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UF UNIVERSITY of FLORIDA
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HS1200

How to Convert Liquid Fertilizer into Dry Fertilizer in Fertigation for Commercial Vegetable and Fruit Crop Production[1]

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Introduction

Dry and liquid fertilizers are widely used in crop production. In recent years, more and more liquid fertilizers have been used in vegetable and fruit production. Typically, UF/IFAS recommendations are expressed as pounds per acre or kilograms per hectare. Thus, conversion either from a dry fertilizer basis (the UF/IFAS recommendation) to a liquid fertilizer basis, or from a liquid fertilizer source to the UF/IFAS recommended nutrient rate is often required for correct application rate. Thus, the purpose of this publication is to help growers understand the conversion method from liquid to dry fertilizer.

Why can this conversion be tricky?

Dry fertilizer and its active ingredients are both **gravimetric**—in other words, expressed as a **weight per area**. For this type of fertilizer, the calculations are fairly straightforward. For example, 100 pounds of a 10-10-10 fertilizer-grade material contains 10 pounds each of active ingredients nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O), equaling 30 pounds total of active ingredients, while the remaining 70 pounds consist of inactive materials.

Figures 1 through 4 provide examples of fertilizer bags or bottles for either dry or liquid fertilizers.

Liquid fertilizer active ingredients are expressed on a **volumetric** basis. The density of the liquid fertilizer is a key detail because it is impossible to know the weight of a liquid fertilizer before the density is known. Typically, the **net volume** and **net weight** are available on the **liquid fertilizer label** (Figure 3). The liquid **density** can be calculated based on these values. For example, on the Dr. Earth® label (Figure 3), its net volume is 0.946 liters (1 U.S. quart), and its net weight is 1.2 kilograms (2.64 pounds). Therefore, its density is 1.26 kilograms per liter or 10.51 pounds per gallon (2.64 pounds/U.S. quart x 1 gallon/4 quarts/gallon). This source is a 3-3-3 liquid fertilizer. A quart of this liquid fertilizer contains 0.08 pounds (36 grams) each of N, P_2O_5, and K_2O (0.24 pounds or 108 grams of N, P_2O_5, and K_2O in total) and 2.4 pounds (1089 grams) of water or other inactive ingredients.

Liquid fertilizers differ in density. They are related in terms of active ingredients, but the density is NOT always proportional to the total active ingredients. For example,

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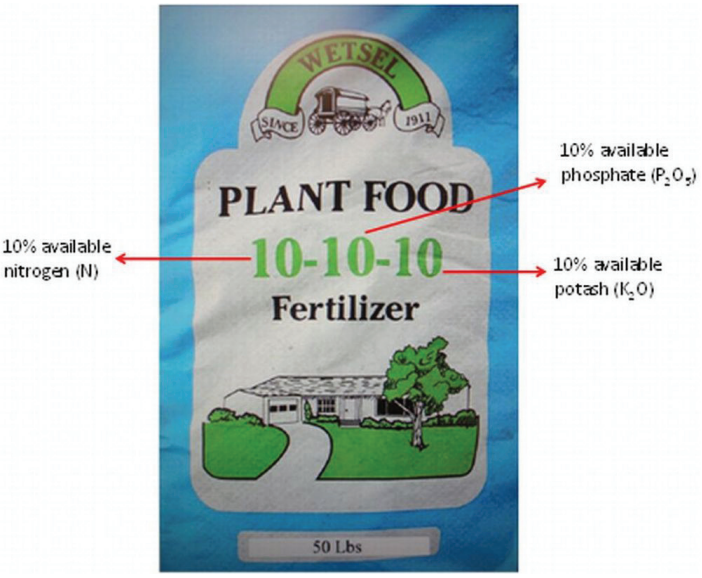

Figure 1. A 10-10-10 dry fertilizer bag label. This 50-pound fertilizer has 5 pounds each of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) active ingredients. Namely, it has 15 pounds of active ingredients and 35 pounds of inactive ingredients.
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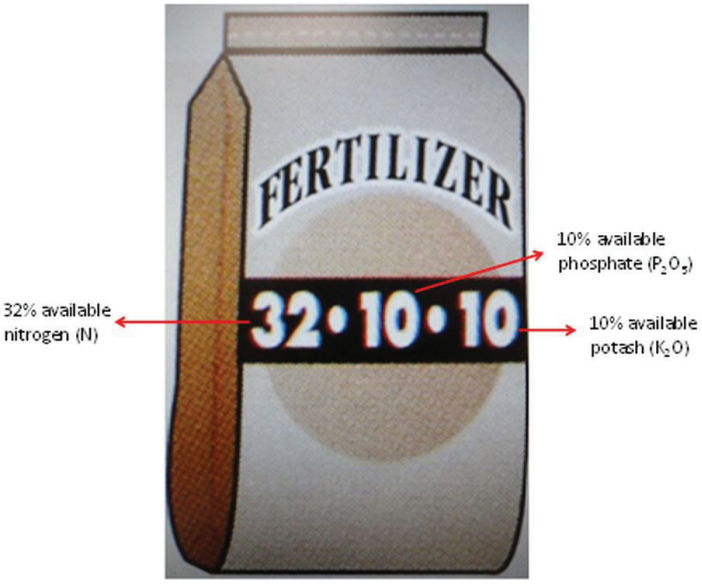

Figure 2. A 32-10-10 dry fertilizer bag label. This 50-pound fertilizer has 16 pounds of nitrogen (N) and 5 pounds each of phosphorus (P_2O_5) and potassium (K_2O) active ingredients. Namely, it has 26 pounds of active ingredients and 24 pounds of inactive ingredients.
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Figure 3. A 3-3-3 liquid fertilizer label. This 1 quart of liquid fertilizer has 0.08 pounds (36 grams) each of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) active ingredients. Namely, it has 0.24 pounds (108 grams) of active ingredients and 2.4 pounds (1092 grams) of water or other inactive ingredients.
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Figure 4. A 4-3-3 liquid fertilizer label. This 1 quart of liquid fertilizer has 0.09 pounds (41 grams) of nitrogen (N) and 0.07 pounds (31 grams) each of phosphorus (P_2O_5) and potassium (K_2O). Namely, it has 0.23 pounds (103 grams) of active ingredients and 2.02 pounds (917 grams) of water or other inactive ingredients.
Credits: Guodong Liu

Dr. Earth® has a lower percentage of active ingredients but greater density than AgGrand®. Dr. Earth® has 9% active ingredients in total (3% each for N, P_2O_5, and K_2O), and its density is 10.51 pounds per gallon (Figure 3). Its total active ingredients per quart are 0.24 pounds. AgGrand® (Figure 4) has a greater percentage (4% + 3% + 3% = 10%) of active ingredients in total but lower density (9.01 pounds per gallon) than Dr. Earth® (10.51 pounds per gallon). Therefore, the former has more active ingredients (0.24 pounds) than the latter (0.23 pounds). This indicates the importance of the density of liquid fertilizers in actual active ingredients. The most common error in conversion from liquid fertilizer to dry fertilizer is neglecting the density. In the above example, if the density of the fertilizers is neglected, crop plants treated with AgGrand® fertilizer may actually be getting less nutrient each of N, P, and K than those treated with Dr. Earth® as the N, P, K source.

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How does one convert liquid fertilizer to dry fertilizer?

To determine how many gallons of a particular liquid fertilizer are needed per acre, use the following equation (Burt, O'Connor, and Ruehr 1995):

$$\frac{lb(nutrient)}{Acre} \times \frac{1Gal(fertilizer)}{?lb(nutrient)} = \frac{Gal(fertilizer)}{Acre}$$

For example, the IFAS recommendation for commercial tomato production in Florida is 200 pounds of N per acre. The injection rate would be 1.5–2.5 pounds per acre per day from 1 through 13 weeks after planting (Olson et al. 2012). For this example, assume 2 pounds per acre per day for a particular fertigation event and 10 acres to fertigate. Then, we need to use 20 pounds of N for the fertigation event. How many gallons of either of the above liquid fertilizers (Dr. Earth® or AgGrand®) are needed to supply 20 pounds of N to 10 acres?

(1) The 3-3-3 (Dr. Earth®) liquid fertilizer (fertilizer density: 10.51 pounds per gallon):

$$\frac{20lb(N)}{10(acre)} \times \frac{Dr\_Earth}{3\%(N)} = \frac{666.7lb(Dr\_Earth)}{10(acre)}$$

$$\frac{666.7lb(Dr\_Earth)}{10(acre)} \times \frac{1Gal(Dr\_Earth)}{10.51lb} = \frac{63.43Gal(Dr\_Earth)}{10(acre)}$$

(2) The 4-3-3 (AgGrand®) liquid fertilizer (fertilizer density: 9.01 pounds per gallon):

$$\frac{20lb(N)}{10(acre)} \times \frac{AgGrand}{4\%(N)} = \frac{500lb(AgGrand)}{10(acre)}$$

$$\frac{500lb(AgGrand)}{10(acre)} \times \frac{1Gal(AgGrand)}{9.01lb} = \frac{55.5Gal(AgGrand)}{10(acre)}$$

AgGrand® has a greater N percentage than Dr. Earth®, so fewer gallons are needed to meet the 20 pounds of N requirement. Table 1 shows the calculation details for different acreage.

How many gallons of either of the above liquid fertilizers are needed to supply 20 pounds of P_2O_5 per 10 acres of tomato?

(1) The 3-3-3 (Dr. Earth®) liquid fertilizer (fertilizer density: 10.51 pounds per gallon):

$$\frac{666.7lb(Dr\_Earth)}{10(acre)} \times \frac{1Gal(Dr\_Earth)}{10.51lb} = \frac{63.43Gal(Dr\_Earth)}{10(acre)}$$

$$\frac{20lb(P_2O_5)}{10(acre)} \times \frac{Dr\_Earth}{3\%(P_2O_5)} = \frac{666.7lb(Dr\_Earth)}{10(acre)}$$

(2) The 4-3-3 (AgGrand®) liquid fertilizer (fertilizer density: 9.01 pounds per gallon):

$$\frac{20lb(P_2O_5)}{10(acre)} \times \frac{AgGrand}{3\%(P_2O_5)} = \frac{666.7lb(AgGrand)}{10(acre)}$$

$$\frac{666.7lb(AgGrand)}{10(acre)} \times \frac{1Gal(AgGrand)}{9.01lb} = \frac{74Gal(AgGrand)}{10(acre)}$$

Both Dr. Earth® and AgGrand® have the same percentage of P_2O_5, but the former's liquid source has greater density, so fewer gallons are needed to supply 20 pounds P_2O_5 per 10 acres. Table 2 shows the calculation details for different scales of fertigation events.

For conversion factors of different units, such as from gallon to quart, from kilogram to pound, and from acre to hectare, please see *Conversion Factors* (http://edis.ifas.ufl.edu/ag126).

Take-home message

1. Dry fertilizer and its active ingredients are both **gravimetric**—in other words, expressed as a weight per area.
2. Liquid fertilizer and its active ingredients are expressed on a **volumetric** basis and expressed as a volume per area.
3. The key point for the conversion from liquid to dry fertilizer is the density of the liquid fertilizer.
4. The greater the density of a liquid fertilizer, the more active ingredient volume. However, the active ingredients of a liquid fertilizer are NOT linearly proportional to the fertilizer's density.
5. To avoid any errors, the conversion calculation from liquid to dry fertilizer must include the liquid fertilizer's density and active ingredient content.

References

Burt, C. M., K. O'Connor, and T. A. Ruehr. 1995. *Fertigation.* San Luis Obispo: Irrigation Training & Research Center.

Olson, S. M., P. J. Dittmar, G. E. Vallad, S. E. Webb, S. A. Smith, E. J. McAvoy, B. M. Santos, and M. Ozores-Hampton. 2012. *Potato Production in Florida.* HS739. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/cv137.

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Table 1. Calculations of liquid nitrogen fertilizer requirement for different fertigation scales and fertilizers with various fertilizer densities

Area fertigated	N requirement	Total N requirement	Fertilizer N content	Fertilizer requirement	Fertilizer density	Total fertilizer needed
(acre)	(lb/acre/event)	(lb/event)	(%)	(lb)	(lb/gal)	(gal/event)
Fertilizer: Dr. Earth® (3-3-3, fertilizer density: 10.51/gal)						
1	2	2	3	66.7	10.51	6.3
2	2	4	3	133.3	10.51	12.7
3	2	6	3	200.0	10.51	19.0
4	2	8	3	266.7	10.51	25.4
5	2	10	3	333.3	10.51	31.7
6	2	12	3	400.0	10.51	38.1
7	2	14	3	466.7	10.51	44.4
8	2	16	3	533.3	10.51	50.7
9	2	18	3	600.0	10.51	57.1
10	2	20	3	666.7	10.51	63.4
Fertilizer: AgGrand® (4-3-3, fertilizer density: 9.01 lb/gal)						
1	2	2	4	50.0	9.01	5.5
2	2	4	4	100.0	9.01	11.1
3	2	6	4	150.0	9.01	16.6
4	2	8	4	200.0	9.01	22.2
5	2	10	4	250.0	9.01	27.7
6	2	12	4	300.0	9.01	33.3
7	2	14	4	350.0	9.01	38.8
8	2	16	4	400.0	9.01	44.4
9	2	18	4	450.0	9.01	49.9
10	2	20	4	500.0	9.01	55.5

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Table 2. Calculations of liquid phosphate fertilizer requirement for different fertigation scales and fertilizers with various fertilizer densities

Area fertigated	P requirement	Total P requirement	Fertilizer P content	Fertilizer requirement	Fertilizer density	Total fertilizer needed
(acre)	(lb/acre/event)	(lb/event)	(%)	(lb)	(lb/gal)	(gal/event)
Fertilizer: Dr. Earth® (3-3-3, fertilizer density: 10.51/gal)						
1	2	2	3	66.7	10.51	6.3
2	2	4	3	133.3	10.51	12.7
3	2	6	3	200.0	10.51	19.0
4	2	8	3	266.7	10.51	25.4
5	2	10	3	333.3	10.51	31.7
6	2	12	3	400.0	10.51	38.1
7	2	14	3	466.7	10.51	44.4
8	2	16	3	533.3	10.51	50.7
9	2	18	3	600.0	10.51	57.1
10	2	20	3	666.7	10.51	63.4
Fertilizer: AgGrand® (4-3-3, fertilizer density: 9.01 lb/gal)						
1	2	2	3	66.7	9.01	7.4
2	2	4	3	133.3	9.01	14.8
3	2	6	3	200.0	9.01	22.2
4	2	8	3	266.7	9.01	29.6
5	2	10	3	333.3	9.01	37.0
6	2	12	3	400.0	9.01	44.4
7	2	14	3	466.7	9.01	51.8
8	2	16	3	533.3	9.01	59.2
9	2	18	3	600.0	9.01	66.6
10	2	20	3	666.7	9.01	74.0