An Evaluation of Three Drift Reduction Adjuvants for Aerial Application of Pesticides

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***Abstract*—Preventing pesticide drift from aerial applications is important for environmental and application efficiency reasons. Proper analysis of drift reduction technologies or techniques is an essential component of the drift prevention process. In the current study, three drift reduction adjuvants were tested with two herbicides under several application conditions used by rotary-wing and fixed-wing aircraft in the U.S. Data was collected using a high speed wind tunnel and laser diffraction equipment. The results of the study indicated application conditions, and not adjuvant inclusion, were the largest drivers of the droplet size distribution and drift potential. Data was further computed in the drift prediction program, AGDISP, where little differences were observed between the treatments. This study highlighted the importance of testing drift reduction technologies or techniques from multiple viewpoints.**

Keywords—drift reduction adjuvant, high speed wind tunnel, pesticide drift

I. INTRODUCTION

APPLICATION of pesticides is nearly ubiquitous with cropping systems in the US. Over 90 percent of corn, soybean, and cotton acres in the US are planted with some variety of genetic modification, with herbicide-tolerant and insect-resistant traits comprising the main technologies behind this adoption [1]. Growers have long been able to apply the herbicide glyphosate (N-(phosphonomethyl) glycine) to their tolerant crops for broad spectrum weed control, and they will soon have the capacity to apply growth regulator herbicides, e.g. dicamba (3,6-dichloro-O-anisic acid) or 2,4-D ((2,4-dichlorophenoxy) acetic acid), to growth regulator-tolerant crops.

DOI: 10.5176/2345-7848_2.1.15

The method of pesticide application has evolved from rudimentary techniques and equipment to being more technology driven through the use of GPS, flow rate controllers, field mapping, etc. Aerial application of pesticides provides growers the opportunity for pest control at critical times during a growing season and is common in row crops, pastures, and forestry systems in the US. Advances in aircraft design allow applicators to apply a range of products to a given area at speeds of 257 km h^{-1} and application times less than 15 minutes for a 61 ha field. However, with these higher application speeds and larger number of treated acres comes an increased potential for the creation of smaller droplets in the spray and increased off-target movement.

With the widespread use of pesticides in the US, questions regarding the human risks associated of pesticide applications have increased [2], and together with environmental concerns [3], has prompted the US EPA to begin programs for evaluating application technologies to mitigate pesticide drift [4]. Evaluations of aerial applications have been on-going for a number of years in the US by a collection of private, public, and government researchers, and the work culminated in the creation of a computer modeling program for drift prediction (AGDISP). This model is based on the principles of Gaussian dispersion into an atmosphere but also utilizes Langragian techniques to incorporate the wake effects of aerial applications [5]. Validation of this model in a field application scenario has been met with success [6], while other researchers contend the methodologies for drift collection need refinement to achieve results comparable to AGDISP [7]. A key element of this model is the knowledge of the droplet size distribution in order to obtain confidence in the drift prediction [6,7]. Spray particle sizes can be obtained by a variety of methods, though a common technique is the use of laser diffraction systems in wind tunnels constructed to simulate the application scenario [8].

Much like ground applications, there exist a wide variety of solution chemistries, nozzle types, and operational procedures aerial applicators may choose from to maximize pesticide efficacy and reduce off-target movement. Investigations of commercially available technologies for drift reduction will benefit the applicator, the environment, and the public at large. Therefore, the objective of this study was to evaluate the performance of three drift reduction adjuvants (DRAs) in two herbicide formulations across a range of airspeeds common to aerial applications. The authors hypothesized that all DRAs would reduce drift potential as measured by droplet size distribution and AGDISP modeling.

II. MATERIALS AND METHODS

A. Spray Particle Size Determination

All data for this experiment was generated in a high speed wind tunnel at the Pesticide Application and Technology Laboratory (PAT Lab) in North Platte, NE. The wind tunnel is comprised of a 149 kW electrical motor which powers a forward-curve centrifugal fan. The fan outlet measures 0.3 by 0.3 meters and opens into enclosed sections measuring 1.2 by 1.2 meters and a total length of 4.9 meters. The boom and nozzle delivery system is immediately downwind of the outlet. The boom and nozzle were traversed vertically through the airstream by a linear actuator. The measurement zone was situated 0.5 meters downwind of the nozzle tip. All particle size measurements were made using a Sympatec HELOS/VARIO KF (Sympatec Inc., Clausthal-Zellerfeld, Germany) using the manufacturer denoted R6 lens. This lens is capable of measuring droplets from 9 to 1,750 µm. A minimum of three replications were made per treatment for statistical analysis, with a replication being a single traverse of the spray plume through the measurement zone.

Two herbicide products were used; Base Camp Amine 4 (2, 4-Dichlorophenoxyacetic acid, dimethylamine salt, 46.8%, Wilbur-Ellis, San Francisco, CA USA) and Roundup PowerMax (*N*-(phosphonomethyl) glycine as a potassium salt, 48.7%, Monsanto, St. Louis, MO USA). Each herbicide was tested alone or with one of three DRAs; DRA #1 (modified vegetable oil, amine salts of organic acid, and organic acid, 100%), DRA #2 (modified vegetable oil, aliphatic mineral oil, amine salts of organic acids, aromatic acid, 100%), and DRA #3 (phytobland base oil, tall oil fatty acids, N, N-Bis-2-(omega-hydroxypoloxyethylene/polyoxypropylene) ethyl alkylamine, 100%). Usage rates were 1 part DRA #1 to 4 parts herbicide, 292 mL ha^{-1}, and 0.25%v/v, respectively. DRA #1 was premixed with the herbicides before addition to water, DRAs #2 and #3 were added last in the mixing order. The carrier volume for each treatment was 94 L ha^{-1}. The two nozzles tested were an 80° flat fan with a 03 orifice and a 40° flat fan with a 15 orifice. The tips were held using a CP11-TT (Transland, LLC, Wichita Falls, TX) nozzle body which was attach to a CP-06 swivel which was oriented parallel with the airstream. The CP11-TT body has an inherent deflection giving the actual nozzle tips 8° downward orientation relative to the airstream. The nozzle was approximately 9 cm below the airfoil boom. A pressure of 276 kPa was tested at three operational airspeeds. The airspeed of 129 km h-1 was chosen to be representative of rotary-wing (helicopter) applications, while airspeeds of 193 km h-1 and 257 km h-1 were chosen to be representative of fixed wing applications in the U.S.

B. Statistical Analysis

The treatments were arranged in a factorial design, and the factors in this experiment were herbicide, adjuvant, nozzle type, and airspeed. Data for this experiment were subjected to ANOVA using either PROC GLM or PROC MIXED in SAS Enterprise Guide (SAS, Cary, NC, USA) based on the model options inherent in each procedure. Replication was set as a random class variable for analysis. Data were separated by airspeed for statistical analysis. The data were further separated by herbicide type and nozzle type in PROC MIXED. Means were separated using the TUKEY procedure with the level of Type I error set at 0.05.

C. *Modeling of Drift Potential using AGDISP*

After determining the droplet size distributions (DSD) for each treatment, the data was modeled in AGDISP v8.26. This program was made available to the authors by the US Forest Service. For each modeling iteration, the following settings were used:

- Application Method: Aerial, Air Tractor 402B, release height of 10 feet, 25 spray lines
- Application Technique: user defined DSD
- Meteorology: Default values (2.24 m s^{-1} wind speed, perpendicular wind flow to flight path, 29.44 ºC, 80% RH
- Spray Material: Water, spray material does not evaporate
- Stability: Overcast
- Surface: 0 degree uphill and sideslope angle
- Canopy: None
- Surface Details: Surface roughness of 0.04 m
- Transport: 0 m
- Advanced: All default except default swath offset set to 0 swath

III. Results and Discussion

A. *Droplet Size Distributions*

An ANOVA overview is presented in Table 1 for the dependent variable "%Vol<100 µm", which was one of four dependent variable analyzed in this experiment. All main effects and interactions thereof are significant at α=0.05. The ANOVA tables for the three other dependent variables (Dv0.1, VMD, and Dv0.9) are not shown for brevity, however; it is noted all effects and interactions thereof are also significant at α=0.05. The dependent variable "%Vol<100 µm" was selected as an indicator of the fine portion of the spray that is typically most prone to drift. The effect size for each main effect and interaction thereof is also presented in Table 1. For the dependent variable "%Vol<100 µm", the main effects that explained the vast majority of the dataset variability were airspeed and nozzle type at 58.3% and 26.0%, respectively (Table 1). Airspeed is the dominant factor in DSD for aerial applications. At airspeeds above 129 km h^{-1}, the force of the air movement upon the spray droplets induces a secondary atomization event, typically defined as an air shear effect. This can substantially lower the DSD of the resultant application. When the mean values of all dependent variables across the three tested airspeeds were compared, it was evident the data displayed the air shear effect. For example, the percent of the spray volume less than 100 µm for the glyphosate treatments with the CP 4015 were averaged at 0.6 % at 129 km h-1, while at 193 and 257 km h-1 the averages were 3.2% and 9.3%, respectively (Tables 4 and 6). Similar trends were found in other similar comparisons in the dataset.

TABLE 1. ANOVA table of fixed effects and interactions for the dependent variable "<100 µm". Analysis of the Type III fixed effects in PROC GLM of SAS was used to determine significance at p<0.05.

Effect	df[a]	F Value	η^{2b}	Pr>F
Herbicide	1	2281.7	0.062	<.0001
Nozzle	1	9569.44	0.260	<.0001
Airspeed	2	10780.2	0.583	<.0001
Adjuvant	3	341.31	0.028	<.0001
Herbicide*Nozzle	1	14.63	0.000	0.0002

Herbicide*Airspeed	2	456.84	0.025	<.0001
Nozzle*Airspeed	2	273.27	0.015	<.0001
Herbicide*Adjuvant	3	136.84	0.011	<.0001
Adjuvant*Nozzle	3	57.46	0.005	<.0001
Adjuvant*Airspeed	6	19.94	0.003	<.0001
Herbicide*Nozzle*Airspeed	2	13.46	0.001	<.0001
Herbicide*Adjuvant*Nozzle	3	22.68	0.002	<.0001
Herbicide*Adjuvant*Airspeed	6	4.45	0.001	0.0005
Adjuvant*Nozzle*Airspeed	6	9.15	0.002	<.0001
Herbicide*Adjuvant*Nozzle*Airspeed	6	6.71	0.001	<.0001

[a]df- degrees of freedom
[b]η^2- total variation being accounted for by given effect

TABLE 2. Droplet Size Distribution (DSD) for the treatment consisting of the herbicide 2,4-D with two aerial nozzles, two airspeeds used by fixed-wing aircraft, and three drift reducing adjuvants. Data were subjected to a TUKEY means separation using PROC MIXED in SAS. Means within each column are not different if followed by the same letter (α=0.05). The two nozzle types and airspeeds were analyzed separately.

Nozzle[a]	Wind Speed	Adjuvant	Dv0.1[b]		VMD[c]		Dv0.9[d]		**< 100** µm[e]		Spray Classification[f]
	km h^{-1}		µm		µm		µm		**%**		
CP 4015	193	DRA #1	231	B	455	C	659	C	1.0	B	Coarse
		DRA #2	252	A	508	A	866	A	0.8	B	Coarse
		DRA #3	222	C	470	B	707	B	1.4	AB	Coarse
		none	208	D	452	C	675	BC	1.8	A	Coarse
	257	DRA #1	132	AB	298	B	575	A	5.5	AB	Medium
		DRA #2	136	A	305	B	582	A	5.1	B	Medium
		DRA #3	129	B	298	B	525	B	5.9	A	Medium
		none	133	AB	316	A	599	A	5.6	AB	Medium
CP 8003	193	DRA #1	132	A	257	A	400	A	4.6	B	Medium
		DRA #2	132	A	257	A	404	A	4.6	B	Medium
		DRA #3	122	B	257	A	418	A	6.1	A	Medium
		none	125	B	260	A	421	A	5.7	A	Medium
	257	DRA #1	98	A	202	AB	326	A	10.4	C	Fine
		DRA #2	96	AB	194	B	305	A	11.0	B	Fine
		DRA #3	92	B	197	AB	320	A	12.1	A	Fine
		none	93	AB	204	A	337	A	11.7	A	Fine

[a]Transland, LLC, Wichita Falls, TX USA
[b]Dv0.1- The droplet diameter (µm) at which ten percent of the spray volume contains droplets at the given size and below
[c]VMD- Volume Median Diameter
[d]Dv0.0 The droplet diameter (µm) at which ninety percent of the spray volume contains droplets at the given size and below

[e]<100- The percent of the spray volume containing droplets 100 µm in diameter and below
[f]Spray classifications based on ASABE S572.1 guidelines

TABLE 3. Droplet Size Distribution (DSD) for the treatment consisting of the herbicide glyphosate with two aerial nozzles, two airspeeds used by fixed-wing aircraft, and three drift reducing adjuvants. Data were subjected to a TUKEY means separation using PROC MIXED in SAS. Means within each column are not different if followed by the same letter (α=0.05). The two nozzle types and airspeeds were analyzed separately.

Nozzle[a]	Wind Speed	Adjuvant	Dv0.1[b]		VMD[c]		Dv0.9[d]		**< 100** µm[e]		Spray Classification[f]
	km h⁻¹		µm		µm		µm		**%**		
CP 4015	193	DRA #1	176	B	374	A	645	B	2.3	C	Medium
		DRA #2	184	A	379	A	682	AB	1.9	C	Coarse
		DRA #3	164	C	380	A	697	A	3.2	B	Medium
		none	133	D	334	B	588	C	5.5	A	Medium
	257	DRA #1	107	A	245	A	470	AB	8.6	B	Fine
		DRA #2	104	A	230	B	433	B	9.1	B	Fine
		DRA #3	105	A	245	A	462	AB	9.0	B	Fine
		none	98	B	240	A	482	A	10.4	A	Fine
CP 8003	193	DRA #1	122	A	234	A	377	A	5.6	C	Medium
		DRA #2	127	A	232	A	362	A	4.7	D	Medium
		DRA #3	109	B	229	AB	390	A	8.1	B	Medium
		none	103	B	223	B	376	A	9.2	A	Fine
	257	DRA #1	84	AB	169	A	274	A	14.9	C	Fine
		DRA #2	89	A	170	A	269	A	13.4	D	Fine
		DRA #3	79	B	170	A	281	A	16.6	B	Fine
		none	72	C	164	A	279	A	19.2	A	Fine

[a]Transland, LLC, Wichita Falls, TX USA
[b]Dv0.1- The droplet diameter (µm) at which ten percent of the spray volume contains droplets at the given size and below
[c]VMD- Volume Median Diameter
[d]Dv0.0 The droplet diameter (µm) at which ninety percent of the spray volume contains droplets at the given size and below
[e]<100- The percent of the spray volume containing droplets 100 µm in diameter and below
[f]Spray classifications based on ASABE S572.1 guidelines

Nozzle type accounted for 26.0% of the treatment effect for this dataset (Table 1). The nozzles tested were different in two important ways. First, the plume angles were 40 degrees different. The wider spray plume angle of the CP 8003 nozzle resulted in more force upon the entire spray plume versus the narrower angle CP 4015, and hence overall smaller DSD. For example, the VMD of the treatments involving 2,4-D through a CP 4015 nozzle produced VMD's that were twice as large as the sprays through a CP 8003 nozzle (Table 2). At 257 km h^{-1}, this effect was less in magnitude, which can be explained by the air shear effect as described previously. In addition to the spray plume angle of the nozzles, the orifice size had an effect on the DSD. In general, the larger the orifice size, the larger droplets produced [9]. The data from this experiment support previous findings.

The DSD of the glyphosate only solutions were consistently smaller than the 2,4-D only solutions at a given nozzle by airspeed combination. When using the CP 8003 nozzle at an airspeed of 257 km h^{-1}, the VMD of the glyphosate treatments were 170 µm and below, and the %Vol<100 µm ranged 13.4 to 19.2 percent (Table 3). The similar treatment with 2,4-D had VMD values 204 µm and below and percent of the spray volume less than 100 µm between 10.4 and 12.1 percent. Overall, herbicide choice accounted for 6.2% of the variability of the treatments, the third highest accountancy in this experiment (Table 1). The differences in DSD of the herbicide solutions is likely a result of the higher surfactant concentration of the glyphosate formulation versus the 2,4-D formulation. The presence of a surfactant in pesticide formulations will decrease the dynamic surface tension versus pure water alone or other solutions containing less surfactant, resulting in modified spray sheet breakup and overall smaller DSD [10].

Adjuvant inclusion had little effect on the DSD of the treatments, particularly as airspeed increased. At 129 km h^{-1} airspeed, representative of rotary-wing applications, adjuvant inclusion had the greatest effect on DSD when using the CP 4015 nozzle (Tables 4 and 5). At airspeeds representative of fixed-wing applications, inclusion of a DRA had the greatest effect when combined with the herbicide glyphosate. When included, the DRAs altered the percent of the spray volume less than 100 µm by approximately 2.5 to 6.0 percent for the glyphosate treatments. This compared to 0.8 to 1.5 percent for the 2, 4-D treatments. The DRAs behaved disparately across the treatments in this experiment, as well. For example, DRA#3 had the highest VMD at 193 km h-1 when using the CP 4015 nozzle with glyphosate but the third lowest VMD when applied with 2,4-D.

TABLE 4. Droplet Size Distribution (DSD) for the treatment consisting of the herbicide 2,4-D with two aerial nozzles, one airspeed used by rotary-wing, and three drift reducing adjuvants. Data were subjected to a TUKEY means separation using PROC MIXED in SAS. Means within each column are not different if followed by the same letter (α=0.05). The two nozzle types were analyzed separately.

Nozzle[a]	Wind Speed	Adjuvant	Dv0.1[b]		VMD[c]		Dv0.9[d]		**< 100** µm[e]		Spray Classification[f]
	km h^{-1}		µm		µm		µm		**%**		
CP 4015	129	DRA #1	391	B	678	B	910	C	0.0	A	Extremely Coarse
		DRA #2	415	A	732	A	1010	A	0.0	A	Ultra Coarse
		DRA #3	374	C	687	B	964	B	0.1	A	Ultra Coarse
		none	329	D	632	C	887	C	0.2	A	Extremely Coarse
CP 8003	129	DRA #1	141	A	280	A	444	A	3.9	AB	Medium
		DRA #2	146	A	281	A	438	A	3.3	B	Medium
		DRA #3	134	A	273	A	427	A	4.7	A	Medium
		none	144	A	281	A	438	A	3.5	AB	Medium

[a]Transland, LLC, Wichita Falls, TX USA
[b]Dv0.1- The droplet diameter (µm) at which ten percent of the spray volume contains droplets at the given size and below
[c]VMD- Volume Median Diameter
[d]Dv0.0 The droplet diameter (µm) at which ninety percent of the spray volume contains droplets at the given size and below
[e]<100- The percent of the spray volume containing droplets 100 µm in diameter and below
[f]Spray classifications based on ASABE S572.1 guidelines

TABLE 5. Droplet Size Distribution (DSD) for the treatment consisting of the herbicide glyphosate with two aerial nozzles, one airspeed used by rotary-wing aircraft, and three drift reducing adjuvants. Data were subjected to a TUKEY means separation using PROC MIXED in SAS. Means within each column are not different if followed by the same letter (α=0.05). The two nozzle types were analyzed separately.

Nozzle[a]	Wind Speed	Adjuvant	Dv0.1[b]		VMD[c]		Dv0.9[d]		**< 100 µm[e]**		Spray Classification[f]
	km h⁻¹		µm		µm		µm		**%**		
CP 4015	129	DRA #1	306	A	609	A	1018	A	0.2	B	Extremely Coarse
		DRA #2	277	B	558	B	861	B	0.4	AB	Extremely Coarse
		DRA #3	239	C	529	C	862	B	0.7	AB	Very Coarse
		none	206	D	490	D	776	C	1.6	A	Very Coarse
CP 8003	129	DRA #1	137	AB	274	A	438	A	4.2	B	Medium
		DRA #2	142	A	270	A	424	AB	3.4	B	Medium
		DRA #3	123	BC	249	B	396	B	5.6	A	Medium
		none	121	C	250	B	399	B	6.0	A	Medium

[a]Transland, LLC, Wichita Falls, TX USA
[b]Dv0.1- The droplet diameter (µm) at which ten percent of the spray volume contains droplets at the given size and below
[c]VMD- Volume Median Diameter
[d]Dv0.0 The droplet diameter (µm) at which ninety percent of the spray volume contains droplets at the given size and below
[e]<100- The percent of the spray volume containing droplets 100 µm in diameter and below
[f]Spray classifications based on ASABE S572.1 guidelines

TABLE 6. RESULTS OF AGDISP CALCULATIONS FOR THE FIXED-WING TREATMENTS.

Nozzle[a]	Airspeed	Solution	Downwind Deposition[b]	Airborne Drift[c]
	km h^{-1}		%	%
CP 4015	193	2,4-D	0.5653	0.1584
		2,4-D + DRA #1	0.3833	0.0507
		2,4-D + DRA #2	0.3165	0.0405
		2,4-D + DRA #3	1.46	0.6022
		Glyphosate	0.7401	0.1305
		Glyphosate + DRA #1	0.7401	0.1305
		Glyphosate + DRA #2	0.6556	0.1024
		Glyphosate + DRA #3	0.9182	0.2663
	257	2,4-D	1.49	0.6753
		2,4-D + DRA #1	1.53	0.5814
		2,4-D + DRA #2	1.42	0.5228
		2,4-D + DRA #3	1.59	0.6678
		Glyphosate	2.63	1.44

		Glyphosate + DRA #1	2.3	0.9857
		Glyphosate + DRA #2	2.47	0.9625
		Glyphosate + DRA #3	2.33	1.09
CP 8003	193	2,4-D	1.72	0.4876
		2,4-D + DRA #1	1.51	0.3002
		2,4-D + DRA #2	1.49	0.2784
		2,4-D + DRA #3	1.8	0.5322
		Glyphosate	2.54	0.8456
		Glyphosate + DRA #1	1.83	0.346
		Glyphosate + DRA #2	1.66	0.2474
		Glyphosate + DRA #3	2.31	0.672
	257	2,4-D	3.08	1.46
		2,4-D + DRA #1	2.88	1.19
		2,4-D + DRA #2	3.07	1.25
		2,4-D + DRA #3	3.23	1.51
		Glyphosate	4.7	2.73
		Glyphosate + DRA #1	3.98	1.74
		Glyphosate + DRA #2	3.75	1.37
		Glyphosate + DRA #3	4.25	2.2

[a]Transland, LLC, Wichita Falls, TX USA
[b,c]Percent of applied rate at 61 meters downwind

The spray classifications reported in Tables 2-5 are based on established guidelines [11] using reference nozzle data generated at the PAT Lab. At 257 km h^{-1}, the DRAs had little to no effect on the spray classifications. At 193 km h^{-1}, DRA inclusion resulted in a larger spray classification in four cases, but this was only when included with the herbicide glyphosate. No differences in spray classification were observed when using 2,4-D. At 129 km h^{-1}, spray classifications were overall larger when each herbicide was tested with a DRA, but this was only observed for the CP 4015 nozzle. The impact of DRAs on the DSD and spray classifications is important to consider, because pesticide label requirements will often define upper or lower limits for DSD and/or spray classification.

Overall, the treatment main effects and interactions were significant ($p<0.05$) (Table 1). The dependent variables that explained the most variability in effect size were airspeed, nozzle type, and herbicide, appropriately (Table 1). DRA inclusion had little to no effect, and sometimes an undesirable effect, on the dependent variables VMD, Dv0.9, and %Vol<100 µm (Tables 2-5). Nevertheless, the DRAs did increase, overall, the Dv0.1 and decrease, overall, the %Vol<100 µm versus no DRA inclusion. Adjuvants formulated for drift reduction are often characterized by their ability to alter the lower diameters of droplet distributions, while not altering the middle to higher droplet diameters [10].

While differences between the drift potential from DRA inclusion or not within each nozzle type by airspeed by herbicide are observed in AGDISP (Table 6), the authors agreed the magnitude of differences to be unimportant. This is an important finding to consider given the multiple statistical differences observed in the DSD data. The discrepancy might be explained by the high repeatability of laser diffraction measurements, resulting in low treatment variability and thus ease of mean separation for the DSD data, and the empirical and mathematical framework upon which the AGDISP model was built. The droplet dispersion algorithms of models such as AGDISP do not fully account for near wake or far-field (generally >100 meters) droplet dispersion behaviors [7]. Therefore, the AGDISP model predicts less differences between treatments than would otherwise be inferred from DSD data. Based on the AGDISP results, the authors would not anticipate observing differences between treatments in a field experiment.

IV. CONCLUSION

DRA inclusion had little effect on the DSD and AGDISP modelling for drift potential in this experiment. At airspeeds below an air shear effect (approximately 129 km h-1) (Brad ASTM Paper), the DRAs had the greatest magnitude of change on the DSD dependent variables, particular Dv0.1 and %<100 µm (Tables 4 and 5). At airspeeds used by fixed-wing aircraft, the effect of DRA inclusion on the DSD and AGDISP results were minimal.

The results of this experiment demonstrated that the effectiveness of inclusion of such DRAs into an aerial pesticide application are ultimately dependent upon the operating conditions. Overall, airspeed had the greatest treatment effect. At airspeeds below the air shear effect, the DSD was most affected by nozzle type. At higher airspeeds, the DSD could be influenced towards lower drift potential by inclusion of a DRA, particularly when using a narrower angle, higher flow rate nozzle and at a lower airspeeds for fixed-wing aircraft.

ACKNOWLEDGMENT

All authors express their gratitude towards Annah Geyer, Research Technician at the PAT Lab, for her work towards the completion of this project. The data presented in this manuscript is a factual finding of how various application parameters affect droplet size; in no way should anything in this manuscript be considered an endorsement of any product on behalf of the University of Nebraska-Lincoln nor the USDA-ARS.

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