Monitoring Cotton Root Rot Infection in Fungicide-Treated Cotton Fields Using Airborne Imagery

Chenghai Yang, USDA-ARS, College Station, TX
Gary N. Odvody, Texas AgriLife Research and Extension Center, Corpus Christi, TX
Richard R. Minzenmayer, Texas AgriLife Extension, Ballinger, TX
Robert L. Nichols, Cotton Incorporated, Cary, NC
Thomas Isakeit, J. Alex Thomasson,
Texas A&M University, College Station, TX
Carlos J. Fernandez, Juan A. Landivar,
Texas AgriLife Research and Extension Center, Corpus Christi, TX

Abstract:

With authorization to use Topguard® fungicide on cotton in Texas in 2012 and 2013 through section 18 exemptions from registration, many growers used this product to treat their fields that had been historically infected with cotton root rot, caused by the soilborne fungus *Phymatotrichopsis omnivora*. The objectives of this study were to use airborne multispectral imagery to monitor the progression of cotton root rot infection in cotton fields treated with the fungicide and to assess the efficacy and performance of the fungicide treatments. Airborne multispectral imagery was taken from a number of treated cotton fields in the Coastal Bend near Edroy, TX and the Southern Rolling Plains near San Angelo, TX multiple times during the 2013 growing seasons. Temporal images revealed that the fungicide either completely controlled the disease within the season or delayed the initiation of the disease until near the end of the season. Comparison of images taken in 2013 with those under natural infection conditions in previous years showed that the fungicide with a rate of 2.34 L/ha (32 oz/acre) performed well in irrigated fields. The results from this study will be useful for assessing the efficacy of the fungicide and refining application methods and rates for optimal control of the disease.

Introduction:

Cotton root rot, caused by the soilborne fungus *Phymatotrichopsis omnivora*, is a serious and destructive disease affecting cotton production. Effective controls of cotton root rot in cotton (*Gossypium hirsutum*) were lacking until a commercial formulation of flutriafol

(Topguard® - Cheminova, Inc., Wayne, NJ) showed considerable promise for suppressing this disease in recent field studies (Isakeit et al., 2010, 2012). Section 18 exemptions were approved for the 2012 and 2013 growing seasons to allow Texas cotton growers to use the fungicide at planting for the control of the disease because the manufacturers were making acceptable progress toward registration and there are not effective alternative means of control.

Airborne multispectral imagery had been used to monitor the progression of cotton root rot infections in selected cotton fields near Corpus Christi and San Angelo, TX during the 2010-2012 growing seasons (Yang et al., 2011, 2012). Image data and ground observations showed that yearly initiation and spread of the disease typically emanates from the same sites within a field with seasonal variability in extent that is partially due to such environmental factors as weather and moisture conditions. This recurrent pattern of cotton root rot incidence provides the producer with confidence to use aerial imagery for making treatment decisions.

Aerial imagery has proven to be an accurate and effective method to record cotton root rot infections in cotton fields (Yang et al., 2010, 2013). The images can be used to map the extent of the damage and estimate infected areas within fields and help producers make fungicide application decisions to control this disease. Generally, only portions of the field are infected, so it is probably not necessary to treat the whole field. Therefore, it is important to define the infected areas and understand the seasonal spread of the disease within fields so that variable rate technology can be used to apply the fungicide only to the infected areas for more effective and economical control.

With section 18 exemptions and eventual registration of the fungicide to control cotton root rot, research is needed to assess the performance and efficacy of fungicide treatments under diverse growing conditions. The objectives of this study were to use airborne multispectral imagery to monitor the progression of this disease under flutriafol-treated conditions and to assess the performance of fungicide treatments.

Materials and Methods:

Study Sites

This research was conducted in a 30 km by 12 km rectangular area near Edroy, TX and a 30 km by 10 km rectangular area near San Angelo, TX. Each area covered the 12 study fields that were also used in 2010-2012. Data from three of the fields were presented and analyzed in this paper. A flutriafol-treated circular field near Edroy (27°58'19"N, 97°42'29"W), designated Field 1, was used to illustrate the progression of cotton root rot within the growing season in 2013. Field 1 and another treated semicircular cotton field near San Angelo (31°26'42"N, 100°16'49"W), designated as Field 2, were used to demonstrate the efficacy of the fungicide for the control of this disease. A third circular field near Edroy (28° 5'23"N, 97°37'4"W), designated as Field 3, was used to illustrated the effect of a reduced rate in 2013 from the full rate in 2012 on the control of the disease. These fields were center-pivot irrigated and had a history of cotton root rot.

Airborne Multispectral Image Acquisition

Images used in this paper were acquired in 2001, 2011, 2012, and 2013. Three different imaging systems were involved. A three-camera imaging system described by Escobar et al. (1997) was used to acquire images of Field 1 in 2001. The system captured 8-bit images with 1024 × 1024 pixels in three spectral bands: green (555-565 nm), red (625-635 nm), and near-infrared (NIR) (845-857 nm). A four-camera imaging system described by Yang (2012) was used to take images of Fields 1 and 2 in 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 NIR (810-850 nm). A two-camera imaging system was used to take images in 2012 and 2013. The system consisted of two Canon EOS 5D Mark II digital cameras with a 5616 x 3744 pixel array (Canon USA Inc., Lake Success, NY). 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 near-infrared (NIR) images. Images from each camera were stored in 16-bit RAW and 8-bit JPEG files. All the imaging systems were flown at altitudes of 3048 m (10000 ft) and pixel size achieved was approximately 1.3 m in 2001 and 1.0 m in 2011-2013.

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 root mean square (RMS) errors for rectifying the images were within 1-2 m. All images were resampled to 1 m resolution using the nearest neighborhood technique. All procedures for image registration and rectification were performed using ERDAS Imagine (Intergraph Corporation, Madison, AL).

Image Classification

The rectified three-band and four-band images were classified using ISODATA (Iterative Self-Organizing Data Analysis) unsupervised classification (ERDAS, 2010). The spectral classes in each classification map were then grouped into root rot-infected and non-infected zones. The root rot-infected areas and non-infected areas were estimated from the best two-zone classification maps.

Fungicide Treatments

Cotton growers in Texas were allowed to use Topguard fungicide (11.8% of 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 application rates from 1.17 to 2.34 L/ha (16-32 oz/acre). Producers generally treated their fields uniformly since variable rate application equipment and prescription maps were not readily available. Fields 1 and 2 received a full rate of 2.34 L/ha, while Field 3 received 2/3 of the full rate.

Results and Discussion:

Figure 1 shows the color-infrared (CIR) images of Field 1 on four different dates during the 2013 growing season. Root rot was not detected until the imaging dates near the end of the growing season. Since root rot in the infected areas occurred when the bolls on the plants were established, it only had a small effect on yield. This field has been historically affected by cotton root rot. Figure 2 presents the CIR images acquired in 2001 and 2011 for the field. The estimated percent root rot areas for the field were 17.0% in 2001 and 17.5% in 2011. The overall infection patterns between the two years were similar, though there were changes in the locations of infected areas. A change detection analysis showed that 9.0% of the field was infected in both years, while 8.0% of the field was infected only in 2001 and 8.5% only in 2011 in addition to the common infection areas. Thus, a total of 25.5% of the field was infected in either 2001 or 2011 (Yang et al., 2012).

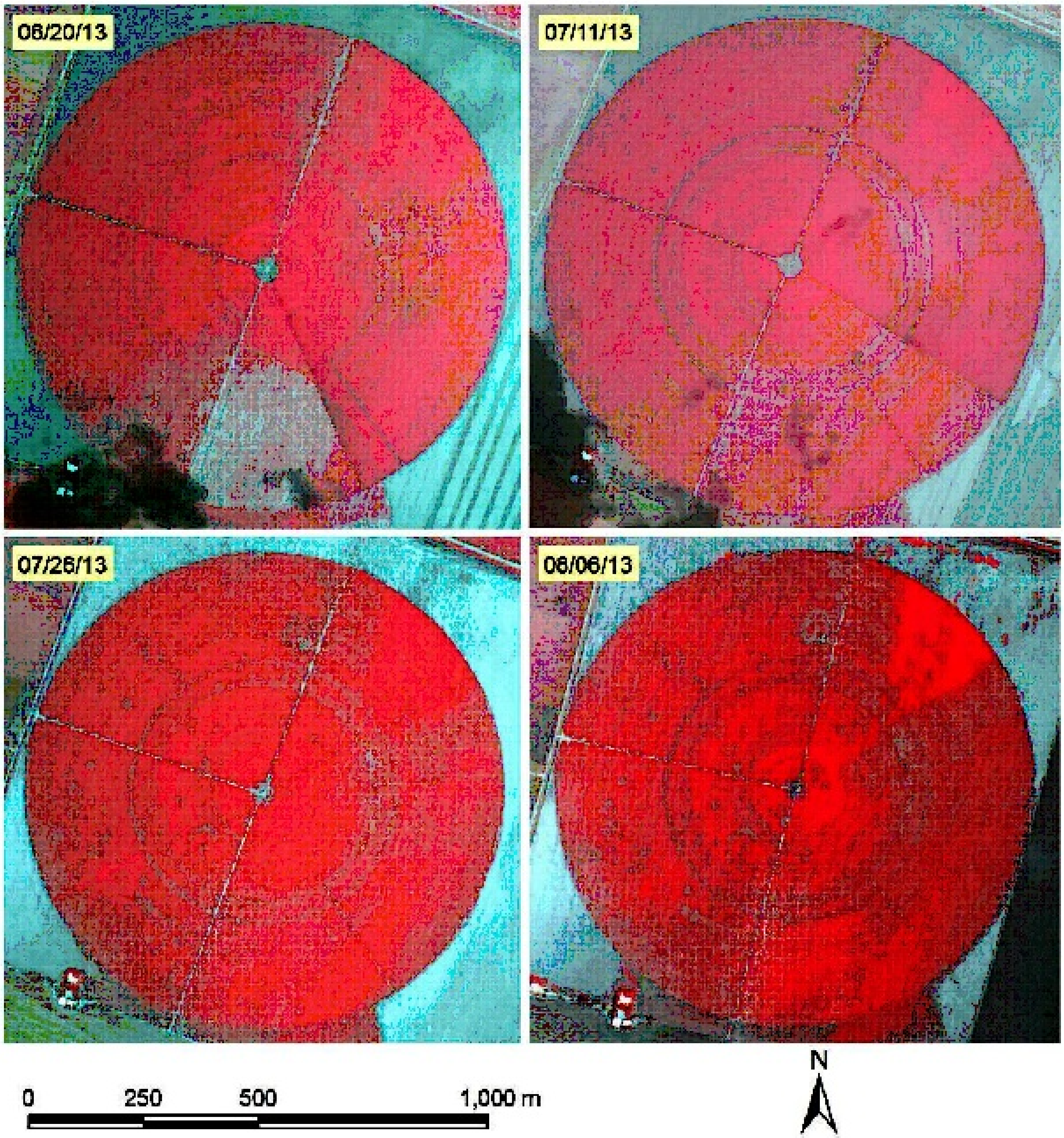

Figure 1. Airborne CIR images acquired on four dates during the 2013 growing season for a 102-ha cotton field near Edroy, Tx (Field 1) treated with flutriafol at 2.34 L/ha (32 oz/acre).

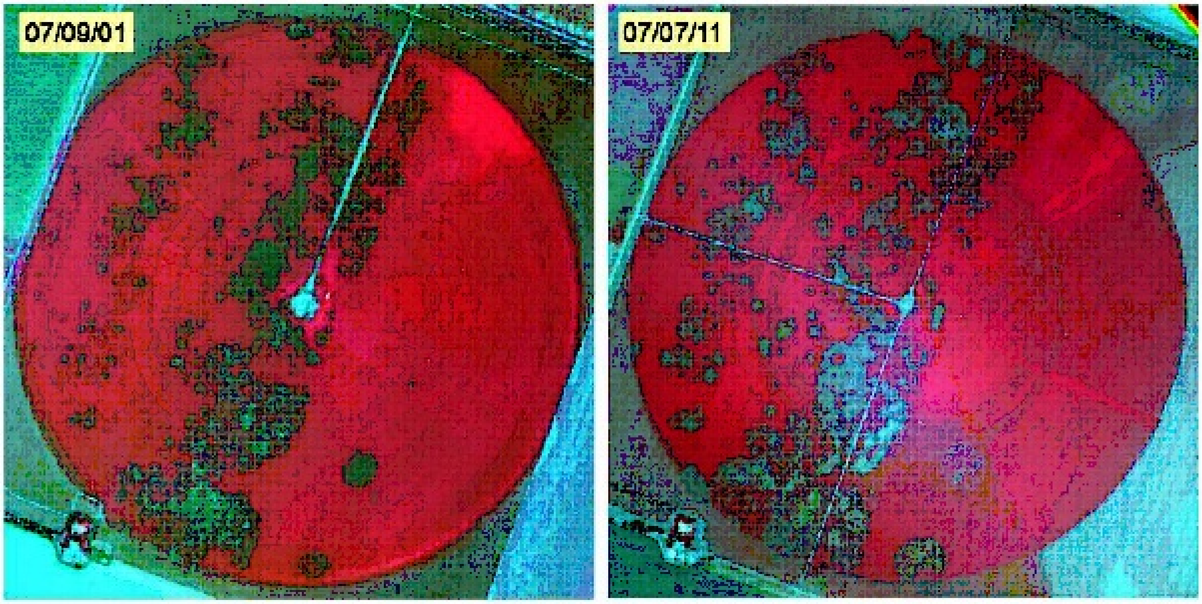

Figure 2. Airborne CIR images acquired in 2001 and 2011 for a 102-ha cotton field near Edroy, Tx (Field 1) with natural root rot infection.

Figure 3 shows a CIR image of Field 2 acquired near the end of the 2011 growing season and its classification map. A CIR image of the field acquired near the end of the 2013 season is also shown on the figure. There was no fungicide treatment in 2011 and the classification map indicates that 36% of the field was infected. The field was treated with flutriafol at a rate of 2.34L/ac in 2013 and no root rot was found. The stress shown on the lower left and right corners of the field was due to lack of moisture. Clearly, the fungicide treatment performed excellently for this field. In comparison, Field 1 may have required a slightly higher rate to completely suppress the fungus for the growing season.

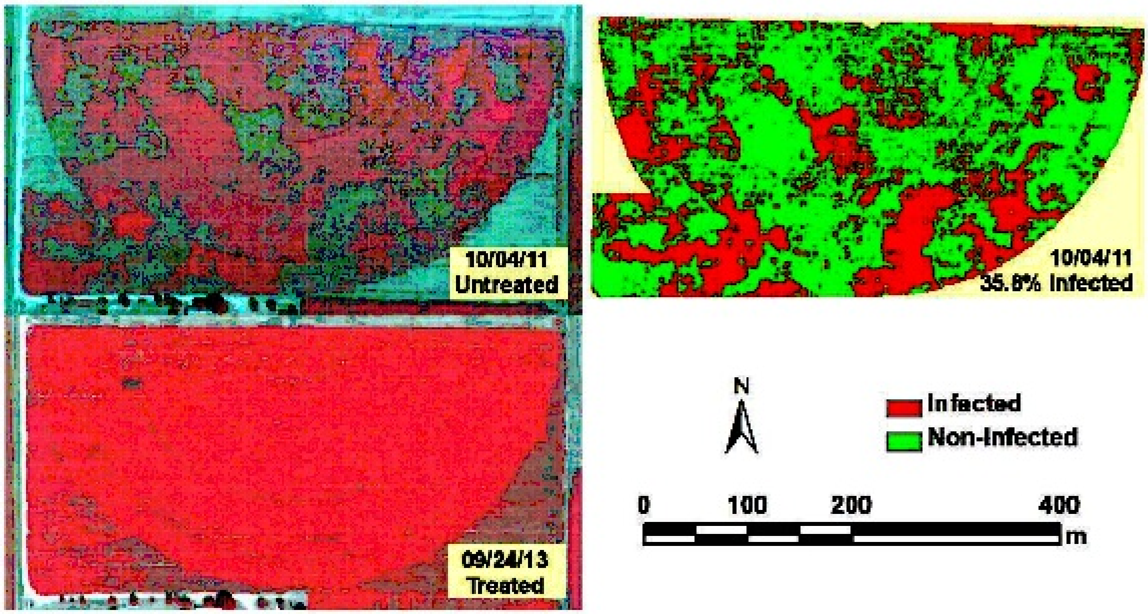

Figure 3. Airborne CIR images acquired in 2011 and 2013 and a classification map of the 2011 image for an 11-ha cotton field near San Angelo, Tx (Field 2) showing the effect of a flutriafol treatment at 2.34 L/ha (32 oz/acre).

Figure 4 shows CIR images of Field 3 taken shortly before harvest in 2012 and 2013. The field was treated with flutriafol at the full rate of 2.34 L/ha in 2012. The treatment suppressed the fungus for most portions of the field in 2012, even though the lower-portions of the field were infected toward the end of the season. The farmer did not even notice the root rot infection since the fungicide delayed the initiation of the disease until shortly before defoliation. This late infection did not cause any significant yield loss because most of the bolls were fully developed by that time. For the 2013 growing season, the farmer reduced the application rate to about 2/3 of the full rate (1.46 L/ha). However, more portions of the field were infected, including the upper portions of the field, where very little root rot was found. Therefore, a reduced rate didn't work effectively for the field and a higher rate would be necessary to control the disease.

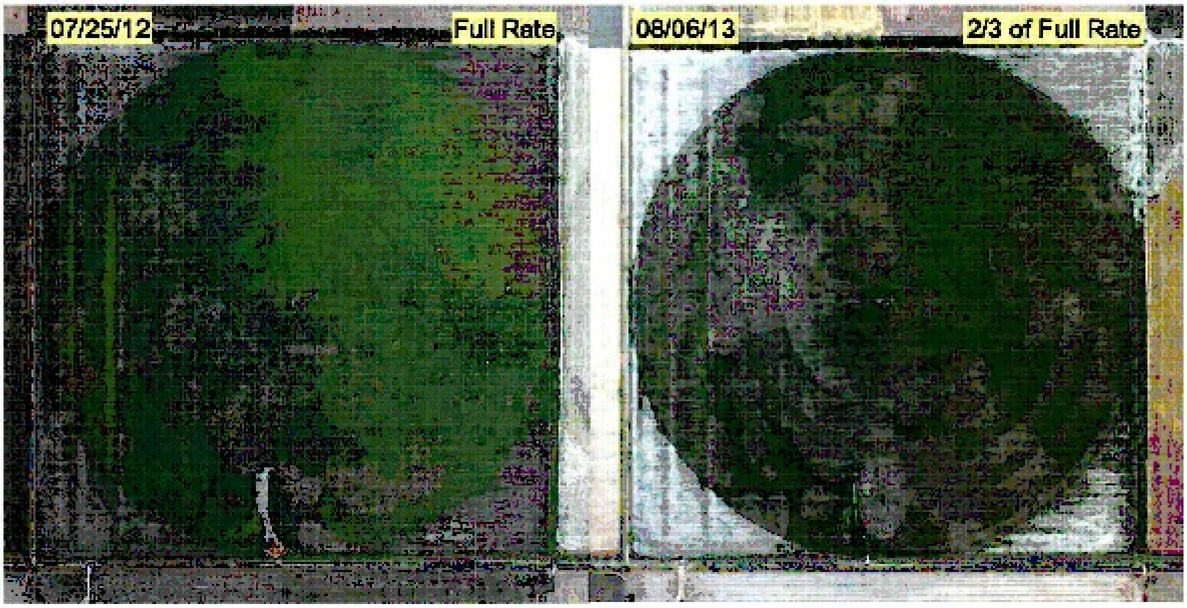

Figure 4. Normal color images showing the effect of flutriafol treatments in a center-pivot irrigated circular cotton field near Edroy, Tx (Field 3) in 2012 and 2013. The rate was 2.34 L/ha)32 oz/acre) in 2012 and 1.46 L/ha (20 oz/acre) in 2013.

Figure 5. A CIR image showing dryland and irrigated cotton fields treated or untreated with flutriafol within a 5.6 km by 3.7 km area near San Angelo, Tx in 2013.

Figure 5 shows one single CIR image covering a 5.6 km by 3.7 km area within the San Angelo study area. Both dryland and irrigated fields treated or untreated with flutriafol are shown in the image. The semi-circular field near the center of the image is Field 2. Flutriafol appeared to be an effective fungicide for cotton root rot. The response of fungicide treatments was more consistent in irrigated fields than in dryland fields as both the fungus and the fungicide need moisture to be active. A section 18 again has been granted to Texas for 2014 and a full registration from the U.S. Environmental Protection Agency is expected this year. Cotton Incorporated will continue to fund the research with more emphasis on regional evaluation of treatment efficacy and practical image-based site-specific treatment plans in the future.

Conclusions:

Airborne multispectral imagery is an effective tool not only for monitoring and mapping cotton root rot infection and progression within and across growing seasons, but also for assessing the performance and efficacy of fungicide treatments. Imaging data in 2012 and 2013 indicate that Topguard (flutriafol) is an effective fungicide for the control of this disease. However, other factors such as weather conditions can affect the performance of the fungicide. The recommended full application rate worked well for many of the fields we studied, though the optimal rate may vary with field and other growing conditions. More research is needed to refine the application methods and rates for both dryland and irrigated fields.

Historical image data have shown that cotton root rot tends to occur in the general same areas within a field over recurring yeas, though other factors such as weather and cultural practices may affect its initiation and severity. This recurrent pattern of cotton root rot incidence provides the producer with greater confidence to use aerial imagery for making either uniform or site-specific treatment decisions.

With the section 18 exemptions in the last two years, producers generally treated their fields uniformly as variable rate application equipment and prescription maps were not readily available. Some severely infected fields may justify a uniform flutriafol application, while most fields only need a partial treatment. To implement the site-specific management of cotton root rot, more research is needed to develop practical procedures for generating prescription maps from image data (including buffer zone creation to accommodate the potential variation of the infection), adapt variable-rate control components and systems to existing applicators for site-specific application, and assess the performance and efficacy of site-specific treatments (including identifying skipped areas and newly infected areas), and perform economic analysis. As the fungicide is expected to be registered to control cotton root rot, more research should be focused on refining the application methods and rates, developing practical methodologies for site-specific management of the disease, and assessing the performance and economic benefits of site-specific treatments on individual fields, over a farm and across a region.

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