

# Making Applications More Difficult to Make Applications More Efficient

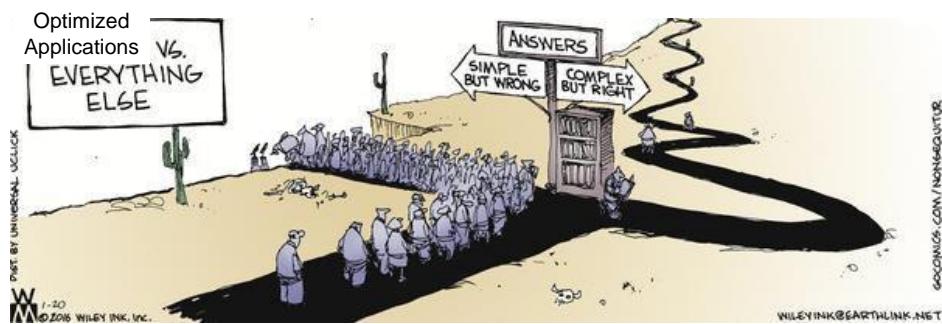
Greg R. Kruger  
Weed Science and Application Technology Specialist  
WCREC, North Platte, NE



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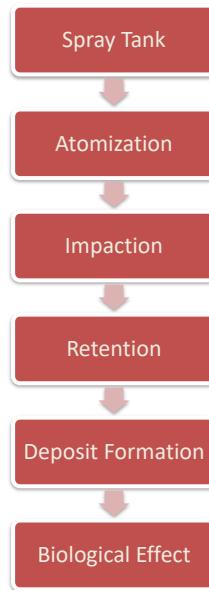
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## The Pesticide Application

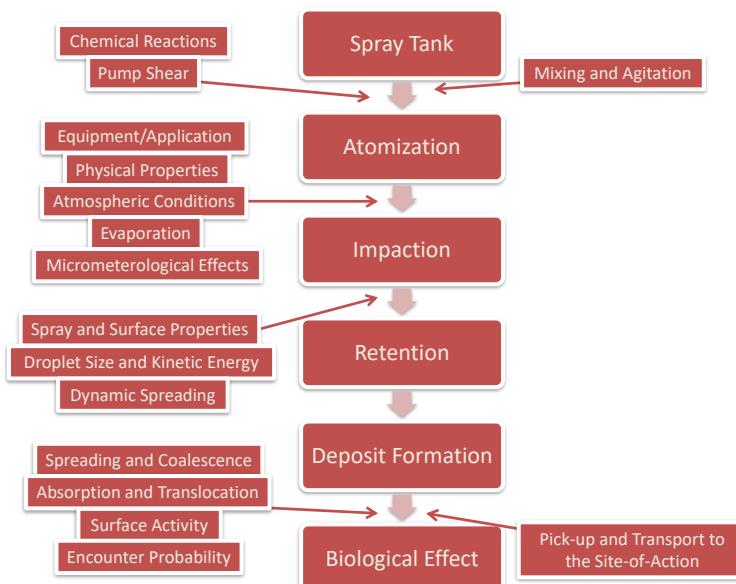


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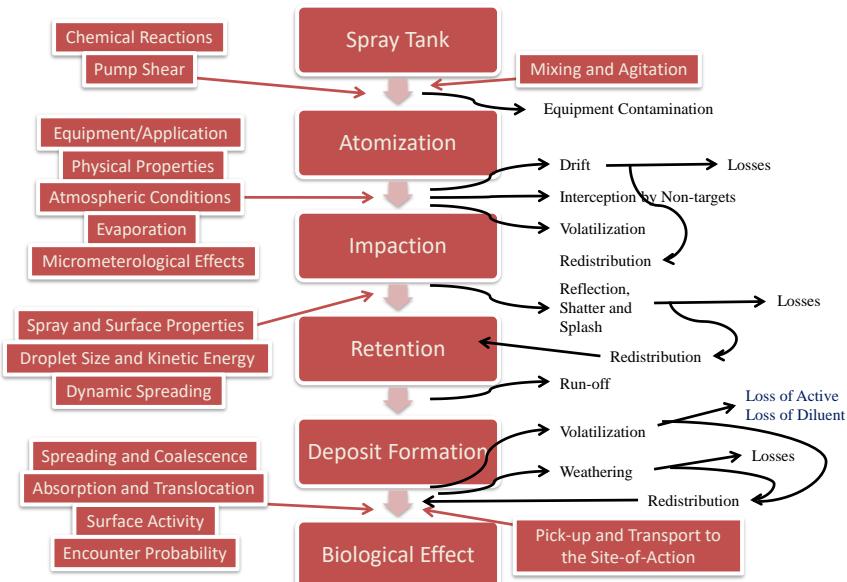
# Process for Pesticide Efficacy



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Ebert et al. 1999

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## Definition of Drift:

Movement of spray particles and vapors off-target causing less effective control and possible injury to susceptible vegetation, wildlife, and people.

Adapted from National Coalition on Drift Minimization 1997 as adopted from the AAPCO Pesticide Drift Enforcement Policy - March 1991

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## Types of Drift:

**Vapor Drift** - associated with volatilization  
(gas, fumes)

**Particle Drift** - movement of spray particles  
during or after the spray application

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## Particle Drift – *Big 4*

### 1. Wind Speed

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# Wind Speed



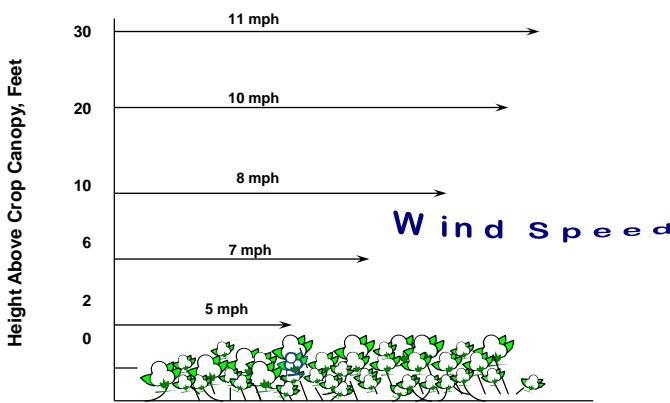
When the wind speed doubles, there is almost a 700% increase in drift when readings are taken from 90 feet downwind from the sprayer. Hence the recommendation of spraying in 10 mph winds or less.



**700% Increase** → **90 ft.**

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## Wind Speeds Gradients:



The relation between height above the canopy of a crop like cotton or soybean and the speed of wind.

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# Particle Drift – *Big 4*

1.Wind Speed

2.Boom Height

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## Boom Height

When the boom height was increased from 18 to 36 inches, the amount of drift increased 350% at 90 feet downwind.



350% Increase → 90 ft.

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# Particle Drift – *Big 4*

1.Wind Speed

2.Boom Height

3.Distance from  
Susceptible Vegetation

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## Distance Downwind



If the distance downwind is doubled, the amount of drift decreases five-fold. If the distance downwind increases from 100 to 200 feet, you have only 20% as much drift at 200 feet as at 100 feet.



80% Decrease

200 ft.

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# Particle Drift – *Big 4*

1. Wind Speed
2. Boom Height
3. Distance from Susceptible Vegetation
4. Spray Particle Size

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## Comparison of Micron Sizes (approximate values)

Pencil lead		2000 $\mu\text{m}$
Paper clip		850 $\mu\text{m}$
Staple		420 $\mu\text{m}$
Toothbrush bristle		300 $\mu\text{m}$
Sewing thread		150 $\mu\text{m}$
Human hair		100 $\mu\text{m}$

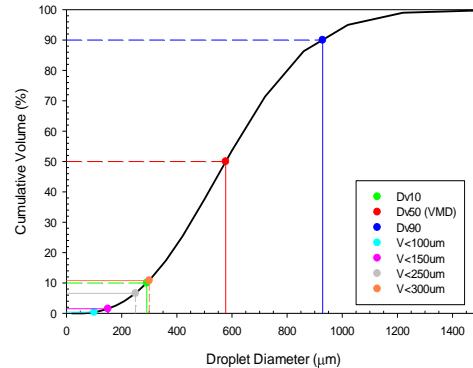
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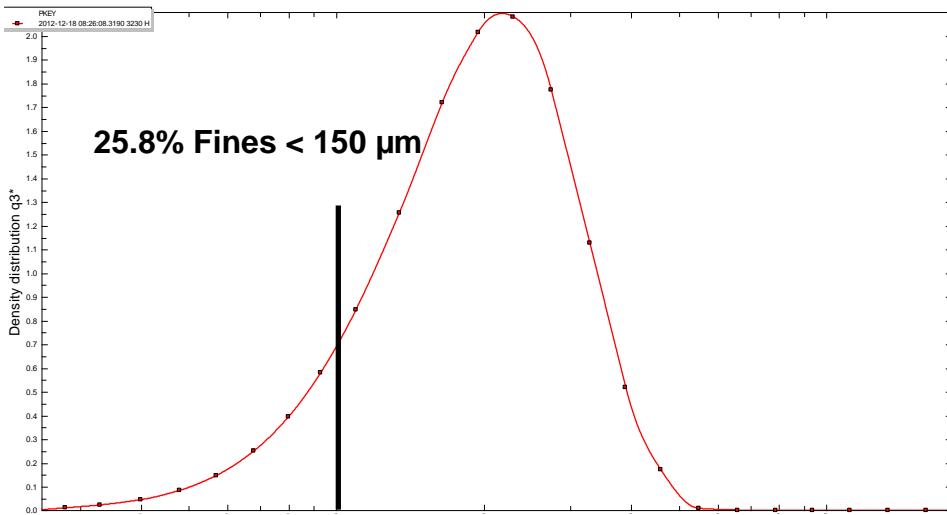
## Data Analysis

- Droplet size data were statistically analyzed using a full factorial response surface model
- Four main model factors along with potential interaction effects were evaluated
  - Nozzle
  - Application Volume Rate
  - Orifice Size
  - Formulation
- All possible factorial combinations of the four main factors were tested
- Percent fine droplets to relate to drift potential – Vol < 150  $\mu\text{m}$  (%)
- $D_{v0.5}$  (VMD) relates to efficacy



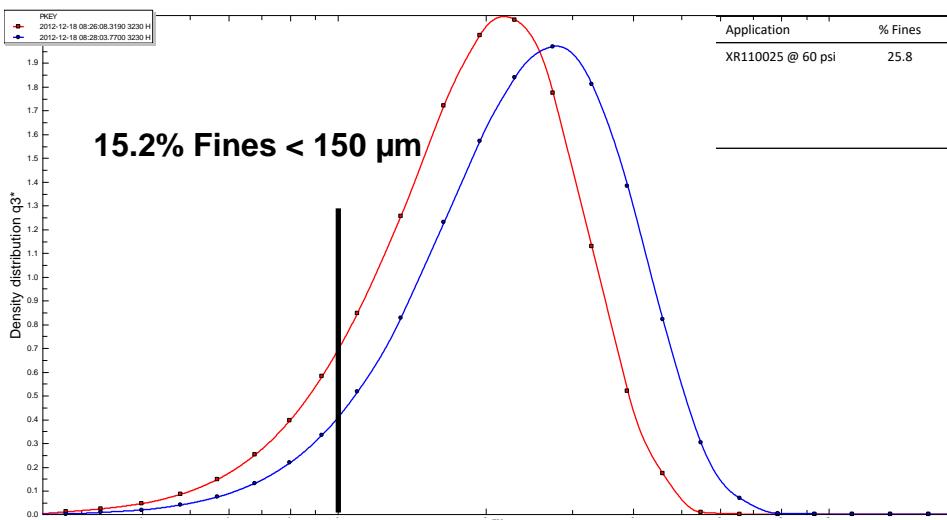
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## XR110025 at 60 psi using Water



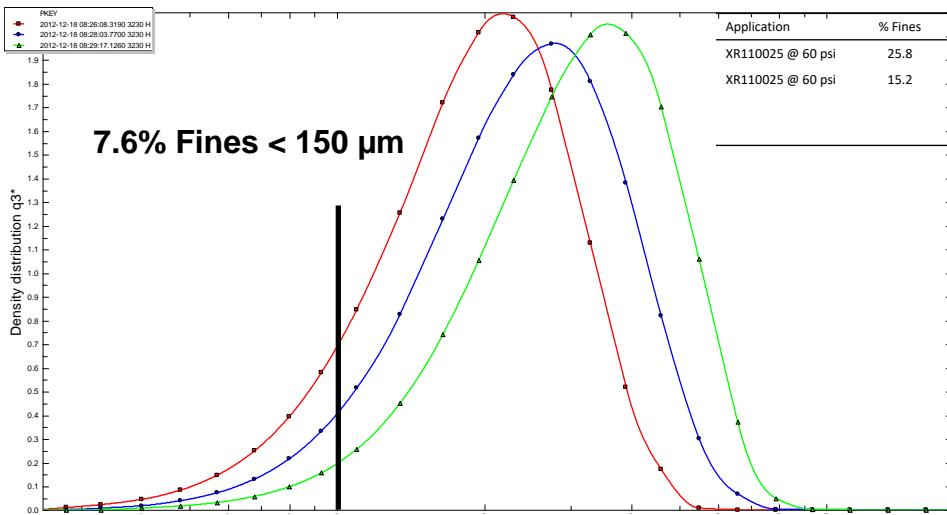
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## XR110025 at 30 psi using Water



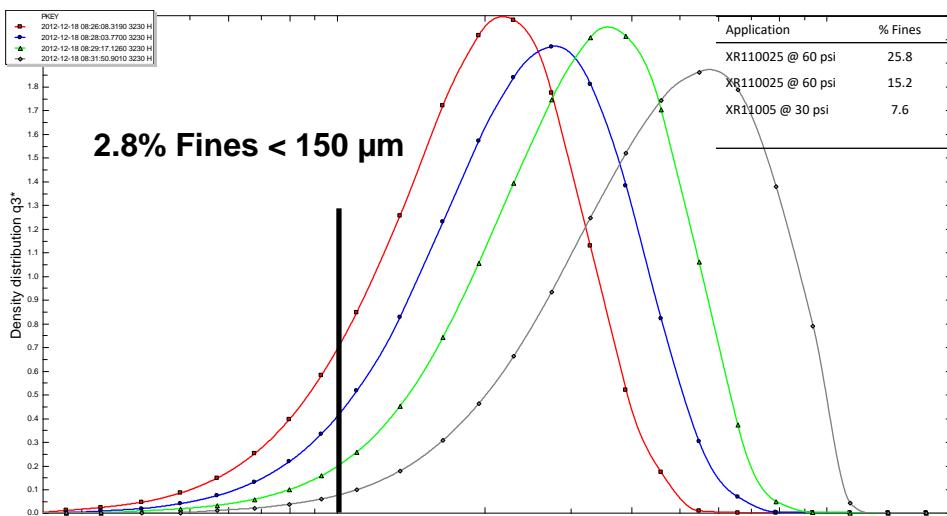
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## XR11005 at 30 psi using Water



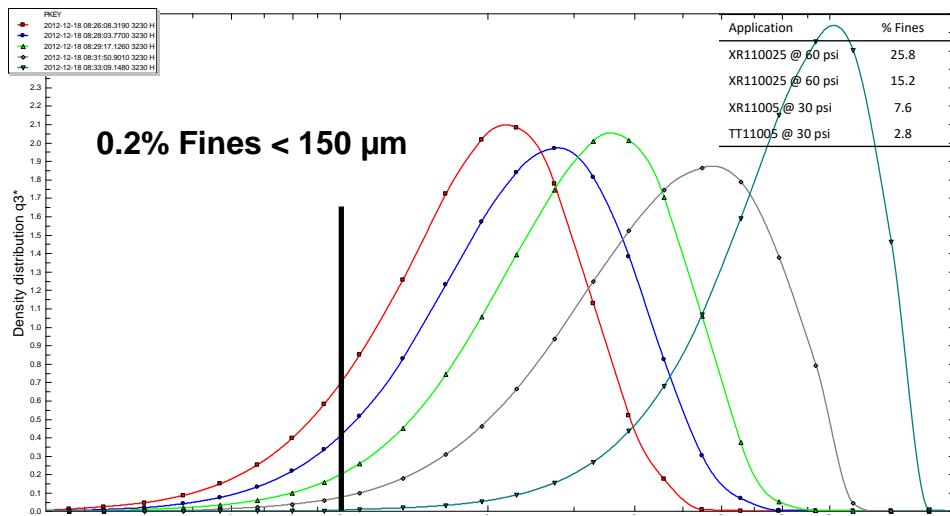
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## TT11005 at 30 psi using Water



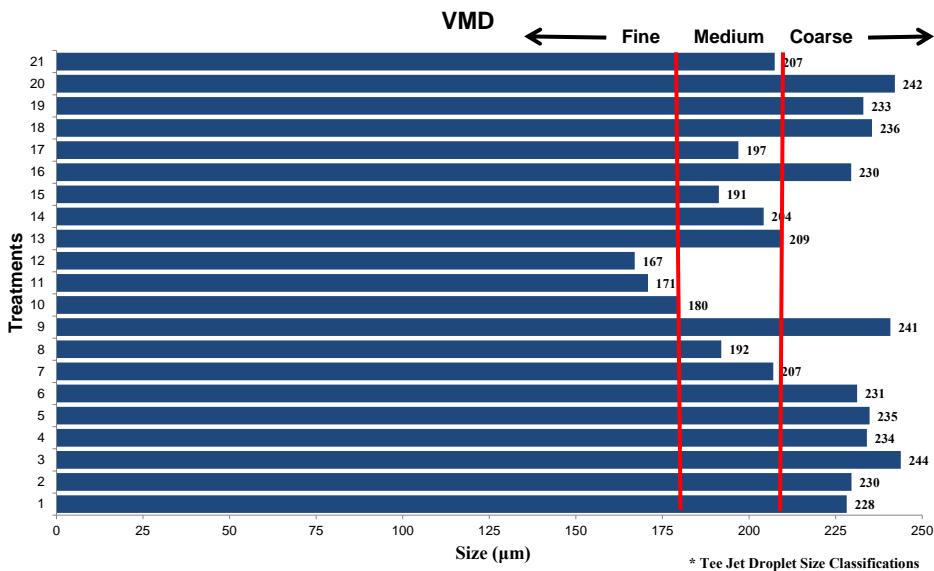
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## TTI11005 at 30 psi using Water



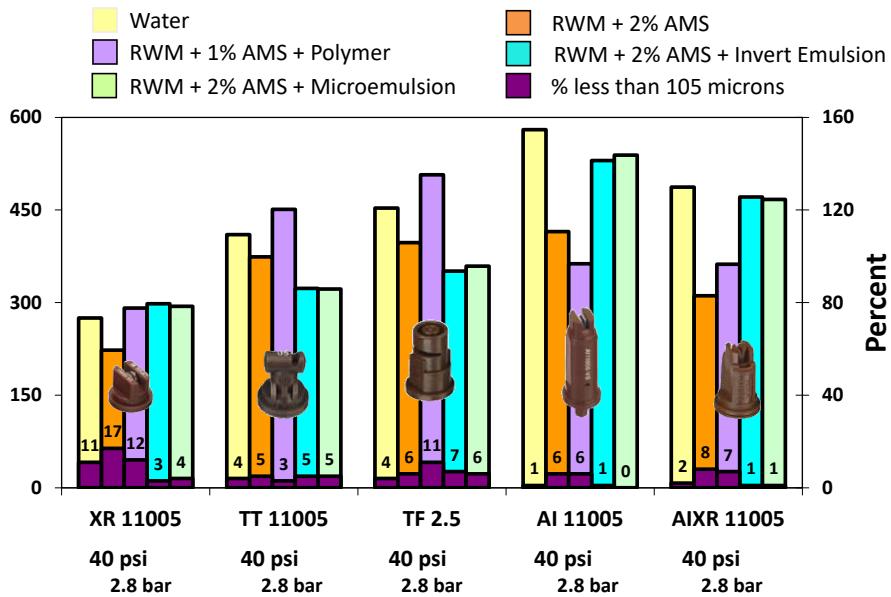
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## Effect of Various Herbicides & Adjuvants on a “Medium” Spray Quality



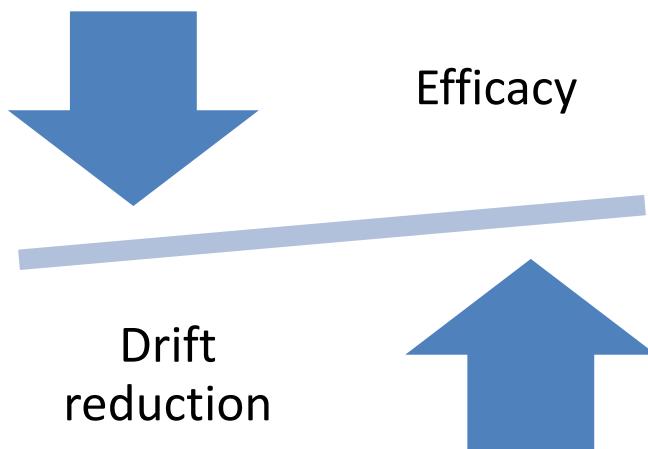
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## Volume Median Diameter (VMD)



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## Relationship Between Drift and Efficacy



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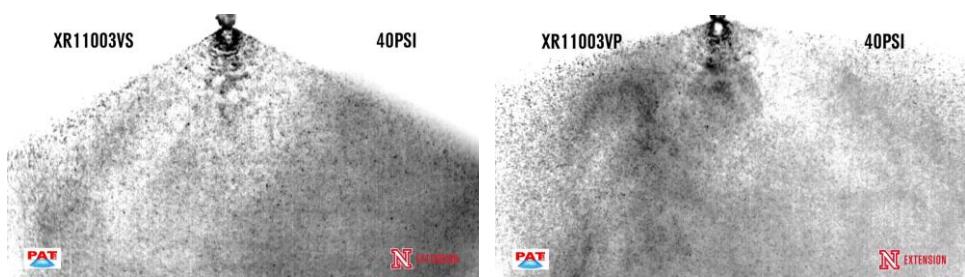
## How far will particles go?

Droplet	Diameter (in $\mu\text{m}$ )	Time to fall 10 ft	Travel distance in 3 mph wind
Fog	5	66 min	15,840 ft
Very fine	20	4.2 min	1,100 ft
Fine	100	10 sec	44 ft
Medium	240	6 sec	28 ft
Coarse	400	2 sec	8.5 ft
Fine rain	1,000	1 sec	< 5 ft

Source: *Herbicide Spray Drift*, NDSU Extension

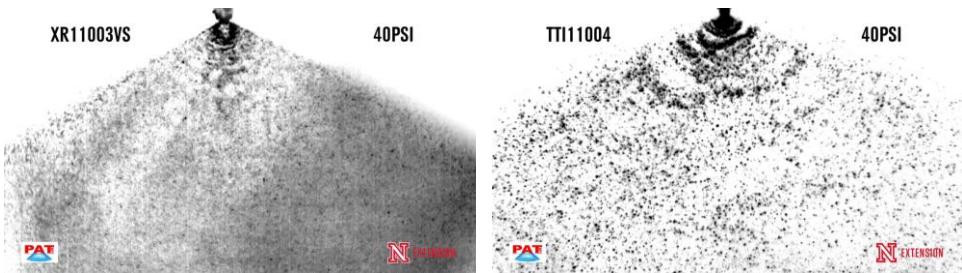
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## TEEJET XR11003-VP



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# TEEJET TTI11004



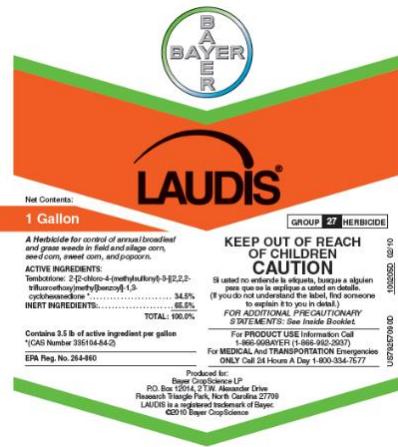
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			Herbicide		Fungicide		Insecticide		
	Incorporated	Pre-Emergence	Contact	Systemic	Contact	Systemic	Contact	Systemic	Liquid Fertilizer
Turbo TeeJet	Good	Good	Good	Good+	Good	Good+	Good	Good+	Good
Air Induction	Good+	Good+	Good	Good+	Good	Good+	Good	Good+	Good+
Extended Range flat fan	-	-	Good+	Good	Good+	Good	Good+	Good	Good
Pre-orifice flat fan	Good+	Good+	Good	Good+	Good	Good+	Good	Good+	Good
Standard flat fan	-	-	Good	Good	Good	Good	Good	Good	-
Twin orifice flat fan	-	-	Good+	-	Good+	-	Good+	-	-
Turbo Flood Jet	Good+	Good+	-	Good	-	Good	-	Good	Good+
Turfjet	Good+	Good+	-	Good	-	Good	-	Good	Good+
Solid Cone	-	-	-	Good	-	Good	-	Good	Good+

Pgs. 2-3

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## Know the Label – The Label is the Law!



### APPLICATION INFORMATION

Uniform, thorough spray coverage is important to achieve consistent weed control. Select nozzles and pressure that deliver MEDIUM spray droplets as indicated in nozzle manufacturer's catalogs and in accordance with ASAE Standard S-572. Nozzles that deliver COARSE spray droplets may be used to reduce spray drift provided spray volume per acre (GPA) is increased to maintain coverage of weeds. Flat fan nozzles of 80° or 110° are recommended for optimum post-emergence coverage.

Do not use nozzles that produce FINE (e.g., Cone) or EXTRA COARSE (e.g., Flood jet) spray droplets.

### Ground Application

LAUDIS can be applied broadcast in a minimum of 10 gallons of water per acre (unless a higher volume is specified for a tank-mix partner). For weed control in dense weed populations or under adverse growing conditions, 15 to 20 gallons of water per acre is recommended. Good coverage is essential to achieve optimum weed control.

Typically, flat-fan nozzles operated at 30-60 psi will deliver MEDIUM spray droplets providing optimum coverage and spray penetration. Lower pressures in the boom and/or higher volume flat fan nozzles typically deliver COARSE sprays. Refer to nozzle manufacturer catalogs.

- Boom height should be based on the height of the crop - at least 15 inches above the crop canopy.
- Air induction nozzles should be used at or near 80 psi to produce a medium droplet size.
- Proper agitation should be maintained within the tank to keep the product dispersed.

See the Spray Drift Management section of this label for additional information on proper application of LAUDIS.

### Mixing Instructions

LAUDIS must be applied with clean and properly calibrated equipment. Prior to adding LAUDIS, ensure that the spray tank, filters and nozzles have been thoroughly cleaned and that agitation system is working.

1. Fill spray tank with 50% of the required volume of water, and begin agitation.
2. Agitate the LAUDIS product container thoroughly by shaking, circulating or stirring prior to adding the herbicide into the spray tank.
3. Add the appropriate amount of LAUDIS slowly to the spray tank or mixing system and ensure complete dispersion. Maintain and ensure thorough dispersion and sufficient agitation during both mixing and spraying.
4. If tank mixing with another pesticide, add the tank mix product next (except in the case of glyphosate which should be added after the nitrogen fertilizer is dispersed).
5. Add nitrogen fertilizer.
6. Add the adjuvant.
7. Fill the spray tank with balance of water needed.

4

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## Know the Label – The Label is the Law!



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The Chemical Company

## Group 14 Herbicide

SPECIMEN

# SHARPEN™ X

POWERED BY KIXOR® HERBICIDE

A broadleaf herbicide for use in the following field and row agricultural crops: chickpea (garbanzo beans), corn (field, pop, silage), cotton, fallow and postharvest, field pea, small grains, sorghum (grain), soybean, sunflower (harvest aid/desiccation only); and noncrop areas

**Active Ingredients:**  
isatetralin; N-[2-chloro-4-fluoro-5-(3-methyl-2,6-dioxo-4-frutononyl)-3,6-dihydro-pyrimidinyl]benzoyl-N-tosyloxymethylsulfone ..... 29.74%  
Other Ingredients ..... 70.26%

Total: 100.00% Contains 3.8 pounds active ingredient contained per gallon formulated as a water-based suspension concentrate.

EPA Reg. No. 7609-278

EPA Est. No.

## KEEP OUT OF REACH OF CHILDREN

## CAUTION/PRECAUCION

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See Inside for complete First Aid, Precautionary Statements, Directions For Use, Conditions of Sale and Warranty, and state-specific crop and/or use site restrictions.

In case of an emergency endangering life or property involving this product, call day or night 1-800-632-HELP (4357).

## Net Contents:

BASF Corporation  
26 Davis Drive, Research Triangle Park, NC 27709

## Mode of Action

Sharpen™ herbicide is a potent inhibitor of protoporphyrinogen-oxidase belonging to herbicide mode of action group 14 (protoxides). Sharpen™ rapidly absorbed by roots and foliage. Following absorption of protoporphyrinogen-oxidase, plant death is the result of membrane damage. Under active growing conditions, susceptible broadleaf weeds will exhibit characteristic necrotic injury symptoms within hours and die within a few days. Susceptible emerging seedlings will usually die as they reach the soil surface or shortly after emergence.

## Resistance Management

While weed resistance to protoporphyrinogen-oxidase inhibitors is relatively infrequent, populations of resistant species are known to exist. Resistance management practices include:

1. Following labeled application rate and weed growth stage recommendations.
2. Avoid overlapping applications of herbicides with the same mode of action.
3. Utilizing tank mixes and sequential applications with one or more effective herbicides possessing different modes of action.
4. Using crop rotation so that crop competition, tillage or herbicides with alternative modes of action can be used to control weed escape.

## Crop Tolerance

Crops are tolerant to Sharpen when applied according to label directions as a preplant to preemergence treatment and under normal environmental conditions. Crop injury may occur under stressful growing conditions (e.g. low soil temperature, severe drought, high salt concentration, excessive moisture, high soil pH, high salt concentration, or drought). Severe crop injury will result if Sharpen is applied post-emergence (over the top) to any crop.

## Application Instructions

Sharpen may only be applied prior to crop emergence, except for harvest desiccation uses.

## Application Rates

Application rates of Sharpen may vary depending on soil texture and organic matter. Refer to Table 3 for soil texture groups used in this label.

Table 3. Soil Texture Groups

Coarse	Medium	Fine
Sand	Silt	Sandy clay
Loamy sand	Silt loam	Silty clay loam
Loam	Sandy loam	Clay loam
Sandy loam	Clay	Clay

## Application Methods and Equipment

Sharpen may be applied by ground or air. Thorough spray coverage is required for optimum broadleaf weed control and should be achieved with proper equipment, nozzle and spray volume selection.

Use and configure application equipment to provide an adequate spray volume, an accurate and uniform distribution of spray droplets over the treated area, and to avoid overlap. Application equipment should be adjusted to maintain continuous agitation during spraying with good mechanical or bypass agitation. Avoid overlaps that will increase rates above the use rates specified in this label.

Sharpen may be applied using either water or sprayable fluid nitrogen fertilizer solutions as the spray carrier. Additionally, Sharpen may be impregnated on and applied with dry fertilizer.

## Aerial Application Requirements

**Water Volume:** Use 3 or more gallons of water per acre for weed control applications. Use a minimum of 5 gallons of water per acre for harvest desiccation applications.

The following measures must be followed to reduce the risk of spray drift to nontarget areas from aerial application:

1. The distance of the outermost nozzles on the boom must not exceed 3/4 the length of the feed whelpipe or 90% of rotor blade diameter.
2. Use straight-stream nozzles such as straight-stream nozzles 10-16 or larger. **DO NOT** use nozzles producing a mist droplet spray.
3. Nozzles must always point backward parallel with the direction of travel and never be pointed downward more than 45 degrees.

4. Without compromising aircraft safety, applications should be limited to 100 feet or less above the crop canopy or tilled plants.

5. **DO NOT** apply during periods of temperature inversions or stable atmospheric conditions.
6. Avoid spraying directly onto nontarget areas by maintaining a 100-foot buffer between the point of direct application and the **closest downwind edge** of sensitive nontarget areas (such as grasslands, forested areas, shelter belts, woodlands, hedgerows, open areas, and shrub lands).

## Ground Application Requirements

**Spray Carrier Volume:** Use 5 or more gallons of water per acre for weed control applications. Use a minimum of 7 gallons of water per acre for harvest desiccation applications.

Thorough spray coverage is required for control of emerged broadleaf weeds. High populations and/or varieties of weeds may require higher spray volumes.

Controlling fall-germinated weeds in the spring (e.g. horseweed/marestail) will also require thorough spray coverage. Use a minimum of 10 to 20 gallons of water per acre in these situations to increase spray coverage and optimize burn-down activity. Use a minimum

8

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The Chemical Company

## Group 14 Herbicide

# SHARPEN™ X

POWERED BY KIXOR® HERBICIDE

A broadleaf herbicide for use in the following field and row agricultural crops: chickpea (garbanzo beans), corn (field, pop, silage), cotton, fallow and postharvest, field pea, small grains, sorghum (grain), soybean, sunflower (harvest aid/desiccation only); and noncrop areas

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## Resistance Management

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1. Following labeled application rate and weed growth stage recommendations.
2. Avoid overlapping applications of herbicides with the same mode of action.
3. Utilizing tank mixes and sequential applications with one or more effective herbicides possessing different modes of action.

## Crop Tolerance

Crops are tolerant to Sharpen when applied according to label directions as a preplant to preemergence treatment and under normal environmental conditions. Crop injury may occur under stressful growing conditions (e.g. low soil temperature, severe drought, high salt concentration, excessive moisture, high soil pH, high salt concentration, or drought).

Severe crop injury will result if Sharpen is applied post-emergence (over the top) to any crop.

## Application Instructions

Sharpen may only be applied prior to crop emergence, except for harvest desiccation uses.

## Application Rates

Application rates of Sharpen may vary depending on soil texture and organic matter. Refer to Table 3 for soil texture groups used in this label.

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3. Nozzles must always point backward parallel with the direction of travel and never be pointed downward more than 45 degrees.

4. Without compromising aircraft safety, applications should be limited to 100 feet or less above the crop canopy or tilled plants.

5. **DO NOT** apply during periods of temperature inversions or stable atmospheric conditions.
6. Avoid spraying directly onto nontarget areas by maintaining a 100-foot buffer between the point of direct application and the **closest downwind edge** of sensitive nontarget areas (such as grasslands, forested areas, shelter belts, woodlands, hedgerows, open areas, and shrub lands).

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Controlling fall-germinated weeds in the spring (e.g. horseweed/marestail) will also require thorough spray coverage. Use a minimum of 10 to 20 gallons of water per acre in these situations to increase spray coverage and optimize burn-down activity. Use a minimum

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to reduce drift potential is to apply the largest droplets that provide sufficient coverage and control.

**Volume.** Use high flow rate nozzles to apply the highest practical spray volume. Nozzles with

higher rated flows produce larger droplets. When higher flow rates are

needed, use higher flow rate nozzles instead of increasing pressure.

Pressure. DO NOT exceed the nozzle manufacturer's recommended pressures. For

many nozzle types, lower pressure produces larger droplets. When higher flow rates are

needed, use higher flow rate nozzles instead of increasing pressure.

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Sandy loam	Clay	Clay



The Chemical Company

SPECIMEN

## Group 14 Herbicide

## Medium to Coarse Spray Droplets 10 MPH Winds or Less 50' Set back from the Downwind Edge of Susceptible Species

A broadleaf herbicide for use in the following field and row agricultural crops: chickpea, garbanzo beans, corn (field, pop, silage), cotton, fallow and postharvest, field pea, small grains, sorghum (grain), soybean, sunflower (harvest aid/desiccation only); and no-till/cropland areas

**Active Ingredients:**  
Isoproturon-N-[2-(chloro-4-fluoro-5-(3-methyl-2,6-dioxo-4-trifluoromethyl-3,6-dihydro-1H-pyrimidinyl)benzoyl)-N-(propyl-N-methylsulfamoyl)]..... 29.74%  
Other Ingredients..... 70.26%  
**Total:** ..... 100.00%  
Contains 10 pounds active ingredient contained per gallon formulated as a water-based suspension concentrate.

EPA Reg. No. 7909-278

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## Resistance Management

While several mechanisms of resistance have been observed, populations of resistant weeds are known to exist. Resistance management practices include:

1. Following labeled application rate and weed growth stage recommendations.

2. Avoiding repeated applications of herbicides with the same mode of action.

3. Rotating tank mixes and sequential applications with other modes of action.

Herbicides with different modes of action can be used to control weed escapes.

## Crop Tolerance

Crops are tolerant to Sharpen when applied according to label directions as a preplant to preemergence treatment and under normal environmental conditions. Crop injury may occur under stressful growing conditions (e.g. low soil temperature, high soil salinity, high soil pH, high salt concentration, or drought). Severe crop injury will result if Sharpen is applied post-emergence (over the top) to any crop.

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Sandy loam			

## Application Methods and Equipment

Sharpen may be applied by ground or air. Thorough spray coverage is required for optimum broadleaf weed control and to avoid drift with proper adjusment, nozzle and spray volume selection.

Use and configure application equipment to provide an adequate spray volume, an accurate and uniform distribution of spray droplets over the treated area, and to avoid drift. Adjust spray volume and pressure as needed to adjust to maintain continuous agitation during spraying with good mechanical or bypass agitation. Avoid overlaps that will increase rates above the use rates specified in this label.

Sharpen may be applied using other types of spray equipment than liquid fertilizer solutions, as the spray carrier.

Additionally, Sharpen may be incorporated on and applied with bulk fertilizers.

## Aerial Application Requirements

When applying Sharpen by air, follow the pattern or zone for weed control applications. Use a minimum of 6 gallons of water per acre for hard and desiccation applications.

1. The distance of the outermost nozzles on the boom must not exceed 3/4 the length of the fixed wing sprayer or 90% of rotor blade diameter.

2. All nozzles on the boom such as straight-stream nozzles (0-ft or larger) **DO NOT** use nozzles producing a mist droplet spray.

3. Nozzles must always point backward parallel with the direction of travel and never be pointed downward more than 45 degrees.

4. Without compromising aircraft safety, applications should be limited to 10 ft or less above the crop canopy or tilled plants.

5. **DO NOT** apply during periods of temperature inversions or stable atmospheric conditions.

6. Avoid application to sensitive species and non-target areas by maintaining a 100-foot buffer between the point of direct application and the **closest downwind edge** of sensitive species (such as grasslands, forested areas, shelter belts, wetlands, hedgerows, riparian areas, and shrub lands).

## Ground Application Requirements

**Spray Carrier Volume.** Use 5 or more gallons of water per acre for hard and desiccation uses of Sharpen that contain nitrogen fertilizer for weed control applications. Thorough spray coverage is required for control of emerged broadleaf weeds. High populations and/or variable weed infestations may require higher spray volumes.

Controlling fall-germinated weeds in the spring (e.g. horseweed/burweed) will also require thorough spray coverage. Use a minimum of 10 to 20 gallons of water per acre in these situations to increase spray coverage and optimize burn-down activity. Use a minimum

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For Agricultural or Commercial Use Only  
NOT FOR SALE OR USE IN CALIFORNIA

EPA Reg. No. 279-3242

EPA Est. 279-

Active Ingredient: Caffeine/methylamine

By Wt.

21.3%

Other Ingredients: Water

100.0%

This product contains 10 pounds active ingredient per gallon. Contains Petroleum Distillates.

KEEP OUT OF REACH OF CHILDREN  
CAUTION

If swallowed: Mix with water and drink 1 to 2 glasses of water, then give artificial respiration, preferably by mouth-to-mouth resuscitation. If breathing is difficult, give oxygen. If breathing has stopped, begin resuscitation. Call a poison center or physician immediately. If in eyes: Hold eye open and rinse slowly and gently with water for 15 to 20 minutes. Remove contact lenses, if present, and continue rinsing eye. Call a poison center or physician immediately. If on skin (not in eyes): Wash with plenty of water for 10 to 20 minutes. Call a poison center or physician immediately. If on clothing: Remove contaminated clothing and wash with plenty of water. If skin irritation or rash occurs, wash thoroughly and repeat washings.

If swallowed: Call a poison center or physician immediately for treatment advice. If breathing is difficult, give oxygen. If breathing has stopped, begin resuscitation. If on skin (not in eyes): Wash with plenty of water for 10 to 20 minutes. Call a poison center or physician immediately. If on clothing: Remove contaminated clothing and wash with plenty of water.

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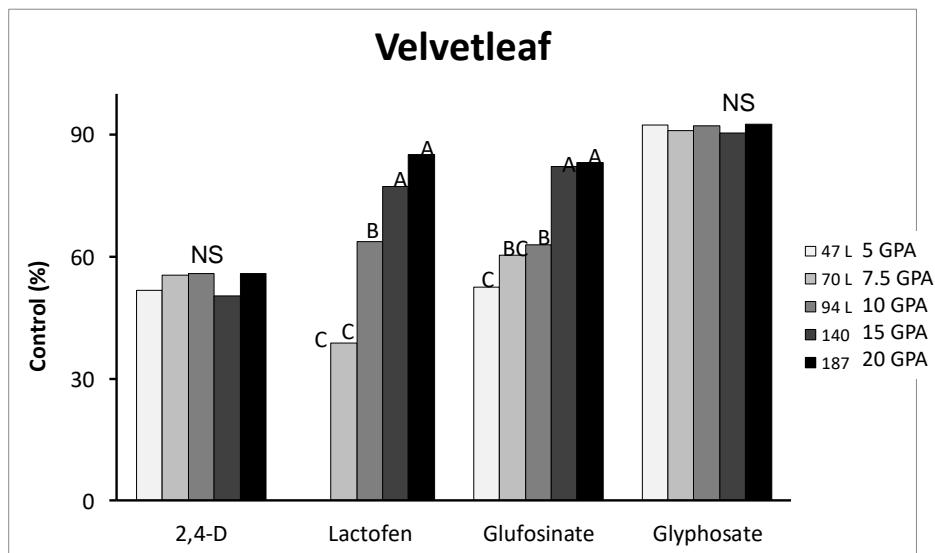


# Materials and Methods

Carrier volume GPA	Nozzle	Application speed mph
5	XR11001	4
7.5	XR11001	4
10	XR11001	4
15	XR110015	4
20	XR11002	4.8

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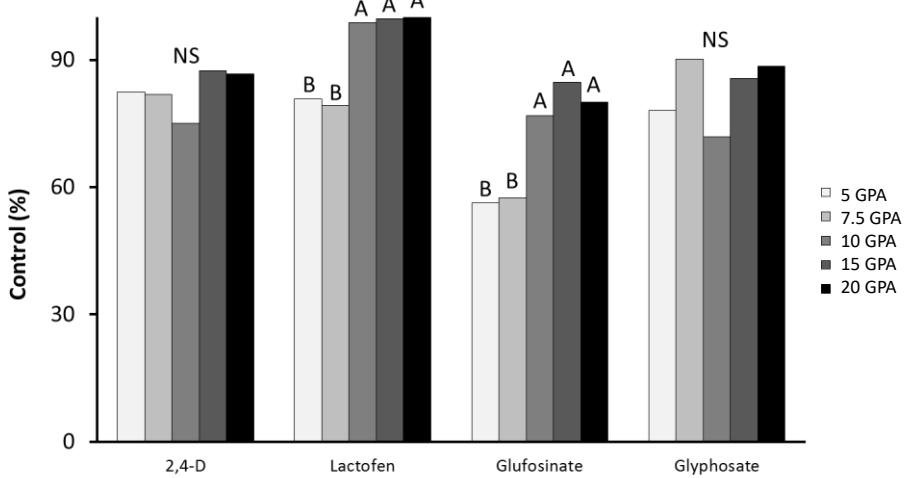
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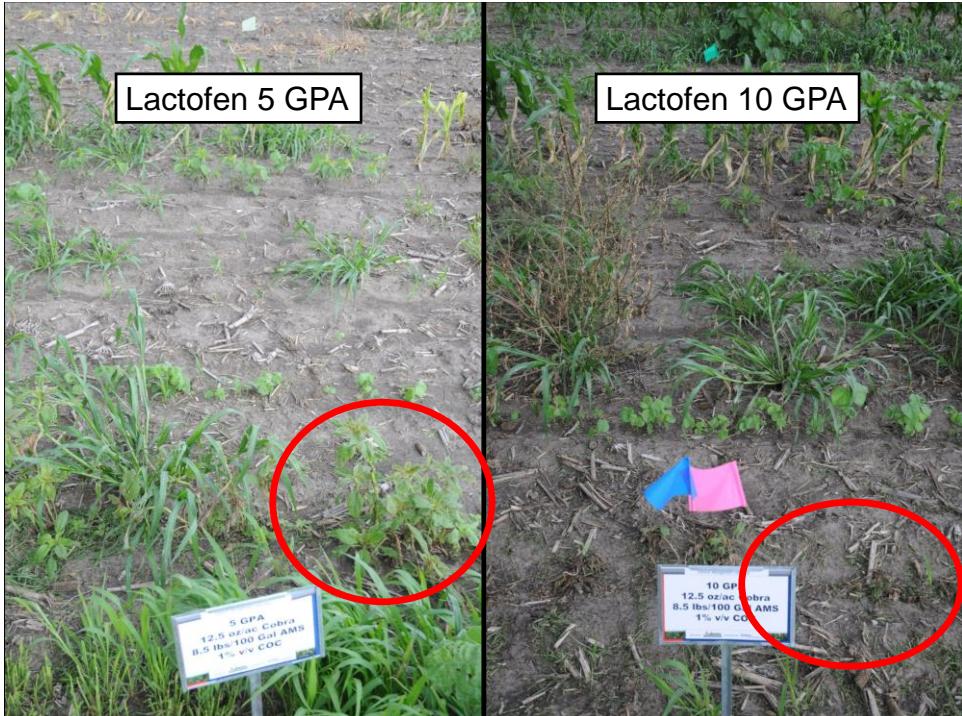
44

# Results

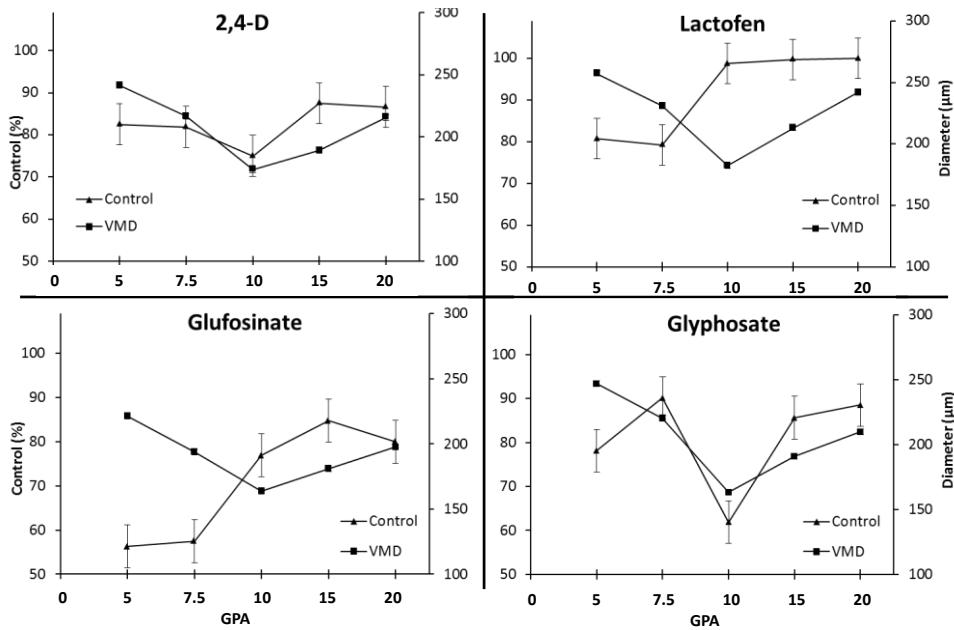
## Amaranth



45

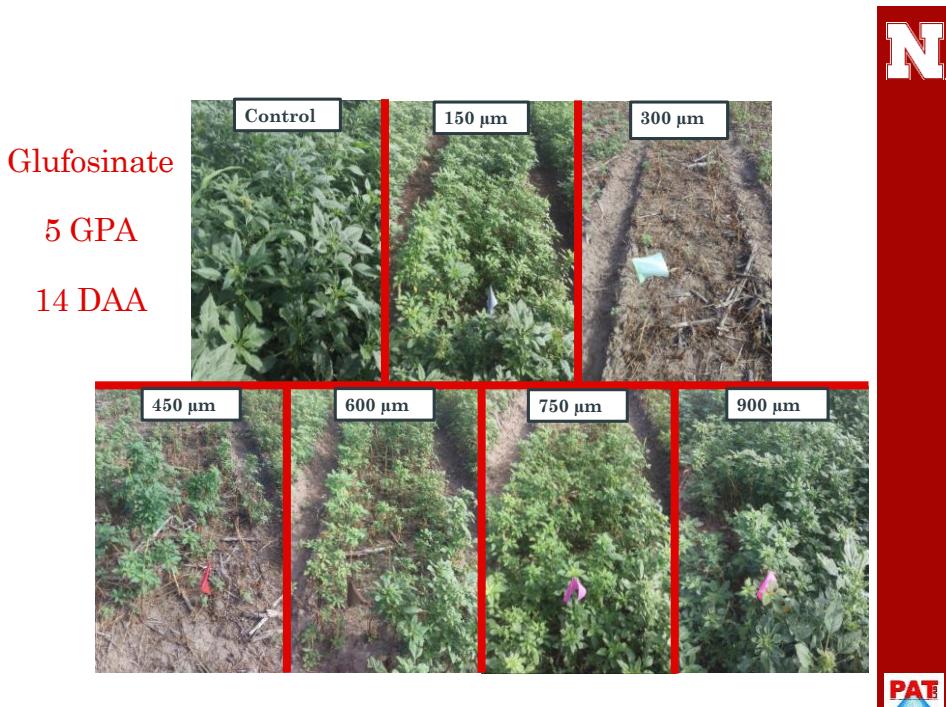


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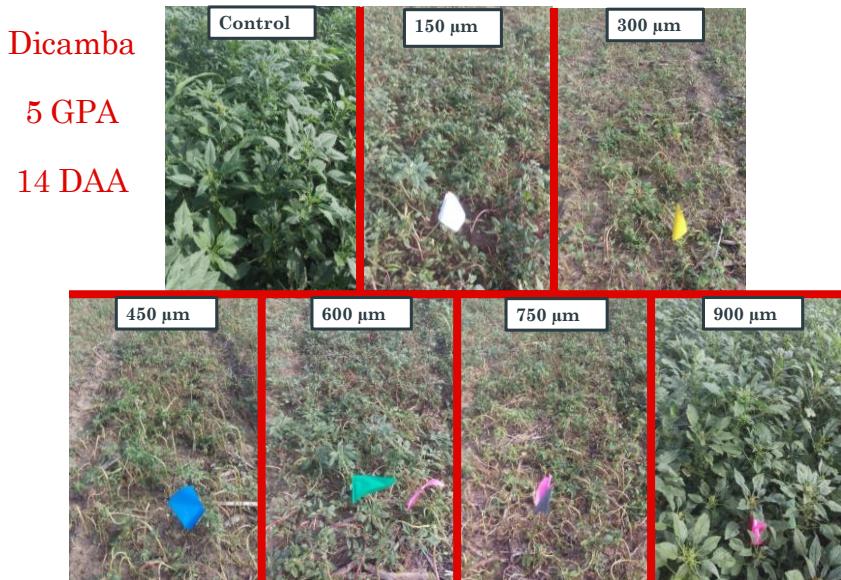
## Amaranth

47



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N



PAT

49

N

## Optimum droplet sizes for maximum Palmer amaranth control

	Dicamba		Glufosinate	
5 GPA	150 μm	Fine	270 μm	Medium
20 GPA	626 μm	Extremely Coarse	488 μm	Very Coarse

PAT

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## How droplet size affects droplets per square inch

Droplet Size (microns)	2 GPA	10 GPA	15 GPA	20 GPA
200	289	1,445	2,167	2,890
500	18	90	135	180
1,000	2	12	18	24

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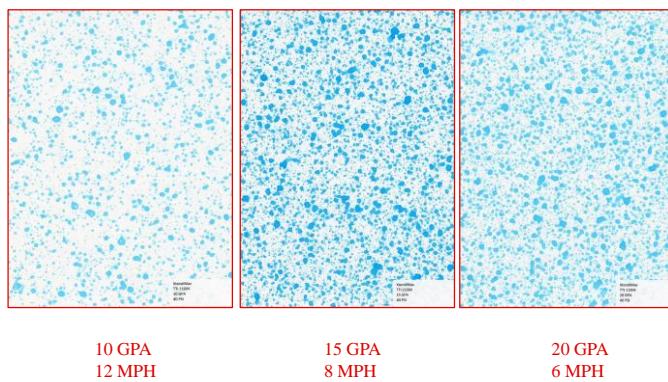


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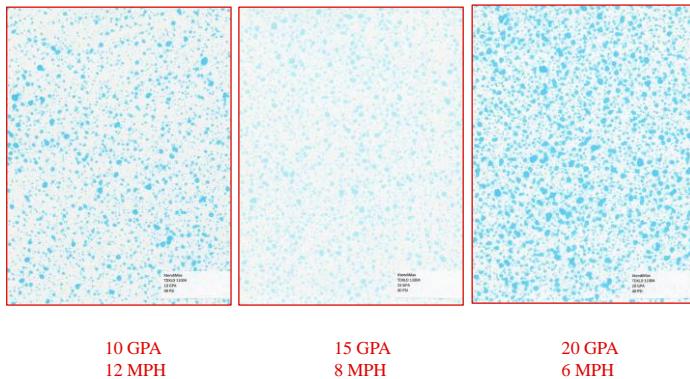


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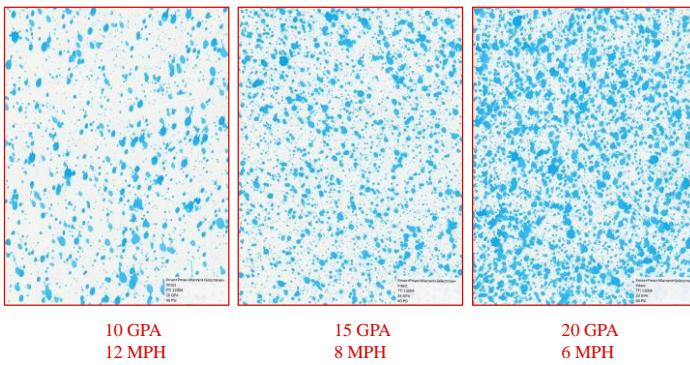
### XtendiMax Alone – TTI11004 @ 40 PSI



54

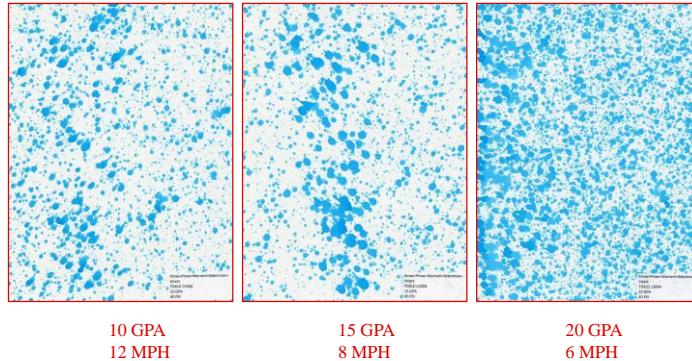
**XtendiMax Alone – TDXL-D11004 @ 40 PSI**

55

**XMAX + PMAX + SELECTMAX + WARRANT + INTACT  
TTI11004 @ 40 PSI**

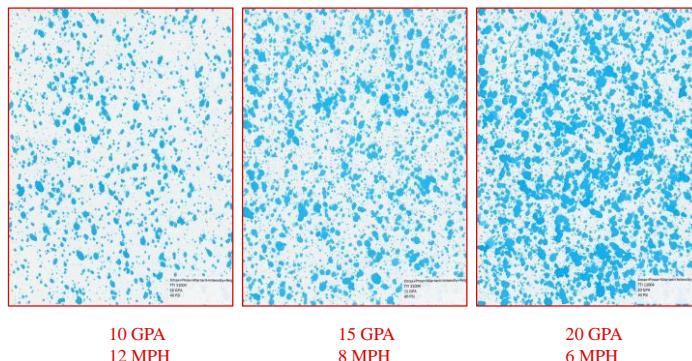
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XMAX + PMAX + SELECTMAX + WARRANT + INTACT  
TDXL-D11004 @ 40 PSI



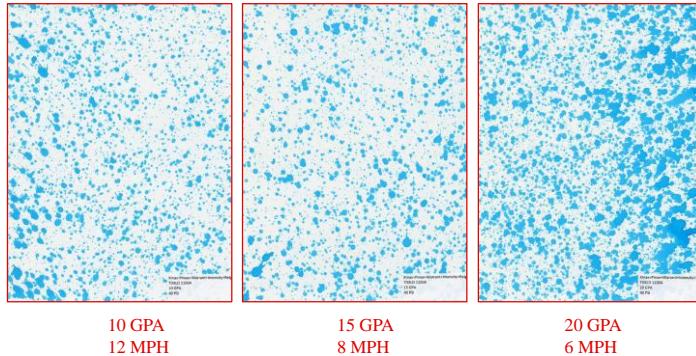
57

XMAX + PMAX + INTENSITY + WARRANT + REIGN  
TTI11004 @ 40 PSI



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XMAX + PMAX + INTENSITY + WARRANT + REIGN  
TDXL-D11004 @ 40 PSI



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## Take Home Messages!

- Particle drift can be influenced by formulation
- Nozzle selection has the greatest influence on particle size
- Adjuvants can reduce drift potential, but must be tested
- There is no substitute for common sense – if the wind is blowing droplets will move
- Pay attention to sensitive vegetation in surrounding areas
- Drift **WILL** happen! Mitigating drift is essential!

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## Questions?



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