

FERTILIZER CALCULATIONS AND PRACTICE QUESTIONS



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Fertilizer injectors (proportioners) take a concentrated fertilizer solution from the stock tank and add it to the irrigation water. If we have an injector ratio of 1:100, this means 1 gallon of fertilizer concentrate is added to 99 gallons of water. For a 1:100 injector, the fertilizer in the stock tank is 100 times more concentrated than the water that the plants will receive. This means that if a plant receives fertilizer at 200 ppm nitrogen, in the stock tank this will be mixed at 20,000 ppm nitrogen.

Part 1 – Calculations using the fertilizer label

The bags of commercial fertilizer that we use contain a label which specifies how much to use to achieve a given fertilizer concentration. On the table, simply find the column that corresponds to your injector ratio; and the row that corresponds to your target fertilizer concentration.

Ounces of Peters Professional 20-10-20 General Purpose Per Gallon of Concentrate						
Nitrogen ppm N	Injector Ratios* 					E.C.** mmhos/cm
	1:15	1:100	1:128	1:200	1:300	
25	0.35	1.69	2.16	3.38	5.06	0.16
50	0.5	3.38	4.32	6.75	10.13	0.33
75	0.75	5.06	6.48	10.13	15.19	0.49
100	1.0	6.75	8.64	13.50	20.25	0.65
 150	1.5	10.13	12.96	20.25	30.38	0.98
200	2.0	13.50	17.28	27.00	40.50	1.30
300	3.0	20.25	25.92	40.50	60.75	1.95
400	4.0	27.00	34.56	54.00	***	2.60

Question 1a: You wish to apply Peter's 20-10-20 fertilizer at a rate of 150 ppm N. You have a 1:200 injector. How many ounces / gallon of fertilizer concentrate will you need for the stock tank?

From the chart above find the row for 150 ppm N and the column for 1:200 – this shows us that 20.25 ounces per gallon of fertilizer is needed in the stock tank.

Question 1b: Your stock tank holds 5 gallons. So how many ounces of 20-10-20 will you need from question 1a to mix up 5 gallons of concentrated fertilizer?

Since 20.25 ounces per gallon of concentrate are required; and our stock tank holds 5 gallons we will need:

$$20.25 \text{ (oz/gal)} \times 5 \text{ gal} = 101.25 \text{ oz}$$

Question 1c: Given the ounces of fertilizer needed from question 1b. Convert the answer from ounces to grams.

If you are using a scale to weigh in grams, the conversion factor is:

$$1 \text{ ounce} = 28.3 \text{ grams}$$

Equation 1

So we simply multiply our answer from 1b by 28.3 to get the answer:

$$101.25 \text{ oz} \times 28.3 \text{ (g/oz)} = 2,865.4 \text{ g}$$

The fertilizer table also lists the EC (salt reading) that should result from this fertilizer. We can use this to calculate the EC of the water that will reach our plants. By checking this water coming off the end of the hose we can make sure that our stock tank was mixed correctly and our injector is functioning correctly. Remember that the tap water you are using also has some level of salts dissolved in it (for example the salt reading from Cornell water is 0.4 mmhos/cm). You can calculate what the final EC should be of the water hitting your plants from the equation below.

$$\text{final EC} = \text{EC of tap water} + \text{EC of fertilizer}$$

Equation 2

Question 1d: What should be the EC of the water hitting your plants using the fertilizer mix described in questions 1a-c?

You can see from the fertilizer label (above) that our fertilizer EC should be 0.98, so fill this into equation 2:

$$\begin{aligned} \text{final EC} &= 0.4 \text{ (EC of Cornell tapwater)} + 0.98 \text{ (EC of fertilizer)} \\ \text{final EC} &= 1.38 \text{ mmhos/cm (note that: mmhos/cm} = \text{dS/m)} \end{aligned}$$

Part 2 – Calculations using the percentage of a nutrient in the fertilizer

Now let's look at the case where we need to mix a fertilizer that does not have a table to give us the mixing values. When we mix fertilizers we typically have a target in mind in terms of ppm (parts per million) of a particular nutrient. However, fertilizers are usually weighed in ounces and then mixed in stock tanks measured in gallons. Because we are converting from ppm (parts per million) to ounces per gallon we need to use a conversion factor:

$$1 \text{ ounce E} / 100 \text{ gal water} = 75 \text{ ppm} \quad \text{Equation 3}$$

(where E is any soluble element)

In the fertilizers we use, any given element (such as nitrogen or calcium) is only 1 part of the fertilizer, therefore we need to know the percentage it makes up of the fertilizer. In the case of N this is usually quite easy as the fertilizer bag lists the percentage of N-P₂O₅-K₂O (so we know that our bag of 20-10-20 contains 20% nitrogen), for other fertilizers we may need to look up the values from a table, for example: epsom salts (magnesium sulfate or MgSO₄·7H₂O) contains 9.9% Mg and 13% S). Note that the percentage can be represented as a decimal fraction (df), ex: 9.9% → 0.099 and 13% → 0.13. Once we have the decimal fraction we can easily calculate the ounces of fertilizer needed to achieve a target ppm using the following equation:

$$\text{oz fert per gal irrigation water} = \text{target ppm} / (75 \times 100 \times \text{df}) \quad \text{Equation 4}$$

where df = the decimal fraction of the element of interest

Note: the equation calculates ounces per gallon of final irrigation water; to account for the injector we must multiply by the correct proportion (ex: multiply by 100 for a 1:100 injector)

Question 2a: We wish to make up a solution of 30 ppm magnesium using Epsom salts (MgSO₄·7H₂O); how many ounces per gallon of final irrigation water are required; and assuming we are using a 1:200 injector; how many ounces are required per gallon of concentrate in the stock tank.

Using a lookup table we found that Epsom salts contains 9.9% magnesium, so the decimal fraction is 0.099, plug this and the target concentration (30 ppm) into equation 4 and solve:

$$\begin{aligned} \text{oz fert per gal irrigation water} &= 30 \text{ ppm} / (75 \times 100 \times 0.099) \\ &= 30 / (742.5) \\ &= 0.04 \text{ ounces per gallon irrigation water} \end{aligned}$$

Now account for the 1:200 injector:

$$0.04 \text{ oz per gal} \times 200 \text{ (injector proportion)} = 8 \text{ oz per gal stock concentrate}$$

Now let's say we wanted to know how much sulfur was provided by adding 30 ppm magnesium with Epsom salts, we can use a related equation to calculate this, but in this case use the df for sulfur, because that is the nutrient of interest:

$$\text{ppm} = \text{ounces fert per gal irrigation water} \times 75 \times 100 \times \text{df} \quad \text{Equation 5}$$

Question 2b: What ppm of sulfur was provided when Epsom salts was added at the rate of 30 ppm magnesium?

$$\begin{aligned} \text{ppm} &= 0.04 \text{ (oz Epsom salts per gallon)} \times 75 \times 100 \times 0.13 \\ &= 39 \text{ ppm S} \end{aligned}$$

Equation 4 can also be used with fertilizers that contain micronutrients (ex: iron chelate products, etc.) you just have to get the correct percentage for the nutrient of interest and convert to the df (decimal fraction).

Question 2c: We want to apply a 1-time soil drench of 20 ppm Iron (Fe). We will use an iron chelate product (Fe-EDDHA) that contains 6% Iron. How many ounces of the product are required per gallon of irrigation water? How many ounces per gallon of stock concentrate if we are using a 1:200 injector?

To solve, use equation 4, noting that 6% iron \rightarrow 0.06 df

$$\begin{aligned} \text{oz fert per gal irrigation water} &= 20 \text{ ppm} / (75 \times 100 \times 0.06) \\ &= 20 / (450) \\ &= 0.044 \text{ ounces per gallon irrigation water} \end{aligned}$$

Now account for the 1:200 injector:

$$0.044 \text{ oz per gal} \times 200 \text{ (injector proportion)} = 8.9 \text{ oz per gal stock concentrate}$$

Conversion Factors

1 ounce = 28.3 grams

1 gram = 0.035 ounces

to convert from ounces to grams multiply by 28.3

to convert from grams to ounces multiply by 0.035

The three numbers on the fertilizer bag are listed in terms of N-P₂O₅-K₂O

If we want to know the amount of P and K, a conversion is needed

1 ounce of P₂O₅ = 0.44 ounces of P

1 ounce of P = 2.3 ounces of P₂O₅

to convert from P₂O₅ to P multiply by 0.44

For example: 10 ounces of P₂O₅ = 4.4 ounces of P

Similarly, 100 ppm of P₂O₅ = 44 ppm of P

1 ounce of K₂O = 0.83 ounces of K

1 ounce of K = 1.2 ounces of K₂O

to convert from K₂O to K multiply by 0.83

For example: 10 ounces of K₂O = 8.3 ounces of K

Similarly, 100 ppm of K₂O = 83 ppm of K

PRACTICE EXERCISE

Just after morning break the head grower asks to you mix up a fertilizer solution for a crop of patio planter tomatoes.

Here is the information given to you:

- Crop: Tomatoes in 1 gallon pots, in Metro-Mix
- Use Peters Excel All Purpose 21-5-20 fertilizer at **150 ppm nitrogen** with every watering from a 20 gallon concentrate stock tank with a 1:200 injector
- Supplement with calcium nitrate at **100 ppm calcium** (Note that calcium nitrate contains 19% Ca and 15.5% N).

In your excitement to begin, you spilled your coffee over the fertilizer labels, therefore you will not be able to use tables for how much fertilizer to use – instead you will have calculate yourself:

Questions

- 1) Calculate how many ounces of 21-5-20 you will need per 1 gallon of irrigation water (use equation 4).
- 2) Now take into account your injector ratio and size of your stock tank, and calculate how many ounces of 21-5-20 will be required for your 20 gallon stock tank.
- 3) Calculate how many ounces of calcium nitrate you will need per 1 gallon of irrigation water (use equation 4).
- 4) Now taken into account your injector ratio and size of your stock tank; calculate how many ounces of calcium nitrate will be required for the 20 gallon stock tank.
- 5) The calcium nitrate also contains 15.5% N. Calculate how many ppm of N is contained in 100 ppm of calcium from calcium nitrate. (Use equation 5)

ANSWER SHEET

PRACTICE EXERCISE

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Questions

- 1) Calculate how many ounces of 21-5-20 you will need per 1 gallon of irrigation water (use equation 4).

$$\begin{aligned}\text{oz fert per gal irrigation water} &= 150 \text{ ppm} / (75 \times 100 \times 0.21) \\ &= 150 / (1575) \\ &= 0.0952 \text{ oz fert per gallon irrigation water}\end{aligned}$$

- 2) Now take into account your injector ratio and size of your stock tank, and calculate how many ounces of 21-5-20 will be required for your 20 gallon stock tank.

First account for the 1:200 injector, then for the 20 gallon tank

$$\begin{aligned}0.095 \text{ oz per gal} \times 200 \text{ (injector proportion)} &= 19 \text{ oz per gal stock concentrate} \\ 19 \text{ oz per gal stock} \times 20 \text{ gallon tank} &= 380 \text{ oz per 20 gallon stock tank}\end{aligned}$$

- 3) Calculate how many ounces of calcium nitrate you will need per 1 gallon of irrigation water (use equation 4).

$$\begin{aligned}\text{oz fert per gal irrigation water} &= 100 \text{ ppm} / (75 \times 100 \times 0.19) \\ &= 100 / (1425) \\ &= 0.07 \text{ oz per gallon irrigation water}\end{aligned}$$

- 4) Now taken into account your injector ratio and size of your stock tank; calculate how many ounces of calcium nitrate will be required for the 20 gallon stock tank.

First account for the 1:200 injector, then for the 20 gallon tank

$$\begin{aligned}0.07 \text{ oz per gal} \times 200 \text{ (injector proportion)} &= 14 \text{ oz per gal stock concentrate} \\ 14 \text{ oz per gal stock} \times 20 \text{ gallon tank} &= 280 \text{ oz per 20 gallon stock tank}\end{aligned}$$

- 5) The calcium nitrate also contains 15.5% N. Calculate how many ppm of N is contained in 100 ppm of calcium from calcium nitrate. (Use equation 5)

$$\begin{aligned}\text{ppm} &= 0.07 \text{ (oz calcium nitrate per gallon)} \times 75 \times 100 \times 0.155 \\ &= 81.4 \text{ ppm N}\end{aligned}$$