Grower 101:
Calculations Part III: Fertilizers

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

By Thomas Boyle

By using a formula, you can calculate the amount of fertilizer needed to prepare a stock solution.

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.

Conversion Constants By Measurement Units

Units	Conversion Constant
Ounces of fertilizer per gallon	75
Pounds of fertilizer per gallon	1,200
Grams of fertilizer per liter	10

Figure 1. The conversion constant is determined by the desired units; included are conversion constants for three common units of measurement.

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. 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 = 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:

$$X = \frac{150\text{-ppm nitrogen} \times 200}{17\text{-percent nitrogen} \times 75} = \frac{30{,}000}{1{,}275} = 23.53 \text{ or roughly } 23\tfrac{1}{2} \text{ oz. per gal.}$$

3. Answer:
   - Add 23½ 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 ➧

Grows Like Wild!

You'll finish a 4" pot in just six to eight weeks!

It's all in the breeding: revolutionary Suntory container and bedding plants are actually a unique cross of propagated seed hybrids and a super-vigorous wild strain discovered by Suntory breeders. When you grow Suntory plants, you'll experience a far higher yield and a much shorter time to market. And, retailers love Suntory in their stores because they hold their blooms so much longer than others. All of which means these ultra-performance plants will make your sales grow like wild, too!

Suntory, first in innovation, brings you:

- **The first calibrachoa – now in 21 customer-pleasing colors!**
- **The first vegetative petunia, nierembergia, and viola**
- **The first disease-resistant verbenas**
- **More varieties and brilliant colors to choose from, including 25 new introductions this year!**

THE **SUNTORY** COLLECTION

ASTORIA,™ MILLION BELLS,® SURFINIA,® TEMARI,® ANGEL EARRINGS,® TAPIEN,® SUMMER SPLASH,® GREAT CASCADE,™ PRIMA,™ ILUMINA,™ SUMMER WAVE ® and VIOLINA™

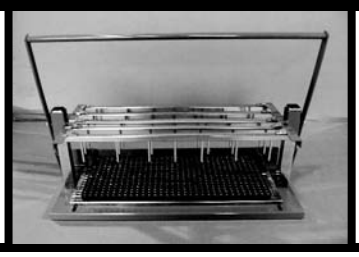
Call for a FREE catalog:
800-877-6737
or visit surfinia.com

Distributed by
Jackson & Perkins
WHOLESALE, INC.

Write in 506

"ECONO POPPER"

- PORTABLE
- UNIVERSAL
- LIGHTWEIGHT
- HAND OPERATED
- ASSEMBLY REQUIRED



ADJUSTS TO FIT VIRTUALLY ANY TRAY

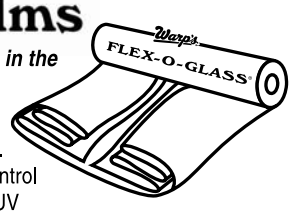
WWW.PLUGPOP.COM

Antal/Cayson Equipment
7474 SE Johnson Creek Blvd • Portland, OR 97206
Toll Free (877) 758-4767 • Local (503) 775-5610

Write in 780

Warp's® FLEX-O-GLASS® Greenhouse Films

The industry's FIRST 4-Year Film. Proven in the field by over 16 years of reliable use.



The FIRST Greenhouse Film with a *proven* FOUR YEAR WARRANTY

Complete 4-Year Product Line.
Standard Widths cut to your Custom Length.
• 4-Year UV Clear • 4-Year Condensate Control
• 4-Year Thermal with C.C. • 4-Year White UV
• 1-Year Clear & White • Over-Winter Clear & White

WARP BROS. • 4647 W. Augusta Blvd. • Chicago, IL 60651 • www.warpbros.com
Pioneers in Plastics • Family Owned Since 1924
Call for the location of the distributor closest to you 1(800) 621-1078 ext. 222

Made in U.S.A.

Write in 782

Joe Theisen, grower/owner of J. Theisen Inc. in Michigan

Joe started using Dyna-Gro Foliage-Pro® and Pro-TeKt® on his poinsettia crop in 2004. Half way through the growing season he commented: "I don't know why everyone is not using this, but I sure don't want my competitors to find out about it."

Switching to Dyna-Gro™ from Peters® :

- **Eliminated salt build up**
- **Reduced fungicide and growth regulator use**
- **Produced stronger, darker green foliage**
- **Greatly reduced shipping damage**
- **His customers were impressed with the quality of his plants**
- **Use of Dyna-Gro Nutrition Solutions cost no more than Peters® but produced better plants**

Call or email us for pricing and samples.

800-DYNA-GRO (396-2476)
info@dyna-gro.com
510-233-0254 • www.dyna-gro.com
1065 Broadway, San Pablo, CA 94806

DYNA-GRO™ The Nutrition Solution®

Write in 716

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:

$$X = \frac{\text{200-ppm nitrogen x 128}}{\text{20-percent nitrogen x 75}} = \frac{\text{25,600}}{\text{1,500}} = \text{17.07 or roughly 17 oz. per gal.}$$

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 x 16 oz. per lb. = 400 oz. per bag**

2. Using the information in Example 1, we then divide 400 by 23½ to determine the number of gallons of stock we can prepare from one bag of fertilizer:
- **400 oz. per bag ÷ 23½ 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:

$$X = \frac{\text{300-ppm nitrogen x 100}}{\text{15-percent nitrogen x 1,200}} = \frac{\text{30,000}}{\text{18,000}} = \text{1.67 lbs. per gal.}$$

3. Solve the problem for 10 gals. of concentrate:
   - 1.67 lbs. per gal. x 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:

$$\textbf{Amount of fertilizer to make the desired volume of stock solution} = \frac{\textbf{Desired concentration in parts per million x Dilution factor x Total gallons or liters}}{\textbf{Percent of element in fertilizer x Conversion constant}}$$

Bugs beware. A new generation insecticide is bagging the most ferocious pests. It's Safari.™ A super-systemic, broad spectrum solution with quick uptake and knockdown, spray or drench. So you get a new level of command over whiteflies, aphids, scale, fungus gnats, leafminers and mealybugs. And since *Safari*'s residual control is unsurpassed, you apply less, and less often. To see the science behind *Safari*, visit valent.com/safari today.

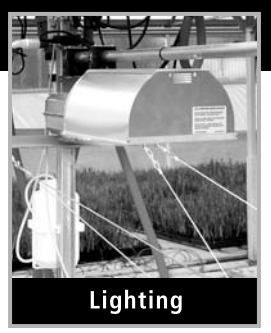
Safari™
INSECTICIDE
Where the wild things aren't.

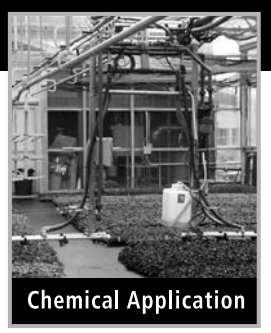
PROFESSIONAL VALENT® PRODUCTS

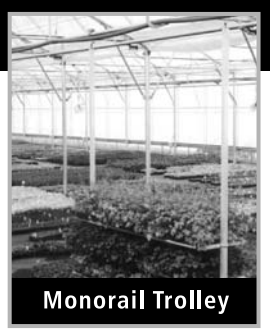
Products That Work, From People Who Care™ | **www.valentpro.com** | 800-89-VALENT (898-2536)
Read and follow the label instructions before using.
Safari and *Products That Work, From People Who Care* are trademarks of Valent U.S.A. Corporation. ©2005 Valent U.S.A. Corporation. All rights reserved. 05P-1077
***Safari* is registered in most states. Check with www.valentpro.com or call 800-89-VALENT (898-2536) for current registration status.**

Write in 520

Water. Food. Light. Space...


Lighting


Chemical Application


Monorail Trolley

...one BOOM that DELIVERS it all.

With an ITS boom, watering is just the beginning. Savvy owners like yourself have increased the value of their ITS systems by using them for spraying, lighting, transport and more.

Monorail Trolley Carts: When space is tight, you'll save time and money by hanging a cart to the ITS overhead rails. The lightweight trolley is easy to assemble and connect, but tough enough to move a dozen flats between bays or connected greenhouses with little vibration.

Chemical Spraying: Whether you're looking for broad coverage or small, specialized applications, you'll get easy, consistent and dependable results by attaching a chemical injector to your ITS Boom System.

Targeted Lighting: The ITS boom is ideal for increasing light to photoperiod-sensitive crops. Lights can be attached to the irrigator to run at night, triggering or delaying blooms as needed. When bench time to market is critical, ITS has it under control.

ITS IRRIGATION SYSTEMS
(866) 868-1238

Solaris GREENHOUSE & IRRIGATION SOLUTIONS
A Division of McConkey Company

Write in 718

management

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:

$$X = \frac{\textit{125-ppm nitrogen x 150 x 50 gals.}}{\textit{16-percent nitrogen x 1,200}} = \frac{\textit{937,500}}{\textit{19,200}} = \textit{48.8 lbs. of fertilizer}$$

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:
   - $\frac{\text{.25-gal. stock}}{\text{28-gals. dilute}} = \frac{\text{1-gal. stock}}{\text{X-gals. dilute}}$
   - .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! GPN

Thomas Boyle is a professor in the Department of Plant, Soil & Insect Sciences at the University of Massachusetts. He can be reached at tboyle@pssci.umass.edu or (413) 545-3586.

LearnMore
For more information related to this article, go to www.gpnmag.com/lm.cfm/gp060609

buy with confidence

GUTTER CONNECT VENLO FREESTANDING COLDFRAME BENCHES HEATING

BUILDING SUPERIOR PRODUCTS • BUILDING SUPERIOR PRODUCTS • SINCE 1986

TOLL FREE 1-888-786-4769

DeCloet can design the best greenhouse to suit your individual needs. We also provides installation, benches, heating, ventilation and complete after sales services. **Buy with confidence; choose DeCloet.**

PREFERRED U.S. DISTRIBUTORS

B.F.G. Supply 1-800-883-0234
IN. OH. PA. E.N.Y. MI. IL. IA. MO. WI. MN. MO.

Williamson Greenhouses 1-800-752-2954 – NC.

DECLOET GREENHOUSE MANUFACTURING LTD.

In an industry as specialized as greenhouse manufacturing experience is everything.

Write in 725