MATH 110 Landscape Horticulture Worksheet #5

Ratios and Percentages

All fertilizers have three numbers on the label, which indicate the fertilizer analysis, or "percentage by weight" of **nitrogen**, **phosphate** (P_2O_5) and **potash** (K_2O), always in that order. In the picture to the left, the bag of lawn fertilizer has 25% nitrogen (N), 5% phosphate, and 5% potash. P is the symbol for the element phosphorous, and K is the symbol for the element potassium, and O is the symbol for the element oxygen.

Nitrogen (N) is the main nutrient for new, green growth. Plants that are almost all leaf (such as lawn grasses) need plenty of nitrogen, so the first number is especially high in fertilizers for lawns because grass must continuously renew itself after mowing. The higher the number, the more nitrogen the fertilizer provides.

Phosphate (P_2O_5) Contains phosphorous, which promotes root development, which helps strengthen plants. It also increases blooms on flowers. Lots of phosphorous is great for bulbs, fruit development, perennials, and newly planted trees and shrubs. They depend on strong roots, so fertilizers meant for these plants often have high middle numbers.

Potash (K_2O) Contains potassium, which improves the overall health of plants. It helps them withstand very hot or cold weather and defend against diseases. Most soils already have some potassium, so the third number in the fertilizer analysis is usually smaller than the other two. Fertilizers for some tropical plants, especially palms, contain extra potassium because these plants have a special need for it. Fertilizers meant for fall, such as *Winterizer*, also contain extra potassium to help prepare plants for cold weather.

Other nutrients are often found in fertilizer, but usually not in as large amounts as nitrogen, phosphate and potash (sometimes referred to as N, P, and K). These nutrients can include calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe) and other trace elements.

The three numbers for fertilizers form *ratios* which indicate the relative amounts of the nutrients to each other. In our picture above, the 25-5-5 lawn fertilizer would have a 5-1-1 ratio (I got this ratio by dividing each number by 5). That is, there is a 5:1 ratio of nitrogen to phosphate (there is 5 times as much nitrogen as phosphate) and a 5:1 ratio of nitrogen to potash and a 1:1 ratio of phosphate to potash (they have the same amounts in the bag).

Ratios can be helpful when looking for the "right mix" for a certain type of plant or situation. For example, vegetable gardens often call for a 1-2-1 ratio. But you probably won't find a bag of fertilizer

with those three numbers on it. But you can probably find a bag of fertilizer which has a ratio of 5-10-5 or 10-20-10. These bags have the nutrients in the same ratio. The smaller numbers just mean that fertilizer is less concentrated than the bag with the bigger numbers. That means those with larger numbers on the label could be applied at lower amounts to yield the same results. In other words, 5 lbs of a 20-20-20 fertilizer would yield the same amount of actual nutrients as 10 lbs of a 10-10-10 fertilizer.

The advantage of a bag of fertilizer with the larger numbers is comes largely in transportation and storage costs savings: A smaller bag of more concentrated fertilizer takes up less space and is easier to carry around than a bigger bag with the same ratio (but smaller numbers).

Most trees like a 2-1-1 ratio, which would be a fertilizer product such as 10-5-5 or 20-10-10. Many lawns prefer a 3-1-2 ratio fertilizer, so a fertilizer product with 30-10-20 on the label would be a good ratio match. But to really tell how much fertilizer you might need for a particular job you should test the soil (that's another topic you'll learn about in another class).

Example 1: For the photo to the right (a 40 pound bag of lawn fertilizer), what is the weight of nitrogen, phosphate and potash in the bag?

There is 12% nitrogen, 12% phosphate, 12% potash in this bag (the rest of the bag is some kind of filler like sand or granular limestone). You first need to convert 12% into decimal form. To do that, move the decimal place over two spaces to the *left*. The decimal point for the percentage number is often not shown, but it is really there. In other words, we usually don't bother including the decimal place for a percentage like 12% (We don't write 12.%) But you can pretend it is there and move that decimal over two places to the left. We can therefore write 12% as 0.12 and then 12% of 40 pounds is

(0.12)x(40 pounds) = 4.8 pounds. So there are 4.8 pounds of nitrogen, 4.8 pounds of phosphate, and 4.8 pounds of potash.

Example 2: Say you have purchased a 50-lb bag of 8-0-24 fertilizer. (a) Calculate the weight of the three nutrients, nitrogen, phosphate and potash. (b) How many pounds of filler are in the bag?

There is 8% nitrogen: (0.08)x(50 lb) = 4 lbs nitrogen.

There is 0% phosphate, so there is 0 pounds of phosphorous.

There is 24% potash: (0.24)x(50 lb) = 12 lbs of potassium.

That is a total of 16 pounds of nutrients, so there must be 50 lb – 16 lb = 34 pounds of filler in the bag.

Example 3: A soil test on a lawn comes back with the recommendation that the lawn receive fertilizer in a 3-1-2 ratio. Your local home garden store only has the following fertilizers: 9-3-5, 12-4-4, 21-14-14, 21-7-9, 27-9-18 and 24-16-8. Which fertilizer should you buy?

You need to compare the ratio of the three numbers for each fertilizer. To do that, first try to reduce the numbers down by dividing out common factors from each number:

9-3-5: Dividing each number by 3 gives 3-1-1.67. This is close but not quite 3-2-1.

12-4-4: Dividing each number by 4 gives 3-1-1. Not quite the right ratio.

21-14-14: Dividing each number by 7 gives 3-2-2. Not quite the right ratio.

21-7-9: Dividing each number by 7 gives 3-1-1.29. Not quite the right ratio.

27-9-18: Dividing each number by 9 gives 3-1-2. **That's the one to buy!**

24-16-8: Dividing each number by 8 gives 3-2-1. Not quite the right ratio.

Example 4: A 20-5-10 fertilizer contains 20 percent nitrogen. How much of this fertilizer should be applied to a lawn area of 4000 square feet if the recommendation from a soil test is for 1 pound of nitrogen per 1,000 square feet?

Since 1/5 of the fertilizer is nitrogen (20% = 1/5), for every 1 lb of nitrogen you need to apply 5 pounds of fertilizer. Since 1 lb of nitrogen is needed for each 1000 square feet, this 4000 square foot lawn then needs

$$(4000\,\cancel{\text{sq ft}})\,x\left(\frac{5\text{ lbs fertilizer}}{1000\,\cancel{\text{sq ft}}}\right)$$ = 20 pounds of fertilizer is needed for this job.

Example 5: If it you were to use a 10-4-6 fertilizer with the same 1 pound of nitrogen per 1,000 square feet recommendation, then how much fertilizer should you apply to the same lawn as in example 4?

This fertilizer has 10% nitrogen, or 1/10 of the fertilizer is nitrogen. That means if you apply 10 lbs of fertilizer, 1 pound will be nitrogen. So a 4000 sq.ft. lawn needs

$$(4000\,\cancel{\text{sq ft}})\,x\left(\frac{10\text{ lbs fertilizer}}{1000\,\cancel{\text{sq ft}}}\right)$$ = 40 pounds of fertilizer. This should have been easy to see without doing the math: Since this fertilizer contains half as much nitrogen (10%) as the fertilizer in the previous example (20%), you have to apply twice as much to get the same amount of nitrogen into the soil.

Example 6: Determine how much it will cost to fertilize an area that is 200 ft. long and 90 ft. wide at a rate of 1 pound of nitrogen per 1,000 square feet. Each bag of 30-12-18 fertilizer weighs 50 pounds and costs $10.00.

The fertilizer contains 30% nitrogen. That means a 50 lb bag of fertilizer contains (0.30)x(50 lbs) = 15 lbs of nitrogen. Since 1 lb of nitrogen is needed for each 1000 sq. ft. of lawn, each bag of fertilizer can cover 15,000 sq.ft. of land. The area of the plot of land is (200 ft)x(90 ft) = 18,000 square feet. So you will have to buy two bags of fertilizer, costing you $20. The amount of the fertilizer *used* can be found by forming the ratio of the area of the plot of land to the area that a single bag will cover.

$$\left(\frac{18{,}000\ \text{sq ft}}{15{,}000\ \frac{\text{sq ft}}{\text{bag}}}\right) = 1.2\ \text{bags}$$ of fertilizer are needed for this job, leaving you with 8/10th of a bag leftover. To get the cost of the actual fertilizer *used*, $\left(\frac{\$10}{\text{bag}}\right)\text{x}(1.2\ \text{bags})$ = $12.

Example 7: How much of a 5-3-4 organic fertilizer do you need to get the same amount of phosphate as if you were using 15 pounds of a 15-10-10 chemical fertilizer?

5-3-4 fertilizer has 3% phosphate.15-10-10 fertilizer has 10% phosphate and therefore (15 lbs) x (0.10) = 1.5 lbs of phosphate are in 15 lbs of that 15-10-10 fertilizer. We can write an equation that we can solve to find the amount of 5-3-4 fertilizer needed:

(0.03)x(Z lbs of 5-3-4) = (1.5 lbs of phosphate in 15 lbs of 15-10-10) In words this equation says 3 percent of the unknown amount Z of 5-3-4 equals the 1.5 pounds of 15-10-10. You can solve for the unknown number of lbs of 5-3-4 by dividing both sides of the equation by 0.03. You get

$$\left(\frac{0.03}{0.03}\right)\text{x}(Z) = \left(\frac{1.5\ \text{lbs of phosphate in 15 lbs of } 15-10-10}{0.03}\right)$$

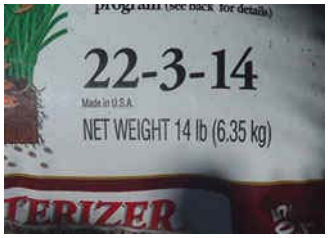
This leaves us

$$Z = \left(\frac{1.5\ \text{lbs of phosphate in 15 lbs of } 15-10-10}{0.03}\right) =$$ 50 lbs of organic 5-3-4 fertilizer are needed to get the same phosphate as 15 lbs of 15-10-10 fertilizer. Note that you could have also just formed the ratio of the phosphate numbers → 10:3 or

$\frac{10}{3} = 3.333$. So there is 3.333 times as much phosphate in the 15-10-10 fertilizer as in the same amount of 5-3-4 fertilizer. So if you needed 15 lbs of 15-10-10, you would need (15 lbs)x(3.333) = 50 lbs of 5-3-4 to get the same amount of phosphate. Which method you use is up to you.

Homework Problems

1. For the fertilizer shown in the photo below, how many pounds of nitrogen, phosphate and potash are there? How many pounds of filler are there?



2. A bag of fertilizer at *Home Depot* is labeled: 4-lb bag *Scotts* 20-27-5 Starter Fertilizer 5,000 Sq. Ft. $12.98 each. You just resodded your lawn and the salesman at Home Depot says this is the fertilizer your new lawn needs. Your lawn is 7400 sq. ft. and you plan on fertilizing it twice this year. How many bags should you buy for the year?

3. In the past you fertilized your lawn every spring with 6 pounds of 36-6-6. You could only find 18-3-3 at the store this spring. How many pounds of 18-3-3 should you use on your lawn to get the same results?

4. How much of a 2-2-4 organic fertilizer do you need to get the same amount of potash as if you were using 18 pounds of a 15-10-12 chemical fertilizer?

5. A soil test on a large flowerbed comes back with the recommendation that it receive fertilizer in a 3-2-4 ratio. Your local home garden store only has the following fertilizers: 12-6-18, 12-8-14, 21-14-28, 21-9-13, 27-18-32 and 24-16-32. Which of these fertilizers could you buy?

6. Knowing how much nitrogen is in a bag of fertilizer is fairly easy. The percentage is listed right on the bag. To determine the actual amount of the element phosphorus (P) that is in phosphate (P_2O_5) and how much the element potassium (K) is in potash (K_2O) you have to do a little math. Use these formulas: 44% of P_2O_5 is phosphorous, and 83% of K_2O is potassium. If you have a 50 lb bag of 20-5-10 fertilizer, how many pounds of nitrogen, phosphorus and potassium are there in the bag?

7. The putting greens on a 9-hole golf course total 14,500 sq ft. The bag of fertilizer shown below is 40 pounds. If you need to apply nitrogen to the greens at a rate a 1 pound of nitrogen per 1000 sq. ft., how many bags of this fertilizer should you buy?

8. A plot of land in South Florida is 100 ft wide and is 250 ft long. The 250 ft length lies along a canal that eventually drains into the Everglades. Knowing that runoff of phosphate-rich fertilizer is a major source of groundwater pollution, you decide to not spread the fertilizer within 10 ft of the water (your spreader has a deflector shield that keeps the spread pattern semicircular.) Using a 20-2-6 slow release fertilizer at a rate of 1 lb nitrogen per 1000 sq.ft., how many pounds of fertilizer do you need to do the job?

9. A homeowner buys a bag of fertilizer with a label that says to apply 2 lb of the packaged product per 1000 ft^2 of surface area. If the area of the homeowner's lawn to be treated totals 1875 ft^2, how much product will the homeowner need to apply?

10. A gardener applies a dry 20-10-20 fertilizer to her flowerbeds, using 2 pounds of potash per 1000 square feet, 2 times a year. If a 50 lb bag of this fertilizer costs $11.50, how much is this gardener paying a year for this application?