USING MOSAICKED AIRBORNE IMAGERY TO ASSESS COTTON ROOT ROT INFECTION ON A REGIONAL BASIS

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Abstract

Cotton root rot is a serious and destructive disease in many of the cotton production areas in Texas. Since 2012, many cotton growers in Texas have used the Topguard fungicide to control this disease in their fields under Section 18 emergency exemptions. Airborne images have been used to monitor the progression of this disease and the performance of fungicide treatments in south and central Texas in the last few years. The objective of this study was to develop methods and procedures to mosaic individual airborne images taken over a cotton growing area as one single image to assess the extent and severity of cotton root rot infection in fungicide-treated and nontreated fields on a regional basis. Airborne RGB and near-infrared (NIR) images taken from a 13 km by 32 km (8 mi by 20 mi) area in San Angelo, TX near the end of the 2013 growing season were used for this study. The images were taken at 3050 m (10000 ft) above ground level and each image had a pixel array of 5616 x 3744 covering a ground area of 5.5 km by 3.6 km (3.4 mi by 2.3 mi) with a pixel size of 1.0 m. Images were taken along three flight lines with 30% sidelap and 30-60% forward overlap. Procedures were developed to create a mosaicked four-band image from individual RGB and NIR images. The mosaicked image clearly showed the distribution and severity of root rot-infected fields within the imaging area. The image will be useful for both growers and county agents to assess the effectiveness of the fungicide control program and make management decisions for more effective control of the disease on a regional basis.

Introduction

Cotton root rot, caused by the soilborne fungus *Phymatotrichopsis omnivora*, has plagued the cotton industry for over a century. Recent field studies have shown that the fungicide flutriafol (Topguard, Cheminova, Inc., Wayne, NJ) is able to control the disease (Isakeit et al., 2012). Therefore, Section 18 exemptions have been granted to allow Texas cotton growers to use the fungicide at planting for the control of the disease since 2012, and many cotton growers in Texas have used this product to treat their fields. As a result, root rot infection has been significantly reduced or completely eliminated in treated fields (Yang et al., 2014b). However, since the fungus is deep in the soil, infected fields need to be treated every year to suppress the disease. Generally, only portions of the field are infected, so it will become less expensive if only infected areas within the field are treated.

With the support of Texas State Support Committee and/or Cotton Incorporated since 2010, USDA and Texas A&M University researchers have been monitoring and mapping the progression of cotton root rot within and across growing seasons in the coastal Bend and Southern Rolling Plains areas of Texas using aerial imagery and ground measurements. The results from the last four years along with the image data we collected from 2000 to 2002 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., 2014a, 2014b). This recurrent pattern of cotton root rot incidence should provide the producer with greater confidence to use aerial imagery for making site-specific treatment decisions.

With the advances of imaging technology, a single airborne image can cover a large geographic area and still provide high spatial resolution. The objective of this study was to develop methods and procedures to mosaic individual images taken over a continuous area as one single image to assess the extent and severity of cotton root rot infection in fungicide-treated and nontreated fields on a regional basis.

Materials and Methods

This study was conducted in a 13 km by 32 km (8 mi by 20 mi) rectangular area near San Angelo, TX. The study area covered 12 study fields from which airborne imagery was collected in 2010-2014. The center coordinates of the study area are (31°24′12″N, 100°14′00″W).

A two-camera imaging system mounted on a Cessna 206 aircraft was used to take continuous images from the study area in 2013 and 2014. 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. Both cameras had a pixel array of 5616 × 3744 and stored images in 14-bit RAW (CR2) and 8-bit JPEG format. The images were captured at 3050 m (10000 ft) above ground level covering a ground area of 5.5 km by 3.6 km (3.4 mi by 2.3 mi) with a pixel size of 1.0 m. To achieve 30% sidelap and 30-60% forward overlap, images were taken along three flight lines spaced at 3840 m (12600 ft). Figure 1 shows the geotagged color images (thumbnails) taken on September 24, 2014 plotted in Google Earth (Google Inc., Mountain View, CA).

Figure 1. Geotagged color images (thumbnails) plotted in Google Earth. The images were acquired at 3048 m (10000 ft) above ground level near San Angelo, TX on September 24, 2014.

A total of 108 pairs of color and NIR images were acquired and only 56 of them were selected to provide sufficient forward overlap, while minimizing the load of image processing. A number of processing steps were performed on the images before they were mosaicked into a single multispectral image. These steps include vignetting removal and conversion of raw image files to Tiff format, pre-processing of images for image registration, registration of the NIR band image to the standard color image, stacking the registered NIR image with the color image to create a four-band image, georeferencing each four-band image using ground control points derived from Google Earth, pre-processing of georeferenced images for mosaicking, and mosaicking the images. Each of these steps involved using one or more software packages including Digital Photo Professional (Canon USA Inc., Lake Success, NY), Picasa Google Inc., Mountain View, CA), Google Earth, and ERDAS Imagine (Intergraph Corporation, Madison, AL).

Based on different color correction methods and overlap functions used in the mosaicking procedure, eight different mosaicked images were generated. Color corrections adjust the display and pixel values of images in order to correct for any imbalances in color or light between the overlapping images. The two correction methods used were color balancing, where the colors in each image are balanced with regard to other images included in the mosaic, and histogram matching, where the histogram of each image is adjusted to make them more similar. Overlap functions are for prescribing how pixel values are assigned for areas where images overlap. Two overlay functions, overlay and feather, were used. The overlay function uses the pixels from the image loaded last, which is on the top of the stack order, for the mosaicked image, and the feather function uses a linear interpolation of pixels in the overlap area. The eight mosaicked images were created using no color correction and the overlay function, no color correction and the feather function, histogram matching and the overlay function, histogram matching and the feather function, color balancing and the overlay function, color balancing and the feather function, histogram matching and color balancing with the overlay function, and histogram matching and color balancing with the feather function.

Results and Discussion

The root mean square (RMS) errors for registering the NIR band images to the RGB images ranged from 0.1 to 0.7 pixels with an average of 0.3 pixels using second-order transformations based on nine control points, indicating that the NIR and RGB images were well aligned with an error less than one pixel. The RMS errors for georeferencing the registered four-band images based on nine control points extracted from Google Earth ranged from 2.8 to 7.2 m with an average of 4.3 m using second-order transformations.

Figure 2 shows the mosaicked image with no color correction and the simple overlay function. The image appears patchy in the overlapping areas. Although the feather function was able to smooth the patch appearance in overlapping areas, the mosaicked image still doesn't look continuous and there are two apparent dividing lines along the flight line direction around the overlapping areas.

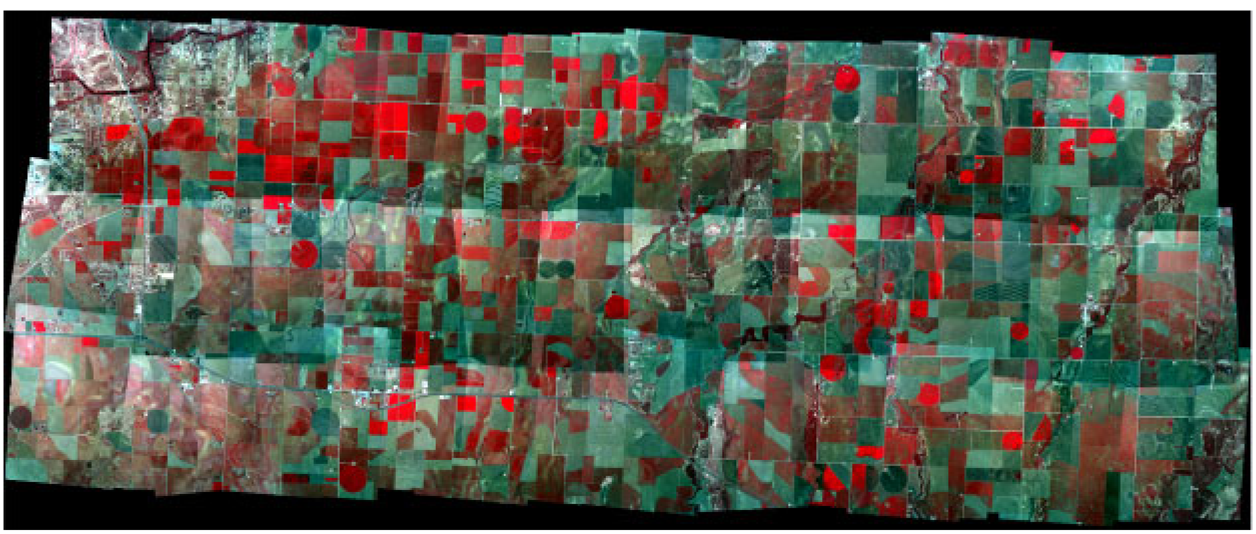

Figure 2. A mosaicked image generated with no color correction and a simple overlay function for a 13 km by 32 km (8 mi by 20 mi) cropping area near San Angelo, TX.

Figure 3 shows the mosaicked image with color balancing and the feather function. The image looks continuous and there are no obvious artifacts as a whole. Histogram matching could improve the appearance of the mosaicked image, but it was not as effective as color balancing. Mosaicked images generated with color balancing and histogram matching look similar to those with color balancing alone. Therefore, the combination of color balancing and the feather function was sufficient for image mosaicking.

Figure 3. A mosaicked image generated with color balancing and a feather function for a 13 km by 32 km (8 mi by 20 mi) cropping area near San Angelo, TX.

With the mosaicking image, a farmer can quickly see all his/her fields and zoom in to any particular field to assess its conditions, and a county agent can evaluate the overall distribution and severity of the root rot infection and the performance of the treatments on a regional basis.

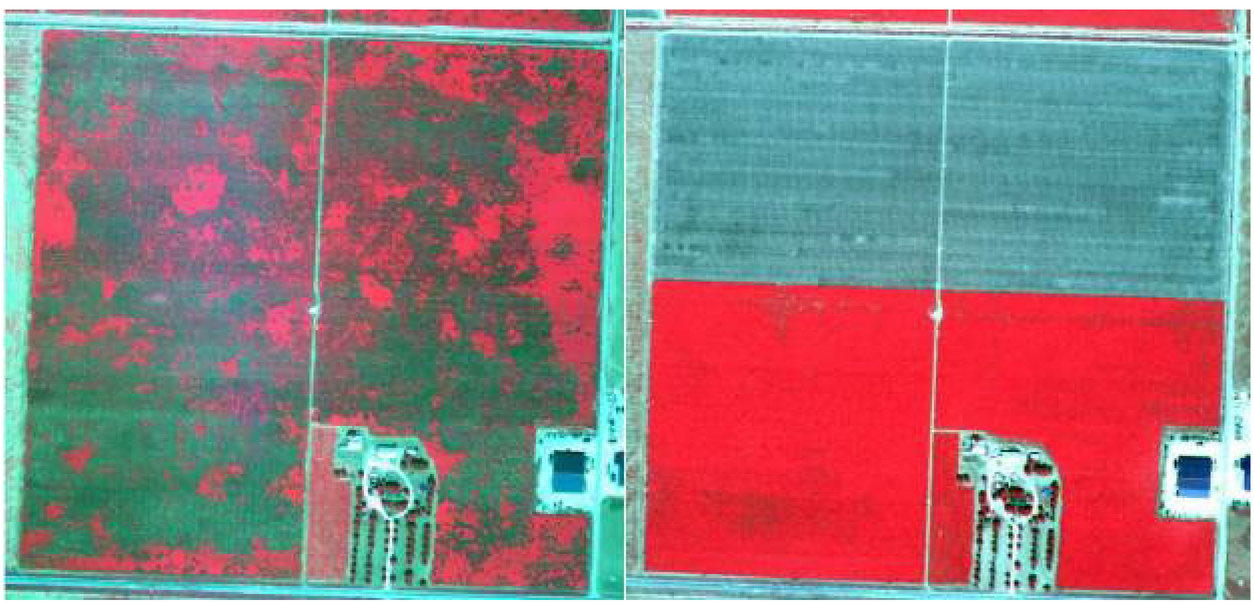

Figure 4. Airborne CIR images acquired in 2010 with natural root rot infection (left) and in 2013 with flutriafol treatment (right) for a cotton field near San Angelo, TX (Field 3).

Figure 4 shows CIR images of a cotton field taken shortly before harvest in 2010 (left) and 2013 (right). The field had natural root rot infection in 2012 and was treated with flutriafol at the full rate of 2.34 L/ha (32 oz/acre) in 2013. The treatment completely suppressed the fungus in the field for the growing season.

Figure 5 shows one single RGB image centered at (31°27′12″N, 100°15′45″W) between Fields 6 and 7 as shown in Figure 1. The image was acquired at 1830 m (6000 ft) above ground level on October 2, 2014 with a ground cover of 3.3 km by 2.2 km (2.0 mi by 1.4 mi). Both dryland and irrigated fields treated or untreated with flutriafol are shown in the image. Flutriafol appeared to be effective for the control of 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. The rectangular field near the upper central portion of the area didn't seem to be treated. The infected areas can be clearly seen in the color image.

Figure 5. A RGB color image showing dryland and irrigated cotton fields treated or untreated with flutriafol within a of 3.3 km by 2.2 km (2.0 mi by 1.4 mi) area near San Angelo, TX in 2014.

Summary

The procedures and methods developed in this study can be used to generate mosaicked images from multiple images taken from continuous areas. Mosaicked images will allow both growers and county agents to evaluate the overall distribution and severity of the root rot infection over their farms or on a regional basis. They will also be useful for assessing the effectiveness of the fungicide control program and making management decisions for more effective control of the disease.

The most time consuming part of the image mosaicking process is image registration and georeferencing. Apparently, high resolution satellite imagery will be more appropriate and effective if large areas need to be imaged. However, it is not always easy to obtain satellite images over a desired target area at a specified time period due to satellite orbits, competition for images at the same time with other customers, and weather conditions. We were not able to obtain WorldView 2 high resolution satellite imagery from the study area within a one-month period before harvest in 2012 or in 2013. Despite its limitations, airborne imagery remains to be a useful image source due to its relatively low cost, high spatial resolution, easy deployment and near-real-time availability for visual assessment and analysis.

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Disclaimer

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