Paper Number: AA04-006
An ASAE Meeting Presentation

The Affect of Application Volume and Deposition Aids on Droplet Spectrum and Deposition for Aerial Applications

Robert E. Wolf

Biological and Agricultural Engineering Dept., 148 Seaton Hall, Manhattan, KS 66506.

Written for presentation at the
2004 ASAE NAAA/ASAE Technical Session
38th Annual National Agricultural Aviation Association Convention
Silver Legacy Hotel and Casino, Reno, Nevada, USA
December 6-9, 2004

Abstract. *A field study was conducted to determine the influence of application volume and tank mix deposition aids on droplet spectrum and deposition for a fixed wing aerial application. The study involved using a turbine powered aircraft to apply four products designed to improve deposition in 9 and 28 L/ha tank mix solutions. Kromekote papers were used to collect the data at low, medium, and high positions in full canopied soybeans. Comparisons were made using Dropletscan™ software to calculate droplet statistics and deposition (percent area coverage) for both collector materials.*

Differences in coverage were found between products in all three collector positions in the canopy (top, middle, and bottom) with the top position being significant. Significant differences were found in the application volume and product comparisons for percent area coverage at all levels in the canopy. Typically the higher application volumes (28 L/ha) resulted in higher coverage's for all products tested. The combination treatment of Interlock and Preference resulted in the highest amount of coverage in the canopy. The presence of the soybean canopy reduced the amount of coverage in the top of the canopy nearly 3 times.

Droplet size was slightly affected by the different tank mix products. The trend was for the higher application volume treatments to show increased droplet sizes.

Keywords. Aerial application, deposition, droplet size, spray, deposition aid products

Introduction

One of the most critical aspects of any crop protection product application is determining the proper set-up parameters for the equipment used to make that particular application. Concerns about application volumes (GPA), tank-mix components, application height, nozzle type and pressure, droplet size, coverage, canopy deposition, and other critical application parameters are being commonly debated. This concern has become especially critical as two troublesome soybean pests, soybean aphid and soybean rust, have appeared. Controlling both may be dependent on achieving adequate canopy penetration depositing the material into the lower parts of the plants where needed. Efficient application practices are needed for on-target deposition and improved efficacy.

Advances in aerial application equipment technology enable the pilots to fine-tune their applications to match the requirements for controlling the targeted pest. One such parameter, management of spray droplet spectrum, is a critical issue in the search of accurate and efficient crop protection application systems. If proper adjustments are made to the aircraft, then nozzle type, orifice size, pressure, shear orientation, and aircraft speed can all be factored into determining a specified droplet spectrum which can then be evaluated. Models are currently available for this purpose.

Aerial application studies have found that applicator adjustment of variables such as spray rate and droplet spectra can improve deposition and distribution in broadleaf row crop canopies (Kirk, et al., 1992). Carlton, et al., 1983, found that application rate had a major influence on spray coverage of leaf surfaces. Uk and Courshee, 1982, found that foliage density has a major influence on the amount of deposit density within the canopy. French, et al., 1992, found that adjuvants did not significantly affect deposition characteristics when added to the tank mix in ground-applied insecticides for aphid control. However, the Spray Drift task Force has reported that materials added to aerial spray tank mixes will alter the physical properties of the spray mixture affecting the droplet size spectrum. (SDTF, 2001). Wolf, et al., 2003, found that the addition of deposition aids to the tank mix for aerial applications tended to increase spray droplet size.

With new nozzle configurations and higher pressure recommendations (Kirk, 1997), and with the continued development of materials to add to tank mixes, applicators seek to better facilitate making sound decisions regarding the addition of these products into their tank mixes.

Objective

The objective of this study was to evaluate the affect of deposition aids and application volume on droplet spectrum and canopy penetration for aerial application.

Materials and Methods

A field study was conducted to determine the affect of deposition aids and application volume on droplet spectrum and canopy penetration during fixed wing aerial applications. All treatments were applied using a fixed wing aircraft, an Air Tractor 401W (Air Tractor Inc., Olney, Texas with a Walters Engine Conversion, Cascade Flying, Garfield, WA), equipped with drop booms; CP-09 nozzles (CP Products, Inc., Mesa, Arizona) with a 30 degree deflection; using the .062 orifice (33 nozzles) setting for the 9 l/ha treatments and a combination of 2/3 .078 and 1/3 .125 orifice (35 nozzles) settings for the 28 l/ha treatments (1 and 3 GPA); and spraying at 200 kPa (29 psi). Both configurations were classified as a medium droplet spectrum according to the USDA-

ARS models.   The applications were made at an average GPS measured air speed of 208 km/h (129 MPH) and an application height of 3-3.7 m (10-12 feet).

The study was conducted on August 31, 2004 from 8:00 to 10:00 AM using a circle of soybeans near Garden City, Kansas. The study area was flat and the soybeans were rated at growth stage R6, 90-117cm tall (36-46 inches), and with a 90% canopy fill. Five different products and tank mix combinations (Table 1) including water only were evaluated in two application volumes over three repetitions. All ten treatments were completely randomized. Spray mixes containing 189 liters (50 gal) of tap water, crop oil concentrate at 219 ml/ha (3 ounces per acre), a pink marking dye, and deposition aids were applied at 9 and 28 l/ha (1 and 3 GPA). Temperature, relative humidity, wind direction, and wind velocity was recorded using a Davis weather station averaged during the time of application for each treatment. Wind speed averaged over all treatments was 14 km/hr (8.8 MPH) and ranging from 8-18 km/hr (5-11 MPH). The direction ranged from 170 – 210 degrees. Flights were either at 180 or 360 degrees (parallel to the wind). Relative humidity ranged from 87% at the beginning of the study to 63% at the end. Temperature ranged from 14-21°C during the duration of the study.

Spray deposits were collected for measurement and analysis using 5 x 9 cm (2 x 3.5 inch) kromekote papers (KKP).   Seven collector rods holding 3 kromekote papers each were placed in the canopy of each treatment. Each collector rod had single kromekote papers placed at the top, 90 cm (36 inches); middle, 51 cm (20 inches); and bottom, 25 cm (10 inches) of the canopy (Figure 1). An additional set of 4 papers per treatment was placed in an area with no canopy to collect and measure droplet spectra information at 90 cm (36 inches) above the ground. GPS was used to mark the flight paths in 18.3m (60 foot) wide swaths. Marker flags were positioned at the treatment center line to assist the pilot in verifying swath locations

After all treatments and replications were completed and dried, the collection papers were placed in prelabeled-sealable bags for preservation. Because of the high humidity a desiccant pack was placed in each bag to prevent the papers from absorbing additional water. Data envelopes were used to organize and store the papers 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 papers. DropletScan™ has been tested as a reliable source for predicting droplet stain characteristics when compared to other card reading methods (Hoffman 2004).

Statistical analyses of the data were conducted with SAS 8.2 (SAS, 2001).   The model used was a General Linear Model (GLM) procedure to analyze the kromekote paper data by treatment as summarized with DropletScan® looking at comparisons of product, volume, mix, and volume-mix interaction. The LS Means for each product were tested and used to report the differences (alpha = 0.10) found for each treatment.

Results and Discussion

Amount of coverage differs at the three measured levels in the canopy (top, middle, and bottom). As would be expected more coverage was found in the top of the canopy when compared to the middle and bottom positions. When averaged across all treatments the coverage in the top (1.14%) was about 3 and 5 times more than the middle (0.36%) and bottom (0.21%) respectively (Table 2 and Figure 2). By comparison, the average coverage of the collections outside the canopy was 2.95%.

A minimum affect on droplet spectrum was found as a result of adding deposition aid products to the tank mixes. Average volume median diameter (VMD) for all treatments when measured outside the canopy was 298 microns with a range of 334 to 254 (Table 2 and Figure 3). Only treatment 4, Preference at 9 l/ha, was significantly different at 254 microns. By contrast, the largest VMD measured was with treatment 3, Preference at 28 l/ha. Except for treatment 10, all the 28 l/ha treatments resulted in a larger VMD. Only slight differences occurred when all products are compared to water (Figure 3).

For all treatments and comparisons the only significance measured was for volume in the top of the canopy. Table 2 reports the means for all treatments in the top, middle, bottom, and outside the canopy positions. Figure 4 provides a graphic representation. Without canopy interference (no canopy), treatment means for percent area coverage ranged from 5.07% (Preference at 28 l/ha) coverage to 1.76% (water at 9 l/ha). Treatments 2 and 8 had significantly less coverage than all other treatments. None of the other treatments were significantly different.

For the in-canopy comparisons, significant differences were found in the top of the canopy. Coverage ranged from a high of 2.0% (Interlock and Preference at 28 l/ha) to a low of 0.63% (water at 9 l/ha). A combination of Interlock and Rivet had the next best coverage at 1.67%. Treatments 1, 3, 7, 9, and 10 were not significantly different from each other. Treatment 5 was significantly less than 1, 3, 7, 9, and 10, but had significantly more coverage than treatments 2, 4, 6, and 8. Treatments 4 and 8 had significantly less than all other treatments. Differences were also observed in the middle and bottom canopy locations, however fewer were significant (Figure 4).

Except for treatment 10 (Interlock and Rivet at 9 l/ha), all the 28 l/ha treatments resulted in more coverage in the top of the canopy when compared to the 9 l/ha. The differences were significant. For the middle canopy measurements the results were mixed between the comparisons of application volume. For the bottom measurements the 28 L/ha application volumes had better coverage. Except for the top canopy measurements, both the high and low volume water treatments typically resulted in the poorest coverage. When an average coverage (total of top, middle, and bottom averaged) across all canopy positions is computed for the 28 l/ha treatments, the combination of Interlock and Preference had the best coverage at 0.97%. The combination of Interlock and Rivet had the next best coverage at 0.83% (Figure 5).

Conclusions

This study was conducted to determine the influence of deposition aid products and application volume on droplet spectrum and soybean canopy penetration during fixed wing aerial applications. An Air Tractor 401W was used to apply the treatments. Differences were found based on position in the canopy with the average coverage amounts 3-5 times higher in the top of the canopy when compared to the middle and lower positions. When compared to a no canopy measurement average the presence of the soybean canopy reduced the amount of coverage in the top of the canopy nearly 3 times.

Even though differences were measured in the droplet spectrum (volume median diameter reported), only Preference was significantly smaller than the other treatments including water. A small amount of influence might be attributed to the addition of the different deposition aids, mainly at the 28 l/ha application volume. The trend was for the higher application volume treatments to show increased droplet sizes within each treatment group, except for the combination of Interlock and Rivet at both 9 and 28 l/ha where the trend was reversed.

Differences were found when comparing treatments at all canopy positions. However, the only significant differences measured were for the volume comparisons in the top of the canopy. No other comparisons were significant. The highest amount of coverage occurred with a combination of Interlock and Preference at 28 l/ha. The lowest coverage was measured with the 9 l/ha water treatment. When an average of total coverage was computed, the 28 l/ha treatments of Interlock and Preference combined and Interlock and Rivet combined resulted in the better coverage's compared to the other treatments.

In general, adding deposition aid products to the tank mixes significantly improved the amount of coverage in the top of the canopy. This trend was similar in the middle and bottom canopy locations though fewer of the comparisons were significant. The findings of this study support using higher application volumes to achieve increased coverage in the canopy. At 28 l/ha, the combination of Interlock and Preference resulted in the highest amount of coverage in the canopy.

Acknowledgements

Special appreciation is expressed to Tom Miller, Randy Smith, and Brian Oyler of Ingalls Aerial, Ingalls, KS, for the donation of the aircraft, mixing and loading facilities, and time to this study. Also, I would especially like to thank Agriliance, Inc. for their generous donations of product, time, and funds to support this study.

References

Carlton, J.B., L.F. Bouse, H.P. O'Neal, and W.J. Walla. 1993. Mechanical factors affecting aerial spray coverage of soybeans. *Transactions of the ASAE*. 26(6) 1065-67.

French, N.M., S.B. Ramaswamy, S.B. Smith, and D.B. Paroonogian. 1992. Effect of three adjuvants on coverage, persistence, and efficacy of ground-applied chlorpyrifos for suppression of cotton aphid. *Journal of Economic Entomology*. 85(4): 1347-1355.

Hoffmann, W. C. and Hewitt, A. J., 2004. Comparison of three imaging systems for water sensitive papers. Presented at Joint ASAE/CSAE Annual International Meeting, Paper No. 041030. ASAE, 2950 Niles Road, St. Joseph, MI 49085.

Kirk, I.W., L.F. Bouse, J.B. Carlton, E. Franz , and R.A. Stermer. 1992. Aerial spray deposition in cotton canopies. *Transactions of the ASAE*. 35(5) 1393-99.

Kirk, I.W. 1997. Application parameters for CP nozzles. Presented at 1997 Joint ASAE/NAAA Technical Meeting, Paper No. AA97-006. ASAE, 2950 Niles Road, St. Joseph, MI 49085.

SDTF, 1997. A Summary of Ground Application Studies, Contact David R. Johnson at Stewart Agricultural Research Services, Inc. P.O. Box 509, Macon, MO. 63552.

SDTF. 2001. A Summary of Tank Mix and Nozzle Effects on Droplet Size. Spray Drift Task Force. Contact David R. Johnson at Stewart Agricultural Research Services, Inc., P.O. Box 509, Macon, MO 63552.

Uk, S. and R.J. Courshee. 1982. Distribution and likely effectiveness of spray deposits within a cotton canopy form fine ULV sprays applied by aircraft. *Pesticide Science* 13:529-536.

Wolf, R.E. and D.R. Gardisser. 2003. Field comparisons for drift reducing/deposition aid tank mixes. Presented at the 2003 Joint ASAE/NAAA technical meeting, Paper No. AA03-002. ASAE, 2950 Niles Road, St. Joseph, MO 49805.

Table and Figures

Table 1. Treatment, application volume, mix code, mix rates, and mix volume.

Treatment[1]	Volume(gpa)	Mix Code	Mix Rate[2]	Mix Volume
1	3	a	COC 3 fl oz/A	51fl oz / 51 gal
2	1	a	COC 3 fl oz/A	150 fl oz / 50 gal
3	3	b	COC 3 fl oz/A Preference 0.25% v/v	51 floz/51gal 16.3floz/51 gal
4	1	b	COC 3 fl oz/A Preference 0.25% v/v	150 floz/50 gal 16floz/50 gal
5	3	c	COC 3 fl oz/A Premix w/Placement 4 oz Preference 0.25% v/v	51 floz/51 gal 68 floz/51 gal 16.3 floz/51 gal
6	1	c	COC 3 fl oz/A Premix w/Placement 4 oz Preference 0.25% v/v	150 floz/50 gal 200 floz/50 gal 16 floz/50 gal
7	3	d	COC 3 fl oz/A Interlock 4 fl oz/a Preference 0.25%v/v	51 floz/51 gal 68 floz/51 gal 16.3 floz/51 gal
8	1	d	COC 3 fl oz/A Interlock 4 fl oz/a Preference 0.25%v/v	150 floz/50 gal 200 floz/50 gal 16 floz/50 gal
9	3	e	COC 3 fl oz/A Interlock 4 fl oz/a Rivet 0.5% v/v	51 floz/51 gal 68 floz/51 gal 32.6 floz/51 gal
10	1	e	COC 3 fl oz/A Interlock 4 fl oz/a Rivet 0.5% v/v	150 floz/50 gal 200 floz/50 gal 32 floz/50 gal

[1] Treatments 1 and 2 were mixed using tap water and crop oil concentrate only.

[2]All products and mixing directions provided by Agriliance. Tap water and crop oil concentrate was common to all treatments.

Table 2. LS Means and rank for percent area coverage for top, middle, bottom canopy positions; no canopy position, and VMD and rank for no canopy.

Treatment[1]	Top[2]	Rank	Middle	Rank	Bottom	Rank	No Canopy	Rank	VMD	Rank
1	1.17[a]	5	0.23[b]	Tie 8	0.10[b]	Tie 6	2.80[a]	4	300[a]	5
2	0.63[d]	10	0.23[b]	Tie 8	0.07[b]	10	1.76[b]	10	293[a]	7
3	1.17[a]	4	0.30[a]	5	0.23[a]	Tie 3	5.07[a]	1	334[a]	1
4	0.77[c]	Tie 7	0.20[c]	10	0.10[b]	Tie 6	2.40[a]	8	254[b]	10
5	0.87[b]	6	0.27[a]	Tie 6	0.10[b]	Tie 6	2.50[a]	7	300[a]	4
6	0.77[c]	Tie 7	0.63[a]	1	0.60[a]	1	2.53[a]	6	282[a]	8
7	2.00[a]	1	0.53[a]	3	0.37[a]	2	4.60[a]	2	327[a]	2
8	0.77[c]	Tie 7	0.33[a]	4	0.10[b]	Tie 6	1.83[b]	9	299[a]	6
9	1.67[a]	2	0.60[a]	2	0.23[a]	Tie 3	2.70[a]	5	279[a]	9
10	1.57[a]	3	0.27[a]	Tie 6	0.17[a]	5	3.33[a]	3	311[a]	3
Average	1.14		0.36		0.21		2.95		298	

[1]See table 1 for description of products used in each treatment.

[2]Means with the same letter are not significantly different.

Figure 1. Example collector with top, middle and bottom kromekote papers in position.

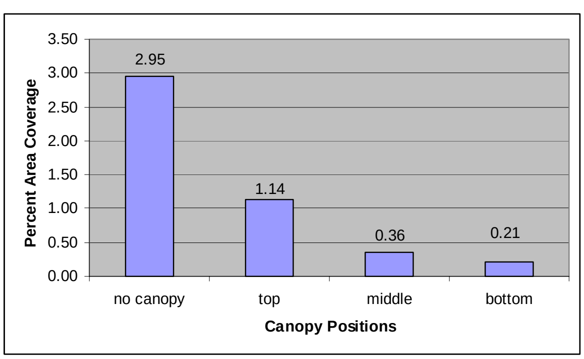

Figure 2. Average LS Means for percent area coverage for each canopy position compared to a no canopy collection.

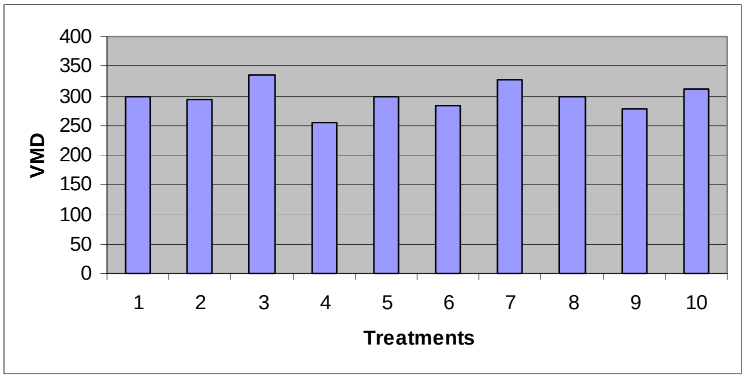

Figure 3. VMD for no canopy measurement.

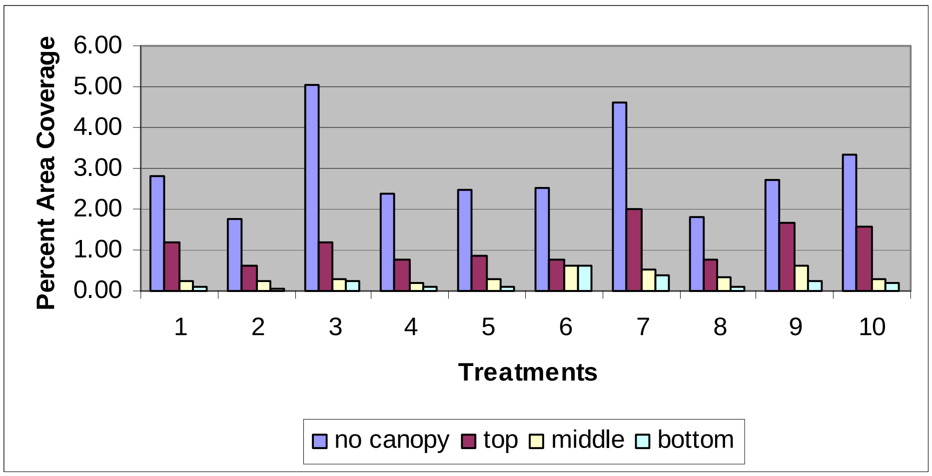

Figure 4. LS Means for percent area coverage for no canopy, top, middle, and bottom posititions.

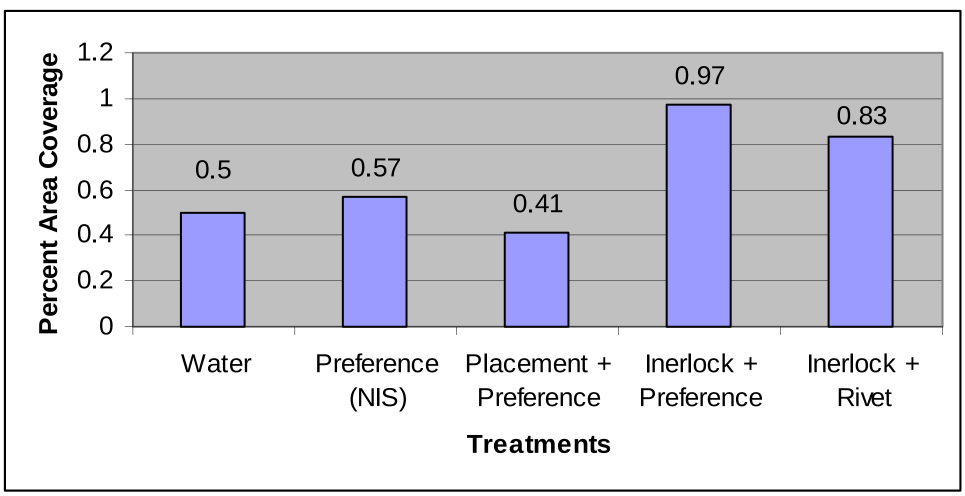

Figure 5. Average coverage across canopy for all the 28 l/ha treatments.