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OPPORTUNITIES FOR PRESCRIPTION INSECTICIDE APPLICATIONS IN LOUISIANA: DEVELOPMENT AND EVALUATION OF AERIAL SVI

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Abstract

During the past two years, researchers in Louisiana have been adapting a conventional aerial application system to one capable of applying site-specific prescription pesticide treatments. A commercial agricultural aircraft owned by Barham Brothers Aviation of Rayville, LA has been modified to include an automatic flow control unit integrated with an AG-NAV 2 on-board computer and Trimble global positioning system (GPS) unit. The software and hardware components in this system were calibrated in multiple non-pesticide trials using well-defined land areas. In 2002, an experiment compared insecticide performance in a site-specific prescription that of a full-field broadcast treatment. The prescription was based on a historical yield map and delineated between those highest (80%) and lowest (20%) yielding areas of the field. The spatially variable insecticide (SVI) treated plots excluded the lowest yielding field zones whereas the comparable broadcast treatments were applied to the entire plot area. Post-treatment samples indicated the presence of insects only in the non-treated areas of the SVI plots. However, mean seed cotton yields were not significantly different between the SVI and broadcast-treated plots. The SVI- treated plots received 20% less insecticides during the season compared to that in the broadcast-treated plots.

Introduction

Novel cotton plant protection strategies are being developed by researchers and rapidly adopted by producers. Progress in several areas including cultivars, pesticides, engineering, etc., is improving the efficiency of cotton production and the net value of the crop. Recent advances in geospatial and precision technologies used in other professional disciplines offer considerable opportunities to cotton producers. However, these tools must be adapted to address the specific plant protection needs of producers on a timely basis. Decision support systems based on precision agriculture technologies must be developed in a user-friendly format and transferred to producers, commercial pesticide applicators, and agricultural consultants.

Spatially variable insecticide (SVI) application research is still in the exploratory stages. Willers et al. (1999) applied remote imagery to the distribution of tarnished plant bugs, *Lygus lineolaris* (Palisot de Beauvois). These insects were found in specific areas of the fields and not randomly distributed across the entire field. Remotely sensed images were used to identify those field areas most likely to be infested with tarnished plant bugs. High clearance pesticide application equipment was modified to make prescription insecticide applications that targeted those infested areas. Ground applications of SVI treatments were evaluated by Dupont et al. (2000) and reduced total insecticide use by ca. 40% compared to broadcast applications. Site-specific insecticide applications based on imagery were used by Sudbrink et al. (2002) to reduce insecticide inputs by 20-to-35% below that used in conventional blanket treatments. Frigden et al. (2002) used remotely-sensed imagery to create field maps detailing highly probable areas associated with tarnished plant bug infestations. The SVI treatments reduced the total amount of insecticide (44%) without significantly reducing seedcotton compared to blanket (broadcast) treatments.

An alternative method of creating prescriptions is based upon spatial variation of yields across cotton fields. Geo-referenced yield maps can indicate the contribution of well-defined field zones to total yield for the entire field. Researchers in Tennessee (personal communication, T. Sharp, Jackson State University, TN) have begun to use yield maps coupled with remotely sensed images to develop full season variable rate crop production plans. Crop inputs (seed, fertilizer, insecticides, PGR's, defoliants) are applied at variable rates depending on the yield history of those fields. The goal of these crop management strategies is to reduce inputs for the lower yielding areas of fields that are not contributing as much as higher yielding areas to total production output for the entire field.

The objective of this study was to initiate the development of a site-specific aerial pesticide application system and evaluate its performance as a component of a cotton IPM strategy.

Development/Validation of Aerial SVI Methodology

A prototype system for SVI treatments has been in the developmental phases for two years. The approach of the Louisiana team of researchers was to adapt an example of current technology being used by commercial agricultural pilots for pesticide application. Although several systems were found in agricultural aircraft within Louisiana, the AG-NAV 2 (AG-NAV Development Inc., Pinehurst, TX) on-board computer coupled with a Trimble (Trimble Corporation, Sunnyvale, CA) GPS unit was representative of the systems being used. The SVI required that actual liquid flow rates during flights could be adjusted automatically with variation in aircraft speed. The Auto Cal II unit (Houma Avionics, Houma LA) is a flow control unit used on limited aircraft to maintain constant application volumes, regardless of speed. A commercial agricultural aircraft owned by Barham Brothers Aviation (Rayville, LA) equipped with the AG-NAV 2 system and modified with the Auto-Cal II unit was used in these studies.

The compatibility and accuracy of the AG NAV 2 DGPS system and Auto Cal II controller was evaluated in several tests were conducted at the Rayville, LA, airport. A baseline test evaluated the pilot and system using manual operation of the equipment. The North/South runway at Rayville is 3985 ft in length. The first trial specified a rate of 2.0 GPA across a 50-ft swath with the pilot manually operating the spray valve within the boundaries of the runway as done in a conventional pesticide application. A 50-ft swath traveling 3985 ft is ca. 4.57 acres. This experiment used three replications and included a total of six passes per replication. The predicted amount of spray for each replication was 54.89 gal. Flight one, two, and three used 52 gal., 54 gal., and 61 gal. total spray volume, respectively. The actual amount applied ranged between 52 and 61 gal. (17% variation) with an average output of 55.6 gal. This average volume was ca. 0.77 gal. or 1.49% above the predicted rate. This test was dependent on the hand-eye coordination of the pilot with the aircraft moving ca. 175 ft per second. The pilot initiated opening the valve just prior to crossing the field boundary and closed it slightly late to not miss any of the target area. In most operations, 10-to-15% more spray than is actually needed for the field area is used so the pilot can manage spray swath overlap on field borders and for final passes adjacent to field obstructions.

Two trials evaluated the automatic operation of the spray system using a pre-loaded geo-referenced map of four plots loaded into the AG-NAV 2 system. The application prescription files were generated in the AG- NAV 2 software on a notebook PC. At the present time, all prescription boundaries are manually created to conform to the limitations of the software. The aircraft runway at Rayville, LA was divided into 4 linear zones with a swaths of 50 ft. The zones consisted of 1123 feet, 819 ft, 810 ft and 801 ft which represented 1.29 acres, 0.94 acre, 0.93 acre, and 0.92 acre, respectively. Each plot was individually assigned an application rate of 2.5 GPA, 2.0 GPA, 3.0 GPA, or 0.0 GPA (exclusion zone). The test area was treated six times within the same flight. The test was repeated three times. The predicted amount of required spray was 47.41 gal. The pilot transferred the prescription files to the AG-NAV 2 system on the aircraft, initiated automatic operation of the controller, and flew across the test plots. Ground observers verified the operation of the system and could actually detect a variation in application volume according to the prescription. In flights one, two, and three, the total volumes of 49.1 gal., 48.0 gal., and 48.2 gal, respectively, were applied. The average of the three flights was 48.43 gal. or ca. 102% of the predicted rate. In the second trial validating SVI system, two zones were assigned rates of 2.0 GPA and two others were assigned rates of 3.0 GPA. All equipment and test procedures were similar to those employed in the preceding trial. The predicted spray volume was 60.0 gal. In the first, second, and third flights, total volumes of 59.1 gal., 61.9 gal., and 60.0 gal., respectively, were applied. The mean spray volume applied was 60.3 gal. or ca. 101% of the predicted rate.

The liquid spray pressure in the boom varied between 18-to-43 PSI during these trials because the Auto Cal II controller continually adjusted output volume as ground speed of the aircraft changed. These trials were conducted on successive days during a south wind of five-to-ten mph. Ground speed varied from 108-to-126 mph due to head winds and tail winds. Ground speed variation normally occurs due to the fact that the aircraft accelerates as it dives into the field and decelerates as it climbs and exits the field. In addition, aircraft speed is influenced by natural winds.

The post-flight review of application data recorded by the AG NAV 2 system further indicated all system components operated properly. The prototype system changed application rates with rapid adjustments reflecting changes in speed and zone boundaries. The ability to apply the desired rate evenly over the target area would suggest that more efficient results should be obtained from the pesticides applied and that a cost-effective reduction in pesticide rates might be accomplished without influencing product efficacy and crop value.

Prescription SVI Performance in a Field Trial

A 220 acre cotton (Stoneville 4892 RR) field on Somerset Plantation (Hardwick Planting Company) near Newellton, LA, was selected for this project. The treatments in this experiment compared insecticide performance in a site-specific prescription (SVI) to that of a full-field broadcast treatment. The field boundaries were geo-referenced by physically traveling along the field margins and recording site coordinates to create a base field map. The SVI prescription was developed using historical yield data. Yield data representing crop performance during 1999, 2000, and 2001 for this field had been archived and was obtained from a private supplier (Ouachita Fertilizer, Monroe, LA). The prescription was based on a historical yield map and delineated between those highest (80%) and lowest (20%) yielding areas of the field (Fig. 1). The SVI plots excluded treatment on the lowest yielding field zones whereas the comparable broadcast treatments were applied to the entire plot area. The prescription was generated by manually drawing boundaries enclosing irregular blocks of the lowest yielding (20%) field zones in the AG-NAV 2 software and transferring to the system on the aircraft (Fig. 2).

The treatments (SVI vs. broadcast) were arranged in a RBD with four replications. The field was divided into rectangular blocks consisting of four spray swath widths (50 ft/swath) and the entire row length. Each of eight blocks was assigned one of the two application strategies (Fig. 3). Three insecticide treatments including Baythroid 2EC (0.033 lb AI/acre) + Orthene 90S (0.6 lb AI/acre) on Jul 30, Orthene 90S (0.6 lb AI/acre) on Aug 11, and Orthene 90S (0.6 lb AI/acre) on Aug 28 were applied to the test area using a single site-specific prescription.

Insecticide performance between the broadcast whole-field treatments and the SVI applications was compared using efficacy measurements and final yield. Field scouting was based upon the yield map used to generate the prescription. The crop yield sampling maps were accessible with ArcPad (ESRI Inc., Redlands, CA) software loaded on an IPAQ (Compaq Computers, Palo Alto, CA). Random sites within each plot were sampled for arthropod pests using the appropriate sampling procedures (Fig. 4). Although arthropod pest densities were relatively low during the 2002 season, numbers of heliothines and heliothine damaged fruiting forms were recorded prior to insecticide application and in post-treatment samples.

The as-applied spray data recorded by the AG-NAV 2 system indicated the areas the actual sprayed areas and exclusion zones in the SVI plots (Fig. 5). Site-specific seed cotton harvest data was recorded by GPS equipped mechanical pickers using Ag Leader (Ag Leader Technology, Ames, IA) and Agri-Plan (Agri-Plan Inc., Stow, MA) yield monitors. These fields were not harvested until late November and had been subjected to extreme weather conditions resulting from two hurricanes and one tropical storm.

The pre-spray arthropod surveys showed significant variations in densities across the field. The field was treated according to the Hardwick Planting Company agricultural consultant's recommendations. Post-treatment samples indicated the presence of insects only in the non-treated areas of the SVI plots (Fig. 6). The insecticide treatments effectively reduced insect densities in the sprayed zones for the broadcast and SVI plots. Seedcotton yields across the field varied similarly to that presented in the historical yield map (Fig. 7). Mean seedcotton yields between the SVI (1757.9 lb/acre) and broadcast treatments (1820.9 lb/acre) were not significantly different. The actual area sprayed in the SVI plots represented only 79.8% of the total land area in the plots. The reduction in insecticides across the exclusion zones in the SVI treatments justified the use of the technology. Insecticide costs for the 3 applications were estimated at $21.66 per acre. If these simple economic data of a 20% reduction in insecticide inputs ($21.66/acre) for the SVI plots were extrapolated to a field of 1000 acres, a comparable reduction in insecticide use could result in over $2000 less for insect pest management.

Summary

Production costs can be moderated by using SVI technology in prescription applications with sufficient science-based data to support recommendations. If prescription applications can be successfully implemented at the farm level, IPM tactics will become a more important part of a holistic production system. The opportunity to apply site-specific prescription insecticide applications will decrease the amount of treated acreage and result in significant environmental and economic benefits. The use of SVI technology in prescription applications can reduce the risk of off-target movement of pesticides and lower soil and water contamination. The results of this study will contribute to the integration of precision agricultural technologies into current IPM strategies and further reduce foliar insecticide requirements. Scientific and economic bases for SVI action thresholds, application timing, and user simplicity are the keys to widespread implementation of these technologies.

Acknowledgments

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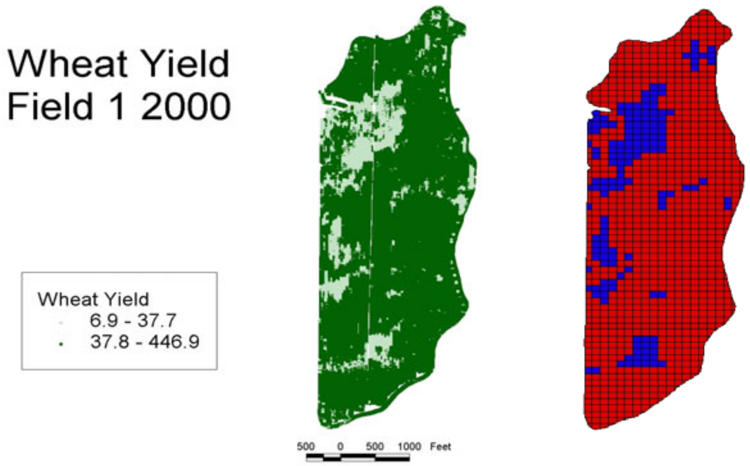

Figure 1. Historical yield data used to generate a yield map and SVI prescription.

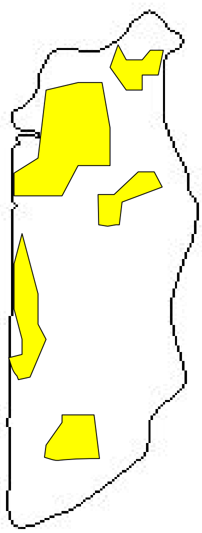

Figure 2. Prototype prescription manually developed for the SVI application strategy.

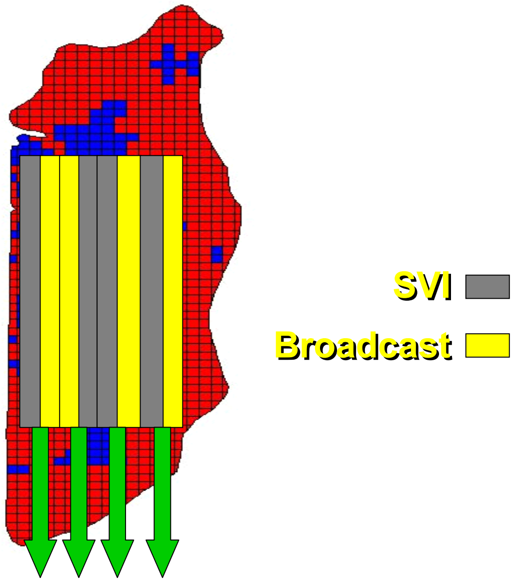

Figure 3. Test design and plot layout.

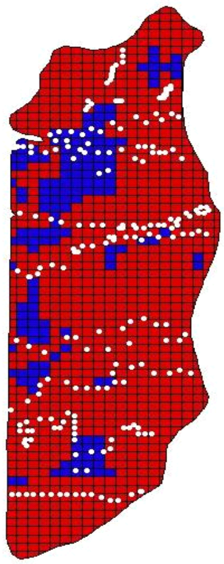

Figure 4. Random sites used for pre and post treatment evaluation of pest densities.

Figure 5. As-applied spray data for the SVI applications.

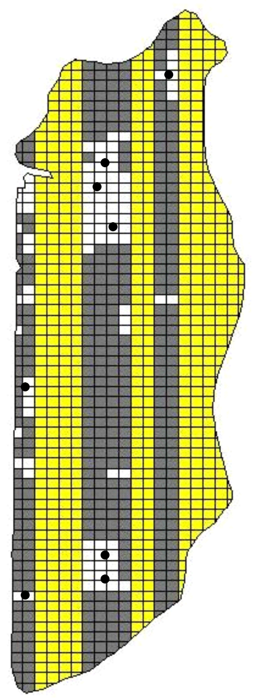

Figure 6. Post-treatment surveys of heliothine larvae (•sites indicate larval presence in non-treated areas of SVI plots).

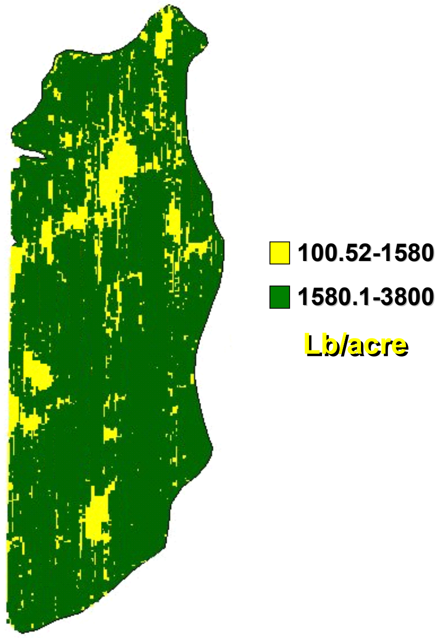

Figure 7. Spatial distribution of seed cotton yields for field 1, 2002.