

# Sprayer Calibration and Nozzle Selection

## Non-Crop Vegetation Management

**Marcelo L Moretti**

**Assistant Professor, Dept. of Horticulture**

**[marcelo.moretti@oregonstate.edu](mailto:marcelo.moretti@oregonstate.edu)**

## **Objective of this talk:**

- **Importance of calibration**
- **Calibration check list**
- **Droplet size dynamics**
- **Nozzle selection**

# Spray calibration:

“the process of measuring and adjusting the amount of pesticide your equipment will apply over a target area.” (source: Pesticide Environmental Stewardship)

- **Save money**
- **Environmental benefit**
- **Reduce crop injury**
  
- **It's the law. Cannot exceed label rate!**



# Spray calibration: When to calibrate?

## Periodically

- Adjust equipment for pesticide used
- Verify along the season



## Before calibrating:

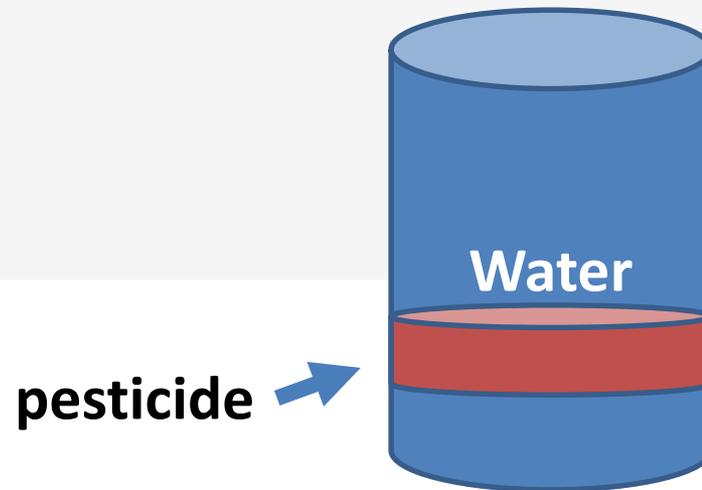
- Use Personal Protection Equipment
- Clean your sprayer
- Use water



# Sprayer calibration Step 1:

- Refer to label and select spray volume

Spray volume = Carrier (water) + pesticide  
20 GPA = 19 gal + 1 gal



## Sprayer calibration Step 2:

- Define ground speed
- Calculate speed:
  - $\frac{\text{distance (MPH)}}{\text{time}}$
- Use average of multiple runs

## Sprayer calibration Step 3:

### Calculate flow volume:

- **GPM** = gallons per minute
- **GPA** = gallons per acre
- **Mph** = miles per hour
- **W** = nozzle spacing inches

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

# Sprayer calibration Step 3:

## Nozzle spacing

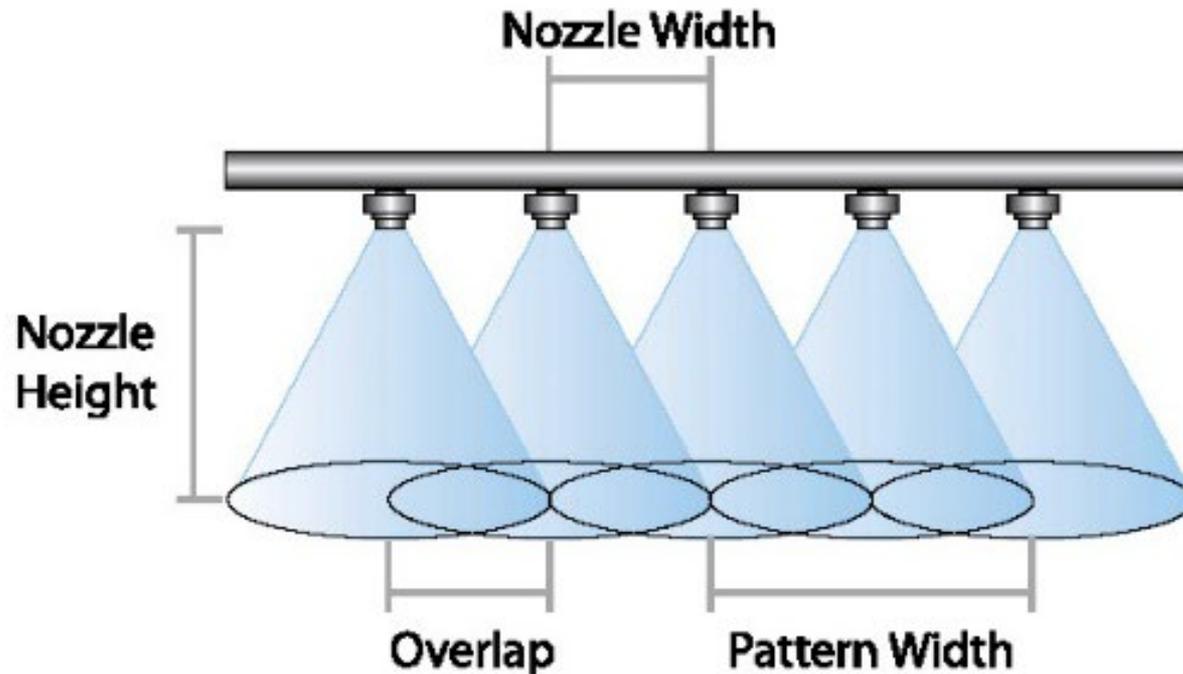


Figure from Virginia Cooperative Extension

## Sprayer calibration Step 4:

Doing the math

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

$$GPM = \frac{20 \times 6 \times 20}{5940} = 0.4040$$



## Sprayer calibration Step 6:

### Collecting nozzle output

Collect volume for 30s  
Transform to GPM (1 min)  
 $\text{Ounces per min} \div 128 = \text{GPM}$

Collect 3 runs

Your GPM should be within 5% of calculated value

Evaluate all nozzles

Example:

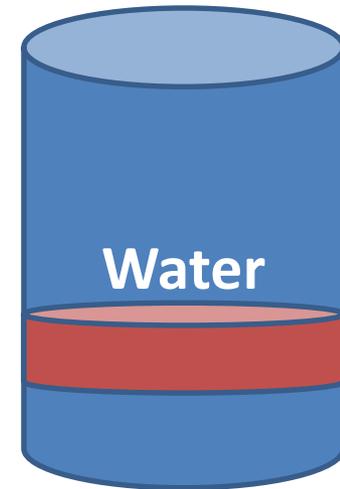
We calculated  $\text{GPM} = 0.4040 \pm 0.02$



# Sprayer calibration Step 7: Broadcast application

## Total spray solution

pesticide →



How many gallons do I need to treat the area?

Gallons x total A = volume of solution

Per A

Calculating amount of product

rate x total A = amount of pesticide

Per A

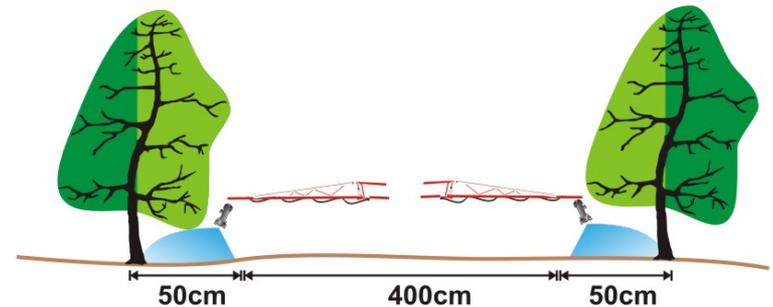
# Sprayer calibration Step 7: Banded application

## Treated area

$\frac{\text{Band width} \times \text{area}}{\text{Row width}} = \text{treated area}$

$\frac{4 \text{ ft}}{20 \text{ ft}} \times 100 \text{ A} = 20 \text{ treated A}$

$\text{GPA} \times \text{treated area} = \text{volume}$   
 $20 \text{ gpa} \times 20 \text{ A} = 400 \text{ gallons}$

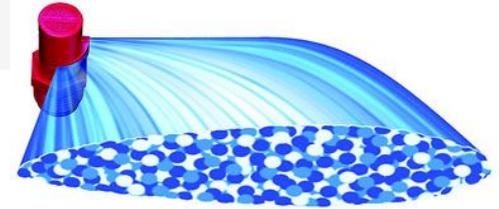


Banded application using off-centre boomless flat fans.  
20% of the planted area receives spray

Source: [Sprayers101.com](http://Sprayers101.com)

# Boomless and off center nozzles

Boom Height, Pressure,  
Nozzles size affect spray width



 "R", "L"	CENTER NOZZLE "C" 	 PSI	DROP SIZE	CAPACITY THREE NOZZLES IN GPM	SPRAY WIDTH "W" (FEET)		NOZZLE SPACING "X" = 30"																								
							HEIGHT = 24"										HEIGHT = 36"														
							GPA FOR THREE NOZZLES										GALLONS PER 1000 SQ. FT.					GPA FOR THREE NOZZLES					GALLONS PER 1000 SQ. FT.				
							24" HEIGHT	36" HEIGHT	4 MPH	6 MPH	8 MPH	10 MPH	15 MPH	20 MPH	2 MPH	3 MPH	4 MPH	5 MPH	4 MPH	6 MPH	8 MPH	10 MPH	15 MPH	20 MPH	2 MPH	3 MPH	4 MPH	5 MPH			
(B)1/4XP10R (B)1/4XP10L	1/4TTJ06 (50)	30	XC	2.26	25.0	27.0	11.2	7.5	5.6	4.5	3.0	2.2	0.51	0.34	0.26	0.20	10.4	6.9	5.2	4.1	2.8	2.1	0.47	0.32	0.24	0.19					
		40	XC	2.60	27.0	30.0	11.9	7.9	6.0	4.8	3.2	2.4	0.55	0.36	0.27	0.22	10.7	7.2	5.4	4.3	2.9	2.1	0.49	0.33	0.25	0.20					
		50	XC	2.91	30.0	32.0	12.0	8.0	6.0	4.8	3.2	2.4	0.55	0.37	0.27	0.22	11.3	7.5	5.6	4.5	3.0	2.3	0.52	0.34	0.26	0.21					
		60	XC	3.17	31.0	34.0	12.7	8.4	6.3	5.1	3.4	2.5	0.58	0.39	0.29	0.23	11.5	7.7	5.8	4.6	3.1	2.3	0.53	0.35	0.26	0.21					
(B)1/4XP20R (B)1/4XP20L	1/4TTJ06 (50)	30	XC	4.02	28.0	29.0	17.8	11.8	8.9	7.1	4.7	3.6	0.81	0.54	0.41	0.33	17.2	11.4	8.6	6.9	4.6	3.4	0.79	0.52	0.39	0.31					
		40	XC	4.60	32.0	33.0	17.8	11.9	8.9	7.1	4.7	3.6	0.81	0.54	0.41	0.33	17.3	11.5	8.6	6.9	4.6	3.5	0.79	0.53	0.39	0.32					
		50	XC	5.17	34.0	35.0	18.8	12.5	9.4	7.5	5.0	3.8	0.86	0.57	0.43	0.34	18.3	12.2	9.1	7.3	4.9	3.7	0.84	0.56	0.42	0.33					
		60	XC	5.73	35.0	37.0	20	13.5	10.1	8.1	5.4	4.1	0.93	0.62	0.46	0.37	19.2	12.8	9.6	7.7	5.1	3.8	0.88	0.59	0.44	0.35					
(B)1/4XP25R (B)1/4XP25L	1/4TTJ08	30	XC	4.95	29.0	32.0	21	14.1	10.6	8.4	5.6	4.2	0.97	0.64	0.48	0.39	19.1	12.8	9.6	7.7	5.1	3.8	0.88	0.58	0.44	0.35					
		40	XC	5.80	32.0	34.0	22	15.0	11.2	9.0	6.0	4.5	1.0	0.68	0.51	0.41	21	14.1	10.6	8.4	5.6	4.2	0.97	0.64	0.48	0.39					
		50	XC	6.39	34.0	35.0	23	15.5	11.6	9.3	6.2	4.7	1.1	0.71	0.53	0.43	23	15.1	11.3	9.0	6.0	4.5	1.0	0.69	0.52	0.41					
		60	XC	6.98	35.0	37.0	25	16.5	12.3	9.9	6.6	4.9	1.1	0.75	0.57	0.45	23	15.6	11.7	9.3	6.2	4.7	1.1	0.71	0.53	0.43					
(B)1/2XP40R (B)1/2XP40L	1/4TTJ10	30	XC	7.93	31.0	34.0	32	21	15.8	12.7	8.4	6.3	1.4	0.97	0.72	0.58	29	19.2	14.4	11.5	7.7	5.8	1.3	0.88	0.66	0.53					
		40	XC	9.00	33.0	36.0	34	23	16.9	13.5	9.0	6.8	1.5	1.0	0.77	0.62	31	21	15.5	12.4	8.3	6.2	1.4	0.94	0.71	0.57					
		50	XC	10.2	35.0	37.0	36	24	18.0	14.4	9.6	7.2	1.7	1.1	0.83	0.66	34	23	17.1	13.6	9.1	6.8	1.6	1.0	0.78	0.62					
		60	XC	11.2	37.0	40.0	37	25	18.7	15.0	10.0	7.5	1.7	1.1	0.86	0.69	35	23	17.3	13.9	9.2	6.9	1.6	1.1	0.79	0.63					
(B)1/2XP80R (B)1/2XP80L	1/4TTJ15	30	XC	15.0	35.0	38.0	53	35	27	21	14.1	10.6	2.4	1.6	1.2	0.97	49	33	24	19.5	13.0	9.8	2.2	1.5	1.1	0.89					
		40	XC	17.5	37.0	40.0	59	39	29	23	15.6	11.7	2.7	1.8	1.3	1.1	54	36	27	22	14.4	10.8	2.5	1.7	1.2	0.99					
		50	XC	19.1	38.0	41.0	62	41	31	25	16.6	12.4	2.8	1.9	1.4	1.1	58	38	29	23	15.4	11.5	2.6	1.8	1.3	1.1					
		60	XC	21.0	40.0	42.0	65	43	32	26	17.3	13.0	3.0	2.0	1.5	1.2	62	41	31	25	16.5	12.4	2.8	1.9	1.4	1.1					

# Boomless and off center nozzles



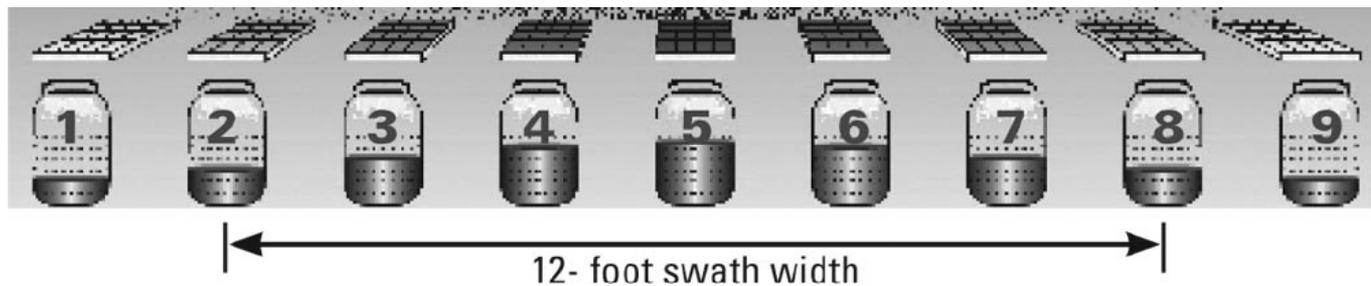
CENTER NOZZLE "C"		NOZZLE SPACING "X" = 30"																		
		PSI	DROP SIZE	CAPACITY THREE NOZZLES IN GPM	SPRAY WIDTH "W" (FEET)		HEIGHT = 24"										GPA FOR THREE			
					24" HEIGHT	36" HEIGHT	GPA FOR THREE NOZZLES					GALLONS PER 1000 SQ. FT.					GPA FOR THREE			
						4 MPH	6 MPH	8 MPH	10 MPH	15 MPH	20 MPH	2 MPH	3 MPH	4 MPH	5 MPH	4 MPH	6 MPH	8 MPH		
10R 10L	1/4TTJ06 (50)	30	XC	2.26	25.0	27.0	11.2	7.5	5.6	4.5	3.0	2.2	0.51	0.34	0.26	0.20	10.4	6.9	5.2	
		40	XC	2.60	27.0	30.0	11.9	7.9	6.0	4.8	3.2	2.4	0.55	0.36	0.27	0.22	10.7	7.2	5.4	
		50	XC	2.91	29.0	32.0	12.0	8.0	6.0	4.8	3.2	2.4	0.55	0.37	0.27	0.22	11.3	7.5	5.6	
		60	XC	3.17	31.0	34.0	12.7	8.4	6.3	5.1	3.4	2.5	0.58	0.39	0.29	0.23	11.5	7.7	5.8	
20R 20L	1/4TTJ06 (50)	30	XC	4.02	28.0	29.0	17.8	11.8	8.9	7.1	4.7	3.6	0.81	0.54	0.41	0.33	17.2	11.4	8.6	
		40	XC	4.60	32.0	33.0	17.8	11.9	8.9	7.1	4.7	3.6	0.81	0.54	0.41	0.33	17.3	11.5	8.6	
		50	XC	5.17	34.0	35.0	18.8	12.5	9.4	7.5	5.0	3.8	0.86	0.57	0.43	0.34	18.3	12.2	9.1	
		60	XC	5.73	35.0	37.0	20	13.5	10.1	8.1	5.4	4.1	0.93	0.62	0.46	0.37	19.2	12.8	9.6	
25R 25L	1/4TTJ08	30	XC	4.95	29.0	32.0	21	14.1	10.6	8.4	5.6	4.2	0.97	0.64	0.48	0.39	19.1	12.8	9.6	
		40	XC	5.80	32.0	34.0	22	15.0	11.2	9.0	6.0	4.5	1.0	0.68	0.51	0.41	21	14.1	10.6	
		50	XC	6.39	34.0	35.0	23	15.5	11.6	9.3	6.2	4.7	1.1	0.71	0.53	0.43	23	15.1	11.3	
		60	XC	6.98	35.0	37.0	25	16.5	12.3	9.9	6.6	4.9	1.1	0.75	0.57	0.45	23	15.6	11.7	
40R 40L	1/4TTJ10	30	XC	7.93	31.0	34.0	32	21	15.8	12.7	8.4	6.3	1.4	0.97	0.72	0.58	29	19.2	14.4	
		40	XC	9.00	33.0	36.0	34	23	16.9	13.5	9.0	6.8	1.5	1.0	0.77	0.62	31	21	15.5	
		50	XC	10.2	35.0	37.0	36	24	18.0	14.4	9.6	7.2	1.7	1.1	0.83	0.66	34	23	17.1	
		60	XC	11.2	37.0	40.0	37	25	18.7	15.0	10.0	7.5	1.7	1.1	0.86	0.69	35	23	17.3	
80R 80L	1/4TTJ15	30	XC	15.0	35.0	38.0	53	35	27	21	14.1	10.6	2.4	1.6	1.2	0.97	49	33	24	
		40	XC	17.5	37.0	40.0	59	39	29	23	15.6	11.7	2.7	1.8	1.3	1.1	54	36	27	
		50	XC	19.1	38.0	41.0	62	41	31	25	16.6	12.4	2.8	1.9	1.4	1.1	58	38	29	
		60	XC	21.0	40.0	42.0	65	43	32	26	17.3	13.0	3.0	2.0	1.5	1.2	62	41	31	

# Granular application

## Distribution pattern

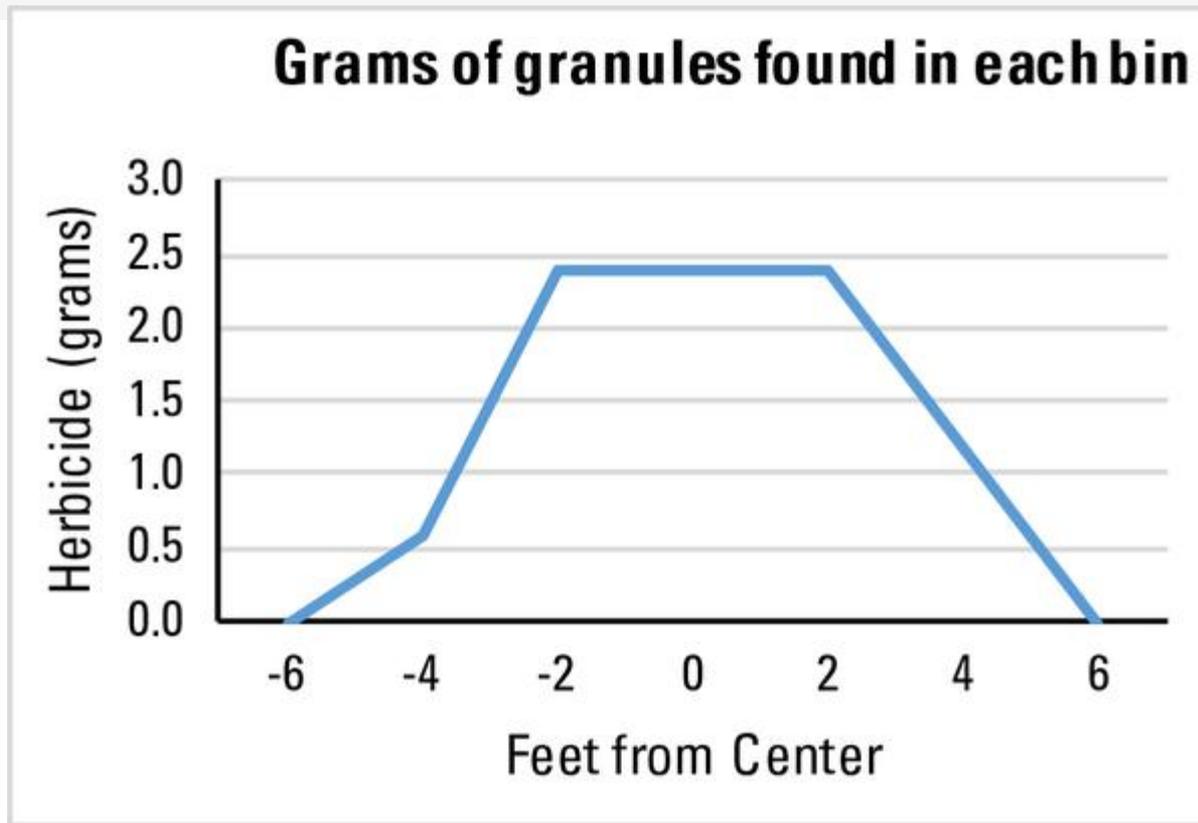
Distance and Effective Swath Width for Rotary Spreaders to Equal 1,000 Square Feet.

Effective Swath Width (feet)	Distance (feet)
6	167
8	125
10	100
12	84
14	72



# Granular application

## Overlap 30 to 50%



Source: <https://content.ces.ncsu.edu/calibrating-hand-held-granular-spreaders-for-nursery-weed-control>

# Granular application

1. Fill  $\frac{3}{4}$  full
2. Weight spreader
3. Operate for known time
4. Weight again
5. Determine difference



Source: <https://content.ces.ncsu.edu/calibrating-hand-held-granular-spreaders-for-nursery-weed-control>

# Granular application

## 6. Calculate area

Speed:

1 mph = 1.46 ft/s

Assuming:

3 mph = 4.4 ft/s

12 ft width = 84 ft

$84 \text{ ft} / 4.4 \text{ ft.s} = 19 \text{ s}$

Oz/1000 sq ft.

1000 sq ft	
Swath (ft)	distance (ft)
6	167
8	125
10	100
12	84
14	72

# Sprayer calibration:

## Additional Resources

Pesticide Stewardship.org

Nozzle manufactures apps



North Carolina State Extension – Joe Neal

<https://content.ces.ncsu.edu/calibrating-hand-held-granular-spreaders-for-nursery-weed-control>

## Important considerations:

### Nozzle size and GPA

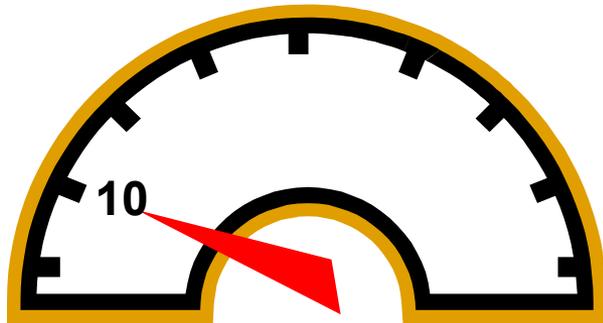
What happens if you double your pressure ? From 20 psi to 40 psi

- A. GPA doubles
- B. GPA does not change
- C. It depends
- D. I'm done with math, don't touch the nozzles.

# Spray pressure and calibration

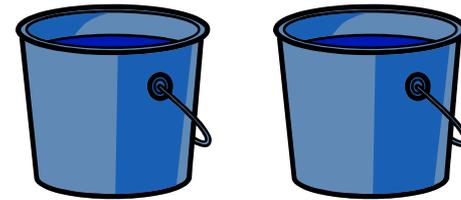
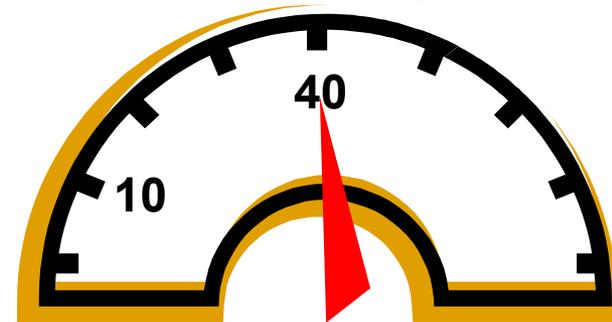
- Increase pressure 4 times to double the nozzle output

Sprayer pressure  
at 10 psi



Sprayer output = 1 bucket

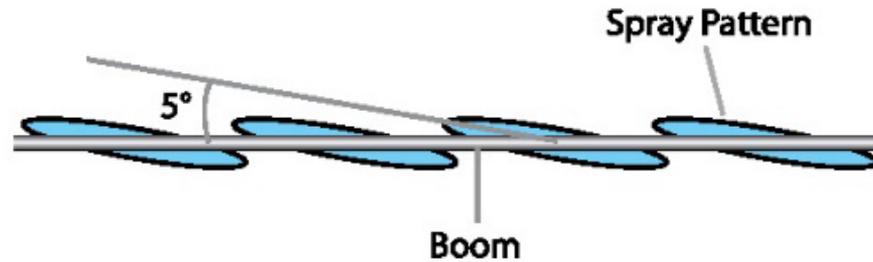
Sprayer pressure  
at 40 psi



Sprayer output =  
2 buckets

# Nozzle pattern

Nozzle spray fans don't touch each other



Patterns Do Not Intersect

Figure 3. Flat-fan nozzles angled 5 degrees from the boom.

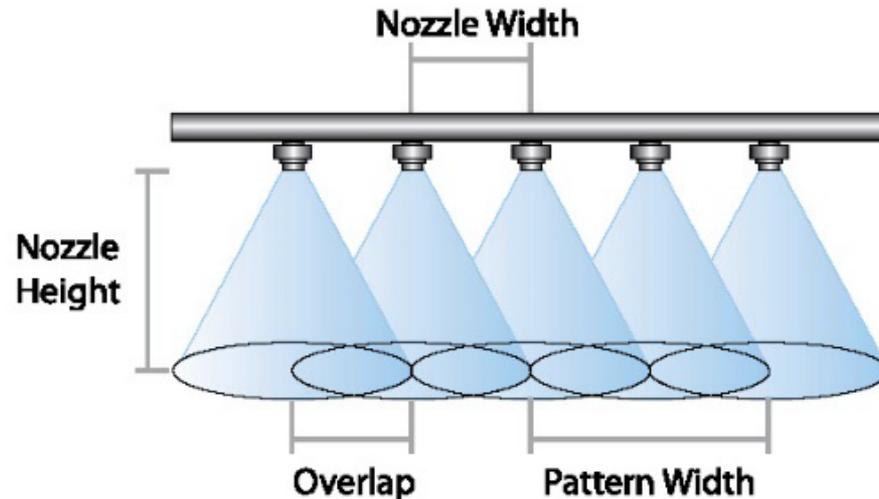


Figure 4. Nozzle overlap of 100 percent.

# Nozzle pattern

	 (Inches)			
		 20°	 30°	 40°
TP, TJ	65°	22–24"	33–35"	NR*
TP, XR, TX, DG, TJ, AI, XRC	80°	17–19"	26–28"	NR*
TP, XR, DG, TT, TTI, TJ, DGTJ, AI, AIXR, AIC, XRC, TTJ, AITTJ	110°	16–18"	20–22"	NR*
FullJet®	120°	10–18"***	14–18"***	14–18"***
FloodJet® TK, TF, K, QCK, QCTF, 1/4TTJ	120°	14–16"****	15–17"****	18–20"****

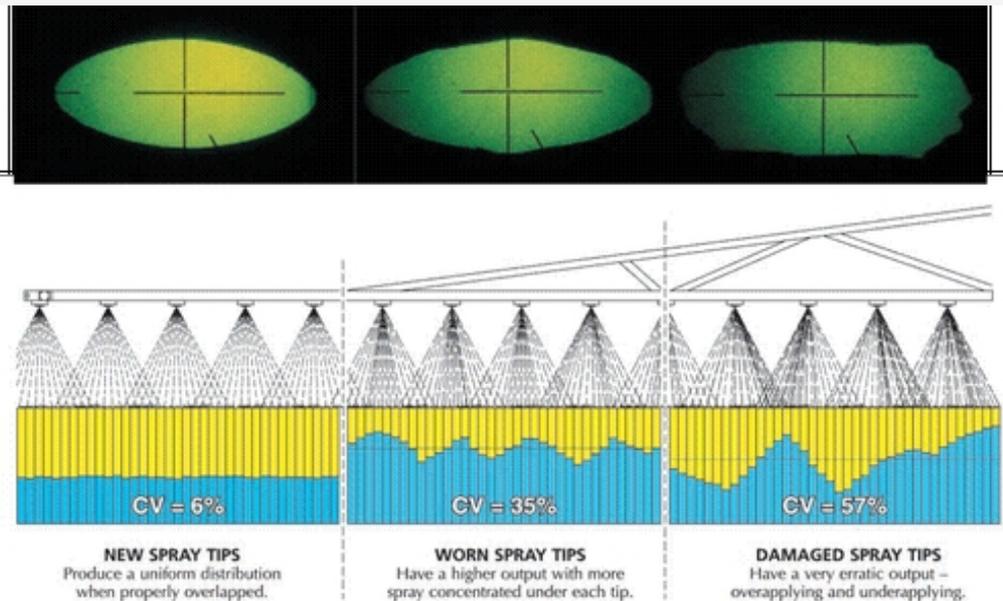
\* Not Recommended. \*\* Nozzle height based on 30° to 45° angle of orientation.

\*\*\* Wide angle spray tip height is influenced by nozzle orientation. The critical factor is to achieve a double spray pattern overlap.

Figure Teejet

# Check spray pattern

- Check nozzle output of all nozzles
- Nozzle wear out
- Variation among new nozzles exists
- Check nozzle alignment



# Nozzle selection: nozzle material

- Brass nozzle
- Plastic
- Ceramic
- Stainless steel

Factors to consider:

- Corrosion, abrasion, longevity, price

# Nozzle selection: nozzle type

- Match the nozzle to the job
- Apps available to help the process
- Pesticide label has droplet recommendation (medium, coarse, etc).



# Droplet classification

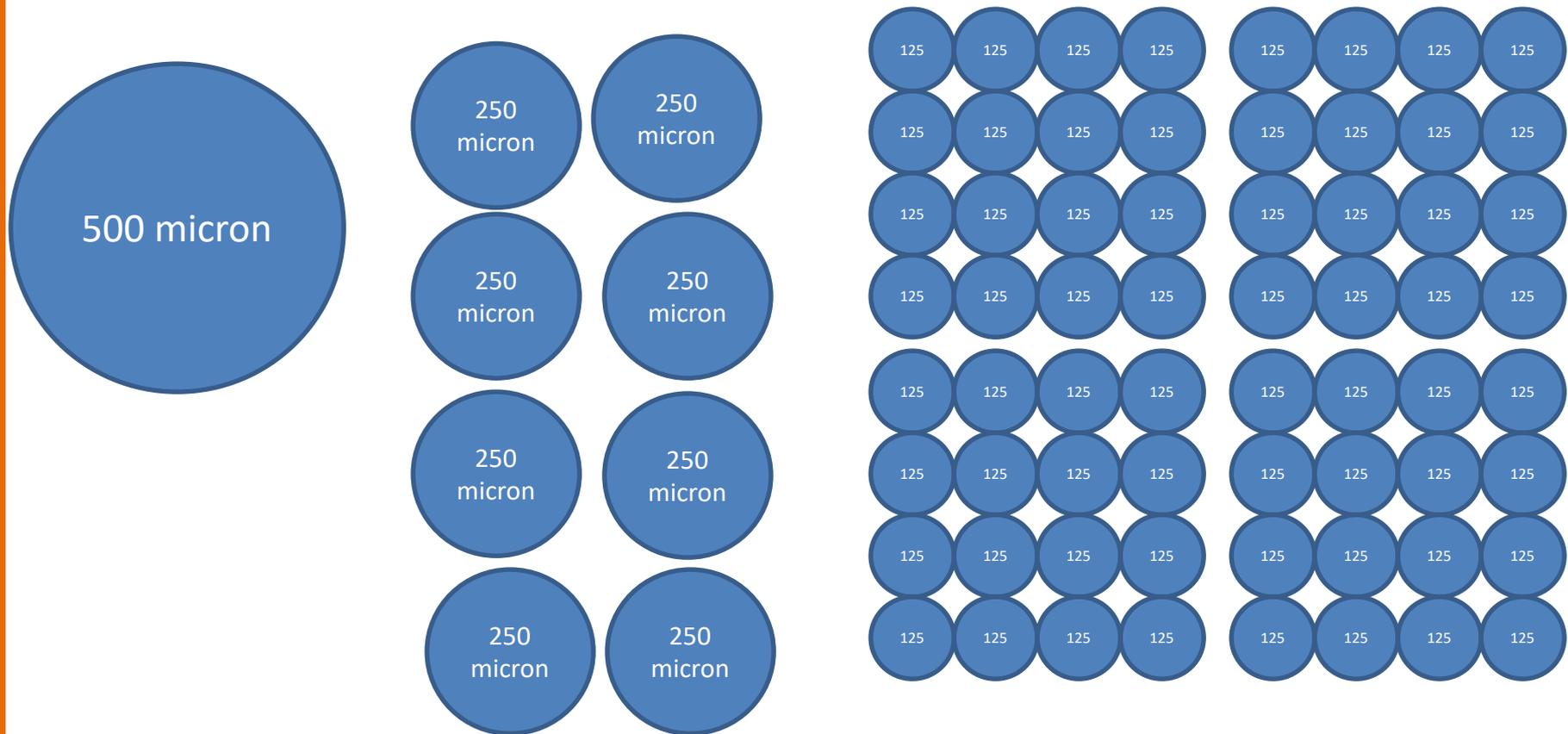
Droplets are classified by their volume medium diameter

- Nozzle produces a range of droplets sizes  
    narrow ranges – more uniformity

CATEGORY	SYMBOL	Dv0.5 (VMD) $\mu\text{m}$
Extremely Fine	XF	~50
Very Fine	VF	<136
Fine	F	136 - 177
Medium	M	177 - 218
Coarse	C	218 - 349
Very Coarse	VC	349 - 428
Extremely Coarse	XC	428 - 622
Ultra Coarse	UC	>622

# Nozzle selection and herbicide performance

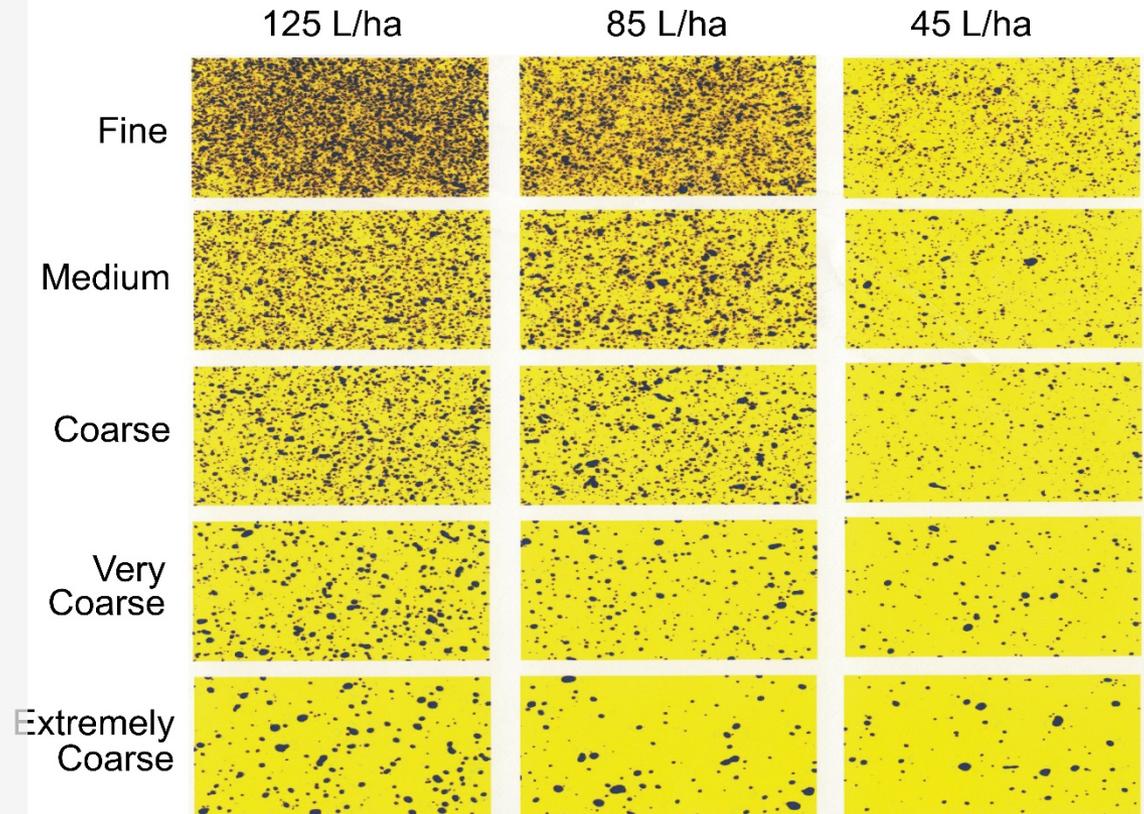
Droplet size affects coverage



As diameter is reduced by half, volume is reduce by  $1/8^{\text{th}}$ .

# Droplet size and coverage

Droplet size will affect coverage  
Contact herbicides  
↑ coverage  
↑ efficacy



Sprayers101

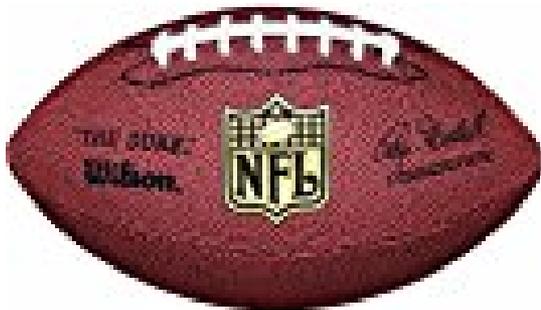
# Droplet size and pressure

Do not increase pressure in an attempt to improve coverage.

 	 PSI	110°XR/XRC  15-60 PSI
<b>04</b> AI AIC AITTJ60 AIXR AI3070 TT TTI TTJ60 XR XRC (50)	20	M
	30	M
	40	M
	50	F
	60	F
	70	—
	80	—
	90	—

# Droplet size and pressure

Dividing the droplet diameter in  $\frac{1}{2}$   
 Reduces weight in 4-fold



450 g



110 g

	PSI	110°XR/XRC
		
		15-60 PSI
<b>04</b>	20	M
<b>AI AIC AITTJ60</b>	30	M
<b>AIXR AI3070</b>	40	M
<b>TT TTI TTJ60</b>	50	F
<b>XR XRC</b>	60	F
<b>(50)</b>	70	—
	80	—
	90	—

# Droplet size and coverage

Droplet size will affect droplet travel time to target:

**At the spray tip: all droplets 43 mph**

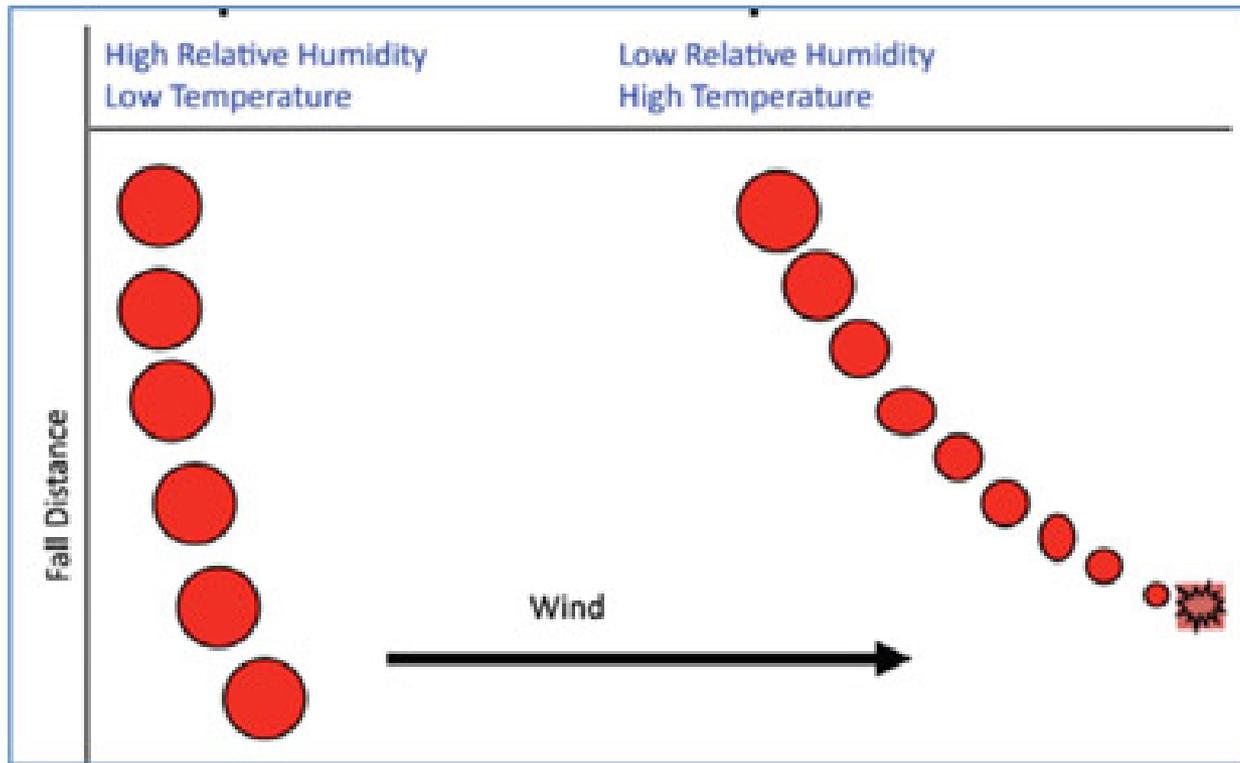
20 inches below nozzle:

- Large droplet 17 mph
- Small droplet 4.3 mph

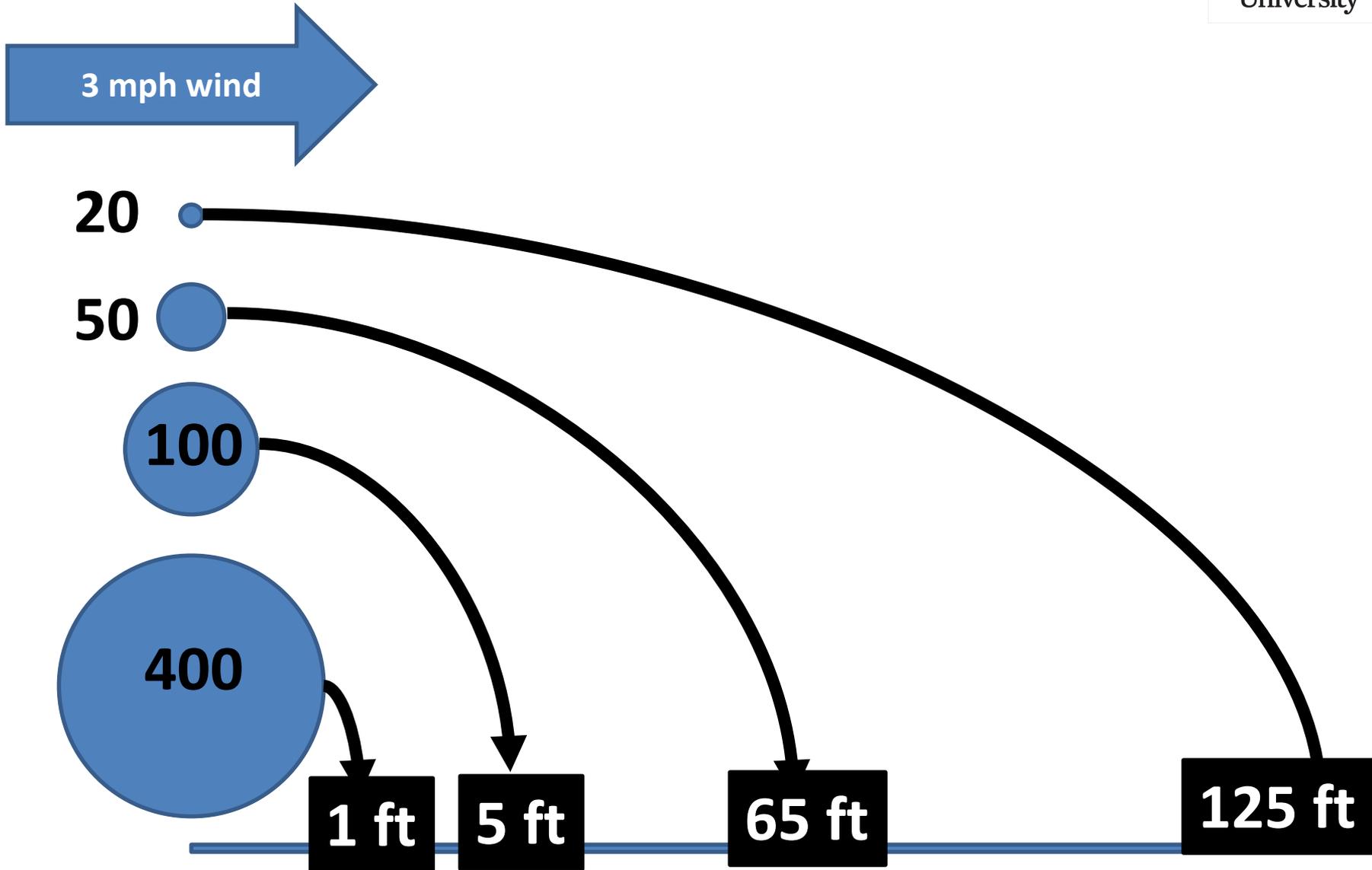
Longer travel time more chances to be moved away

# Droplet size classification

## Evaporation of Droplets

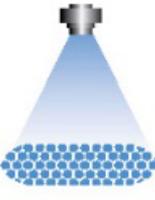


# Small droplets are drift prone



# Nozzle types and uses

**Table 7. Nozzle guide for spraying.**

		Broadcast Spraying							
									
		<b>Extended Range Flat Fan</b>	<b>Standard Flat Fan</b>	<b>Drift Guard Flat Fan</b>	<b>Twin Flat Fan</b>	<b>Turbo Flood Wide Angle</b>	<b>Full Cone</b>	<b>Flood Nozzle Wide Angle</b>	<b>Raindrop Hollow Cone</b>
<b>Herbicides</b>									
Soil-incorporated	Good			Very Good		Very Good	Very Good	Good	Good
Pre-emerge	Very Good (on low pressure)	Good	Very Good			Very Good	Very Good		Good
Post-emerge Contact	Good	Good			Very Good				
Post-emerge Systemic	Very Good (on low pressure)	Good	Very Good			Very Good			Good

# Nozzle selection



Understand the pesticide chemistry

Follow label recommendation for droplet size

	 PSI	 110°XR/XRC	 TT	 TTJ60	 AIXR	 AI3070	 AITTJ60	 110°AI/AIC	 TTI	GPM
		15-60 PSI	15-90 PSI	20-90 PSI	15-90 PSI	20-90 PSI	20-90 PSI	30-115 PSI	15-100 PSI	
<b>04</b> AI AIC AITTJ60 AIXR AI3070 TT TTI TTJ60 XR XRC (50)	20	M	VC	VC	XC	UC	UC	—	UC	0.28
	30	M	C	C	XC	XC	XC	UC	UC	0.35
	40	M	C	C	VC	VC	VC	XC	UC	0.40
	50	F	M	M	VC	VC	VC	VC	UC	0.45
	60	F	M	M	VC	VC	C	VC	UC	0.49
	70	—	M	M	C	C	C	VC	UC	0.53
	80	—	M	M	C	C	M	VC	XC	0.57
90	—	M	M	C	C	M	VC	XC	0.60	

# Summary



Oregon State  
University

- Calibrate periodically
- Visually inspect spray pattern
- Replace old or worn nozzles
- Select the right nozzle for the job

# Additional resources



Oregon State  
University

<https://pesticidestewardship.org/calibration/>

<https://sprayers101.com/>

Nozzles: Selection and Sizing (Virginia Tech publication)

[https://pubs.ext.vt.edu/content/dam/pubs\\_ext\\_vt\\_edu/442/442-032/442-032\\_pdf.pdf](https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/442/442-032/442-032_pdf.pdf)

Ozkan, E. Calibrating boom sprayers. Ohio State University Extension publication AEX-520, Columbus, Ohio

Nozzle Manufacturer website

# Questions?

**Marcelo L Moretti**

**Assistant Professor, Dept. of Horticulture**

**[marcelo.moretti@oregonstate.edu](mailto:marcelo.moretti@oregonstate.edu)**

**(541) 737 -5454**