SITE-SPECIFIC TOPGUARD APPLICATION BASED ON AERIAL IMAGERY FOR EFFECTIVE MANAGEMENT OF COTTON ROOT ROT

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Abstract

Cotton root rot is a century-old cotton disease that can be controlled with Topguard Fungicide recently. As this disease tends to occur in the same general areas within fields in recurring years, site-specific application of the fungicide only to the infected areas can be more effective and economical than uniform application. The objectives of this research were to demonstrate how site-specific fungicide application can be implemented using historical aerial imagery and variable rate technology. Procedures were developed for creating binary prescription maps from historical aerial imagery. Two different variable rate liquid control systems were adapted to two existing cotton planters, respectively, for site-specific fungicide application at planting. One system was used for site-specific Topguard application on two fields near Edroy, TX and the other on two fields near San Angelo, TX. Airborne multispectral imagery was taken during the growing seasons to monitor the performance of the site-specific treatments. Yield monitor data were collected from one field in each location. Preliminary results showed that the variable rate systems performed well and site-specific Topguard treatments effectively controlled cotton root rot. This research provides producers, crop consultants and extension personnel with useful information and assurance that site-specific Topguard application based on historical aerial imagery will be a cost-effective and environmentally-friendly approach to effective control of cotton root rot.

Introduction

Topguard Fungicide containing the active ingredient flutriafol was used in Texas from 2012 to 2015 to control cotton root rot under a Section 18 emergency exemption by the U.S. Environmental Protection Agency (EPA). As a result, growers achieved lower cotton root rot incidence, higher yields and better fiber quality (Drake et al., 2013; Yang et al., 2014). In 2015, Topguard Terra Fungicide, a new and more concentrated formulation developed specifically for this market, was registered by the EPA. It provides the same level of cotton root rot control as Topguard Fungicide. Growers generally treat their fields uniformly even though they are aware that only portions of their fields are infected. There are probably two main reasons for the uniform treatment. One reason is that growers want to make sure all existing and potential new infections are treated since they are not sure if infected areas will expand from year to year. The other reason is that site-specific application equipment and prescription maps are not readily available for their use. Since only portions of the field are infected, it may not be appropriate to treat the whole field. Therefore, it is necessary to define the infected areas within the field so that variable rate technology can be used to apply the fungicide only to the infected areas for more effective and economical control.

Airborne multispectral imagery had been used to monitor the progression of cotton root rot infections in selected cotton fields near Corpus Christi, TX in 1999-2002. Because there was no effective treatment, aerial imaging was discontinued until Topguard was found to able to control the disease. Airborne imagery was taken from the same cotton fields near Corpus Christi and from selected fields near San Angelo, TX during the 2010-2012 growing seasons when Topguard was not used to treat cotton root rot. Image data and ground observations showed that cotton root rot tends to occur in the same general areas within fields in recurring years with seasonal variability in extent that is partially due to weather and moisture conditions (Yang et al., 2012). This recurrent pattern of cotton root rot incidence indicates that historical remote sensing imagery can be used for site-specific management of the disease in the future years.

The objectives of this study were to: 1) create prescription maps from historical aerial imagery for site-specific Topguard application; 2) adapt variable rate application systems to existing tractors and planters for implementing site-specific Topguard application; and 3) evaluate the performance and efficacy of site-specific Topguard treatments using aerial imagery and yield maps.

Materials and Methods

Study Sites

This research was conducted in four fields with a history of cotton root rot in the Coastal Bend and Southern Rolling Plains areas of Texas. A 112-ac dryland field near Edroy (28°00′5″N, 97°38′33″W), designated as Field 1, and a 28-ac irrigated field near San Angelo (31°26′31″N, 100°22′16″W), designated as Field 2, were selected for presentation in this paper.

Image Acquisition and Processing

Images used in this paper were acquired in 2010 and 2015 using two imaging systems. A four-camera imaging system was used to take images of Fields 1 and 2 in 2010. The system captured 12-bit images with 2048 × 2048 pixels in four spectral bands: blue (430-470 nm), green (530-570 nm), red (630-670 nm), and near-infrared (NIR 810-850 nm). A two-camera imaging system was used to take images in 2015. The system consisted of two Canon EOS 5D Mark II digital cameras with a 5616 x 3744 pixel array. One camera captured normal color images with blue, green and red bands, while the other camera was equipped with a 720-nm long-pass filter to obtain NIR images. Images were acquired between 1200 and 1500h local time under sunny conditions on July 30, 2010 from Field 1 and on September 27, 2010 from Field 2, shortly before harvest when cotton root rot was fully expressed for the season. The flight altitudes were 2740 m (9000 ft) above ground level (AGL) with a pixels size of 0.9 m in 2010 and 1070 m (3500 ft) AGL with a pixel size of 0.35 m in 2015.

An image-to-image registration procedure based on the first-order polynomial transformation model was used to align the individual band images in each composite image. The registered images were then rectified to the Universal Transverse Mercator (UTM), World Geodetic System 1984 (WGS-84), Zone 14, coordinate system based on a set of ground control points around the field located with a Trimble GPS Pathfinder ProXRT receiver (Trimble Navigation Limited, Sunnyvale, CA). The root mean square (RMS) errors for rectifying the images were within 1-2 m in 2010 and within 1 m in 2015. The images in 2010 were resampled to 1-m resolution using the nearest neighborhood technique and the images in 2015 were degraded by a factor of 3 and then resampled to 1-m resolution. All procedures for image registration and rectification were performed using ERDAS Imagine (Intergraph Corporation, Madison, AL).

Prescription Map Creation

A field boundary or an area of interest (AOI) was defined for each field. Normalized difference vegetation index (NDVI) images were created for each field. The NDVI images were then classified into root rot-infected and non-infected zones using ISODATA (Iterative Self-Organizing Data Analysis) unsupervised classification (Intergraph Corporation, 2013; Yang et al., 2015). To accommodate the potential expansion and temporal variation of the disease, a 5-m buffer zone around the infected areas was created as part of the treatment areas in the prescription maps.

Variable Rate Controller Adaption

A John Deere variable rate control system consisting of a controller, a servo valve, a flowmeter, and a shutoff valve was integrated with the John Deere GS2 Display and the StarFire RTK GPS receiver already mounted on a John Deere 8230 tractor owned by a producer in Edroy, TX. A transparent flow divider was used to distribute the flow evenly to the shanks of a 12-row 38-in planter. A modified in-furrow method with Y-shaped splitters was used to apply the fungicide on the sides of seed furrow and not in direct contact with the seed. Wylie Implement Company in Corpus Christi, TX installed the system.

A Trimble Field-IQ spray control system consisting of similar control components was integrated with the Trimble FMX Display and the StarFire RTK GPS receiver already mounted on a John Deere 8210 tractor owned by a producer in San Angelo, TX. The flow was evenly distributed to the shanks of an 8-row 40-in planter. The T-band application method was used to apply the fungicide in a concentrated 3-4 inch wide band at planting perpendicular to row direction. Wylie Implement Company in Lubbock, TX installed the system.

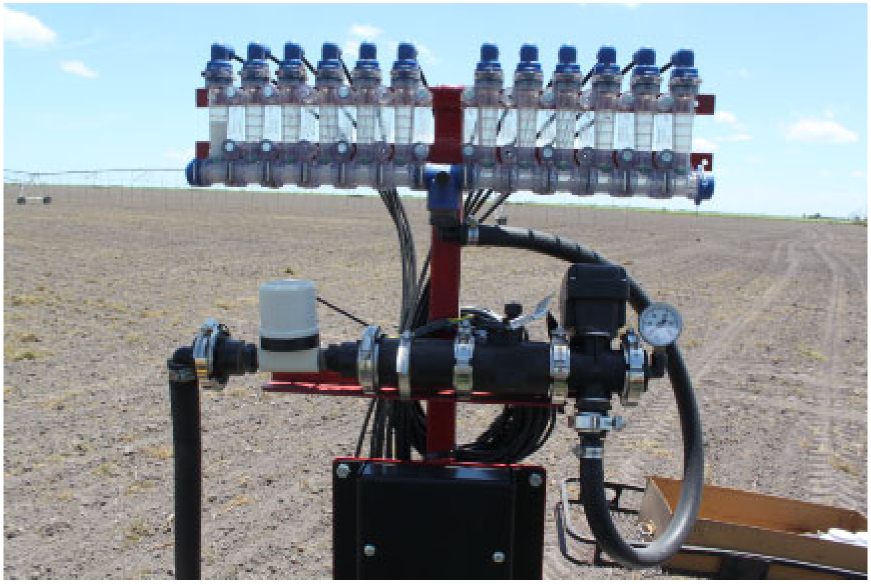

Figure 1. A variable rate control system consisting of a controller, a servo valve, a flowmeter, a servo valve and a shutoff valve integrated to a John Deere tractor equipped with John Deere GS2 Display and StarFire RTK GPS.

Site-Specific Fungicide Application
Topguard Terra Fungicide was applied at 4 fl oz/ac of product (half rate) with 6 gal/ac of water for Field 1 on May 1, 2015, about six weeks behind the normal planting date due to excessive rainfalls. About one month later, Topguard Fungicide was applied at 32 fl oz/ac of product (full rate) with 5 gal/ac of water for Field 2. Both systems performed well for site-specific fungicide application.

Figure 2. Site-specific Topguard Terra application (Y-shaped splitter, 4 fl oz/ac) in a 112-ac dryland field near Edroy, TX on May 1, 2015 at planting.

Yield Monitoring
Field 1 was harvested by a John Deere cotton picker, but no yield data were collected. Field 2 was harvested by a John Deere cotton stripper and yield data were collected with a John Deere yield monitor mounted on the stripper.

Results and Discussion

Figure 3 shows an airborne color-infrared (CIR) image taken in 2010, a corresponding two-zone classification map, and a two-zone prescription map for Field 1. The infected plants had a greenish color, while the noninfected plants had a reddish tone. Approximately one-third of the field was infected in 2010. With a 5-m buffer added to the infected areas, about 57% of the field (green areas) was treated with Topuard Terra Fungicide. Figure 4 shows an airborne CIR image taken in 2010, a corresponding two-zone classification map, and a two-zone prescription map for Field 2. About 37% of the field was infected in 2010, while 61% of the field was treated with Topuard Fungicide.

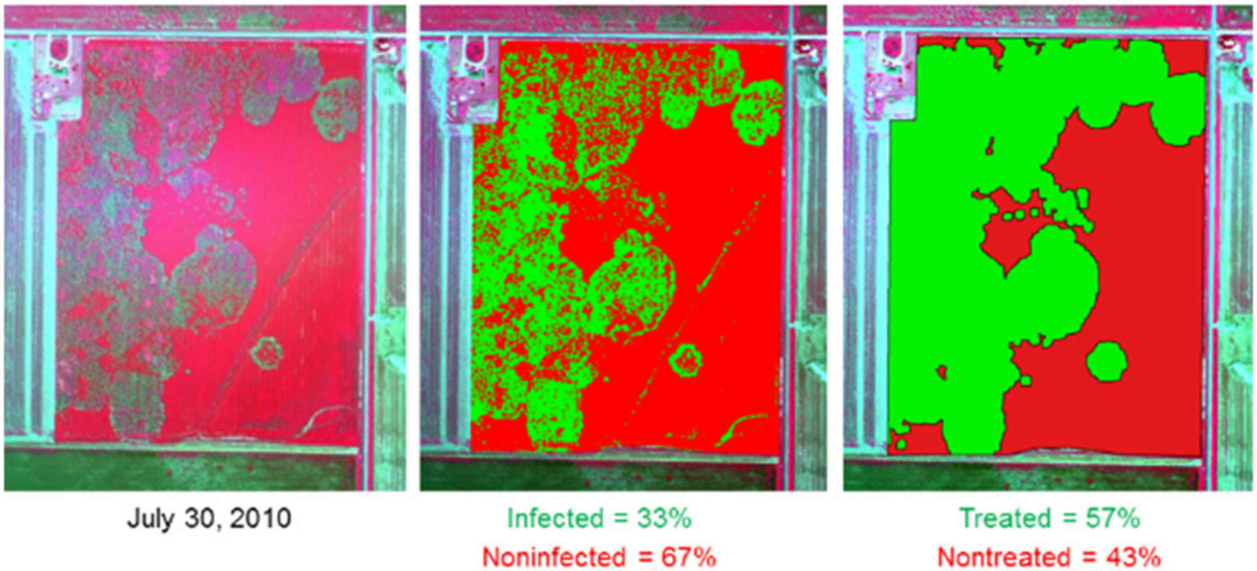

Figure 3. An airborne color-infrared image (left), a corresponding two-zone classification map (center), and a prescription map (right) for a 112-ac cotton field near Edroy, TX (Field 1). The green areas in the prescription map were treated with Topguard Terra Fungicide at 4 fl oz/ac of product (half rate) with 6 gal/ac of water.

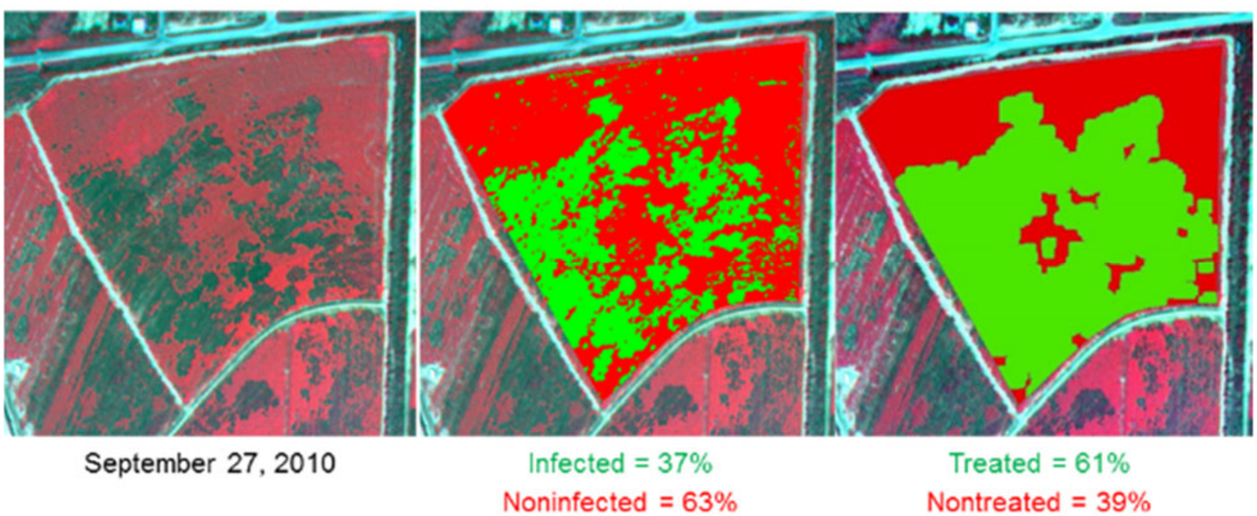

Figure 4. An airborne color-infrared image (left), a corresponding two-zone classification map (center), and a prescription map (right) for a 28-ac cotton field near San Angelo, TX (Field 2). The green areas in the prescription map were treated with Topguard Fungicide at 32 fl oz/ac of product (full rate) with 5 gal/ac of water.

Figure 5 compares the airborne CIR images between 2010 (natural infection) and 2015 (infection with site-specific treatment) for Field 1. Clearly, the fungicide effectively controlled the disease in the treated areas, though root rot started showing up in treated areas toward the end of the growing season since the fungicide was only applied at half of the full rate. This late infection did not cause a significant yield loss because most of the bolls were fully developed by that time. However, at around the flowing stage, root rot started infecting some nontreated areas (near the middle) within the field where root rot may have spread since 2010. These newly-infected areas within the field should be added to the prescription maps for the coming years. Root rot damage in nontreated areas right across the west border of the field can be clearly seen from the dark areas in the 2015 CIR image and the ground photo. Figure 6 shows the airborne CIR images in 2010 and 2015 for Field 2. Similarly, the fungicide effectively controlled the disease in the treated areas, though root rot occurred at a small number of treated areas toward the end of the season. The light reddish tone on the CIR image in 2015 was due to small plant size and low canopy cover caused by the dry weather and limited irrigation during the growing season.

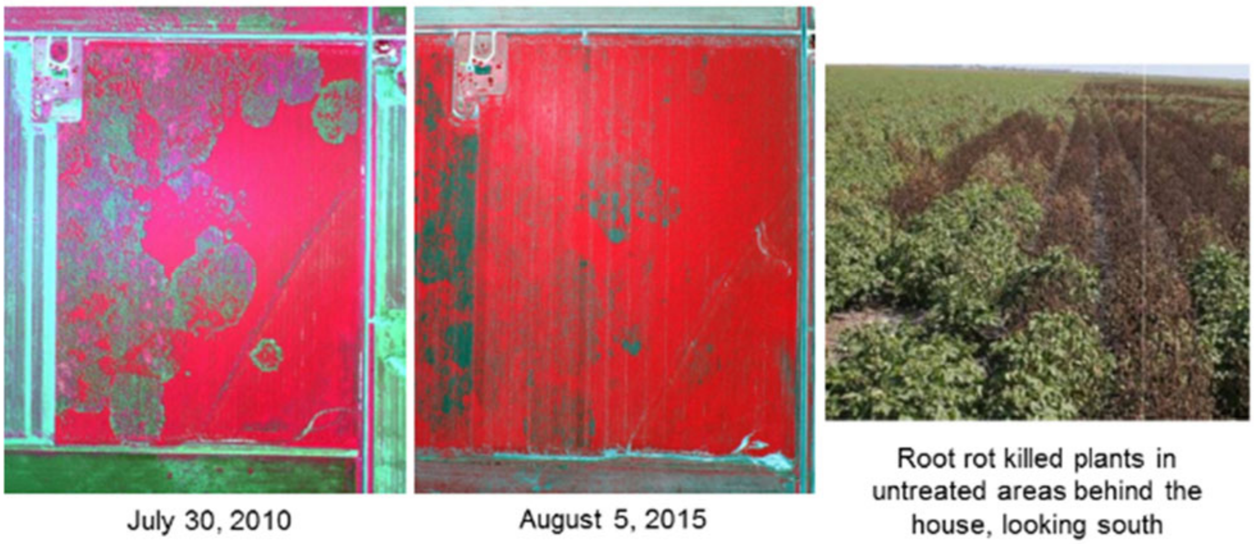

Figure 5. Comparison of airborne color-infrared images acquired in 2010 (natural infection) and 2015 (infection with site-specific treatment) for a 112-ac cotton field near Edroy, TX (Field 1). The photo on the right shows root rot damage in untreated areas compared with treated areas behind the house at the upper left corner.

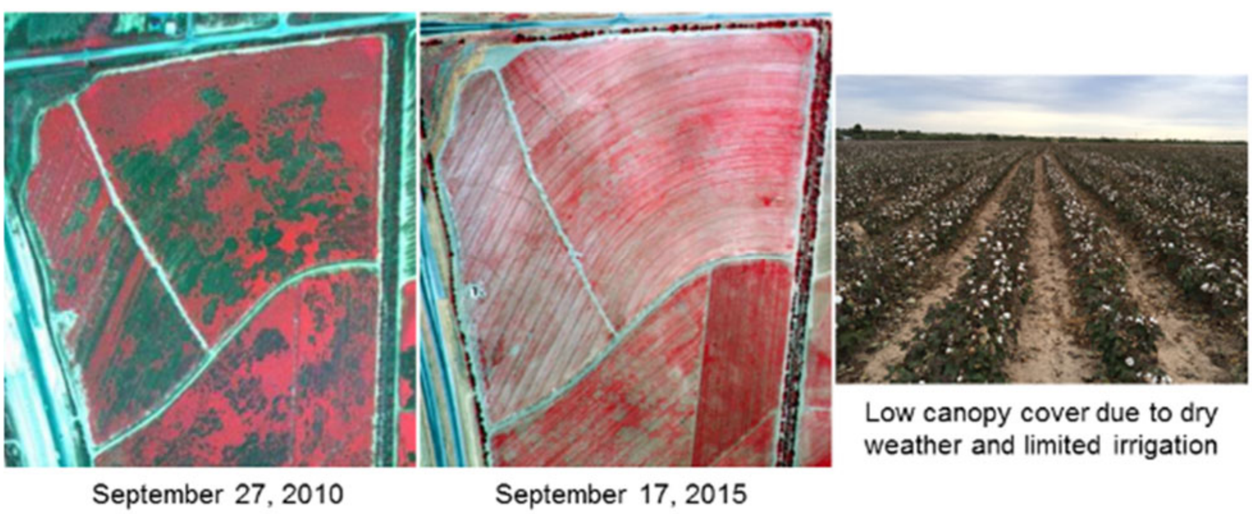

Figure 6. Comparison of airborne color-infrared images acquired in 2010 (natural infection) and 2015 (infection with site-specific treatment) for a 28-ac cotton field near San Angelo, TX (Field 2). The photo on the right shows treated and nontreated areas within the field.

Conclusions

Airborne multispectral imagery is an effective tool for mapping cotton root rot infection and can be used to generate prescription maps and assess fungicide performance. Variable rate controllers can be easily adapted to existing tractors/planters/applicators for site-specific flutriafol application. More field experiments are needed to evaluate the performance and efficacy of site-specific fungicide treatments in terms of root rot occurrence and yield in treated and nontreated areas under different application strategies and environmental conditions.

Acknowledgements

This project was funded by the Texas State Support Committee and Cotton Incorporated, Cary, NC. The authors wish to thank Fred Gomez and Lee Denham of USDA-ARS at College Station, TX for taking the aerial imagery for this study. Thanks are also extended to Jim Ermis of Edroy, TX and Douglas Wilde of San Angelo, TX for allowing us to use their fields and equipment for this study. Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. USDA is an equal opportunity provider and employer.

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