AERIAL SPRAY DEPOSITION CHARACTERISTICS OF TRACER™ AND SELECTED ADJUVANTS

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Abstract

Manufacturers of crop protection products continually seek improved materials for control of economic pests. Many manufacturers have explored biologically derived products for control of specific pests. Tracer™ is a new product of this type. The active ingredient in Tracer™ is a naturally derived fermentation product. This study is part of a series to optimize application parameters for this new class of compounds. Laboratory and field studies were conducted to determine the influence of two types of non-ionic spray adjuvants on the performance of Tracer™. Our results do not demonstrate a significant benefit on spray deposition or efficacy from adding these spray adjuvants to spray mixes of Tracer™ for aerial application.

Introduction

Tracer™ is a recently registered material for control of lepidopterous insect pests in cotton. The material is labeled in the Naturalyte™ class of compounds. The active ingredient is spinosad, a naturally derived fermentation product (Henderson, 1997). Previous research indicated that the material was most effective when applied at 5 gpa with 200 μm droplets (Kirk, et al., 1998). Other research indicated that canopy penetration and deposition were increased with selected spray adjuvants. This study was conducted to determine the influence of a non-ionic paraffinic crop oil concentrate and a non-ionic organosilicone surfactant on aerial spray deposition in closed canopy cotton and on efficacy of Tracer™ on tobacco budworm larvae.

Materials and Methods

A commercial cotton field on the Leon Denena homeplace, Robertson County, Texas, was selected for the study. Tracer™, 2.2 oz/acre, was applied aerially at a 5 gpa water-based spray rate on closed canopy cotton in three treatments: (1) Tracer™ plus 5 oz/acre Dyne-Amic$_{®}$; (2) Tracer™ plus 5 oz/acre Agri-Dex$_{®}$; and (3) Tracer™ alone. The treatments were applied in three replications in a Latin Square arrangement of treatments. Each replicated treatment plot was approximately 6 acres. Spray applications were made on July 30, 1998, and on August 7, 1998. Spray deposition measurements were only made on July 30; bioassay measurements were made for both spray applications. The cotton plants in the plots averaged about 40 inches high. Except for limited sections of the second block, the canopy was closed when the spray applications were made.

Spray Deposition

A fluorescent dye tracer, caracid brilliant flavine FFS at a rate of 5 gm/acre, was applied with all treatments. Aerial applications were made with an Air Tractor AT-402B with 44 CP nozzles operated with the 0.171-in orifice, 90º deflector, 30 psi, 130 mph, and 65 ft spray swath. (Droplet parameters for these application conditions with each spray mix were measured in a wind tunnel in three replications in a separate laboratory study.) Each treatment plot was marked with three sub-sampling locations on a diagonal across the plot. Leaf samples for bioassays and fluorometric spray deposition, and water sensitive paper cards (WSP) for spray deposition samples were collected from these locations. Two leaves from top-canopy and two leaves from mid-canopy at each location were collected prior to spraying for fluorescence background on the leaves. Six leaves from top-canopy and six leaves from mid-canopy at each location were collected and placed in individual plastic bags within 30 minutes of spray application to determine spray deposits by fluorescence analysis. The leaves were washed in 20 ml of methanol and an aliquot of the effluent decanted to a sample tube for fluorescence measurements in a spectrofluorophotometer. Leaf areas were determined with an area meter. WSP cards were folded in half and attached to cotton leaves at top and mid-canopy, six per canopy level at each sample location, to characterize spray deposition (Half of the folded card was on the top leaf surface and the other half was on the bottom leaf surface.). The cards were placed in the plots immediately prior to spray application and were retrieved within 30 minutes of the spray application. Card surfaces on the top and bottom of leaves were analyzed with computerized image analysis to determine droplet deposition characteristics. Spread factors for each spray mix were determined by measuring stain sizes on WSP and droplet sizes between silicon solutions with an ocular micrometer. A series of uniform-size droplets were generated and stain size and droplet size were measured for each size class with each spray mix.

Bioassays

Ten leaf samples were collected at both top and mid-canopy levels from each location. Prespray samples were taken for background or initial larval mortality. Post spray samples were taken on 0, 4, and 7 days after treatment (DAT) for the first application and 0, 3, and 6 DAT for the second application. Leaves from a cotton field that had not been sprayed were used for mortality check samples for each

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1145-1148 (1999)
National Cotton Council, Memphis TN

sampling day. The leaves were placed in petri dishes and a single laboratory-reared tobacco budworm larva (second to fourth instar) was placed on each leaf. Larval mortality was assessed 24 and 72 h after placement on the leaves.

Results and Discussion

Spray Deposits by Fluorometric Analysis

Spray deposits in this discussion are reported in gallons per acre on cotton leaf surfaces. The measurement technique combines the deposits on both top and bottom surfaces of the leaves. However, experience has shown that a major portion of the spray is deposited on the top surface of leaves from aerial applications. It must be considered when assessing leaf deposits in full canopy cotton that the leaf area index of the crop could be in the range of three to four. Consequently, average deposits on leaves would be expected to be considerably lower than the applied spray rate.

Background fluorescence on the cotton leaves from the prespray analyses was 0.046 and 0.045 gpa for the top and mid-canopy leaves, respectively. Because background levels were relatively low and uniform, corrections in the deposit data were not made for background fluorescence.

There was no significant difference between spray mixes for average spray deposits on cotton leaves (Table 1). As expected, there was significantly more deposit on top-canopy leaves than on mid-canopy leaves. However, there was no significant interaction between spray mixes and canopy level (df = 2, F = 0.78, P = 0.46) – indicating that none of the spray mixes give preferentially improved top or mid-canopy spray deposition.

Table 1. Mean spray deposits on cotton leaves at top and mid-canopy for three spray mixes, gallons per acre.

Spray Mix	Top-Canopy[1]	Mid-Canopy[1]
Tracer™	1.9	0.5
Tracer™ + Agri-Dex®	1.9	0.6
Tracer™ + Dyne-Amic®	2.1	0.5

[1] Top-canopy means were significantly higher than mid-canopy means (df = 1, F = 162.53, P = 0.0001) but top-canopy and mid-canopy means were not significantly different within spray mixes (df = 2, F = 0.14, P = 0.87).

Spray Deposits on Water Sensitive Paper

Spread Factor. The relationship between the size of the stain on (WSP) and the size of the droplet that made the stain is a major element in the analysis of spray deposits on WSP. The relationship can be different for different materials and is not constant or linear because large droplets make relatively larger stains than small droplets. Spread factor relations for each spray mix were used in image analysis computations. Statistical analyses were not conducted to determine differences between relationships for the different spray mixes, but it is apparent that a single relation could be used to describe a spread factor for the three Tracer™ spray mixes. Data for each spray mix and an equation describing the computed line for a third order least squares fit of data combined from the three spray mixes are shown in Figure 1.

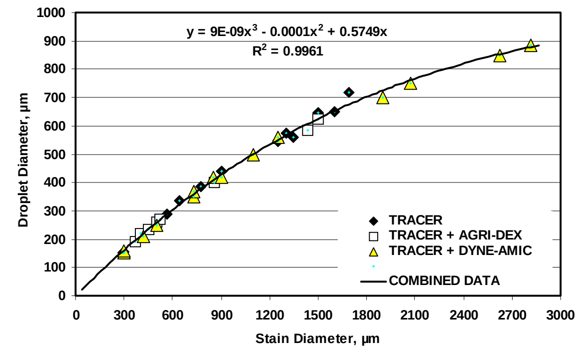

Figure 1. Stain and droplet size relation on WSP for Tracer™ alone and mixed with selected adjuvants in water.

Droplet Density. Droplet density on WSP was not significantly different between the three spray mixes with a grand mean of 30 droplets per cm^2 (df = 2, F = 1.47, P = 0.23). Neither was there a significant interaction between spray mix and canopy level (df = 2, F = 0.22, P = 0.80) nor between spray mix and leaf surface (df = 2, F = 0.61, P = 0.54), which, if present, would perhaps indicate an advantage or benefit associated with one spray mix over another. Droplet density, as expected, was higher at the top of the canopy than at mid-canopy and was higher on the top surface of leaves than on the bottom surface of leaves (Table 2). These data follow patterns similar to those observed in previous studies (Kirk, et al., 1998).

Table 2. Spray droplet density on top and bottom leaf surfaces at top and mid-canopy, average for all treatments.

Canopy Level and Leaf Surface	Spray Droplets / cm^2 [1]
Top–canopy, Top of Leaf	59a
Top-canopy, Bottom of Leaf	23b
Mid-canopy, Top of Leaf	26b
Mid-canopy, Bottom of Leaf	12c

[1] Means followed by the same letter in a column are not significantly different based on Fisher's Protected $LSD_{0.05}$.

Spray Coverage. Spray coverage on WSP was not significantly different between spray mixes for top and mid-canopy (df = 2, F = 2.22, P = 0.11). However, there was a significant interaction between spray mix and leaf surface (df = 2, F = 4.66, P = 0.01). These means are presented in Table 3. Tracer™ + Dyne-Amic® gave significantly higher coverage on WSP on the top surface of leaves than Tracer™ + Agri-Dex® or Tracer™ alone.

Table 3. Percent area covered by droplet stains on WSP on top and bottom leaf surfaces from three spray mixes.

Spray Mix	Leaf Surface	Spray Coverage, %
Tracer™	Top	1.8b
	Bottom	0.4c
Tracer™ +	Top	1.7b
Agri-Dex®	Bottom	0.2c
Tracer™ +	Top	2.5a
Dyne-Amic®	Bottom	0.2c

[1] Means followed by the same letter in a column are not significantly different based on Fisher's Protected $LSD_{0.05}$.

Droplet Size. Droplet size measured on WSP for the three spray mixes followed a similar pattern as expressed in the spray coverage data. There was a significant interaction between spray mix and leaf surface for droplet size deposited on WSP (df = 2, F = 19.99, P = 0.0001), Table 4.

Table 4. Spray droplet size on WSP on top and bottom leaf surfaces from three spray mixes.

Spray Mix	Leaf Surface	$D_{V0.5}$, μm
Tracer™	Top	174b
	Bottom	88c
Tracer™ +	Top	175b
Agri-Dex®	Bottom	75c
Tracer™ +	Top	201a
Dyne-Amic®	Bottom	57d

[1] Means followed by the same letter in a column are not significantly different based on Fisher's Protected $LSD_{0.05}$.

There is some discrepancy between data on droplet size and percent coverage on WSP when compared to other related measurements in this study, some of which tend to be more precise. The differences observed for Tracer™ + Dyne-Amic® do not correspond with observations of spread factor measurements in the laboratory and droplet size measurements in the wind tunnel (Table 5). Because of the unique nature of organosilicone surfactants and the longer card drying time under high humidity field conditions as compared to laboratory conditions, it is possible that the droplet stains from Tracer™ + Dyne-Amic® spread more extensively in the field than the laboratory. This could account for the differences previously discussed for WSP data.

Spray Quality. Atomization parameters and spray quality as measured in a wind tunnel (Bouse and Carlton, 1985) for each of the three spray mixes used in the field study are shown in Table 5. An analysis of Tracer™ without dye was also included in the wind tunnel study to assess the influence of the fluorescent dye on atomization.

Table 5. Atomization parameters and spray quality measured in a wind tunnel for field application conditions and spray mixes*.

Spray Mix	$D_{V0.5}$, μm [1]	%V<100, μm [1]	%V<200, μm [1]	Spray Quality
Tracer™ (no dye)	320a	4.56c	12.09c	Medium
Tracer™	312b	5.35b	14.08b	Medium
Tracer™ + Agri-Dex®	308b	5.61b	14.62b	Medium
Tracer™ +Dyne-Amic®	258c	9.90a	26.96a	Medium

* $D_{V0.5}$ = volume median diameter; %V<100 μm = percentage of the spray volume in droplets less than 100 μm diameter; %V<200 μm = percentage of the spray volume in droplets less than 200 μm diameter; spray quality is an atomization characteristic defined by the British Crop Protection Council (BCPC) for a standard set of Lurmark nozzles characterized with a Malvern 2600 instrument.

[1] Means followed by the same letter in a column are not significantly different based on Duncan's Multiple Range Test, a = 0.05.

It is interesting to note that the spray quality for all of the spray mixes fit into the same BCPC category. However, significant differences are noted in the individual atomization parameters. It is apparent that dye reduced droplet size and increased percentages of small droplets. Dyne-Amic® produced smaller droplet sizes and increased the percentages of small droplets compared to Tracer™ and Tracer™ + Agri-Dex®.

These data do not correlate with field data for droplet size measured on WSP. We noted in the previous section that there was a possibility for different drying times and spread factors for Tracer™ + Dyne-Amic® in the field and in the laboratory. This phenomenon could possibly account for the differences observed here as well. The smaller droplet sizes observed on WSP from field deposits, compared to droplet sizes measured in the wind tunnel follow the patterns observed in previous studies. Smaller droplet measurements on WSP than measured in the wind tunnel are generally accounted for by water evaporation from airborne spray droplets between atomization and deposition.

Efficacy of Tracer™ with Selected Adjuvants in a Bioassay

Larval mortality in the laboratory bioassay was highly variable. We believe the primary contributor to variability was the difference in sizes of larvae available for placement on field-treated leaves on different days after treatment (DAT). Larvae for placement 4 DAT on the first application were the largest. Observation of the 3 DAT data for the second application also suggests that the larvae may also have been large and/or more difficult to kill because the percent control is lower for 3 DAT than for 6 DAT. In view of these inconsistencies in the data (Table 6), we have chosen to graphically present prespray, 0 DAT, and 6 or 7 DAT, depending on the application, to show the response of the three spray mixes on percent larval control 72 h after larval placement, Figure 2. Percent mortality was computed by Abbott's equation (Abbott, 1925). There was not a consistent effect between spray mixes for percent mortality in top or mid-canopy. Percent mortality was numerically higher for top canopy than for mid-canopy for spray mixes with the two adjuvants and was numerically higher for Tracer™ alone at mid-canopy. Consequently, the data from top and mid-canopy levels were combined for this presentation.

Table 6. Percent larval mortality 72 h after leaf harvest and larval placement, compared to check for three spray mixes applied in two spray applications [Day of year 211(July 30) and 219 (August 7)].

Spray Mix	Day of Year						
		Spray Day			Spray Day		
	210	211	215	218	219	222	225
Tracer™	64	93	7	37	82	23	62
Tracer™ + Agri-Dex®	57	70	17	38	81	20	66
Tracer™ + Dyne-Amic®	64	64	1	22	90	47	43

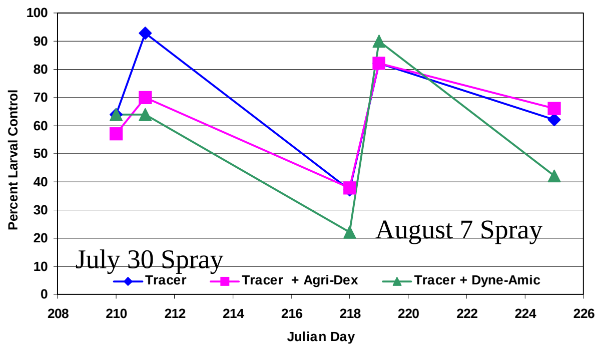

Figure 2. Percent larval mortality, 72 hours after leaf harvest and larval placement, in laboratory bioassays for three spray mixes and two spray applications.

The bioassay data are difficult to interpret, except through simplifications such as shown in Figure 2. There are numerous interactions in a complete analysis of the data, some of which remain after simplification, as can be noted in Figure 2. Application of Tracer™ with Dyne-Amic® did not increase percent larval mortality on the first spray as with the second spray. The rate of decline in percent larval mortality, with time from application, was less for Tracer™ with Agri-Dex® than for the other two spray mixes on the first application. And the rate of decline in percent larval mortality, with time from application was higher for Tracer™ with Dyne-Amic® than for the other two spray mixes on the second application.

Data from the various analyses do not support the hypothesis that the two non-ionic adjuvants included in the study gave increased spray deposits within closed cotton canopy. Neither do the larval bioassay data support the hypothesis, although confounded by non-uniform larval sizes for the different larval placement days.

Summary

Spray adjuvants are marketed to improve performance of crop protection sprays, some for spray deposition, canopy penetration, spray adhesion, leaf penetration, UV protection, spray drift, and various other factors. Application parameters for new classes of crop protection products must be optimized for maximum effectiveness. This study was conducted to determine if addition of two different types of spray adjuvants to Tracer™, a recently registered material for control of lepidopterous insect pests in cotton, would improve spray deposition and efficacy. Laboratory and field studies did not show a consistent benefit from adding the adjuvants to aerial spray mixes of Tracer™.

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Acknowledgments

Special appreciation is extended to Leon Denena, Owner, and Steve Perone, Crop Consultant; their cooperation facilitated this study on Denena Farms. We also extend our appreciation to Dr. D. J. Porteous, Dow AgroSciences (retired); this study was initiated under his guidance. Greg Wells and Jennifer Murray assisted with sample collection and processing. Lena Arndt provided larvae for the bioassays. Clint Hoffmann, Carlos Garza, Phil Jank, and Charlie Harris assisted with sample collection, processing, and data analysis. Hal Tom piloted the aircraft.

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