SLIDE 1:
This is Steve Johnson, University of Maine Cooperative Extension, bringing you this information on sprayer calibration. It is possible to receive a Maine Board of Pesticides Control recertification credit for this presentation. As this presentation is approximately a half hour, another presentation would also have to be viewed. Additionally, a test must be passed with a minimum of 80 percent correct answers on each presentation. While there is no charge for viewing this information, there is charge for taking each test, whether the tests are passed or not.

SLIDE 2:
There are important issues for proper calibration with any and every sprayer. Choose the right equipment for the job. A hand sprayer won't work in a large field. A large field sprayer won't work in a greenhouse or on a front lawn. The equipment must be set up properly. The pest to be controlled must be correctly identified and the right chemical chosen to do the job of pest control. The label and the application recommendations must be reviewed. You need to choose the nozzle and calibrate the sprayer.

SLIDE 3:
How do you know if your sprayer is performing correctly? You can check your volume output. Are you applying the correct dosage? Check your nozzle performance; check your plant coverage. Any one of these can be an indication that your sprayer is not performing correctly.

SLIDE 4:
Sprayers that are not calibrated properly can lead to poor pest control. Possibly, additional applications to control the pest that wasn't controlled the first time, a waste of time and resources, and potentially, phytotoxicity or crop damage.

SLIDE 5:
With sprayer calibration, before you begin, you need to flush the sprayer with clean water. The nozzle and screens must be removed and cleaned and then need to be replaced. The sprayer should be checked for leaks. You need to gather your calibration tools which would be a measuring tape possibly, a stop watch or a watch capable of measuring seconds, and a container marked in ounces for collection of the nozzle output.

SLIDE 6:

Useful relationships that would help. A gallon is 4 quarts, 8 pints, 128 ounces. An acre is 43,560 square feet.

SLIDE 7:
Some useful formula that would help sprayer calibration. GPM or gallons per minute is the gallons per acre times the miles per hour times the width of the nozzle spacing in inches divided by 5940. Again, to calculate the gallons per minute, you will have the gallons per acre, the miles per hour, and the width of the nozzle spacing in inches.

SLIDE 8:
Conversely, for gallons per acre, you need the gallons per minute which is easily measured off a sprayer, miles per hour times the width of the nozzle spacing in inches. With the nozzle spacing is also your application width.

SLIDE 9:
The correct pressure for the sprayer needs to be set. Different nozzle selections have different pressure regimes they need to be within.
Make sure all the nozzle tips have been cleaned. Hopefully, they have been removed, cleaned, and the screens and nozzle tips replaced. Check the appropriate tip selection table which is available on many websites and from tip manufacturers to determine the pressure required to deliver the appropriate output. Most nozzles have a range in which they will deliver a volume based on some pressure. The sprayer needs to be operated at the correct pressure and a collection jar or container needs to be collected and measured for the output for one minute. The pressure could be adjusted as needed. Again, the pressure will affect droplet size. It’s important to check more than one nozzle; in fact, it would be best to check every nozzle on the spray rig. If the nozzle output any nozzle is off by 10% or more, then the nozzle should be replaced.

Slide 10:
Calibrating field sprayers--these are the big sprayers. Three things need to be done. You need to determine the ground speed, measure the output under fields conditions, and measure the area to be treated.

Slide 11:
First time the ground traveled. Fill the sprayer tank half full of water. Mark off 50 feet using markers that are visible along the strip of the field. This

area should be far enough into the field that spraying speed has been reached by the time the 50 foot measuring area is reached. Record the time required to travel the marked off 50 feet. Assume for the next example, that it took 8 seconds for the sprayer to travel 50 feet.

SLIDE 12:
Continuing the example, the distance measured and traveled was 50 feet, the time required to travel those 50 feet was 8 seconds. Use the following formula to calculate ground speed: Miles per hour equals feet x 60 divided by 88 x number of seconds need to travel said feet; 50 x 60, divided by 8 x 88 equals 4.26 or about 4 ¼ miles per hour was the traveling rate of the spray rate.

SLIDE 13:
Continuing to calibrate field sprayers, you need to measure the nozzle output under field conditions. Now you have run the spray rig at the appropriate pressure and measured all the nozzle outputs and found the average was 32 ounces. To find the 10% error rate, you take the 32 oz. average collection for a minute, you move the decimal place one space to the left. The 32 ounces becomes 3.2 ounces. This is the 10% error. Add 3.2 to 32 for + 10% or subtract 3.2 from 32 for – 10% error which gives a range of 35.2 to 28.2. It's a range of which the nozzle should be in. Any nozzle between 35.2 and 28.2 is okay. Greater than 35.2 or less than 28.2 is outside of the 10% error rate and that nozzle should be replaced.

SLIDE 14:
Continue with calibrating field sprayers, measure the output under field conditions. You have checked all your nozzles and the average is 32 ounces per minute. All nozzles are within the 10% of this average. The 32 ounces per minute equals ¼ or 0.25 gallons per minute. The 32 ounces divided by 128 ounces/gallon gives that value. The field speed calculated previously was 4.26 miles per hour. These nozzles on this rig are 20 inches apart. So, the gallons per acre equals gallon per minute x 540 divided by miles per hour x the width as the previous formula showed. This is 0.25 x 5940 divided by 4.26 times 20 or 1485 divided by 85.2 which yields a 17.43 or 17 gallons per acre.

SLIDE 15:

You need to measure the area to be treated. Measure the boom length. Alternately, you measure the nozzle spacing and count the nozzles. There are 56 nozzles with an18-inch spacing. You can use the following formula to calculate the boom length. The number of nozzles times the nozzle spacing in inches divided by 12 equals the boom length; 56 times 18 divided by 12 is 84 foot boom length.

SLIDE 16:
A different example. Your sprayer traveling 4 miles per hour has 12-inch nozzle spacing and delivered an average of 19 ounces per minute. What is the gallons per acre this sprayer applies? The gallons per minute would be the ounces per minute divided by 128 or 0.148 and the gallons per acre would be 0.148 times 5940 divided by 4 for the miles per hour times 12 inch width or 48; 879 divided by 48 yields 18 gallons per acre that this sprayer in this example delivers.

SLIDE 17:
Calibrating field sprayers, sometimes band applications are done. When banding a material only a portion of the total crop or the crop area receives the spray. Calibration is based on the actual treated acres not the total acres. This is the field acres versus the treated acres.

SLIDE 18:
As an example, a 4-row planter sprays a 12-inch band centered over 36-inch rows. It is sprayed for 500 feet and uses ½ gallon of water. What is the application rate? The treated width is 12 inches; so 12-inch treated rate divided by 12 to put into feet x 4 for 4 bands so the treated width is 4 feet. Your gallons per acre equals 0.5 gallons that you used in the proportion of the acre. This would be 43,560 divided by 4 feet treated width times the 500 feet that it was taken. This relates to 10.9 gallons per acre.

SLIDE 19:
Continuing the example, a 4-row planter sprays a 12-inch band centered over 36-inch rows. You are treating 4 12ths or .333 or 33 percent of an acre. This sprayer has a 250-gallon tank divided by the 10.9 gallons per acre. This would yield 23 treated acres. However, you are only treating a third of the total acres you are driving over because you are treating 4 out of 12 feet. So, 23 treated acres divided by the .333 acres treated would yield 69 acres. So a 250-gallon tank on this band applicator will treat 69 acres of a 12-inch band centered over 36-inch rows.

SLIDE 20:
Hand sprayers are used by some and they too need to be calibrated. Two things need to be done. Measure the time required to spray an area that is 1/128th of an acre and collect the volume sprayed in an area that is 1/128th of an acre.

SLIDE 21:
Measure out an area that is equal to 1/128th of an acre. This is approximately, 340 square feet or an area 18.5 by 18.5, 10 by 34, or 1.5 by 228 feet.

SLIDE 22:
Measure the time it takes to spray one of these 1/128th of an acre pieces that you have marked out.

SLIDE 23:
Next, collect the spray volume for the same time it took to spray the measure 1/128th of an acre and measure the collected water in ounces.

SLIDE 24:
The area was 1/128th of an acre. I happen to choose a 10 by 34 foot area. It took 51 seconds to spray that area. During the 51 seconds, I collected 40 ounces. This relates to 40 gallons per acre. The reason this works the amount collected in ounces in 1/128th of an acre equals the number of gallons per acre. It's a fast and easy way to calibrate a hand sprayer.

SLIDE 25:
If you need to increase the spray rate of the sprayer, several things you can do. You can slow the rig down, you can use larger nozzles, you can decrease the nozzle spacing, or you can increase the pressure.

SLIDE 26:
To decrease the rate, you need to speed up, use a smaller nozzle, increase the nozzle spacing, or decrease the pressure.

SLIDE 27:
When changing the sprayer output, the speed is only feasible within a limited range of speed. Again, you don't expect to be able to spray at 1 mile per hour or you don't expect to be able to spray at 15 miles per hour.

Realizing that the speed is a linear relationship, doubling the ground speed decreases the rate by half. Decreasing the ground speed by half will double the spray output.

SLIDE 28:
Pressure again is only feasible within a limited pressure range. That's because the nozzles are designed only to work within a narrow range of pressure. The pressure must be increased by a factor of 4 in order to double the actual flow rate. At 20 psi, or pounds per square inch, if a nozzle delivers 10 gallons per acre, you have to move up to 80 psi to double the rate to 20 gallons per acre. Higher pressure decreases droplet size and increases drift potential. Higher pressures will also increase nozzle wear.

SLIDE 29:
Realistically, nozzles are the best choice for large changes in outputs. The flow rate through a nozzle varies with the size of the nozzle tip and the nozzle pressure. Increasing the orifice size or the pressure will increase the nozzle flow rate. If the number of nozzles on the boom are decreased by one-half, then the gallons per acre are decreased by one-half. Again, doubling the sprayed width per nozzle decreases the gallons per acre by one-half. Cutting the droplet size in half will result in eight times the number of droplets. This is mainly related to pressure.

SLIDE 30:
I have some examples of applications that may occur or may be specific labels on how the sprayer needs to be calibrated or how to calculate what goes into a sprayer.

SLIDE 31:
How much pesticide do I add to the tank? You will need to know how many gallons it takes your sprayer to cover one acre or a set piece of area. What is the labeled rate of the pesticide? You will calculate: How many acres you can spray with a certain volume and how much material do I add to the tank? This would be the dose.

SLIDE 32:
Decide the proper amount to the pesticide tank, divide the capacity of the tank by the gallons per treated acre to find the treated acres per tank of spray. That was demonstrated earlier. To determine how much

chemical to add to the tank, multiply the recommended formulated rate per acre by the number of treated acres the tank will cover.

SLIDE 33:
For an example, if you are treating land with a 80WP material which contains 80% active ingredient at the rate of 2.5 pounds of formulated material per acre. As this material has an a.i. limit per acre, you need to calculate how much a.i. there is in a 2.5 pounds of formulated material. So, how much formulated material are you applying per acre? 2.5 pounds according to label of formulated material per acre. What's the percent a.i. ? 80WP has 80% a.i. per pound. What is the pounds of a.i. per acre you are applying? At 2.5 pounds formulation divided by .80 pounds a.i., this yields 2 pounds a.i. per acre are being applied in this situation.

SLIDE 34:
When using some materials, it is required that you add a surfactant at the rate of 0.25 percent by volume. How much surfactant should be added to a 300-gallon spray solution? 0.25 percent equals 0.0025; 0.0025 times 300 gallons equals 0.75 or 3 quarter gallons or 3 quarts of surfactant. So, you would add 3 quarts of surfactant in this 300-gallon spray solution to get a 0.25 percent by volume.

SLIDE 35:
You need to treat 10 acres for with a preplant material at the rate of 1 gallon per acre. Your sprayer has at tank capacity of 500 gallons and has been calibrated to deliver 25 gallons per acre at 5 miles per hour. How much material are you going to need?

1 gallon of material per acre times 10 acres equals 10 gallons of material. How much water do you need?
25 gallons of water per acre times 10 acres equals 250 gallons of water or about half of the tank. How many tank loads will you use?
250 gallons water divided by 500 gallon tank capacity equals one half load. How much material per gallon of water do you need?
10 gallons of material / 250 gallons of water equals 0.04 gallons of material per gallon of water.

SLIDE 36:

Another example, you have a 500 gallon tank and need to apply an 80WP material containing 80% a.i. at the rate of 0.55% by weight.

How much formulated material do you need?
(0.55% = 0.0055)

$$\text{The pounds material} = \frac{(\%\text{ by weight} \times \text{gallons} \times 8.34 \text{ lbs. per gallon})}{(\%\text{ strength of material})}$$

This becomes $\frac{(0.0055 \times 500 \times 8.34)}{(0.80)}$ or

28.7 pounds into the 500-gallon tank.

SLIDE 37:
Another example, how much material containing 10 percent active ingredient should be added to a 35 gallon tank if the recommended treatment calls for a 400 ppm (parts per million) active ingredient of a material? You take the:

$$\frac{400}{1{,}000{,}000} \times \frac{1}{0.10 \text{ percent a.i.}} \times 128 = \frac{\text{ounces of gallon}}{\text{that equals gallon mix}}$$

That equals 0.512 ounces of the 10 percent a.i. per gallon of material.

35 gallons x 0.512 ounces per gallon equals 17.92 ounces material would go into the 35 gallon tank to get a 400 ppm concentration of the 10 percent a.i. material.

SLIDE 38:
Another example, your sprayer travels 5 miles per hour, has 16 inch nozzle spacing, and delivers an average of 20 ounces per minute per nozzle.

What are the gallons per acre this sprayer applies?

You need to convert the ounces per minute to gallons per minute. So it is 20 ounces divided by 128 = 0.156 per minute. The

$$GPA = \frac{GPM \times 5940}{MPH \times Width} \quad \text{This equals} \quad \frac{0.156 \times 5940}{5 \times 16} = \frac{926}{80}$$

Equals 12. This sprayer produces 12 gallons per acre.

SLIDE 39:
Another example, you are applying material at the rate of 2 pounds of material per acre. Your sprayer has a capacity of 600 gallons and is calibrated to 20 gallons per acre.

How many acres will this rig do on one tank load?

The number of acres it will do would be the 600 gallons divided by 20 gallons per acre or 30 acres.

How many pounds of material per tank is required?

Again, you have 2 pounds of material per acre; so 30 acres x 2 pounds per acre equals 60 pounds per material into the 600 gallon tank.

SLIDE 40:
Another example, you are applying material across 200 acres at the rate of 2 pounds a.i. per acre. Your sprayer has a capacity of 600 gallons and is calibrated to 20 gallons per acre. The material comes in either an 80WP or a 4EC formulation.

How much of each formulated material do you need?

Take the total a.i. needed equals 200 acres x 2 pounds a.i. equals 400 pounds a.i. This is what is required to do the 200 acres.

If you use an 80 WP that’s 400 pounds a.i. divided by 0.80 or 500 pounds of 80WP will be required to do the 200 acres.

If you choose the 4EC, your 400 pounds a.i. divided by 4 (4 pound gallon) equals 100 pounds 4EC.

SLIDE 41:

Another example, your sprayer is calibrated for 20 gallons per acre and have been applying a material at the rate of one quart per acre. You have 15 gallons of mixed material left in the tank and have 4 acres left to treat. How much more water and material need to be added?

So 15 gallons left out of 20 gallons per acre equals 0.75 acres of mixed material.

4 acres - 0.75 acres equals 3.25 acres.

3.25 acres added to the spray tank times 20 gallons per acre equals 65 gallons.

At 3.25 acre times 1 quart equals 3.25 quarts.

So, to the tank that has 15 gallons of mixed material, you add another 65 gallons of water and 3.25 quarts of your material.

SLIDE 42:
Another example, you want to apply 2 pounds a.i. of a material that is formulated as a 4 pound a.i. per gallon material (e.g. 4 EC). How much 4 EC do you apply per acre?

2 pounds a.i. divided by 4 pounds a.i. per gallon equals 0.5 gallons of 4 EC or 2 quarts or half gallon of material per acre in this situation.

SLIDE 43:
Another example, you want to apply one half pounds active ingredient of a material that is formulated as a 80 WP.

How much product do you apply per acre?

Your 0.5 pounds a.i. divided by 0.80 equals 0.625 pounds of formulated material per acre. That is how much material per acre that you apply.

SLIDE 44:
Another example, if the recommendation from the label is to apply 1 quart of formulated material per 40 gallons. Your sprayer holds 1

gallon of spray mixture. So how much material will you need to add to the 1 gallon of water?

1 quart equals 32 ounces equals one quarter gallon. Again, you are putting 1 quart of formulated material per 40 gallons.

So, your 0.25 gallons divided by 40 equals 0.00625 gallons or 0.8 ounces of material per gallon.

1 fluid ounce equals 2 tablespoons or 24cc from a syringe

Therefore, just over one and a half tablespoons of material per gallon need to be added. Please, please:

DO NOT USE MEASURING SPOONS FROM THE KITCHEN AND RETURN THEM. IF YOU USE ANY SORT OF MEASURING DEVICE FOR PESTICIDES, IT NEEDS TO STAY AWAY FROM THE KITCHEN AND AWAY FROM ANYONE THAT MAY THINK IT WOULD BE FOR FOOD.

SLIDE 45:
This gallon, how much area would it spray?

1 gallon (40 gallons per acre) So, 1 40^{th} of 43560 or 1089 square feet or about 30 by 36 feet.

SLIDE 46:
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