Understanding variables and common conversion factors used in calibration
(or, where did that 495 and 990 come from?!)

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The Fundamental Relationship, a concept by Professor D. Ken Giles (Emeritus), UC Davis Biological and Agricultural Engineering Department, is a way of talking about calibration without numbers and formulas. It is valuable for teaching concepts important to calibration. Since it is a relationship, it describes the variables needed and their *relationship* to each other.

Fundamental relationship:

Application Rate (gallons/acre) =   Flow rate (gallons/minute)
Spray Volume   Land rate (acres/minute)

We see here that land rate is inversely proportional to application rate. Thus, when land rate (either speed or swath width or both) are increased (and no other factors change), application rate is decreased.

Likewise, flow rate is directly proportional to application rate. Thus, when flow rate is increased, (and no other factors change), application rate is also increased. When flow rate is decreased (and no other factors change), application rate is also decreased.

The Fundamental Relationship is also a good way to do the math of calibration, because nothing needs to be memorized. As long as the UNITS are checked, you can't go wrong. The Fundamental Relationship works for ANY sprayer calibration, as long as the units are tracked correctly and the flow rate correlates to the land rate, i.e., the land rate used is the swath that the nozzles (flow rate) are covering. So if the flow rate (GPM) used in the formula is for ½ of an airblast set up, the swath width in the land rate calculation would be ½ of the row width. If, for example, it is for a weed sprayer with 2 nozzles, the swath width would be the width the 2 nozzles are covering. Remember to think about this as what area is being covered by the spray.

Flow rate units are straight forward: gallons/minute.

Land rate can be a bit tricky because no one thinks in terms of acres covered per minute.

Land rate is tractor speed * swath width covered by the nozzles used to calculate flow rate.

Land rate in the above needs to be calculated in the units "acres/min". Since there are 43,560 ft.^{2} in an acre, the easiest way to calculate is to use the swath width in feet, and the speed in feet/min. Multiplied, this then will give you land rate in ft.^{2} per minute which can then be converted to acres per minute.

USING MPH as Speed

When you measure speed in the field, those who have a speedometer on their tractor will tell you their speed in MPH. To go from a land rate with speed as MPH to acres/minute, the following unit conversion is used when multiplying the speed in MPH times the swath width in feet:

1 mile/5280 feet*43,560 ft.^{2}/1 acre*60 minutes/1 hour=**495**

Land rate (acres/min) =   Speed (miles/hour) * swath width (feet)
495

Note: speed should always be measured and verified. Speedometers are notoriously incorrect!

Calculating nozzle flow rate (GPM):

You can also use the fundamental relationship to calculate the flow rate needed for a desired spray volume (application rate) when you have a set land rate (speed and swath width). This is necessary to help you choose your nozzles. Tractor speed is first determined by checking the coverage-using water sensitive paper or another coverage indicator like kaolin clay, and the fan-using ribbon in the canopy, to go as fast as safely possible while still getting adequate coverage. Swath width for any given field is set. What is left then is to calculate the GPM needed to achieve that application rate at that speed and swath width. This will allow you to select your nozzles based on individual nozzle GPM for a certain pressure.

The fundamental relationship becomes:

Flow rate (gallons/minute) = Application rate (gallons/acre) * Land rate (acres/minute)

This is the flow rate for the ENTIRE sprayer (both sides, correlating to the swath width).

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GPM=GPA*Land rate

OR if using MPH for speed:

GPM=GPA* Miles/Hour * swath width (feet)
495

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To get the required GPM for **one** side of the sprayer, you multiply by ½:

GPM (one side of sprayer) = GPA* Miles/Hour * swath width (feet) * 1

<div align="center">495   2</div>

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GPM (one side of sprayer) =GPA * Miles/Hour * swath width (feet)
990

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I've seen some folks round up the 990 to 1000, which makes the above formula easier to remember.

Why I think the "495 formula" is bad for calibration.

In my experience of teaching calibration math, folks often want to fall back on the formula they have used instead of trying the "Fundamental Relationship". The problem I have with the "495 or 990" formulae, is that with using ground speed in MPH, often the step of measuring speed-a CRITICAL STEP FOR OPTIMIZING SPRAY COVERAGE-is eliminated. Ground speed is assumed, the speedometer is assumed to be correct, and the entire step of measuring and setting speed is omitted-big mistake! Setting speed using flagging in the canopy and looking at the FAN*SPEED*CANOPY interaction is probably the most important step of calibration and optimizing coverage. So, if you must use the "495 formula", please actually measure your ground speed!

Measuring speed manually.

Typically, at least 100 feet are marked off to measure actual speed with a stopwatch. If you measure actual tractor travel time for a 100 foot length, you will likely find most common spraying speeds are timed in seconds. These can be converted to minutes, and then used in the formula for speed as feet per minute which is then multiplied by the swath (or row) width in ft. to obtain ft.^{2} per minute which can then be converted to acres per minute. For example, at 3 MPH, you are travelling:

3 miles/hour*5280 feet/mile*1 hour/60 minutes=264 feet/minute

If swath width is 6 feet, the land rate (or area the nozzles are covering) is calculated as:
264 ft./min * 6 ft.= 1584 ft.^{2}/minute.
In acres covered per minute, we divide by 43,560 ft.^{2}/acre to obtain a land rate of 0.036 acres/minute.

To travel 100 feet at this speed, it takes .37 minute or 22.7 seconds. So, it is not uncommon to time 100-foot tractor runs in 21-23 seconds (which is why you need a good stopwatch!). These runs are best done on the type of terrain to be sprayed; and it's always good to take several times and average.

Remember that the speed is written as distance travelled/time. Sometimes when measuring speed, I've noticed that it will be written as time/distance travelled, which gives the wrong number. Track units!