2004 BELTWIDE COTTON CONFERENCES, SAN ANTONIO, TX – JANUARY 5-9

EVALUATING SITE-SPECIFIC AERIAL INSECTICIDE APPLICATIONS BASED ON HISTORICAL YIELD DATA

J. Temple, K. Paxton, H. Niu, B.R. Leonard, and R.D. Bagwell
LSU AgCenter
Baton Rouge, LA
D. Magoun
University of Louisiana
Monroe, LA
E. Barham
Barham Flying Service
Rayville, LA

Abstract

The high cost of production inputs and narrow profit margins of the cotton industry constantly forces producers to rapidly adopt the newest and most advanced technologies. Many precision agricultural technologies are now available to cotton producers. Field management decisions have been historically based on the average data representing a whole field. Global positioning systems/geographical information systems (GIS) technologies allow producers to identify and reference intra-field variability, divide the field into management zones, and selectively apply inputs. This experiment compared the efficacy and value of spatially variable insecticide (SVI) applications to that of whole-field broadcast treatments. Yield and profit maps were created from previous (2001) cotton yield/production data and were used to develop SVI prescriptions. Treatments included whole-field broadcast sprays, yield-based SVI sprays, and profit-based SVI sprays. Five successful aerial applications were made to the test field during the 2003 growing season. There were no significant differences in yields among treatments. The whole-field, SVI-yield, and SVI-profit treatments produced lint yields of 880 lb/acre, 839 lb/acre, and 828 lb/acre, respectively. Seasonal insecticide costs per acre (based on the entire area) were $42, $28, and $31 for the whole-field, SVI-yield, and SVI-profit treatments. There was a 32% and 25% reduction in area sprayed using the SVI-yield and SVI-profit treatments compared to the whole-field sprays. The SVI treatments showed promise in this test and warrant further evaluation.

Introduction

The United States agricultural industry is constantly developing new products, more efficient cropping practices, and innovative technologies to compete in a global market. Low commodity prices and higher input costs are responsible for the gradual decline in profitability of U. S. agricultural products. Producers are constantly evaluating new tools and techniques to lower costs and increase the efficiency of their farm operations. 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 agricultural technologies must be developed in a user-friendly format and transferred to producers, commercial pesticide applicators, and agricultural consultants.

Insect pest management still represents one of the greatest expenses incurred by a cotton producer. A promising site-specific technology that can reduce insect management inputs is based upon spatially variable insecticide (SVI) applications. SVI application research is still in the exploratory stages. Most prescriptions for SVI have been based upon remotely sensed data used to generate vegetation indices that are related to plant health and insect pest densities. One such vegetation measurement, normalized difference vegetative index (NDVI), has been used to apply ground SVI applications to control tarnished plant bugs (Willers et al. 1999). SVI treatments have resulted in 20% to 40% reductions in insecticide use compared to whole-field broadcast applications (Dupont et al. 2000, Sudbrink et al. 2001, Frigden et al. 2002).

Yield monitors and geographical information systems (GIS) have become important tools in detecting in intra-field variation. Historical yield data provides producers another tool in making future management decisions. Most agricultural fields have inherent variability due to soil type, nutrient availability, or drainage. This inherent variability results in yields that vary in quantity and/or quality across fields. Researchers are currently attempting to define variable input management zones based on yield data and remotely sensed imagery (Sharp et al. 2003). Geo-referenced yield maps can delineate between those field zones that contribute significantly to total yield for the entire field and those that do not. By restricting insect management inputs only to those field zones that are producing profitable yields, producers should be able to more efficiently manage pests. Leonard et al. (2003) used a prescription based on historical yield map to reduce insecticide costs by 20% with no significant effect on yield. The objective of this study was to evaluate the use of historical yield data in creating management zones for aerial SVI applications.

Materials and Methods

This study was conducted at Hardwick Planting Company near Newellton, LA, during 2003. The cotton field (270 acres) was planted with Stoneville 5599 on May 15. Agronomic and pest management practices recommended by the LSU AgCenter were used across the entire test field to maintain all plots in a similar manner.

Field boundaries were geo-referenced using a Trimble (Trimble, Sunnyvale, CA) backpack global positioning system (GPS) receiver enabled with WAAS. A yield map (Figure 1) was created from previous (2001) cotton yield data using Arc View 3.3 (ESRI, Redlands, CA) software. The field was divided into nine blocks and each block was assigned one of three treatments. The field further was partitioned into 100 ft. X 150 ft. blocks (spray on/off grids) using Enhanced Farm Research Analyst (Illinois Council on Food and Agricultural Research, Champaign, IL). Treatments included whole-field broadcast sprays, SVI-yield based sprays and SVI-profit based sprays. The whole-field broadcast treatment was considered the producer standard. The SVI treatments were designed to restrict insecticide applications from those areas producing the lowest yields and profits. The SVI-yield treatment only considered yield data. Yield data were analyzed to create a four classes equal interval yield map for entire field. Spray grids in the SVI-yield treatment were not sprayed if the yield in those grids were in the lowest class (25% of the plot area). The profit map incorporated production input costs with the raw yield data. Profits for the field were generalized using the LSU AgCenter's cost per acre (Paxton 2003) for irrigated stacked gene cotton (Bollgard/Roundup Ready). A map was developed in a similar matter to that for the SVI-yield treatment. Spray grids were not treated in the SVI-profit treatment, if profits for that grid fell in the lowest (25%) class. Treatments were assigned to plots in randomized complete block design and replicated three times (Figure 2). The SVI prescriptions were generated in Arc View 3.3 using NASA's AG 20/20 (ITD, Stennis, MS) software (Figure 3). Prescriptions were then modified for compatibility with the aircraft's pesticide application system. The final prescription included 218 acres of treated area and 52 acres of non-treated area (Figure 4).

Insecticide applications were made using a fixed wing aircraft equipped with an Ag-Nav II (Ag-Nav Development, Pinehurst, TX) computer, Trimble GPS, and Auto Cal II unit (Houma Avionics, Houma LA). The Auto Cal II unit is a flow control unit used to maintain constant application volume, regardless of aircraft speed. Five insecticide treatments including Baythroid 2EC (0.033 lb AI/acre) + Orthene 90S (0.5 lb AI/acre) on Jul 21, Orthene 90S (0.5 lb/acre) on Aug 1, Bidrin 8EC (0.5 lb AI/acre) on Aug 7, Bidrin 8EC(0.5 lb AI/acre) on Aug 18, and Orthene 90S (0.5 lb/acre) on Aug 26 were applied to the test area using a single prescription that recognized all treatments across the field (Table 1). The actual treatment application timing for insect pests was determined by Howard Anderson, Hardwick Planting Company's agricultural consultant, and considered pest occurrence and density across the entire field.

Pre- and post-treatment insect densities were recorded using hand-held computers equipped with GPS receivers. Field scouts used one computer for navigation and another one for data collection (Figure 5). The Visor Pro with Palm OS operating system (Handspring, Mountain View, CA) equipped with Magellan (Thales, San Dimas, CA) GPS and Scoutlink (Bayer Agriculture Division, Kansas City, MO) software was used to record insect densities and sample site location. The Axim with Windows CE 2003 operating system (Dell, Round Rock, TX) equipped with Teletype (Teletype, Boston, MA) GPS and Arc Pad 6 (ESRI, Redlands, CA) was used for site-specific navigation of the treated and non-treated field zones. The primary pests sampled across the test area included tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beavois), and heliothine (bollworm, *Helicoverpa zea* [Boddie], and tobacco budworm, *Heliothis virescens* [F.]) larvae and eggs. Tarnished plant bug densities were determined using a standard 3 ft. x 3 ft. shake cloth. Samples consisted of two shakes per site for a total of 12 row feet. Heliothines were sampled by visually inspecting 10 random plants per sample site for presence of eggs and larvae. Treatments were evaluated for differences in yield using GPS equipped John Deere four row cotton harvesters with Ag Leader (Ag Leader Technology, Ames, IA) and Agri Plan (Agri Plan Inc., Stow, MA) yield monitors (Figure 6). This technology measures yield from seedcotton flow rate and assigns yield values to individual points (latitude/longitude). Mean yield was calculated using yield measurements from > 4,000 individual points per plot.

Insect and yield data was imported into Excel (Microsoft, Bellevue, WA), Arc View 3.3, and SMS Basic (Ag Leader Technology, Ames, IA) for analysis. Data were subjected to analysis of variance procedures (SAS Institute 1990) and means compared according to Fisher's protected LSD (P=0.05).

Results and Discussion

Five successful aerial applications were made to the test field during the 2003 growing season. Pre-treatment insect counts showed significant spatial variations in densities across the field. Pre-treatment counts on July 31 showed a mean of 2.5 TPB per sample site. Post-treatment counts indicated insecticides reduced insect densities in the broadcast plots and sprayed zones of the SVI plots. Post-treatment counts on Aug 5 showed 1.2 TPB per site in the treated portions of the field and 5.0 TPB per site in the non-treated zones. TPB numbers remained higher in the non-treated areas of the SVI plots throughout the growing season. There were no significant differences among the three treatments in lint yields for 2003 (P= 0.41). The whole-field broadcast treatment had the highest lint yield at 880 lb/acre, followed by 838 lb/acre in the SVI-yield treatment, and 828 lb/acre in the SVI-profit treatment (Figure 7). The costs of foliar sprays for insect control were $42/acre for the whole-field broadcast treatment, $28/acre for the SVI-yield treatment, and $31/acre for the SVI-profit treatment (Figure 8). There was a 32% reduction in area treated for the SVI-yield and 25% reduction in area treated for the SVI-profit treatments of the field as compared to a whole-field treatment. SVI technology significantly reduced input costs for insect management within the conditions of this test, but did not significantly impact yield.

These data support the use of SVI to moderate insect management costs and should contribute to the integration of precision agricultural technologies into current IPM strategies. The opportunity to apply site-specific prescription insecticide applications will decrease the amount of treated acreage and result in significant environmental benefits. SVI technology can be used in prescription applications with sufficient science-based data. Scientific and economic bases for SVI action thresholds, application timing, and user simplicity are the keys to widespread implementation of these technologies.

Acknowledgments

This study is part of a project that was selected for funding by USDA-ARS/CSREES (IFAFS), NASA-ESE (AG 20/20), and the J. Bennett Johnson Science Foundation. Appreciation is also extended to the LSU AgCenter, University of Louisiana at Monroe, Cotton Incorporated and Louisiana's cotton producers for their partial funding of this project. The authors wish to thank Don Cook, Ashley Peters, Melissa Willrich, John Lee, Jonathan Sharp, Trey Price, and the numerous student workers at the Macon Ridge Research Station for their assistance with these studies.

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Table 1. Application rates for treatments and cost per acre for insecticide.

Date	Insecticides	Rate/acre lb AI	Cost/acre[1]
July 21	Orthene 90S + Baythroid 2EC	0.5+0.033	$14
August 1	Orthene 90S	0.5	$8
August 7	Bidrin 8EC	0.5	$8
August 18	Bidrin 8EC	0.5	$6
August 26	Orthene 90S	0.5	$6

[1]Insecticide costs per acre were calculated using data from Paxton (2003).

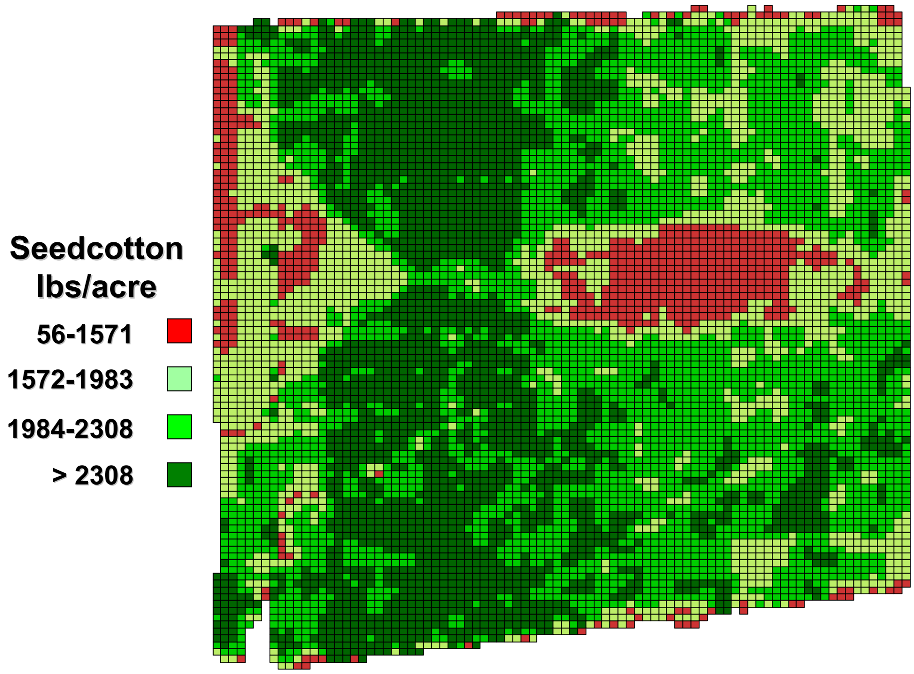

Figure 1. Cotton yield data (2001) used to generate grid map and SVI prescription.

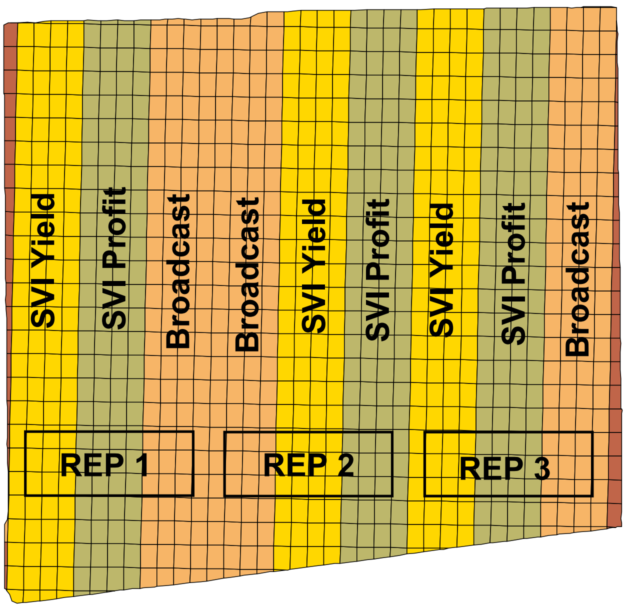

Figure 2. Diagram of experimental design.

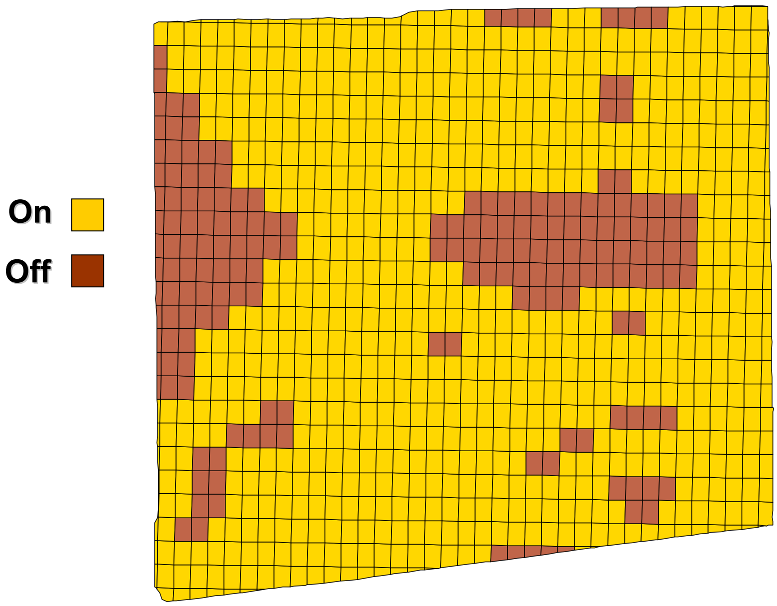

Figure 3. SVI prescription generated for aerial application with exclusion zones generated from raw yield and profit maps.

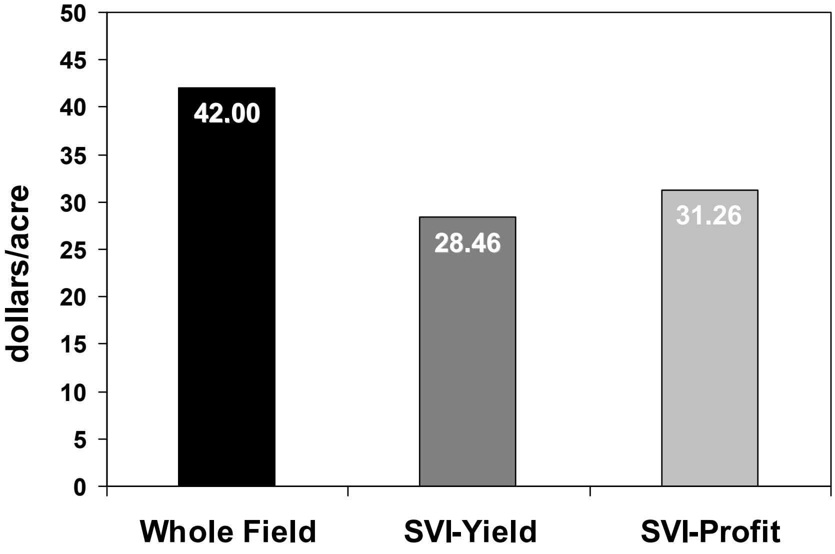

Figure 4. Amount of sprayed acreage for each treatment.

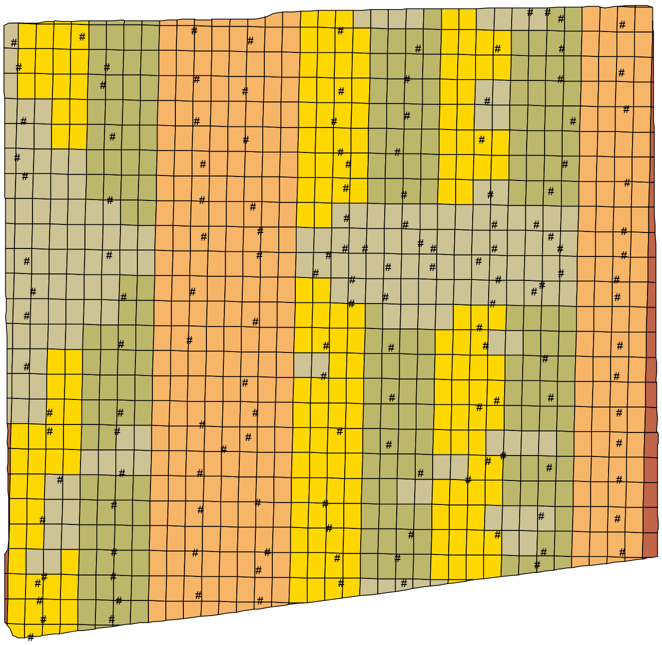

Figure 5. Pre-treatment random survey sites for tarnished plant bug and heliothines.

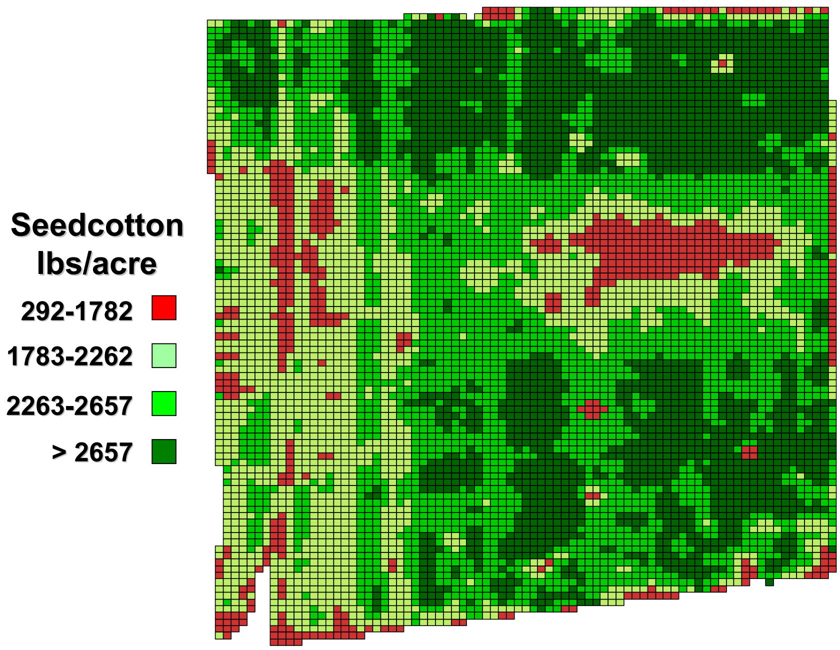

Figure 6. Spatial distribution of seed cotton yields, 2003.

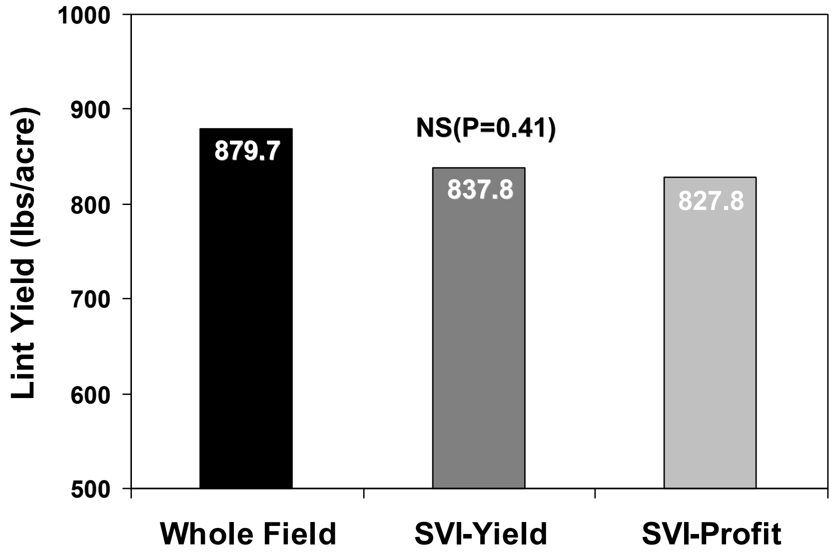

Figure 7. Lint yields for whole field broadcast, SVI-yield, and SVI-profit treatments, 2003.

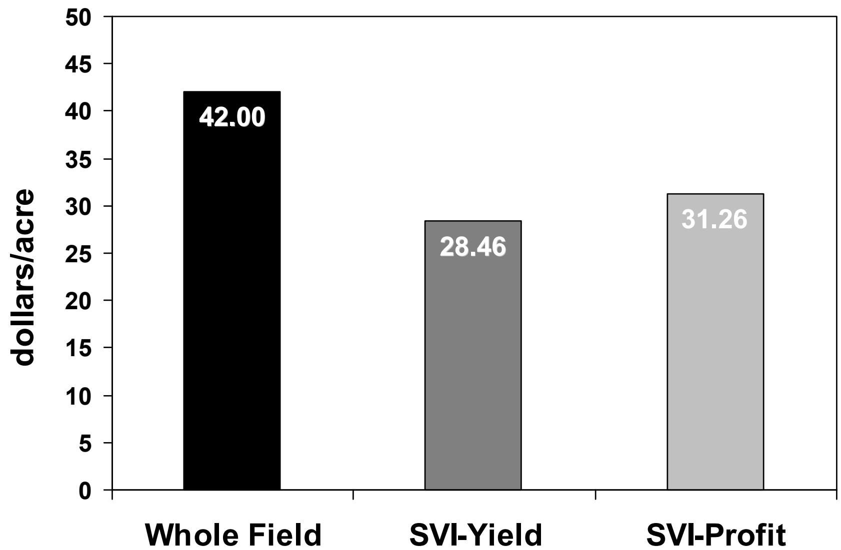

Figure 8. Insecticide cost per acre for (5 applications) using broadcast, SVI-yield, and SVI-profit application strategies (cost does not include application, other pest management practices, or boll weevil eradication fees).