INSIGHTS
International Plant Nutrition Institute

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Math Anxiety: Fertilizer Calculations

YOU MAY KNOW people who suffer from math anxiety. They avoid situations where mathematics and calculations are required. However, avoiding math is simply not an option when working with agriculture. The International Plant Nutrition Institute (IPNI)... in cooperation with university specialists...has recently published a "how-to" workbook that presents commonly used mathematical concepts in agriculture. It begins with simple arithmetic and advances all the way to complex modeling. More details are available at the end of this newsletter.

Most of us do not use sophisticated math on a regular basis, but a review of commonly performed calculations will be the subject of this and future *INSIGHTS*. We'll start with some of common calculations that are made when dealing with fertilizers.

Fertilizer Notation

Commercial fertilizers are required to show on their label the minimum percentage of nutrients that the manufacturer guarantees to be present. The chemical analysis is composed of at least three numbers separated by dashes. The first number indicates the percent N, the second number indicates the percent P as P_2O_5, and the third number shows the percent K as K_2O based on weight.

The nutrient content of the fertilizer is indicated by these three numbers, but the tradition of using the oxide form of P and K can be a bit confusing and is set in fertilizer law. From the percent N value on the label, it is not obvious if the N is present as nitrate, ammonium, or urea. Similarly, the P in most commercial fertilizers is chemically present as phosphate (PO_4), but this number is mathematically converted to P_2O_5 equivalents for display on the fertilizer label. Potassium fertilizers are never present as K_2O, but the K present in the fertilizer is mathematically converted to reflect this chemical equivalent.

These conversions are done by comparing the ratios of molecular weight between them.

Converting K to K_2O; K_2O to K:	
K = 39 g/mole K_2O = 94 g/mole	(39 + 39)/94 = 0.83 lb K/ lb K_2O 94/(39 + 39) = 1.21 lb K_2O/ lb K
Converting P to P_2O_5; P_2O_5 to P:	
P = 31 g/mole P_2O_5 = 142 g/mole	(31+ 31)/142 = 0.44 lb P/lb P_2O_5 142/(31 + 31) = 2.29 lb P_2O_5/lb P

Some common questions regarding solid fertilizers can be answered with relatively simple math. Here are a few examples.

How much actual N, P, and K are contained in 200 lb of 10-20-10 fertilizer?	
10% N x 200 lb = 20 lb N	
20% P_2O_5 x 200 lb = 40 lb P_2O_5	40 lb P_2O_5 x 0.44 = 17.6 lb P
10% K_2O x 200 lb = 20 lb K_2O	20 lb K_2O x 0.83 = 16.6 lb K

How much fertilizer is required to replace the nutrients removed in 5 tons of switchgrass?
One ton of harvested switchgrass removes 22 lb N, 5 lb P, and 48 lb K
Nitrogen:
22 lb N/ton x 5 ton = 110 lb N removed
Phosphorus:
5 lb P/ton x 5 ton = 25 lb P → then convert P to P_2O_5 → 25 lb P x 2.29 lb P_2O_5 /lb P = 57 lb P_2O_5
Potassium:
48 lb K/ton x 5 ton = 240 lb K → then convert K to K_2O → 240 lb K x 1.21 lb K_2O/lb K = 290 lb K_2O

What is the nutrient content of a blend of 50 lb of 11-52-0 (MAP) and 50 lb 13-0-44 (KNO_3)?
In the final blend, the 50 lb of MAP will contribute 5.5 lb N and 26 lb P_2O_5. The 50 lb of KNO_3 will contribute 6.5 lb N and 22 lb K_2O.
The final 100 lb blend will contain 12 lb N, 26 lb P_2O_5 and 22 lb K_2O.
The composition of the fertilizer blend will be 12-26-22.

How much fertilizer material is needed for a 50 lb N/A preplant application on 6 acres using urea as the N source? (Fertilizer analysis for urea is 46-0-0).
50 lb N/A x 6 A x 1 lb urea/0.46 lb N = 652 lb urea required for the 6 acres

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Abbreviations and Notes: N = nitrogen; P = phosphorus, K = potassium.

Liquid Fertilizers

Liquid fertilizers are labeled based on the nutrient content in 100 lb of material. These values are calculated the same as with dry fertilizers. However, fluid fertilizers are commonly applied based on their volume (gallons of material) instead of their weight. Converting from a weight of liquid (pounds or tons) to a volume (gallons) requires knowledge of the liquid density. **Density is defined as the mass of material divided by the volume.**

For example, if a 5 gal bucket of fluid fertilizer weighs 60 lb, the density is 60 lb/5 gal = 12 lb/gal. It is important to precisely measure both the volume of the container and the weight of the added fertilizer (without including the weight of the container).

A complicating factor in determining fertilizer density is that most liquids become more dense in cold temperatures and less dense (expand) in warm temperatures. Luckily, these differences are relatively minor at the temperature range of most agronomic operations.

How many pounds of N, P_2O_5, and K_2O in 200 gal of ammonium polyphosphate (10-34-0) fluid fertilizer? (use a density of 11.65 lb/gal)
200 gal x 11.65 lb/gal = 2,330 lb fertilizer
2,330 lb x 10% N = 233 lb N
2,330 lb x 34% P_2O_5 = 792 lb P_2O_5 ; No K_2O present.

How much N is present in 250 gal of UAN liquid fertilizer (32-0-0) at 40 °F compared to 80 °F?
Note: the density is 11.12 lb/gal at 40 °F and 10.99 lb/gal at 80 °F.
40 °F: 250 gal x 11.12 lb/gal = 2,780 lb; 2,780 lb x 32% N = 890 lb N
80 °F: 250 gal x 10.99 lb/gal = 2,747.5 lb; 2,747.5 lb x 32% N = 880 lb N
(This 32.5 lb change in the weight of UAN represents a 1% change in density when the temperature is corrected.)

The density of a liquid is measured by floating a hydrometer in the material. This instrument provides a measurement of "specific gravity", which is the ratio of the fertilizer density and water density. Once the temperature-corrected density of water is known, the density of the fluid fertilizer can be calculated. There are also published tables available that show these density coefficients for various fluid fertilizers.

How many pounds of K_2O are present in 1 ton of liquid potassium thiosulfate (0-0-25)? How many gallons? (use a density of 12.2 lb/gal)
1. One ton of liquid is 2,000 lb; 2,000 x 25% K_2O = 500 lb K_2O
2. 2,000 lb x 1 gal/12.2 lb = 164 gal

How much fertilizer should I apply?

To determine the amount of dry fertilizer to apply, the nutrient recommendation (usually given in lb/A) and the nutrient content of the fertilizer must be known.

How much DAP fertilizer (18-46-0) should be added for a fertilizer recommendation of 70 lb P_2O_5/A?
70 lb P_2O_5 x 100 lb DAP/46 lb P_2O_5 = 152 lb DAP
Since DAP contains 18% N, the 152 lb DAP will also provide 27 lb N (152 x 0.18)

Calculating the quantity of fluid fertilizer to apply may require an additional step to convert the weight of the fertilizer to gallons of product delivered to the field.

How many gallons of UAN (28-0-0) are required to supply 150 lb N? (use a density of 10.7 lb/gal)
1. 150 lb N x 1 lb UAN/0.28 lb N = 536 lb UAN
2. 536 lb UAN x 1 gal/10.7 lb = 50 gal

How much does it cost?

Fertilizer prices are usually provided in costs per ton (2,000 lb) of material. Fertilizer prices are occasionally given in price per pound of N, P_2O_5, or K_2O and not as a specific fertilizer product. The "per pound" terminology is sometimes referred to as a "unit". Without close attention, this difference in pricing and terminology can be confusing.

If N fertilizer is sold at \$0.65/lb, what is the price per ton of urea (46-0-0)? What is the price per ton of ammonium sulfate (AS, 21-0-0-24)?
1. \$0.65/lb N x 0.46 lb N/ lb urea = \$0.30/lb urea \$0.30/lb urea x 2,000 lb/ton = \$600/ton
2. \$0.65/lb N x 0.21 lb N/lb AS = \$0.14/lb AS \$0.14/lb AS x 2,000 lb/ton = \$280/ton

What is the price of a pound of N if a ton of UAN (32-0-0) costs \$500? What is the cost of N in one gal of UAN? (use a density of 11 lb/gal)
1. 2,000 lb UAN x 0.32 lb N/lb UAN = 640 lb N → \$500/640 lb N = \$0.78/lb N
2. 2,000 lb UAN x 1 gal/11 lb = 181.8 gal → 640 lb N/181.8 gal = 3.5 lb N/gal 3.5 lb N/gal x \$0.78/lb N = \$2.73/gal