ADVANCEMENTS IN SPRAYER TECHNOLOGY FOR SWEETPOTATO WHITEFLY CONTROL

Alvin R. Womac, Joseph E. Mulrooney, Kevin D. Howard, and Harold R. Sumner
Agricultural Engineer, Entomologist, Agricultural Engineer,
and Agricultural Engineer, respectively
University of Tennessee, Knoxville,TN; USDA-ARS, Stoneville, MS;
USDA-ARS, Stoneville, MS; and USDA-ARS, Tifton, GA, respectively.

Abstract

Spray equipment investigations indicated that several high-volume air-assisted sprayers provided the greatest spray coverage on the underside of cotton leaves. Use of a trip-type metal support for drop nozzles either with or without air-assistance provided a high degree of nozzle-orientation control and spray-targeting to the leaf underside. Experiments were conducted on mature cotton to examine the following factors: (1) type of sprayer, (2) level of air assistance, (3) air-assistance angle, (4) application spray rate (gpa), (5) canopy level, and (6) side of leaf. All factors were determined to be statistically important. Generally, increased spray rate and level of air assistance increased canopy penetration and spray deposition. It should be noted that the experiments discovered varying optimum sprayer settings that depended on the exact shape, position, and orientation of the targeted plant surface. Range of mean bifenthrin deposits due to type of sprayer were: (1) leaf upperside, 230 - 580 ng/cm^2, (2) leaf underside, 130 - 460 ng/cm^2. Bifenthrin (0.08 lb/ac) uniformly applied to all upper- and under-side leaf surfaces of mature, lapped cotton should result in a deposit of about 75 ng/cm^2.

Introduction

The problem of spraying the underside of the cotton leaf to kill the sweetpotato whitefly (SPW) (*Bemisia tabacia* Gennadius) is well known (Becker et al., 1992). However, the most practical and efficient means of solving this spray-targeting problem is still unknown. Other factors such as insecticide effectiveness against the SPW and mobility of the SPW to host crops have a large impact on control (Becker et al., 1992), yet obtaining sufficient spray contact with the pest also remains as a necessary link in the control of this and other difficult to control cotton pests such as the beet armyworm and aphid.

Several sprayers were developed to use "air assistance" as a means to improve spray coverage (Orcutt, 1992). The term "air assistance" is a generic notation for those sprayers using air to either atomize or convey spray liquid to the target. The concept of using air to improve cotton sprayer performance is not new. In the late 1960's, Harrell et al. (1970) developed a dual, air-assisted sprayer for applying chemicals to cotton foliage. They mounted a pneumatic nozzle in an air duct outlet above each row. Treatments applied with the sprayer did not control cotton insects after the crop rows grew together, because the spray pattern was too narrow to give complete coverage. Other early spray tests were conducted with a Myers Downdraft row-crop sprayer (F.E. Myers Co., Ashland, OH).

An air-assisted sprayer (Degania, FMC, Jonesboro, AR) was tested in dense, lapped cotton by Manor et al. (1989) and was found to improve overall droplet coverage and defoliation. However, SPW control on the leaf underside was not significantly different from that of hydraulic nozzle applications. The lack of difference in SPW control due to sprayers in this test may have reflected the actual case. However, the separation (P=0.05) between insecticide sprayer treatments in all application tests is often difficult due to the inherent, high sample variability encountered under field conditions and due to the low test precision.

May (1991) reported that an air-assisted sprayer (Twin, Hardi Inc., Davenport, IA) increased spray deposition of fluorescein tracer on the underside of sugarbeet leaves and found that deposit increased with increasing air exit velocity. Constrasting these results, he found that the deposit by a Degania decreased with increasing air exit velocity. The exact reason for these differences was not determined.

Manor et al. (1991) developed a "canopy air jet" to envelop and penetrate the cotton row from all sides. Their tests indicated near total coverage of both sides of the leaves at all heights. This was much greater coverage than was achieved by over-the-top applications made with and without air-assistance. Drawbacks to widespread application of this concept may be the physical size contraints, low field capacity due to low sprayer width, and difficult passage through dense cotton.

Thus, many questions arise regarding the design, selection, adjustment, and operation of sprayers for cotton pest control. This is especially true for the air-assisted sprayers that are more complex than the conventional, over-the-top, hydraulic sprayer.

The objective of this study was to investigate cotton spray methods to improve spray penetration, deposition, and SPW control. The study was based on examination of the following factors: (1) type of sprayer, (2) level of air assistance, (3) air-assistance angle, (4) spray rate (gpa), (5) canopy level, and (6) side of leaf.

Methods and Materials

We conducted three spray penetration and deposition experiments using various designs of air-assisted sprayers, drop-nozzle sprayers, and conventional hydraulic over-the-top sprayers. The experiments paralleled the test protocol developed for the nationwide SPW experiments (Womac and Howard, 1992).

Experiment 1 investigated the effects of sprayer type, application spray rate, level of air-assistance, canopy location, and side-of-leaf using the following sprayers: (1) Hardi Twin (Hardi Inc., Davenport, IA) air-assisted sprayer, (2) drop-nozzle sprayer with nozzles on trip-type metal drops, and (3) conventional over-the-top hydraulic sprayer. Application spray rates were 5 and 10 gpa for all sprayers. Level of air-assistance for the Twin ranged from no airflow, one-half airflow rate, to full airflow rate. Two canopy levels were investigated: top and mid-height of mature cotton. Full test details were described by Womac et al. (1992). Briefly, the experiment involved separate spray applications of fluorescent tracer (Fluorescent Yellow Dye), bifenthrin (Capture 2EC) insecticide, and butifos (Def 6) defoliant and ethephon (Prep). The spray deposition was then traced and examined through the use of Ciba-Geigy brand water-sensitive paper (source: Spraying Systems Co.), plastic sheets, cotton leaves, squares, bolls, and defoliation ratings. Concurrent tracing methods were used whenever possible.

Experiment 2 examined the effects of sprayer type, canopy location, and side-of-leaf using the following sprayers: (1) Berthoud Air Cannon (Berthoud, France), (2) FMC Degonia Air-Sleeve (FMC Corp, Jonesboro,AR), (3) drop nozzle with nozzles on flexible hose drops, (4) conventional over-the-top hydraulic sprayer, and (5) Proptec air-assist sprayer [redacted]. An ESS (ESS, Athens, GA) electrostatic sprayer was included in this study but the results are not presented due to a faulty charge grounding connection. This was their first copy of this particular production sprayer and the connection has been fixed. Application spray rate was 20 gpa and the applications were with bifenthrin (Capture 2EC) insecticide at a rate of 0.08 lb/ac. Canopy sample locations were: top and mid-height of mature cotton. The spray deposit was sampled on the top and bottom of cotton leaves located in the top and middle of the cotton. Two sample methods were used: (1) USDA leaf washers (Carlton, 1992), and (2) water-sensitive paper strips. The leaf washers removed the chemical from 14.5 cm^2 of leaf surface with 3 ml of methanol. Strips of water-sensitive paper (13 x 52 mm) were folded across the upper- and under-sides of cotton leaves and fastened with paper clips. Bifenthrin was quantified by gas chromatography and papers were examined under a digital image-analysis system.

Experiment 3 studied the effects of sprayer type, air-assistance angle and direction, canopy location, and side-of-leaf using the following sprayers: (1) Hardi Twin air-assisted sprayer, (2) Hardi Mini-Variant modified with spout/nozzle drops, and (3) conventional over-the-top hydraulic nozzles. Air-assistance angles for the Twin were 30 degrees forward and 30 degrees rearward. Direction of Mini-Variant spouts was approximately 45 degrees up and toward the row. Spouts were located about 2 feet below the top of the canopy. Canopy sample locations were top and mid-height of mature cotton. Application spray rate was 10 gpa. Test method was similar to that of Test 2.

Results

The results from experiment 1 indicated that increasing the spray rate from 5 to 10 gpa increased upward-facing water-sensitive paper coverage from 11.8 to 14.5 percent and 3.0 to 5.4 percent in the top and middle of the canopy, respectively, based on the mean for all sprayers. At 5 gpa, the Twin at full air produced the highest coverage of 13.3 percent and 4.2 percent in the top and middle of the canopy. The coverage by the drop nozzle was not statistically different (P=0.05) from that of the over-the-top application. At 10 gpa, the Twin at full air produced the highest coverage (7.3 percent) in the middle of the canopy. Increasing the air velocity from no air to full air increased the penetration of the canopy middle for the 5 and 10 gpa applications from 2.5 to 4.2 percent and 3.2 to 7.3 percent, respectively.

Bifenthrin concentrations washed from leaves showed trends similar to water-sensitive paper data above. The overall mean concentration washed from 5 and 10 gpa treatments were 17.0 and 21.3 ppb, respectively. The leaf deposition increases for each sprayer due to increased spray rate were 6.9, 0.5, and 5.3 ppb for the Twin, drop nozzle, and over-the-top sprayer, respectively. In contrast, the deposition increases for each sprayer based on wash concentration removed from squares were 16.5, -21.6, and -2.3 ppb for the Twin, drop nozzle, and over-the-top sprayer, respectively. The different trend in deposition between leaves and squares may have depended on different droplet interception characteristics due to shape, orientation, and size of the targets.

Defoliation results indicated the same rating (P=0.05) for the Twin and over-the-top applications at 5 and 10 gpa spray rate. The drop-nozzle sprayer produced decreased ratings due to strips missed where the cotton lapped in the row middles. Water-sensitive paper coverage data showed similar trends.

The overall bifenthrin deposits from experiment 2 were as follows: Berthoud - 342 ng/cm^2, Degonia - 517 ng/cm^2, drop nozzle - 236 ng/cm^2, over-the-top - 319 ng/cm^2, and Proptec - 399 ng/cm^2. The sprayers with the greatest deposit tended to be of a design that produced high velocity/volumes of air. The experiment mean distribution in deposit for canopy locations and leaf surfaces were as follows: upper canopy - 392 ng/cm^2, mid canopy - 333.2 ng/cm^2, upper leaf surface 426 ng/cm^2, and underside of leaf - 299 ng/cm^2. All sprayers placed more bifenthrin in the upper regions of the canopy except the Degonia. All sprayers targeted the greatest amount of bifenthrin on the upper side of the leaf. The rank order (and deposit) of bifenthrin deposit levels washed from the underside of the leaf was as follows: Degonia (456 ng/cm^2), Proptec (349 ng/cm^2), Berthoud (316 ng/cm^2), over-the-top (203 ng/cm^2), and drop nozzle (172 ng/cm^2). Theoretically, bifenthrin (0.08 lb/ac) uniformly applied to the upper and lower leaf surfaces of mature, lapped cotton results in a deposit of about 75 ng/cm^2. The drop nozzle was of the flexible tube type that could not control the orientation of the nozzle. It tended to sway back and forth and with a twisting motion that prevented good coverage. Previous experiences with drop nozzles (experiment 1) on trip-type metal drops showed that coverage and bioassays conducted on the underside of leaves gave results equivalent (P=0.05) to that of the Twin sprayer.

Experiment 3 found that angle of air assistance affected bifenthrin deposit level. Overall mean deposits were as follows: Twin with air angled down and forward - 339 ng/cm^2, Twin with air angled down and rearward - 268 ng/cm^2, Mini-Variant with drops - 550 ng/cm^2, Conventional over-the-top - 431 ng/cm^2. The rank order (and deposit) of bifenthrin deposit levels washed from the under side of the leaf was as follows: Mini-Variant with drops (572 ng/cm^2), Twin with air angled forward (247 ng/cm^2, Over-the-top (193 ng/cm^2), Twin with air angled rearward (187 ng/cm^2). The over-the-top application gave the greatest deposit (669 ng/cm^2) on the leaf upper side.

Summary

The high air volume sprayer types (Twin, Degonia) produced high spray deposit coverage. The high air volume Mini-Variant with spouts on metal drops produced the highest deposit on the lower side of the leaf. The drop nozzle sprayer using flexible drops gave low deposit levels on the lower side of the leaf. Mounting air-assisted or conventional hydraulic nozzles on metal support drops improved coverage on the lower side of the leaf. This trip-type metal support provided the nozzle stability required to consistently target the lower side of the leaf where the SPW resides. Nozzle and air spout orientation should face upward and toward the row for direct spray impingment.

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