EARLY DETECTION OF SPIDER MITES IN COTTON USING MULTISPECTRAL REMOTE SENSING

G. J. Fitzgerald, S. J. Maas and W. R. DeTar
USDA-ARS
Shafter Research and Extension Center
Shafter, CA

Abstract

The potential for early detection of spider mites in cotton in California was investigated using a digital multispectral remote sensing system. Images were acquired on 26 dates during the 1998 growing season in the green (550 nm), red (660 nm), and near infrared (850 nm) wavelengths. Results indicate that through the use of computer enhancement and digital processing, spider mite damage can be detected early in the season and distinguished from other types of image anomalies, such as water stress.

Introduction

Spider mites, *Tetranychus* spp., are a serious concern to cotton production in California. The wounds inflicted on plant leaves due to their feeding result in leaf puckering and discoloration early in the disease cycle and in severe cases, leaf drop (Anonymous, 1996). The strawberry spider mite, *Tetranychus turkestani*, is the most serious of the mite pests on cotton in the San Joaquin Valley. The reddish discoloration that appears on the upper surface of the leaves may be detectable through remote sensing. Previous research has shown that remote sensing can be effective in detection of the cotton aphid, *Aphis gossypii* Glover and silverleaf whitefly, *Bemisia Argentifolii* & Perring which excrete honeydew, providing a medium for sooty-mold fungus to develop on the leaves (Summy, et al., 1997). This fungus is darker than the leaves and highly visible, especially in near infrared (NIR) wavelengths.

Early mite detection might allow farmers to apply less pesticide since only the "hot spots" would need application. These could be located through field scouting with the use of portable Global Positioning Systems (GPS) and a map provided to the farmer. Reduced pesticide application could lower costs to the farmer and benefit the environment by reducing the area extent of application.

This study evaluates the potential for detection of mite damage in cotton through remote sensing.

Materials and Methods

Between June and September of 1998, 26 flights were made in a light aircraft equipped with the SAMRSS (Shafter Airborne Multispectral Remote Sensing System) digital camera package over research plots at the Shafter Research and Extension Center, CA. The SAMRSS package consists of three digital cameras fit with specially coated filters allowing transmission of light at 550nm (green), 660 nm (red), and near infrared (850 nm) wavelengths. The cameras are connected to a computer system that captures the images and writes them directly to a hard drive where they are stored for later analysis. The package is flown in a light aircraft designed for aerial surveillance, equipped with a down-looking portal through which the cameras are pointed. Flights occurred within 15 minutes of solar noon to reduce the image processing difficulties associated with shadows. The SAMRSS package was flown at 5000 feet (1525 m) above the ground surface which resulted in a pixel resolution of about two feet (0.64 m).

Mites were collected from the research plots on several dates during the growing season. Transects were walked and leaves sampled every 5 feet (1.5 m) along rows in areas exhibiting mite damage. Mites were counted in the laboratory. Field positions were recorded for later correlation to remotely sensed images.

Images were analyzed using ENVI software from Research Systems, Inc. Digital numbers were converted to percent reflectance using radiometer data collected from ground panels similar to the tarps described by Moran, et al. (1997). The square wooden panels were painted black, gray, or white, resulting in reflectance values of 6%, 18%, and 80%, respectively. Images were georectified using ground control points visible in the images whose locations were known from measurements made with GPS equipment.

Several image analysis techniques were applied to the three images taken on each date. The best, in terms of detection of mite damaged areas in the field, was the use of a Bit Error filtering technique (Anonymous,1997) on the NIR band. Using standard deviation and a nearest neighbor analysis algorithm, this filter compares the value calculated for each pixel to a tolerance. Pixels that are "bad" are assigned a value of zero (black). The "good" pixels selected represent those that were between 2 and 4 standard deviations from the image mean and have values less than the tolerance. Thus, this filter is a spatially-explicit algorithm that takes into account the shape of anomalies within an image.

Results and Discussion

Preliminary results show that mite damage can be detected with the SAMRSS package (Figures 1a,b). Figure 1a shows a NIR image of the research plots on Day 231 (8/19/98). Ground data collected on this date confirm that dark areas in the images could be identified with areas damaged by mites, especially in the western (left) portion of the field. Figure 1b shows the results of applying a Bit Error filter to the image in Figure 1a. Areas with mite damage are

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represented by lighter areas that appear roughly circular or as semi-circular shapes on the edges of the field. The lines running through the image are walkways. Thus, mite damage can be identified from NIR images both by visual inspection and, more quantitatively, by computer enhancement.

To test if the same analysis technique could be used to predict mite damage earlier in the season, analysis using the same input variables (standard deviation and tolerance) was performed on images from earlier dates. Figures 2 and 3 show images acquired on Days 222 and 202, respectively and their Bit Error image enhancements. The image enhancements show reasonably good agreement with the dark mite areas in the images, particularly in the western region of the field. There is a poorer relation to dark spots in more isolated areas in the center of the field. Dates earlier than Day 202 show poor correlation between the NIR and computer enhanced images. This may be because of low mite infestations or the inability of the software to distinguish mite damaged areas. Thus, although mite damage can be detected relatively early, it has not been determined whether very early infestations can be detected. Continuing studies in 1999 will use image analysis to predict mite damaged areas, determine whether mites can be detected early enough for the farmer to take corrective measures, and provide a measure of accuracy for prediction of mite damage.

The square field to the east (right) in the figures was a water stress study. The darker strips show areas of reduced reflectance which represent poorer plant growth and/or leaf wilting. The darker horizontal strips in the rectangular field was part of an irrigation management study. Despite the darker coloration of these areas, the filtering technique did not select them. This was likely due to the shape of the mite damaged areas. Unlike the water stressed areas, the mite damaged canopy appeared dark at the center in the NIR wavelengths and was roughly circular. Moving away from the central "hot spot", the canopy became increasingly brighter in a relatively uniform manner. Thus, the shape of the damaged areas is a signature that can be used for identification.

The results presented indicate that remote sensing may be a promising new technology for mite and insect damage detection in cotton. The morphology of this type of arthropod damage in the crop can be used as an identification tool during computer enhancement. Leaf discoloration was not shown to be as effective in identification of mite damage. This will be investigated further in 1999. Mite damage can be detected, but must be done sufficiently early in the season to be useful to farmers. Various image enhancement techniques will be tested in 1999 to determine the effectiveness of mite detection and the usefulness to farmers.

Disclaimer and Acknowledgments

Mention of specific suppliers of remote sensing software in this manuscript is for informative purposes only and does not imply endorsement by the United States Department of Agriculture.

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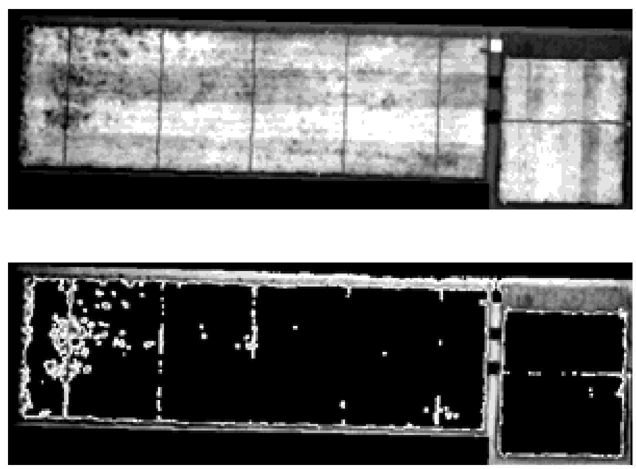
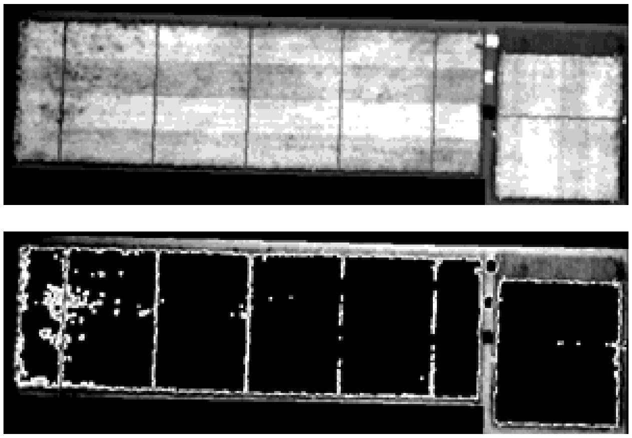
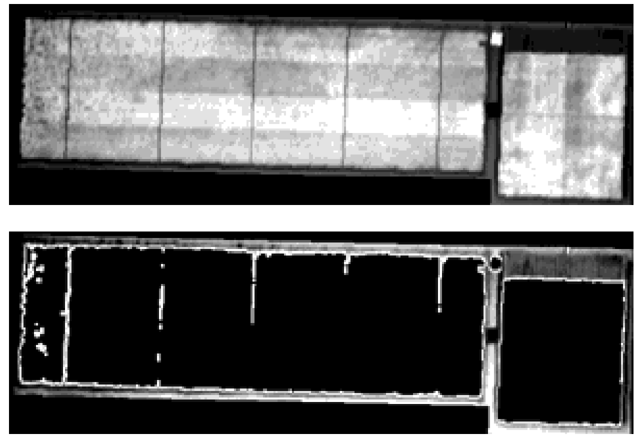


Figures 1a,b. Day 231 NIR (top) and enhanced (bottom) images. Dark spots in NIR image and light areas in enhanced image are mite damaged and potentially mite damaged areas.



Figures 2a, b. Day 222 NIR and enhanced images.



Figures 3a,b. Day 202 NIR and enhanced images.