USING AIRBORNE IMAGERY TO MONITOR COTTON ROOT ROT INFECTION BEFORE AND AFTER FUNGICIDE TREATMENT

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ABSTRACT

Cotton root rot is a severe soilborne disease that has affected cotton production for over a century. Recent research has shown that a commercial fungicide, flutriafol, has potential for the control of this disease. To effectively and economically control this disease, it is necessary to identify infected areas within the field so that variable rate technology can be used to apply fungicide only to the infected areas. The objective of this study was to use airborne imagery to monitor cotton root rot infection in cotton before and after fungicide treatment to the soil. A 105-ha irrigated cotton field with a historically consistent spatial pattern of infection was selected for this study. Airborne multispectral imagery with visible and near-infrared wavebands was taken from the field in 2001 and 2011 under natural root rot infection and again in 2013 with uniform flutriafol treatment at planting. The imagery was rectified and then classified into infected and noninfected zones using unsupervised classification. The classification results showed that the fungicide treatment reduced root rot infection from approximately 17% in both 2001 and 2011 to less than 2% in 2013. Although overall spatial patterns of infection between 2001 and 2011 were similar, there were slight 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. Thus a total of 25.5% of the field was infected in either 2001 or 2011. Change detection also showed that the infection in 2013 occurred within the infected areas in either 2001 or 2011, indicating a higher rate of fungicide may be needed to more effectively control the fungus with the season. Results from this study demonstrate that airborne multispectral imagery in conjunction with image classification techniques can be a useful tool not only for detecting and mapping cotton root rot infection, but also for assessing the efficacy of fungicide treatments and for optimizing site-specific treatment plans.

Keywords: Airborne imagery, cotton root rot, fungicide treatment, image classification, change detection.

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 2012-2014 growing seasons to allow Texas cotton growers to use the fungicide at planting for the control of the disease.

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 2010-2013 growing seasons (Yang et al., 2012, 2014). 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). 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.

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.

METHODS

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 between 2010 and 2013. Each area covered 12 study fields. One 102-ha center-pivot irrigated field near Edroy (27°58′19″N, 97°42′29″W) with image data in 2001, 2011 and 2013 was used in this paper. Images were collected with natural cotton root rot infection in 2001 and 2011 and with fungicide treatment in 2013. The field was uniformly treated with Topguard fungicide (11.8% of active ingredient flutriafol) at an application rate of 2.34 L/ha (32 oz/acre).

Images from the field were acquired using three different imaging systems. A three-camera imaging system described by Escobar et al. (1997) was used to acquire images 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 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 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 and 2013.

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).

The rectified three-band in 2001 and four-band images in 2011 and 2013 were classified using ISODATA (Iterative Self-Organizing Data Analysis) unsupervised classification (Intergraph Corporation, 2013). 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.

RESULTS AND DISCUSSION

Figure 1 presents the color-infrared images acquired in 2001 and 2011 for the field. On the CIR images, non-infected plants showed a reddish-magenta tone, while infected plants had a cyanish or greenish color. Root rot-infected areas could be easily separated from the non-infected areas on the CIR images. 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). To accommodate the potential variation of the infection, if we expand the combined map by 1-2 m around the infected areas, about 33-38% of the field should be treated.

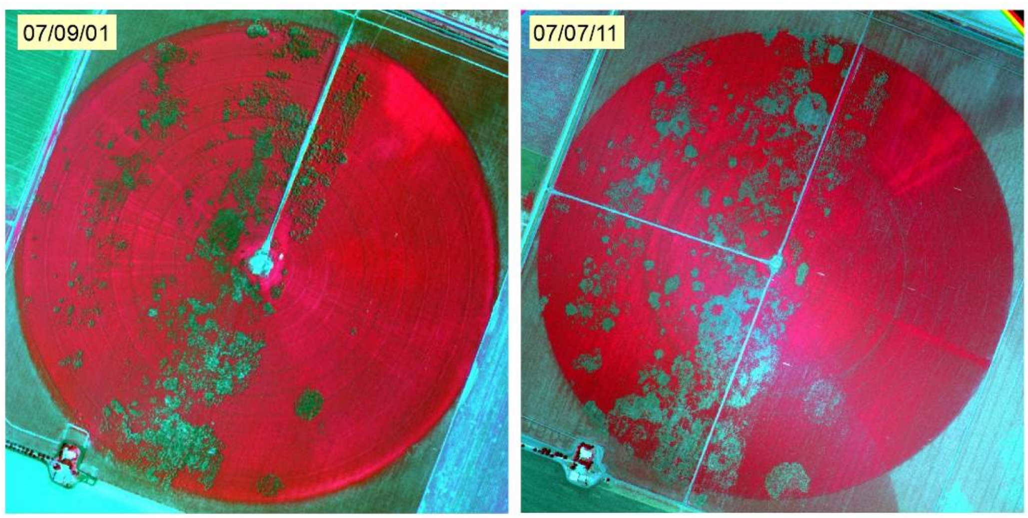

Fig. 1. Airborne color-infrared images acquired in 2001 and 2011 for a 102-ha cotton field with natural root rot infection.

Figure 2 shows the CIR images of the field on four different dates during the 2013 growing season. Root rot was not detected until near the end of the growing season on July 26 and August 6. Image classification showed that the infected areas in 2013 were less than 2% of the total area. Since cotton root rot in the infected areas occurred late in the season when the bolls on the plants were already established, it only had a relatively small effect on yield.

With the section 18 exemptions in the last three 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, such as the one in this example, only need a partial treatment. As the fungicide is expensive, site-specific treatment will be very beneficial.

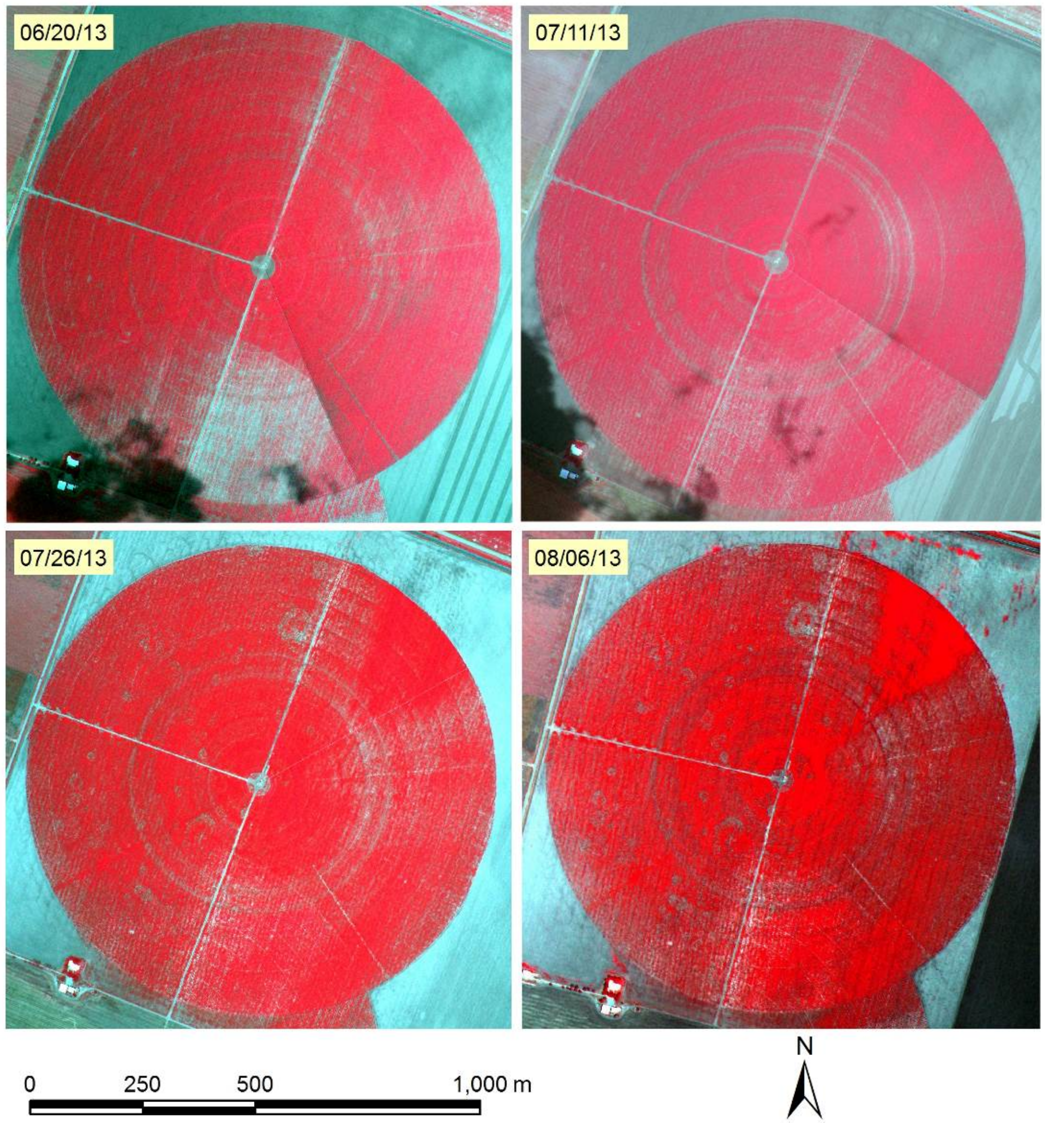

Fig. 2. Airborne color-infrared images acquired on four dates during the 2013 growing season for a 102-ha cotton field treated with flutriafol at a rate of 2.34 L/ha (32 oz/acre).

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 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 application rate worked well for the field and many other 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.

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, adapt variable-rate control components and systems to existing applicators for site-specific application, and assess the performance and efficacy of site-specific treatments, and perform economic analysis. As the fungicide is expected to be registered to control cotton root rot soon, 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.

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