TURFGRASS MANAGEMENT MATHEMATICS

Recently I returned to the home farm near Cameron, WI where I grew up. We were going to move the last things out of our farmhouse so it could be sold. In amongst the books in the attic was a small thin book called Arithmetic in Agriculture that must have belonged to my father when he as a student in Dairy Science at UW-Madison in the 50's. On the third page of the book, which was copyright 1951, was a picture of a young farmer in bib overalls sitting at a desk with pencil and notebook. The caption read, "Arithmetic will help you solve many farm problems." Think of this for a minute; the problems in this book were meant to be worked out without a calculator, or a smartphone, or calling a friend who is good at math. A slide rule might be helpful; raise your hand if you can work a slide rule! What a great time we live in, because all these tools are available to use today, although phone a friend is a last resort.

A firm grasp of mathematics is also vital for a turfgrass manager. If you make a math mistake you will waste time and money and eventually kill grass. Mathematics allows us to calculate how much of an input to apply, calculate the cost of different applications and determine how many workers or man hours to allow for a project. It is never a bad idea to review and sharpen our mathematical skills and this article is intended to do that. Let's review some principles before we do some calculations.

SIGNIFICANT FIGURES AND PRECISION

How accurate do our calculations have to be? It depends on the situation. If we apply a 2x rate of sand topdressing to a field we will not even notice, but a 2x rate of metribuzin and we may be looking at some dead turf. In general, we match the precision of measuring the material to the amount that is going to be applied. We handle sand topdressing with tractor scoops and topdressers and in most cases two significant figures are all that are needed. A typical π inch topdressing application applies 33 yd^3 tons per acre. The 33 represents two significant figures. An application of ammonium nitrate (34-0-0) equivalent to 1 lb N/1000 ft^2 to the playing surface of a football field would require 169.4 lbs. Do we need this kind of accuracy? Four significant figures? No, in this case we can still use two significant figures and round this number up to 170 lbs.

What if we are making an application of MSM Turf to control wild garlic on the same football field? Using the 0.5 oz per 1000 ft^2 rate this application would take 28.8 oz of product and in this instance we can again use two significant figures and round this number to 29 oz. In the case of smaller areas or products with very small use rates three significant figures may be warranted.

A POWERFUL TOOL

One of the most useful and powerful tools that is commonly used on turfgrass math is the equation of ratios. In many cases we have determined or been given the rate we need for a set area such as 5 oz of product/1000 ft^2 or 2 lbs of product per acre. We know the area over which we will be applying our product and now we must determine how much of the product to apply. For example, the label on kwiksorb wetting agent says to apply 5 fl oz of product per 1000 ft^2 or 218 fl oz/acre. We want to apply this to the playing surface of our sand-based football field that measures 360 ft x 160 ft or 57,600 ft^2. To solve this we set up the following:

$$\frac{5\ fl\ oz}{1000\ ft^2} = \frac{x\ fl\ oz}{57{,}600\ ft^2}$$

In this case our units also align so we do not have to do any conversions at this point. To solve the problem we cross multiply and divide.

$$\frac{5\ fl\ oz \times 57{,}600\ \cancel{ft^2}}{1000\ \cancel{ft^2}} = 288\ oz\ of\ kwicksorb$$

We could also use the rate for an acre (43,560 ft^2) which is 218 fl oz

$$\frac{218\ fl\ oz \times 57{,}600\ \cancel{ft^2}}{43{,}460\ \cancel{ft^2}} = 288\ oz\ of\ kwicksorb$$

In equal ratios the product of the means is equal to the product of the extremes. What does this mean? Let's write the equation a little different. 218 fl oz/43,560 = 288 fl oz/57,600

ft^2. The extreme values in this case are the ones on the outside of the equation and the means are those near the = sign. And 218 fl oz x 57,600 ft^2 does equal 43,560 ft^2 x 288 fl oz. (If you multiply these out there is a small discrepancy due to rounding.)

One of the most import calculations a turfgrass manager makes is the determination of how much of an input to apply to an area of turfgrass. Every calculation of this type comes down to the same principle applying an amount of a product over an area. Most discussions of turfgrass mathematics spend some time discussing the determination of areas of different shapes and even how to determine the areas of oddly shaped features such as golf greens and sand bunkers. When I think of athletic fields I don't see many of these odd shapes but mostly rectangles and quarter circle arcs of baseball and softball diamonds. For the rectangular shapes the areas are easily determined by multiplying the length by the width. Most field managers know the length and widths of their fields because at some point they have pulled a tape and measured them. With today's technology it is also fairly easy to determine areas of fields using smart phone apps such as Measure My Land, Planimeter, or Google Earth.

Nearly every product we apply to turfgrass is not in a pure form so we must determine application rates to allow for this. For example, if we are applying 21-0-0 fertilizer it only contains 21% N so even though we have applied 100 lbs. of product we have only applied 21 lbs. of N. Two applications that apply a product in a pure form are topdressing and irrigation. We will begin with some examples of those applications.

Example: How much sand topdressing is required to apply 1/4th inch of topdressing to an area of soccer fields that is 250 yards long and 75 yards wide?

A topdressing layer can be visualized as long, wide, and thin box; in this case 250 yards long, 75 yards wide and 1/4th inch thick. We have units of yards and inches so we need to convert the inches into yards.

$$\frac{1}{4}\ inch\ X\ \frac{1\ yd}{36\ inches} = 0.00694\ yds$$

$$250\ yds \times 75\ yds \times 0.00694\ yds = 130\ cubic\ yds$$

So we will need 130 cubic yards of sand for this application. Our sand supplier sells sand by the ton and a cubic yard of dry sand weighs 2700 lbs.

$$130\ \cancel{yd^3} \times \frac{2700\ \cancel{lbs}}{\cancel{yd^3}} \times \frac{1\ ton}{2000\ \cancel{lbs}} = 176\ tons$$

Now the sand is probably not totally dry depending on the weather. If I were buying sand for this application I would buy 15% extra to allow for this water.

$$176\ tons + (15\ \% \times 176\ tons) = 202\ tons\ of\ sand$$

So for this application I would order 202 tons of sand.

Example: How much water is needed to apply 1 inch of irrigation to a football field with the dimensions 130 yds by 70 yds? In this case it may be easier to work in cubic feet.

$$130\ yds \times \frac{3\ ft}{yd} \times 70\ yds \times \frac{3\ ft}{yd} \times 1\ in. \times \frac{ft}{12\ in.}$$

$$= 6{,}800\ ft^3 \times 7.5\ \frac{gallons}{ft^3} = 51{,}100\ gallons$$

Or we could do an internet search and ask "How many gallons are in an acre inch of water?"

Answer 27,152 gallons. The problem now is an equation of ratios.

$$130\ yds \times \frac{3\ ft}{yd} \times 70\ yds \times \frac{3\ ft}{yd} = 81{,}900\ ft^2$$

$$\text{so}\quad \frac{27{,}152\ gal}{43{,}560\ ft^2} = \frac{x\ gal}{81{,}900\ ft^2}$$

Solving for x we get 51,000 gallons.

Sand and water are some of the commodities that are "pure" in that the contain 100% of their ingredient.

CHEMICAL APPLICATIONS

With the exception of fertilizer, all of our chemical applications that are sprayed or spread on turfgrass almost always come with a label that gives of a rate of product to use per area of turfgrass.

Example: We have an adult softball 4-plex with full skin infields, 65 ft bases and 275 ft to centerfield. Each field has 61,450 ft^2 of grass area. Each field is grassed with MS-Pride bermudagrass and we need to apply Primo-MAXX to tighten up our canopy and cut down on our mowing. We are treating 61,450 ft^2 x 4 = 245,800 ft^2 of grass area. The rate of Primo Maxx for athletic field height (1/2 inch) hybrid bermudagrass is 11 oz per acre.

$$\frac{11\ fl\ oz}{43{,}560\ ft^2} = \frac{x\ fl\ oz}{245{,}800\ ft^2} = \frac{11\ fl\ oz \times 245{,}800\ \cancel{ft^2}}{43{,}560\ \cancel{ft^2}}$$

$$= 62\ fl\ oz\ Primo\ Maxx$$

FERTILIZER APPLICATIONS

Fertilizers are a bit different than other chemical applications in that they are made in response to a soil test or fertility plan, and we must take into account the percent element of interest (usually N) in the fertilizer.

For example we have 233,000 ft^2 of bermudagrass soccer fields on soils modified with shallow sand cap. Our fertility plan calls for 1.5 lbs of N per 1000 ft^2 for the months of June, July, August and September. Our soil test also indicates we need to apply some potassium per our soil test so we choose a 20-0-20 fertilizer. How much 20-0-20 do we need to purchase?

$$\frac{1.5 \textit{ lbs of N}}{1000 \cancel{ft^2 \textit{ month}}} \times 233{,}000\ ft^2 \times 4 \textit{ months}$$

$$= 1{,}398 \textit{ lbs of N are needed for the summer}$$

To supply this we are using 20-0-20 which is 20% by weight N. In this case we **divide** the amount of N we need by the percent N in the fertilizer expressed as a decimal.

$$\frac{1.398 \cancel{\textit{lbs of N}}}{\frac{0.2 \cancel{\textit{lbs of N}}}{1 \textit{ lb of fertilizer}}} = 6{,}990 \textit{ lbs of fertilizer}$$

Whether we choose to buy the fertilizer in seven 1000 lb bulk bags or 140 50 lb bags we will need to buy 7000 lbs of fertilizer. How much product will we need to apply per 1000 ft^2?

$$\frac{1.5 \cancel{\textit{lbs of N}}}{\frac{0.2 \cancel{\textit{lbs of N}}}{1 \textit{ lb of fertilizer}}} = \frac{7.5 \textit{ lbs of fertilizer}}{1000\ ft^2}$$

One last problem. We have a 2 youth baseball fields with 140,000 ft2 of tall fescue that have become infested with chickweed and shepherds purse. We have chosen to apply a 19–0–10 fertilizer product impregnated with Confront herbicide at the rate of 0.68% active ingredients (aI). Our crew applies 8 50 lb bags of the product to the area while the foliage is moist to be most effective. To be effective in killing these weeds Confront needs to be applied at a rate of 0.75 lbs of aI per acre. Was enough Confront applied to be effective?

We applied 8 bags X 50 lbs/ bag = 400 lbs of fertilizer. The fertilizer contained 0.68% aI. So we applied

$$400 \cancel{\textit{lbs fert.}} \times \frac{0.68 \textit{ lbs of aI}}{100 \cancel{\textit{lbs fert.}}}$$

= 2.7 lbs aI applied, but does this meet or exceed 0.75 lbs aI per acre?

$$\frac{0.75 \textit{ lbs aI}}{43{,}560\ ft^2} = \frac{x \textit{ lbs aI}}{140{,}000\ ft^2}$$

= 2.4 lbs of aI needed so we have applied enough Confront to be effective.

Our fertility program recommends that we apply 1.5 lbs of N/1000 ft^2 to the fields as well.

$$\frac{1.5 \textit{ lbs N}}{1000 \cancel{ft^2}} \times 140{,}000 \cancel{ft^2} = 210 \textit{ lbs N}$$

Have we applied enough N?

We applied 400 lbs of fertilizer that contained 19% N or 400 lbs X 0.19 lbs N/lb = 76 lbs N so no we did not apply enough N. In fact we need to apply 210 lbs N – 76 lbs of N = 134 lbs N short. We have some 30-0-0 in the shop. How much 30-0-0 will we need?

$$\frac{134 \textit{ lbs N}}{\frac{0.3 \textit{ lbs N}}{1 \textit{ lb fertilizer}}} = 447 \textit{ lbs of } 30-0-0$$

For practical purposes we would apply 450 lbs of 30-0-0 or 9 50 lb bags.

Now to make these applications we need to calibrate our equipment. Calibration is a separate process from these mathematic problems and should be the subject of a future article. Errors are often made when these processes are combined. They are best uncoupled in my opinion. A very efficient turf manager I know has his crew spend time in the winter calibrating their fertilizer spreaders with all the products they plan to use in the upcoming year.

I hope I have given you some problems that you can follow. Now, go practice. ■

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