



American Society of
Agricultural and Biological Engineers

An ASABE Section Meeting Presentation

Paper Number: AA09-001

Aerial Comparisons of Drift Reducing Tank Mixes

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**Written for presentation at the
2009 ASABE/NAAA Technical Session**

Sponsored by ASABE Technical Committee PM-23/6/2

43rd Annual National Agricultural Aviation Association Convention

Silver Legacy Resort & Reno Convention Center, Reno, NV

December 7, 2009

Abstract. *A field study was conducted to determine the influence of adding spray drift control/deposition aid products to tank mix solutions for fixed wing aerial applications. An Air Tractor 502A was used to apply treatments at 28 l/ha with 10 different products. The products were compared to each other and water alone. The aircraft was configured to simulate a typical high speed herbicide application scenario. Downwind horizontal and vertical drift characteristics were evaluated for each product. Results of the study show that drift control/deposition aid products added to the tank mix do affect the amount of horizontal and vertical spray drift for the application scenarios and operating conditions used. Results indicate that several products tended to result in more downwind deposits when compared to water while others reduced the amount of downwind drift deposits. Significant differences were found. After additions of the drift control/deposition aid products, the droplet size spectrum among treatments ranged from 398 to 331 microns (VMD). The average micron size (VMD) of the water treatments without drift control/deposition aid products was 362 microns. The average droplet size for all treatments was 361 microns (VMD).*

Keywords. Aerial application, drift minimization, deposition, droplet size, spray, drift, drift control products, deposition aids

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Introduction

Controlling or minimizing the off-target movement of sprayed crop protection products is critical. Researchers have conducted numerous studies over time to better understand spray drift problems.

Even though a better understanding of the variables associated with spray drift exists, it is still a challenging and complex research topic. Environmental variables, equipment design issues, many other application parameters, and all the interactions make it difficult to completely understand drift related issues (Smith, et al., 2000). Droplet size and spectrum has been identified as the one variable that most affects drift (SDTF, 1997). Many forces impinge on droplet size, but it is still the drop size that must be manipulated to optimize performance and eliminate associated undesirable results (Williams, et al., 1999). Drift is associated with the development of high amount of fine droplets (Gobel and Pearson, 1993).

Off-target drift is a major source of application inefficiency. Application of crop protection products with aerial application equipment is a complex process. In addition to meteorological factors, many other conditions and components of the application process may influence off-target deposition of the applied products (Threadgill and Smith, 1975; Kirk et al., 1991; Kirk, 2003; Salyani and Cromwell, 1992). Spray formulations have been found to affect drift from aerial applications (Bouse et al., 1990). Materials added to aerial spray tank mixes that alter the physical properties of the spray mixture affect the droplet size spectrum. (SDTF, 2001). With new nozzle configurations and higher pressure recommendations (Kirk, 1997), and with the continued development of drift reducing tank mix materials, applicators seek to better facilitate making sound decisions regarding the addition of drift control products into their tank mixes. Kirk (2003) reported that some drift control products were effective, some ineffective, and some were not sufficiently effective in reducing drift. In a major aerial evaluation of drift reducing compounds it was found that some products advertised as drift control additives did not reduce the amount of drift, but in fact resulted in more drift (Wolf, et al., 2005). Lan, et al., 2008, reported that most the products included in a study reduced the amount of fine sprays.

Objective

The objective of this study was to evaluate the influence of selected drift control products/deposition aids on horizontal and vertical spray drift during a high speed fixed wing aerial application scenario.

Materials and Methods

A field study was conducted to determine the influence on reducing drift when selected tank mix drift control products/deposition aids were added to the spray tank during fixed wing aerial applications. One fixed wing aircraft, an Air Tractor 502A (Air Tractor Inc., Olney, Texas), was equipped with drop booms; CP-11TT straight stream nozzles (CP Products, Inc., Mesa, Arizona) with a standard 8 degree deflection; using the #15 orifice size; and spraying at 303 kPa (44 psi). The AT 502A flew at a ground speed of 251 km/h (156 MPH). The pilot was instructed to use an application height of 3-3.7 m (10-12 feet). Based on USDA droplet prediction models using the above parameters, the $Dv0.1$, $Dv0.5$, and $Dv0.9$ were calculated at 213, 304, and 539 microns respectively. The droplet spectra classification, based on the ASABE Standard S572, was determined to be medium with a % volume less than 200 microns at 7.65%.

The study was conducted on September 4, 2008 between 10:00 am and 1:45 pm at the Rucker Brothers airstrip in Burdett, Kansas. The study area was flat, open and dry over a closely mowed grass runway. The canopy off the runway was a 45-60 cm (18-24 inches) tall pasture grass. Ten different products plus tap water were evaluated in three replications. All products were completely randomized for the study. Three identical tap water treatments were strategically placed in the spray order as a check. Spray mixes containing 189 liters (50 gal) of tap water, X-77 Spreader (Loveland Industries, Greeley, Colorado) at

0.25% volume/volume, and individual drift control additives/deposition aids were applied at 28 L/ha (3 GPA). All tank mix treatments were prepared based on recipes provided by each participating company (Appendix A). Temperature, relative humidity, and maximum and average wind velocities were recorded using a WatchDog 550 Weather Station (Spectrum Technologies Inc., Plainfield, IL) for the duration of the experiment and averaged during the exact time of each treatment. In addition, wind direction and speed were monitored by observing a flag and ribbon placed at the top of the tower with one Kestrel 4500 and two Kestrel 3000 (Nielson-Kellerman, Chester, PA) hand-held instruments and three simple compasses. To minimize tank mix contamination between treatments, a hot water-high pressure washer was used to facilitate spray system cleanout.

Spray drift deposits were collected for measurement and analysis using horizontal collectors, a drift tower with vertical collectors, and 2.5 X 7.6 cm (1 X 3 inch) water sensitive paper (WSP) (Spraying Systems Company, Wheaton, Illinois). To collect the horizontal drift, WSP was placed on 2.5 X 10 cm (2 X 4 inch) blocks sloped toward the flight line and placed downwind from the flight line along the drift line at 15.25 m (50 feet) increments to a distance of 91.4 m (300 feet). A total of six horizontal wsp's were collected for each treatment (H50, H100, H150, H200, H250, and H300). Three retractable towers capable of extending to 12.2 m (40 feet) and designed to hold WSP at 1.53 m (5 feet) increments was used for the vertical drift collection. A total of nine vertical wsp's were collected for each treatment (V0, V5, V10, V15, V20, V25, V30, V35, and V40). The collector layout is shown in Appendix B. Each treatment included four parallel back and forth passes along the flight line for a minimum distance of 213.5 m (700 feet), 106.75 m (350 feet) before and after the drift collection line. Marker flags were positioned along the flight line to assist the pilot in locating the flight line and with the spray timing. To facilitate timing and shorten the duration of the study three identical drift collection stations were used to simulate the repetitions. All treatments were applied in a crosswind. The crosswind speed averaged for the all treatments was 12.6 Km/h (7.8 mph). The crosswind average wind speed was used to normalize all the data. The average for the maximum and minimum wind speeds was 14.2 Km/h (8.8 MPH) and 10.1 Km/h (6.3 MPH) respectively. The crosswind direction remained within tolerable limits during the study, thus shifting the collector system was not necessary to maintain the approximate 90-degree crosswind for each treatment. During the first pass for each treatment, an under boom collection was taken on water sensitive paper to determine the influence of drift control/deposition aid on droplet spectra. Average temperature for the duration of the experiment was 19.6 C (67.2 F). Average humidity was 44.9 percent.

After each replication, the collection cards were placed in pre-labeled-sealable bags for preservation. Data envelopes were used to organize and store the cards until analysis was complete. DropletScan® (WRK of Arkansas, Lonoke, AR; and WRK of Oklahoma, Stillwater, OK; Devore Systems, Inc., Manhattan, KS) was used to analyze the cards. Each wsp was 2.5 X 7.6 cm (1 X 3 inch) with 40% of the central area scanned. Percent area coverage (PAC) was the statistic measured and reported. Because of scanning problems with DropletScan®, some of the cards were scanned using the scanning system developed at the USDA ARS in College Station, TX. The system consists of a Basler A102fc RGB CCD Firewire camera with 1392X1040 pixels and a 6.45 µm pixel size (Basler AG, Ahrensburg, Germany); Infinity K2/S lens with CF-1 objective (Infinity Photo-Optical, Bolder Colorado), and LabVIEW (National Instruments, Austin Texas) camera control and image capture program. Each image had 10.1 µm/pixel over a 1.4 cm² area with three captured for each card or a 4.2 cm² total area. The images were analyzed in Vision Assistant (National Instruments, Austin Texas) using a custom script to measure stain diameters. A Visual Basic 6 program (Microsoft, Seattle Washington) was used to combine the stain diameters of the three images for each card. Then the USDA spread factor was applied to each stain diameter and droplet spectrum parameters calculated.

Spray droplet stains collected on water sensitive paper are a good indicator of spray drift when comparing the amount of coverage obtained on the cards (Wolf et al., 1999, Wolf and Frohberg

2002). DropletScan™ has been tested as a reliable source for predicting droplet stain characteristics when compared to other card reading methods (Hoffmann, et al., 2004), Wolf, et al., 2005, Wolf, 2005). Since the cards are placed outside and downwind from each treatments target area, differences in the amount of area covered on the card will reflect the amount of drift. For this study, the percent area coverage for the horizontal and vertical drift profiles is used as a means to separate differences in treatments.

Statistical analyses of the data were conducted with SAS 9.1.3 (SAS Institute, Cary, NC, 2003). The model used was a General Linear Model (GLM) procedure to analyze the water sensitive paper data by horizontal and vertical distance. The average crosswind speed was used to normalize all data to account for deviation in wind velocity during each treatment. The LS Means for each product were tested and used to report the differences found at each horizontal and vertical distance.

Results and Discussion

Horizontal and vertical data from the field study are shown in Tables 1 and 2. A summary table showing the total horizontal, total vertical and total overall coverage (drift) is shown in Table 3.

All data for both the horizontal and vertical treatments were normalized for the average wind speed of 12.6 Km/h (7.8 MPH). LS means are used to estimate differences. Using water treatments as a reference, products that contained more coverage at the horizontal and vertical sample locations (H50-H300 and V0-V40) can be differentiated from those that had less coverage.

For all treatments compared, coverage (drift) was measured at each horizontal collector location (H50 – H300). The presence of heavy deposits on the first horizontal (H50) collector position is likely to be the result of windblown swath displacement. For most of the treatments, the amount of coverage has reduced appreciably beyond H100. However, some of the products were still showing coverage above 2% at H200. The top three treatments for reducing horizontal coverage (drift) in these comparisons were INT 908, Control, and Interlock 0.8. Tap water 3 and tap water + oil were ranked 4 and 5 respectively for horizontal drift reduction. The remaining products had coverage amounts greater than tap water 3.

Vertical measurements also show coverage on all the collector locations (V0 – V40) for all treatments. For most of the products the higher amounts of coverage occurred at the collector locations V5 – V15. This would indicate a higher amount of flux in the airstream in the area represented by the release height from the airplane. As with the horizontal measurements, the top three treatments for reducing coverage vertically downwind were Interlock 0.8, INT 908, and Control. Tap water 3 and tap water + oil were again ranked 4 and 5 respectively.

When total horizontal and total vertical coverage was combined for each treatment to obtain the total overall drift, INT 908 was measured with the lowest amount (36.5% PAC). Control was next at 37.7% followed by Interlock 0.8 at 37.8%. These were not significantly different from each other. These three products, tap water 3, and tap water + oil were all significantly better for reducing coverage than all the remaining products.

When all the tap water treatments were averaged together (50.6% PAC), six of the treatments were measured with more drift than the averaged water alone. They were Formula 1 (53.3%), Interlock 1.25 (53.9%), Superb HC + Interlock (61.5%), #PX056-Z (63.5%), AG06037 (71.4%), and AG08050 (74.6%). The remaining four treatments were measured with less drift than the averaged water alone. They were tap water + oil (41.6%), Interlock 0.8 (37.8%), Control (37.7%), and INT 908 (36.5%).

Comparisons of the effect of each drift control/deposition aid on droplet size shows very little differences among treatments. The range in droplet size for the treatments was 398 to 331microns (VMD). The

water only treatments ranged from 345 to 374 microns (VMD) with an average of 362 microns. The average of all treatments was 361 microns (VMD) (Table 4).

Another factor to include in evaluating each product relates to considerations given to the mixing, loading, and tank cleanout properties. Observations recorded during the mixing and loading phase of this study indicate that certain products exhibited characteristics that may hinder good application techniques. Formula 1 was noted for being difficult to clean from the spray system. Foam was noted in the mixing and loading process with #PX056-Z. However, it did seem to dissipate prior to application. This product required two rinses to get it removed from the spray system. INT 908 required a large amount of product in the mix (5 gal) and was reported to be slimy, clumpy, and somewhat hard to mix. This product required triple rinsing of the spray system to get it removed. Since a high-pressure/hot-water system was used to clean the tank and booms, most products were not noted as difficult to remove from the system.

Conclusions

This study was conducted to determine the influence of drift control/deposition aid products on crosswind drift from high speed aerial applications using fixed wing aircraft. An Airtractor 502A was used to apply the treatments. Differences in products are shown at all horizontal and vertical collector positions. Results show that many of the products did not provide any benefits for drift reduction. A few of the products exhibited the potential to reduce the amount of drift. The researchers are confident that the final results in this study will provide useful information to aerial applicators regarding decisions they need to make about drift control/deposition aid products.

Acknowledgements

Special appreciation is expressed to Cary and Jane Rucker, Rucker Flying Service, Inc., Burdette, KS, for the donation of the aircraft, airstrip, facility, and time to this study. We would especially like to thank the participating companies for their generous donations of product, time, and funds to support this study. A special thank you is offered to Spraying Systems Company for their support in providing the water sensitive paper used to collect the drift. We are also very grateful to the many, many people providing technical support with sample collection, processing, and data compilation. The food and beverage donors were also very much appreciated.

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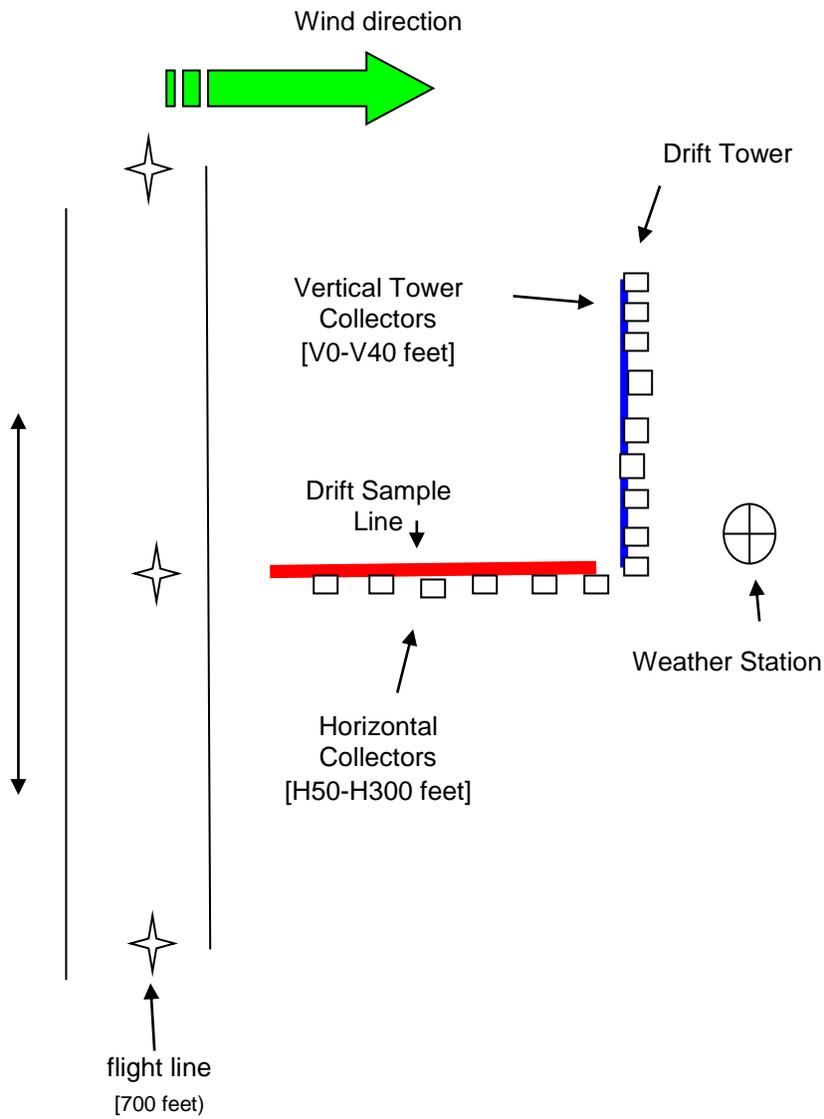
Appendix A: Product, company, and mixing rate.

Product Name	Product Company	Mixing rate ^a
Tap water - 1	Local supply	X-77 only
Superb HC + Interlock	Winfield Solutions	133 oz + 33 oz / 50 gal
Formula 1	United Suppliers	1.5 qt / 50 gal
#PX056-Z	Precision Labs, Inc	5 qt / 50 gal
Tap water - 2	Local supply	X-77 only
Ag 06037	Winfield Solutions	64 oz / 50 gal
Ag 08050	Winfield Solutions	80 oz / 50 gal
Interlock 1.25	Winfield Solutions	80 oz / 50 gal
Control	GarrCo Products, Inc	2 oz /50 gal
Tap water - 3	Local supply	X-77 only
INT 908	Rosen's	5 gal / 45 gal
Tap water + Prime Oil ^b	Local supply + Winfield Solutions	266 oz / 50 gal
Interlock 0.8	Winfield Solutions	50 oz / 50 gal

^a All tank mixes included X-77 at .25% v/v (16 ounces per 50 gallon load).

^bOil to simulate a suggested tank mix with fungicide (Prime Oil @ 1 pint/acre).

Appendix B: Drift collector diagram. Three similar towers were used for simultaneous collections.



Tables

Table 1. LS Means for horizontal drift deposits recorded as percent area coverage¹ (PAC) on water sensitive paper for thirteen products.

Product	feet along ground away from center of flight line						Total
	50	100	150	200	250	300	
Tap Water 1	31.3	7.1	3.4	1.4	0.7	0.4	44.2
Superb HC + Interlock	30.7	11.1	4.6	2.2	1.1	0.5	50.2
Formula 1	25.7	9.3	4.0	2.0	1.2	0.6	42.9
#PX056-Z	21.9	15.8	5.2	2.7	1.6	0.6	47.7
Tap Water 2	21.4	12.5	4.4	2.2	1.3	0.9	42.7
AG 06037	28.3	15.1	5.5	2.9	1.6	0.7	54.0
AG 08050	31.1	15.8	4.3	2.4	1.5	0.7	55.8
Interlock 1.25	23.8	9.4	3.9	2.4	1.0	0.5	41.1
Control	24.5	6.1	2.0	0.8	0.4	0.2	33.9
Tap Water 3	24.3	10.2	2.9	1.6	0.5	0.2	39.8
INT 908	24.0	6.3	1.3	0.8	0.4	0.2	32.9
Tap Water + oil	21.2	8.6	3.1	1.9	0.6	0.3	35.7
Interlock 0.8	26.5	5.5	1.8	0.8	0.3	0.1	35.1

¹Percent area coverage from scanned water sensitive paper – 40% of 2.54 X 7.62 cm (1 X 3 inch).

Table 2. LS Means for vertical drift deposits recorded as percent area coverage¹ (PAC) on water sensitive paper for thirteen products.

feet above the ground at 300 feet perpendicular from center of flight line										
Product	0	5	10	15	20	25	30	35	40	Total
Tap Water 1	0.3	0.9	1.0	0.9	0.8	0.7	0.5	0.4	0.4	5.9
Superb HC + Interlock	0.9	1.9	2.2	2.0	1.3	1.5	0.8	0.5	0.3	11.3
Formula 1	1.0	1.6	2.1	1.9	1.5	1.0	0.6	0.4	0.4	10.5
#PX056-Z	1.1	2.2	2.7	2.4	2.2	1.8	1.5	1.1	0.7	15.7
Tap Water 2	1.5	2.3	2.1	2.2	1.7	1.7	1.3	1.2	1.0	15.0
AG 06037	1.4	2.3	2.6	2.8	2.6	2.0	1.8	1.1	0.8	17.4
AG 08050	1.8	2.6	2.7	2.9	2.7	1.8	1.5	1.6	1.1	18.8
Interlock 1.25	0.9	1.4	1.9	2.0	1.9	1.7	1.2	0.9	0.9	12.8
Control	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.2	3.8
Tap Water 3	0.4	0.7	0.7	0.6	0.5	0.4	0.5	0.3	0.3	4.3
INT 908	0.2	0.4	0.5	0.4	0.6	0.5	0.5	0.3	0.3	3.7
Tap Water + oil	0.6	0.8	0.8	1.0	0.8	0.8	0.5	0.3	0.4	5.9
Interlock 0.8	0.2	0.4	0.5	0.3	0.4	0.4	0.3	0.1	0.1	2.7

¹Percent area coverage from scanned water sensitive paper – 40% of 2.54 X 7.62 cm (1 X 3 inch).

Table 3. LS Means and ranks for total horizontal, total vertical, and total overall drift deposits recorded as percent area coverage¹ (PAC) on water sensitive paper for thirteen products.

Product	Total Horizontal ³	rank	Total Vertical ³	rank	Total Drift ^{2,3}	rank
Tap Water 1	44.2 ^{cde}	9	5.9 ^{ab}	5	50.1 ^{bcd}	6
Superb HC + Interlock	50.2 ^{ef}	11	11.3 ^{bc}	8	61.5 ^{ef}	10
Formula 1	42.9 ^{bcde}	8	10.5 ^{bc}	7	53.3 ^{cde}	7
#PX056-Z	47.7 ^{def}	10	15.7 ^{cde}	11	63.5 ^{ef}	11
Tap Water 2	42.7 ^{bcde}	7	15.0 ^{cde}	10	57.6 ^{de}	9
AG 06037	54.0 ^f	12	17.4 ^{de}	12	71.4 ^{fg}	12
AG 08050	55.8 ^f	13	18.8 ^e	13	74.6 ^g	13
Interlock 1.25	41.1 ^{abcde}	6	12.8 ^{cd}	9	53.9 ^{cde}	8
Control	33.9 ^{ab}	2	3.8 ^a	3	37.7 ^a	2
Tap Water 3	39.8 ^{abcd}	5	4.3 ^a	4	44.1 ^{abc}	5
INT 908	32.9 ^a	1	3.7 ^a	2	36.5 ^a	1
Tap Water + oil	35.7 ^{abc}	4	5.9 ^{ab}	5	41.6 ^{ab}	4
Interlock 0.8	35.1 ^{abc}	3	2.7 ^a	1	37.8 ^a	3

¹Percent area coverage from scanned water sensitive paper - 2.54 X 7.62 cm (1 X 3 inch).

²Represents all horizontal and vertical collectors which includes H50 or the swath adjustment amount.

³Treatments with different letters represent significance at 0.05%.

Table 4. Product effect on droplet size.

Product	VMD/microns ¹	Product	VMD/microns
Tap Water 1	374	Interlock 1.25	348
Superb HC + Interlock	380	Control	336
Formula 1	398	Tap Water 3	368
#PX056-Z	393	INT 908	356
Tap Water 2	345	Tap Water + oil	347
AG 06037	331	Interlock 0.8	379
AG 08050	333		
Average - 361			

¹Droplet size reported is a composite score measured by DropletScan™ for five water sensitive papers positioned under the boom for each treatment. Collections were taken during the first pass for each treatment.