 gal
- 1000 mg = 1 g
- 454 g = 1 lb

Now we have all the givens we need. Let’s look at an example.

How do you determine how much 20-10-20 fertilizer is needed to supply 150 ppm N with a 5-gal stock tank and a fertilizer injector set to a 100:1 concentration?

Start by writing down the concentration you know you want to end up with. In this case, 150 ppm of N or 150 mg N/l.

Let’s review the given we have so far:

- 3.78 l = 1 gal
- 1000 mg = 1 g
- 454 g = 1 lb

Now we have all the givens we need. Let’s look at an example.

How do you determine how much 20-10-20 fertilizer is needed to supply 150 ppm N with a 5-gal stock tank and a fertilizer injector set to a 100:1 concentration?

Start by writing down the concentration you know you want to end up with. In this case, 150 ppm of N or 150 mg N/l.
Note that we are multiplying by 1. This allows you to cancel out the units that are the same in the numerator and denominator. Now we can cancel out "mg N" leaving the units g N/l water.

\[
\frac{150 \text{ mg N}}{1 \text{ l water}} \times \frac{1 \text{ g N}}{1000 \text{ mg N}}
\]

Continue this process by converting liters to gallons.

\[
\frac{150 \text{ mg N}}{1 \text{ l water}} \times \frac{1 \text{ g N}}{1000 \text{ mg N}} \times \frac{3.78 \text{ liter}}{1 \text{ gal water}}\times \frac{100 \text{ g fertilizer}}{20 \text{ g N}}
\]

Now we're left with grams of nitrogen per gallon of water. We are getting closer. Now, let's convert grams of nitrogen to grams of fertilizer. Remember that our fertilizer is a 20-10-20, which means that is has 20% nitrogen. One way to think of this is that 100 grams of fertilizer contains 20 grams of nitrogen.

So, where are we now? We have calculated how many grams of fertilizer are needed in each gallon of irrigation water. Right now, we have a normal strength solution. Our example is asking us to calculate a concentrated solution of 100:1. This means for every 100 gallons of water applied, 1 gallon of stock solution will also be applied through a fertilizer injector. We also know that our stock tank holds 5 gallons.

After canceling everything out we are left with grams of fertilizer. This is how much fertilizer we need to add to our stock tank to apply 150 ppm N with a 100:1 concentration. Multiply and divide and you get the answer 1417.5 grams of fertilizer.

If your scale measures in pounds you'll need to do one more step.

If we are measuring in pounds, we'll need to add 3.12 pounds of fertilizer to our stock tank to apply 150 ppm N with a 100:1 concentration.

You just finished one of the two basic equations. Let's look at the other one.

We just determined that we need to add 1417.5 grams of fertilizer to supply 150 ppm nitrogen using a 100:1 concentration. The fertilizer we used was a 20:10:20. So, in addition to the nitrogen, we are also adding phosphorus and potassium. For the next equation, we'll determine how much phosphorus we are providing. This is basically the first calculation in reverse.

Start off with the amount of fertilizer we are adding to our stock tank. The final units we want are ppm or mg/l. As with the previous calculation, we will use our givens until we end up with these units.

\[
\frac{1417.5 \text{ g fertilizer}}{5 \text{ gal stock}} \times \frac{1 \text{ gal stock}}{100 \text{ gal water}} \times \frac{3.78 \text{ l water}}{1 \text{ gal water}}
\]

Multiply to convert to liters.

\[
\frac{1417.5 \text{ g fertilizer}}{5 \text{ gal stock}} \times \frac{1 \text{ gal stock}}{100 \text{ gal water}} \times \frac{3.78 \text{ l water}}{1 \text{ gal water}}\times \frac{20 \text{ g N}}{100 \text{ g fertilizer}} \times \frac{100 \text{ g fertilizer}}{20 \text{ g P} \text{O}_5} \times \frac{43 \text{ g P}}{100 \text{ g P} \text{O}_5} \times \frac{1000 \text{ mg P}}{1 \text{ g P}}
\]

Lastly, we'll convert grams phosphorus to milligrams phosphorus.

When we calculate this, we determine that we added 32.25 mg/l P or 32.25 ppm P.

This is the second basic equation. We can also use it to determine how much potassium we added.

\[
\frac{1417.5 \text{ g fertilizer}}{5 \text{ gal stock}} \times \frac{1 \text{ gal stock}}{100 \text{ gal water}} \times \frac{3.78 \text{ l water}}{1 \text{ gal water}} \times \frac{20 \text{ g K} \text{O}_3}{100 \text{ g fertilizer}} \times \frac{83 \text{ g K}}{100 \text{ g K} \text{O}_3} \times \frac{1000 \text{ mg K}}{1 \text{ g K}}
\]

We added 124.5 mg/l K or 124.5 ppm K.
With these two basic calculations, you can use any nutrient solution recipe program. You can see how they are used to calculate a recipe in this article: Hydroponics Systems: Using the Two Basic Equations to Calculate a Nutrient Solution Recipe.

Authors

Elsa Sánchez, Ph.D.
Professor of Horticultural Systems Management
ess11@psu.edu
814-863-2433

Robert Berghage, Ph.D.
Associate Professor of Horticulture
rdb4@psu.edu
814-863-2190

Thomas Ford
Extension Educator
tgf2@psu.edu
814-472-7986

Francesco Di Gioia, Ph.D.
Assistant Professor of Vegetable Crop Science
fxd92@psu.edu
814-865-2571

Nick Flax
Extension Educator, Green Industry

extension.psu.edu

Penn State College of Agricultural Sciences research and extension programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

Where trade names appear, no discrimination is intended, and no endorsement by Penn State Extension is implied.

This publication is available in alternative media on request.

Penn State is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to all qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national origin, disability, or protected veteran status.

© The Pennsylvania State University 2022

Code: ART-6470