SITE-SPECIFIC MANAGEMENT OF COTTON ROOT ROT USING AIRBORNE AND SATELLITE IMAGERY

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Abstract

Cotton root rot is a serious cotton disease that can now be effectively controlled with Topguard Terra Fungicide. The objectives of this research were to demonstrate how site-specific fungicide application could be implemented based on historical remote-sensing imagery and variable-rate technology. Procedures were developed for creating binary prescription maps from historical airborne and satellite imagery. Two different variable-rate liquid control systems were adapted to two existing cotton planters, respectively, for site-specific fungicide application at planting. A system was used for site-specific application on two fields in 2015 and other two different fields in 2016 near Edroy, Texas and the other system on two fields in both 2015 and 2016 near San Angelo, Texas. Airborne multispectral imagery taken during the growing seasons was used to monitor the performance of the site-specific treatments. Two years of field experiments showed that the variable-rate systems performed well and site-specific fungicide treatments effectively controlled cotton root rot. Any newly infected areas identified by the imagery will be added to the prescription maps for future use. The results of this study will provide cotton growers, crop consultants, and agricultural dealers with practical guidelines for implementing site-specific fungicide application using historical imagery and variable-rate technology for effective management of cotton root rot.

Introduction

Cotton root rot is a serious and destructive disease in many of the cotton production areas in Texas. Topguard (flutriafol) had been used in Texas from 2012 to 2015 to control cotton root rot under Section 18 emergency exemptions granted by the U.S. Environmental Protection Agency (EPA). As a result, there were low incidences of lower cotton root rot with higher crop yields, and better fiber quality (Drake et al., 2013; Yang et al., 2014). In early 2015, Topguard® Terra Fungicide, a new and more concentrated formulation of flutriafol developed specifically for this market, was registered by the EPA. It provides the same level of control for cotton root rot as Topguard. Despite the fact that only portions of their fields are infected, growers generally treat their fields uniformly with the fungicide at planting. Therefore, it is necessary to develop methodologies for creating prescription maps and adapting variable-rate systems to existing tractors and planting machinery so this technology can be used to apply fungicide only to the infected areas for more effective and economical control.

Remote sensing studies have demonstrated that cotton root rot tends to occur in the same general areas within fields over recurring years, though other factors such as weather and cultural practices may affect its initiation and severity (Yang et al., 2016). This recurrent pattern of root rot incidence in cotton should provide the producer with greater confidence to use remote-sensing imagery for making site-specific treatment decisions. The objectives of this study were to: 1) create prescription maps from historical aerial and satellite imagery for site-specific management of cotton root rot; 2) adapt variable-rate application systems to existing planting machinery for implementing site-specific Topguard Terra application; and 3) evaluate the performance and efficacy of site-specific treatments using aerial imagery and yield maps.

Materials and Methods

Study Sites

This research was conducted in multiple fields with a history of cotton root rot in the Coastal Bend and Southern Rolling Plains areas of Texas in 2015 and 2016. A 41-ha (101-ac) field near Edroy with the field center coordinates (28°0′9″N, 97°46′2″W), designated as Field 1, and a 12-ha (30-ac) irrigated field near San Angelo with the field center coordinates (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 study were acquired from a satellite sensor and two airborne imaging systems. A GeoEye-1 satellite scene, acquired on July 27, 2009, was used to create a prescription map for Field 1. The satellite image had spatial resolution of 2-m and a dynamic range of 11 bits, and it contained four spectral bands: blue (450-510 nm), green (510-580 nm), red (655-690 nm), and near infrared (NIR, 780-920 nm). An airborne image acquired by a four-camera imaging system on September 27, 2010 was used to create the prescription map for Field 2. The four-camera system was capable of capturing 12-bit imagery with 2048 × 2048 pixels in four spectral bands: blue (430-470 nm), green (530-570 nm), red (630-670 nm), and NIR (810-850 nm). An airborne two-camera imaging system was used to take images to monitor the performance of site-specific treatments during the 2016 growing season. The two-camera system consisted of two Nikon D810 digital cameras with a 7360 x 4912 pixel array. One camera captured red-green-blue (RGB) color images, while the other camera was equipped with an 830-nm long-pass filter to obtain NIR images. All the airborne images were acquired between 1200 and 1500h local time under sunny conditions. The flight altitudes were 2740 m (9000 ft) above ground level (AGL) with a pixel size of 0.9 m in 2010 and 1220 m (4000 ft) AGL with a pixel size of 0.3 m in 2016.

The four band images from the four-camera system were aligned to each other using an image-to-image registration procedure based on the first-order polynomial transformation model and were then stacked as a four-band composite image. Similarly, the RGB and NIR images from the two-camera system were aligned and stacked as a six-band image as the NIR image contained three NIR bands. As the three NIR bands were similar, the NIR image recorded in the red channel was used. The aligned or 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 each field located with a Trimble GPS Pathfinder ProXRT receiver (Trimble Navigation Limited, Sunnyvale, CA). All procedures for image registration and rectification were performed using ERDAS Imagine (Intergraph Corporation, Madison, AL). The GeoEye-1 image was rectified to the same coordinate system at delivery.

Prescription Map Creation

The prescription maps were created from the four-band GeoEye-1 satellite image for Field 1 and from the aligned four-band composite image for Field 2. A field boundary or an area of interest (AOI) was defined for each field and a normalized difference vegetation index (NDVI) image was created within the AOI 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). To accommodate the potential expansion and temporal variation of the disease, a 10-m buffer for Field 1 and a 3-m buffer for Field 2 around the infected areas were created as part of the treatment areas in the prescription maps.

Variable-rate Controller Adaption

For the Edroy study site, 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 GS 2 Display and the StarFire RTK GPS receiver already mounted on a John Deere 8230 tractor owned by a producer near Edroy, TX in 2015. A transparent flow divider was used to distribute the flow evenly to the shanks of a 12-row 0.965-m (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. In 2016, the tractor equipped with the variable-rate system was sold to another producer. The GS 2 Display was replaced with a John Deere GS 3 2630 Display.

For the San Angelo site, 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

1.016-m (40-in) planter. The T-band application method was used to apply the fungicide in a concentrated 7.6-10.2 cm (3-4 inch) wide band at planting perpendicular to the row direction. The system was used in 2015 and 2016.

Site-Specific Fungicide Application

Topguard Terra was applied at 0.585 L/ha (8 fl oz/ac) of product (full rate) with 56.1 L/ha (6 gal/ac) of water on the east half of Field 1 on March 18 and the west half on March 24, 2016 (Figure 1). Due to some rainfall on March 19 (one day after planting), the east half of the field had poor stand and was replanted on April 6. No fungicide was applied for replanting. For Field 2, Topguard Terra was applied also at 0.585 L/ha (8 fl oz/ac) of product with 56.1 L/ha (6 gal/ac) of water on June 14, 2016.

Figure 1. Site-specific Topguard Terra application (Y-shaped splitter) at planting in a field near Edroy, TX in 2016.

Results and Discussion

Figure 2 shows the color-infrared (CIR) composite image taken in 2009, a corresponding two-zone classification map, and a two-zone prescription map for Field 1. The infected plants had a greenish color, while the non-infected plants had a reddish tone. Approximately 11% of the field was infected in 2009. With a 10-m buffer added to the infected areas, about 37% of the field (green areas) was treated with Topuard Terra Fungicide. Figure 3 shows an airborne CIR image taken in 2010, a corresponding two-zone classification map, and a two-zone prescription map with a 3-m buffer for Field 2. About 37% of the field was infected in 2010, while 59% of the field was treated with the fungicide.

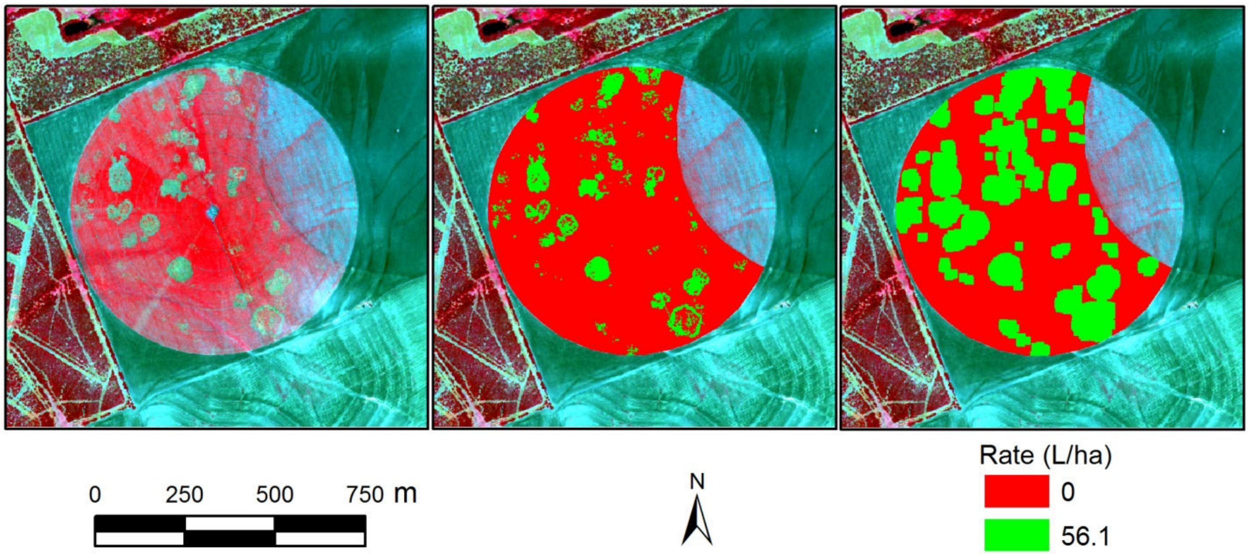

Figure 2. A color-infrared composite image (left), a corresponding two-zone classification map (center), and a prescription map (right) for a 41-ha (101-ac) cotton field near Edroy, TX (Field 1). The green areas in the prescription map were treated with Topguard Terra Fungicide at 0.585 L/ha (8 fl oz/ac) of product (full rate) with 56.1 L/ha (6 gal/ac) of water.

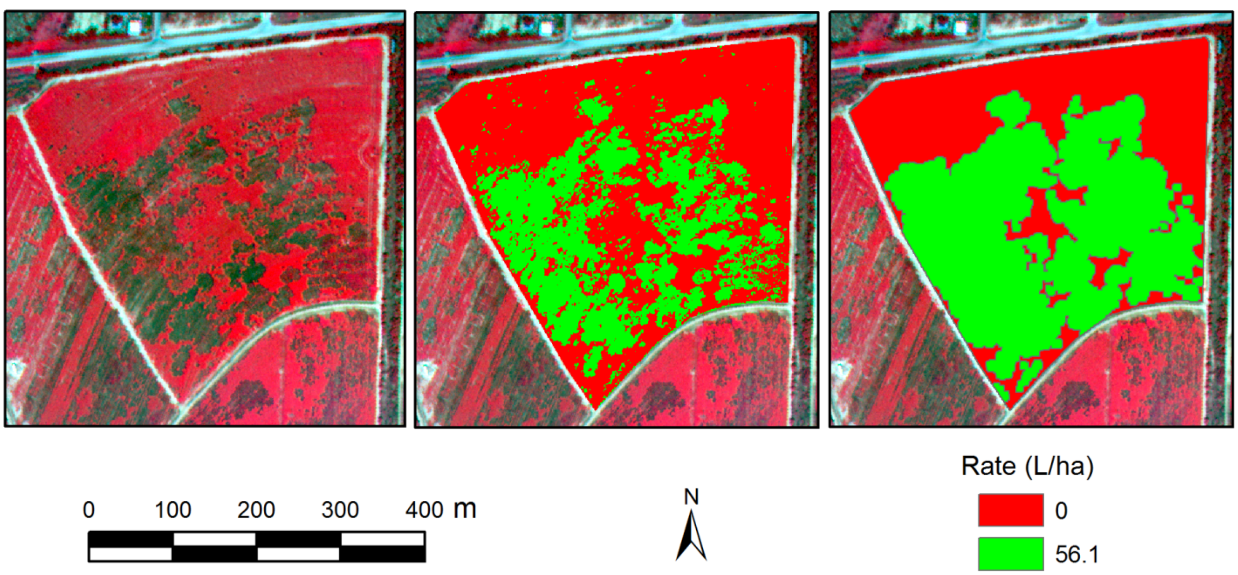

Figure 3. An airborne color-infrared image (left), a corresponding two-zone classification map (center), and a prescription map (right) for a 12-ha (30-ac) cotton field near San Angelo, TX (Field 2). The green areas in the prescription map were treated with Topguard Terra Fungicide at 0.585 L/ha (8 fl oz/ac) of product (full rate) with 56.1 L/ha (6 gal/ac) of water.

Figure 4 compares the GeoEye satellite CIR images on July 27, 2009 with natural infection, the as-applied map, and an airborne CIR image taken on July 20, 2016 with the site-specific treatment for Field 1. Clearly, the fungicide effectively controlled the disease in the treated areas, though root rot started showing up in a few treated areas toward the end of the growing season. This late infection did not cause a significant yield loss because most of the bolls were fully developed by that time. Figure 5 shows the airborne CIR images in 2010 and 2016 along with an as-applied map 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. As shown on the as-applied map, six swaths near the south portion of the field were not treated due to an equipment problem. Root rot occurred in these non-treated areas as shown by the dark gray tone on the CIR image. Small root rot patches were also seen in the treated areas toward the end of the season.

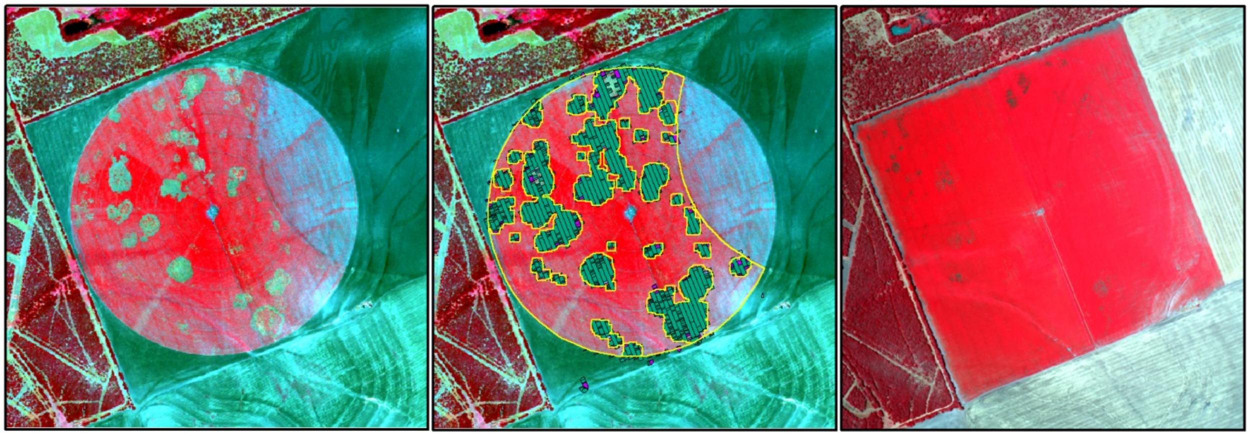

Figure 4. Comparison of GeoEye-1 satellite image acquired on July 27, 2009 with natural infection (left), as-applied map (center), and airborne image acquired on July 20, 2016 with site-specific treatment for a 41-ha (101-ac) cotton field (Field 1).

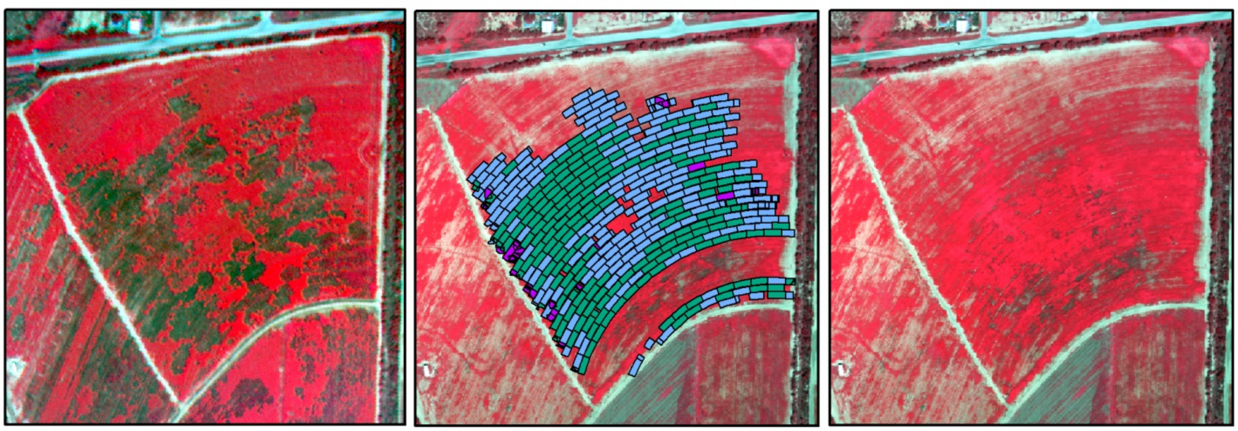

Figure 5. Comparison of airborne color-infrared images acquired September 27, 2010 with natural infection (left), as-applied map (center), and airborne image acquired on September 20, 2016 with site-specific treatment for a 12-ha (28-ac) cotton field near San Angelo, TX (Field 2).

Conclusions

Historical airborne and high-resolution satellite imagery can be a valuable useful data source for documenting root rot infection in cotton fields and can be used to generate prescription maps for site-specific management of cotton root rot. Variable-rate controllers can be adapted to existing planting machinery for implementing site-specific Topguard Terra fungicide application. Airborne imagery along with yield maps can be used to evaluate the performance and efficacy of site-specific treatments. Future research needs to focus on the performance and efficacy of site-specific fungicide treatments in terms of root rot occurrence and yield in treated and non-treated areas under different field management practices and environmental conditions.

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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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