USING AIRBORNE IMAGERY TO MONITOR COTTON ROOT ROT PROGRESSION IN FUNGICIDE-TREATED AND UNTREATED COTTON FIELDS

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Abstract

Cotton root rot (*Phymatotrichopsis omnivora*) is a serious and destructive disease that has affected cotton production in the southwestern and south central U.S. for over a century. Recent field studies have shown that Topguard fungicide (flutriafol) has considerable potential for controlling this disease. After approval of a section 18 exemption allowing use of Topguard for controlling cotton root rot in 2012, many Texas cotton growers used this product to treat fields historically infected with the disease. The objective of this study was to use airborne multispectral imagery to monitor the progression of cotton root rot infection in cotton fields treated or untreated with the fungicide. Airborne multispectral imagery with blue, green, red and near-infrared bands was taken of a number of infected fields in the Coastal Bend near Edroy, TX and the Southern Rolling Plains near San Angelo, TX multiple times during the 2012 growing season. These images were compared with the images taken in previous years to document the consistency and variability of the disease incidence over the years. Images taken from fields with fungicide-treated and untreated areas were used to illustrate the efficacy of Topguard for the control of the disease. Although dry weather conditions in 2012 made it difficult to assess the efficacy of the fungicide in dryland fields, the performance of the fungicide in irrigated fields was generally positive. As another Section 18 has been approved for use of the fungicide in Texas in 2013, the findings from this study, including the historical images, will be useful for identifying infected fields for whole-field and site-specific treatments and for assessing the efficacy of the fungicide in the coming years.

Introduction

Cotton root rot, also known as Texas root rot or Phymatotrichum root rot, is caused by the soilborne fungus *Phymatotrichopsis omnivora*. It is a serious and destructive disease affecting cotton production in the southwestern and south central U.S. and has plagued the cotton industry for more than 100 years. Cotton root rot is one of the most difficult plant diseases to control. In the last few years, intensive field experiments have shown that Topguard® fungicide (flutriafol) is able to control this disease (Isakeit et al., 2010, 2012). A section 18 exemption was approved for the 2012 season that allowed Texas cotton growers to use flutriafol at planting in their infected fields.

Topguard may need to be applied every year in order to suppress the disease. Treatment will be less expensive if only infected areas within a field are to be treated. The most effective strategy is to delineate the infected areas within the field so that variable rate technology can be used for more effective and economical control applications. Remote sensing is perhaps the only practical means for effectively mapping this disease because of large numbers of infected areas and their irregular shaped disease borders within cotton fields. Airborne multispectral imagery had been used to map infected areas near the end of the growing season in the Coastal Bend region near Edroy, TX from 1999-2002 (Yang et al., 2005). Since 2010, airborne multispectral imagery has been used to monitor the progression of the disease within and across growing seasons in the Coastal Bend region and the southern Rolling Plains near San Angelo, TX (Yang et al., 2011, 2012). This information is important to further our understanding of the development and progression of the disease. It can also be used to formulate the site-specific strategies for the

control of the disease. The objectives of this study were to use airborne multispectral imagery for monitoring the progression of cotton root rot infections within and across growing seasons and for assessing the efficacy of flutriafol for the control of the disease in 2012.

Materials and Methods

Study Sites

This research was conducted in the Coastal Bend near Edroy, TX and the Southern Rolling Plains near San Angelo, TX. A 20 km by 10 km rectangular area near Edroy and a 20 km by 10 km rectangular area near San Angelo were selected for this study. Each area covered the 12 study fields used in the previous years. A center-pivot irrigated semicircular field near Edroy (28°1'10.86"N, 97°42'49.22"W) was used to demonstrate the consistency and change of cotton root rot between 2002 and 2012. A drip-irrigated field near San Angelo (31°26'29.45"N, 100°22'17.72"W) and a center-pivot irrigated circular field near Edroy (28°5'23.61"N, 97°37'4.25"W) were used to illustrate the efficacy of Topguard fungicide for the control of this disease.

Airborne Multispectral Image Acquisition

A three-camera imaging system described by Escobar et al. (1997) was used to acquire images in 1999-2002. The system captured 8-bit images with 1024 × 1024 pixels in three spectral bands: green (555-565 nm), red (625-635 nm), and NIR (845-857 nm). A four-camera imaging system described by Yang (2012) was used to take images in 2009-2011. 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 2012. The system consists of two Canon EOS 5D Mark II digital cameras with a 5616 x 3744 pixel array (Canon USA Inc., Lake Success, NY). One camera captures normal color images with blue, green and red bands, while the other camera is equipped with a 720-nm long-pass filter to obtain near-infrared (NIR) images. Images from each camera are stored in 16-bit RAW and 8-bit JPEG files.

Airborne imagery was acquired from the center-pivot irrigated semicircular field near Edroy on 19 July 2002 and 25 July 2012, from the drip-irrigated field near San Angelo on 7 September 2012, and from the center-pivot irrigated circular field near Edroy on 25 July 2012. All images were acquired at altitudes of 3048 m (10000 ft) between 1130h and 1430h local time under sunny conditions. The ground pixel size achieved was 1.3 m in 2002 and 1.0 m in 2012.

Image Alignment and Rectification

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 Survey 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 RMS errors for rectifying the images were approximately 1-2 m. All images were resampled to 1 m resolution using the nearest neighbor technique. All procedures for image registration and rectification were performed using ERDAS Imagine (ERDAS Inc., Norcross, GA).

Image Classification

The rectified three-band and four-band images were classified into 2-12 spectral classes using ISODATA (Iterative Self-Organizing Data Analysis) unsupervised classification (ERDAS, 2010). The process began with arbitrary class means from the image statistics based on the number of classes specified. It repeatedly performed a classification and recalculated new class statistics, which were used for the next iteration. The process continued until the number of iterations reached 100 or the convergence threshold reached 1.00. The spectral classes in each classification map were then grouped into root rot-infected and non-infected zones by comparing with the original image and based on ground observations. The root rot-infected areas and non-infected areas were estimated from the best two-zone classification maps.

Fungicide Efficacy Assessment

Since 2012 was the first year when cotton growers in Texas were allowed to use Topguard fungicide (11.8% active ingredient flutriafol) to treat cotton root rot, applications made by producers varied in numbers of fields treated, types of fields treated (dryland or irrigated), and fungicide rates used (1.2-2.4 L/ha or 16-32 oz/ac). Producers generally didn't leave untreated areas within treated fields. The dry weather conditions were not favorable for the

fungicide's activity. These factors made it difficult to evaluate the efficacy of the fungicide. In this article, airborne images taken from two fields were used to illustrate the visual difference between treated and untreated areas.

Results and Discussion

Figure 1 shows the color-infrared (CIR) images acquired in 2002 and 2012 for the semicircular field (untreated) near Edroy, TX. On the CIR images, healthy plants showed a reddish-magenta tone, while infected plants had a greenish or cyanish color. Root rot-infected areas could be easily separated from the non-infected areas on the CIR images. Figure 2 shows the two-zone classification maps for both years for the field. The estimated percent root rot areas for the field were 14.6% in 2002 and 6.4% in 2012. The overall infection patterns between the two years were similar, but the infection in 2012 was not fully expressed, partly due to the dry weather conditions. Cotton root rot occurred in the same general areas within the field. This recurrent pattern of the disease was also found in many other fields (Yang et al., 2012)

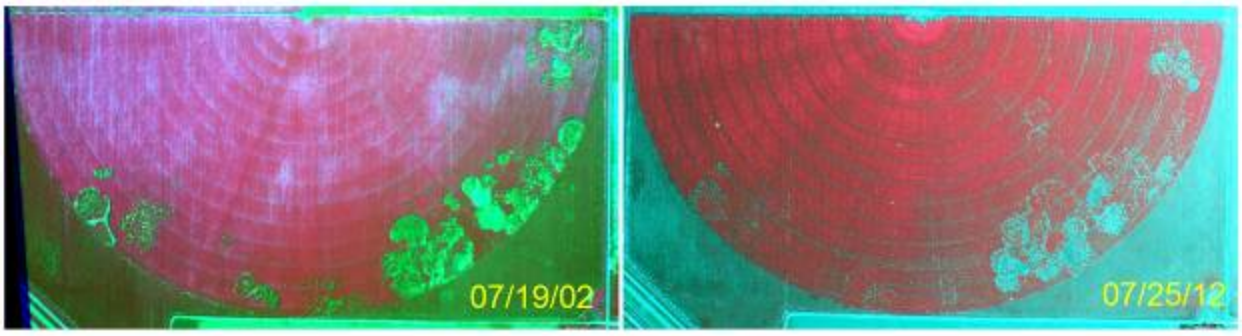

Figure 1. Airborne CIR images acquired in 2002 and 2012 from a 98-ha cotton field infected with cotton root rot near Edroy, TX.

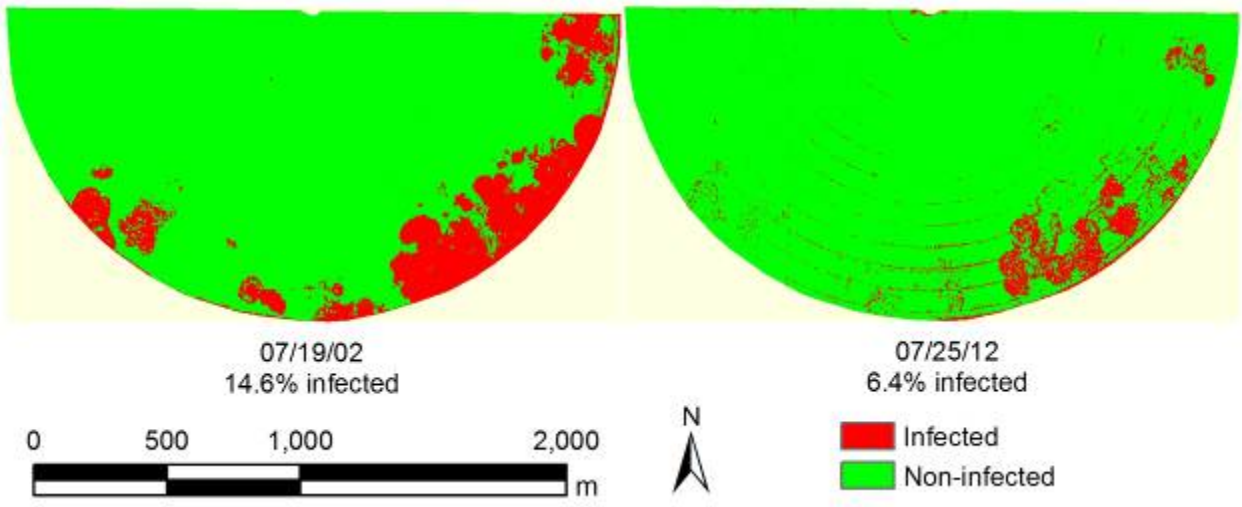

Figure 2. Two-zone classification maps for a 98-ha root rot-infected cotton field (untreated) near Edroy, TX.

Figure 3 shows a CIR image taken shortly before harvest from the drip-irrigated field near San Angelo, TX in 2010. A small rectangular area in the lower-left corner of the field was treated with Topguard when the fungicide was tested for the control of the disease. The plants in the treated area with a red color on the CIR image were healthy, while the plants in the untreated areas with a dark grayish color on the image died before harvest. Figure 4 shows a CIR image taken shortly before harvest from the center-pivot irrigated circular field near Edroy, TX in 2012. The entire field was treated with Topguard at 1.2 L/ha (16 oz/ac), except the sections within the two yellow box where no fungicide was applied.

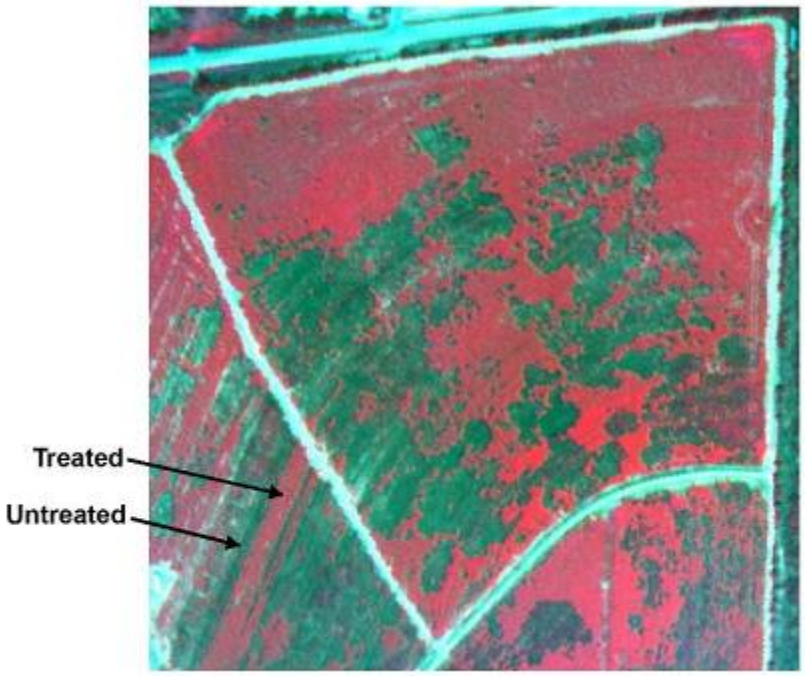

Figure 3. A CIR image showing the efficacy of Topguard fungicide in a cotton root rot-infected field near San Angelo, TX in 2010 when the fungicide was tested for the control of the fungus.

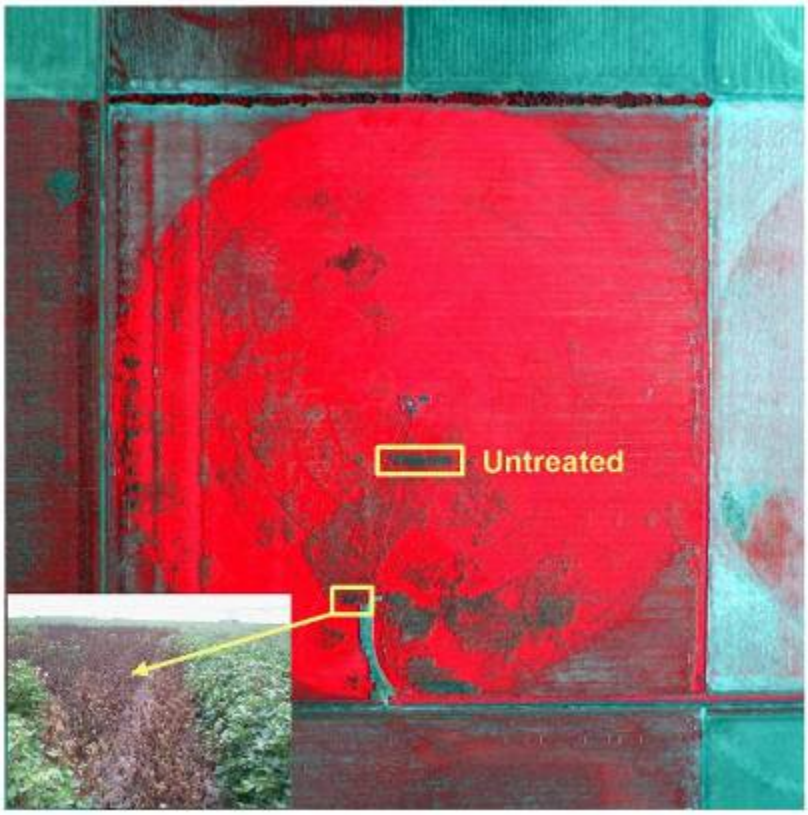

Figure 4. A CIR image showing the efficacy of Topguard fungicide in a cotton root rot-infected field near Edroy, TX in 2012 when a section 18 exemption was approved for use of the fungicide at planting in Texas in 2012.

In the CIR image, the two sections had a dark gray color. The ground photo confirmed the death of the plants in the lower section. The farmer did not notice cotton root rot in the lower-left portions of the field until near the end of the season since the fungicide delayed root rot infection. Although the fungus infected some of the treated plants later in the season, it did not cause large yield loss because most of the bolls were fully developed at the time of the infection. The farmer claimed that the area in the lower-left portion of the field produced about 1120 kg/ha (2 bales/ac) and the healthy area in the upper-right portion made about 1680 kg/ha (3 bales/ac). In comparison, the two sections where no fungicide was applied produced essentially no yield.

Figure 5 presents a normal color image showing a 4 km by 3 km cropping area near San Angelo, TX with both dryland and irrigated cotton fields that were treated or untreated with Topguard fungicide. Although it is difficult to evaluate the efficacy of the fungicide without the control or historical records, the fungicide was generally effective in controlling the disease or delaying the infection, especially in center-pivot irrigated fields.

Figure 5. A normal color image showing dryland and irrigated cotton fields treated or untreated with Topguard fungicide within a 4 km by 3 km area near San Angelo, TX in 2012

Conclusions

Airborne multispectral imagery was an effective tool for monitoring and mapping cotton root rot infection and progression within and across growing seasons. The disease tended to occur in the same general areas in recurring yeas, though other factors such as weather and cultural practices affected its severity. Aerial images of some fields taken in the last 12 years demonstrated remarkable consistency of infected areas. This recurrent pattern of cotton root rot incidence provides the producer with greater confidence on the use of aerial imagery for making treatment decisions.

Although Topguard can control cotton root rot, the historical and current aerial images helped confirm observations that many factors including weather and irrigation methods can affect the control results. The dry weather conditions in 2012 made it difficult to assess the efficacy of the fungicide in dryland fields, but the fungicide provided more consistent disease control in irrigated fields, especially under center-pivot systems. The findings from this study will be useful for identifying the most efficient fungicide application approaches needed in individual fields. Cotton root rot disease patterns in some cotton fields will essentially require whole-field fungicide applications, while others will require only site-specific treatments which will significantly reduce producer costs. More research is needed to assess the efficacy of flutriafol for controlling cotton root rot using new and historical images and ground-based technologies in a multidisciplinary approach in the coming years.

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Disclaimer

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