Increasing Pesticide Efficacy Through Proper Application Technique

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Current professional work / research interests:

I currently work as a Regional Agronomist for Winfield Solutions in Eastern Iowa. My job is to educate farmers and agronomists about agronomic principals, and help them understand what is going on in their fields and how they can optimize their yields while still maintaining the quality of their fields.

Module Contents

Chapter 1: Introduction

Chapter 2: Sprayer Calibration

Chapter 3: Maintaining a Good Spray Pattern

Chapter 4: Selecting the Proper Nozzle Output

Chapter 5: Selecting the Proper Nozzle

Chapter 6: Managing Drift

Chapter 7: Increasing Deposition/Coverage

Chapter 8: Adjuvants and Surfactants

Chapter 9: General Mixing Order

Chapter 10: General Cleaning Procedures

Chapter 11: Summary

Chapter 12: Test

Chapter: 1 Introduction

- Pesticides being placed in a spray tank does a farmer no good if they do not reach the site of action in the pest that the pesticide is trying to control.
    - This learning module is designed to help agronomist understand how an application can be made to see the full benefit of the pesticides that are going into the spray tank.
    - This module is designed to help avoid problems like the one shown below.

Rickard, 2013

Chapter 2: Sprayer Calibration

Importance

Even application of chemical across the whole boom

Correct chemical dosage on the weeds

Mix enough product to spray the entire field

Nozzle code

First letters on a spray nozzle tells the type of spray nozzle

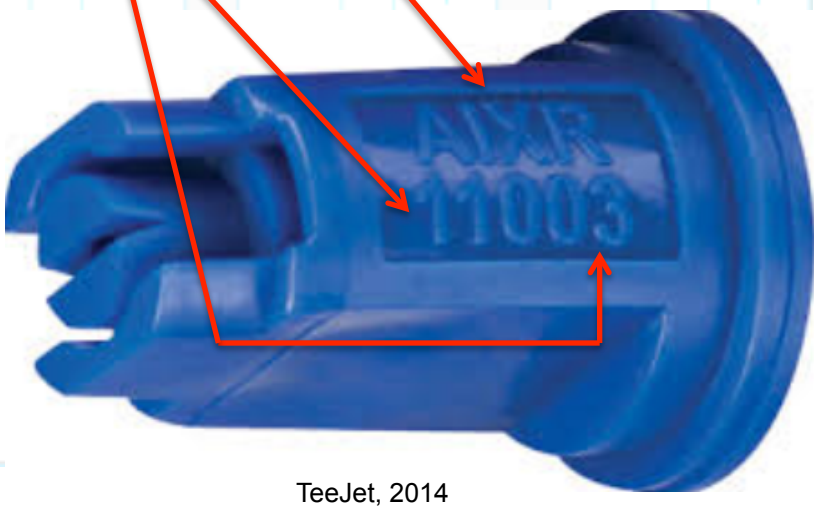
Example: AIXR

First set of 2 or 3 numbers is the width of the pattern

Example: 110 Degrees

Last 2 numbers are the gallons per minute at 40 PSI

Example: 0.3 Gallons per minute



TeeJet, 2014

Chapter 2: Sprayer Calibration

Measuring cup method

1. Set sprayer to 40 PSI
2. Hold a measuring cup under nozzle for 15 seconds
3. Take measurement in ounces per 15 seconds
4. Multiply results by 4 to get ounces per minute
5. Divide results by 128 to get gallons per minute

TeeJet, 2014

Spot on spray calibrator method

1. Turn calibrator on
2. Switch to Gal/Min
3. Set sprayer to 40 PSI
4. Hold calibrator below the nozzle at slight angle
5. Wait till read out is displayed

TeeJet, 2014

Chapter 3: Maintaining a Good Spray Pattern

Maintain proper boom height

- Determined by nozzle spacing and degree of fan
- The chart below shows the relationship of boom height and nozzle angle to the amount of spray overlap.
- For ideal spray coverage, the nozzles should provide 100% overlap
- If a boom is set up on 20 inch nozzles spacing's with 110 degree nozzles, the lowest boom height that will provide 100% overlap would be 15 inches.

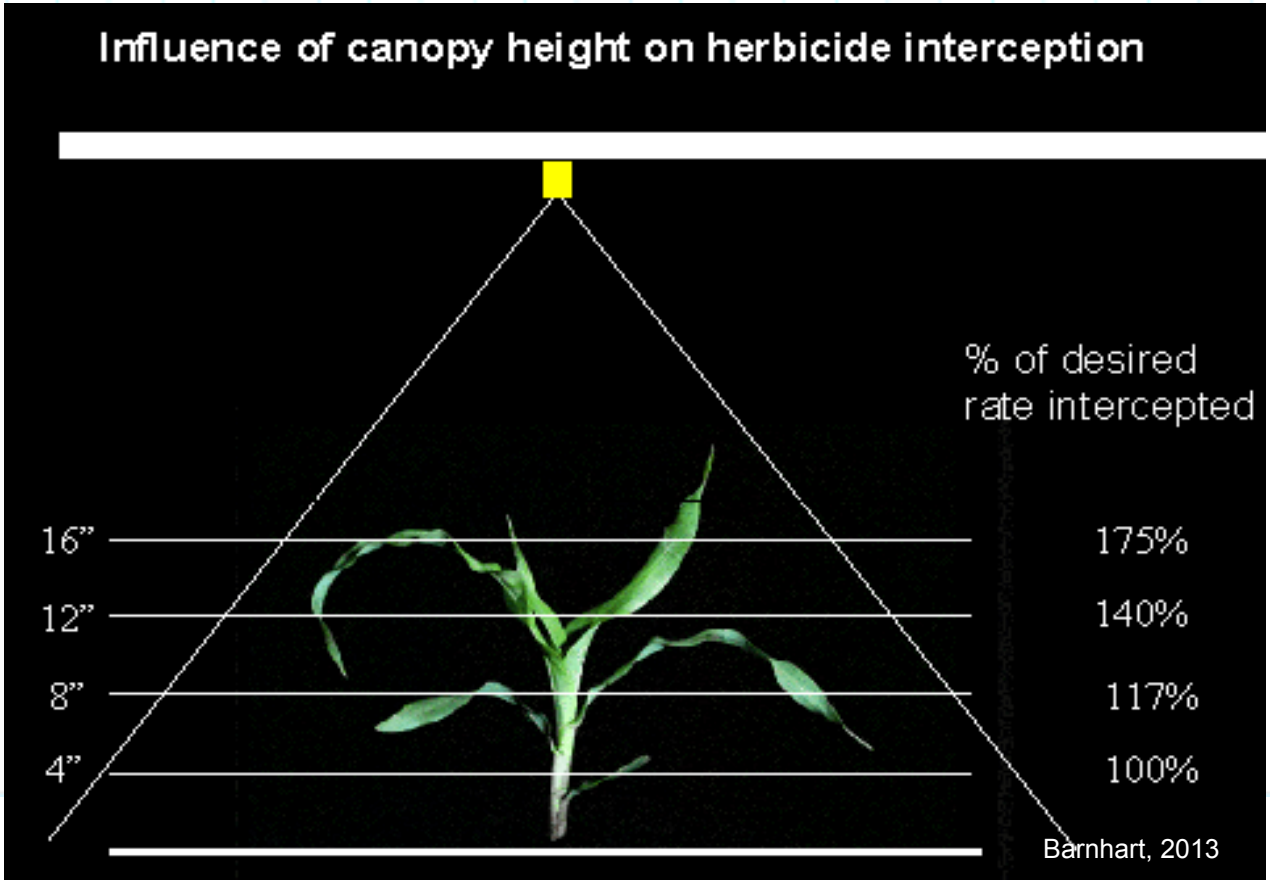
Nozzle Angle	Recommended Minimum Nozzle Height Over Target (inches)			
	20” Nozzle Spacings		30” Nozzle Spacings	
	30-50% Overlap	100% Overlap	30-50% Overlap	100% Overlap
73 Degree	20	NR	29	NR
80 Degree	17	24	26	NR
110 Degree	10	15	14	24

Barnhart, 2013

Chapter 3: Maintaining a Good Spray Pattern

Maintain proper boom height

- Improper boom height can increase the amount of chemical being applied to a crop row
- This picture shows that the target height was at 4 inches, but the canopy height was at 16 inches.
- This example would indicate that 175% of the desired rate is being put overtop of the corn plant because the boom height was too close to the canopy.



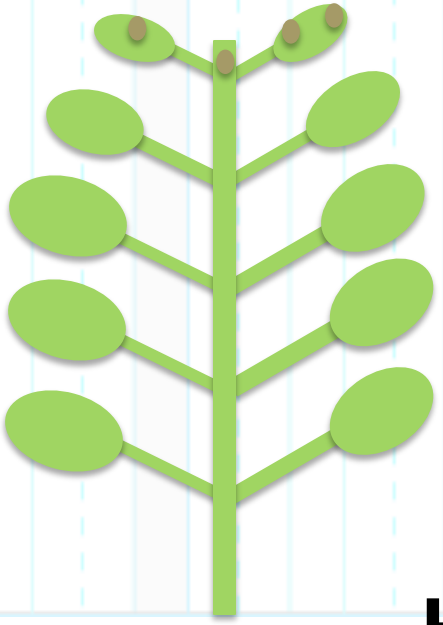
Chapter 4: Selecting a Proper Nozzle Output

- **Desired gallons per acre must be determined to decide nozzle output**
  - This will depend on what type of chemical is being sprayed
    - Contact pesticides once in the plant do not move from where the droplet landed
      - Examples
        - Strobilurin fungicides
        - Fomesafen
        - Glufosinate
      - Use high volumes of water and a small droplet size
    - Systemic pesticides once in the plant move throughout the entire plant.
      - Examples
        - Dicamba
        - 2-4D
        - Glyphosate
      - Larger droplet sizes with lower volumes of water can be used

Chapter 4: Selecting a Proper Nozzle Output

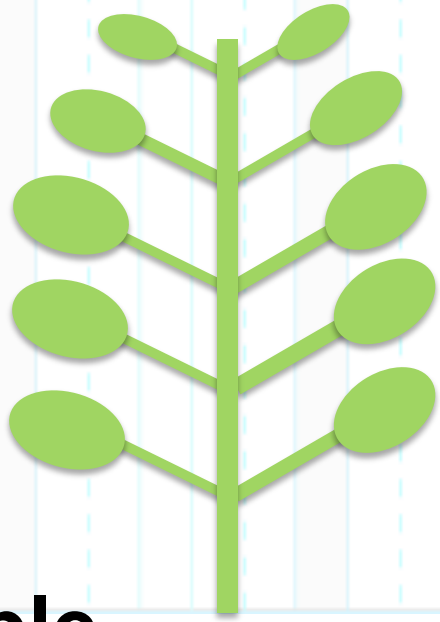
Contact

- Coverage is extremely Important
  - High carrier volumes
  - Small droplets



Systemic

- Coverage not as important
  - Lower carrier volumes
  - Larger droplets



Herbicide Example

Chapter 4: Selecting a Proper Nozzle Output

- **Here are a few examples of pesticides showing activity as contact or systemic**

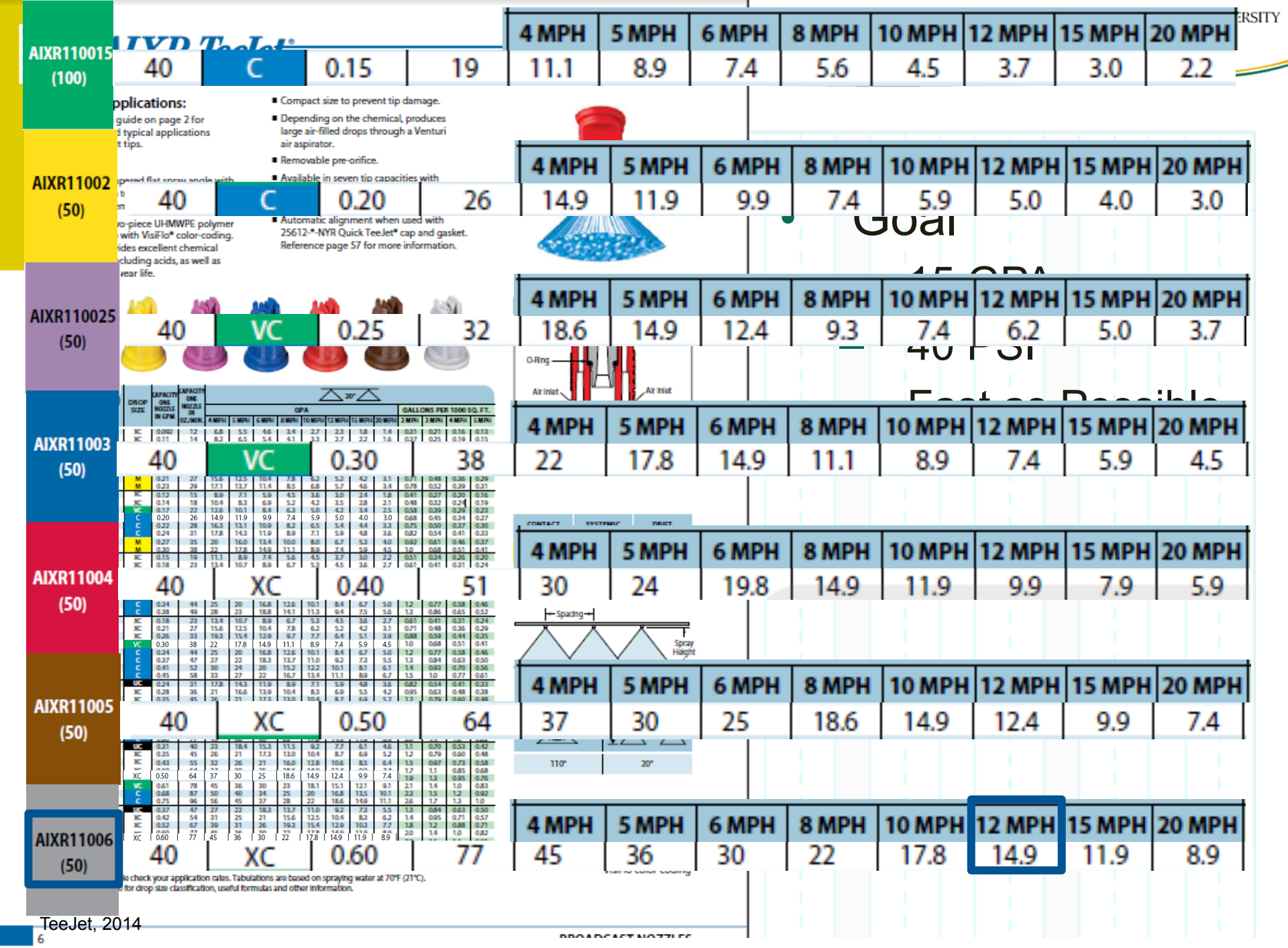
Contact (non -translocated)	Intermediate*	Systemic (translocated)	
Aim	Atrazine	Accent	Glyphosate
Authority/Spartan	Princep/	Ally	Balance
Basagran	Simazine	Amber	Beacon
Blazer	Sencor	Assure II	Exceed, Spirit
Buctril/Moxy	Command	Callisto	Glean
Cobra	Liberty	Classic	Permit
Gramoxone	Ignite	Fusilade	Harmony
Flexstar		Poast Plus	Peak
Reflex		Banvel/Sterling	Stinger
Resource		Clarity	Basis
Ultra Blazer		2,4-D & 2,4-DB	Tordon
		MCPA	Scepter
		Pursuit	Laudis

* Command & triazine herbicides move upward from roots to leaves when soil applied, but not down from foliage to the roots if post applied. Liquid fertilizer can provide contact action. Simazine is not as effective post as other triazines.

Barnhart, 2013

Chapter 4: Selecting a Proper Nozzle Output

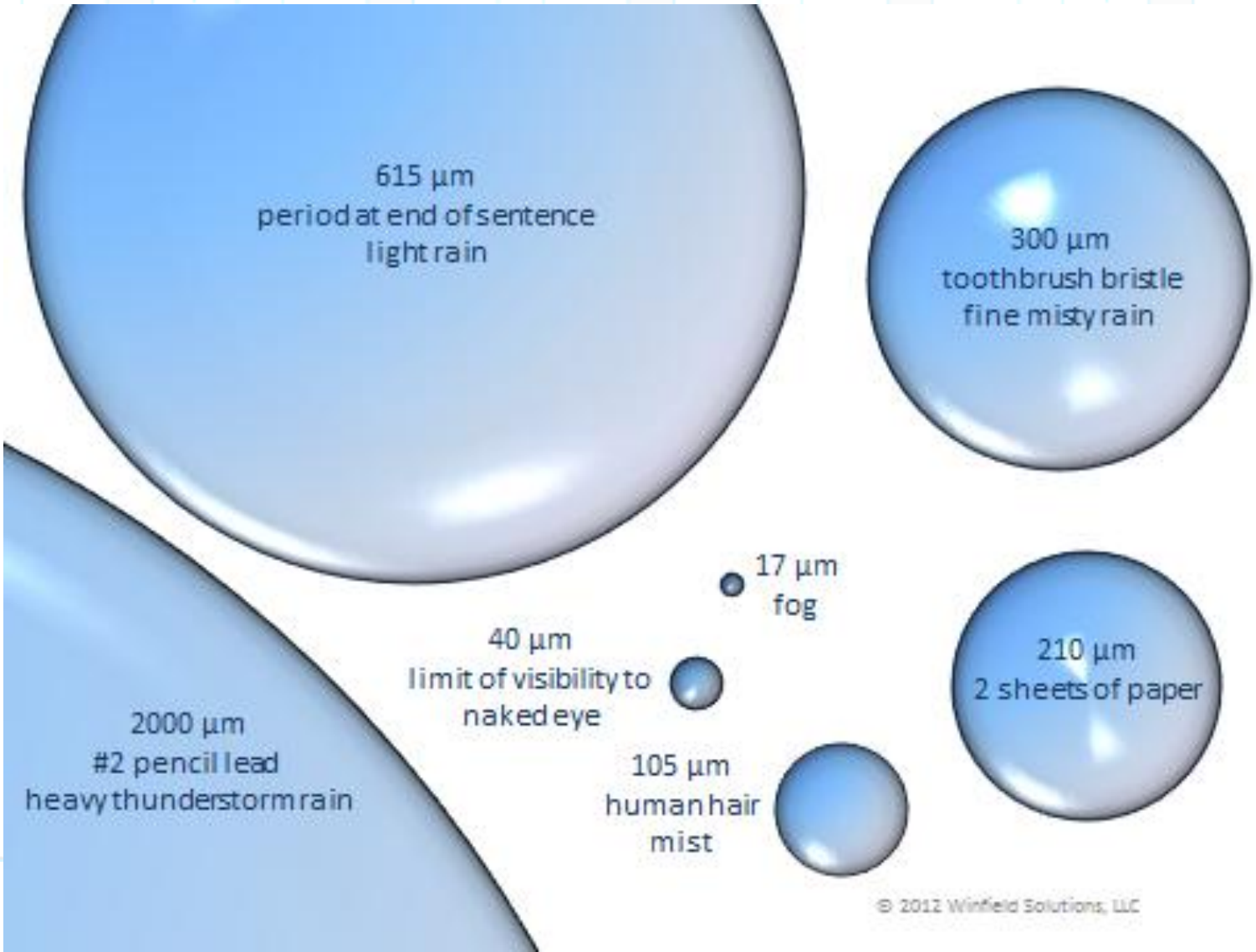
- **Nozzle output selection is based on**
  - Gallons per acre desired
  - Speed
  - Nozzle orifice size
  - Nozzle pressure
- **Once nozzle output conditions are determined, nozzle manufacturer charts can be used to figure out which nozzle size is needed.**
  - 1st select the pressure the nozzle should be run at
  - 2nd select the speed that the sprayer will be running at
  - 3rd move down the chart to find the desired gallons per acre
  - 4th select the proper nozzle size based on the above information
  - The next few slides give some samples of how to use the manufacture's charts to come up with the correct nozzle orifice size.



Goal- Volume- 15 GPA, Pressure- 40 PSI, Speed- Fast as Possible

Chapter 5: Selecting the Proper Nozzle

- **Micron size comparisons**



Chapter 5 Video: Selecting the Proper Nozzle, spray patterns

Nozzle Spray Patterns

https://www.youtube.com/watch?v=dmuqKQrVNZ8&feature=player_detailpage

Chapter 6: Managing Drift

- **Why manage drift?**
  - Drift can cause off target injury
  - Drift reduces the amount of chemical being applied
- **Ways to decrease drift**
  - Decrease spray pressure
    - Slow down
    - Increase the size of the nozzle orifice
    - Use of Pulse Width Technology
  - Change spray tips to tips with larger droplet sizes
  - Use a drift control agent
- **What are different factors that effect drift**
  - Droplet size
  - Wind speed
  - Boom height
  - Pesticide being sprayed

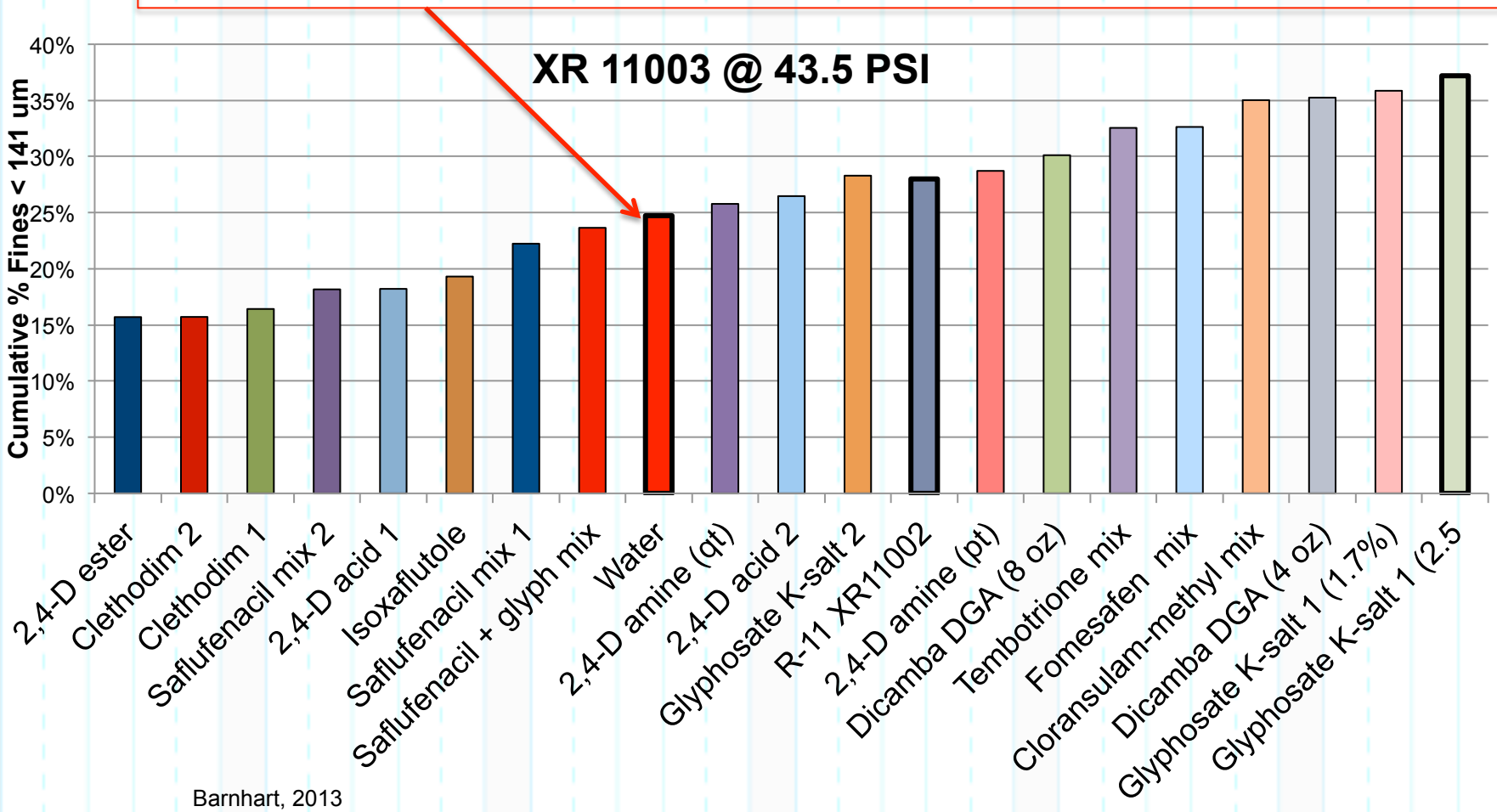
Chapter 6: Managing Drift

Pressure Comparison

https://www.youtube.com/watch?v=Ykkm5uhwSKk&feature=player_detailpage

Chapter 6: Managing Drift

- **Effect of herbicide on percentage of driftable fines**
  - Notice that every herbicide to the right of this bar increases driftable fines



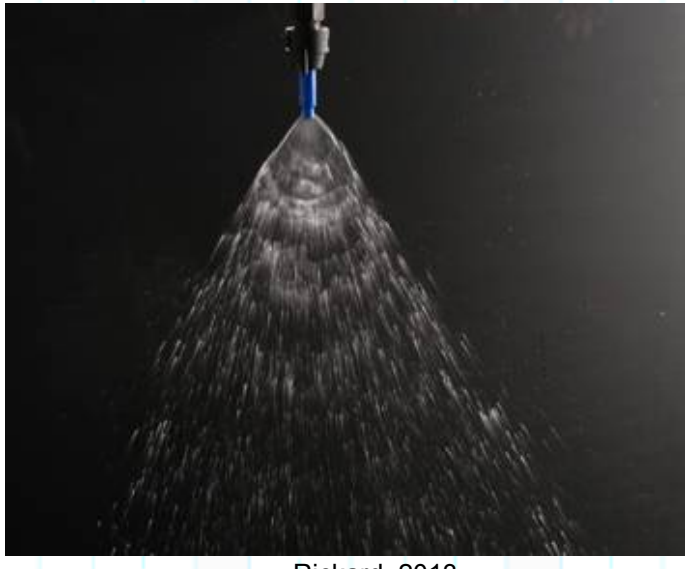
Barnhart, 2013

Chapter 6: Managing Drift

- **Types of Drift Control Agents**
  - **Thickeners or viscosity modifiers**
    - These products thicken up the solutions by changing the viscosity of the solution
    - They work by lumping the fine droplets together
    - These products will also increase the size of larger droplets
    - Viscosity modifiers may decrease the efficacy of certain pesticides
    - These should not be used with Air Induction Nozzles
  - **Encapsulators**
    - These products suspend the pesticide in capsules which are too large to fit in a small droplet
    - They work by greatly decreasing the amount of herbicide in the driftable fines
    - These products do not change the look of the spray
  - **Spray droplet modifiers**
    - Reduces drift by reducing the number of fine droplets
    - This product works differently than the viscosity modifiers because it does not effect the viscosity of the solution
    - This product works by narrowing the range of different sized droplets coming out of a spray nozzle.
    - These products do not decrease pesticide efficacy
    - Droplet modifiers can be used with any spray nozzle

Chapter 6: Managing Drift

- **Increasing the viscosity of a spray solution can reduce the fan width on air induction nozzles.**



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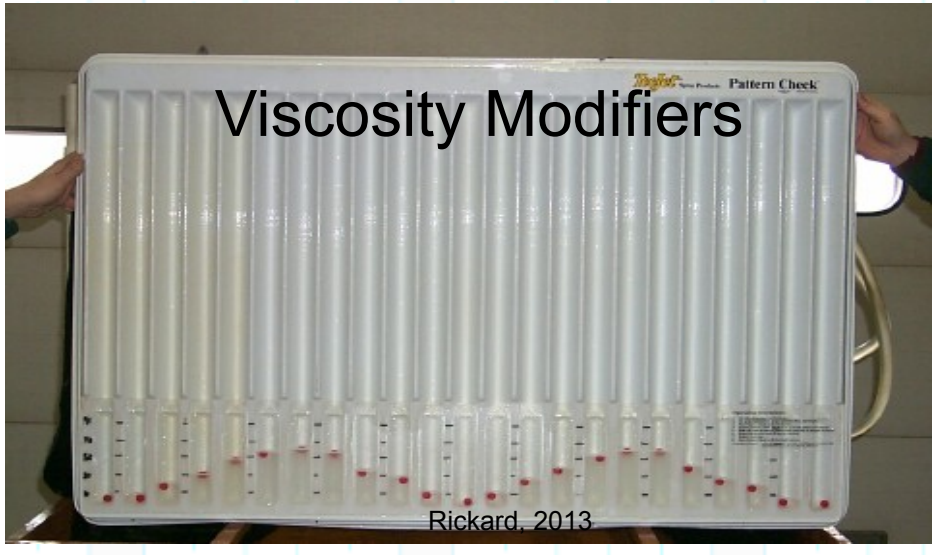

Rickard, 2013

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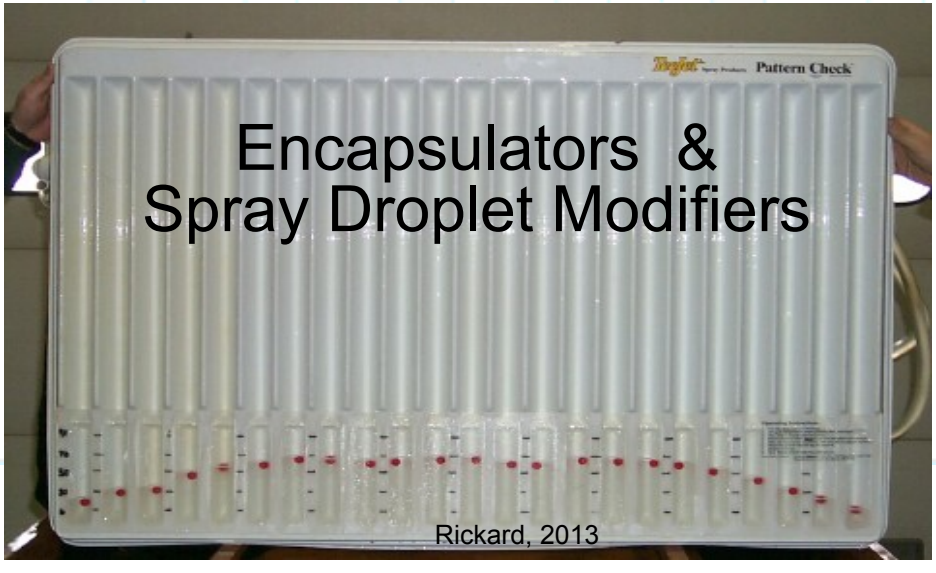
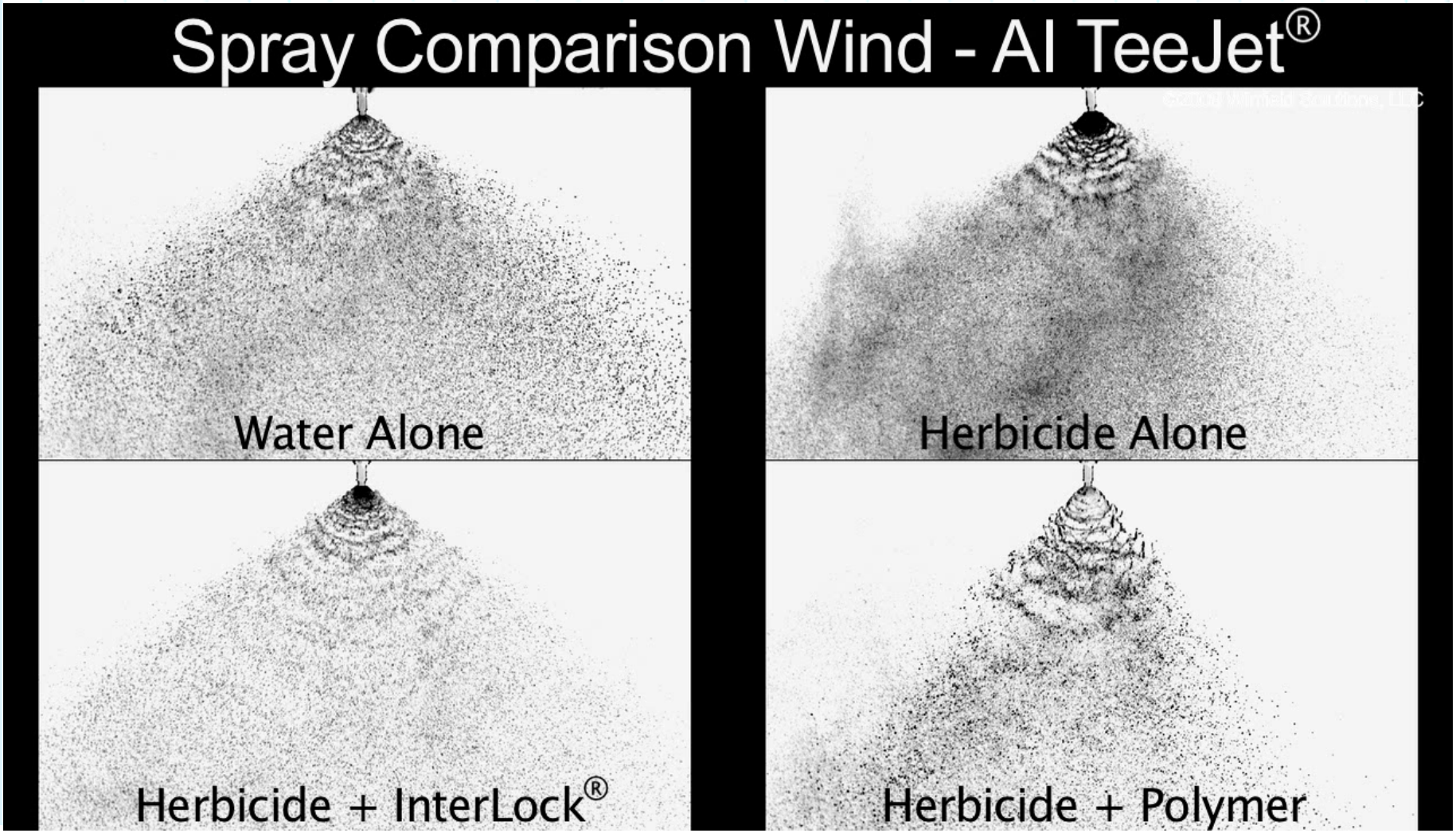


Rickard, 2013

Chapter 6: Managing Drift

Interlock- Spray Droplet Modifier
Polymer- Viscosity Modifier

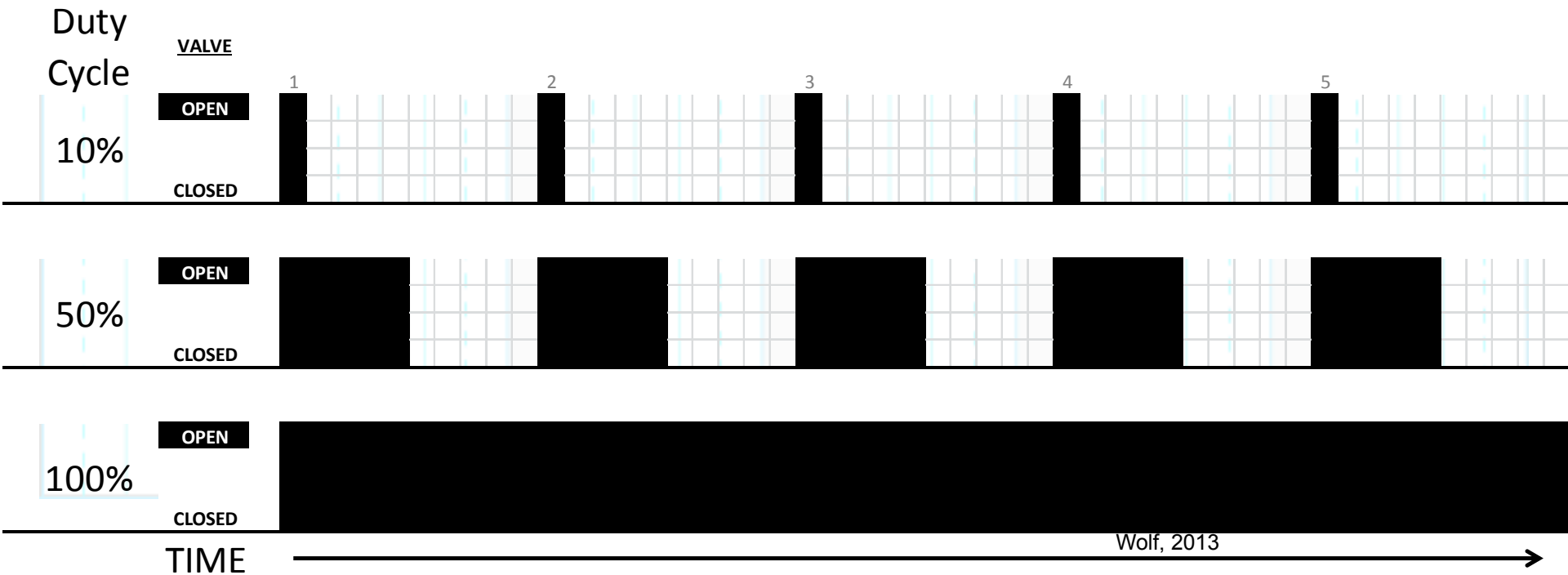
- **Use a drift control agent**




Wolf, 2013

Chapter 6: Managing Drift

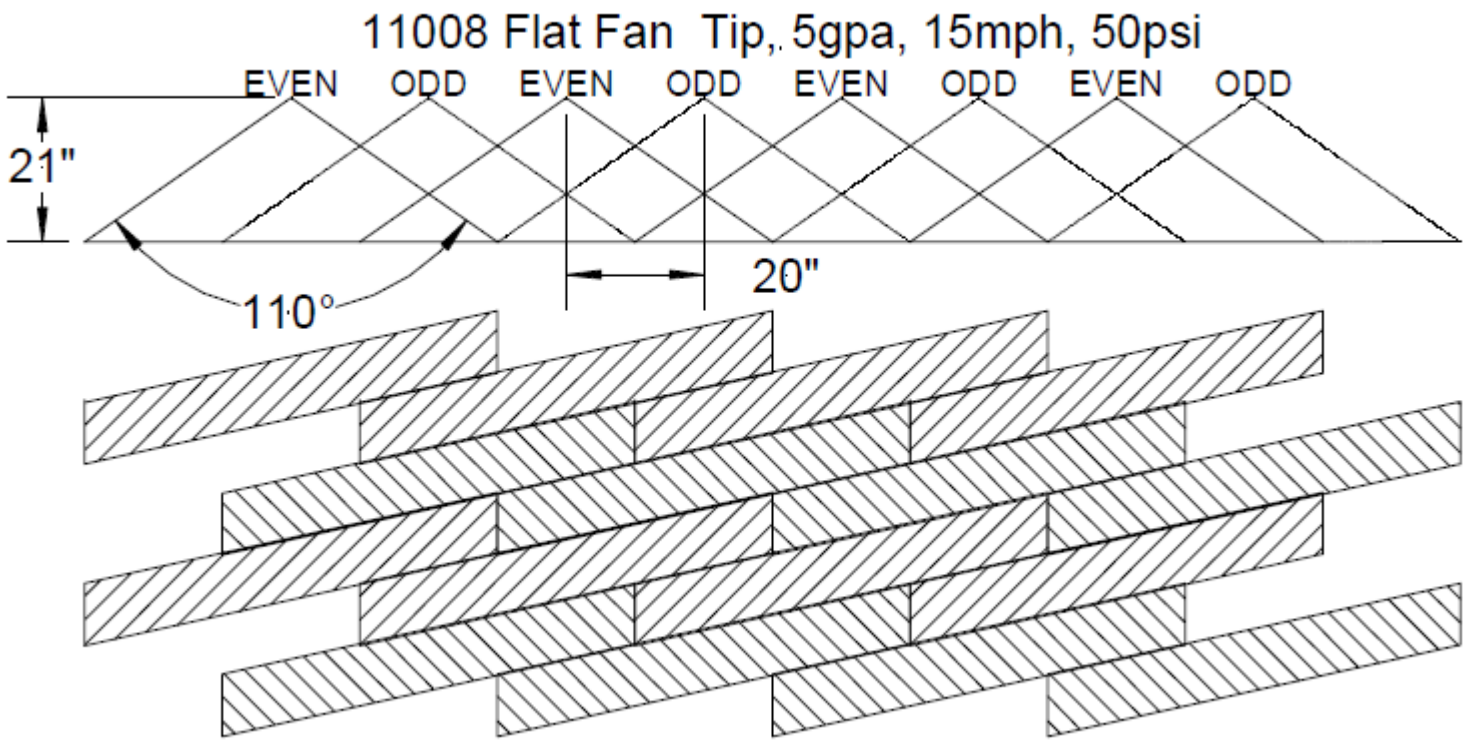
- **Pulse width technology**
  - Decouples flow rate from application pressure
  - Solenoids are used to rapidly shut the spray pattern on and off at a rate of 10 times per second
  - The flow rate is controlled by varying the width of the pulse.
  - The longer the pulse width, the more chemical is put through the spray tip
    - This change in the width of the pulse is referred to as the duty cycle
  - As the sprayer speeds up, the duty cycle is increased to increase the flow rate through the nozzle. All of this is done without increasing the pressure at the nozzle tip which decreases the drift potential.



Wolf, 2013

Chapter 6: Managing Drift

- **Pulse width technology**
  - When one nozzle is on, its neighboring nozzle is off. This offset pattern provides an even application as long as proper boom height is maintained



Wolf, 2013

Increasing pressure can decrease droplet size and canopy penetration

Wolf, 2013

Chapter 7: Increasing Deposition/Coverage

- **Small droplets decrease terminal velocity which decrease the amount of time for evaporation and the amount of pesticide that penetrates the canopy**

Droplet Diameter (microns)	Terminal Velocity (ft/sec)	Final Drop diameter (microns)	Time to evaporate (sec)	Deceleration distance (in)
20	.04	7	0.3	<1
50	.25	17	1.8	3
100	.91	33	7	9
150	1.7	50	16	16
200	2.4	67	29	25

*Conditions assumed: 90 F, 36% R.H., 25 psi., 3.75% pesticide solution

Schoper, 2010

Chapter 8: Adjuvants and Surfactants

- **Adjuvants are materials added to a spray tank to aid or modify the action of a chemical**
  - Some adjuvants are made to increase the efficacy of the spray solution
  - Some adjuvants are made to increase ease of handling for a particular chemical
- **Surfactants are Surface Acting Agents**
  - These products change the surface tension of the water usually reducing it to increase droplet spread on a leaf
  - All surfactants are adjuvants, but not all adjuvants are considered surfactants
    - Those adjuvants that do not effect the surface tension of water are not considered surfactants
- **Adjuvant usage**
  - Certain adjuvants will increase the activity of some pesticides while decreasing the effectiveness of other pesticides, so it is important to know which adjuvant to use with which type of application.
  - Pesticide labels will often tell a user which type of adjuvant should be used with a particular product.

Chapter 8: Adjuvants and Surfactants

Sufactants

Mode of action: decrease surface tension of water
Preference is a non ionic surfactant
Interlock is a spray droplet modifier

https://www.youtube.com/watch?v=SqxV5RnvRm4&feature=player_detailpage

Chapter 8: Adjuvants and Surfactants

- **Crop Oil Concentrates (COC)**
  - Increases efficacy of certain herbicides by increasing the amount of herbicide that moves through the waxy layers of the leaf surface
  - Oils can also help with droplet spreading across the leaf surface
  - Certain formulations of this product can decrease the efficacy of glyphosate
  - Only use High surfactant oil Concentrates (HC) formulations with glyphosate
  - The example below shows the increase efficacy with a COC on an ACCase group 1 herbicide

Without Crop Oil Concentrate

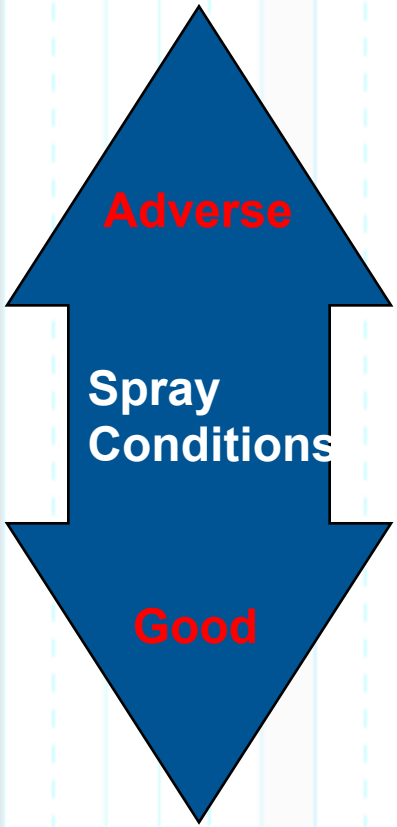
Barnhart, 2013

With Crop Oil Concentrate

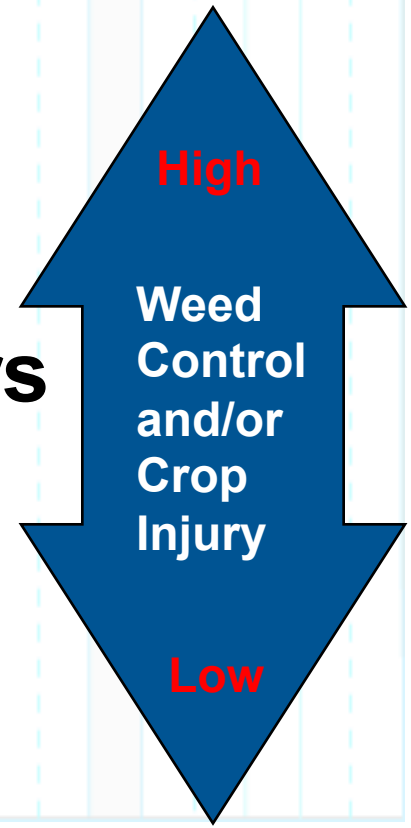
Barnhart, 2013

Chapter 8: Adjuvants and Surfactants

- **Adjuvant recommendations may change depending on**
  - Weather conditions
  - Weed height
  - Crop stage and height

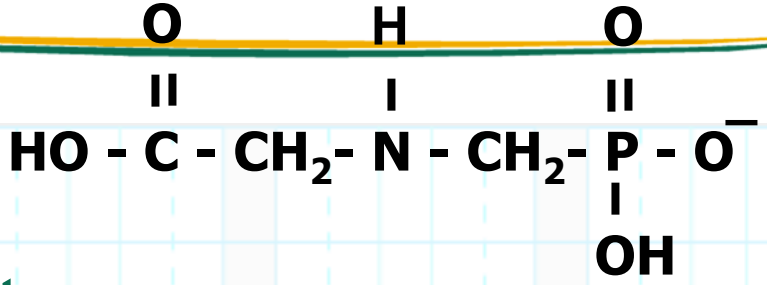


Oils and Fertilizers
Methylated Seed Oils
Crop Oil Concentrates
Surfactants and Fertilizers
Nitrogen Fertilizers
Silicone Surfactants
Non-Ionic Surfactants

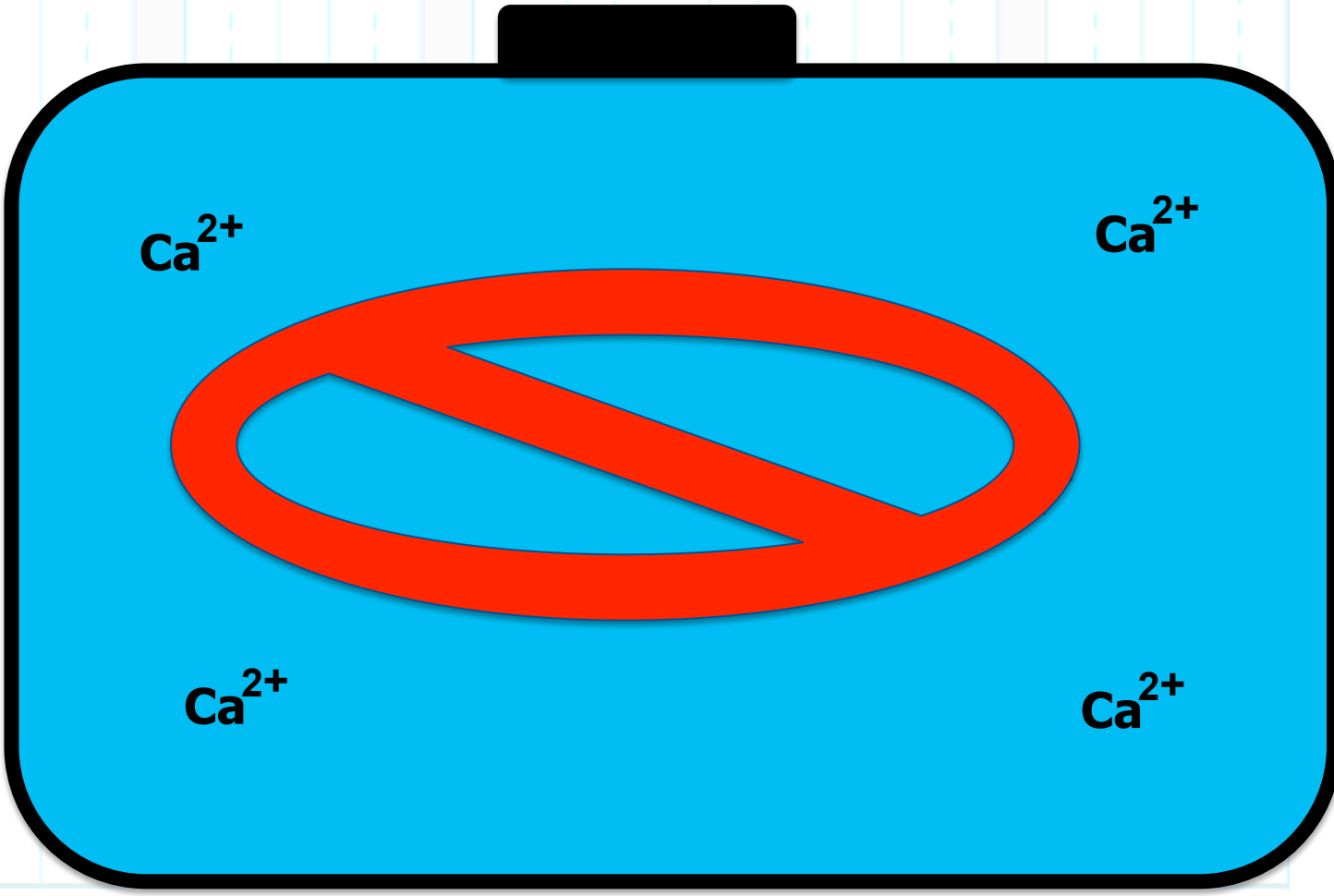


Barnhart, 2013

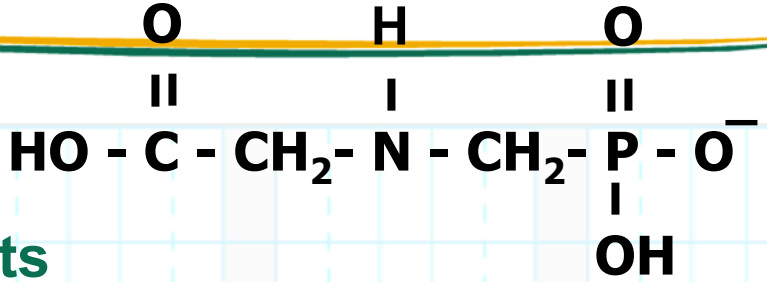
Glyphosate Molecule →



Chapter 8: Adjuvants and Surfactants

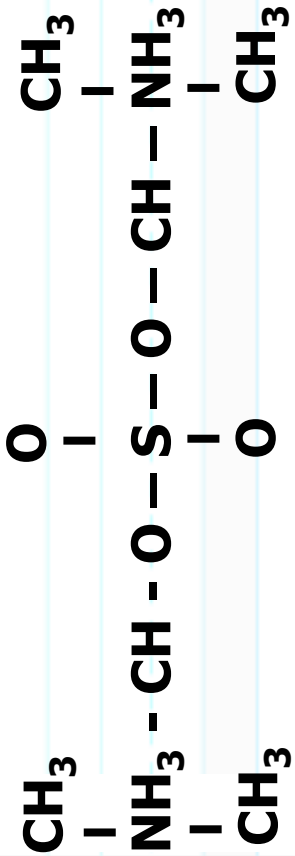


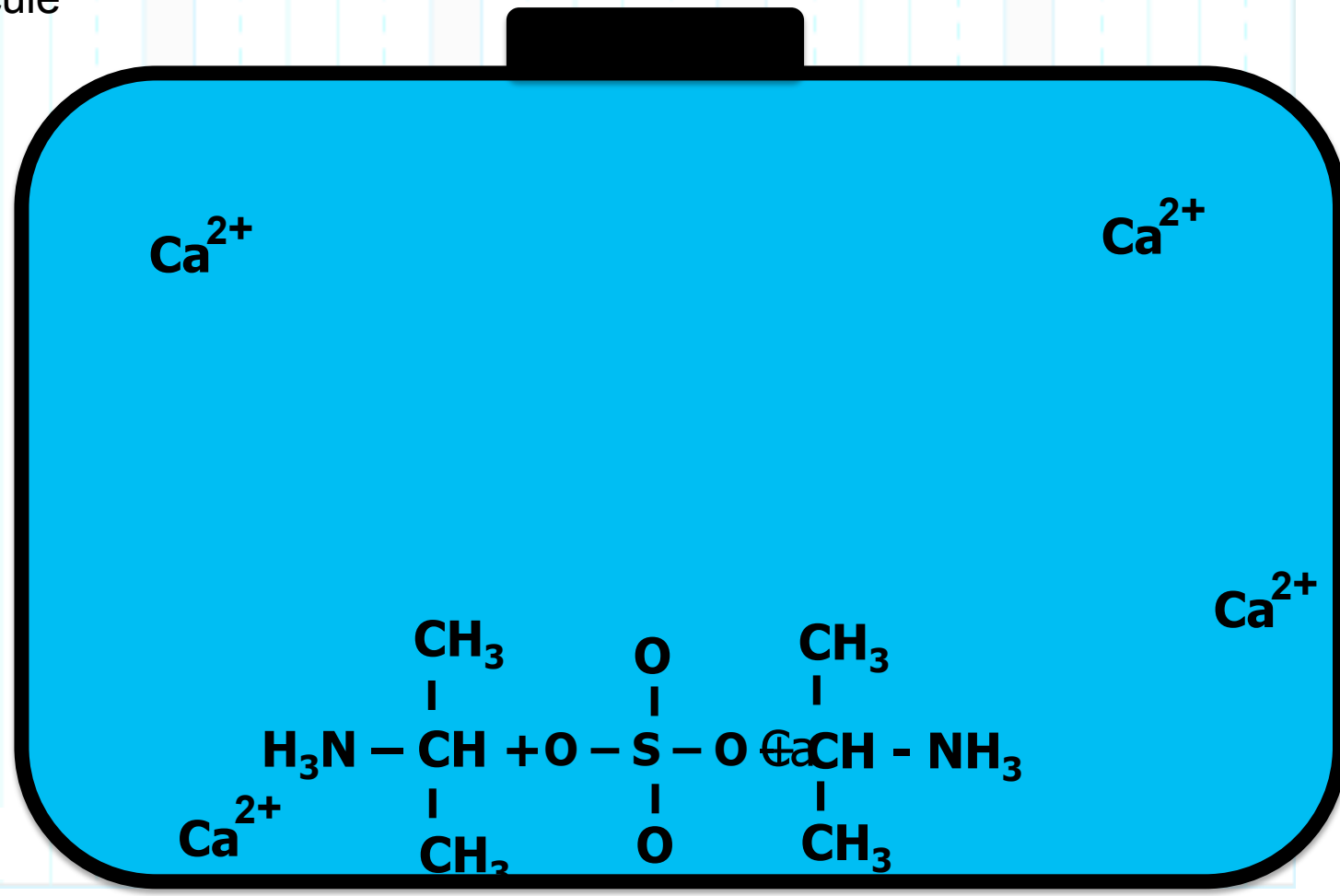
Glyphosate Molecule →



Chapter 8: Adjuvants and Surfactants

Ammonium Monosulfate Molecule (AMS)





Chapter 8: Adjuvants and Surfactants

- **Here are two different water analysis reports, notice that both of them require a different amount of AMS to counteract the Cations in the solution**

Spray Water Analysis Report

Agriliance B.D.M.	=					
Company Name:	=					
Mailing Address	=					
City	=					
State	=					
Zip	=					
Phone	=					
Water Source	=	WELL				
Sample ID.	=	1 GRAFTON, IA SAMPLE				
Date Received	=	10-18-04				
Date Reported	=	10-20-04				
AGVISE Lab No		10788			Antagonism Coefficient	A.M.S. Requirement
pH			7.4			
Sodium			19	ppm	x 0.005* =	0.09402
Calcium			52	ppm	x 0.009* =	0.46652
Magnesium			10	ppm	x 0.014* =	0.1466
Potassium			6	ppm	x 0.002** =	0.01226
Hardness			173	mg equivalent CaCO3/L		
SAR (Sodium Adsorption Ratio)			0.62			
Recommended AMS required for 100 gallons of water =						**0.72** lbs AMS

Note: The amount of AMS given above is an estimate of the amount required to overcome the antagonistic effect of the cations in your water. This estimate is based on the cations listed above and the coefficients provided by North Dakota State University* and Agriliance **.

Schoper, 2010

Spray Water Analysis Report

Winfield Solutions AM	=						
Company Name:	=						
Mailing Address	=						
City	=						
State	=						
Zip	=						
Phone	=						
Water Source	=	CITY					
Sample ID.	=	NA					
Date Received	=	12-20-12					
Date Reported	=	12-21-12					
AGVISE Lab No		12-10846			Antagonism Coefficient	A.M.S. Requirement	
pH			7.7				
Sodium			248	ppm	x 0.005* =	1.23918	
Calcium			320	ppm	x 0.009* =	2.88056	
Magnesium			140	ppm	x 0.014* =	1.96266	
Potassium			14.0	ppm	x 0.002** =	0.028	
Iron			0.301	ppm	x 0.014* =	0.00421	
Hardness (mg equivalent CaCO3/L)			1386	ppm			
SAR (Sodium Adsorption Ratio)			2.91				
Recommended AMS required for 100 gallons of water =						**6.11**	lbs AMS

Note: The amount of AMS given above is an estimate of the amount required to overcome the antagonistic effect of the cations in your water. This estimate is based on the cations listed above and the coefficients provided by North Dakota State University* and Winfield Solutions **.

Barnhart, 2013

Chapter 8: Adjuvants and Surfactants

- **High fructose corn syrup and alkyl polygulcoside (CornSorb Technology)**
  - Increases leaf uptake of herbicides and micronutrients
    - Increases humectancy of solution
      - Keeps the droplet wetter longer
    - Increase uptake through the waxy layers on the leaf


Wolf, 2013

Chapter 9: General Mixing Order

- **General pesticide mixing order**
- **Wales or dales method**
  - Fill the sprayer half way full of water
  - (D/W) Add Wettable powders, Water dispersible granuales, and/or Dry flowables
    - If formulations are having trouble dissolving, consider pre-slurrying them in a bucket of water and than adding them to the tank especially when mixing with liquid fertilizer
  - (A) Agitate
  - (L) add Liquid formulations
  - (E) add Emulsified concentrates
- **Other considerations**
  - Surfactants, oils, and drift control agents should be added last
  - If a compatibility agent is required, it should be the first thing in the tank
  - AMS and adjuvants containing AMS should be added before herbicides requiring water conditioning agents (glyphosate, Liberty, etc.)
  - Suspension Concentrates (SC) formulations should be added to the tank first because of the reduction in solubility at lower pH's


Wolf, 2013


Wolf, 2013

Chapter 10: General Cleaning Procedures

- **General cleaning guidelines**
  - Most sprayer contamination occurs in the lines and tips rather than the tank
    - Make sure to look for dead spots in the sprayer
      - Dead spots are any areas on the sprayer that do not have flowing water through them during operation
        - This could be a line off the manifold that is not in use such as a fence row sprayer
        - The more common area where this occurs is in a wet boom where the line extends past the last nozzle and is capped at the end
      - These dead spots can have chemical hang up in them, every time the sprayer is stopped, some of that chemical dissolves back into the line
        - Example: It takes as little as 0.0005 ounces/acre to see visual damage to soybeans with Dicamba and only 0.04 ounces/acre to have yield loss
  - To help avoid contamination in the lines, flush with water and tank cleaner after every day of spraying

Rickard, 2013

Chapter 11: Conclusion

- Adding pesticides into a spray tank does not guarantee that the pesticide will make it to the site of action to kill the pests.
- Applicators can increase the chances of controlling pests by
  - Calibrating the sprayer
  - Maintaining even applications across the entire boom
  - Choosing the right nozzles, droplet sizes, and gallons per acre
  - Controlling drift and managing deposition into the canopy
  - Using adjuvants
  - Mixing in the correct order
  - Cleaning the sprayer correctly after an application is finished

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