REMOTE SENSING AND SITE SPECIFIC MANAGEMENT OF COTTON ARTHROPODS IN THE MISSISSIPPI DELTA

D. L. Sudbrink Jr., F. A. Harris, J. T. Robbins, and P. J. English
Mississippi State University
Delta Research & Extension Center
Stoneville, MS

Abstract

Remote sensing technologies and site-specific management techniques were investigated for use in detection and control of cotton pests in the Mississippi Delta. Tarnished plant bugs occurred above threshold levels more frequently in vigorously growing cotton canopy than in slower growing canopy. Vigorous and slower growing canopy areas were visibly discernable with remotely sensed imagery. Prescription spray maps were generated from this imagery which reduced insecticide application requirements by 30-50%. Reddish cotton leaves that were severely infested by spider mites were discernable from healthy green and and yellow early mite-stressed leaves using a spectro-radiometer. Plant maturity and cutout parameters were used on a site-specific basis to reduce pesticide applications for late season arthropods by 30%.

Introduction

Several arthropod pest species attack cotton in the Mississippi Delta and frequently cause substantial economic injury. Early detection of spot-infestations of these pests on a site-specific basis could allow for reduced application of insecticides with variable rate technology. Remote sensing is a promising technology which can be used in detection of pests and associated crop conditions on a site-specific basis (Allen et al. 1999).

Tarnished plant bug (TPB), *Lygus lineolaris,* is a key pest of cotton in the Mississippi Delta that attacks developing squares and bolls and can seriously limit yield if not controlled. These insects have been found in abundance in vigorously growing portions of cotton fields which generally have taller plants and/or greater canopy closure (Willers et al. 1999). These vigorous growth areas have been the focus for site-specific insecticidal applications in on-farm tests which use remotely sensed imagery to target variable rate technology and reduce applications by 40-60% (Willers et al. 2000, DuPont et al. 2000). Multi-spectral remotely sensed imagery of cotton fields is acquired aerially and nromalized differntial vegetation indices (NDVI) are calculated for vegetation types. Prescription spray maps are generated from classed NDVI values which allow for corrective variable rate application of pesticides. While this technique has been shown to reduce applications at the farm field level, more information is needed about its applicability and reliability that require more intensive quantification methods.

Spider-mites, *Tetranychus* spp., are foliar pests that occasionally flare up in Delta cotton fields, especially late in the season in hot dry August weather. Preliminary investigations indicated that spider mite infestations could be detected in cotton fields with remote sensing techniques (Sudbrink et al. 2000). Crop maturity factors such as cut-out can play an important role in termination of pesticide applications especially in late season when spider mites increase in number (Harris et al. 1997). Detection of cut-out by remote sensing could help in site specific termination of end-of-season pesticide applications.

In Summer of 2000, a study was initiated to determine the feasibility of using remote sensing to detect cotton pest damage and associated crop development and maturity factors in the Mississippi Delta. Specific objectives for the study were to: evaluate remote sensing capabilities for identifying factors in crop development and maturity related to pest populations, and evaluate site-specific methods for cotton pest management.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1145-1147 (2001)
National Cotton Council, Memphis TN

Materials and Methods

Lygus-Crop Vigor Study

Two 2.5-ha cotton fields were planted at two locations within NASA fly-over zones at Stoneville & Tribbett, MS. Each field was divided into an 8 x 8 grid of contiguous 12-row x 12m plots. Each plot was divided into two triangular sub-plots. Sample sites were selected weekly to represent average vegetative conditions in each subplot. Each site was marked in a geo-referenced lattice of grid points that were sampled weekly for crop physiological parameters using the COTMAN system and for arthropod populations using sampling techniques used by Mississippi pest managers. Field data were recorded with a GPS unit & geo-spatial data were mapped in ArcView. Remotely sensed imagery was collected by aerial hyper-spectral and multi-spectral sensors and with GPS-linked multi-spectral aerial videography. A GER 1500 spectro-radiometer was used to collect reflectance data on crop condition.

Spider-Mite/Crop Maturity Study

Spider mite populations were monitored at the same two 2.5-ha cotton fields throughout the season. At each sample site, five leaves were taken from each 5th node down from the top for a total of ten leaves per plot (n=640). Spider mites were counted on each leaf using a small 10x microscope. COTMAN parameters such as square-shed and cut-out were monitored at each site as well. Field data was recorded with a GPS unit & geo-spatial data was mapped in ArcView. Remotely sensed imagery was collected by multi-spectral sensors and with aerial videography. A GER 1500 spectro-radiometer was used to collect reflectance data of leaf condition.

Results and Discussion

Lygus-Crop Vigor Study

Mid-June. At mid-June at Stoneville, plant vigor appeared to be closely related to canopy intensity in aerial imagery with a close correlation between plants $\geq$12" tall and darker portions of the field image (Figs. 1a & 1b.). Normalized difference vegetation index (NDVI) values obtained from spectro-radiometry data were greater in the vigorous plots than in slower developing plots (Table 1.). Tarnished plant bug (TPB) populations increased to above threshold levels in 20% of all plots in mid-June and 92% of above-threshold samples occurred in vigorous plots (Fig. 1b & 1c). More plant bugs were found in vigorous plots than in slower developing plots (Table 1). Within the vigorous plant plots, TPB was found above threshold in 56% of plots. A X^2 test showed that this ratio was not significantly different from random. TPB was found above threshold levels in only 8% of non-vigorous plots. This ratio was significantly different from random in a X^2 test which indicated scarcity of plant bugs in the slower developing canopy. A proposed prescription map of the field was developed from imagery that would have targeted a site-specific insecticide application to only 50% of plots (Fig. 1d). However, nearby boll weevil traps triggered a blanket malathion application at the proposed time of application, precluding a site-specific application.

Mid-July. By mid-July, TPB populations had rebounded from previous insecticide applications and were again found above threshold levels. Plant vigor appeared to be closely related to canopy intensity patterns in aerial imagery with a close correlation between plants >30" tall and darker portions of the field image (Figs. 2a & 2b). NDVI values were greater for the vigorous plots (Table 2). TPB numbers were much higher (>4x) in vigorous plots than in slower developing plots (Table 2). TPB populations were found above threshold levels in 55% of all plots on 13 July (Fig. 2c).

TPB was found above threshold in 75% of vigorous plots. A X^2 test showed that this ratio was significantly different from random indicating a possible preference for vigorous areas by TPB. Plant bugs were found above threshold levels in only 14% of non-vigorous plots. This ratio was significantly different from random in a X^2 test. A prescription map for site-specific application was made based on imagery of vigorously growing areas (Fig. 2d). On 14 July, a site-specific application of Orthene (0.5 lbs. a.i./acre) was made on vigorous plant plots reducing overall application by 30% (Fig. 2d).

Spider Mites and Leaf Canopy Readings

In the spectro-radiometry readings, wavelengths of reddish leaves damaged by spider mites were discernable from those of healthy green and yellow mite-stressed leaves in the near infra-red (NIR) spectrum (Figs. 3). However, green and yellow leaves were not significantly different at the NIR band commonly used in multi-spectral imagery (840nm) (Table 3). Reflectance measurements of each leaf type had significantly different values in the visible green band (540nm) with yellow leaves having the highest reflectance, followed by green and then red damaged leaves (Fig. 3 & Table 3). NDVI values were significantly different for each of the leaf types with green leaves having the greatest value followed by yellow and then red leaves. However, in the study fields, spider mite hot-spot infestations were not readily discernible from other levels of infestation in preliminary aerial videography. Hyper-spectral imagery may provide the wavelengths necessary to separate the differing canopy stresses.

Crop Maturity and Cutout

Approximately 30% of plots at Stoneville, had reached cutout by 7/19/00. Radiometry data taken on that date showed significantly different NDVI values for cutout vs. pre-cutout plots (Table 4.). Spider mite populations increased to above threshold levels in hot dry August weather and some damage was visible yet not discernable in preliminary imagery. On 8/11/00, spider mite populations exceeded threshold levels primarily in the more vigorous plant growth areas (Fig. 4b.). By that date, the plots that had reached cutout on 7/19/00, had also reached cut-out+750 hu. (the time selected for termination of pesticide applications for foliar insects) (Fig. 4c). Pesticide applications were terminated for the cutout+750 hu. plots producing a prescription map that reduced overall application by 30% (Fig. 4d). Curacron 1.0 lbs. a.i./acre was sprayed on 14 August to control spider mites in the remaining plots (on 70% of total plots) (Fig. 4d).

Acknowledgements

The authors would like to thank Dr. Jeff Willers, USDA-ARS Crop Science Research Laboratory, Starkville for his assistance in experimental design We also thank Ms. Libba LaMastus, Deparment of Plant & Soil Science, Mississippi State University, and Mr. Johnny Williams, GPS Inc., for assistance with spectro-radiometry. This work was funded by grants from Mississippi State University's Remote Sensing Technologies Center and Advanced Spatial Technologies in Agriculture program, NASA, & USDA.

References

Allen, J. C., D. D. Kopp, C. C. Brewster, & S. J. Fleischer. 1999. 2011: An agricultural odyssey. American Entomologist. 45: 96-104.

Harris, F. A., F. T. Cooke, G. L. Andrews, R. E. Furr. 1997. Monitoring node above white flower as basis for cotton insecticide treatment termination. Miss. Agr. Exp. Sta. Bull. 1068. 21 p.

Dupont, J. K., R. Campenella, M. R. Seal, J. L. Willers, and K. B. Hood. 2000. Spatially variable insecticide applications through remote sensing. Proc. 2000 Beltwide Cotton Conf., SanAntonio, TX. p. 426-429.

Sudbrink, D. L., F. A. Harris, J. T. Robbins, G. L. Snodgrass, S. J. Thomson. 2000. Remote sensing of late-season pest damage to cotton & wild host plants of tarnished plant bug in the Mississippi Delta. Proc. 2000 Beltwide Cotton Conf., SanAntonio, TX. p. 1220-1223.

Willers, J. L., J. K. DuPont, R. Campanella, M. R. Seal, K. B. Hood, J. Williams and D. Woodard. 2000. Employment of spatially variable insecticide applications for tarnished plant bug control in cotton. Proc. 2000 Beltwide Cotton Conf., SanAntonio, TX. p. 1133.

Willers, J. L., M. Seal and R. Luttrell. 1999. Remote sensing line intercept sampling for tarnished plant bugs (Heteroptera: Miridae) in Mid-South Cotton. J. Cotton Sci. 3: 160-170.

Table 1. Spectro-radiometry values for vigorous plots (plants >12") vs. slower developing plots, Field 7, Stoneville, MS, 6/20/00.

Plot data	% reflectance Green band (540nm)	% reflectance in Red band (695nm)	% reflectance in NIR band (840nm)	NDVI values	TPB/z 10swps
Vigorous	10.78 ns	6.625 ns	64.16 ns	0.813*	0.70*
Slower	11.03 ns	7.219 ns	58.78 ns	0.780*	0.18*

* - indicates significant difference in a t-test at the 0.05 level.

Table 2. Spectro-radiometry values for vigorous plots (plants >30") vs. slower developing plots, Field 7, Stoneville, MS, 7/12/00.

Plot data	% reflectance Green band (540nm)	% reflectance in Red band (695nm)	% reflectance in NIR band (840nm)	NDVI values	TPB/ 3ft. of row
Vigorous	9.68 ns	6.44 ns	61.70*	0.814*	4.22*
Slower	9.46 ns	6.50 ns	53.46*	0.779*	0.667*

* - indicates significant difference in a t-test at the 0.05 level.

Table 3. Spectro-radiometry values for mite damage on leaves, Field 7, Stoneville, MS, 8/11/00.

Leaf type	% reflectance Green band (540nm)	% reflectance in Red band (695nm)	% reflectance in NIR band (840nm)	NDVI values
Green (healthy)	9.34 b	6.53 a	59.76 a	0.803 a
Yellow (stressed)	15.00 a	13.40 a	59.20 a	0.630 b
Red (mite Damaged)	4.55 c	25.70 a	46.64 b	0.320 c

***** - Means followed by the same letter do not significantly differ (P=0.05, Waller-Duncan test).

Table 4. Spectro-radiometry values for plots at cutout vs. pre-cutout, Field 7, Stoneville, MS, 7/19/00 (cutout plots on 7/19/00 were also > or = NAWF=5+750 hu. on 8/14/00).

Plot data	% reflectance Green band (540nm)	% reflectance in Red band (695nm)	% reflectance in NIR band (840nm)	NDVI values	NAWF
Cutout	9.92 ns	6.62 ns	54.34 *	0.775 *	4.17 *
Pre-cutout	9.88 ns	6.42 ns	63.82 *	0.811 *	5.84 *

* - indicates significant difference in a t-test (P=0.05).

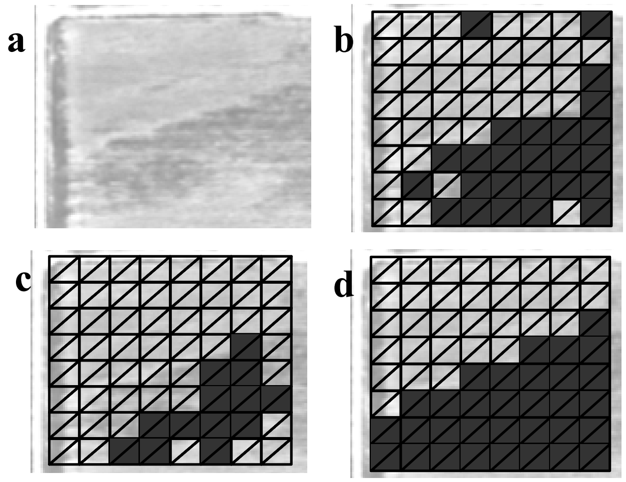

Figure 1. a. Multi-spectral imagery of cotton in field 7, Stoneville, MS, mid-June, 2000; b. plots with plants >12" (grey), 6/15/00; c. TPB above threshold levels (grey), 6/16/00; d. Prescription spray plots, (grey).

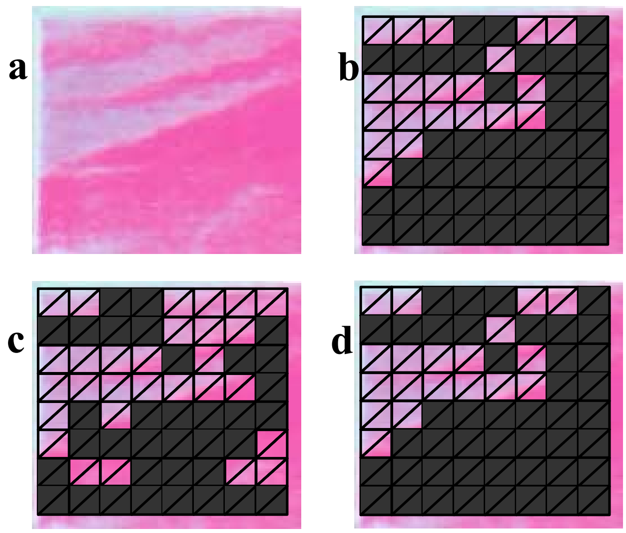

Figure 2. a. Multi-spectral imagery of cotton in field 7, Stoneville, MS, mid-July, 2000; b. Vigorously growing areas (plant ht. >30" (grey), 7/12/00; c. TPB above threshold levels (grey), 7/13/00; d. Prescription spray plots, (grey).

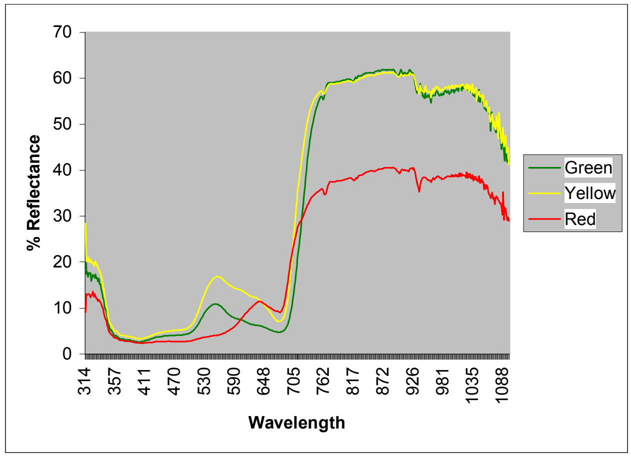

Figure 3. Reflectance spectra for cotton leaf types in mite infested fields, Stoneville, MS, 8/11/00.

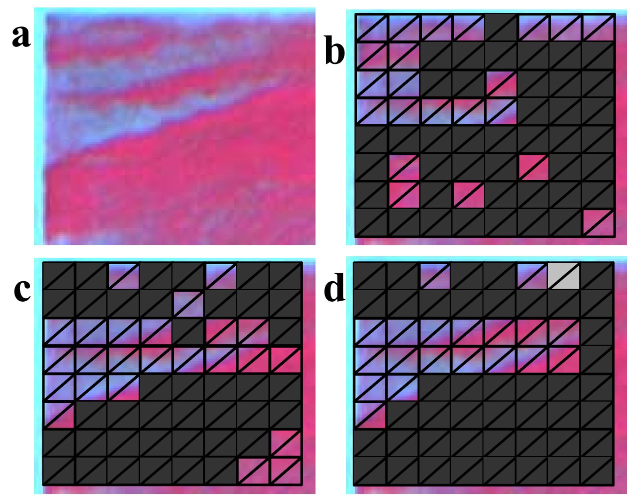

Figure 4. a. Multi-spectral imagery of cotton in field 7, Stoneville, MS, mid-August, 2000; b. spider mites above threshold levels (grey), 8/11/00; c. Plots that reached cut-out (NAWF=5) + 750 hu. (clear plots), 8/14/00; d. Prescription spray plots (grey) for Curacron application (1.0 lbs./a) 8/14/00, (70% of field sprayed).