Field Test Comparisons of Drift Reducing Products for Fixed Wing Aerial Applications

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Abstract

A field study was conducted to determine the influence of adding spray drift control products to tank mix solutions for fixed wing aerial applications. Downwind horizontal and vertical drift was collected on water sensitive paper (wsp) for measurement and analyzed with DropletScan™ software. Percent area coverage for the horizontal and vertical drift profiles was used as a means to separate differences in treatments. Average crosswind speed was used as a covariate to account for deviation in wind velocity during each treatment. Covariate-adjusted least squares means were computed for each combination of product and airplane at three wind speeds according to observed percentiles during the study (low – 6.8 Km/h, medium – 11.3 Km/h, and high – 18.5 Km/h). These means were compared within wind speed group using pair wise t-tests to report the differences found at each horizontal and vertical distance. Summary data was reported representing a worst case scenario utilizing the low or 6.8 Km/h wind speed profile. From the summary data, a low-score performance value was complied for each product over all the horizontal and vertical distances to determine product rank. When compared to water, results show that some of the products did not provide any benefits for drift reduction and in fact may have increased the drift potential. A few of the products exhibited the potential to reduce the amount of drift.

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. Particularly, a recent group of studies conducted by the industries Spray Drift Task Force (SDTF 1997) generated numerous reports to support an Environmental Protection Agency (EPA) spray drift data requirement for product reregistration and future label guidance statements on drift minimization.

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; 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.

Water-sensitive papers (wsp) are often used as an indicator for the presence of spray deposition (Matthews 1992). Water in the spray stains the wsp and the spot size can be observed or measured, thus, permitting the use of wsp to evaluate the number of droplets per unit area and for measuring the percent area covered (Syngenta 2002). Droplet sizing is also possible when a proper spread factor (Syngenta 2002) or calibration equation has been prepared for a particular imaging process (Smith et al. 1997). Fox et al. (2000) found while comparing water and oil-sensitive papers that laboratory spray trials confirmed spot values very similar to calculated values and concluded that percent area covered was a highly reliable parameter when using wsp.

Spray droplet stains collected on wsp are a good indicator of the amount of downwind movement of spray droplets (drift) when comparing the amount of coverage obtained on the wsp (Wolf et al. 1999; Wolf and Frohberg 2002). Since the cards are placed outside and downwind from each treatments target area, differences in the amount of area covered on the wsp will reflect the amount of drift. DropletScan™ has been tested as a reliable source for predicting droplet stain characteristics when compared to other card reading methods (Hoffman 2004).

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 two selected fixed wing aerial application scenarios.

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. Two aircraft with different application scenarios were used to make the comparisons. One of the fixed wing aircraft, an Air Tractor 502A (Air Tractor Inc., Olney, Texas), was equipped with drop booms; CP-09 nozzles (CP Products, Inc., Mesa, Arizona) with a 5-degree deflection; using a combination of .078 and .125 orifice settings; and spraying at 276 kPa. The second, a Cessna 188 Ag Husky (Cessna Aircraft Co., Wichita, KS), was equipped with Ag-Tips (Ag-Tips, Arrowwood, Alta, Canada); CP-03 nozzles with a 30-degree deflector; also using a combination of .078 and .125 orifice settings; and was spraying at 179 kPa. The AT 502A ground speed was radar measured at 241 km/h and the Cessna was measured at 185 km/h. Pilots were instructed to use an application height of 3.0-3.7 m. Both aircraft made all treatments.

The study was conducted on September 25 and 26, 2002 at the Goodland airport in Goodland, Kansas. The study area was flat, open and dry with a 15-25 cm desert-like grass and weed canopy. Twenty-one different products (two were water only) were evaluated in three repetitions using the two airplanes (Table 1). All products and both airplanes were completely randomized over both days of the study. There were 121 treatments evaluated. Spray mixes containing 560 liters 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. All tank mix treatments were prepared based on recipes provided by each participating company (Table 1). Temperature, relative humidity, and maximum and average wind velocities were recorded using Kestrel 3000 (Nielson-Kellerman, Chester, PA) hand-held instruments averaged during the time of application for each treatment. To minimize tank mix contamination between treatments, a hot water-high pressure washer was used to facilitate hopper cleanout. Water was included on both days of the study as a check. Products were divided into four groups dependent on chemistry. The groups were specified by the researchers and each company indicated which group its product should be placed in. The groups were polyacrylamide, guar, oil, and non-traditional or combination. Table 2 lists the different classifications for the products used in this study.

TABLE 1—Product code assignments, companies, mixing rates.

Product Code	Product Name	Product Company[1]	Suggested Mixing rate[2]	Experiment Mixing Rate/60 gallon load[2]
A	Formula One	United Suppliers	3 qt/100 gal	1.8 quarts
B	HM0226	Helena	1% v/v	76.8 ounces
C	AMS 20/10	United Suppliers	10 lb/100 gal	6 pounds
D	Border EG 250	Precision Labs	10 oz/100 gal	169.8 grams
E	Control	Garrco Products	4 oz/100 gal	2.4 ounces
F	INT VWZ	Rosen's	15 lb/100 gal	9 pounds
G	Inplace	Wilbur-Ellis	8 oz/acre	1.25 gallons
H	Garrco #3	Garrco Products	8 oz/100 gal	4.8 ounces
I	INT YAR	Rosen's	9.0 lb/100 gal	5.4 pounds
J	Border Xtra 8L	Precision Labs	2.5% v/v	192 ounces
K	HM 2005C	Helena Chemical	9 lb/100 gal	5.4 pounds
L	Double Down	United Suppliers	2.5 gal/100 gal	1.5 gallons
M	Liberate	Loveland Industries	1 qt/100 gal	19.2 ounces
N	Target LC	Loveland Industries	2 oz/100 gal	36 ml
O	HM 2052	Helena Chemical	1% v/v	76.8 ounces
P	INT HLA	Rosen's, Inc	2 lb/100 gal	1.2 pounds
Q	HM 0230	Helena Chemical	0.5% v/v	38.4 ounces
R	Valid	Loveland Industries	1 pt/100 gal	288 ml
S	Tap Water	Goodland, KS		
S2	Tap Water	Goodland, KS		
T	41-A	San-Ag	2 oz/100 gal	34.05 grams

[1]As of Dec. 2002

[2]All tank mixes including water treatments contain X-77 at .25% v/v

TABLE 2—Product group assignments based on solution chemistry[1]

	Polyacrylamide	Guar	Oil	Non-traditional or combination
Product	A,C,L,T,N,Q	D,F,J,I,P,K	G,B	E,H,M,R,O

[1]Designation determined by submitting company to fit suggested group assignment determined by the researcher.

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 water sensitive paper (wsp) (Spraying Systems Company, Wheaton, Illinois). To collect the horizontal drift, wsp was placed on 2.5 X 10 cm blocks sloped toward the flight line and placed downwind from the flight line along the drift line at 15 m increments to a distance of 107 m. A total of seven horizontal wsp were collected for each treatment (H15, H30, H46, H61, H76, H91, and H107). A retractable tower capable of extending to 12.2 m and designed to hold WSP at 1.5 m increments was used for the vertical drift collection. A total of nine vertical wsp were collected for each treatment (V0, V1.5, V3.0, V4.6, V6.1, V7.6, V9.2, V10.7, and V12.2). The collector layout is shown in Figure 1. Each treatment included four parallel back and forth passes along the flight line for a minimum distance of 214 m, 107 m 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 two identical drift collection stations were used to simulate the repetitions. Collection station I was used to record data for each treatment as repetition 1 and 3. Collection station II was used for all treatments representing repetition 2. As test airplane 1 cycled through the collector stations (3 repetitions of 4 passes), airplane 2 was being rinsed and readied for the next test treatment. Each 3-rep treatment took approximately 20 minutes. All treatments were applied in a crosswind. The crosswind average speed averaged for the two days was 11.9 Km/h. The average for the maximum wind speeds was 17.1 Km/h. The collector system was easily shifted to maintain the 90-degree crosswind for each treatment. Wind direction was monitored by observing a flag and ribbon placed at the top of the tower. For purposes of improving the statistical analysis of the data, three wind speeds according to observed percentiles during the study (low – 6.8 Km/h, medium – 11.3 Km/h, and high – 18.5 Km/h) were calculated. Average temperature for the two days was 12.7C. Average humidity was 50 percent. After each repetition of each treatment, the wsp's were placed in prelabeled-sealable bags for preservation. Data envelopes were used to organize and store the wsp 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. Percent area coverage for the horizontal and vertical drift profiles was used as a means to separate differences in treatments. There were 2,016 water sensitive papers analyzed by DropletScan™ in this phase of the study.

Statistical analyses of the data were conducted with SAS 8.2 (SAS Institute, Cary, NC, 2003). Modeling was done using the general linear model (GLM) procedure to analyze the water sensitive paper data separately by horizontal and vertical distance. The average crosswind speed was used as a covariate to account for deviation in wind velocity during each treatment. Models incorporating main effects of wind and its interactions with product and airplane were considered first and reduced by backward elimination separately for each horizontal and vertical distance to include only those terms that were significant at alpha = 0.10. Covariate-adjusted least squares means were computed for each combination of product and airplane at three wind speeds according to observed percentiles during the study (low – 6.8 Km/h, medium – 11.3 Km/h, and high – 18.5 Km/h). These means were compared within wind speed group using pair wise t-tests to report the differences found at each horizontal and vertical distance. Summary data was reported representing a worst case scenario utilizing the low or 6.8 Km/h wind speed profile. From the summary data, a low-score performance value was complied for each product over all the horizontal and vertical distances to determine product rank.

Results and Discussion

Summary data from the low wind profile for the field study are shown in Tables 3 and 4. Because of the range of the deposits on both the horizontal and vertical collectors, a single graphical display does not facilitate observing the differences that may exist between products. The products were compared by averaging across both airplanes at each sample location. Table 3 contains the LS means for a worst case wind speed scenario of 6.8 Km/h. This data was used to estimate differences on the horizontal collectors. Using the water treatments as a reference for each comparison, products that contained more coverage at the horizontal sample locations (H15-H107) can be differentiated from those with less coverage.

Vertical measurements taken from the tower collectors present some interesting findings. Except for a limited number of treatments, coverage amounts were measured for all products for all nine collector positions (V0-V12.2) to a height of 12.2m. Refer to Table 4 to view this data. Again using a worst case wind speed scenario (6.8 Km/h), several products were measured with more drift than water. The highest amount of drift in the vertical profile appeared in the V3.0-V4.6 collector position. This is evidence of a higher concentration of droplets moving in the wind stream at release height from the aircraft.

To better understand the influence on drift, a summary procedure tabulating the lowest score for performance (ability to reduce drift) for each product over all horizontal and vertical distances was calculated. Each product was ranked from lowest to highest amount of drift with a one representing the least amount of drift. Results and final rank for all products using this procedure can be found in Tables 5-10. For the horizontal collections, products C and P were tabulated with the lowest total points with the Air Tractor and product H had the lowest total for the Cessna. Products A, Q, G, F, D, R, O, and K all

TABLE 3—LS Means for horizontal drift deposits at 6.8 Km/h recorded as percent area coverage[1] on water sensitive paper for twenty-one products with airplane interaction.

		Meters						
Product[2]	Airplane[3]	Hpct15[4]	Hpct30	Hpct46	Hpct61	Hpct76	Hpct91	Hpct107
A	AT	12.54	1.35	1.38	0.73	0.34	0.17	0.07
A	C	10.01	1.51	1.32	0.33	0.22	0.13	0.05
B	AT	14.66	3.10	0.81	0.62	0.32	0.13	-0.02
B	C	12.98	2.00	1.85	0.82	0.52	0.24	0.35
C	AT	6.51	0.84	0.17	0.09	0.02	0.00	0.00
C	C	14.52	2.41	0.80	0.45	0.48	0.14	0.17
D	AT	11.42	6.10	0.53	0.97	0.42	0.53	0.44
D	C	7.46	2.17	0.78	0.34	0.09	0.10	0.14
E	AT	10.48	2.21	0.40	0.17	0.16	0.01	-0.01
E	C	7.06	1.94	0.48	0.27	0.14	-0.02	-0.04
F	AT	21.84	5.20	1.25	0.45	0.27	0.21	0.19
F	C	9.12	0.99	1.33	0.19	0.09	0.06	0.02
G	AT	19.11	4.16	1.74	0.96	0.32	0.21	-0.01
G	C	16.61	4.48	2.17	1.46	0.27	0.04	0.10
H	AT	11.28	1.63	0.76	0.20	0.13	-0.03	-0.04
H	C	6.95	0.71	0.23	0.17	0.08	0.07	0.03
I	AT	12.22	3.21	0.43	0.24	0.11	0.22	0.15
I	C	12.27	2.63	1.32	0.34	0.19	0.22	0.15
J	AT	15.48	1.61	1.15	0.15	0.15	0.15	0.08
J	C	11.80	1.98	0.78	0.27	0.22	0.26	0.18
K	AT	19.36	5.12	1.95	0.92	0.56	0.31	0.30
K	C	16.09	13.78	3.55	1.44	0.61	0.70	0.76
L	AT	14.34	1.90	0.43	0.14	0.16	0.09	0.02
L	C	10.68	1.27	0.64	0.21	0.13	0.01	0.03
M	AT	17.86	3.85	0.99	0.39	0.16	0.09	0.02
M	C	14.77	7.69	2.81	0.74	0.54	0.05	0.11
N	AT	23.91	1.88	0.71	0.52	0.36	0.02	0.03
N	C	22.67	3.08	1.43	0.56	0.33	0.17	0.22
O	AT	10.19	13.31	1.81	1.72	1.04	0.39	0.48
O	C	9.03	1.47	0.86	0.35	0.32	0.10	0.14
P	AT	2.57	1.30	0.21	0.04	0.02	-0.02	-0.02
P	C	7.54	1.80	0.52	0.25	0.08	0.06	0.06
Q	AT	12.39	2.46	1.12	0.80	0.31	0.37	0.19
Q	C	13.08	1.48	0.92	0.36	0.18	0.05	0.08
R	AT	13.61	6.39	1.22	1.18	0.73	0.44	0.23
R	C	13.58	1.95	0.90	0.35	0.21	-0.02	0.07
S	AT	15.04	2.14	0.81	0.51	0.26	0.18	0.11
S	C	10.9	0.84	0.73	0.33	0.23	0.13	0.10
T	AT	13.24	2.37	0.54	0.24	0.21	0.03	-0.01
T	C	10.26	1.38	0.72	0.22	0.16	0.01	0.04

[1]Percent area coverage from scanned water sensitive paper - 2.54 X 7.62 cm.
[2]Product code is located in Appendix A.
[3]AT=Air Tractor, C=Cessna
[4]Heavier amounts are a result of swath displacement in wind.

TABLE 4—LS Means for vertical drift deposits at 6.8 Km/h recorded as percent area coverage[1] on water sensitive paper for twenty-one products with airplane interaction.

		Meters								
Product[2]	Airplane[3]	vpct0	Vpct1.5	Vpct3.0	Vpct4.6	Vpct6.1	Vpct7.6	Vpct9.2	Vpct10.7	Vpct12.2
A	AT	-0.01	0.28	-0.04	0.07	-0.13	0.44	0.01	0.14	0.21
A	C	-0.04	0.17	0.26	0.11	0.19	0.33	0.16	0.36	0.05
B	AT	0.02	0.17	0.19	0.22	0.01	0.60	0.00	0.21	0.05
B	C	0.19	0.36	0.56	0.30	0.34	0.74	0.45	0.25	0.43
C	AT	-0.01	-0.01	-0.03	-0.02	-0.03	0.02	-0.02	0.01	0.00
C	C	0.13	0.67	0.77	0.77	0.73	0.64	0.65	0.82	0.43
D	AT	0.34	1.43	1.58	1.47	0.71	0.59	0.12	0.27	0.01
D	C	0.10	0.24	0.50	0.22	0.46	0.19	0.52	0.35	0.29
E	AT	0.00	0.07	0.08	0.21	0.28	0.24	0.50	0.42	0.43
E	C	-0.01	0.01	0.19	0.17	0.36	0.41	-0.20	-0.17	-0.26
F	AT	0.09	0.31	0.49	0.45	0.33	0.34	0.18	0.18	0.13
F	C	0.02	0.11	0.12	0.07	0.14	0.11	0.12	0.11	0.07
G	AT	0.00	0.14	0.16	0.18	0.06	0.68	0.16	0.31	0.16
G	C	-0.08	0.00	0.35	0.24	0.49	0.95	0.43	0.60	0.89
H	AT	-0.05	-0.07	-0.05	0.05	0.09	0.05	0.24	0.25	0.36
H	C	0.05	0.10	0.05	0.09	0.02	0.07	0.25	0.17	0.19
I	AT	0.15	0.39	0.41	0.41	0.30	0.32	0.12	0.21	0.11
I	C	0.10	0.41	0.68	0.35	0.49	0.29	0.51	0.38	0.36
J	AT	0.18	0.30	0.34	0.30	0.22	0.25	0.11	0.16	0.14
J	C	0.19	0.53	0.88	0.69	0.72	0.41	0.44	0.49	0.36
K	AT	0.25	0.76	1.10	0.58	0.51	0.39	0.24	0.30	0.06
K	C	0.69	2.99	8.14	3.33	3.68	1.46	3.72	1.75	1.50
L	AT	-0.05	0.08	0.01	0.19	0.07	0.24	0.11	0.13	0.16
L	C	-0.04	0.01	0.11	0.08	0.08	0.17	0.14	0.10	0.01
M	AT	0.02	0.18	0.22	0.21	0.26	0.27	0.37	0.31	0.29
M	C	0.10	0.60	1.85	1.37	3.57	1.31	-0.40	-0.32	-0.52
N	AT	-0.01	0.21	0.01	0.20	0.05	0.32	0.09	0.19	0.26
N	C	0.13	0.28	0.34	0.33	0.33	0.42	0.32	0.32	0.12
O	AT	0.89	1.59	1.72	2.46	2.21	1.68	3.21	2.89	4.01
O	C	0.17	0.22	0.54	0.49	0.79	0.44	-0.10	-0.01	-0.19
P	AT	0.00	0.10	0.06	-0.01	0.03	0.02	0.11	0.05	0.08
P	C	0.08	0.36	0.33	0.39	0.32	0.34	0.21	0.19	0.20
Q	AT	0.21	0.75	0.74	0.77	0.40	0.94	0.36	0.32	0.37
Q	C	0.03	0.17	0.25	0.15	0.16	0.17	0.15	0.11	0.07
R	AT	0.26	0.76	0.95	0.99	0.99	0.89	1.57	1.50	1.60
R	C	0.07	0.11	0.66	0.53	1.02	0.43	-0.14	-0.07	-0.19
S	AT	0.21	0.28	0.19	0.25	0.18	0.32	0.44	0.41	0.20
S	C	0.26	0.44	0.45	0.34	0.37	0.41	0.33	0.27	0.27
T	AT	-0.07	0.04	-0.08	0.08	-0.08	0.17	-0.10	-0.02	0.03
T	C	-0.05	0.07	0.12	0.09	0.16	0.38	0.25	0.27	0.04

[1]Percent area coverage from scanned water sensitive paper - 2.54 X 7.62 cm.
[2]Product code is located in Appendix A.
[3]AT=Air Tractor, C=Cessna

Table 5. Low-score performance value[1] for drift reduction of each product at each horizontal distance for Air Tractor.

	Product																			
Distance	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
15 m	9	13	2	6	4	19	17	5	7	15	18	12	16	20	3	1	8	11	14	10
30 m	3	12	1	18	9	17	15	5	13	4	16	7	14	6	20	2	11	19	8	10
46 m	17	10	1	6	3	16	18	9	4	14	20	4	12	8	19	2	13	15	10	7
61 m	14	13	2	18	5	10	17	6	7	4	16	3	9	12	20	1	15	19	11	7
76 m	15	13	1	17	6	11	13	4	3	5	18	7	7	16	20	1	12	19	10	9
91 m	11	9	1	20	4	13	13	1	15	10	16	7	7	5	18	1	17	19	12	6
107 m	11	1	1	19	1	15	1	1	14	12	18	8	8	10	20	1	15	17	13	1
Total	80	71	9	104	32	101	94	31	63	64	122	48	73	77	120	9	91	119	78	50

[1]Values based on drift amount verses other products (from Table 3) at each horizontal position (lowest drift = 1, etc.)

Table 6. Low-score performance value[1] for drift reduction of each product at each horizontal distance for Cessna.

	Product																			
Distance	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
15 m	7	13	16	3	2	6	19	1	12	11	18	9	17	20	5	4	14	15	10	8
30 m	8	13	14	15	10	3	18	1	16	12	20	4	19	17	6	9	7	11	2	5
46 m	13	17	9	7	2	15	18	1	13	7	20	4	19	16	10	3	12	11	6	5
61 m	8	18	15	10	6	2	20	1	10	6	19	3	17	16	12	5	14	12	8	4
76 m	11	18	17	3	6	3	14	1	9	11	20	5	19	16	15	1	8	10	13	7
91 m	13	18	15	11	1	8	5	10	17	19	20	3	6	16	11	8	6	1	14	3
107 m	6	19	16	13	1	2	10	3	15	17	20	3	12	18	13	7	9	8	11	5
Point Total	66	116	102	62	28	39	104	18	92	83	137	31	109	119	72	37	70	68	64	37

[1]Values based on drift amount verses other products (from Table 3) at each horizontal position (lowest drift = 1, etc.

Table 7. Final rank[1] of each product for horizontal drift for Air Tractor and Cessna.

Air Tractor				Cessna			
Product	Code	Point Total	Rank[2]	Product	Code	Point Total	Rank[2]
AMS 20/10	C	9	Tie 1	GARCO #3	H	18	1
INT HLA	P	9	Tie 1	CONTROL	E	28	2
GARCO #3	H	31	3	DOUBLE DOWN	L	31	3
CONTROL	E	32	4	INT HLA	P	37	Tie 4
DOUBLE DOWN	L	48	5	41-A	T	37	Tie 4
41-A	T	50	6	INT VWX	F	39	6
INT YAR	I	63	7	BORDER EG 250	D	62	7
BORDER XTRA 8L	J	64	8	TAP WATER[3]	S	64	8
HM0226	B	71	9	FORMULA ONE	A	66	9
LIBERATE	M	73	10	VALID	R	68	10
TARGET LC	N	77	11	HM 0230	Q	70	11
TAP WATER[3]	S	78	12	HM 2052	O	72	12
FORMULA ONE	A	80	13	BORDER XTRA	J	83	13
HM 0230	Q	91	14	INT YAR	I	92	14
INPLACE	G	94	15	AMS 20/10	C	102	15
INT VWX	F	101	16	INPLACE	G	104	16
BORDER EG 250	D	104	17	LIBERATE	M	109	17
VALID	R	119	18	HM0226	B	116	18
HM 2052	O	120	19	TARGET LC	N	119	19
HM 2005C	K	122	20	HM 2005C	K	137	20

[1]Rank based on low-score performance value totals for each product at all horizontal positions; [2] 1 = lowest drift;
[3]Tap water used as a base line for separating differences.

Table 8. Low-score performance value [1] for drift reduction of each product at each vertical position for Air Tractor.

	Product																			
Distance	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0	4	10	4	19	7	12	7	2	13	14	17	2	10	4	20	7	15	18	15	1
.5 m	11	8	2	19	4	14	7	1	15	13	17	5	9	10	20	6	16	17	11	3
3.0 m	3	10	4	19	8	15	9	2	14	13	18	5	12	5	20	7	16	17	10	1
4.6 m	4	11	1	19	9	15	6	3	14	13	16	7	9	8	20	2	17	18	12	5
6.1 m	1	4	3	18	13	15	7	9	14	11	17	8	12	6	20	5	16	19	10	2
7.6 m	14	16	1	15	5	12	17	3	9	7	13	5	8	9	20	1	19	18	9	4
9.2 m	4	3	2	9	18	12	11	13	9	6	13	6	16	5	20	6	15	19	17	1
10.7 m	5	9	2	12	18	7	14	11	9	6	13	4	14	8	20	3	16	19	17	1
12.2 m	13	4	1	2	18	8	10	16	7	9	5	10	15	14	20	6	17	19	12	3
Total	59	75	20	132	100	110	88	60	104	92	129	52	105	69	180	43	147	164	113	21

[1] Value based on drift amount verses other products (from Table 4) at each vertical position (lowest drift = 1, etc.)

Table 9. Low-score performance value[1] for drift reduction of each product at each vertical position for Cessna.

	Product																			
Distance	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0	3	17	14	11	5	6	1	8	11	17	20	3	11	14	16	10	7	9	19	2
.5 m	8	13	19	11	2	6	1	5	15	17	20	2	18	12	10	13	8	6	16	3
3.0 m	7	14	17	12	5	3	10	1	16	18	20	2	19	9	13	8	6	15	11	3
4.6 m	5	10	18	8	7	1	9	3	13	17	20	2	19	11	15	14	6	16	12	3
6.1 m	6	9	16	12	10	3	13	1	13	15	20	2	19	8	17	7	4	18	11	4
7.6 m	7	17	16	5	10	2	18	1	6	10	20	3	19	13	15	8	3	14	10	9
9.2 m	8	16	19	18	2	5	14	10	17	15	20	6	1	12	4	9	7	3	13	10
10.7 m	15	10	19	14	2	6	18	8	16	17	20	5	1	13	4	9	6	3	11	11
12.2 m	7	17	17	14	2	8	19	11	15	15	20	5	1	10	3	12	8	3	13	6
Total	66	123	155	105	45	40	103	48	122	141	180	30	108	102	97	90	55	87	116	51

[1]Values based on drift amount verses other products (from Table 4) at each vertical position (lowest drift = 1, etc.)

Table 10. Final rank[1] of each product for vertical drift for Air Tractor and Cessna.

Air Tractor				Cessna			
Product	Code	Point Total	Rank[2]	Product	Code	Point Total	Rank[2]
AMS 20/10	C	20	1	DOUBLE DOWN	L	30	1
41-A	T	21	2	INT VWX	F	40	2
INT HLA	P	43	3	CONTROL	E	45	3
DOUBLE DOWN	L	52	4	GARCO #3	H	48	4
FORMULA ONE	A	59	5	41-A	T	51	5
GARCO #3	H	60	6	HM 0230	Q	55	6
TARGET LC	N	69	7	FORMULA ONE	A	66	7
HM0226	B	75	8	VALID	R	87	8
INPLACE	G	88	9	INT HLA	P	90	9
BORDER XTRA 8L	J	92	10	HM 2052	O	97	10
CONTROL	E	100	11	TARGET LC	N	102	11
INT YAR	I	104	12	INPLACE	G	103	12
LIBERATE	M	105	13	BORDER EG 250	D	105	13
INT VWX	F	110	14	LIBERATE	M	108	14
TAP WATER[3]	S	113	15	TAP WATER[3]	S	116	15
HM2005C	K	129	16	INT YAR	I	122	16
BORDER EG 250	D	132	17	HM0226	B	123	17
HM 0230	Q	147	18	BORDER XTRA 8L	J	141	18
VALID	R	164	19	AMS20/10	C	155	19
HM 2052	O	180	20	HM 2005C	K	180	20

[1]Rank based on low point summary for each product at all horizontal positions.
[2] 1 = lowest drift.
[3]Tap water used as a base line for separating differences.

tallied higher totals than the tap water used with the Air Tractor. For the Cessna, products I, B, J, C, and K were higher than water (Table 7).

For the vertical profile, product C and T had the lowest point totals for the Air Tractor and product L was the lowest for the Cessna. Products K, D, Q, R, and O and products I, B, J, C, and K were all tabulated with higher totals than water for the Air Tractor and Cessna respectively (Table 10).

Conclusions

This study was conducted to determine the influence of 19 drift control/deposition aid products on crosswind drift from practical aerial applications using fixed wing aircraft. An Air Tractor 502A and a Cessna 188 were used to apply the treatments. Differences in products are shown at all horizontal and vertical collector positions. Differences in airplanes are also present in the findings. Coverage variability for each product indicates that wind speed fluctuation was a major factor in the drift portion of this study. Results show that some of the products did not provide any benefits for drift reduction and in fact may have increased the drift potential. A few of the products exhibited the potential to reduce the amount of drift. Even though differences are present please note that many are very subtle and statistically non-significant. Considerations given to treatments with extremely high or low coverage's when compared to other treatments are noteworthy. Do to the complexities in interpreting the results of this study the researchers would advise a thorough review of this data making a treatment by treatment comparison to water, other treatments, and each aircraft before making specific decisions regarding the use of a particular tank mix additive. Tank mix compatibility and the ability to reduce drift and increase coverage when compared to water should highly influence your decision making process. The researchers are confident that the results in this study will provide useful information to aerial applicators regarding decisions they need to make about drift control/deposition aid products.

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