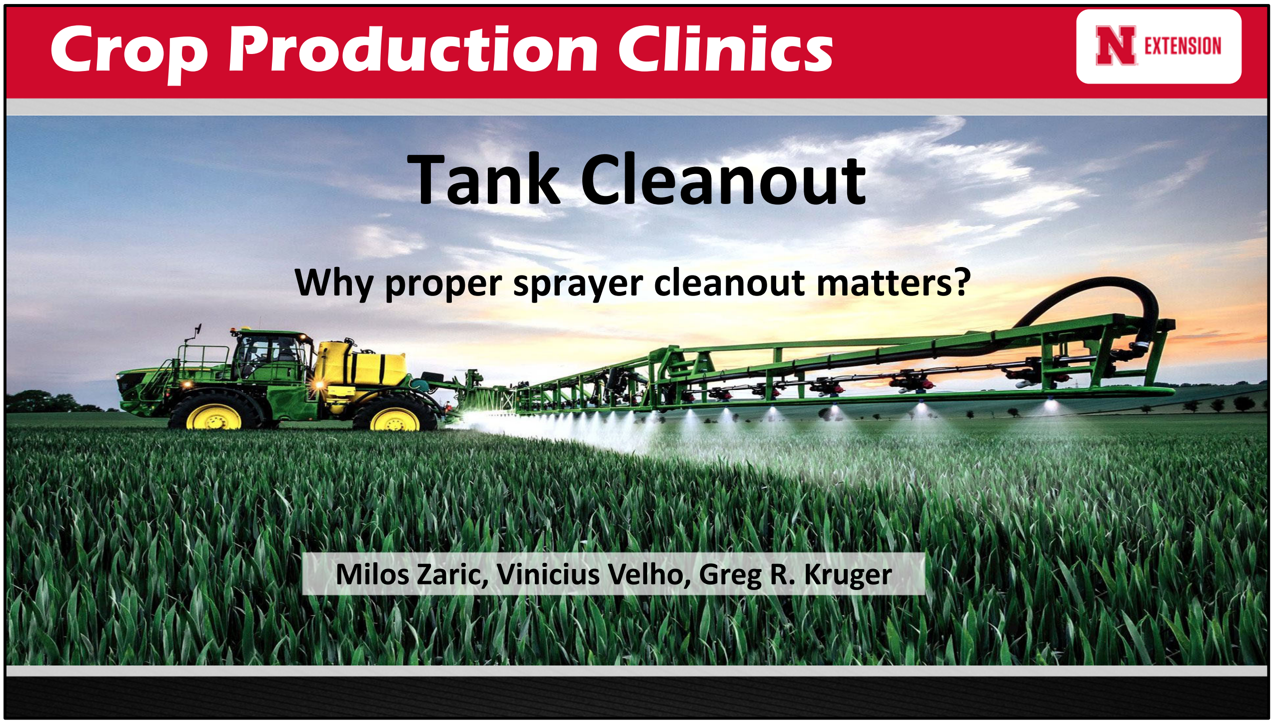
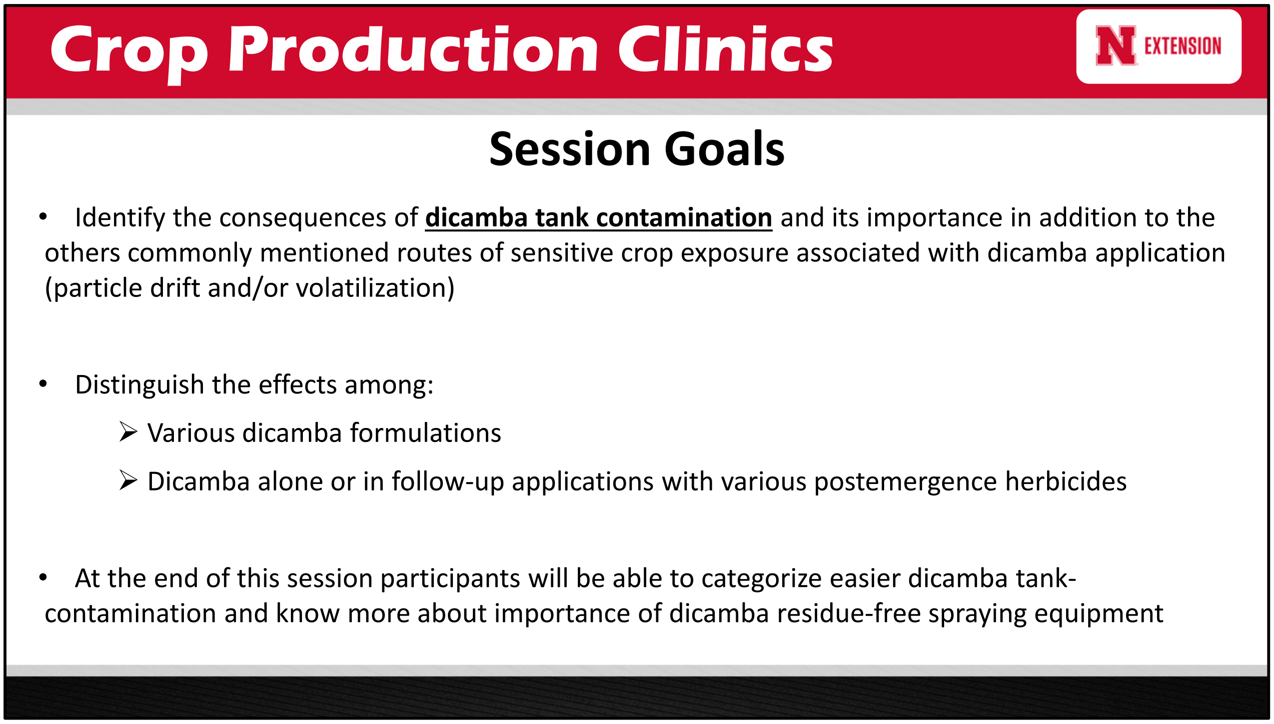


Introduction

Milos Zaric – Graduate Student - mzaric2@unl.edu (Presenter for CPC Sessions on 01/05 (West), 01/06 (Central), 01/07 (East), and 01/20/2021 (Central))
Vinicius Velho - Graduate Student
Greg R. Kruger – Associate Professor



Session focus will be on **dicamba tank contamination** and its importance besides other commonly mentioned exposure routes particle drift and/or volatilization

Crop Production Clinics

N EXTENSION

Potential routes for crop exposure:

1. Volatility
   - Prohibited use of AMS or other ammonium-based products
   - Spraying too late in the season
2. Physical Particle Drift
   - Excessive boom heights
   - Wrong nozzles
   - Illegal tank-mixtures
   - Excessive wind speeds
3. Spraying under temperature inversion
4. Tank Contamination
5.......

Tank contamination

C > B > F > D > E > A > G

16. What do you believe was the main cause for dicamba injury in your non-DR soybean? (85 respondents)	*% Respondents*
a) Tank contamination	*a) 6*
b) Physical drift during application in DR soybean	*b) 19*
c) Volatilization from application in DR soybean	*c) 31*
d) Temperature inversion from application in DR soybean	*d) 14*
e) Physical drift during application in corn	*e) 9*
f) Volatilization from application in corn	*f) 17*
g) Temperature inversion from application in corn	*g) 4*
	(n = 85)

[a]The survey was conducted in two formats: (1) paper copies handed out during 2017 Soybean Management Field Days, held at four major soybean-growing areas of Nebraska (August 08–11, 2017 at North Platte, Ord, Auburn, and Tekamah, respectively); and (2) online using SurveyMonkey (www.survemonkey.com) linked to the University of Nebraska–Lincoln (UNL) CropWatch website (the central resource for UNL Extension information on crop production and pest management; www.cropwatch.unl.edu).
[b]Abbreviations: DR, dicamba-resistant soybean (Xtend® technology, Bayer Crop Science, Research Triangle Park, NC); *n* = number of respondents.

Werle et al. 2018

There are numerous ways for exposure

Survey conducted during 2017 –Nebraska’s soybean growers targeted audience

Tank contamination – **<u>considered as one of the least important ways for soybean exposure. Mainly because it represent the most preventable form. Is this always the case?</u>**

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N EXTENSION

Why proper sprayer cleanout matters?

- Grower or commercial applicator
- The same sprayers used for multiple purposes
- Removing pesticide residues – CRITICAL
- Sprayer contamination can be source of unintended exposure
- Where application started?

Figure credits: Tim Smith

Similar things applies for both growers or commercial applicators
Sprayer dedication just for certain pest management programs is not always possible – sprayers used for multiple purposes
Sprayer cleanout – requires time to be completed - problematic if consider sprayer complexity
How field is "opened" at time of application– the first think to look if something goes wrong (arrow shaped pattern)
Mostly associated about how spray solution is distributed from spray tank

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THE PATHWAY

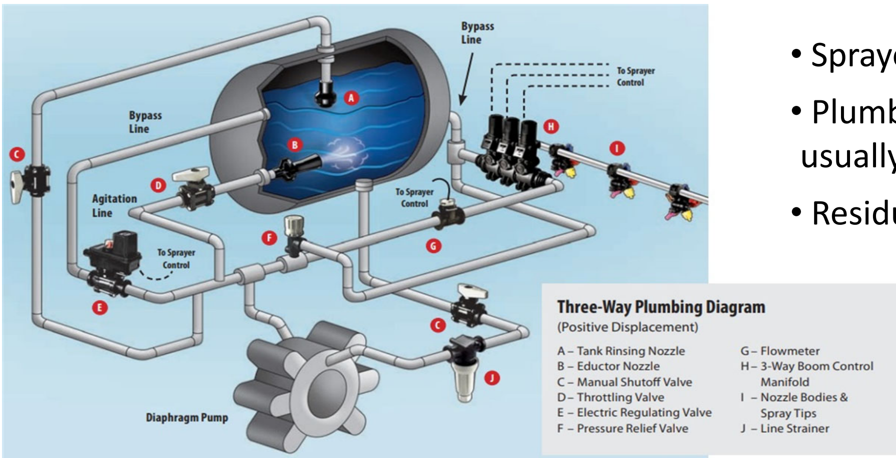

Figure credits: TeeJet

- Sprayer = complexity
- Plumbing complicated and usually interconnected
- Residues easily “trapped”

Limitations on knowledge which part contribute more/less to sprayer contamination – to isolate part from complex spraying system is challenging and might not always give us representable scenario (Supplemental slides on the end shows separation among different hose types)

The best approach consider all of them equally important

More details about each segment mentioned here will be provided with notes of this slide that will be distributed

I would like to point out now problematics associated with end caps

Spray tank – poly vs stainless steel (difference in cleaning, poly depressions where solution can settle)

Hoses – various porosity among materials used to built them

Valves – problematic everything automated (solenoid valves) for example pressure exceed – valves open some of the return lines contaminated (be aware of work)

120 ft boom can hold 35 gallons of solution (plumbing dependent) in theory if not drained well @ 10GPA = 3.5ac or 15GPA = 2.3ac

Screens – manufacturer-based positioning on sprayer and mesh size

120 ft equivalent to 30” = 48 or 15”= 96 carousels (can be problematic) – when switching from 30 – 15 nozzle spacing if not periodically cleaned requires more

efforts for cleanings since residues can build up
End Caps – Next slide more explanation

Just to put in perspective – usually 6 sections * 5 inches * 2 sides each section = 60” or 5 ft where residues can “hide”
Numerous ways how those can be cleaned, to upgrade existing equipment to make cleaning procedures easier
Critical – contamination always present if boom ends are not cleaned thoroughly

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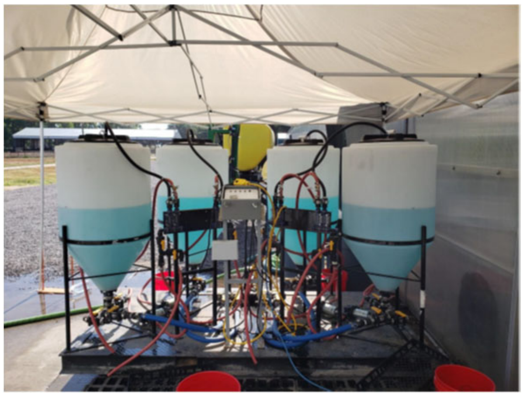
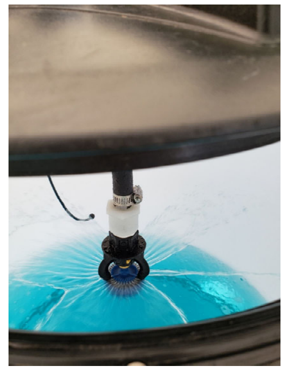
N EXTENSION

Can we remove all dicamba residues across several dicamba formulations by following common cleaning procedures?





Over next several slides we will go through several studies conducted in the PAT Lab, WCREEC, located in North Platte, NE
Since we do not have always 120ft sprayers available – in order to evaluate this system with recirculation is built to help us do simulated studies.

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Evaluated Dicamba Formulations

Active ingredient (WSSA Group)	Trade Name	Rate	Manufacturer
		fl oz/oz ac^{-1}	
Dicamba (4)	Xtendimax	44	Bayer Crop Science
Dicamba (4)	Clarity	32	BASF
Dicamba (4)	Diflexx	16	Bayer Crop Science
Dicamba (4)	Engenia	12.8	BASF
Dicamba + diflufenzopyr(4+19)	Status	10	BASF

Tank contamination possible not just from direct application in dicamba-tolerant crops some of those products used to control weeds in fallow areas and in corn

Worst case scenarios selected

Xtendimax – 2.9 lb gal
Clarity – 4 lb gal
Diflexx - 4 lb gal
Engenia – 5 lb gal
Status – 40% per lb

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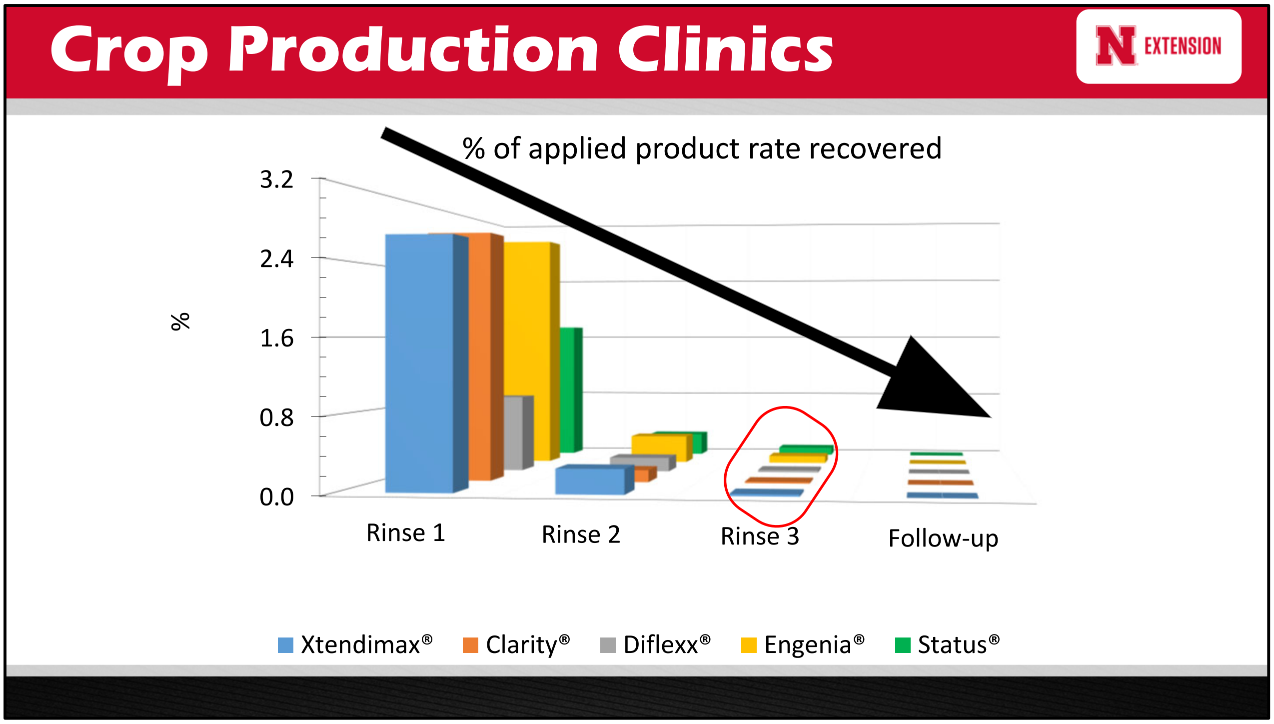
EXTENSION

Step	Procedure	Volume	Agitation time	Sample number
		(%)	(min)	
1	Fill tank	100	20	-
2	Empty tank	-	-	-
3	Fill/Agitate/Empty	10	15	1st sample
4	Fill + **tank cleaner**/Agitate/Empty	10	15	2nd sample
5	Fill/Agitate/Empty	10	15	3rd sample
6	Fill forth time	100	1	4th sample

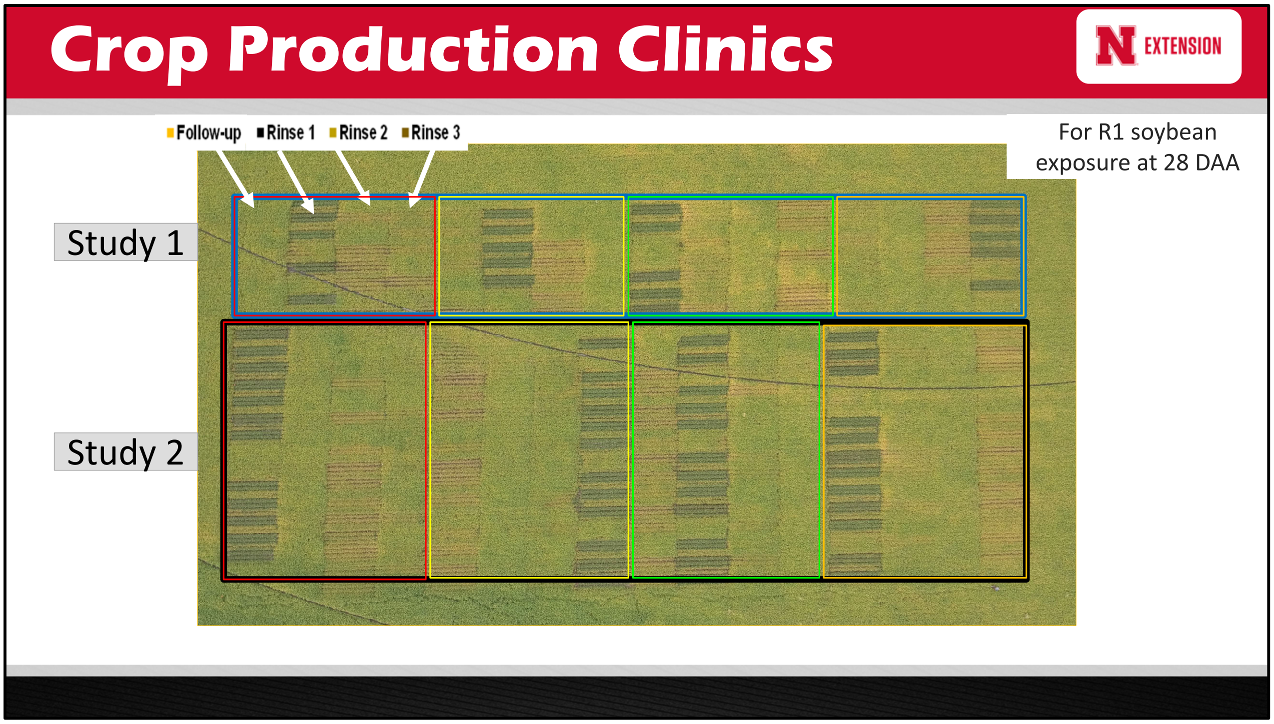
Step 1 – Fill and prepare mixture with dicamba (according to slide 10 and recommended utilized rates) agitate 20min
Step 2 – Empty
Step 3 – 6 – Cleaning procedures and sample collection for chromatography analysis (Part 1) and field studies (Part 2)
***4th sample considered as scenario that would follow up application

Tank cleaner Wipe Out® at 0.25% v/v (Helena Chemical Company)



Data converted from PPB values received after chromatography was completed

Cleaning important but it seems that some formulations in rinse three are recovered more than others. After rinse three still residues present as well and will end up in follow-up application.



Do we see this out in the field? **Quite visible response!**

For CPC we will cover findings from study 1
Each block (color coded) represent individual tank in which simulation of dicamba tank contamination was performed

Field: Late planted soybeans
2,4-D tolerant soybeans - Enlist Mycogen 209E
Entire field replanted due to hail incidence on 06/15/2020

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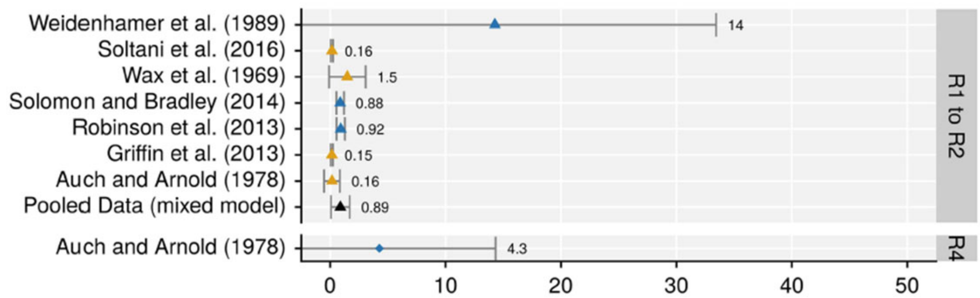

Where yield decrease occurs?

- ❖ Range from 0.9 (Kniss 2018) to about 1 (Egan et al. 2013) g ae ha^{-1}
- ❖ 0.16 – 0.18% of commonly applied rate of 22 fl oz of 2.9lb ormulation or 12.8 fl oz with 5lb formulation (560 g ae ha^{-1})

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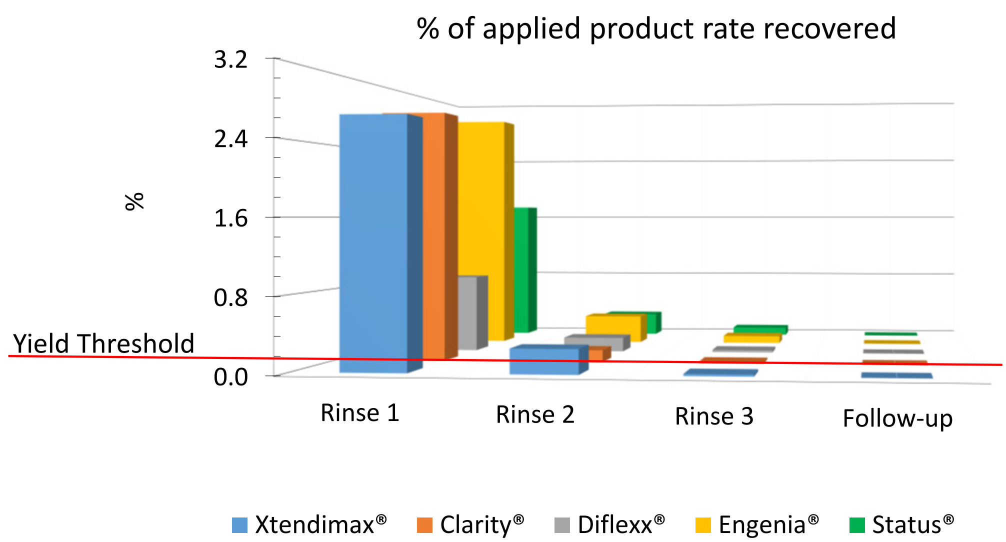

Theoretical % of recovered dicamba amount from applied rate

Conducted meta-analysis studies shows range from 0.9 (Kniss 2018) to about 1 (Egan et al. 2013) g ae ha or 0.16 – 0.18% of rate of 22 fl oz of 2.9lb formulation (560 g ae ha^{-1}), respectively where yield impact occurs.

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		Rinse							
		1		2		3		4	
NO.	Treatment	----------------------		BPA		----------------------			
1	Check	55.0	A	56.5	A	53.2	A	54.5	AB
2	Xtendimax	-	-	45.5	CBD	57.0	A	55.7	AB
3	Clarity	-	-	43.8	D	55.9	A	57.3	A
4	Diflexx	-	-	49.0	CB	57.2	A	56.7	AB
5	Engenia	-	-	44.6	CD	52.2	A	57.3	A
6	Status	-	-	50.4	B	52.5	A	52.0	B
Yield reduction		Estimated 80%		Estimated 20%		No yield loss		No yield loss	

After grower harvested the field yield was on average 57 bushels per acre

Crop Production Clinics

N EXTENSION

Cleaning Procedure	Rinse 1		2		3		4	
	Concentration (µg mL^{-1})							
Triple rinse with water	298.32	a	21.12	a	3.56	a	1.25	a
Ammonium fb glyphosate fb water	521.98	a	16.67	a	0.72	b	0.67	a
Ammonium fb Fimco™ fb water	373.13	a	29.75	a	1.21	ab	0.90	a
Ammonium fb Protank™ fb water	472.65	a	29.96	a	1.28	ab	0.50	a
Sprayer								
Hagie Upfront STS 10	543.05	A	31.75	A	2.55	A	1.09	A
John Deere 6700	270.34	B	16.94	A	0.75	B	0.91	A
SprayCoup 4660	436.16	AB	24.44	A	1.78	AB	0.48	A

[A] Abbreviation: fb, followed by. [B] Dicamba (Clarity®, BASF Corporation, Research Triangle Park, NC 27709, USA) initially applied at 1.12 kg ae ha^{-1}. [C] No sprayer by treatment interactions were observed at $p = 0.05$; therefore, data were combined to show sprayer and treatment effects individually. [D] Means followed by the same uppercase letter within a sprayer column or lowercase letter within a cleaning procedure column are not significantly different based on Tukey's HSD at $p = 0.05$.

Browne et al. 2020

Similar findings reported in literature
Regardless the cleaning procedure and type of sprayer
Dicamba residues detected (for rinse 3 and 4 doses detected way lower than ones for economic impact 3.56 = 0.51 g ae ha^{-1} or 1.25 = 0.18 g ae ha^{-1})
From 0.9 (Kniss 2018) to about 1 (Egan et al. 2013) g ae ha or 0.16 – 0.18% of commonly applied rate of 22 fl oz of 2.9lb formulation (560 g ae ha^{-1}), respectively where yield impact occurs.
There are limitations on knowledge what are consequences in follow up applications (various postemergence herbicides) when dicamba residues are present

From: **Dicamba Retention in Commercial Sprayers Following Triple Rinse Cleanout Procedures, and Soybean Response to Contamination Concentrations**

Authors: **Frances B. Browne, Xiao Li, Katilyn J Price,**

Jianping Wang, Yi Wang, Greg R Kruger, Jeff Golus, Gabrielle de Castro Macedo, Bruno C. Vieira, and Tyler Sandlin

Available at:
https://www.researchgate.net/publication/343834661_Dicamba_Retention_in_Commercial_Sprayers_Following_Triple_Rinse_Cleanout_Procedures_and_Soybean_Response_to_Contamination_Concentrations

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N EXTENSION

Dicamba Simulated Tank-contamination in Common Postemergence Herbicide Applications on Glyphosate-tolerant Soybean

List of herbicides used for evaluation of non-dicamba-tolerant soybean exposure at soybean V3 and R1 growth stage[a].

Active ingredient	Site of Action[b]	Trade name	Rate	Manufacturer
			fl. oz. ac^{-1} or v/v	
Glyphosate[c]	EPSPS	Roundup Powermax	32	Bayer Crop Science
Glyphosate[c]	EPSPS	Roundup Weathermax	32	Bayer Crop Science
Setoxidim[d]	ACCase	Poast Plus	36	BASF
Fluazifop-P-butyl[d]	ACCase	Fusilade DX	12	Syngenta
Clethodim[d]	ACCase	SelectMax	32	Valent
Clethodim[d]	ACCase	Intensity	16	Loveland
Clethodim[d]	ACCase	Section Three	10.7	Winfield
Aciflurofen[e]	PPO	Ultra Blazer	24	UPL
Fomesafen[e]	PPO	Flexstar	32	Syngenta
Lactofen[e]	PPO	Cobra	12.5	Valent
Crop oil concentrate		R.O.C.	1%	Wilbur-Ellis

[a]All herbicides included combination with three different simulated dicamba (XtendiMax, Bayer Crop Science) doses as tank contaminants 0, 0.056, 0.560 g ae ha^{-1} of standard recommended labeled dose of 560 g ae ha^{-1} (22 fl oz of 2.9lb formulation).
[c]Ammonium sulfate 2.5% v v^{-1} (Bronc, Wilbur-Ellis).
[d]Non-ionic surfactant 0.25% v v^{-1} (R-11 Spreader Activator, Wilbur-Ellis).
[e]Crop oil concentrate 1% v v^{-1} (R.O.C., Wilbur-Ellis).

Can response be changed with follow-up applications?

Two field studies were conducted during 2018 and 2019 growing season at the West Central Research, Extension and Education Center in North Platte, Nebraska (41° 05’17.2” N - 100° 46’40.7” W) to evaluate non-dicamba-tolerant soybean exposure to application of postemergence herbicides in tank-mixtures with sub-labeled doses of dicamba.

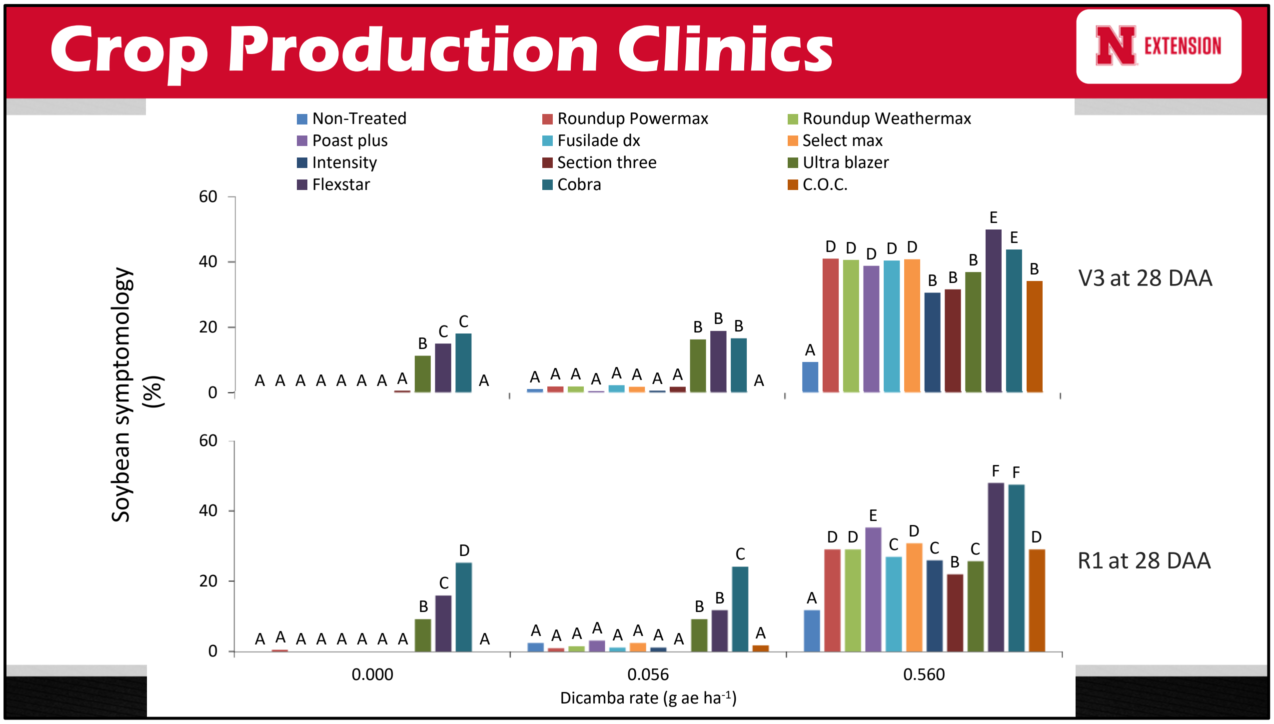
Soil type at this site was Sandy Loam with a sand, silt, and clay percentage of 57, 32, and 11 %, respectively, and a pH of 7.5.

Soybeans were grown in no-till system in crop rotation after corn.

Non-dicamba-tolerant soybean variety (Hoegemeyer 2511NRR, Hoegemeyer Hybrids, Hooper, NE, USA) was planted on May 24, 2018 and May 15, 2019 with a planting rate of 140.000 seeds ac^{-1}.

0 – no dicamba in tank-mix
0.056 – 10.000x less than recommended labeled rate (560 g ae ha^{-1}) or 0.01% of applied rate (22 fl oz of 2.9lb

formulation)
0.56 - 1.000x less than recommended labeled rate (560 g ae ha^{-1}) or 0.1% of applied rate (22 fl oz of 2.9lb formulation)



For simplicity in figure comparison allowed just across herbicides within dicamba rate

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0.056 – 10.000x less than recommended labeled rate (560 g ae ha^{-1}) or 0.01% of applied rate (22 fl oz of 2.9lb formulation)
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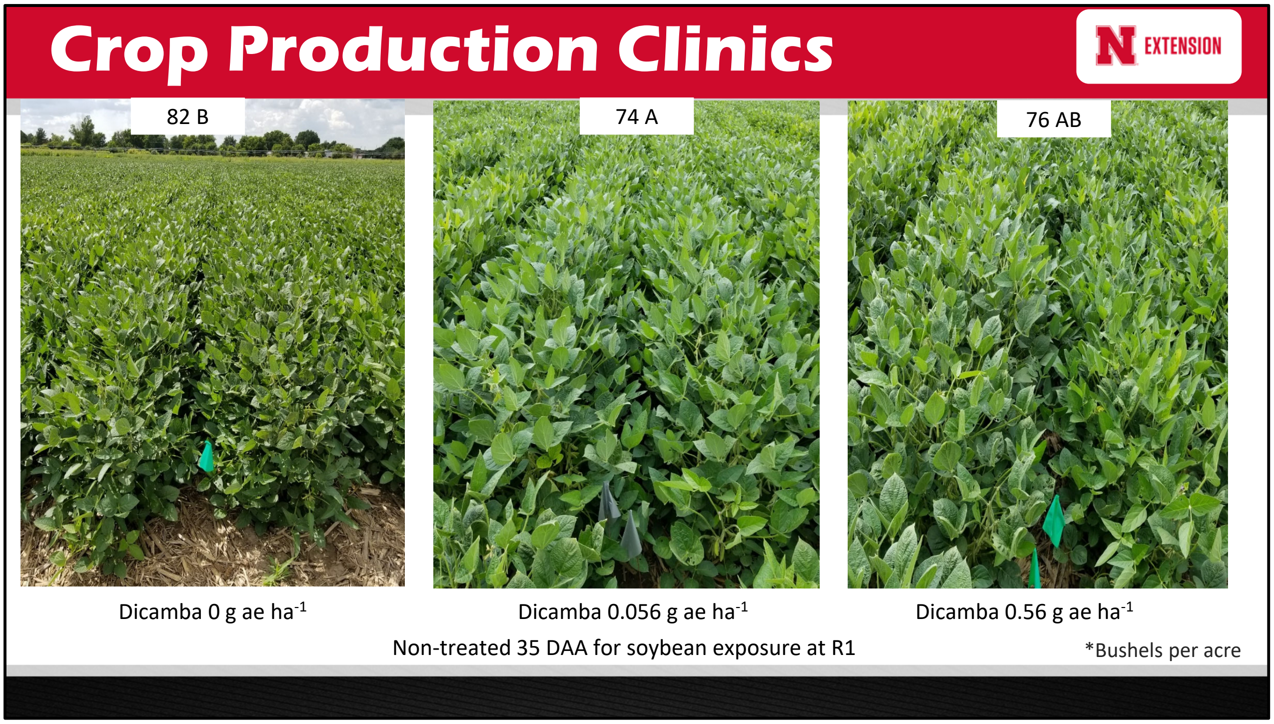

For simplicity in figure comparison allowed just across particular treatment within dicamba rate

0 – no dicamba in tank-mix

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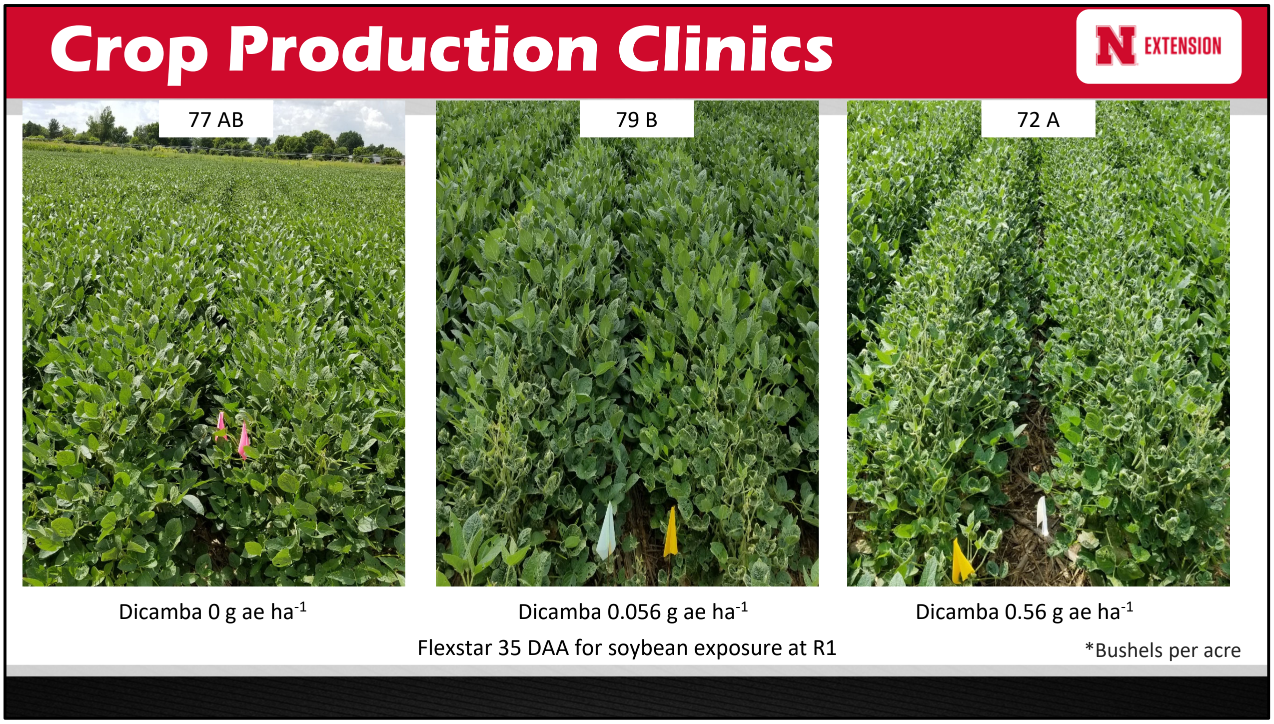
0.56 - 1.000x less than recommended labeled rate (560 g ae ha^{-1}) or 0.1% of applied rate (22 fl oz of 2.9lb formulation)



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N EXTENSION

Soybean yield as percentage of non-treated control for soybean exposure to postemergence in tank-mixtures with sublabel rates of dicamba at V3 and R1 growth stages (2018 and 2019 growing season results combined)

Herbicide	Dicamba rate[a] (g ae ha^{-1}) V3 growth stage 0	V3 0.056	V3 0.560	R1 growth stage 0	R1 0.056	R1 0.560
	%					
Non-treated	100 b	96 b A	87 a A	100 b B	90 a A	93 ab A
Roundup Powermax	97 ab	102 b B	93 a A	89 a A	97 b B	98 b B
Roundup Weathermax	100	95 A	95 A	101 B	98 B	96 B
Poast Plus	96	102 B	101 B	97 ab B	99 b B	90 a A
Fusilade DX	94 a	97 ab A	104 b B	98 B	98 B	91 A
SelectMax	102	98 A	94 A	92 A	96 B	95 B
Intensity	101	99 B	103 B	94 A	101 B	98 B
Section Three	101	102 B	97 A	90 a A	94 ab A	99 b B
Ultra Blazer	96	94 A	97 A	92 A	95 B	98 B
Flexstar	93	100 B	95 A	93 ab A	96 b B	88 a A
Cobra	95	95 A	98 A	92 A	90 A	88 A
COC[b]	98	102 B	103 B	93 A	99 B	91 A

[a]Means followed by the same letter, lower case in the row within growth stage and upper case in the column, do not differ using Tukey and Scott Knott's tests, respectively, at α = 0.05.
[b]Crop Oil Concentrate.

Complex table - for simplicity in figure comparison allowed both directions within and across treatment

0 – no dicamba in tank-mix
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EXTENSION

Take Home Points

- Understand the risk (crop sensitivity, product used, surrounding, etc.)
- KNOW YOUR SPRAYER

- Cleanout procedures - Follow them
- “Hidden” residues may impact response
- Visual response ≠ economical impact
- Environmental conditions - role in recovery

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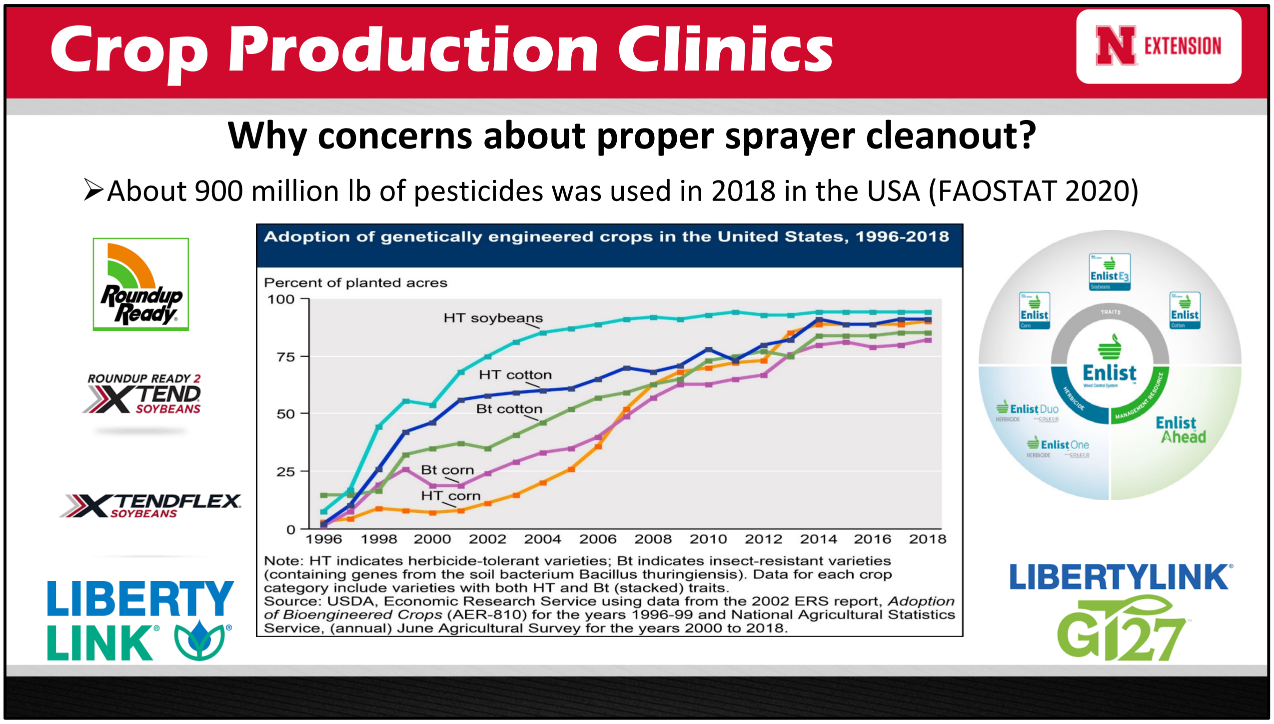
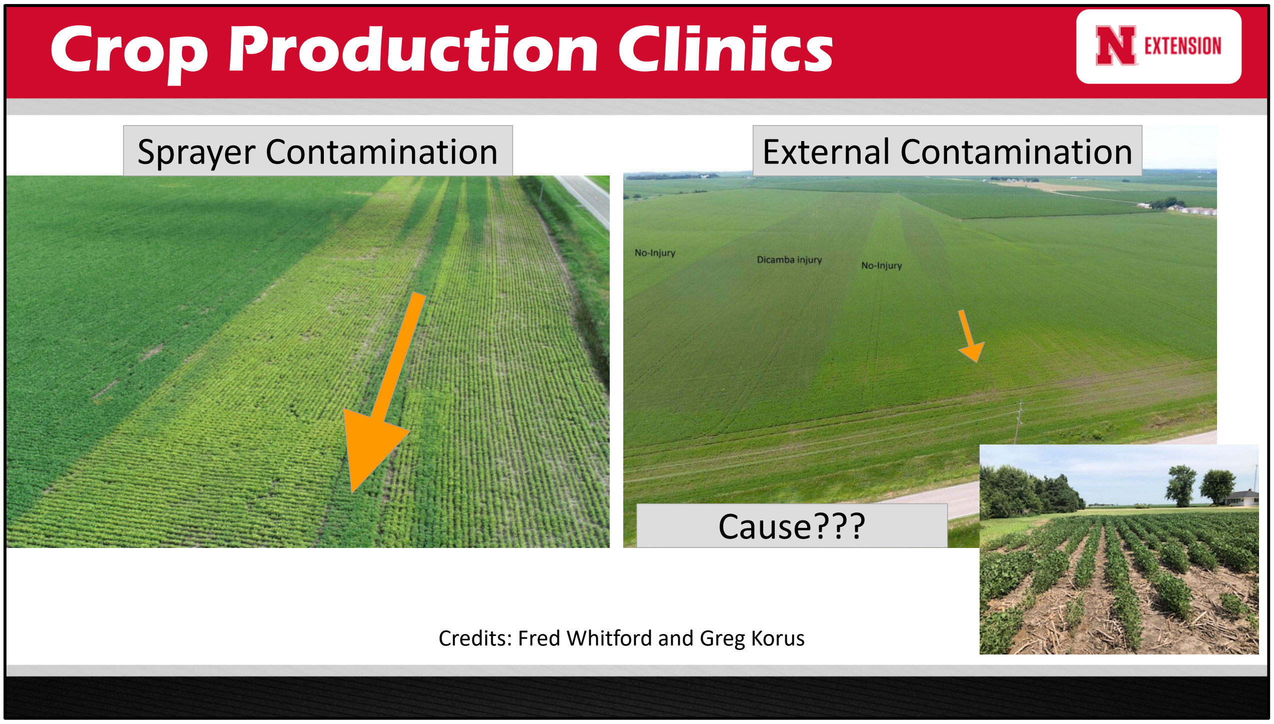
Extension is a Division of the Institute of Agriculture and Natural Resources at the University of Nebraska–Lincoln cooperating with the Counties and the United States Department of Agriculture.
University of Nebraska–Lincoln Extension educational programs abide with the nondiscrimination policies of the University of Nebraska–Lincoln and the United States Department of Agriculture.



Difficulties to develop herbicides with unique modes of actions for weed control has resulted in a significant shift toward development of herbicide-tolerant crops

<u>One of the problems associated with adoptions of HT traits this is especially related with some of the broad-spectrum herbicides which lack in selectivity in terms of crop safety (e.g. glyphosate, dicamba, etc.)</u>

Which can be active at low rates – especially if talking about herbicides can create problems



Various possibilities
Uniformity of symptoms through the field can reveal where was the problem (need to follow all clues thoroughly)
Sprayer Contamination (over finite area usually as time of application increase visual symptoms gradually decrease) – Arrow shape
External Contamination (symptoms constant throughout area unless something changed, for example, new mix load) – often claimed cause particle drift
Suggestion: investigate more clues – typically where sprayer was turning around even if minor dripping present soybean exposed to higher concentration (visible)

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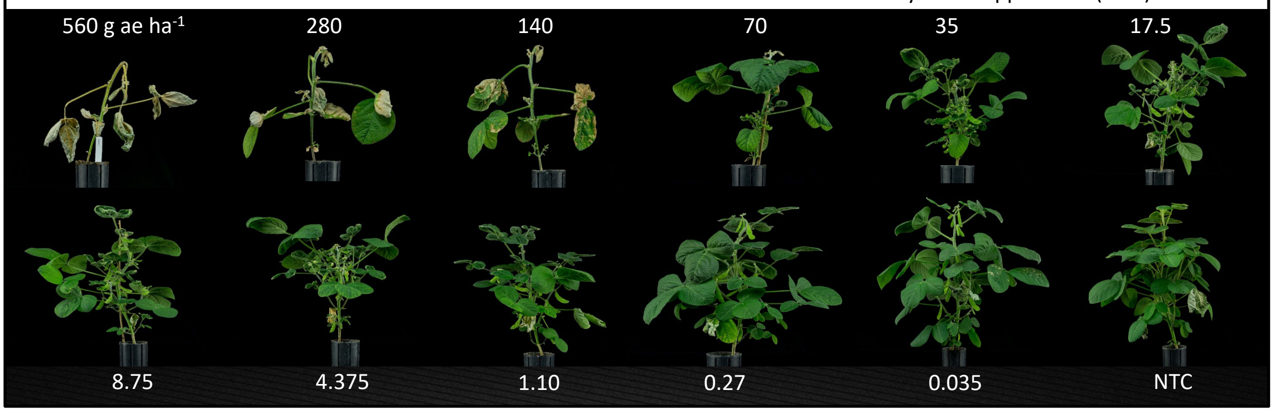
- Failure to remove residues from a sprayer could result in exposure of sensitive crops
- Plant response associated with the concentration of product left-out and product used
- Dependent of growth stage at exposure timing (R more sensitive)
- Cosmetic to total yield loss (exposure route matter)

28 days after application (DAA) of dicamba



Exposure dicamba applied in corn (e.g. Status) to control weeds than used in RR or LL, etc. soybeans (tolerant to glyphosate or glufosinate, etc.)

Consequences - Greenhouse study

560 g ae ha^{-1} equivalent to application of 22 fl oz of 2.9 lb dicamba formulation or 12.8 fl oz of 5 lb dicamba formulation

Active at quite low rates!

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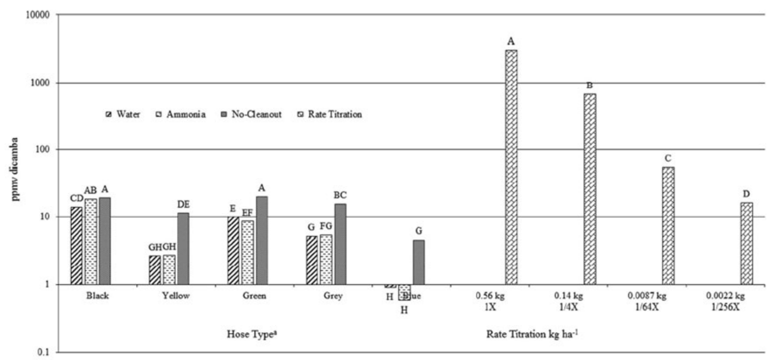


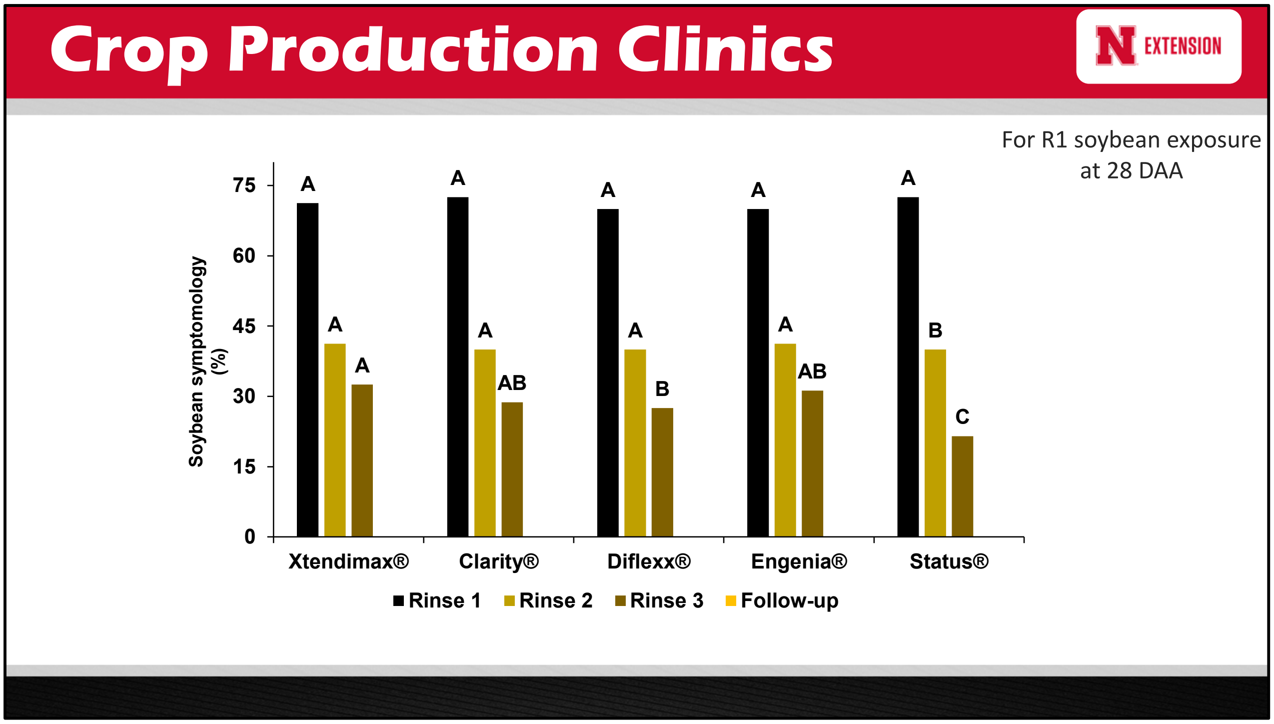
Figure 3. Hose sequestration of dicamba (ppmv) showing all hose type by cleanout procedures and rate titration as comparison. Hose type: yellow, John Deere PMK 4131-08; blue, John Deere PMA 4086-08; green, John Deere PMA 1687-08; gray, John Deere PMA 1628-08; and black, Goodyear.

Cundiff et al. 2017

From: Evaluation of Dicamba Persistence among Various Agricultural Hose Types and Cleanout Procedures Using Soybean (Glycine max) as a Bio-Indicator

Authors: Gary T. Cundiff, Daniel B. Reynolds, and Thomas C. Mueller

Available at: https://bioone.org/journals/weed-science/volume-65/issue-2/wsc.2016.29/Evaluation-of-Dicamba-Persistence-among-Various-Agricultural-Hose-Types-and/10.1017/wsc.2016.29.short



Use of soybean plants as bioindicators to show the impact of cleaning

For simplicity in figure comparison allowed just across particular treatment within dicamba rate

0 – no dicamba in tank-mix
0.056 – 10.000x less than recommended labeled rate (560 g ae ha^{-1}) or 0.01% of applied rate (22 fl oz of 2.9lb formulation)
0.56 - 1.000x less than recommended labeled rate (560 g ae ha^{-1}) or 0.1% of applied rate (22 fl oz of 2.9lb formulation)

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N EXTENSION

ADDITION - EXTERNAL CONTAMINATION???

- Assumption - proper sprayer cleanout performed
- External tanks that are used to refill/mix the sprayer in the field - PROBLEM
- Tanks need to be cleaned or designated (e.g. "hot" loads)

<u>Potential sources</u>

- Mixing and loading facilities
- Shuttles, bulk, and mini bulks
- Inductor cones
- Used hoses for sprayer fill-out
- Nurse tanks on trucks (Tender trucks)