Sprayer Nozzles and Droplet Size

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Coverage vs. Drift Control (It's all about droplet size)

- Larger (coarser) Drops
  - *Less coverage but better drift control*
- Smaller (finer) Drops
  - *Better coverage but less drift control*
- Coverage is pesticide dependent
  - *Contact = smaller drops*
    - *Liberty, Gramoxone*
  - *Systemic = larger drops*
    - *Roundup, 2,4-D, dicamba*

Droplet Size

Goal = larger droplets; eliminating fines

Size Comparison:

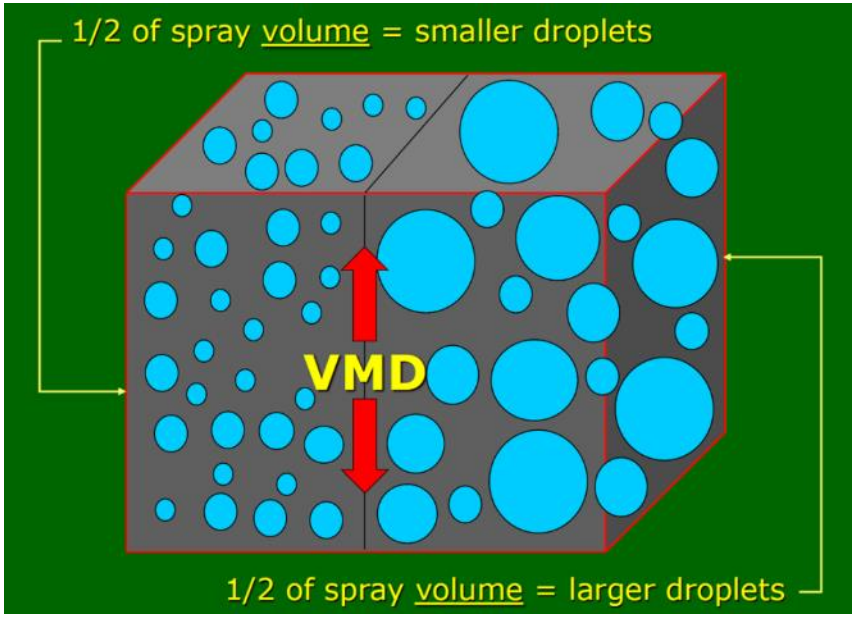
Diameter of Common Items (approximate) in Microns

- 2,000 μm #2 pencil "lead"
- 850 μm paper clip
- 420 μm staple
- 300 μm toothbrush bristle
- 150 μm sewing thread
- 100 μm human hair

- micron (μm) is a unit of measure equivalent to 1/25,000 of an inch.

Volume Median Diameter (VMD)

- value where 50% of the total volume or mass of liquid sprayed is made up of droplets larger than this value, and 50% is made up of droplets smaller than this value.
- $D_{v0.5}$
- Measured in microns

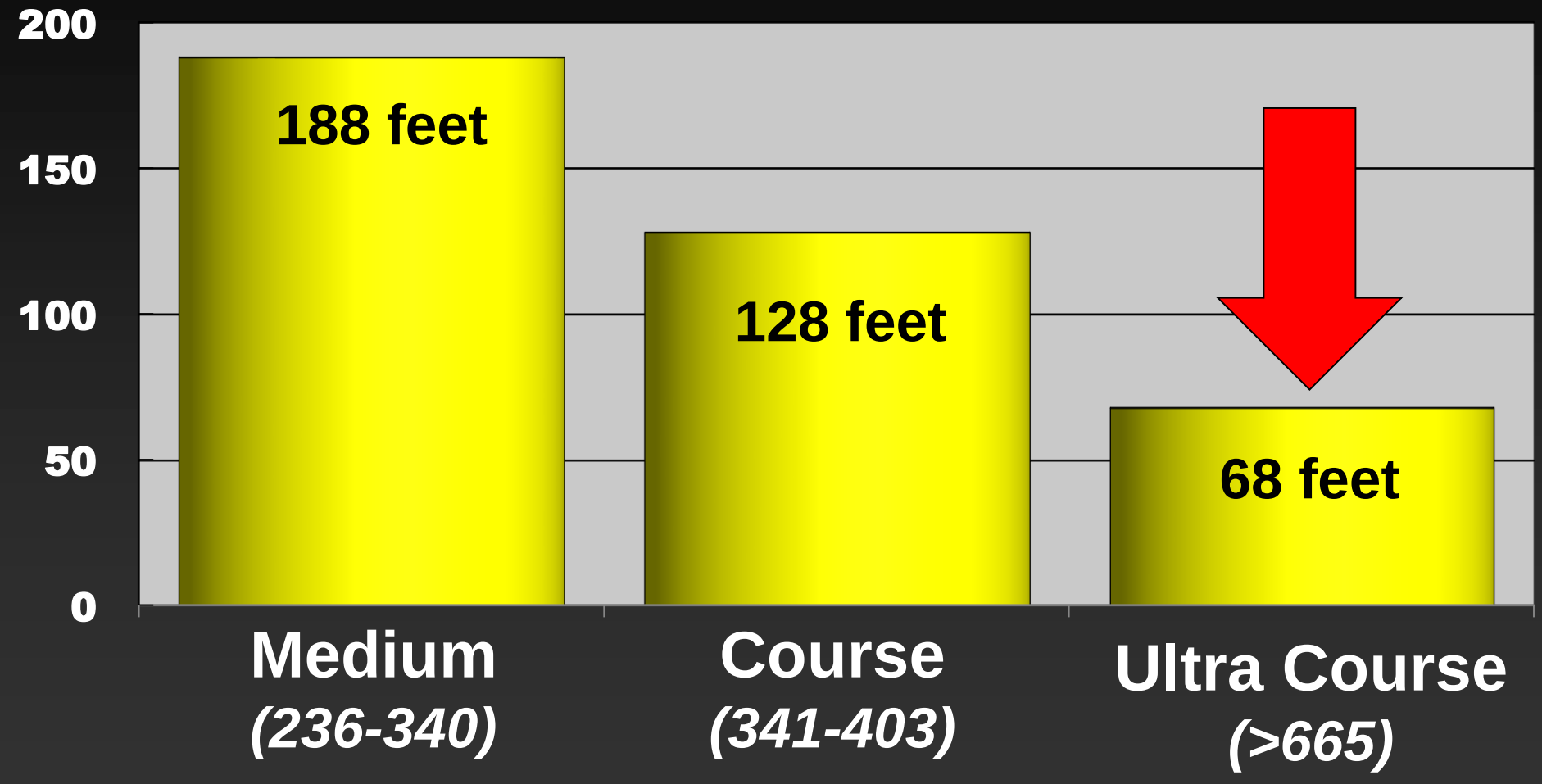


Spray Tip Classification by Droplet Size

Category	Symbol	Color Code	Approximate VMD[2] (Microns)
Extremely Fine	XF	PURPLE	< 60
Very Fine	VF	RED	61-105
Fine	F	ORANGE	106-235
Medium	M	YELLOW	236-340
Coarse	C	BLUE	341-403
Very Coarse	VC	GREEN	404-502
Extremely Coarse	XC	WHITE	503-665
Ultra Coarse	UC	BLACK	>665

[1]Estimated from sample reference graph in ASBAE/ANSI/ASAE Standard S572.1
[2]VMD = Volume median diameter

Distance of Visual Dicamba Damage from Drift in Cotton. Moultrie GA. 2018.



VMD for common nozzle types

11002DG
VMD_{50} = 322 (M)

AIXR 11002
VMD_{50} = 402 (C)

TTI 02
VMD_{50} = 524 (XC)

3.5 MPH - Walking
20” nozzle spacing
20” boom height
35-40 PSI
15 GPA

Size Matters

Advantages & disadvantages of different droplet sizes*

100 micron

- Excellent coverage
- Low droplet bounce
- Very high air evaporation potential
- Quick drying time
- Very high drift potential
- Poor canopy penetration

200 micron

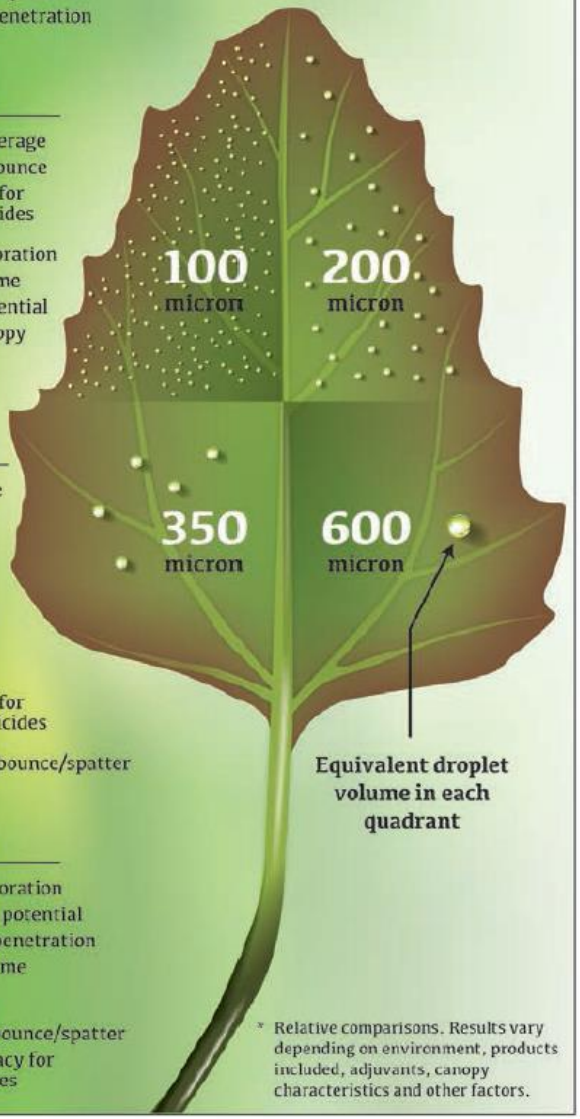
- Very good coverage
- Low droplet bounce
- Good efficacy for contact pesticides
- High air evaporation
- Fast drying time
- High drift potential
- Moderate canopy penetration

350 micron

- Good coverage
- Medium evaporation
- Low drift potential
- Good canopy penetration
- Favorable drying time
- Good efficacy for systemic pesticides
- Some droplet bounce/spatter

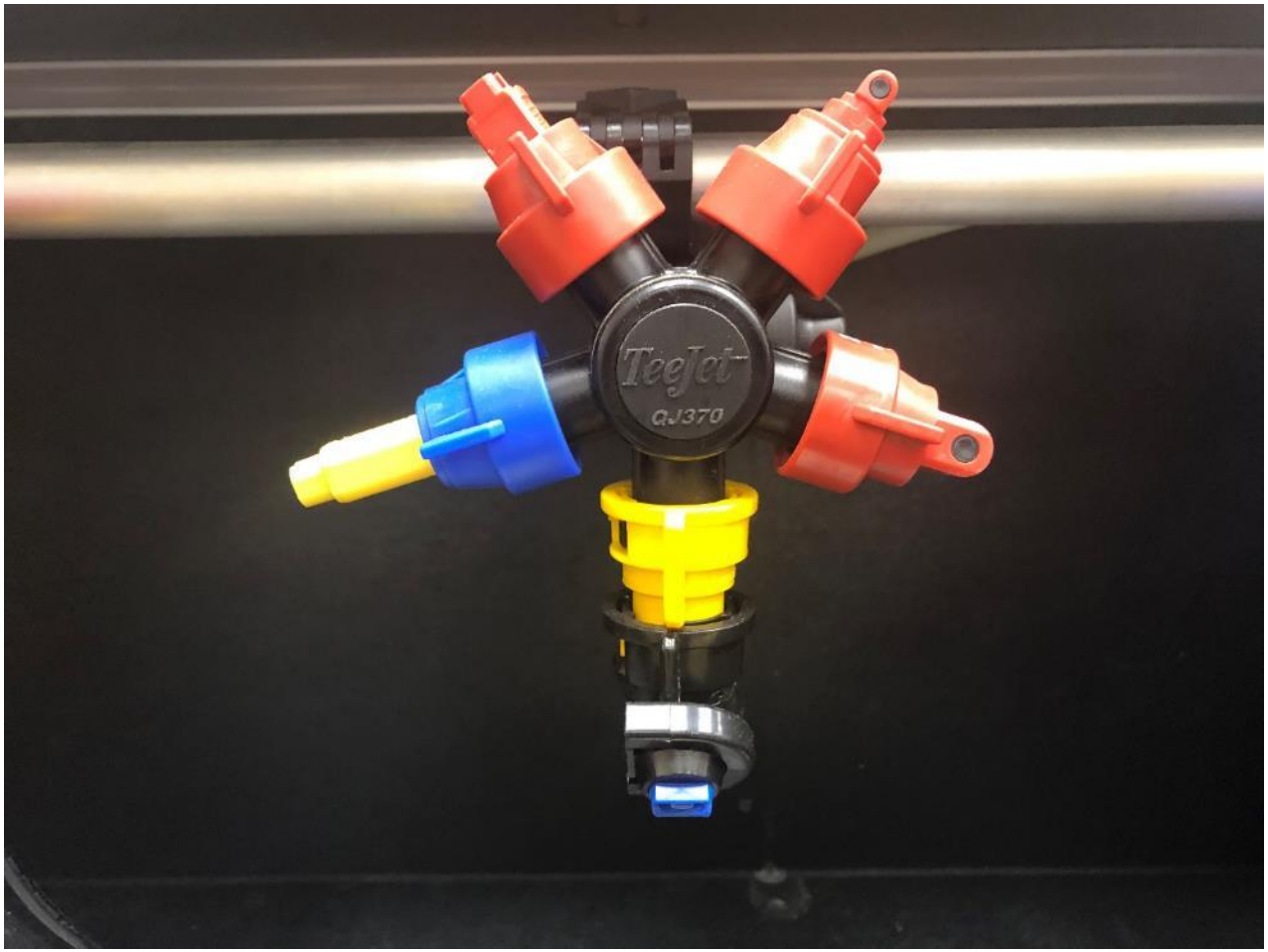
600 micron

- Very low evaporation
- Very low drift potential
- Good canopy penetration
- Long drying time
- Low coverage
- High droplet bounce/spatter
- Reduced efficacy for many pesticides



* Relative comparisons. Results vary depending on environment, products included, adjuvants, canopy characteristics and other factors.

You Can Put More than 1 Nozzle on a Boom



What Nozzles Do I Like?

TeeJet TECHNOLOGIES

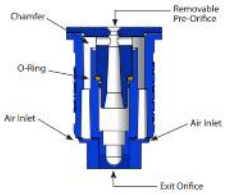
AIXR TEEJET®

AIR INDUCTION XR FLAT SPRAY TIPS

The AIXR TeeJet Flat Spray Tip offers the benefits of obtaining excellent drift resistance without compromising spray coverage. The larger droplets produced by the AIXR make this tip ideal for a wide variety of systemic herbicides and applications where drift control is critical. The unique UHMWPE material used also makes this tip ideal for highly acidic applications, such as applying defoliation products.

AIXR Features and Benefits

- A perfect balance of drift control and coverage – precisely sized, large, air filled drops stay on target and cover the entire plant
- Wide operating pressure range of 15-90 PSI (1-6 bar) gives you fewer driftable droplets at higher pressures than most other tips
- Available in nine VisiFlo® tip capacities
- Unique UHMWPE polymer material provides significantly longer wear life and better acid resistance
- Air-induction design enhances coverage of larger droplets through air inclusion
- Compact design avoids damage
- Easy to remove pre-orifice for quick maintenance
- AIXR 015-06 capacities fit 114441-*-CELR Quick TeeJet® cap and gasket
- AIXR 08-10 capacities fit 114443-*-CELR Quick TeeJet cap and gasket
- For combined assembly of tip, cap and gasket order AIXR110**VP-CE



CROSS SECTION VIEW

AIXR TIP AND CAP

SELECTION GUIDE

CONTACT PRODUCT	SYSTEMIC PRODUCT	DRIFT MANAGEMENT
GOOD	EXCELLENT	EXCELLENT

www.teejet.com

TeeJet TECHNOLOGIES

TTI TWINJET®

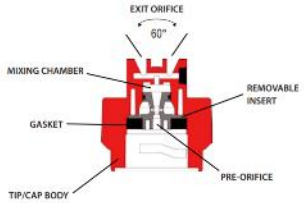
AIR INDUCTION TWIN FLAT SPRAY TIPS

The TTI60 TeeJet air induction twin flat spray tip provides extremely large droplets for maximum drift control along with the improved coverage of a twin spray. The single piece tip & cap design allows for fast, easy installation and, unlike some other twin sprays, has a very compact size. The TTI60 is ideal for the application of systemic, post-emerge herbicides.

TTI60 SPRAY TIP

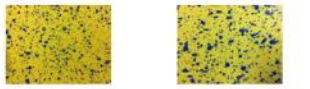
FEATURES:

- TTI60 produces two 110° wide angle, flat spray patterns for uniform coverage in broadcast applications.
- 60° angle between leading and trailing patterns for increased canopy penetration and leaf coverage.
- All in one molded nozzle and Quick TeeJet® cap design provides automatic spray alignment.
- Extremely large drift resistant droplets are produced through the use of a venturi air aspirator.
- Provides excellent drift control and produces minimal driftable fines - less than 1.5%*.
- Acetal construction for excellent chemical and wear resistance.
- Removable pre-orifice allows for disassembly and cleaning.
- Suggested spray pressure range of 20-100 PSI (1.5-7 bar).



TTI60 CROSS-SECTIONAL VIEW

DROPLET SIZE AND COVERAGE



TURBO TEEJET® (TT) (M Droplets)

TTI TWINJET® (TTI60) (XC Droplets)

SELECTION GUIDE

CONTACT PRODUCT	SYSTEMIC PRODUCT	DRIFT MANAGEMENT
N/A	EXCELLENT	EXCELLENT

* -04 capacity spraying water at 40 PSI (2.8 bar). Driftable fines defined as droplets smaller than 150 microns.

www.teejet.com

Other Common Nozzle Questions

- ***How much do they cost (2019)?***
  - TTI-11004-VP-CE = $9.86
  - XRC-11004-VP = $2.96

- ***How long do they last?***
  - How many acres? What was sprayed? What are they made of? (brass, stainless steel, polymer, ceramic)
  - Replace when flow exceeds 10% of new nozzle

Nozzle Requirements for Auxins (tolerant cotton and soybeans)

Manufacturer	Nozzle Type	Part Number	Operating Pressure (psi)							
			20	30	40	50	60	70	80	90
Greenleaf Technologies	TADF03-D	TADF03-D	Min 20		Max 40					
	TADF06-D	TADF06-D	Min 20			Max 50				
	TDXL 11003-D	TDXL 11003-D	Min 20		Max 40					
	TDXL 11004-D	TDXL 11004-D	Min 20			Max 50				
	TDXL 11005-D	TDXL 11005-D	Min 20				Max 60			
	TDXL 11006-D	TDXL 11006-D	Min 20				Max 60			
Pentair Hypro	ULD120-04	ULD120-04 / FC-ULD120-04	Min 20		Max 40					
	ULD120-05	ULD120-05 / FC-ULD120-05	Min 20		Max 40					
John Deere	ULD120-04	PSULD2004 / PSULDQ2004	Min 20		Max 40					
	ULD120-05	PSULD2005 / PSULDQ2005	Min 20		Max 40					
Lechler	ID 110-03	ID 110-03 / ID 110-03C		Min 30	Max 40					
	ID 110-04	ID 110-04 / ID 110-04C		Min 30	Max 40					
	ID 110-05	ID 110-05 / ID 110-05C		Min 30	Max 40					
	ID 80-04	ID 80-04 / ID 80-04C		Min 30	Max 40					
TeeJet® Technologies	AI11003	AI11003-VS / AIC1103-VS		Min 30	Max 40					
	AI8003	AI8003-VS / AIC8003-VS		Min 30	Max 40					
	AI8005	AI8005-VS / AIC8005-VS		Min 30	Max 40					
	TTI11003	TTI11003-VP	Min 20				Max 60			
	TTI11004	TTI11004-VP	Min 20				Max 63			
	TTI11005	TTI11005-VP	Min 20				Max 60			
	TTI11006	TTI11006-VP	Min 20			Max 50				
	TTI60-11003	TTI60-11003VP		Min 30		Max 50				
	TTI60-11004	TTI60-11004VP		Min 30			Max 60			
	TTI60-11005	TTI60-11005VP		Min 30			Max 60			
	TTI60-11006	TTI60-11006VP		Min 30			Max 60			
Wilger	DR110-10	40286-10		Min 30	Max 40					
	UR110-05	40292-05		Min 30		Max 50				
	UR110-06	40292-06		Min 30			Max 60			
	UR110-08	40292-08		Min 30				Max 70		
	UR110-10	40292-10		Min 30				Max 70		
Total Ag Industries	MUG110-02	M-1080		Min 30						Max 90
	MUG110-025	M-1081		Min 30						Max 90
	MUG110-03	M-1082		Min 30						Max 90
	MUG110-035	M-1083		Min 30						Max 90
	MUG110-04	M-1084		Min 30						Max 90
	MUG110-05	M-1085		Min 30					Max 80	

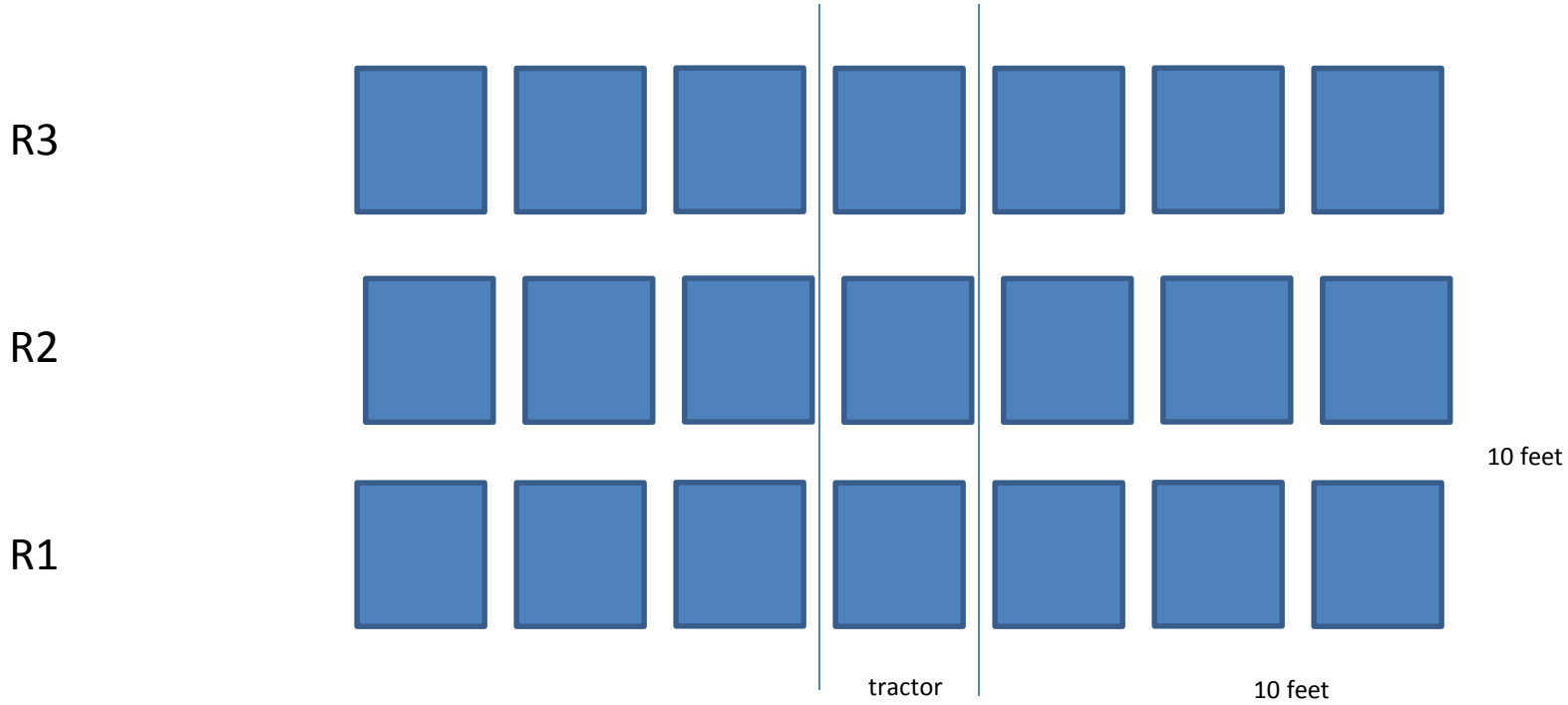
Xtendimax®

Enlist One™

How do “auxin” nozzles work in real world?

Henley Farm, Miller County, April 10, 2017

2017/2018/2019 Nozzle Tests VMD_{50} and Coverage

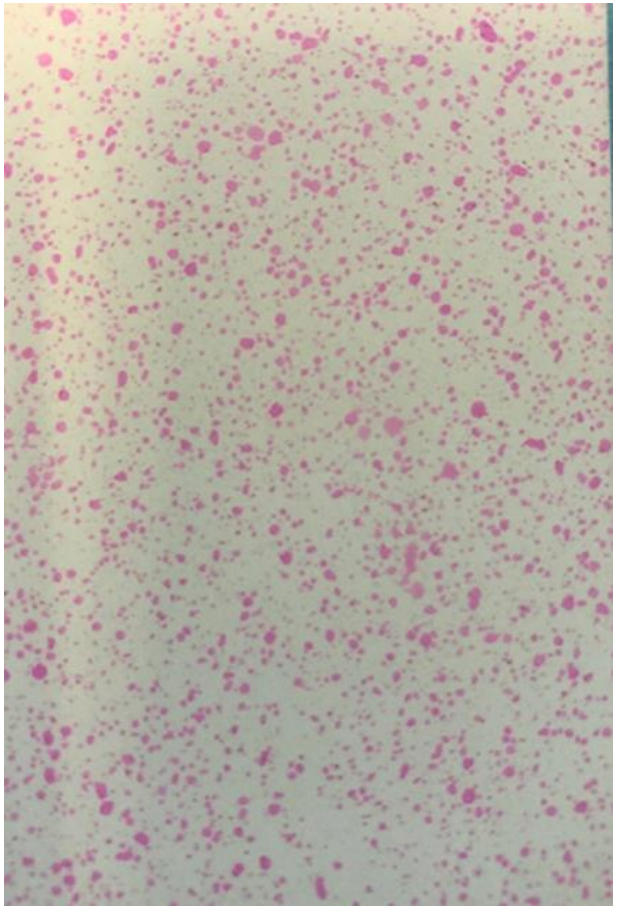


Commercial Sprayer Nozzle Tests - 2019

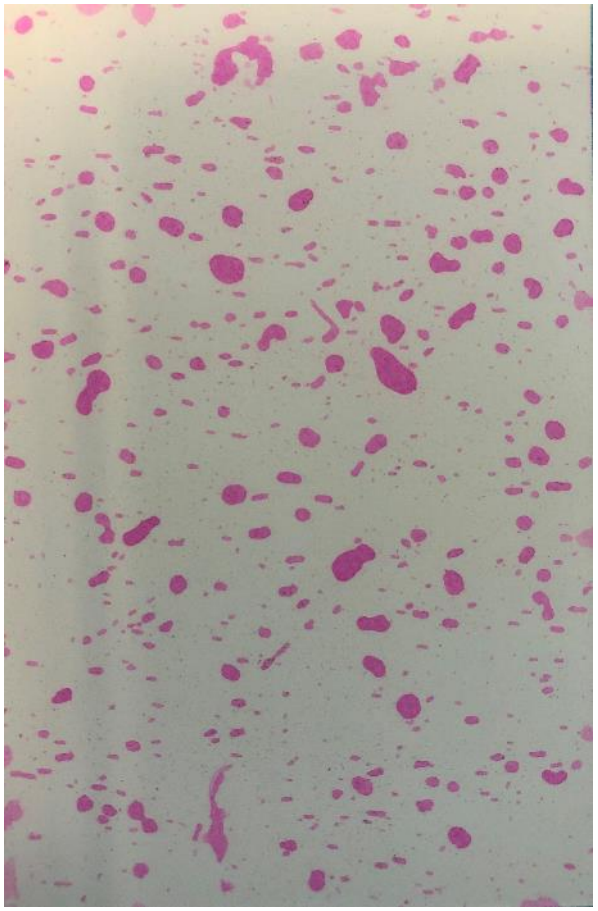
JD4730, 90’ boom, 20” nozzle spacing, 12.5 MPH, 20 GPA, 42-57 PSI

Patterson Farm, Worth County, April 4, 2019

Worth County Nozzle Test
April 4, 2019 (Rep 2, card #2)



XRC-11006



TTI-11006

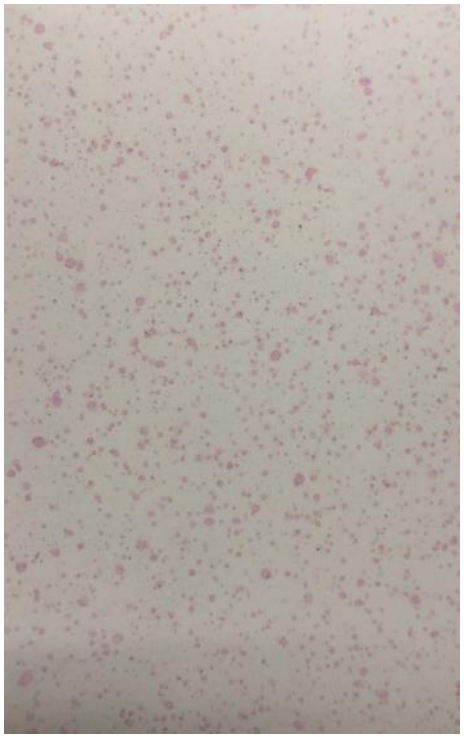
JD 4730, 90’ boom, 20” spacing, 20 GPA, 12.5 MPH, 42-57 PSI, 36” boom height

Commercial Sprayer Nozzle Tests - 2019

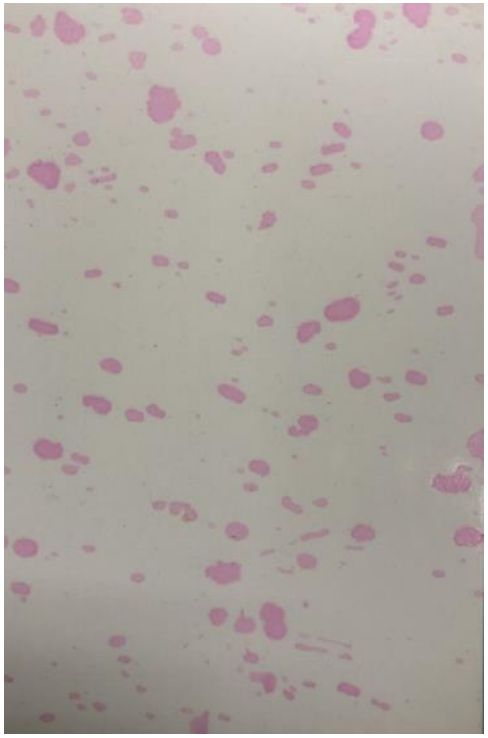
JD4630, 90’ boom, 15” nozzle spacing, 11.6 MPH, 12 GPA, 18-20 PSI

Sikes Farm, Bulloch County, March 21, 2019

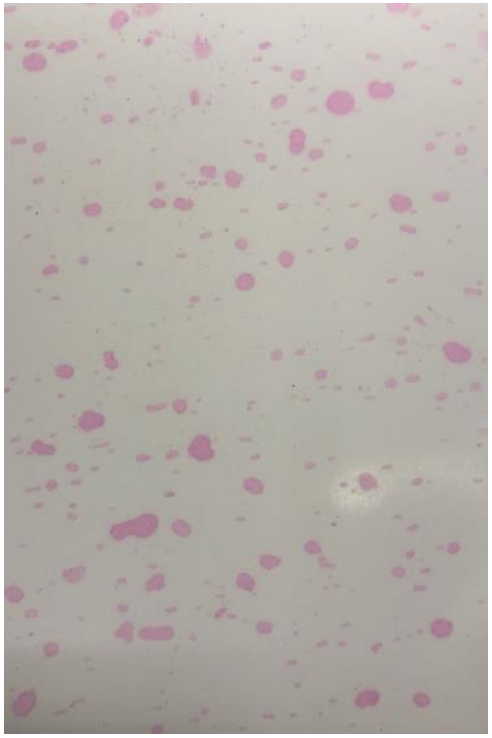
Bulloch County Nozzle Test
March 21, 2019 (Rep 2, card #4)



XRC-11004



TTI-11004



TDXL-11004D

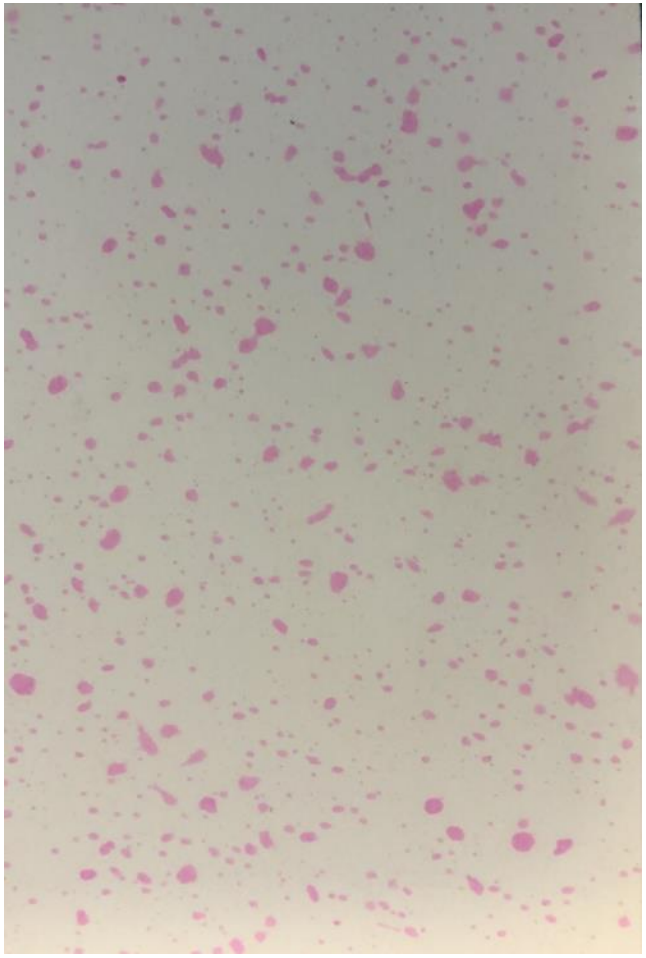
JD 4630, 90’ boom, 15” spacing, 12 GPA, 12 MPH, 28 PSI, 36” boom height (avg.)

Commercial Sprayer Nozzle Tests - 2019

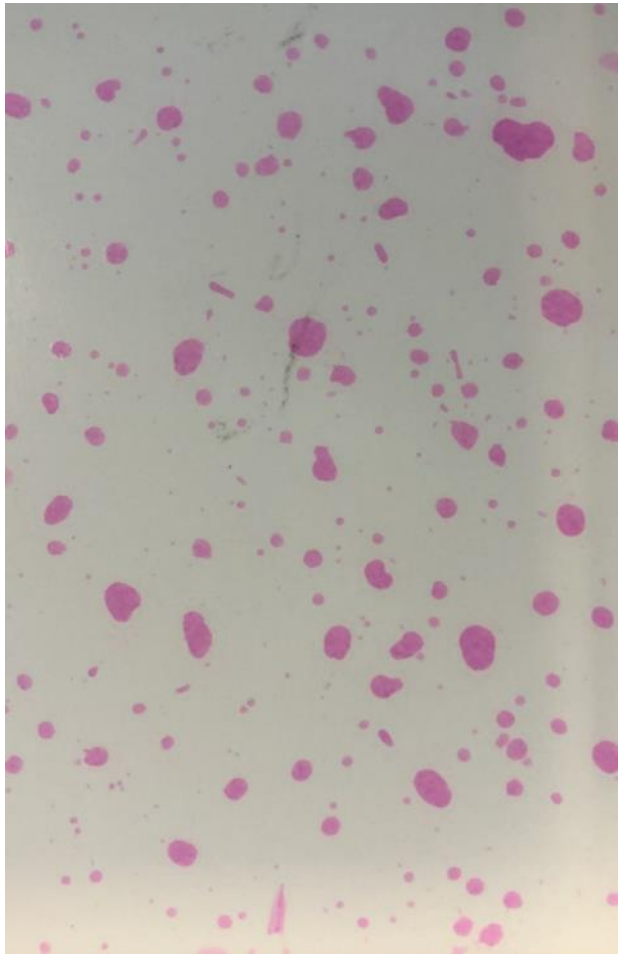
JD4730, 100’ boom, 15” nozzle spacing, 11.6 MPH, 15 GPA, 18-20 PSI

Waters Farm, Pierce County, March 26, 2019

Pierce County Nozzle Test
March 26, 2019 (Rep 1, card #5)



XR-11006



TTI-11006

JD 4730, 100’ boom, 15” spacing, 15 GPA, 11.6 MPH, 18-20 PSI, 36” boom height (avg.)

Droplet Size and Spray Coverage from 2019 Nozzle Tests with Commercial Sprayers

	Bulloch[1,3]			***Pierce[1,4]***		***Worth[2,5]***	
	TTI-11004	XRC-11004	TDXL-11004	TTI-11006	XR-11006	TTI-11006	XRC-11006
VMD_{50} (microns)	456 a[6]	182 b	411 a	381 a	196 b	481 a	348 b
Coverage (%)	11.8 a	8.1 b	12.0 a	5.3 a	3.4 b	10.0 a	7.4 a

[1]According to DepositScan
[2]According to DropletScan
[3]JD4630, 90' boom, 15" nozzle spacing, 12.0 MPH, 12 GPA, 28 PSI, 36" boom height
[4]JD4730, 100' boom, 15" nozzle spacing, 11.6 MPH, 15 GPA, 18-20 PSI, 36" boom height
[5]JD4730, 90' boom, 20" nozzle spacing, 12.5 MPH, 20 GPA, 42-57 PSI, 36" boom height
[6]Means in the same row within same location with the same letter are not significantly different (THSD 0.10). Means from 21 kromekote water sensitive cards.

2019 Nozzle Tests (Weeds, Insects, Disease, Yield)

2019 Nozzle Tests

Pesticides/Fertilizers Applied

County	Total Applications (#)	Herbicides	Fungicides	Insecticides	Other
Bulloch	6	Valor Strongarm Cadre Dual Magnum 2,4-DB	Approach Prima Equus Elatus Convoy Tebusol	Dimilin	Boron PegPower
Pierce	6	Valor Dual Magnum Cadre 2,4-DB	Bravo Priaxor Provost Silver Tebuconazole	Dimilin	Boron
Worth	6	Gramoxone Dual Magnum Warrant Basagran Cadre	Headline Topsin Tebuconazol Convoy Chlorothalinol	Orthene Dimilin	Boron Manganese Ascend

Late-Season Insect, Weed, and Disease Ratings from 2019 Nozzle Tests with Commercial Sprayers**

	Bulloch[1]			***Pierce[2]***		***Worth[3]***	
	TTI-11004	XRC-11004	TDXL-11004	TTI-11006	XR-11006	TTI-11006	XRC-11006
Total # of insects (#/15 sweeps)	8.0	10.0	9.8	7.8	7.8	22.8	20.0
Total # of weeds (#/m^2)	0	0	0	1.4	0.2	0	0
Leaf Spot (1-10)	1.0	1.0	1.0	1.0	1.0	1.2	1.1
White Mold (%)	7.3	8.9	7.1	4.1	5.3	8.7	6.9

[1]JD4630, 90' boom, 15" nozzle spacing, 12.0 MPH, 12 GPA, 28 PSI, 36" boom height
[2]JD4730, 100' boom, 15" nozzle spacing, 11.6 MPH, 15 GPA, 18-20 PSI, 36" boom height
[3]JD4730, 90' boom, 20" nozzle spacing, 12.5 MPH, 20 GPA, 42-57 PSI, 36" boom height

***No significant differences were observed between nozzle type at any location (P>0.10).**

2019 Nozzle Test
XRC-11004-VP

Bulloch Co.
9/9/19
115 DAP

2019 Nozzle Test
TTI-11004-VP

Bulloch Co.
9/9/19
115 DAP

2019 Nozzle Test
TDXL-11004-D

Bulloch Co.
9/9/19
115 DAP

Peanut Yield As Influenced By Nozzle Type from 2019 Nozzle Tests with Commercial Sprayers

	Bulloch[1]			***Pierce[2]***		***Worth[3]***	
	TTI-11004	XRC-11004	TDXL-11004	TTI-11006	XR-11006	TTI-11006	XRC-11006
lbs/A[4]	4312	4338	4188	5037	4994	6588	6581
	P = 0.7624 CV = 7.03			**P = 0.7596 CV = 3.63**		**P = 0.9823 CV = 6.36**	

[1]JD4630, 90' boom, 15" nozzle spacing, 12.0 MPH, 12 GPA, 28 PSI, 36" boom height
[2]JD4730, 100' boom, 15" nozzle spacing, 11.6 MPH, 15 GPA, 18-20 PSI, 36" boom height
[3]JD4730, 90' boom, 20" nozzle spacing, 12.5 MPH, 20 GPA, 42-57 PSI, 36" boom height
[4]Adjusted to 10% moisture.

Summary - 2019

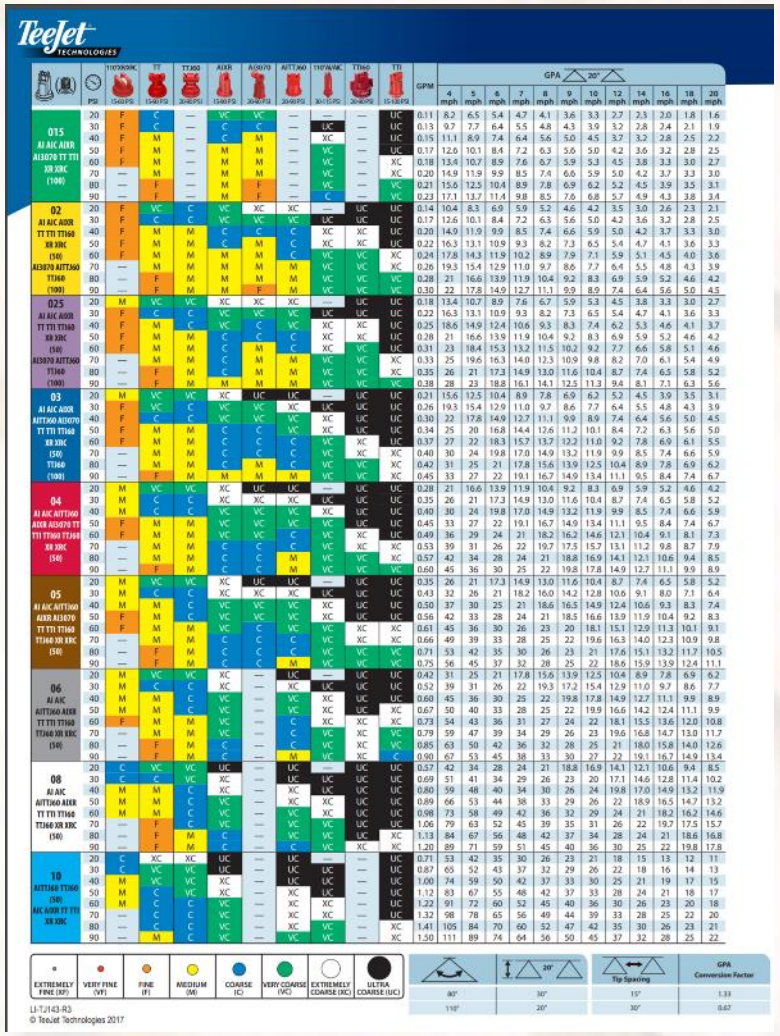
- Spray card analysis
  - *VMD_{50} larger with auxin nozzles (381-481 microns vs. 182-348 microns)*
  - *Coverage better with auxin nozzles in 2/3 tests*
- No differences in weeds, insects, disease, and yield between nozzles were observed in large, on-farm field trials.

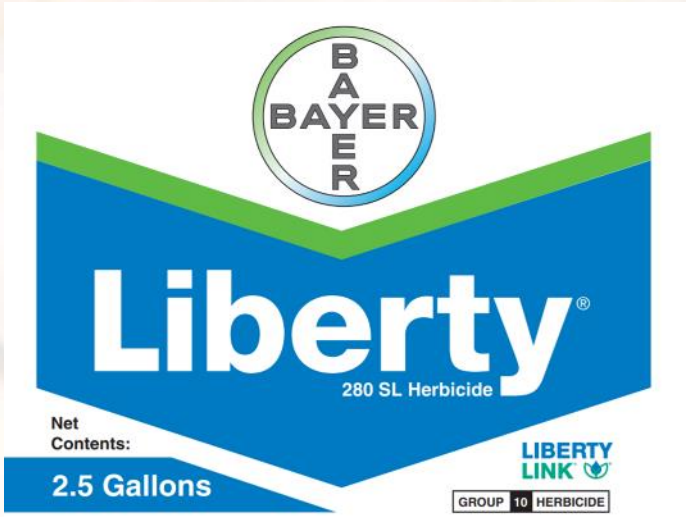
Conclusions

- 6 on-farm, large plot replicated trials in 2018 and 2019
  - *+ 4 site-years small-plot (weed control)*
- No differences between nozzle type for insects, disease, weeds, and yield.
- Suggestions
  - *use at least 12 GPA*
  - *good rotations*
  - *timely applications*
  - *grass control??*

Worth Co.
09/24/19

Liberty (glufosinate) - Nozzles





- "Use nozzles and pressure that generate a ***MEDIUM to COARSE*** size spray droplet. NOTE: Weed control with very coarse, extremely coarse or ultra-coarse nozzles will not provide adequate coverage and will cause unsatisfactory weed control"

What nozzle should I use?

- What are you spraying?
  - contact/systemic
- label information
- multiple nozzle body
  - flat fat/ AIXR/”auxin”
- One nozzle for everything??????
  - Are you timely or late?

Questions/Comments?