Weed Science Research Summary 2020
West Central Research, Extension and Education Center
North Platte, Nebraska

Contents

Assessment of Industrial Hemp Susceptibility to Off-target Movement of Commonly Applied Corn and Soybean Postemergence Herbicides

Authors: Milos Zaric, Bruno Canella Vieira, Marija Savic, Barbara Vukoja, Guilherme Sousa Alves, Greg R. Kruger

Study outline: After the 2018 Farm Bill, industrial hemp has been recognized as a crop legal to grow. Allowance of this commodity to be grown for a variety of purposes (i.e. fiber, grain, hemp oil, cannabinoids, etc.) resulted in increased industrial hemp acreage cultivated throughout the United States. The implementation of industrial hemp fields in areas with adjacent soybean and corn fields raised questions regarding the crop susceptibility to off-target movement of commonly applied herbicides in these crops. At the present time products registered for pest management in industrial hemp are limited. The objective of this study was to examine the sensitivity of industrial hemp to off-target movement of various herbicides registered for use in corn and soybean. This study was conducted in a research wind tunnel at the Pesticide Application Technology Laboratory (University of Nebraska-Lincoln, West Central Research and Extension Center, North Platte, NE). Dual-purpose (grain and cannabinoid) industrial hemp variety was grown under greenhouse conditions. Herbicide solutions (imazethapyr, 2,4-D, dicamba, glyphosate, glufosinate, lactofen, and mesotrione) were mixed at 140 L ha^{-1} carrier volume and sprayed in the low speed wind tunnel (3.6 m s^{-1}) with conventional and air inclusion flat fan nozzles (TP95015EVS and AI95015EVS, respectively) at 207 kPa. Herbicide solutions contained fluorescent tracer (PTSA) at 3 g L^{-1} for fluorometric analysis. During applications, industrial hemp plants (20 – 25 cm) were positioned inside the wind tunnel at different downwind distances from the nozzle (1, 2, 3, 6, 9, and 12 m). Mylar cards (0.01m^2) were positioned along plants to collect spray drift deposits.

Results: Herbicide drift was influenced by nozzle design ($p < 0.0001$), where applications with conventional and air inclusion nozzles had 5% of the spray deposits reaching 5.9 and 2.0 m downwind, respectively. Industrial hemp had greater sensitivity to glyphosate, glufosinate, and mesotrione spray drift, with plants having 50% biomass reduction at 19.3, 8.7, 9.3 m downwind, respectively, for applications with the conventional flat fan nozzle. Biomass reduction was minimized for herbicide applications with the air inclusion nozzle, with plants having 50% biomass reduction at 4.1, 4.0, and 2.9 m downwind for glyphosate, glufosinate, and mesotrione applications, respectively. Considering that all products evaluated in this study are not labeled for industrial hemp, off-target movement from adjacent corn and soybean fields can be considered as high-risk situation for industrial hemp production. Based on the herbicide sensitivity of this crop, the adoption of additional off-target mitigation techniques is necessary.

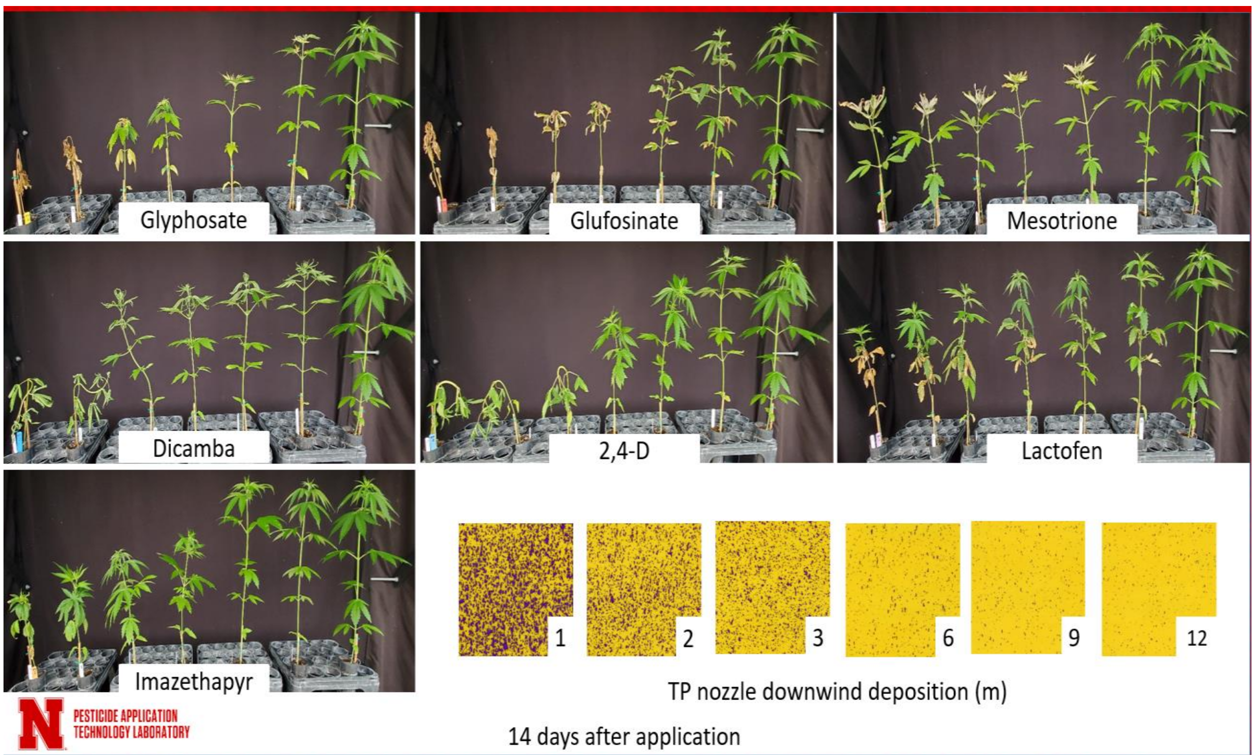

Figure 1. Industrial hemp visual response for all herby evaluated solutions using a flat-fan nozzle (TP) for study conducted in a low speed wind tunnel.

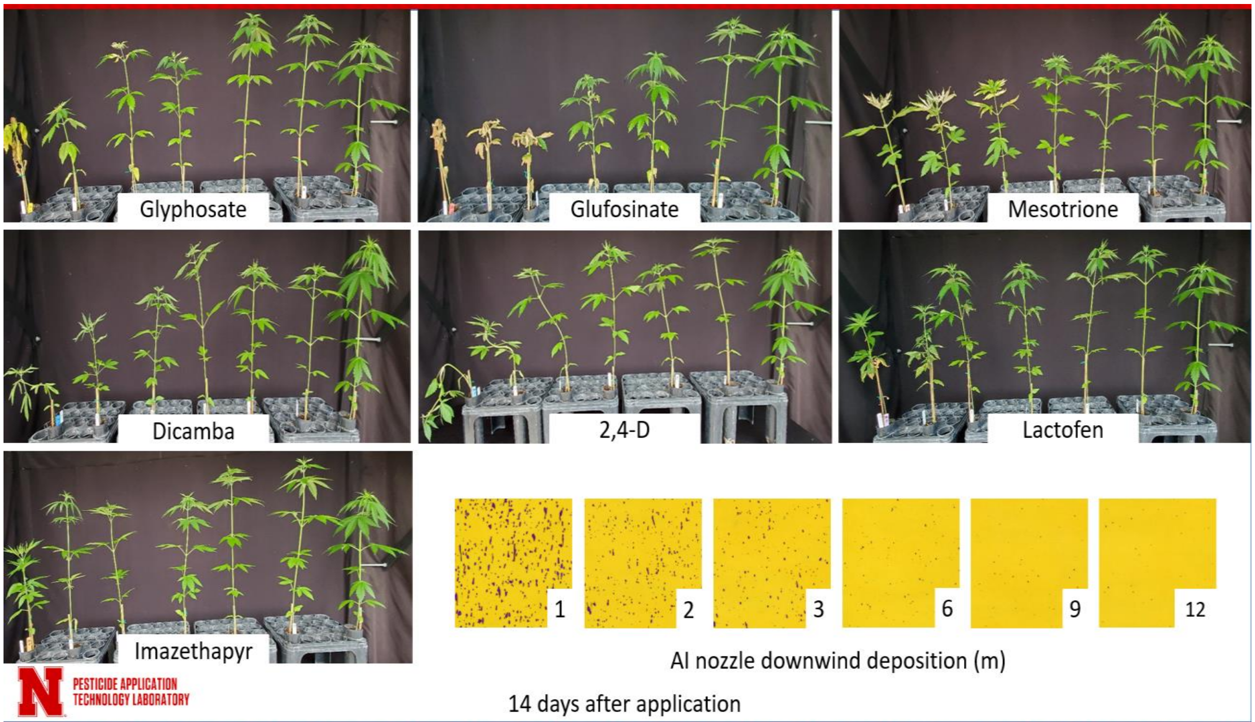

Figure 2. Industrial hemp visual response for all herby evaluated solutions using a flat-fan nozzle (AI) for study conducted in a low speed wind tunnel.

Effects of Drift-reducing Nozzles and Adjuvants on Dicamba Efficacy

Authors: Milos Zaric, Kasey P. Schroeder, Bruno Canella Vieira, Guilherme Sousa Alves, Jesaelen Gizotti de Moraes, Jeffrey A. Golus, Greg R. Kruger

Study outline: The increase in cropping area with dicamba-tolerant crops in the US was followed with increased number of off-target movement (OTM) reported cases. The addition of drift-reducing adjuvants (DRAs) with certain tank-mixtures represents mandatory practice along with drift-reducing nozzle types. In general, the impact of these nozzles and DRAs on weed control is not well understood. The objectives of this study were to evaluate the impact of DRAs added to dicamba tank-mixtures on droplet size distribution (DSD) and control of velvetleaf (*Abutilon theophrasti* Medik.) and common lambsquarters (*Chenopodium album* L.). Examined factors included three levels of solution, nozzle type, and operating pressure. Solution was consisted of dicamba (diglycolamine salt) applied at 560 g ae ha^{-1} either alone or in tank-mixture with two DRAs at 0.5% v v^{-1}. The DRAs used were polyethylene glycol, choline chloride, guar gum (DRA 1) and 2-hydroxypropane-1,2,3 carboxylate, complex trihydric alcohols, oligomeric sugar alcohol condensates (DRA 2). Applications were made at 140 L ha^{-1} using TTI 11004, TDXL 11004-D, and ULD 12004 nozzles at 138, 207, and 276 kPa pressures. DSD was measured using a laser diffraction system in completely randomized design study with three replications. Efficacy studies were conducted in a randomized complete design and split-plot arrangement with four replications and three experimental runs. Pressure versus solution was considered as main plot and nozzle type as subplot. Prior to applications, twelve plants (10 to 15 cm tall) of each weed species per replication were arranged in a continuous line across width of the spray boom. Applications were made using a three-nozzle track spray chamber with nozzles spaced 50 cm apart and above target. Plants aboveground biomass were harvested 28 days after application and dried at 65 °C to a constant weight. Dry weight was converted into percentage of biomass reduction compared to non-treated control and further used to determine the coefficient of variation (CV) across the spray boom.

Results: Across all tested pressures, DSD values followed pattern with TTI>TDXL-D>ULD (largest to smallest) with decrease in percent of driftable fines observed when DRAs were used.

The CV for velvetleaf control was about 5% indicating uniformity in biomass reduction across all treatments tested. For common lambsquarters, uniformity was treatment dependent with CV values ranging from 4 to 11%. The greatest difference was determined for treatments applied using low operational pressures and solution that did not contain DRAs. Even though spray pattern collapses are detected for TDXL-D and ULD nozzles at low operational pressures the addition of DRAs with dicamba in tank-mixture decreased the variation across spray boom. Solution, nozzle selection, and operating pressure need to be considered as critical component for both DSD and dicamba efficacy. Minimization of OTM is a priority, however, there is a critical need to determine which label approved mitigation practices are the most effective and which ones may be detrimental to optimize weed control.

Table 1. Droplet size distribution for volume median diameter and percentage of driftable fines for evaluated dicamba solutions across nozzle types and pressures.

Pressure	Adjuvant	Volume Median Diameter			Driftable fines (<200µm)		
		TTI	TDXL-D	ULD	TTI	TDXL-D	ULD
kPa		µm			%		
138	None	1078 aD	998 bC	905 cC	0.19 bDC	0.20 bF	0.37 aE
	DRA1	1193 bA	1215 aA	1043 cB	0.11 bE	0.05 bG	0.20 aG
	DRA2	1178 aB	1102 cB	1155 bA	0.14 bDE	0.15 bF	0.26 aF
207	None	954 aG	861 bF	774 cE	0.42 cB	0.64 bD	0.97 aC
	DRA1	1113 aC	990 bC	914 cC	0.20 cDC	0.35 bE	0.48 aD
	DRA2	1076 aD	965 bD	908 cC	0.23 cC	0.40 bE	0.52 aD
276	None	869 aH	783 bH	729 cF	0.80 cA	0.98 bB	1.28 aA
	DRA1	1010 aE	890 bE	836 cD	0.37 cB	0.91 bC	1.12 aB
	DRA2	994 aF	832 bG	839 bD	0.38 bB	1.05 aA	1.02 aC

Means followed by the same letter, lower case in the row and upper case in the column, do not differ.

Volume Median Diameter (VMD) - represents the droplet size such that 50% of the spray volume is contained of droplets of lesser diameter.

Table 2. Coefficient of variation (CV) across boom for biomass reduction of velvetleaf and common lambsquarters treated with dicamba solutions sprayed through three nozzle types using different pressures.

Pressure	Adjuvant	Velvetleaf			Common lambsquarters		
		TTI	TDXL-D	ULD	TTI	TDXL-D	ULD
kPa		——%			——%		
138	None	1.5 aA	1.8 aA	1.2 aA	11.3 bB	8.2 aC	7.8 aB
	DRA1	2.7 aB	1.7 aA	1.7 aA	7.0 aA	8.7 aC	9.2 aB
	DRA2	1.1 aA	1.5 aA	5.3 bB	6.1 aA	5.8 aB	4.7 aA
207	None	2.1 aB	1.9 aA	2.0 aA	11.4 bB	7.9 aC	7.1 aB
	DRA1	1.3 aA	1.8 aA	2.4 aA	7.7 aA	6.3 aB	6.3 aB
	DRA2	1.3 aA	1.6 aA	1.2 aA	6.4 bA	4.6 aA	4.5 aA
276	None	1.9 aB	1.4 aA	1.5 aA	10.7 bB	8.2 aC	6.8 aB
	DRA1	1.5 aA	1.8 aA	3.7 bB	6.4 aA	6.8 aC	7.3 aB
	DRA2	1.4 aA	1.5 aA	1.3 aA	5.5 aA	4.3 aA	4.8 aA

Means followed by the same letter, lower case in the row and upper case in the column, do not differ.

Coefficient of variation (CV) - represents parameter that helps in determination of uniformity of biomass reduction for herby evaluated weed species across spray boom.

Dicamba Simulated Tank-contamination in Common Postemergence Non-dicamba-tolerant Soybean Herbicide Programs

Authors: Milos Zaric, Guilherme Sousa Alves, Bruno Canella Vieira, Jeffrey A. Golus, Greg R. Kruger

Study Outline: Development of dicamba-tolerant (DT) crops was driven by a need for broad-spectrum and viable herbicide options for postemergence weed control in soybean. Even though DT crops have provided farmers a feasible approach to control troublesome weeds, there are some concerns associated with dicamba off-target movement and its effects on sensitive broadleaf vegetation. Currently, there are few available studies that evaluate dicamba presence as a tank contaminant. There are even less studies that report the impact of dicamba on sensitive crops when found with different tank-mixtures. Field experiments were conducted in 2018 and 2019 to evaluate the impact of commonly applied postemergence herbicides with simulated dicamba tank contamination on non-DT soybean. The experiment was conducted in a randomized complete block design with a factorial arrangement with four replications. Evaluated treatments included non-treated check, two glyphosate formulations, and three PPO-inhibiting herbicides combined with one of three sub-labeled rates of dicamba as tank contaminants (0, 0.1, and 0.01% of the 560 g ae ha^{-1} rate) applied at two soybean fields at different growth stages (V3 and R1) using a CO_2 backpack sprayer with a six-nozzle boom calibrated to deliver 140 L ha^{-1} using AIXR110015 nozzles at 345 kPa. Visual estimation was recorded at 21 days after treatment. Soybean yield was also collected by harvesting the two middle rows of each plot.

Results: Soybean symptomatology and final yield was depended on interaction between herbicide and sub-labeled rates of dicamba and growth stage of soybean exposure. Across evaluated treatment results indicates glyphosate products followed by the most of the ACCase inhibiting herbicides did not result in difference in terms of soybean symptomology and final yield. However, both response variables were influenced when PPO inhibiting herbicides were found with dicamba tank contamination. Treatment dicamba alone at 0.560 g ae ha^{-1} was estimated to be about 10% while in combination with Flexstar was about 50%. Even though, that applied herbicides caused more visible symptoms and final impact on soybean yield need to be considered as complexed biological process that is commonly dose dependent and may not always result in yield loss. The main takeaway message from this study is if sprayers are not designated just for dicamba applications there might be potential implications on soybean response associated with postemergence herbicide programs used after dicamba was sprayed. The results of this research expand knowledge that will help in education regarding the future management decisions.

Table 1. Visual estimation on soybean symptomology at 21 days after application of postemergence herbicides in tank-mixtures with sublethal doses of dicamba at V3 and R1 growth stages.

Herbicide	Dicamba dose[a] (g ae ha^{-1})					
	V3 growth stage			R1 growth stage		
	0	0.056	0.560	0	0.056	0.560
	%					
Non-treated	0.0 aA	1.1 aA	9.4 bA	0.0 aA	2.5 aA	11.8 bA
Roundup Powermax	0.0 aA	1.9 aA	41.0 bD	0.6 aA	1.0 aA	29.1 bD
Roundup Weathermax	0.0 aA	1.9 aA	40.6 bD	0.0 aA	1.6 aA	29.1 bD
Poast Plus	0.0 aA	0.4 aA	38.8 bD	0.0 aA	3.2 aA	35.3 bE
Fusilade DX	0.0 aA	2.3 aA	40.4 bD	0.0 aA	1.2 aA	27.0 bC
SelectMax	0.0 aA	1.8 aA	40.8 bD	0.0 aA	2.5 aA	30.8 bD
Intensity	0.0 aA	0.6 aA	30.6 bB	0.0 aA	1.2 aA	26.0 bC
Section Three	0.6 aA	1.8 aA	31.6 bB	0.0 aA	0.0 aA	22.0 bB
Ultra Blazer	11.3 aB	16.3 bB	36.9 cC	9.3 aB	9.3 aB	25.7 bC
Flexstar	15.0 aC	18.9 aB	49.9 bE	16.0 aC	11.8 aB	48.0 bF
Cobra	18.1 aC	16.6 aB	43.8 bE	25.3 aD	24.2 aC	47.5 bF
COC[b]	0.0 aA	0.0 aA	34.1 bC	0.0 aA	1.8 aA	29.1 bD

[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 $\alpha = 0.05$.

[b]Crop Oil Concentrate.

Table 2. Yield of soybean exposed to postemergence herbicides in tank-mixtures with sublethal doses of dicamba at V3 and R1 growth stages.

Herbicide	Dicamba dose[a] (g ae ha^{-1})											
	V3 growth stage						R1 growth stage					
	0		0.056		0.560		0		0.056		0.560	
	kg ha^{-1}											
Non-treated	5537	b	5289	bA	4835	aA	5536	bB	5000	aA	5161	abA
Roundup Powermax	5386	ab	5667	bB	5141	aA	4919	aA	5344	bB	5437	bB
Roundup Weathermax	5535		5282	A	5250	A	5587	B	5440	B	5314	B
Poast Plus	5319		5661	B	5601	B	5393	abB	5470	bB	4999	aA
Fusilade DX	5210	a	5354	abA	5753	bB	5403	B	5443	B	5057	A
SelectMax	5666		5430	A	5230	A	5080	A	5335	B	5253	B
Intensity	5592		5497	B	5701	B	5180	A	5566	B	5423	B
Section Three	5616		5664	B	5347	A	5008	aA	5195	abA	5493	bB
Ultra Blazer	5311		5226	A	5380	A	5118	A	5246	B	5408	B
Flexstar	5135		5558	B	5267	A	5164	abA	5290	bB	4854	aA
Cobra	5277		5276	A	5424	A	5111	A	4957	A	4895	A
COC[b]	5447		5633	B	5680	B	5129	A	5464	B	5063	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 $\alpha = 0.05$.

[b]Crop Oil Concentrate.

Air Induction nozzles pattern distribution influenced by work pressure and boom height

Authors: Antonio Augusto Correa Tavares, Milos Zaric, Rone Batista de Olivera, and Greg R. Kruger

Study Outline: The proper configuration of the sprayer during pesticide applications is critical to ensure accurate pesticide applications. Recurrent pesticide drift concerns motivated the development and introduction of new nozzle models on the market. The objective of this study was to evaluate the influence of boom height and work pressure on the spray pattern distribution of air inclusion nozzles.

Results: Spray pattern distribution was influenced by nozzle type, pressure, and boom height. The TTI nozzle had more consistent coefficient of variation (CV) for different boom height and pressure tested in this study. The TTI nozzle had the lowest CV for applications with 0.35 and 0.5 m boom height.

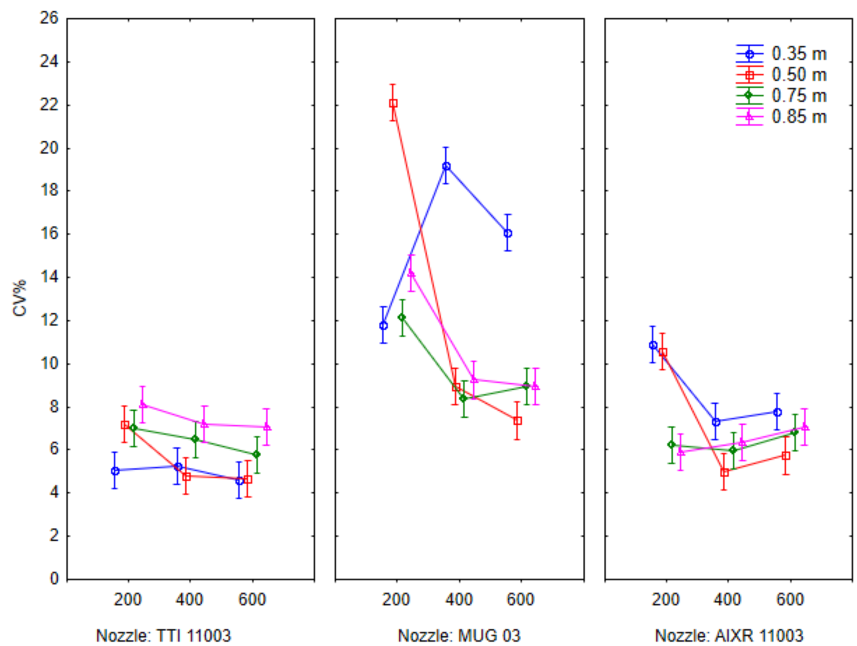

Figure 1. Coefficient of variation (CV%) for applications using TTI11003, MUG03, and AIXR11003 at different pressures and boom heights. Error bars represent the 95% confidence intervals.

Droplet spectrum of mix tank solution of dicamba + glyphosate under influence of nozzle model and work pressure

Authors: Antonio Augusto Correa Tavares, Barbara Vokuja, Rone Batista de Olivera, and Greg R. Kruger

Study Outline: The use of glyphosate and synthetic auxin herbicides in tank mixtures is a feasible and effective alternative to control troublesome weed species. However, drift reduction techniques are needed in order to avoid herbicide injury to the surrounding vegetation. The objective of this study was to evaluate the influence of nozzle selection and pressure on the spray droplet spectrum for applications of dicamba + glyphosate tank mixture.

Results: The TTI11003 and MUG03 nozzles had greater $DV_{0.5}$ when compared to the AIXR1103 nozzle. The MUG03 nozzle had the largest spray droplet size across all pressures tested. Generally, the nozzles with larger $DV_{0.5}$ had lower relative span.

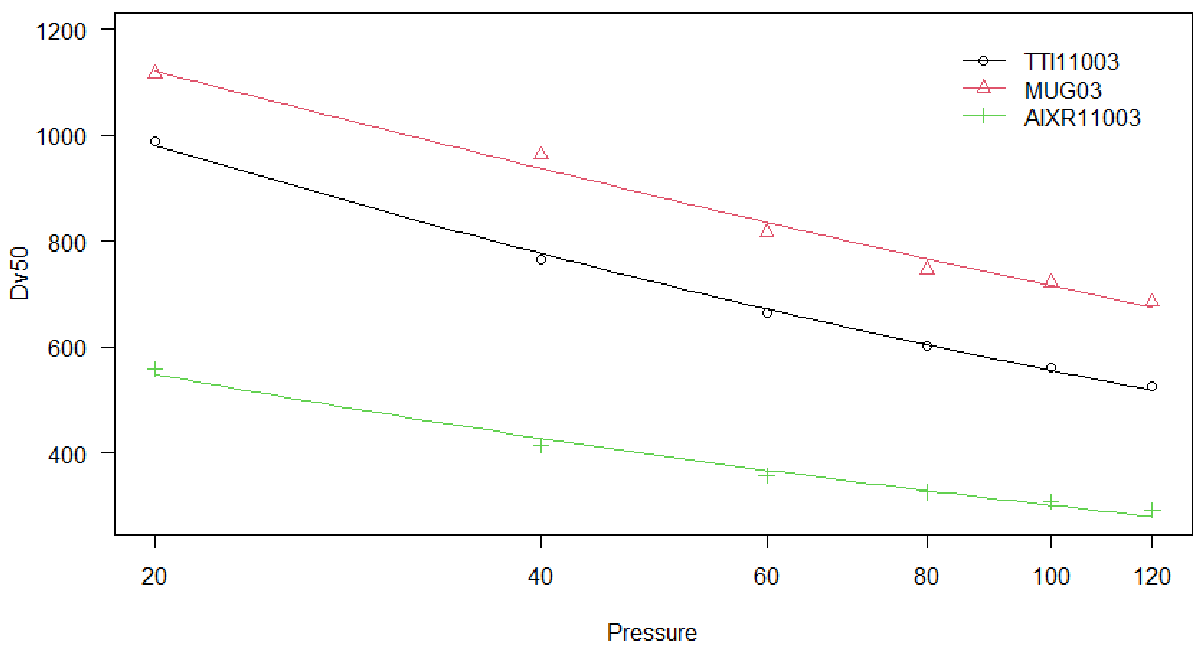

Figure 1. Influence of nozzle type and pressure on the spray $DV_{0.5}$ for dicamba + glyphosate tank mixture.

Weed control under different operational factors

Authors: Antonio Augusto Correa Tavares, Rone Batista de Olivera, and Greg R. Kruger

Study Outline: The introduction of dicamba tolerant soybean allowed farmers to adopt another herbicide active ingredient in weed management programs. The application of herbicides in tank mixture have been proposed as a means to reduce the evolution of herbicide resistance. The objective of this study was to evaluate the influence of nozzle selection, work pressure, and boom height on weed control for applications of glyphosate + dicamba tank mixture.

Results: Nozzle type, working pressure, and boom height did not influence weed control in this study. Overall, waterhemp had lower control (73%) when compared to other weed species tested in this study.

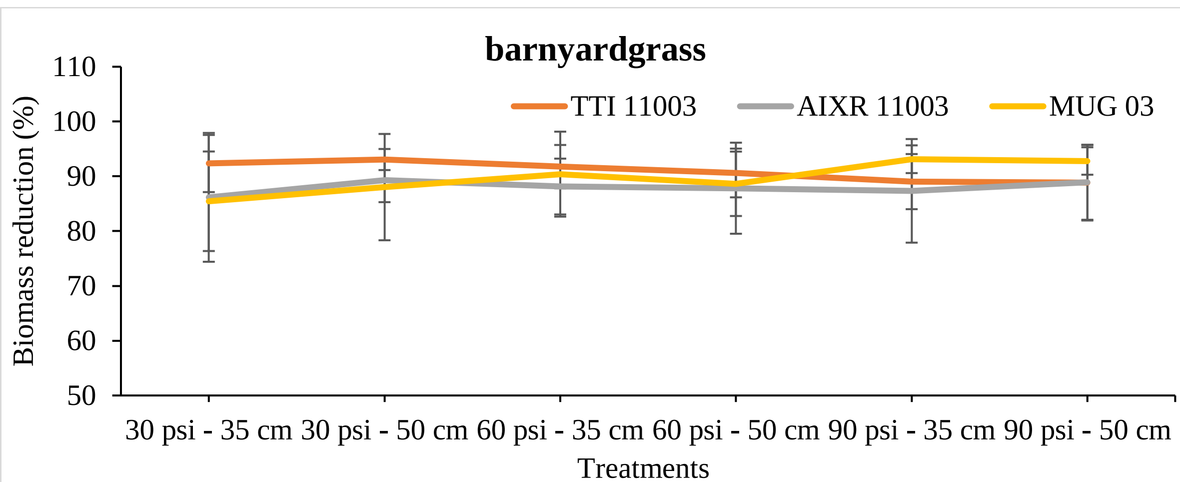

Figure 1. Barnyardgrass biomass reduction for dicamba + glyphosate tank mixture applications with different nozzles, pressures, and boom heights. Error bars represent the 95% confidence intervals.

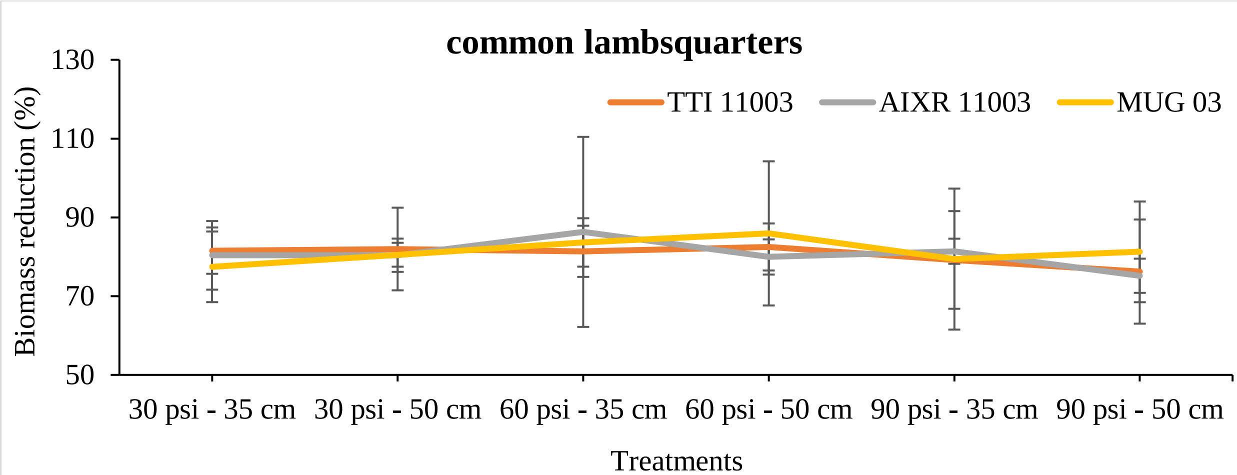

Figure 2. Common lambsquarters biomass reduction for dicamba + glyphosate tank mixture applications with different nozzles, pressures, and boom heights. Error bars represent the 95% confidence intervals.

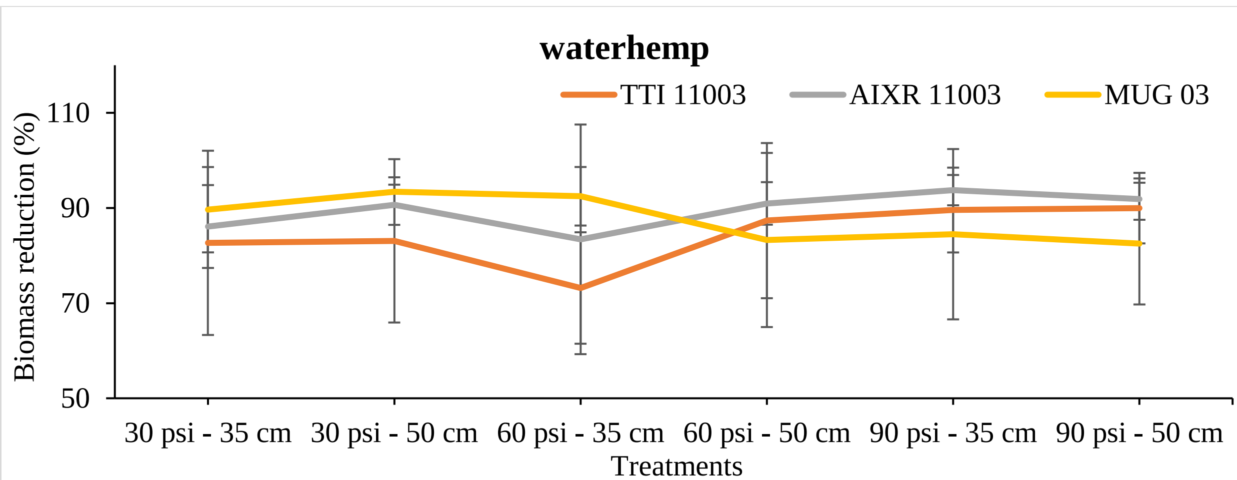

Figure 2. Waterhemp biomass reduction for dicamba + glyphosate tank mixture applications with different nozzles, pressures, and boom heights. Error bars represent the 95% confidence intervals.

Comparison of Spray Drift as Predicted by AGDISP with Field Applications Using Air Inclusion Nozzles

Authors: Barbara Vukoja, Guilherme Souza Alves, Kasey Schroeder, Jeff Golus, Greg Kruger

Study Outline: Spray drift has been a major concern in pesticide applications. Advances in technology have enabled researchers to rely on computer-based models for spray drift prediction, which has become an essential tool for pesticide applications. The comparison of field collected data with the model prediction can improve the confidence that researchers have in the model, and potentially update it with new information on air inclusion nozzles which were not on the market when the model was built. AGDISP estimates downwind spray deposition using several parameters including nozzle type, DSD, and meteorological conditions. The objective of this study was to collect empirical spray drift data in field studies to compare with data modelled by AGDISP.

Results: The ER11004 produced greatest spray drift followed by GA11004 and AIXR11004, respectively. The next step of this study is to compare the drift data collected in this study with the AGDISP drift modeling predictions. Future ground model development focused on nozzle type in order to get accurate downwind deposition for air inclusion nozzles is necessary if the models are going to be used to determine buffers or other regulatory decisions beyond bridging studies to empirical data.

Table 1. Droplet size data for the nozzles tested in this study.

Nozzle	DS classification[1]	Dv10[2]	Dv50[2]	Dv90[2]	RS[3]	Pct <141[4]
			µm			%
ER11004	medium	109	247	426	1.3	17.9
GA11004	very coarse	233	461	707	1.0	2.5
AIXR11004	extremely coarse	259	508	779	1.0	1.7
TDXL11004	extremely coarse	297	584	871	1.0	1.1
TTI11004	ultra coarse	396	773	1114	0.9	0.3

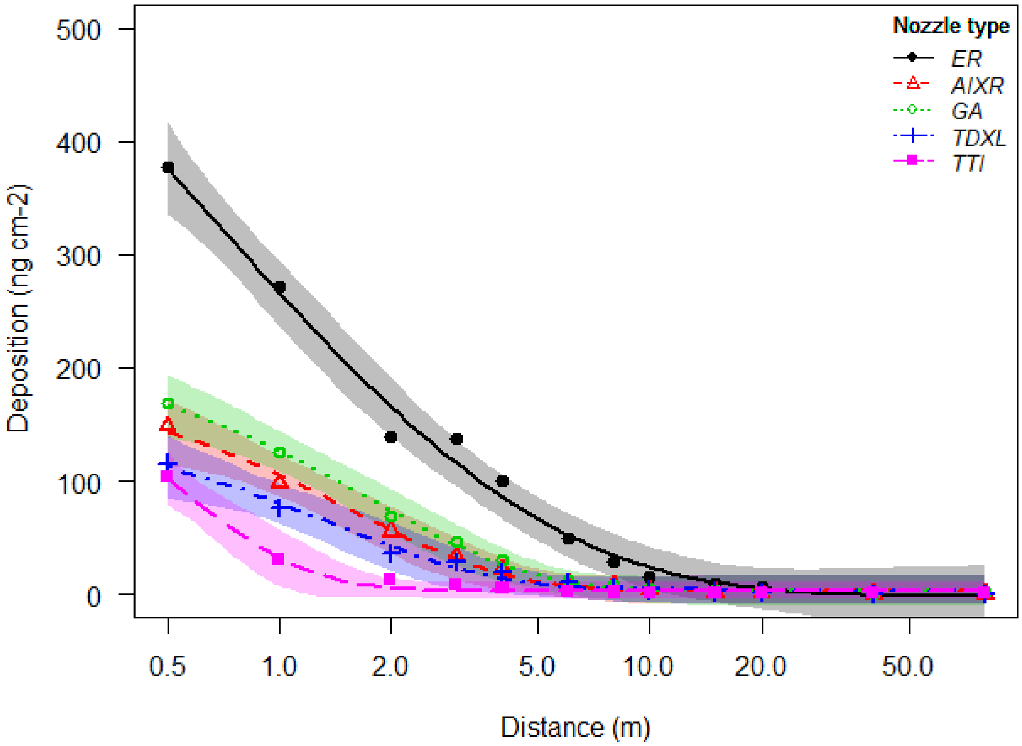

Figure 1. Spray drift deposition for applications with different nozzle types.

Effect of Surfactants on Postemergent Applications of Dicamba, Glufosinate, and 2,4-D on Amaranthus palmeri and Bassia scoparia

Authors: Ely Anderson, Bruno C Vieira, Jeffrey A Golus, Greg R Kruger

Study Outline: Glufosinate tank mixed with dicamba or 2, 4-D could help controlling troublesome weed species by combining two modes of action in a given tank solution. The overall weed control of these herbicides in mixtures could be enhanced with the addition of an adjuvant. The objective of this research was to better understand the interactions between unformulated glufosinate mixtures with 2, 4-D or dicamba alone and in combination with two proprietary anionic surfactant blends.

Results: Results for the North Platte location indicated that herbicide tank solutions influenced palmer amaranth control. Palmer amaranth had better control for applications of dicamba, glufosinate-dicamba tank mixture, and glufosinate with 2,4-D tank mixture. Unformulated glufosinate provided 24% control of Palmer amaranth.

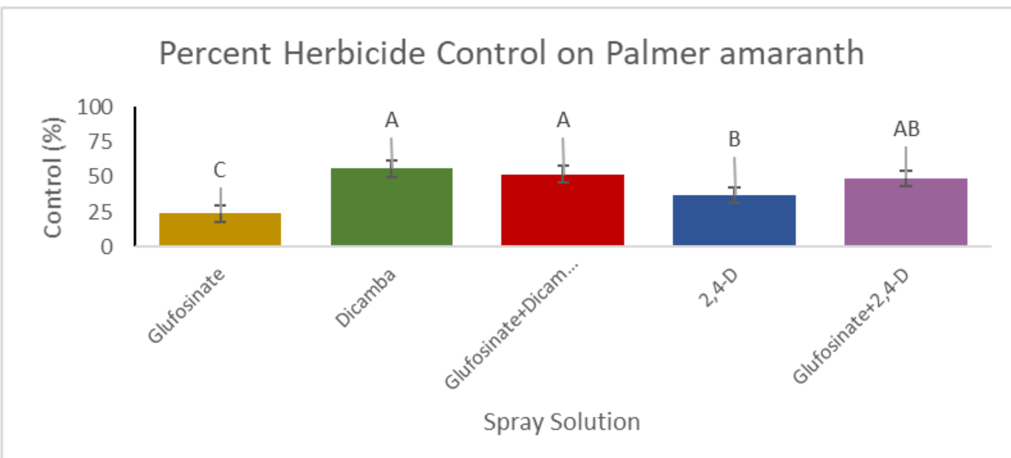

Figure 1. Control of Palmer amaranth using glufosinate, dicamba, and 2,4-D alone and in tank mixtures.

Results from the Scotts Bluff location indicated that the use surfactants influenced kochia control. Surfactant S187 had the greatest kochia control (56%) compared to no surfactant in the tank solution (28%).

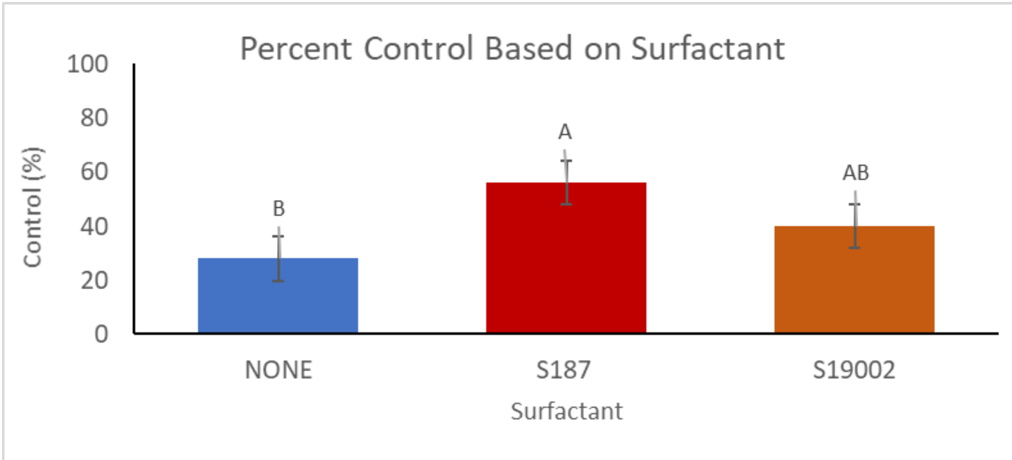

Figure 2. Control of kochia for different surfactants added to the tank solution.

All tank-mixtures applied to Palmer Amaranth and kochia resulted in additivity or synergistic interactions.

Effect of Surfactants on Postemergent Applications of Glufosinate and Glyphosate on Amaranthus palmeri and Bassia scoparia

Authors: Ely Anderson, Bruno C Vieira, Jeffrey A Golus, Greg R Kruger

Study Outline: Herbicide resistant weeds are becoming one of the largest issues in agriculture and having multiple herbicide MOAs in a tank solution could provide better weed control and delay herbicide resistance evolution. Adjuvants have been shown to improve herbicide efficacy in postemergent applications. The objective of this research was to better understand the interaction between glyphosate and glufosinate with two proprietary anionic surfactants.

Results: The use of adjuvants did not influence weed control in the North Platte experiment, where low weed control (<4%) was reported. The use of adjuvants influenced kochia control in the Scotts Bluff location. Treatments with no surfactant (5%) worked better than when a surfactant was added (<3%).

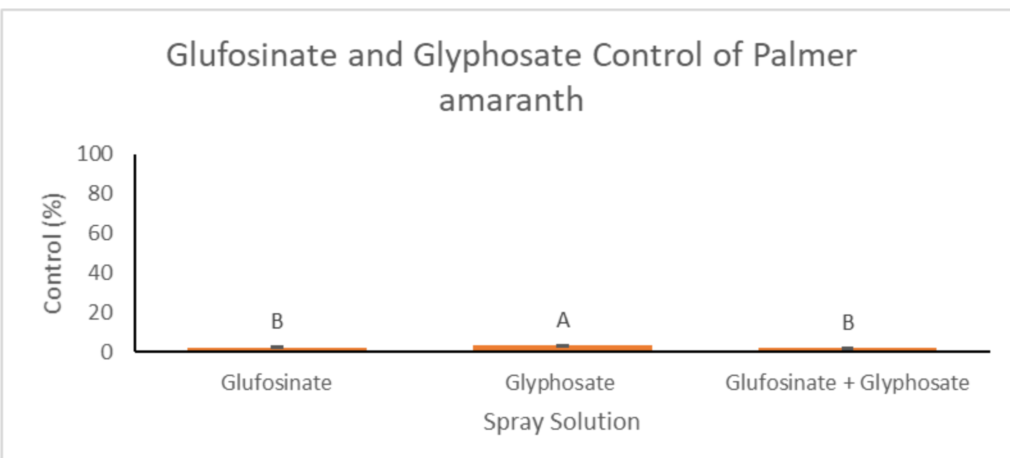

Figure 1: Glufosinate and glyphosate alone and in combination control on Palmer amaranth at the North Platte location.

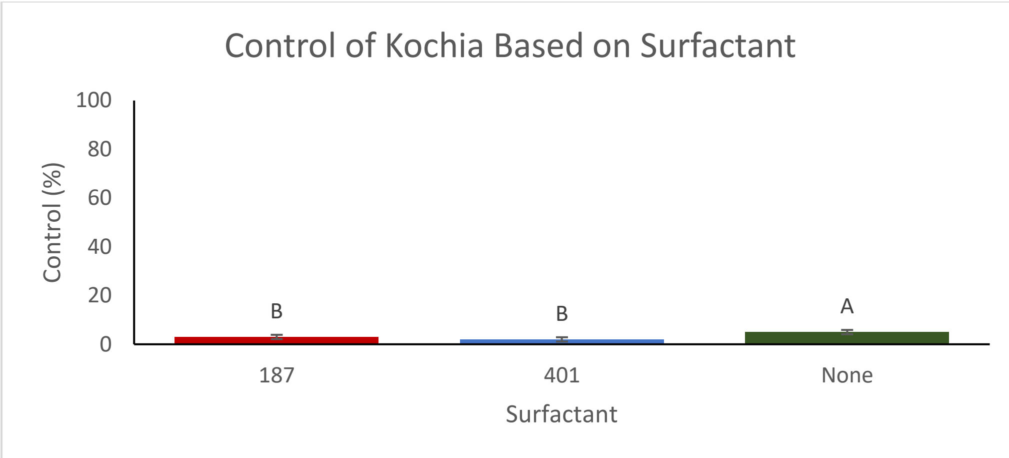

Figure 2. Glufosinate and Glyphosate with anionic surfactants on kochia control

Glufosinate and glyphosate had very low control of Palmer amaranth and kochia. From this, it can be concluded that it is important to understand the surfactants you are working with to achieve the best weed control possible.

Efficacy of Postemergent Formulated Dicamba, Glufosinate, Glyphosate, and 2,4-D and Un-Formulated Glufosinate on *Chenopodium album* L.

Authors: Ely Anderson, Bruno C Vieira, Susan Sun, Greg R Kruger

Study Outline: Different interactions can occur when mixing multiple herbicides at different doses. With this in mind, the objective of this study was to observe common lambsquarters control for different herbicides tank mixtures.

Results:

Half rates of glufosinate, glyphosate, and glufosinate-glyphosate tank-mixtures resulted in <14% common lambsquarters control. Half rates of growth regulators alone or with glufosinate had >57% common lambsquarters control. Synergist herbicide interaction was only observed with glufosinate tank-mixed with dicamba. All other tank-mixtures at half rates resulted in antagonistic and additive herbicide interactions.

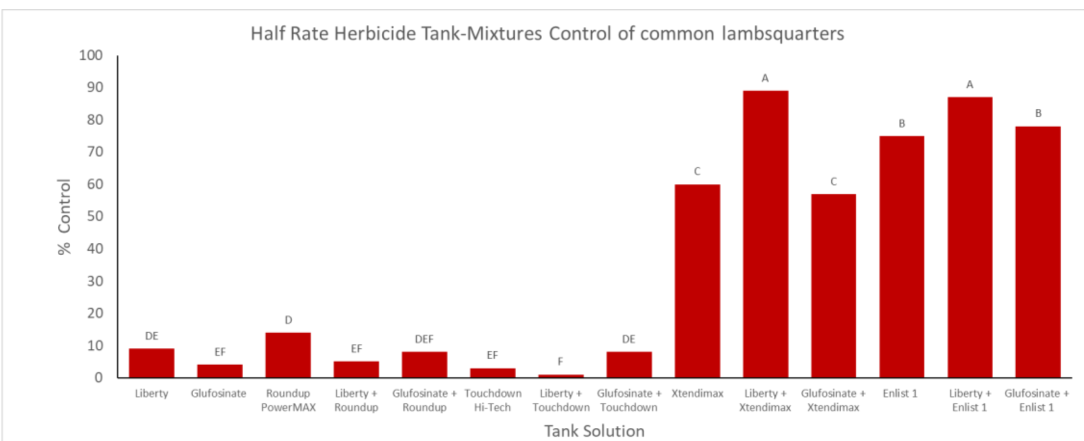

Figure 1: Herbicides at half labeled rates control on common lambsquarters.

Full rate herbicide treatments had weed control ranging from 20% to 97%. Glufosinate tank-mixed with glyphosate resulted in <87% common lambsquarters control. However, when tank-mixing unformulated glufosinate and glyphosate, only 20% control was achieved. All tank-mixtures for full rates resulted in antagonistic and additive herbicide interactions, except for 2,4-D tank-mixed with glufosinate which resulted in synergism.

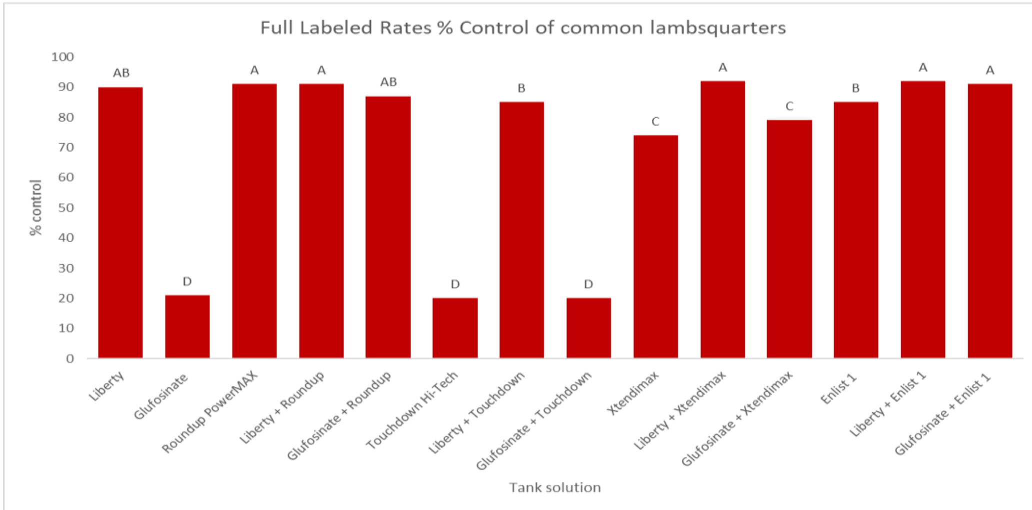

Figure 2: Herbicides at full labeled rates control on common lambsquarters.

Dicamba plus Glufosinate Tank Mixtures Affected by Storage Time and Temperature

Authors: Estefania G. Polli, Guilherme S. Alves, Jesaelen G. de Moraes, Joao V. Oliveira, Greg R. Kruger

Study Outline: The objective of this study was to evaluate the influence of storage time and temperature on efficacy of dicamba plus glufosinate (DpG) formulations in tank-mixture alone or with drift control agent (DCA) on common lambsquarters (*Chenopodium album L.*) control.

Results: Common lambsquarters control decreased 12% when sprayed with solutions stored for 48 hours when compared to solutions sprayed immediate after mixing (Figure 1). However, the solutions stored in natural environment (115F) presented less effective control when compared to solutions stored in controlled environment (68F) (Figure 2). The presence of adjuvant did not influence weed control over time. To achieve a higher common lambsquarters control, it is necessary to spray the herbicide solution as soon as possible after mixing to avoid prolonged storage and temperature variations of mixed solution in the spray tank.

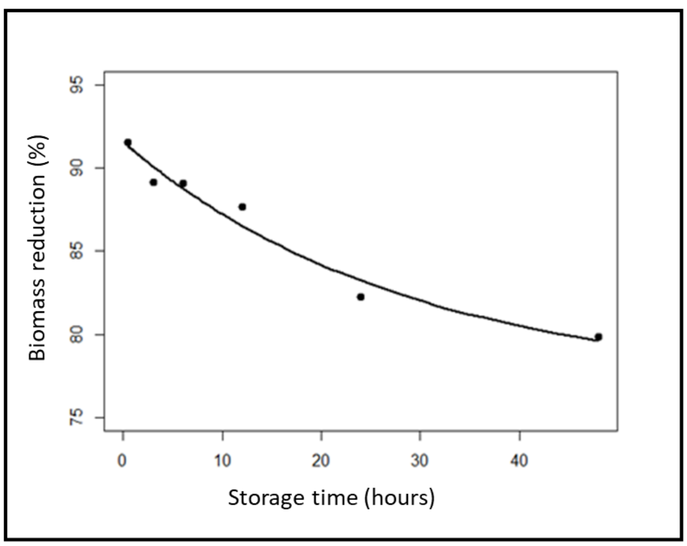

Figure 1. Common lambsquarters control by glufosinate plus dicamba solutions over time.

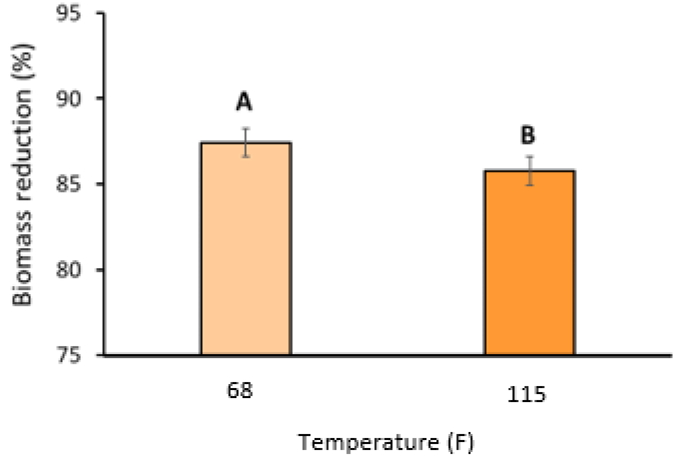

Figure 2. Common lambsquarters control by glufosinate plus dicamba solutions stored at 68F and 115F.

Influence of Surfactant-Humectant Adjuvants on Efficacy of Glufosinate Herbicides on Horseweed and Palmer amaranth Control

Authors: Estefania G. Polli, Guilherme Sousa Alves, Frank Sexton, Greg Kruger

Study Outline: To investigate the influence of surfactant-humectant adjuvants on the efficacy of two glufosinate formulations (Liberty® 280 SL and Interline®) on horseweed (*Erigeron canadensis L.*) and Palmer amaranth (*Amaranthus palmeri S. Watson)* control.

Results: Horseweed and Palmer amaranth mortality (Figure 1) and control (Figure 2) by treatments with surfactant-humectant adjuvants were similar to treatments with no adjuvants for both glufosinate formulations.

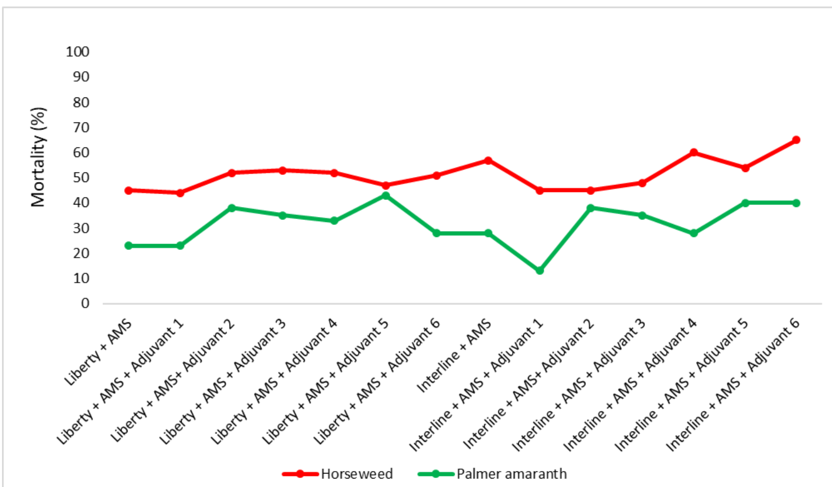

Figure 1. Mortality of horseweed and Palmer amaranth at 28 days after application.

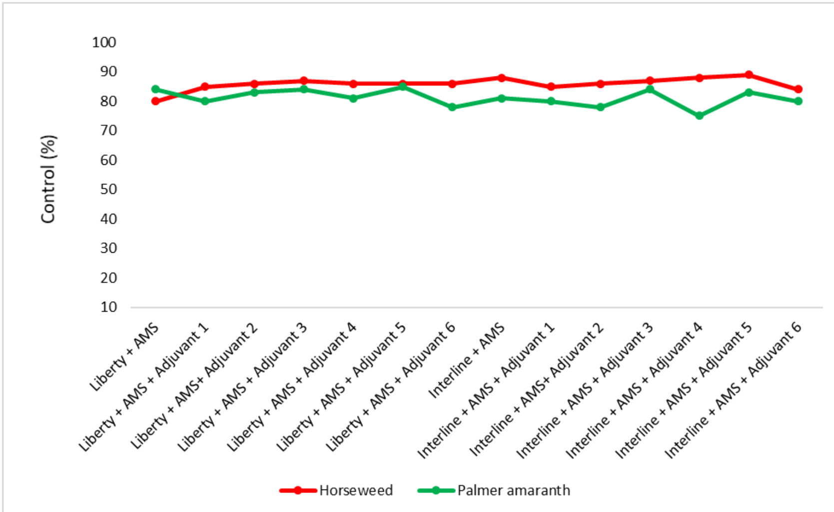

Figure 2. Visual estimation of control of horseweed and Palmer amaranth at 28 days after application.

Management of Troublesome Weeds in XtendFlex® Soybeans as Affected by Drift Reducing Adjuvants

Author: Jesaelen G. Moraes, Guilherme S. Alves, Jeffrey A. Golus, and Greg R. Kruger

Study Outline: XtendFlex® is the first technology with tolerance to dicamba, glyphosate and glufosinate herbicides giving farmers a more flexible weed control when managing tough-to-control and herbicide-resistant weeds. These herbicides will be used in tank mixtures alongside preemergent herbicides and drift reducing adjuvants (DRAs). The objective of this research was to determine the expected control of troublesome weeds to tank mixtures containing two or more herbicide sites-of-action and DRAs. The study was conducted in four XtendFlex® Soybean fields located in the state of Nebraska.

Results: Spray solution by weed species interaction was significant at each location. For grasses, the presence of residual in tank mixture improved control. Antagonistic interactions were suggested when dicamba was applied in combination with glyphosate or glyphosate plus glufosinate. DRA A (Trapline Pro II) may help to overcome potential antagonism, except when glufosinate was present in the tank mixture. For Palmer amaranth, dicamba in tank mixture with glyphosate with no DRAs increased control compared to either herbicide applied alone resulting in the greatest control but no significant different when compared to the triple tank mixtures (dicamba, glyphosate, and glufosinate) containing intact, clethodim plus intact, or clethodim plus acetochlor plus Intact. DRA A may have enhanced grass control because of the presence of non-ionic surfactant in its composition. Percent of density, biomass, or height reduction of grasses or Palmer amaranth can be found in Figure 2. Results were consisted with percent of control based on visual estimations of injury.

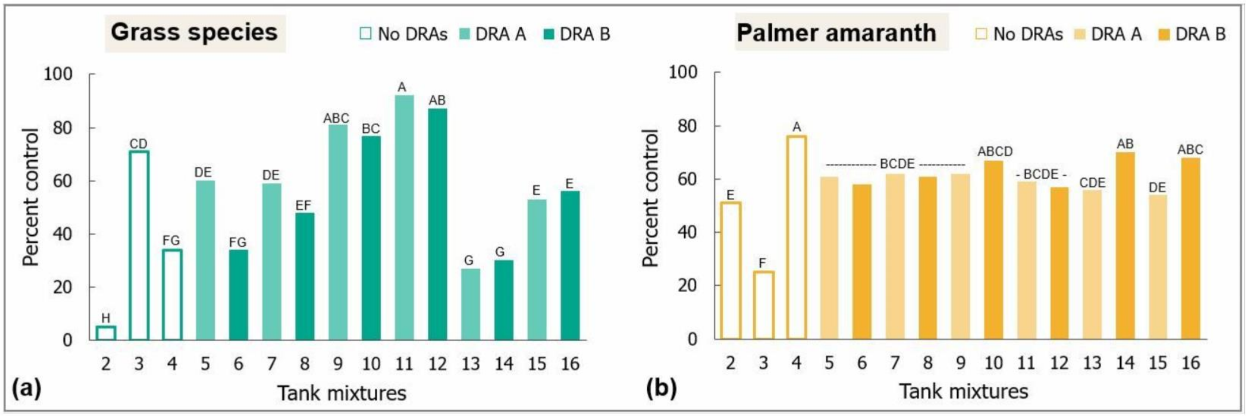

Figure 1. Percent of (a) grasses or (b) Palmer amaranth control based on visual estimation of injury with different herbicide tank mixtures. Bars with the same letter do not differ using Tukey's test at α = 0.05.

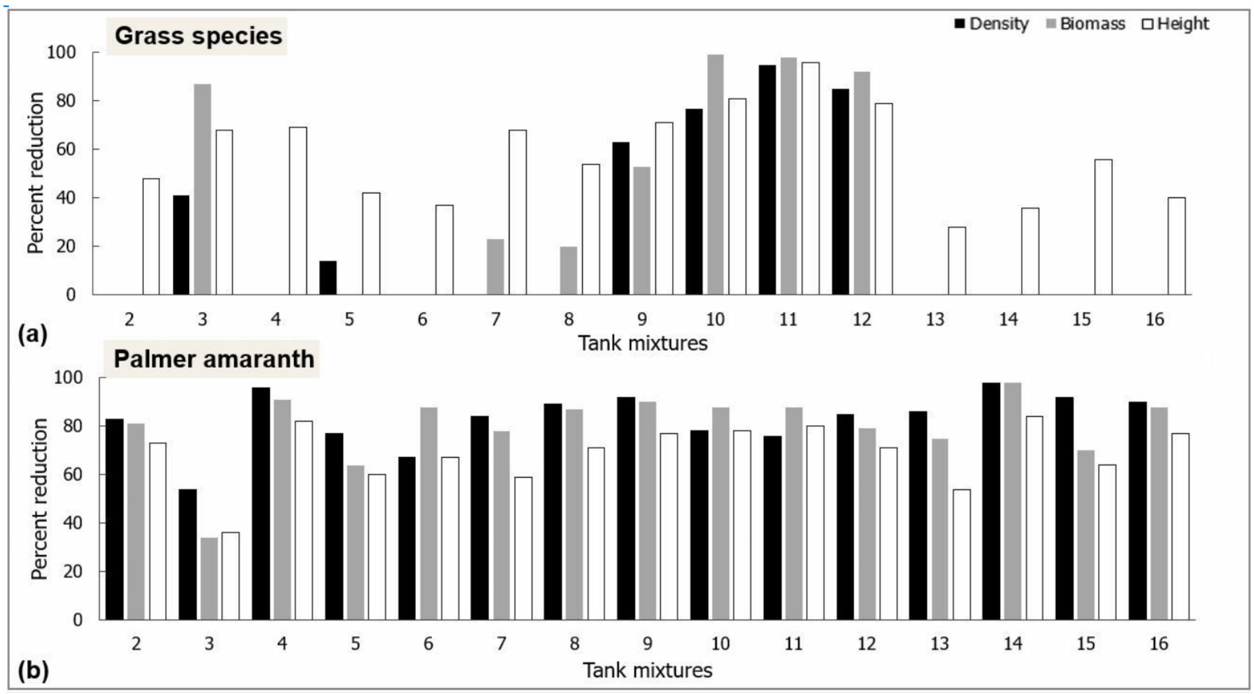

Figure 2. Percent of density, biomass, or height reduction of (a) grasses or (b) Palmer amaranth from rectangles placed between-row treated with different herbicide tank mixtures.

Soybean Symptomology and Yield Response to Sub-Labeled Doses of Dicamba and 2,4-D

Author: Jesaelen G. Moraes, Vitor M. Anunciato, Jeffrey A. Golus, Kasey P. Schroeder, and Greg R. Kruger

Study Outline: Purported soybean injury due to unintended off-target movement of dicamba and 2,4-D has raised concerns. The objective of this research was to investigate the symptomology and consequent impact on yield caused by exposition of plants to sub-labeled doses of two auxin herbicides (2,4-D and dicamba) on the several commonly used soybean varieties in Nebraska. Field experiments were conducted in 2019 and 2020 in North Platte and Gothenburg, NE, using seven soybean varieties (Hoegemeyer 2511NRR, Hoegemeyer 2811NR, Asgrow 2636, Pioneer P27T59R, Pioneer P22T41R2, Syngenta S26-F4L, Syngenta S28-6L, Basf CZ2312LL). Visual estimation of injury and plant heights were collected at 14 and 28 d after treatment (DAT). Number of pods per plant, number of seeds per pod, 100 seed weight, and total seed mass were recorded for six plants from each plot at harvest, as well as soybean grain yield. Data were subjected to ANOVA and dose-response curves were fitted to the data using the log-logistic function of the dr4pl package in R 3.4.2.

Results: Greater symptomology was observed when soybean plants were exposed to dicamba compared to 2,4-D at higher doses. Same symptomology was observed when comparing both herbicides across doses up to 0.056 g ae ha^{-1} (1/10,000x). Differences in symptomology were observed between herbicides when using doses greater than 0.56 g ae ha^{-1} (1/1,000x) but differences in yield were observed only at the highest dose (56 g ae ha^{-1}) regardless of the soybean variety. At least half of the soybean varieties showed a slightly improvement on yield when exposed to lower herbicide doses, but results were herbicide-, dose- and variety-specific. Overall, slight differences could be observed among soybean varieties but results within herbicide and dose were similar overall. Symptomology must be carefully interpreted and may not be an accurate predictor for yield.

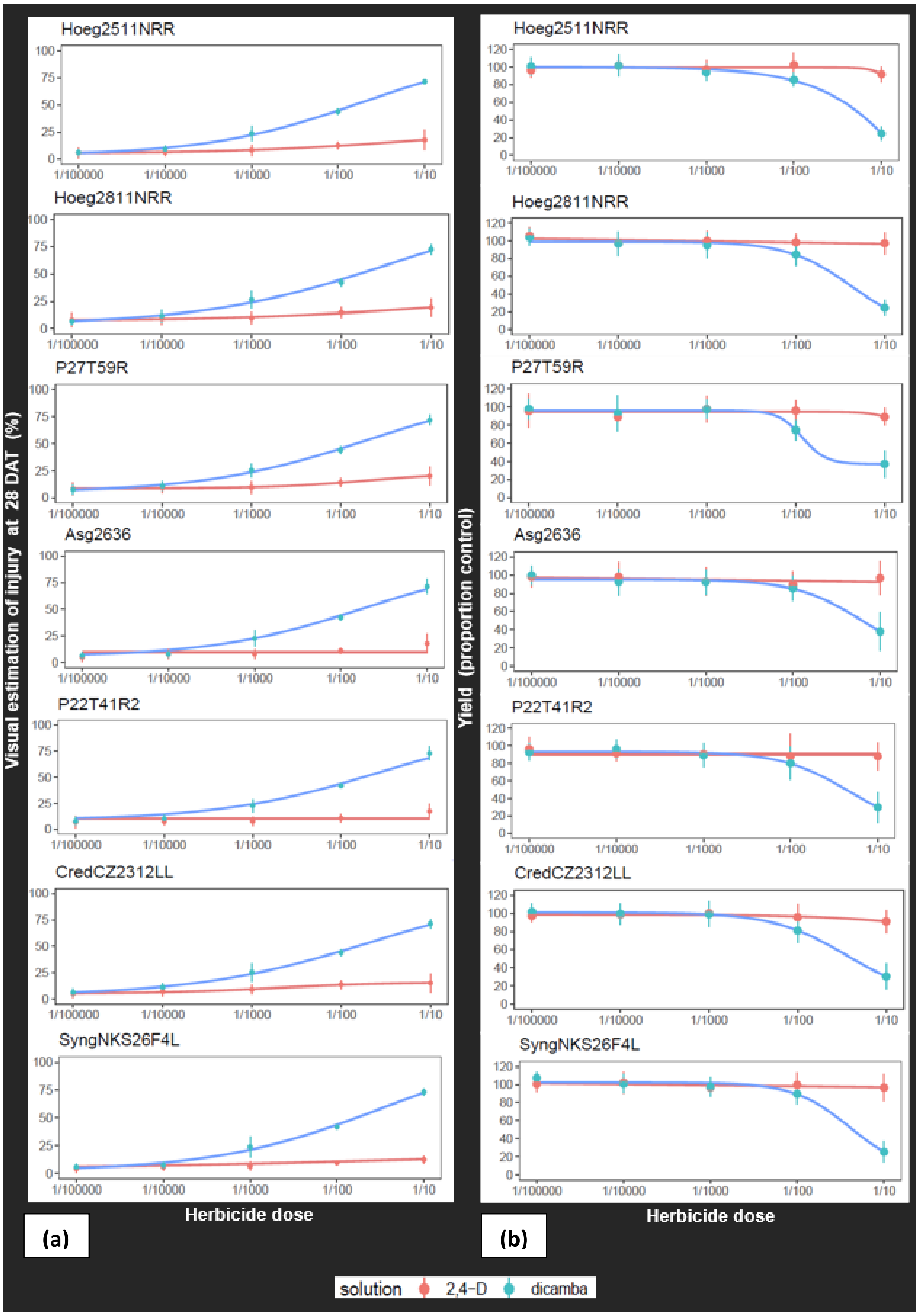

Figure 1. Soybean (a) symptomology at 28 days after application and (b) yield after exposure to sub-labeled doses of 2,4-D and dicamba herbicides at R1 as influenced by soybean varieties.

Single vs twin fan nozzle coverage on broadleaf weeds

Authors: Jessica B. Oliveira, Bruno C. Vieira, Kasey P. Schroeder, Jeffrey A. Golus, Greg R. Kruger

Project Outline: The objective of this study was to evaluate the spray coverage and weed control of dicamba applications using single and double fan nozzles approved on dicamba product label.

Results: The interaction of nozzle design and Kromekote cards position influenced spray coverage (p = 0.0037). Spray coverage on horizontal cards ranged from 25.1 to 35.5% for the nozzles tested herein, whereas spray coverage on vertical cards ranged from 5.3 to 8.5%. The twin fan nozzle TADFD04 had superior spray coverage on horizontal cards (35.5%) compared to the single fan nozzle TTI11004 (29.3%). However, the TADFD04 double fan nozzle had similar spray coverage on horizontal cards compared to the single fan nozzles TDXLD1104 (34.5%) and ULD12004 (33.3%). The twin fan nozzle TTI6011004 had the lowest spray coverage on horizontal cards (25.1%) for the nozzles tested herein. Spray coverage on vertical cards was similar among all nozzles tested in this study. Despite differences in spray coverage on horizontal cards, nozzle design did not influence dicamba control on kochia, common lambsquarters and Palmer amaranth (p = 0.48). Kochia had increased dicamba control (67%) compared to Palmer amaranth (61%) and common lambsquarters (61%) when nozzles were pooled. The advent of double fan nozzles did not improve Palmer amaranth and kochia control for dicamba applications in this study.

Table 1. Percentage of spray deposition in Kromekote cards using single and twin fan nozzles.

Estimation of deposition (%)				
nozzle	position			
	horizontal		vertical	
TTI	29.3	B	8.4	D
TDXLD	34.5	A	5.6	D
ULD	33.3	B	6.1	D
TTI60	25.1	C	5.3	D
TADFD	35.5	A	8.5	D

Means followed by the same letter within a column for each species are not different.

Table 2. Percentage of biomass reduction in weed control with Dicamba using single and twin nozzles.

Estimation of biomass reduction (%)						
nozzle	weed species					
	kochia		Palmer amaranth		common lambsquarters	
TTI	66.1	A	58.4	A	61.1	A
TDXLD	68.2	A	61.7	A	59.2	A
ULD	65.9	A	60.6	A	62.7	A
TTI60	67.0	A	61.6	A	62.1	A
TADFD	68.2	A	64.3	A	63.6	A

Means followed by the same letter within a column for each species are not different.

Glufosinate control and physical properties with different adjuvants on Chenopodium album and Bassia scoparia

Authors: João Victor de Oliveira, Antônio Augusto C. Tavares, Estefania G. Polli, Jesaelen G. Moraes, Rone B. Oliveira and Greg R. Kruger

Study Outline: In order to obtain a satisfactory weed control using contact herbicides, such as glufosinate, it is necessary adequate coverage and deposition. Physical properties of herbicide on leaf surfaces can influence herbicide performance, as well as leaf surface morphology. Adjuvants are capable of modify these physical properties of the solution. The objective of this research was to determine how glufosinate solutions with different physicochemical properties can affect the control of common lambsquarters (*Chenopodium album*) and kochia (*Bassia scoparia*). Plants were grown under greenhouse conditions and were sprayed with a three-nozzle spray chamber calibrated to deliver 140 L ha^{-1} using TT11002 nozzles. Applications were made using glufosinate-ammonium in tank-mixture with nine adjuvants: nonionic surfactant, organo-silicone surfactant, high surfactant oil concentrate, vegetable oil concentrate, modified vegetable oil, drift reduction adjuvant, crop oil concentrate, humectant, and water conditioner. Density and viscosity measurements were made using the fade-out method (DMATM 4500 M density meter) and Hoeppler's falling ball principle (Lovis 2000 M/ME microviscometer), respectively.

Results: The highest values of density were observed in the solutions of glufosinate plus water conditioner (1.0142 g cm^{-3}) and silicone (1.0008 g cm^{-3}), and for viscosity glufosinate plus drift reduction adjuvant (1.3842 mPa s) and crop oil concentrate (1.1390 mPa s). The biggest difference for density was 1.57% between glufosinate plus water conditioner and crop oil concentrate (0.9983 g cm^{-3}), and for viscosity was 26.22% between glufosinate plus drift reduction adjuvant and glufosinate alone (1.0212 mPa s). For kochia, the highest control was obtained with solutions containing glufosinate plus water conditioner (94.5%), humectant (94.3%), drift reduction adjuvant (93.6%), nonionic surfactant (93.4%) and high surfactant oil concentrate (91.2%), and the lowest control was obtained with glufosinate plus silicone (13.8%). For common lambsquarters, the highest control was obtained with solutions containing glufosinate plus water conditioner (94.7%), drift reduction adjuvant (94.0%) and high surfactant oil concentrate (93.9%), and the lowest control was obtained with glufosinate plus silicone (33.6%). Different types of adjuvants modify the physicochemical properties in different ways, and can greatly increase or decrease the control, so it is necessary to find the balance between these changes that is appropriate to be more effective.

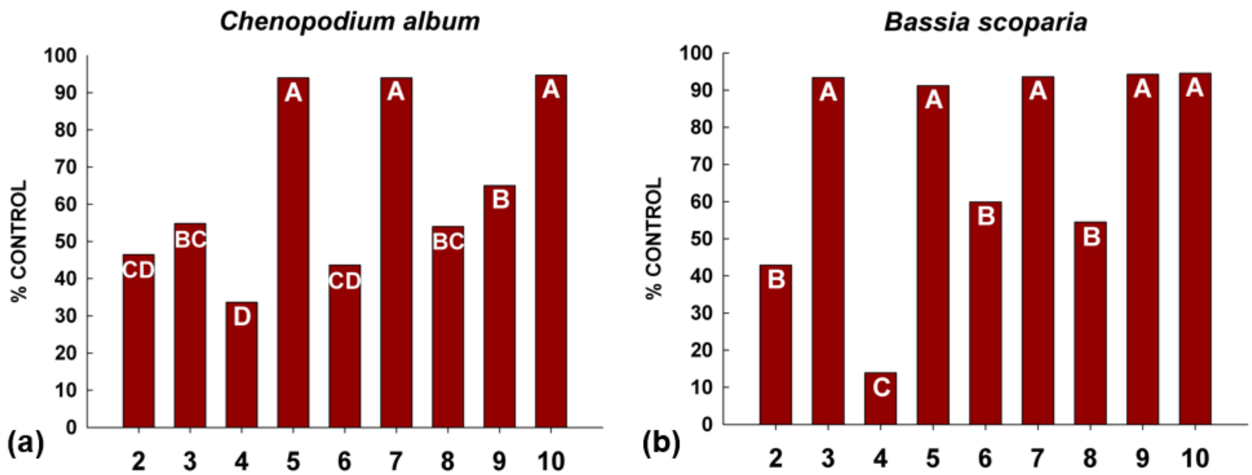

Figure 1. Percent of Bassia scoparia (a) and Chenopodium album (b) Bars with the same letter do not differ using Tukey's test at α = 0.05.

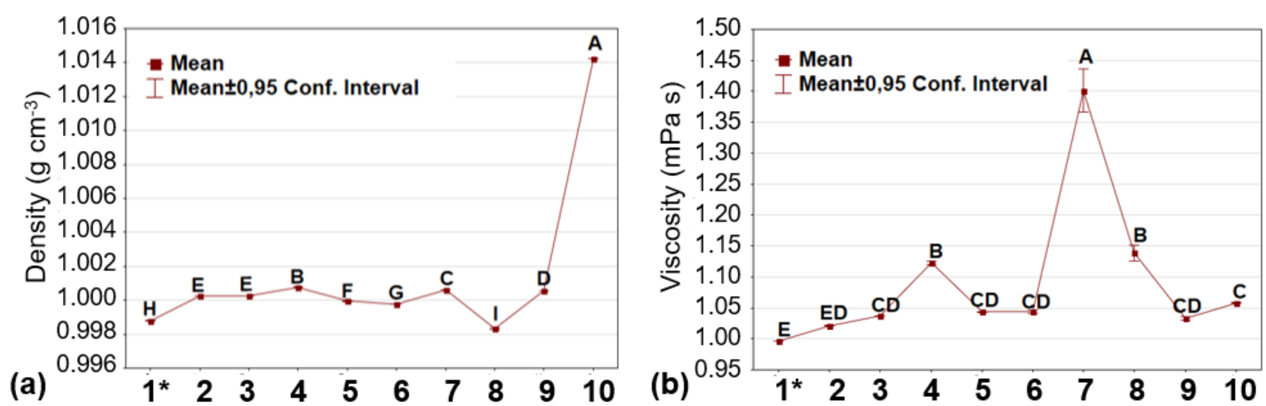

Figure 2. Density (a) and Viscosity (b) Means with the same letter do not differ using Tukey's test at α = 0.05. *Water.

Interaction of Tank mixtures of Glyphosate and Dicamba on Glyphosate resistant Horseweed Control

Authors: Leandro H. S. Guimarães, Estefania G. Polli, Jose H. S. de Sanctis, Guilherme S. Alves, Greg Kruger

Study Outline: A state-wide survey conducted in Nebraska reported horseweed as the second most troublesome weed for farmers. Dicamba plus glyphosate is a common tank mixture for broad spectrum weed control. Previous research has shown antagonistic interactions between dicamba and glyphosate. However, these interactions are not clearly understood. Therefore, the objective of this study was to evaluate the interaction of dicamba plus glyphosate tank mixtures on glyphosate resistant (GR) horseweed.

Results: GR horseweed control increased with increased herbicide doses. The efficacy of dicamba was more pronounced when applied alone. For glyphosate at 1260 g ai ha^{-1} and dicamba at 560 g ai ha^{-1} the estimated GR horseweed biomass reduction was 93%, whereas the observed control was 77%. This study results indicate that dicamba and glyphosate caused an antagonistic effect on GR horseweed. The highest dose of dicamba and glyphosate did not overcome the antagonistic interaction. Therefore, the tank mixture between these herbicides might reduce efficacy on GR horseweed control.

Table 1. Statistical analysis of Dose Response Curve for Dicamba and Glyphosate.

		Dicamba (g ae ha^{-1})[a]					
		0	140	280	560	840	1120
Glyphosate (g ai ha^{-1})[b]	0	0	56	74	73	80	83
	315	38	69 (72)	74 (84)*	85 (83)	84 (88)**	84 (89)**
	630	64	75 (84)**	77 (91)**	83 (90)**	79 (93)**	84 (94)**
	1260	76	71 (89)**	75 (94)**	77 (93)**	82 (95)**	85 (96)**
	1892	74	74 (88)**	88 (93)*	85 (93)**	87 (95)**	86 (95)**
	2522	72	82 (87)**	79 (93)**	85 (92)**	86 (94)**	91 (95)**

[a] Expected value, presented in parenthesis, was determined by the Colby equation: E= (X + Y) – (XY/100), where E is expected percent control with herbicide A + B, X and Y is observed percent control with herbicide A and B, respectively.
[b] Significantly different from the observed value ($P < 0.05$) as determined by t test, indicating antagonism of tank mixing herbicides A and B.
Significance levels: *$P \leq 0.01$; **$P \leq 0.001$.
Red and yellow cells indicate antagonistic and additive interaction between herbicides, respectively.

Drift Potential of Glufosinate applied through a Single, Double or Triple Fan Nozzle

Authors: Livia I. Pereira, Leandro H. S. Guimaraes, Barbara Vukoja, Guilherme S. Alves, Greg R. Kruger

Study Outline: Glufosinate is a nonselective herbicide that can cause injury to nearby susceptible crops due to spray drift depending on nozzle type and tank mix partners. The objective of this study was to evaluate the droplet spectra and drift potential from glufosinate applications using single, double, and triple fan nozzles in a wind tunnel. Glufosinate was applied alone or in tank mixture with three adjuvants: DRA (drift reducing adjuvant), NASWC (non-ammonium sulfate water conditioner), and AMSWC (ammonium sulfate water conditioner). Applications were made using single (AD 11002), double (AD/D 11002), and triple (AD/T 11002) fan nozzles at 206 kPa pressure. Droplet spectra parameters evaluated were Volumetric Median Diameter (VMD), percent fines (V141) and relative spam (RS) measured using a laser diffraction system.

Results: Droplet spectra and drift potential depended on the interaction between solution and nozzle type. Glufosinate plus DRA produced the coarsest VMD (364 to 420 µm) and smallest V141 (3.9 to 4.8%) across nozzle types. The addition of AMS WC to the glufosinate solution decreased the VMD and increased the V141 in comparison with glufosinate alone using the AD/T nozzle. Across solutions and nozzle types, tracer deposition decreased exponentially as downwind distance from the nozzle increased. Within nozzle type, the lowest tracer deposition at 12 m was obtained using the DRA (2 to 13 g cm^{-2}). Glufosinate alone and in tank mixture with the other adjuvants produced similar drift potential at 12 m. The AD/T nozzle produced lower deposition at 12 m than AD/D nozzle across solutions. The AD and AD/T nozzles produced similar drift potential for glufosinate solutions with DRA adjuvant. The results indicate that interactions between nozzle type and adjuvants should be considered to mitigate drift potential from glufosinate applications.

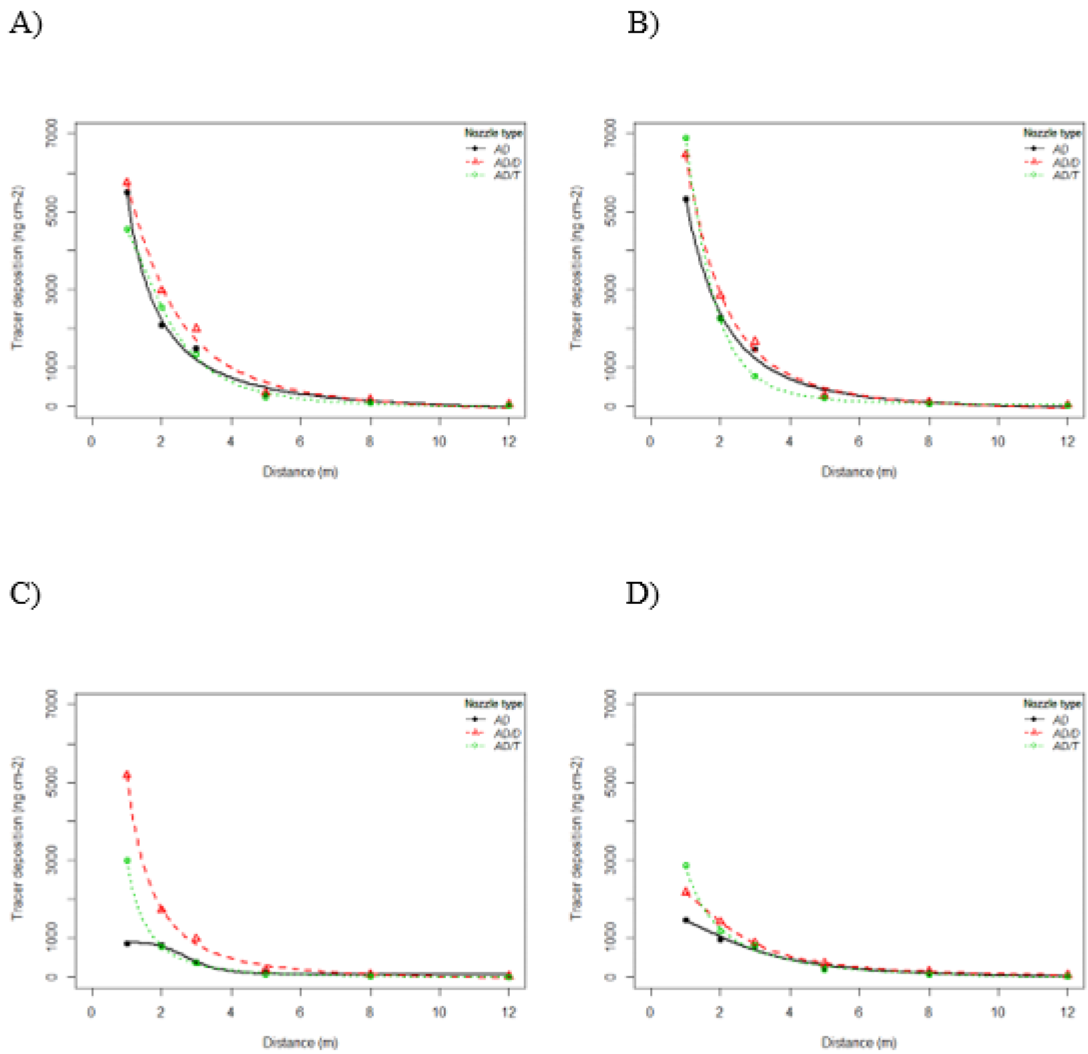

Figure 1. Spray drift deposition; A: Glufosinate; B: Glufosinate + non-AMS WC; C: Glufosinate + DRA; D: Glufosinate + AMS WC.

Comparison of Available ACCase Inhibiting Herbicides for Use in Industrial Hemp

Authors: Marija Savic, Milos Zaric, Jeffrey A. Golus, Kasey P. Schroeder, Greg R. Kruger

Study Outline: Industrial hemp (*Cannabis sativa* L.) is an annual broadleaf plant grown for fiber, grain, and cannabinoid production. Industrial hemp thrives in soil conditions that are favorable for corn production. In 2018 Farm Bill allowed expansion of hemp growth under certain requirements and the crop cultivation area is now continuously increasing. At the present there is no synthetic herbicide registered for use in industrial hemp in the United States. Considering the selectivity of Acetyl CoA Carboxylase (group 1) to control grass weeds in broadleaf crops, the objective of this study was to evaluate the crop safety of this herbicide group on industrial hemp. Herbicides selected for this study included clethodim, fenoxaprop, fluazifop, fluazifop + fenoxaprop, pinoxaden, quizalofop, and setoxidim.

Results: The results of this study suggest that sensitivity of industrial hemp to group 1 herbicides was dose and herbicide dependent. In comparison with the non-treated control within each herbicide at 1x dose the only difference was determined for pinoxaden. Further, product rate in tank-mixture increased plant biomass decreased. Across all examined doses and herbicides evaluated the only treatment which did not impact industrial hemp biomass was observed with quizalofop. Future research should focus on exploring how other clethodim formulations may impact different hemp varieties.

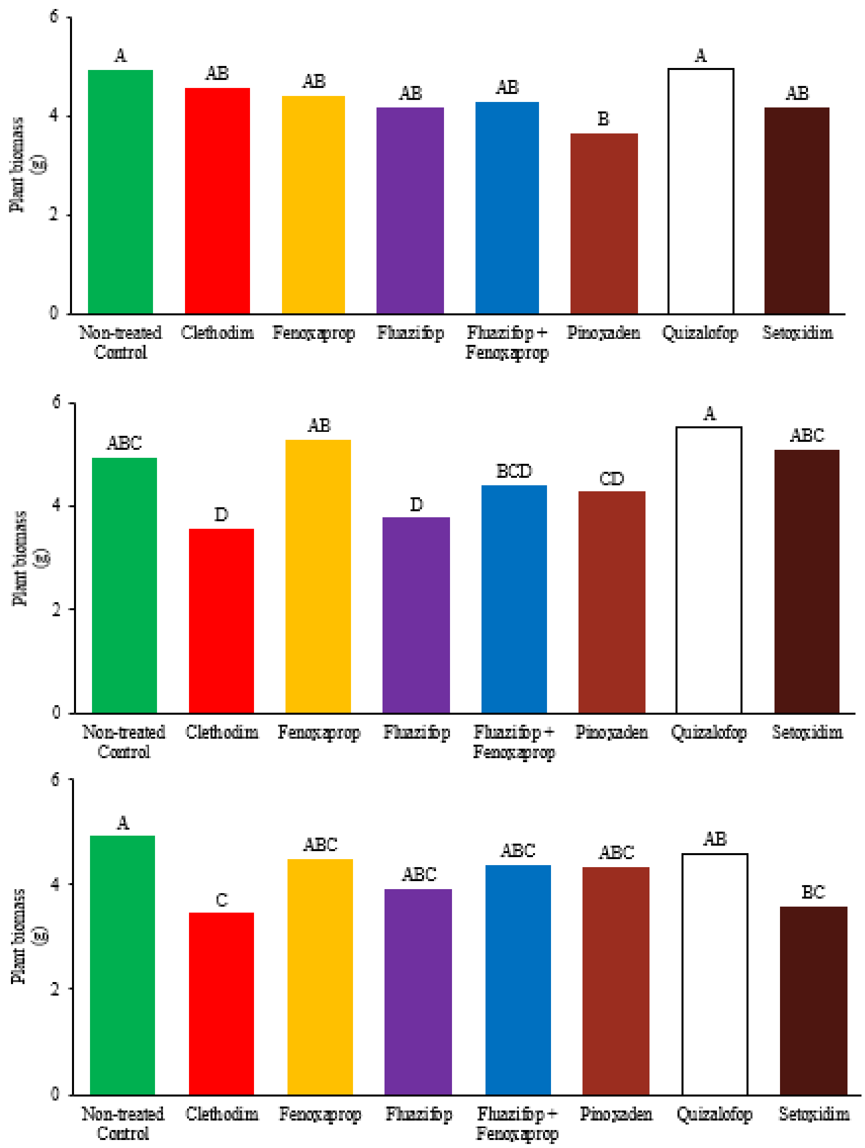

Figure 1. Effect of ACCase inhibiting herbicides on industrial hemp dry biomass production (from the top to the bottom 1, 2, 4-x label rate).

Deposition of a Four Rotor UAS as Influenced by Flight Speed, Flight Height, and Nozzle

Authors: Trenton Houston, Brad K. Fritz, Clint W. Hoffmann, Antonio Augusto Correa Tavares, Greg R. Kruger

Project Outline: UAS (unmanned aircraft system) applications have the potential to be efficient pesticide application platforms under conditions that are not accessible or fit for typical pesticide application equipment. Although this type of application is still under development in the U.S., UAS pesticide applications are common in Asia, as they have replaced backpack sprayers. Many parameters need to be investigated to identify the best combination of application variables such as flight height, flight speed, and nozzle selection. The objective of this research was to investigate different application variables for a UAS application platform. Research was conducted at the Pesticide Application Technology Laboratory in North Platte, Nebraska to better understand the swath width and deposition of a UAS. A four rotor UAS was used with a nozzle spacing of 76 cm and a fight height of 1m and 3m using XR800015, AIXR110015, and AITX110015 nozzles. Tank solution including tracer was applied on photopaper cards spaced at 0.5m spacing across a 15-m sampling line. Cards spray coverage was analyzed using AccuStain.

Results: Flight height ($p<0.2083$) and a nozzle*speed interaction ($p<0.0705$) influenced spray coverage. The XR nozzle at 2.7 m s^{-1} provided the best spray coverage (3.4%) while the AIXR and AITX nozzles were not different at 2.7 m s^{-1}. At the 5.4 m s^{-1} flight speed spray coverage was similar for tested nozzles (0.7-1.1%). More spray coverage was observed at the 1-m flight height (1.9%) compared to the 3-m flight height (1.5%). A better understanding on nozzle selection and application parameters will be important to optimize pesticide applications while mitigating spray drift potential for UAS pesticide applications. Future research will include testing intermediate application heights and application speeds with the nozzles used in this study. Other factors of the application with a UAS will need to be investigated such as UAS drift potential and how the application environmental conditions impact the deposition and swath width of these applications.

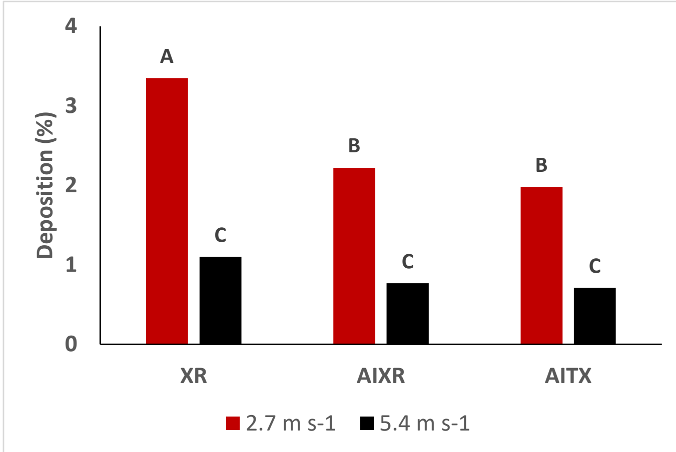

Figure 1. Nozzle*speed interaction at α=0.10 with application speed of 5.4 m s-1 which did not result in deposition differences with the use of different nozzles. The XR nozzle at a application speed 2.7 m s-1 provided the best deposition.

Methodology to Estimate and Analyze UAS Swath Width Using Different Application Parameters

Authors: Trenton Houston, Brad Fritz, Clint Hoffmann, Greg Kruger

Project Outline: Deposition and effective swath width for UAS have not been determined based off application heights and speeds. The percent coverage values often produced swaths with CVs greater than 30 percent, which is higher than target coefficient of variation (CV) for ground and manned aerial applications. Using the CV to determine the ESW of UAS applications is not feasible because of the high CV values and inconsistent swath patterns, ESW should be determined by deposition. Currently, estimated swath widths are used which results in unknown application volumes and potential sub-lethal doses. The objectives of this study were to (1) create a methodology to determine unmanned aircraft systems (UAS) effective swath width (ESW) based off different application parameters, including nozzle and application height and speed; and (2) to use this methodology to determine the effective swath width for different pesticide application situations to deliver the correct volume of solution to the target area of the application by coefficient of variation and percent coverage (deposition). A four rotor UAS was used to apply a tank solution of water and blue dye with AIXR110015, AIXR11002, and AIXR11004 nozzles. Applications were made at 2.2, 2.9, 3.4, 9, and 4.4 m s^{-1} and heights of 1.5, 2.4, and 3 meters. Different application speeds and heights were used to identify how swath width and deposition are affected by speed and height. Kromekote cards were positioned 0.25 meters apart across a 10-meter sampling line. ESW and percent coverage were analyzed using a code in Spyder. Through this coding program, ESW for different nozzles application heights, and speeds can be determined based on the desired application parameter.

Results: There are different levels of coverage and high CVs across the swath width of a UAS. The ESW of a UAS can be determined by truncating the ends of the swath to reduce the impact of the long tails the CV of the swath can be reduced. Another alternative is to overlap the swath patterns to simulate a traditional back and forth application pattern (Figure 1 and 2). This program also allows us to identify a swath width based off the deposition, which can then be related back to a lethal dose for herbicides and other flight parameters such as nozzle selection, flight height, and speed. The data shows that swath width and deposition are a factor of spray deposition, nozzle type, flight speed, and flight height. This algorithm can be used to analyze UAS deposition data to ensure that effective applications are made with the correct ESW for UAS applications.

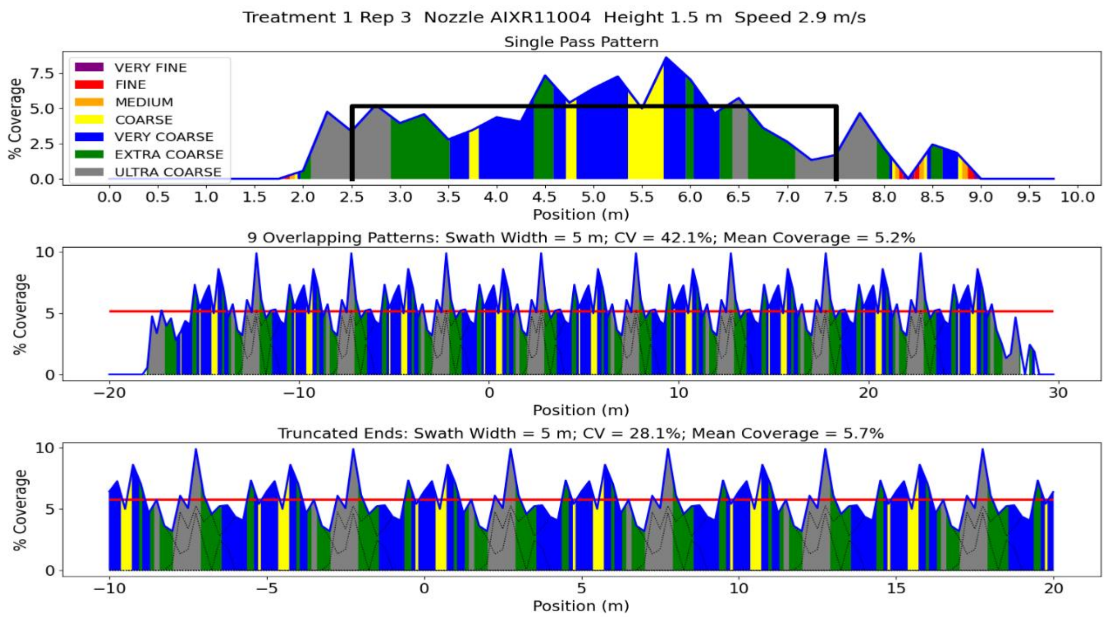

Figure 1: Pattern and percent coverage of an application made at 1.5 meters and 2.9 ms^{-1} with an AIXR11004 nozzle. The graphs illustrate what UAS patterns look like for single pass, back and forth passes, and back and forth passes with truncated ends.

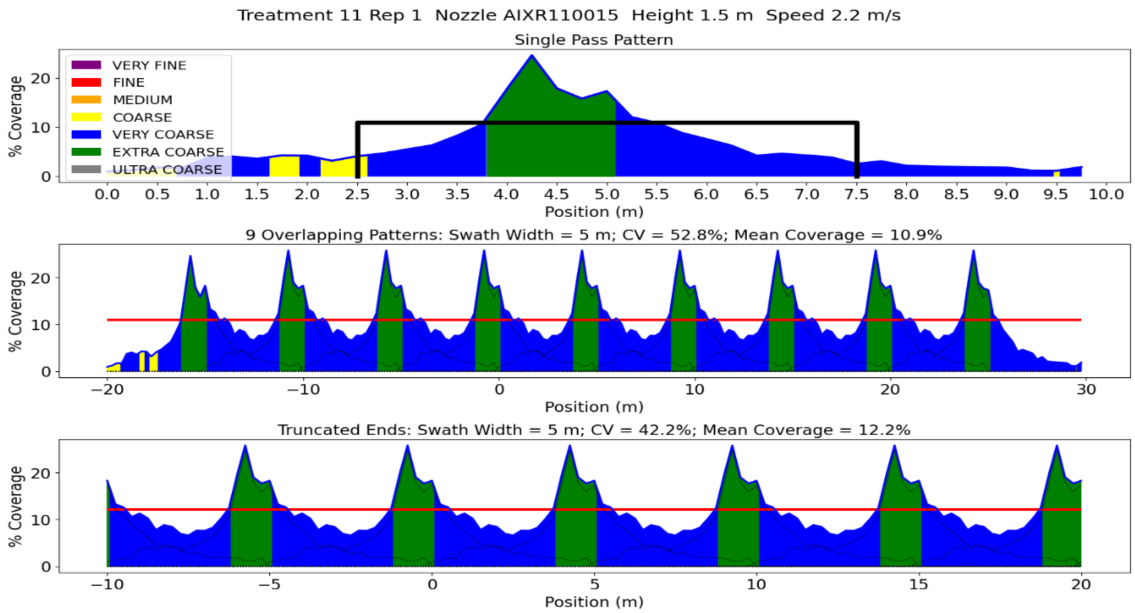

Figure 2: Pattern and percent coverage of an application made at 1.5 meters and 2.2 ms^{-1} with an AIXR110015 nozzle. The graphs illustrate what UAS patterns look like for single pass, back and forth passes, and back and forth passes with truncated ends.

Non-dicamba tolerant soybean response to reinstate from different cleaning procedures of dicamba and clethodim tank mixtures.

Author: Vinicius Velho and Greg Kruger

Study outline: The introduction of dicamba resistant soybeans and cotton broadened the spectrum of post emergent herbicides used in these crops. Dicamba causes epinasty and leaf cupping on sensitive weeds and crops even in low concentrations. An increase in off-target movement report has been noticed and in 2017 it is estimated that over 3.5 million ha of non-dicamba soybeans injury were reported. Sprayer contamination was identified as one major cause of off-target movement of dicamba. Because auxin herbicides are difficult to remove from sprayers, tank cleaners have a severe role in breaking down residues facilitating their removal by rinses. The objective of this study was to determine the reinstate of non-dicamba tolerant soybeans to different cleaning procedures of dicamba and clethodim tank mixtures with and without drift reducing adjuvants and tank cleaner. The study was conducted in the summer of 2020 in Stapleton, NE. Treatments consisted in the combination of dicamba, clethodim and two different drift reducing adjuvants with and without the use of tank cleaner. Three rinsates were collected and the fourth sample was obtained by filling the tank to simulate a future application.

Results: A main effect of rinse (p-value<0.0001) and mixture(p<0.0001) and the interaction between rinse and mixture(p-value<0.0001) influenced soybean response to tank rinsates. Visual estimation of injury was noticed on soybean that were exposed to the first three rinsates but not in the follow-up application. Plant height was also significant to solutions and rinsates (p-value<0.0001) and Xtendimax® alone resulted in a higher plant height reduction and visual estimation of injury. The use of tank cleaner did not affect visual injury and plant height. The use of adjuvants did not impact the cleanout procedures and soybean response. Triple rinse is important to reduce tank contamination issues and avoid damage on sensitive soybeans and other crops.

Efficiency of tank cleaning different dicamba formulations

Author: Vinicius Velho and Greg Kruger

Study outline: Several dicamba formulations are available in the market. Regardless of the product, three rinses are required by label for cleanout procedures. By the reason of dicamba activity in low doses on susceptible crops such as soybean, tank cleaners have an important role in breaking down residues facilitating their removal by rinses. The objective of this study was to evaluate the effect of five commercial products and the use of tank cleaner on the rinsate of non-dicamba tolerant soybean. The study was conducted in the summer of 2020 in Stapleton, NE. Five commercial dicamba products were used with the addition of one tank cleaner in the second rinse. Three rinsates were collected, the fourth collection was obtained by filling the tank to simulate a future application. These solutions were sprayed on soybeans at R1 stage using a backpack sprayer calibrated to deliver 140 L ha-1 with AIXR 11002 nozzles.

Results: Results obtained showed main effects of rinse (p-value<0.001) and mixture (p-value=0.0161) and an interaction between rinse and mixture (p-value=0.0096) influencing soybean response to tank rinsates. Visual estimation of injury in the first three rinses and a plant height reduction at harvest were influenced by commercial products used. No differences between formulations were observed in the first rinse and Status® herbicide. No visual estimation of injury was observed in the follow-up application. Even though visual estimation of injury was observed in the third rinse, there was no difference in plant height between XtendiMax®, Diflexx® and the untreated control. Proper tank cleaning following dicamba application is essential to ensure safe pesticide applications to dicamba-sensitive crops.

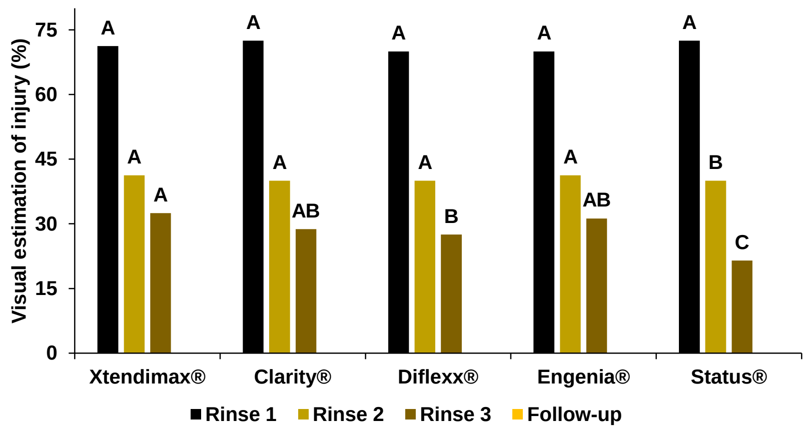

Figure 1. Visual estimation of injury 28 days after application.

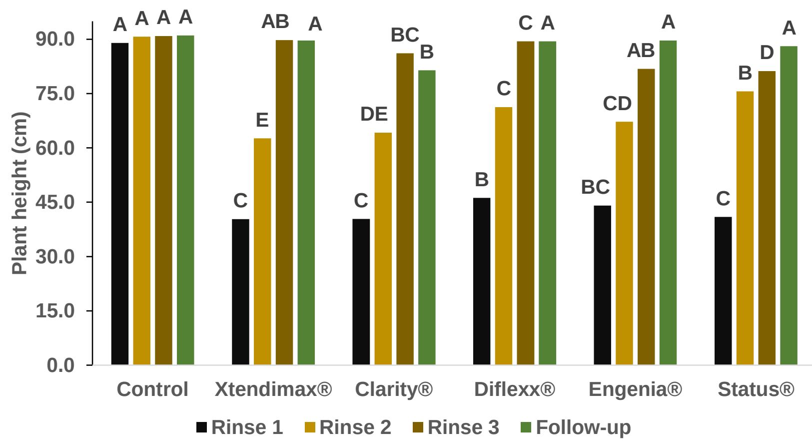

Figure 2. Plant height 28 days after application.

Influence of droplet size in control of velvetleaf and lambsquarters treated with fomesafen

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Study Outline: Velvetleaf (*Abutilon theophrasti*) and common lambsquarters (*Chenopodium album*) are
common weeds in soybean and corn fields, frequently controlled using post-emergent and systemic herbicides. Due to the increase of resistant weeds to these herbicides, the use of contact herbicides has been an alternative in weed management practices. The objective of this study was to evaluate the effect of droplet size on velvetleaf and c. lambsquarters control for fomesafen applications. Two studies were conducted with five rates of fomesafen and four droplet size spectrums. Treatments were applied using a sprayer chamber calibrated to deliver a spray volume of 190 L ha^{-1}. Applications were performed with ER110015, SR11005, DR11005, and UR11004 nozzles. These nozzles represent fine, medium, very coarse, and ultra coarse droplet size, respectively.

Results: Lambsquarters had an unsatisfactory control presenting a linear tendency of control increment but in the lowest doses the control is around 50% and in the highest doses there is a small increase reaching 65%, the exception is the treatments with the drops classified as average according to ASABE, in this treatment the control reaches 72%. Velvetleaf also showed low control not changing even with the increase in dose, the excesses are the ultra coarse drops that have the linear tendency coming out of 40% at the lowest dose and reaching 60% and the average drops reaching 88% in the dose of 610 g ai ha^{-1}, reducing the control reaching 68% control in the highest dose (1008 g ai ha^{-1}). In general, weed control was not satisfactory.

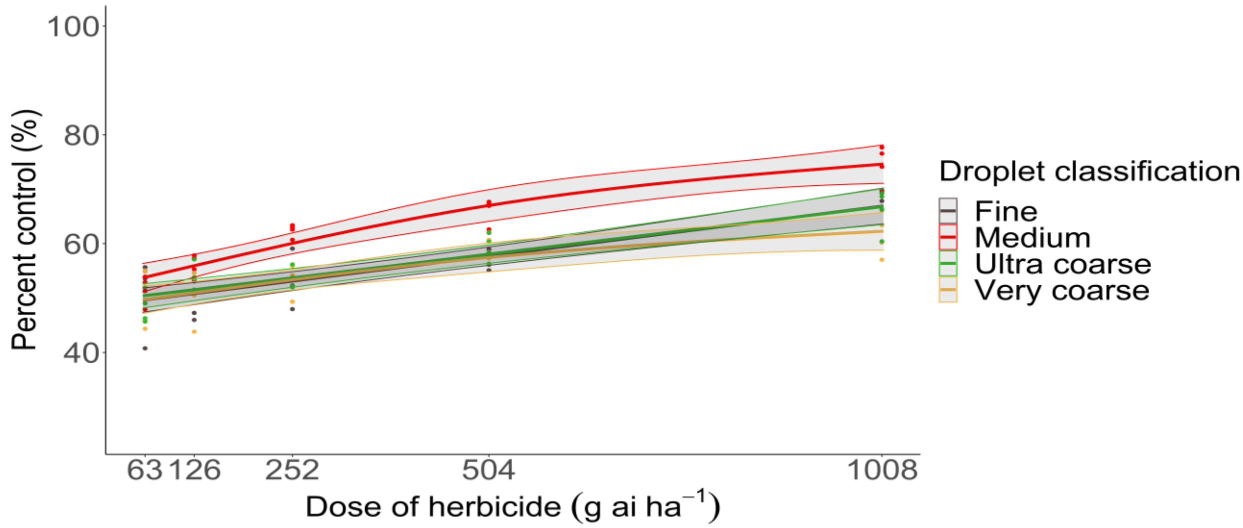

Figure 1. Generalized additive model smoothing representation of lambsquarter percent control for rates of fomesafen by droplet size. Deviance explained = 80.7%. Fine edf = 1.0, p-value>0.01. Medium edf = 1.78, p-value>0.01. Ultra coarse edf = 1.0, p-value>0.01. Very coarse edf= 1.58, p-value>0.01.

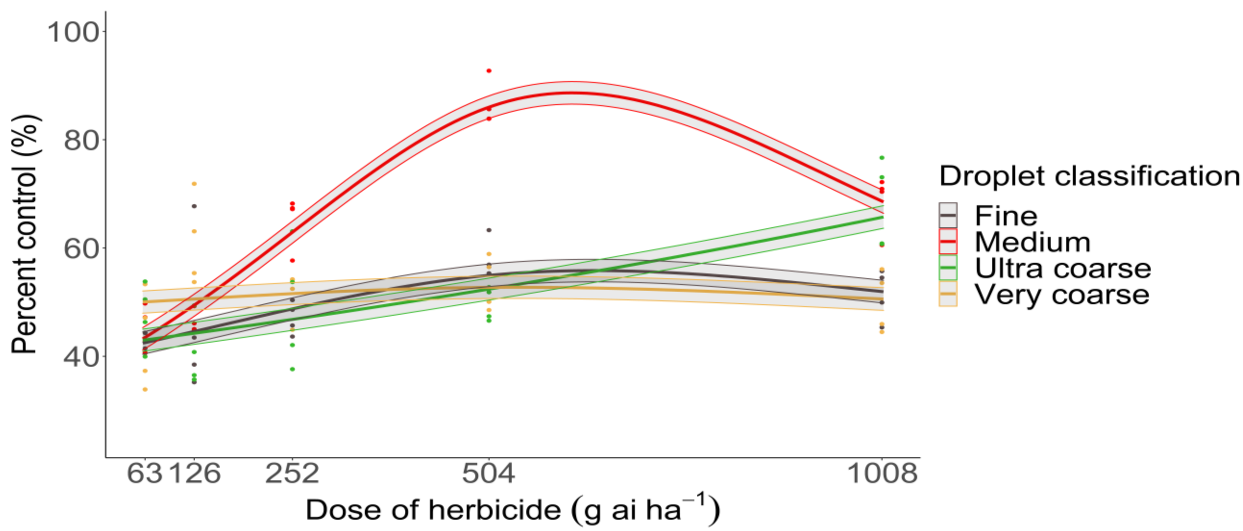

Figure 2. Generalized additive model smoothing representation of velvetleaf percent control for rates of fomesafen by droplet size. Deviance explained = 64.5%. Fine edf = 1.83, p-value = 0.01. Medium edf = 1.97, p-value>0.01. Ultra coarse edf = 1.0, p-value>0.01. Very coarse edf= 1.43, p-value = 0.71.

Interaction between clethodim and dicamba in control of volunteer corn

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Study Outline: Volunteer corn (*Zea mays*) is often a recurrent weed infesting RR soybean fields. The control of volunteer corn is usually based on the application of ACCase inhibitors, where good control is often achieved in post-emergence applications. However, the antagonistic interactions between ACCase inhibitors and growth regulators tank-mixtures are well reported in the literature. This issue is relevant considering the widespread adoption of dicamba-tolerant soybean in the US, where clethodim + dicamba tank-mixture applications are a common practice among farmers. Tank-mixture interactions, different corn growth stages, and the use of surfactants may affect the control of volunteer corn during applications. Therefore, the objective of this study was to investigate volunteer corn control at different growth stages with dicamba + clethodim tank-mixtures in association with different adjuvants. Field studies were conducted in with treatment solutions including clethodim (76.8, 102 and 136 g ai ha^{-1}) and dicamba (560 g ae ha^{-1}) applied alone or in tank-mixture in combination with NIS adjuvant (0.25% v v-1). All treatment solutions included drift retardant agent (0.5% v v^{-1}). Treatments were applied using backpack sprayer with TTI11002 nozzles calibrated to deliver 140 L ha^{-1}. Volunteer corn plants were sprayed at different heights (30, 60 and 90 cm).

Results: Generally, herbicide interactions were antagonistic in this study. The adjuvant R11 decreased the difference between the observed control and estimated control using the Colby equation. These differences increased when clethodim doses were increased. For the mixture of dicamba and clethodim, the best control was achieved when R11 was used.

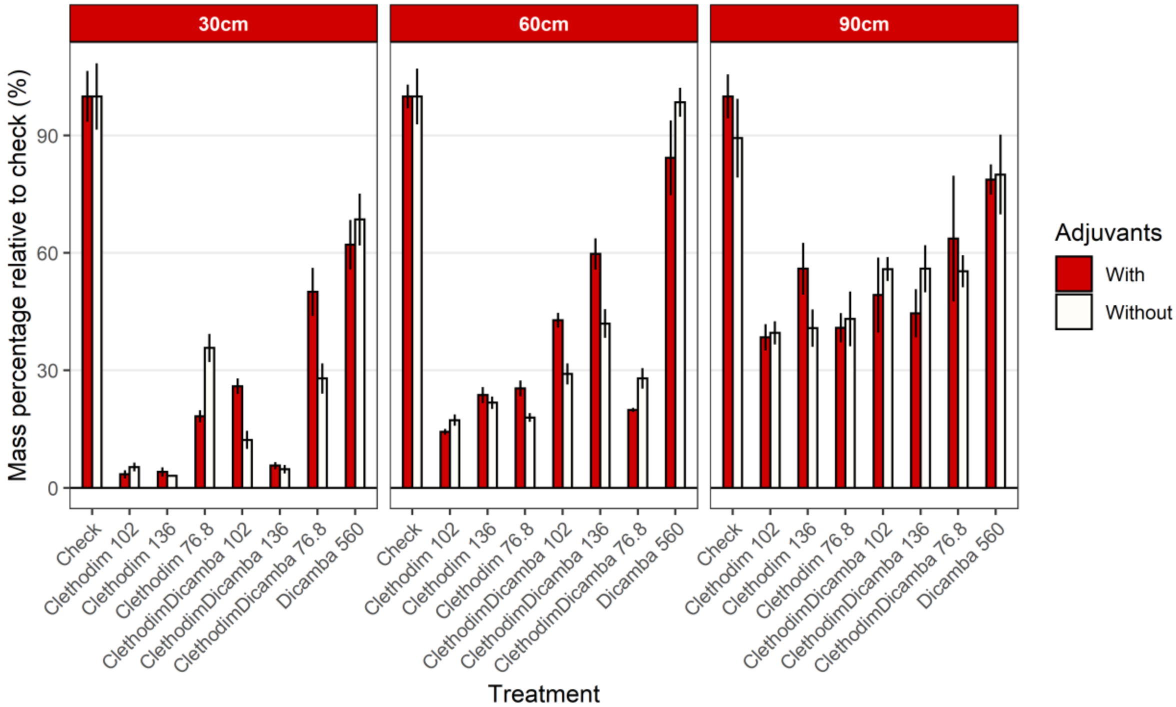

Figure 2. Control of volunteer corn treated in different heights and with different doses of clethodim alone or in mixture with dicamba.