Aerial Spray Deposition on Corn Silks Applied at High and Low Spray Rates

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ABSTRACT

Corn earworm is a major pest of sweet corn, especially when grown organically. Aerial application of insecticides is important for both conventionally- and organically-grown sweet corn production as sweet corn is frequently irrigated to assure return on investment given the high production costs. Aerial insecticide application costs can be minimized through use of reduced spray rates if insecticide efficacy can be maintained at the lower spray rates. The objectives of the study were to characterize deposition on field corn silks when applied at 47.9 L/ha (with VMDs at 230 and 400 μm) and 86.2 L/ha (with VMD at 400 μm) spray rates. Applications of the bioinsecticide, Gemstar®, and the insecticide, Entrust®, which are both approved for use in organic production, were made over three different fields. The amount of spray material deposited on individual silks for each treatment was determined. Deposition of spray material on the silks was very similar across all application treatments. Overall, the 86.2 L/ha rate resulted in the greatest deposition of active material on the corn silks. At the 47.9 L/ha rate, the smaller droplet size sprays resulted in less deposition than the other treatments.

Keywords: Aerial application, spray deposition, corn, corn earworm.

1. INTRODUCTION

Corn earworm, *Helicoverpa zea* (Boddie) is a major insect pest of fresh market and processing sweet corn in the United States (Bartels and Hutchison, 1995; Musser and Shelton, 2003; Speese et al., 2005). The adult moths are highly mobile, and are capable of laying 2,000 or more eggs over a 12-night period (Hutchison et al., 2004). The adult moth oviposits singly on fresh silks, plant parts such as leaves, husks and stems in the vicinity of emerging silks. Larvae hatch and travel along the silk channel, and begin feeding on kernels within the ear tip. Once the larvae become established within the ear, they are protected by the husk tissue and consequently from insecticidal contact.

The introduction of Bt transgenic technology where a Cry gene from *Bacillus thuringiensis* (Berliner) Bt is transferred to the genome of sweet corn inbreds to create transgenic Bt hybrids has resulted in significant reduction of pesticide use on sweet corn. Although Bt sweet corn hybrids will provide high levels of larval control for growers for processing markets, some insecticide applications are still necessary to obtain increased yield of fresh market quality sweet corn (Burkness et al., 2001; Speese et al., 2005).

Numerous studies have been reported on optimization of aerial application practices for pest control in cotton, corn, and weed and brush control, noting that optimum spray rate droplet size combinations are pest specific and vary from one pest or target area to another (Bouse et al., 1992, Hoffmann et al., 1998, and Kirk et al., 1989, 1992, 1998 and 2001). Kirk et al. (1989) found that higher spray rates with smaller droplet volume mean diameters (VMDs) resulted in increased herbicide deposits on yellow foxtail plants. Bouse et al. (1992) found that increased spray rates and decreased droplet VMDs resulted in increased mortality of honey mesquite. Kirk et al. (1992) found that higher spray rates and larger droplet VMDs resulted in increased deposits within the canopy of cotton plants. Hoffmann et al. (1998) found that smaller droplet VMDs and lower spray rates resulted in increased levels of control for the targeted insect pest.

The development of application technology designed to obtain maximum control of the pest in conjunction with timely application of pesticides synchronized with peak larval hatch is essential to obtain sweet corn with fresh-market quality. This study is part of a program to optimize application technology for aerially-applied insecticides for controlling corn earworm on sweet corn. This test was conducted on field corn due to lack of availability of sweet corn fields in the study area and the increased flexibility of insecticide use on field corn. This work is based on the assumption that maximizing deposition of product onto the corn silks will result in the optimum control of corn ear worm larvae feeding on the silks.

2. OBJECTIVES

The objectives of the study were to characterize deposition on field corn silks when applied at 46.8 L/ha (with VMDs at 230 and 400 µm) and 93.5 L/ha (with VMD at 400 µm) spray rates. Applications of the bioinsecticide, Gemstar® (Certis USA, L.L.C., Columbia, MD) which is approved for use in organic production, were made over three different fields.

3. MATERIALS AND METHODS

Three treatment applications were made on three different fields. Aircraft setup, treatment details, study layout and sampling details follow.

3.1 Application Equipment and Treatment Setup

An Air Tractor 402B (Air Tractor, Inc., Olney, TX) was used to make all treatment applications. All treatments were made with CP-11TT nozzles (CP Products, Tempe, AZ). Table 1 shows aircraft and nozzle settings for each treatment. Nozzle flow rates are 5.7 L/min (1.5 gpm) for the #15 orifice at 276 kPa, and 9.5 L/min (2.5 gpm) for the #25 orifice at 276 kPa. The narrow swath of 13.7 m was required to obtain the 86.2 L/ha spray rate for Treatment 3; therefore, the 13.7 m swath was also used in treatments 1 and 2. Droplet $D_{V0.5}$ (the volume median diameter is the diameter of droplet such that 50% of the total volume of droplets is in droplets of smaller diameter) was determined using the USDA-ARS Spray Quality models (Kirk, 2007) and the nozzle and aircraft operating parameters, including spray pressure, nozzle type and deflection, and airspeed.

Table 1. Spray treatment setups and droplet size information.

Treatment	Spray Rate (L/ha)	$D_{V0.5}$[a] (µm)	Swath Width (m)	Orifice Number	Deflection (°)	Spray Pressure (kPa)	Airspeed (kph)	Number Nozzles
1	47.9	230	13.7	15	90	276	193	37
2	47.9	400	13.7	15	10	276	193	37
3	86.2	400	13.7	25	30	276	177	40

[a] $D_{V0.5}$ is the volume median diameter which is the diameter of droplet such that 50% of the total volume of droplets is in droplets of smaller diameter.

Treatments in field 1 was made with Gemstar®, which is a naturally occurring virus of Helicoverpa zea (corn earworm), making it suitable for organic corn production. The Gemstar® was applied at 731 mL/ha. Tank mix solutions required non-chlorinated water with a pH of 7. Treatments in fields 2 and 3 were made with Entrust® mix at 73 mL/ha. Each treatment's spray mixture also contained Caracid Brilliant Flavine fluorescent dye at a rate of 25 g/ha.

3.2 Study Layout

Three field locations near Clay, Texas (30º25'28N, 96º20'29W) were used in this study. The fields were treated on 3, 6, and 9 June 2008, with three days between each field treatment (1, 2, and 3). At each location, the field was divided in to three blocks with each treatment occurring within each block. The blocks served and replications for each treatment. In each replicate block, each treatment plot was flagged for three swath passes. Each swath was sprayed for a distance of 183 m resulting in individual treatment plot sizes of 0.77 ha. For each treatment plot deposition sampling was performed at 18 and 37 m in from the edge of the field along the center swath (Fig. 1). Sampling was done in the center swath to avoid cross contamination between plots. At each of these locations, both mylar and ear silk samples were collected after spray treatment. Five sampling locations were located at each distance. These locations were 4.5 m apart with the center location centered on the middle swath (Fig. 1). Mylar plate (10 x 10 cm) samples were placed on metal plates attached to electric fence post rods that positioned the mylar at the height of the silks. At each distance, the silk samples were collected at matching locations, 5 rows further into the field (Fig. 1).

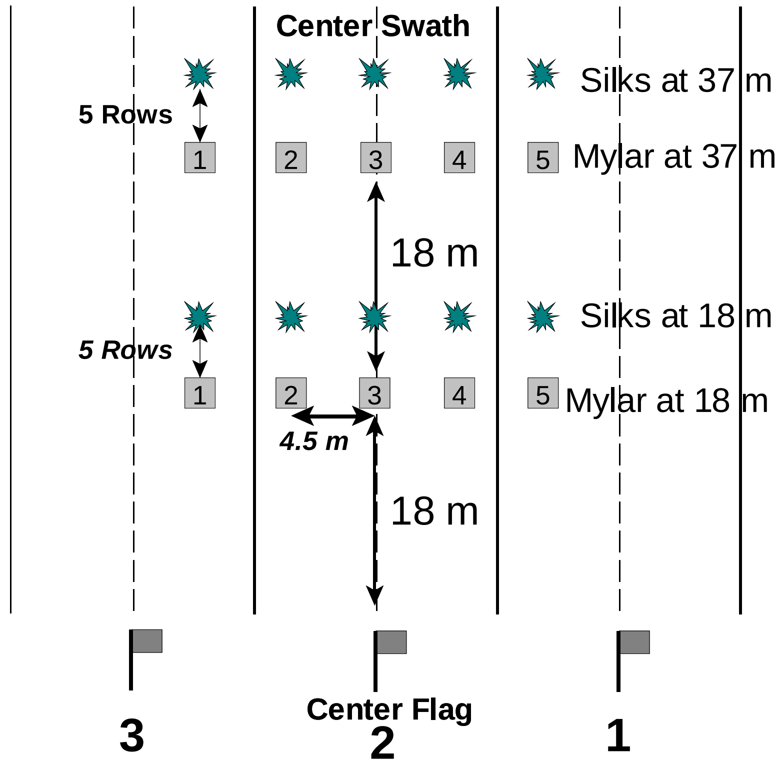

Figure 1. Sampling layout of each treatment plot in each field location.

3.3 Sample Collection and Processing

Immediately after each spray treatment was completed, samples were collected from each plot. Mylar cards were collected and placed into labeled plastic zip-bags, and then into ice chests for storage and transport to the processing laboratory. At each silk sampling location, silks were collected from two top ears, one each from plants on opposing rows. For each silk collected, the ear was broken over such that the silk hung downward. A labeled zip-bag was placed under the silk while the silk was cut free with scissors. Bags with collected silks were placed in ice chests like the mylar.

Mylar plate and ear silks samples were washed in 30 mL of ethanol in the collection bags. Samples were agitated to allow time for dye to dissolve into solution in the ethanol. A sample portion of the wash effluent was placed in borosilicate glass culture tubes (12 x 75 mm). The cuvettes were then placed into a spectrofluorophotometer (Shimadzu, Model RF5000U, Kyoto, Japan) with an excitation wavelength of 427 nm and an emission at 489 nm. The fluorometric readings were converted to µL/cm^2 by comparisons to standards generated using the actual oil and dye mix used. The minimum detection level for the dye and sampling technique was 0.07 ng/cm^2.

3.4 Statistical Analysis

Analysis of the deposition on the mylar and corn silk samples was conducted using SAS PROC MIXED (SAS, 2001). For each set of sampler specific data (i.e. mylar or silks), analysis of variance in deposition was completed with field location and treatment as fixed effects. Random effects included replication, replication within field location, replication by treatment interaction, and distance in field by replication, and sub-sampling locations within distance in field and replication.

4. RESULTS AND DISCUSSIONS

4.1 Meteorological Data

Mean and standard deviation data for wind speed, temperature and relative humidity data are reported in Table 2. Temperature and humidity were similar across all three treatments, but wind speed in treatment 1 was double that of the other two treatments.

Table 2. Meteorological data recorded for all three field locations.

Field	Wind Speed (m/s)	Temperature (°C)	Relative Humidity (%)
1	5.2 ± 0.7	29.3 ± 3.9	70.6 ± 10.2
2	2.1 ± 0.5	28.3 ± 0.7	76.1 ± 2.4
3	2.5 ± 0.5	29.4 ± 1.7	69.1 ± 9.0

4.1 Deposition

Analysis using meteorological data as covariates did not show any significant meteorological effects on deposition on either silks or mylar. There was no significant field location effect on deposition (mass of tracer, i.e. active ingredient, applied at same rate per acre for all treatments, not volume of spray) on either mylar ($P = 0.2851$) or silks ($P = 0.2413$). Therefore, analysis of treatment effects was performed over pooled data across all three field locations. This also indicated that insecticide type did not have any effect on deposition. Treatment effects were significant for deposition on both mylar ($P <= 0.0001$) and silks ($P <= 0.0001$). Treatment 3, the 86.2 L/ha spray rate at 400 µm showed the greatest deposition on both mylar and silk collectors. The two 47.9 L/ha treatments showed the minimum deposition on both silks and mylar.

Table 3. Deposition data and separation of means.

Treatment	Sampler Type	
	Mylar Mean Deposition* (µg/cm^2)	Silks Mean Deposition* (µg/cm^2)
1	0.08 c	1.6 b
2	0.15 b	1.5 b
3	0.24 a	2.6 a

*Means in the same column followed by the same letter are not significantly different based on Duncans' multiple range test (p=0.05)

5. DISCUSSION AND CONCLUSIONS

This study was conducted to optimize aerial application technologies for enhanced spray deposition on corn ear silks for control of corn earworm. Conventional hydraulic nozzles were used to apply two formulations over three fields at spray rates of 47.9 and 86.2 L/ha with median droplet sizes of 230 and 400 µm. Overall, the higher spray rate (86.2 L/ha) with the larger droplet diameter (400 µm) treatment resulted in the maximum deposition of tracer material, and thus active ingredient, on corn ear silks. The 47.9 L/ha treatments resulted in the least deposition with the smaller droplet spray resulting in less deposition on the mylar, but similar deposition to the larger diameter spray on the silks. The optimal treatment setup was the 86.2 L/ha with a volume median diameter of 400 µm. While being less efficient in terms of application time due to spray solution reload and associated ferrying times, than the two 47.9 L/ha treatments, this treatment has less drift potential than the smaller-droplet treatment, and maximizes deposition of active ingredient on the spray target.

6. DISCLAIMER

Mention of a commercial or proprietary product does not constitute an endorsement for its use by the U. S. Department of Agriculture.

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