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GENERATING AERIAL INSECTICIDE PRESCRIPTIONS USING COTTON YIELD AND CROP PROFIT MAPS

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Abstract

Three years of experiments have evaluated spatially variable insecticide (SVI) technology in Louisiana. These studies compared the efficacy and value of SVI applications based on yield maps to that of whole-field broadcast treatments. Yield and profit maps were created from previous 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. Fourteen successful aerial applications were made to the test fields during the 2002-2004 growing seasons. There were no significant differences in yields between SVI and whole-field broadcast treatments during any of the experiments. Insecticide costs were reduced by $5 to $14 per acre depending on number of applications and SVI strategy. In addition, there was a 16% to 32% reduction in area sprayed using the SVI-yield and SVI-profit treatments compared to the whole-field sprays. The preliminary data analysis shows that management zones for reducing crop inputs (insecticides) can be developed from yield and profit maps. The SVI technology can be effectively used to improve production efficiency.

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 increase the efficiency of their farm operations. Precision agriculture and site-specific management refers to the differential application of inputs to cropping systems across a management unit (field or zone) (Hatfield 2000). Researchers and producers have long recognized that pest infestations, yield, nutrient levels, and soil type vary spatially. New technologies allow producers to quantify yield variability in small areas of the field, characterize areas with similar productivity potential, and apply variable inputs such as pesticides, fertilizers, and seeding rates based on this variability (Atherton et al. 1999).

Insect pest management still represents one of the greatest variable 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. Most prescriptions for SVI have been based upon remotely sensed data used to generate vegetation indices that are related to plant vigor. One such vegetation measurement, normalized difference vegetative index (NDVI), has been used to apply 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 intra-field variation. Knowledge of within-field variability allows producers to identify site-specific management needs of an individual field or management zones within a field. Historical yield data provides producers another tool in making future management decisions. Most agricultural fields in Louisiana have inherent variability in soil type, nutrient availability, or drainage that results in spatial variability of crop yields.

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 produce profitable yields, producers should be able to more efficiently manage pests. 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 2002-2004. The cotton fields used in these experiments ranged in sizes from 216 to 270 acres. 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 differential correction. Yield maps were created from a previous year's cotton yield data using Arc View 3.3 (ESRI, Redlands, CA) software. The fields were divided into blocks and each block was assigned one of treatments. The fields were further 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 (SVI-yield) and profits (SVI-profit). Yield data were analyzed to create an equal interval yield map of five classes for the entire field. Spray grids in the SVI-yield treatment were not sprayed if the yield in those grids were in the lowest class (20% of the plot area). The profit map incorporated production input costs with 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 crop value in that grid was unprofitable. Treatments were assigned to plots in randomized complete block design and replicated three or four times. The SVI prescriptions were generated in Arc View 3.3 using NASA's AG 20/20 (ITD, Stennis, MS) software. Prescriptions were then modified for compatibility with the aircraft's pesticide application system.

In 2002 and 2003, insecticides were applied with Gippsland-Aviation (GA) 200 fixed wing aircraft (Gippsland Aeronautics, Australia) 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. In 2002, three insecticide applications were applied to the test area using a single prescription that recognized all treatments across the field. Insect pest pressure was higher in 2003 and five insecticide applications were made to the test area. In 2004, insecticides were applied with the GA 200 and also with a Thrush (Thrush Corporation Inc., Albany, GA) turbine fixed-wing aircraft equipped with a Trimble Ag 170 computer, GPS, and an Auto Cal II unit. Six insecticide treatments were applied to the test area in 2004. The actual treatment application timing for insect pests was determined by Hardwick Planting Company's agricultural consultant, who considered pest occurrence and density across the entire field. The insecticide treatments in all years included single or combinations of products (acephate, dicrotophos, or cyfluthrin).

Pre- and post-treatment insect densities were recorded using hand-held computers equipped with GPS receivers to log each sample site. The primary pests sampled across the test area included tarnished plant bug, *Lygus lineolaris* (Palisot de Beavois), and heliothine (bollworm, *Helicoverpa zea* [Boddie], and tobacco budworm, *Heliothis virescens* [F.]) damage, 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, larvae, and damage. Treatments were evaluated for differences in yield using GPS equipped John Deere four row cotton harvesters with Ag Leader (Ag Leader Technology, Ames, IA) yield monitors. This technology measures 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 were imported into Excel (Microsoft, Redmond, WA), Arc View 3.3, and SMS Advanced (Ag Leader Technology, Ames, IA) for analysis. Yield 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

Fourteen successful aerial SVI applications were made to the test fields during 2002-2004. The insect pest data are currently undergoing analyses are will not be presented in this report. In general, the initial post-treatment samples of insect pests showed infestations were consistently found in the non-sprayed zones of the SVI-treated plots and less common in the sprayed zones of the whole-field broadcast and SVI-treated plots. In 2002-2004, there were no significant differences among treatments in lint yields ($P \geq 0.41$). The whole-field broadcast and SVI-yield treatments produced lint yields of 728 lb/acre and 721 lb/acre, respectively, in 2002. (Fig. 1). The whole-field broadcast treatment produced 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 in 2003. Lint yields in 2004 were highest in the SVI-profit treatment, but occurred in a narrow range of 724 lb/acre to 740 lb/acre among all treatments. The costs of foliar sprays were consistently lower in the SVI treatments compared to that in the whole-field broad cast treatments (Fig. 2). SVI technology reduced input costs for insect management, but did not significantly impact yield within the conditions of these tests. Insecticide costs among treatments ranged from $17/acre to $22/acre in 2002, $28/acre to $42/acre in 2003, and $33/acre to $41/acre in 2004. There was a 25%, 25%-32%, and 16%-18% reduction in area treated in the SVI plots compared to the whole-field broadcast plots in 2002, 2003 and 2004 , respectively (Fig. 3). The reduction in acreage treated with insecticides supports better stewardship of the environment and the general principles of IPM by temporally and spatially restricting pesticide use strategies. 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.

Acknowledgments

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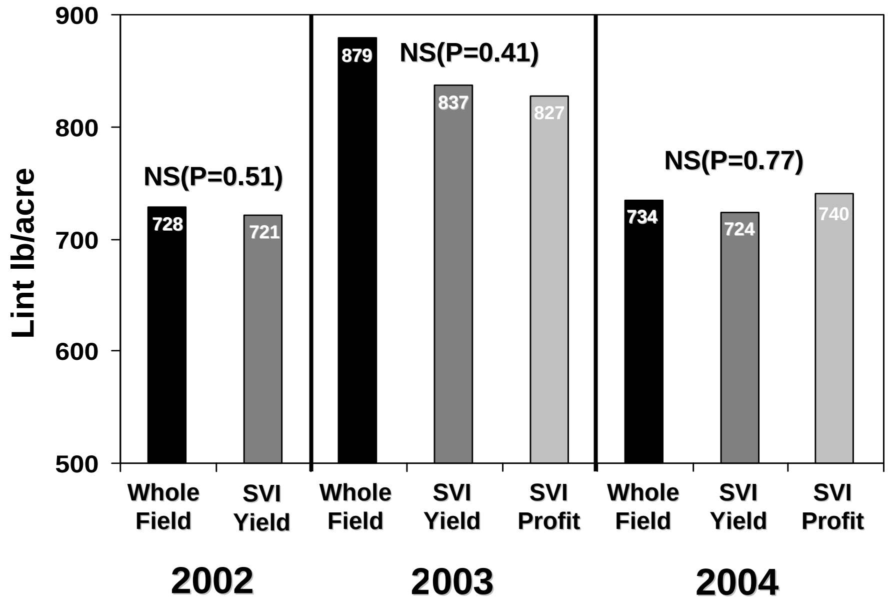

Fig. 1. Lint yields for whole-field broadcast, SVI-yield, and SVI-profit treatments, 2002-2004.

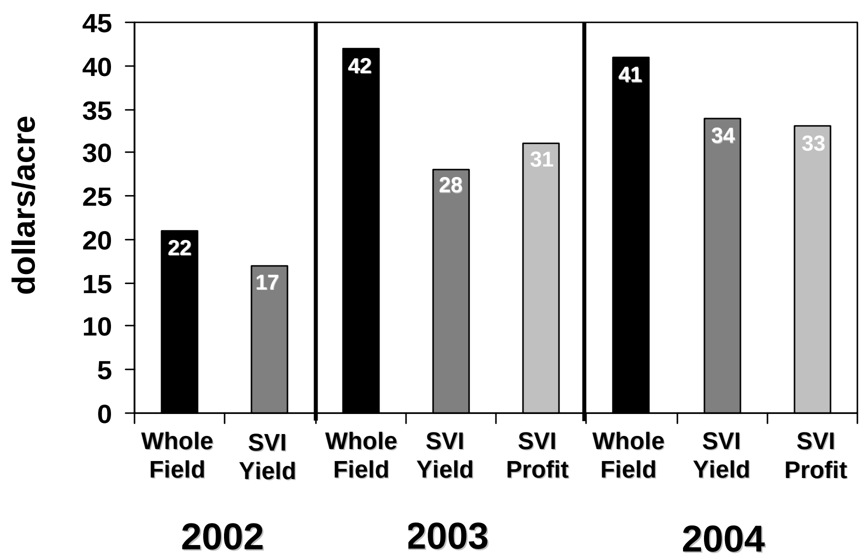

Fig. 2. Insecticide cost per acre, using whole-field broadcast, SVI-yield, and SVI-profit application strategies (cost does not include application, other pest management practices, or boll weevil eradication fees).

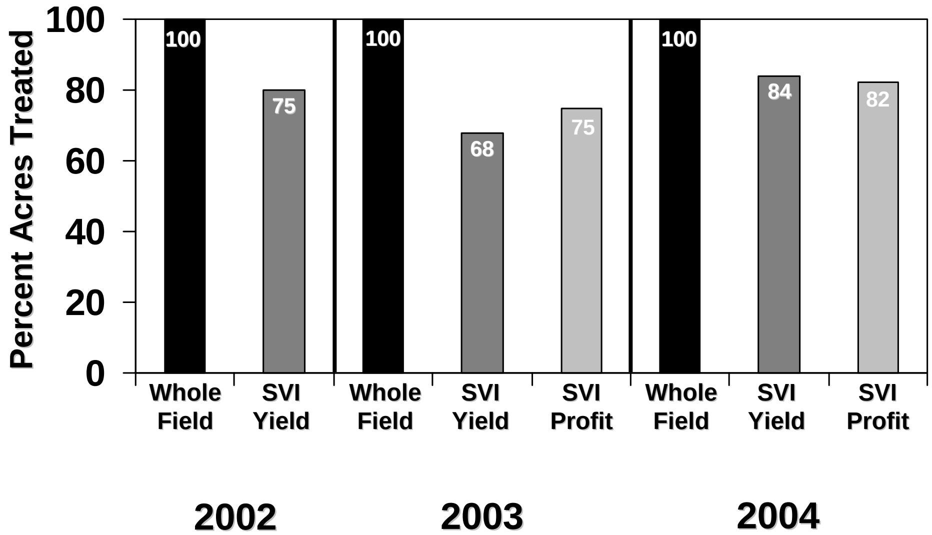

Fig. 3. Percentage of acreage treated with insecticides for whole-field broadcast, SVI-yield, and SVI-profit treatments, 2002-2004.