FERTILIZER CALCULATIONS AND CALIBRATIONS

Paul E. Rieke
Department of Crop and Soil Sciences
Michigan State University

Rising fertilizer costs, the potential for environmental pollution, as well as the need for providing the optimum nutrient needs of turf necessitate careful calculations before applying fertilizers to turf. While some of the calculations may be troublesome at first, they can be mastered by 1) keeping a cool head, 2) reasoning through the problem, and 3) double checking the figures.

I. AREA CALCULATIONS

Perhaps the first step in proper calculations is to determine the size of the area to be fertilized. Most general turf areas can be divided into rectangles which make for easy calculations. The area (A) of a rectangle is determined by multiplying the length (L) times the width (W) A = L x W.

Example I-A. Suppose the lawn area is 80 feet long by 40 feet wide. For easy calculations assume that 1,000 sq ft can be considered equal to M. So the 3,200 sq ft found in this example can be considered 3.2M. This will help keep the figures easier to use in later calculations.

If the turf area has the shape of a trapezoid, (a four-sided figure with two sides parallel), the area is determined by the formula A = (a + b) ÷ 2 x h, where a and b are the lengths of the two parallel sides and h is the height (or perpendicular distance) between the two sides.

Example I-B. A turf area has a trapezoidal shape which has one parallel side 180 feet long and the other 200 feet. The perpendicular distance between the two parallel sides is 50 feet. Area = 200 ft + 180 ft ÷ 2 x 50 ft = 360 ÷ 2 x 50 = 180 x 50 = 9,000 sq ft = 9M.

When the area is circular in nature the formula is Area = $\pi r2$ = 3.14 x r x r where r is the radius (1/2 the diameter).

Example I-C. A circular garden has a turf area with a diameter of 120 ft. The radius is 120 ÷ 2 = 60 ft. The area is 3.14 x 60 x 60 ft = 11,304 sq ft = 11.3M.

Example I-D. Suppose there is a pond in the middle of the garden with a diameter of 20 ft. The turf area around the pond is also circular in shape and has a width of 40 ft around the pond. What is the area of the turf? This is solved by determining the area of the pond then the area of the pond and turf and obtaining the difference between the two figures. The radius of the pond is 10 ft. The radius of the pond and the turf area is 10 + 40 = 50 ft.

Area of the pond = 3.14 x 10 ft x 10 ft = 314 sq ft.

Area of the pond and turf = 3.14 x 50 ft x 50 ft = 7,850 sq ft.

Area of the turf is 7,850 - 314 = 7,536 sq ft = 7.5M.

The area of a triangular-shaped area is figured by Area = b x h ÷ 2 where b is the length of one side of a triangle and h is the perpendicular length from that side to the opposite point of the triangle.

Example I-E. A roadside park has a base measured at 500 ft and the perpendicular height is 800 feet. Area = 500 ft x 800 ft ÷ 2 = 20,000 sq ft = 20M.

For larger turf areas the use of acres is more practical. The conversion from 1,000 sq ft to acres is accomplished by dividing the number of sq ft by 43,560 sq ft per acre. Thus, the park area mentioned would have 20,000 ÷ 43,560 = 0.46 acre.

For very irregularly shaped turfs the area may be divided up into several small units which could be a combination of a number of the shapes discussed. The total area is then the sum of all the smaller components. Most turf areas will fit these shapes, but other methods for determining area of irregularly shaped turfs are 1) using the off-set method or 2) by averaging radius measurements of a circle using the formula for area of a circle.

The reader is referred to the literature cited at the end of this paper for more detailed information on area measurements and calculations.

Surface distance measurements can be made practically by pacing, using a measuring wheel, or using a measuring tape. Pacing is the easiest but is subject to obvious errors. A measuring wheel is helpful for larger turf areas where the accuracy of a long tape is not necessary. The purchase of 100 or 200 foot tape or longer can surely be justified for a business in which area measurement is important.

More sophisticated electronic devices or the use of stadia measurements are not necessary for these types of area determinations. When using a metal tape take care to prevent breakage. Be careful not to pull on the tape when it is coiled as it can be easily broken. The tape should be cleaned and oiled after each use when the tape becomes wet or dirty.

II. DRY FERTILIZER CALCULATIONS

Fertilizer calculations are based on the percentage of nutrient by weight. That is, a 12-4-8 fertilizer has 12 percent N (nitrogen), 4 percent P_2O_5 (phosphoric acid) and 8 percent K_2O (potash). The 12 percent nitrogen applies to any quantity of fertilizer whether it is a few lbs, 100 lbs or several tons. Remember that in using percentages the decimal point must be moved two places. In the above fertilizer the figures to be used for calculations are .12 for N, .04 for P_2O_5, and .08 for K_2O. For example, in a 100 lb bag of 12-4-8 there are 100 x .12 = 12 lbs N; 100 x .04 = 4 lbs P_2O_5; and 100 x .08 = 8 lbs K_2O.

Example II-A. How many lbs of N, P_2O_5, and K_2O are in a 42 lb bag of 18-6-12?

lbs N = 42 x .18 = 7.56 lbs N.

lbs P_2O_5 = 42 x .06 2.52 lbs P_2O_5.

lbs K_2O = 42 x .12 = 5.04 lbs K_2O.

There are different methods for determining the amount of fertilizer needed to provide a certain amount of nutrient. One means is to divide the pounds of nutrient needed by the percentage of that nutrient in the fertilizer.

Example II-B. How much 24-8-12 would be needed to apply 1.5 lbs of N per 1,000 sq ft?

$\frac{1.5 \text{ lbs N needed}}{6.25 \text{ lbs 24-8-12}}$ = 6.25 lbs 24-8-12. Double check your answer: x .24 = 1.5 lbs N.

Note that this calculation does not consider the amount of P_2O_5 and K_2O applied. In most cases fertilizer applications for turfs are based on the nitrogen need. Too often no attention is given to the amount of P_2O_5 and K_2O applied. In this example the amounts applied with the 6.25 lbs 24-8-12/M are:

6.25 lbs 24-8-12/M x .08 = 0.5 lb P_2O_5/M

6.25 lbs 24-8-12/M x .12 = 0.75 lb K_2O/M

Example II-C. How much of the 24-8-12 will be needed for a lawn to receive 1 lb N per 1,000 sq ft which measures 100 ft by 120 ft with 3,500 sq ft given to house, driveway, plantings, and garden?

Area = 100 ft x 120 ft = 12,000 sq ft - 3,500 sq ft (house, etc.)
= 8,500 sq ft = 8.5M lawn.

8.5M x 1 lb N/M = 8.5 lbs N needed for the lawn.

$\frac{8.5 \text{ lbs N needed}}{.24}$ = 35.4 lbs 24-8-12 for the lawn.

Example II-D. 600 lbs of 16-8-8 were applied to a park area 4 acres in size. How much of each nutrient was applied per 1,000 sq ft?

Area = 4 acres x 43.6M/acre = 174M.

600 lbs fertilizer x .16 = 96 lbs N.

$\frac{96 \text{ lbs N}}{174\text{M}}$ = .55 lbs N per M. For P_2O_5 and K_2O the calculations would be the same because their analysis is the same in this fertilizer. This example will show P_2O_5 only.

600 lbs 16-8-8 x .08 = 48 lbs P_2O_5..

$\frac{48 \text{ lbs } P_2O_5}{174\text{M}}$ = .28 lb P_2O_5/M. This is one-half of the N rate applied (as the ratio of 16 to 8 would suggest). The K_2O_5 was applied at the same rate, 0.28 lb/M, of course.

III. LIQUID FERTILIZER CALCULATIONS

Liquid fertilizer calculations are similar to those used for dry fertilizers except that the volume measurement, gallons are the basic unit often considered. Still, for the purposes of determining rates of application of nutrients in lbs per 1,000 sq ft, the gallons must be converted to weight. Most liquid fertilizers will weigh between 10 and 11 lbs per gallon. The actual figures can be found on the label or supplied by the fertilizer manufacturer.

Example III-A. One gallon of 10-3-7 fertilizer is applied per 1,000 sq ft of turf. How much of each nutrient is applied per 1,000 sq ft? Assume one gallon weighs 10 lbs.

10 lbs 10-3-7 x .10 = 1 lb N per M.

10 lbs 10-3-7 x .03 = (P_2O_5) = .3 lbs P_2O_5.

10 lbs 10-3-7 x .07 (K_2O) = 0.7 lbs K_2O.

Example III-B. How much 12-2-6 is required to apply .75 lbs N per 1,000 sq ft on a 5,000 sq ft lawn? The fertilizer weighs 10.5 lbs per gallon.

5,000 sq ft = 5M.

0.75 lbs N/M x 5M = 3.75 lbs N needed.

10.5 lbs fertilizer/gallon x .14 (14% N in fertilizer) = 1.5 lbs N/gallon.

$\frac{\text{3.75 lbs N needed}}{\text{1.5 lbs N/gallon}}$ = 2.5 gallons 14-2-6 needed.

Example III-C. If a 155 gallon drum of 13-3-6 is applied to two acres of turf, how much N is applied per 1,000 sq ft? The fertilizer weighs 11 lbs per gallon.

55 gallons x 11 lbs/gallon = 605 lbs fertilizer.

605 lbs fertilizer x .13 (% N) = 78 lbs N.

Two acres = 87,120 sq ft = 87.1M.

$\frac{\text{78 lbs N}}{\text{87.1M}}$ = 0.9 lbs N/M.

IV. CALIBRATING FERTILIZER APPLICATIONS

In order to calibrate fertilizer applicators, one needs to measure the amount of fertilizer delivered by the spreader over a measured turf area. For a drop-type spreader a tray could be machined which can be attached to the spreader. The fertilizer delivered at a given setting can be weighed and the weight determined. A scales which weighs in grams is useful for accurate weighing of small quantities of fertilizer.

Example IV-A. A distance of 100 feet has been marked off. Using a three-foot wide spreader, 20-5-10 fertilizer is collected in the tray. The weight of fertilizer collected is 908 grams when the spreader is pushed over the 100 ft distance. What is the rate of N application per 1,000 sq ft?

$\frac{\text{908 grams}}{\text{454 grams/lb}}$ = 2 lbs fertilizer delivered.

2 lbs fertilizer x .20 = 0.4 lbs N.

3 ft wide x 100 ft long = 300 sq ft = 0.3M.

$\frac{\text{0.4 lbs N}}{\text{0.3M}}$ = 1.33 lbs N/M.

Once this rate of application is determined a second setting can be calibrated. This should be repeated until the desired rate of application is achieved. It is wise to make one or two additional passes at the desired setting to be sure the first weight obtained was reproducible.

For a centrifugal-type spreader (or a drop-type spreader which does not have a tray to collect the fertilizer) one could weigh the fertilizer and the spreader, then spread the fertilizer over a premeasured distance, and weigh the fertilizer and spreader again. The difference in weights is the amount of fertilizer delivered. For calculation purposes the width of the application for a centrifugal spreader should be the distance between 2 passes with the spreader (not the width that the spreader will throw the fertilizer). This allows for any overlap of application.

Example IV-B. A centrifugal spreader with fertilizer weighs 25.2 lbs before spreading and 16.7 lbs after spreading. The distance covered is 100 ft and the distance between passes is 8 ft. The fertilizer is 18-5-9. What is the rate of N applied per 1,000 sq ft?

25.2 lbs - 16.7 lbs = 8.5 lbs fertilizer.

8.5 lbs fertilizer x .18 (% N) = 1.53 lbs N delivered.

Area = 8 ft x 100 ft = 800 sq ft = 0.8M.

$\frac{1.53 \text{ lbs N}}{0.8\text{M}}$ = 1.9 lbs N/M.

In calibrating liquid applications one needs to determine the weight of fertilizer solution applied per 1,000 sq ft. This can be determined with plain water until the approximate rate of application is achieved. Then the rate of application of fertilizer solution should be measured. A fertilizer solution may change the viscosity of the water and, therefore, the rate of application of solution. The addition of wetting agents or spreader-stickers to improve pesticide effectiveness along with the fertilizer will also change the rate of application to some degree.

Example IV-C. A 15-3-5 fertilizer weighs 11 lbs/gallon and is diluted 1 gallon of fertilizer in 2 gallons of water. This mixture is applied at the rate of 25 gallons on a 12,000 sq ft lawn. What is the rate of N application/1,000 sq ft?

In 24 gallons of solution there are 8 gallons of fertilizer and 16 gallons of water.

$\frac{\text{8 gallons of 15-3-5}}{\text{12M}}$ = 0.67 gallons/M.

0.67 gallons/M x 11 lbs/gallon = 7.3 lbs fertilizer/M.

7.3 lbs fertilizer x .15 = 1.1 lbs N/M.

V. COST OF FERTILIZER

The cost of fertilizer materials varies widely for a number of reasons. One can compare fertilizers based on cost per pound of nutrient, but there are other important considerations than just cost. Although the cost per pound of N is often used to compare fertilizers one should remember that many fertilizers also include P_2O_5 and K_2O and that the form of nitrogen has a major influence on cost. The slow release nitrogen carriers are more expensive per pound of N but the higher cost may be justified with the advantages of the slow release N carrier. The turf manager must determine which is the better alternative budget condition.

If the P_2O_5 and K_2O are not considered the cost of nitrogen can be determined as follows:

Example V-A. 24-X-X can be purchased at $218 per ton. What is the cost per pound of nitrogen?

2,000 lbs/ton x .24 = 480 lbs N.

$\frac{\$218}{\text{480 lbs N}}$ = $0.45/pound N.

Example V-B. Which fertilizer has a cheaper cost per pound? A is 15-X-X $4.50 per 40 lb bag. B is 12-X-X at $1.10 per 10.5 lb gallon.

A: 40 lbs 15-X-X x .15 = 6 lbs N in the bag.

$\frac{\$4.50\text{/bag}}{\text{6 lbs N/bag}}$ = $0.75/lb N.

B: 10.5 lbs fertilizer/gallon x .12 = 1.26 lbs N/gallon.

$$\frac{\$1.10/\text{gallon}}{1.26 \text{ lbs N/gallon}} = \$0.87/\text{lb N.}$$

In all calculations it is well to double check your figures. This gives confidence in your calculations and helps reduce the opportunity for costly and embarrassing applications. The use of a hand calculator is a real asset in making calculations. But whether the figures are determined long-hand or with a calculator watch the decimal points carefully.

We must make applications of fertilizers and pesticides. Hopefully, this exercise will be helpful to some who need to improve their abilities and confidence in their calculations.

REFERENCES

Beasley, R. P. 1972. Erosion and Sediment Control. The Iowa State University Press. Ames, Iowa. (Chapter 13).

Brinker, Russell C. 1969. Elementary Surveying, 5th Edition. International Textbook Co., Scranton, Pa. (Chapters 4 and 11).

Rieke, Paul E. 1975. Accurate Measurement of Land Areas on Golf Courses. The Golf Superintendent 43(6), June. pp. 27-29.