IMPROVING COTTON IPM WITH SPATIALLY VARIABLE INSECTICIDE (SVI) APPLICATIONS

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Abstract

GIS/GPS technologies and decision support systems that are currently available are being adapted to address specific arthropod management needs of producers in a user-friendly format. The associated knowledge to utilize the tools of precision agriculture must be developed in a user-friendly format and transferred to cotton producers, commercial pesticide applicators, and agricultural consultants. This research attempts to address these problems through the collaborative efforts of a multidisciplinary team approach and encompasses the efforts of specialists in the fields of agronomy, entomology, engineering, economics, computer science, statistics, and extension education. The goal of the project is to moderate production costs by integrating spatially variable insecticide (SVI) applications with established IPM practices based on sufficient scientific data. If significant relationships can be established between digital images representing crop development patterns and arthropod pest populations, agricultural consultants can improve the efficiency of their operations by sampling only those areas of fields associated with those pests. Furthermore, SVI applications can target only those areas that need treatment when action thresholds are exceeded. Low yielding areas of fields or those with low pest densities would not be treated. The full potential of geospatial and precision agricultural technologies in cotton production will not be realized until producers, agricultural consultants, extension agents, and commercial pesticide applicators become confident in this technology. Therefore, research and extension scientists must develop a non-biased base of information that can be transferred to the cotton industry. These experiments provide the framework for a science-based assessment of the technologies, demonstrate prescription pesticide applications, calculate the value of these technologies, and technology transfer to producers.

Introduction

Cotton production systems are changing dramatically due to significant varietal, integrated pest management (IPM), and engineering advances. The geospatial and precision technologies that are currently available can be valuable tools for cotton producers. However, these tools must be adapted to address the specific plant protection needs of producers on a timely basis. The associated knowledge to utilize decision support systems based on precision agriculture must be developed in a user-friendly format and transferred to producers, commercial pesticide applicators, and agricultural consultants. The challenges that producers face in the presence of technological advances includes the non-availability of sufficient science-based data to support the technology, an understanding of the on-farm value of the technology and adequate training to utilize precision agricultural information.

Precision Agriculture and Cotton IPM/Entomological Research

The application of remote sensing in crop IPM has been examined by a select group of researchers. In many instances, this research has only been used as a survey tool to record the distribution of specific arthropod species. Riley (1989) and Liebhold et al. (1993) reviewed applications of remote sensing in entomology and found that most studies were associated with arthropod surveys through aerial photos, radar, airborne, and satellite imagery. Those surveys were used to detect the potential habitat of arthropods as an indication of their presence. Examples of this research included color infrared photography to detect undestroyed cotton in support of a boll weevil eradication program (Summy et al. 1989) and evaluation of spider mite (*Tetranychus* spp.) injury to cotton (Fitzgerald et al. 1999).

Spatially variable insecticide (SVI) application research is still in the exploratory stages. Remote imagery has been involved in studies associated with boll weevil eradication (Smith and Wiygul 1997), monarch butterfly distribution (Riley 1989), and spider mite injury to cotton (Fitzgerald et. al. 1999). Willers et al. (1999) found that remote imagery could characterize different plant growth patterns in cotton fields during the production season. Plant et al. (2000) evaluated the correlations between remotely sensed reflectance data and main stem nodes above white flower (NAWF) and main stem nodes above cracked boll (NACB). There was a relatively weak positive correlation between the normalized difference vegetation index (NDVI) and NAWF, but variability was too great for statistical significance. However, the correlation between NDVI and NACB was significant.

Willers et al. (1999) have 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. Using digital images to identify those areas most likely to be infested with tarnished plant bugs, allowed prescription insecticide applications to target only those infested areas. Federal, state, and private researchers in Louisiana and Mississippi have continued to evaluate the potential of SVI applications to control cotton insect pests. Other research efforts evaluating remote sensing and its application in cotton arthropod management include work in Georgia, Mississippi, and selected USDA-ARS locations across the United States.

Spatial Variability of Arthropod Populations

The spatial variability of insect abundance and plant characteristics has not yet been fully explored with respect to arthropod pest management. Most of the action levels to initiate insecticide treatments to control cotton insect pests are based on sampling plans that assume a random distribution of insects across the field. In reality, arthropod pests densities are associated with specific areas of fields, but few efforts have attempted to associate this variability with plant development characteristics at the field level. Research in these areas has been limited by the inability of researchers to examine entire fields, identify well-defined areas of variability, and associate that with arthropod pests densities. Geo-statistical techniques now are available that will allow us to understand the nature of spatial correlation, including its range, direction, and mathematical functional form.

Value of Site-Specific Crop Management

This research compares variable rate application of insecticides with more traditional scouting and blanket application techniques. While it may be generally assumed that variable rate applications (precision agriculture) would reduce the amount of pesticide used, it is not clear from the existing literature if such practices would be profitable (Lowenberg-DeBoer and Swinton 1997). It is difficult to evaluate the profitability of site-specific management because multiple precision agriculture technologies must be integrated into a single system. Furthermore, economic returns of precision agriculture technologies may be masked by simultaneous interactions with other technologies such as crop genetics, tillage, or herbicides (Pierce and Nowak 1999). Only a few of these studies found that site-specific management was profitable in all situations studied. Most of these studies, however, indicated there was potential for profitability.

Goals and Objectives

The specific goal of this research project is to develop crop management strategies using remote sensing and other geospatial technologies to improve the efficacy and profit margin of cotton production at the farm level. These experiments are designed to address production issues associated with crop integrated pest management (IPM), defoliation, and irrigation. The specific objectives of this multi-year study are: 1) to obtain thermal, multispectral, or hyperspectral imagery of cotton fields that capture variation in field growth patterns and associate those patterns with arthropod beneficial/pest colonization, 2) to apply SVI prescription applications to target well-defined field zones associated with arthropod pests, 3) to perform economic analyses comparing conventional plant protection strategies to precision farming technologies, and 4) to develop education programs for the cotton industry on the efficiency and value of precision agricultural techniques.

Procedures

The initial approach and procedures will build upon research conducted during the 2000-2001 seasons. Studies are planned for the next four years at Hardwick Planting Company near Newellton, LA. The research team has established a collaborative relationship with representatives of NASA-EDE and Spectral Visions (ITD Division). Geo-spatial and SVI application technologies were evaluated on a limited basis during previous cropping seasons. The expertise of these scientists will be utilized throughout the current project and collaboration on additional research projects will continue. Long-term cooperative agreements with NASA-EDE and their support organizations are necessary to collect remote sensing images from fixed wing aircraft and satellites that are critical to the success of the project.

Relating Image Data to Field Biology

In the initial tests, the objective is to relate biological characteristics in cotton fields to digital images. The borders of selected cotton fields will be geo-referenced during the early season. Within each field, sampling points will be geo-referenced in a square grid (2-to-4 acres) across a series of test fields. Biological data on the condition of the crop as well as the presence of arthropod infestations will be recorded weekly or as dictated by population densities.

Thermal, multispectral, or hyperspectral images will be collected and processed by NASA-EDE and their collaborators within $\pm$ 3 days of each sample. Vegetation indices (primarily, NDVI) will be used to generate field maps (Moran et al. 1997). Vegetation index thresholds will be related to biological data for each field.

Evaluation of SVI Prescription Applications

Using image data collected in the initial tests, the SVI efficacy will be evaluated against a blanket whole-field treatment. The image data will be used to generate information for SVI prescription applications. In addition to the pre-spray data, post-spray arthropod infestations also will be measured. Equipment-mounted yield monitors or trailer scales will be used to compare seedcotton yields between the two treatments.

Determination of the Economic Value of SVI Applications

Economic data for SVI-treated fields will be compared to that in conventional fields by analyzing whole-field inputs and crop values. Standardized enterprise budgeting techniques will be used to evaluate costs and returns associated with each system. A whole-farm model can be constructed to evaluate the potential impact of alternative production strategies on the efficiency and profitability for typical production units in the study area. Data from the budgets will be used to compare costs per pound of lint as well as other measures of profitability and/or efficiency associated with each treatment. One measure of interest for this study will be the insecticide cost per pound of lint. Other measures of efficiency or profitability, such as resource utilization differences also will be examined. Enterprise budget data will also be used to construct whole-farm models that can be used to evaluate site-specific management within a whole-farm context.

Technology Transfer

The research results will provide the scientific basis for integrating geo-spatial and precision technologies into current cotton production strategies. A demonstration/education program will be developed and executed for producers, pesticide applicators, and agricultural consultants on the efficiency and value of precision agriculture in cotton IPM. Technology transfer will include refereed publications, technical guides, whole-farm demonstrations, training clinics, and oral reports.

Benefits to the Cotton Industry

The long-term benefits of this project can be realized at several levels within the commercial farm production system. The overall net return on crop value will be enhanced by improving the efficiency of crop production practices. If significant relationships can be established between digital images representing crop development patterns and arthropod pest populations, agricultural consultants can improve the efficiency of their operations by sampling only those areas of fields associated with pests. Sampling procedures using GPS/GIS could be more precise and accurate in determining the severity of arthropod pest infestations. The availability of additional knowledge to improve crop management decisions could become an invaluable resource to producers (Figure 3).

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. Opportunities to use selective pesticides to target specific species could become a common practice. Decreasing the actual treatments in fields with pesticides increases the possibility that biological control agents (predators and parasitoids) will be effective in maintaining pest populations below damaging levels.

The ability to utilize selective insecticides, reduce the frequency of pesticide applications, and decrease the amount of treated acreage will result in significant environmental 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 project will contribute the necessary information to integrate precision agricultural technologies into current IPM strategies and will further reduce foliar insecticide requirements. Scientific and economic bases for sampling procedures, SVI, action thresholds, application timing, and user simplicity are the keys to widespread implementation of these technologies. The cotton industry has only rarely had such an opportunity to utilize technologies that could strongly influence the direction of crop production strategies. The days of the "pesticide treadmill" with its disastrous results of pest resurgence, secondary pest outbreaks, and environmental contamination in cotton production systems may be eliminated if a base of information can be developed to support the appropriate development of these technologies.

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