2002 BELTWIDE COTTON CONFERENCES, ATLANTA, GA – JANUARY 8-12

SITE SPECIFIC MANAGEMENT IN MISSISSIPPI DELTA COTTON: EXPERIMENTAL FIELD STUDIES AND ON-FARM APPLICATION

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Abstract

Tarnished plant bugs and stink bugs have become key pests of cotton in the Mississippi Delta. In 2001, remote sensing technologies and site-specific management techniques were investigated for use in detection and control of these cotton pests in experimental and farm fields. In mid June, tarnished plant bug (TPB), numbers were greater in vigorously growing field zones with higher normalized difference vegetation index (NDVI) values than TPB numbers in slower growing zones with lower NDVI values. TPB occurred at or above economic threshold levels in 73%-80% of vigorously growing zones, and in 0%-16% of slower growing zones in mid June. The data indicate a potential preference by TPB for vigorous plant zones. Imagery-based prescription spray maps were created for each field and site-specific applications were made in mid June that reduced applications of insecticide by approximately 25%-35%. In July, site-specific applications were applied again for TPB control in both fields saving approximately 20%-25% of insecticide applications. In late season, NDVI values and TPB numbers were lower in early maturing zones that had reached cutout or node-above-white-flower (NAWF) = 5 + 350 heat units (DD60s). In early August, an imagery based prescription application map was created that terminated insecticide use in cutout zones in a farm field, thus saving approximately 20% of an insecticide application. In mid August, stink bugs reached threshold levels at sites that had grown rapidly in late season. An imagery based prescription spray map was generated which effectively controlled stink bugs, saving approximately 50% of an insecticide application.

Introduction

Several arthropod pest species attack cotton in the Mississippi Delta and frequently cause substantial economic injury. 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. Several species of stink bugs (Hemiptra: Pentatomidae) are direct pests of cotton that feed on and damage developing bolls. They are an emerging pest problem in Mississippi Delta cotton, especially in the reduced insecticide environment following boll weevil eradication and in fields were Bt cotton is grown. Early detection of spot-infestations of these pests on a site-specific basis could allow for reduced application of insecticides using variable rate technology. Remote sensing is a promising technology that can be used in detection of pests and associated crop conditions on a site-specific basis (Allen et al. 1999).

TPB has been found in abundance in vigorously growing portions of cotton fields that generally have taller plants and/or greater canopy closure (Willers et al. 1999). These vigorous growth zones have been the focus for site-specific insecticide applications in on-farm tests that use remotely sensed imagery to target sprays with variable rate technology (Willers et al. 2000). Multi-spectral remotely sensed imagery of cotton fields is acquired aerially and normalized differential 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 that can produce insecticidal savings of 20-50% (DuPont et al. 2000). More information is needed on the applicability of this technique and its reliability that require more intensive quantification methods (Sudbrink et al. 2001).

Crop maturity factors such as cut-out can play an important role in termination of pesticide applications especially in late season when pests 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 the summer of 2001, a study was conducted to determine the feasibility of using remote sensing to detect cotton crop development and maturity factors associated with insect pests. Specific objectives for the study were to (1) evaluate remote sensing capabilities for identifying factors in crop development and maturity related to pest populations, and (2) evaluate site-specific methods for cotton pest management.

Materials and Methods

TPB/Crop Vigor Study

Two experimental fields (approximately 6-acres each) and two farm fields (approximately 33 and 27-acres) were planted with cotton within a remote sensing fly-over zone at Stoneville, MS. In each field, 32 sample sites were distributed within several management zones based on geo-spatial soil cation exchange capacity (CEC) maps. Sample sites were monitored weekly for crop physiological parameters using the COTMAN system and for arthropod populations using sweep nets, drop cloths, and terminal counts. Geo-spatial field data was recorded with a Trimble Ag 124 GPS unit and mapped in ArcView. Remotely sensed imagery was collected primarily with a Duncan 2100 multi-spectral video-camera mounted on an aerial platform. A spectro-radiometer (GER 1500) was used to collect reflectance data of crop condition.

When economic pest thresholds were reached, remotely sensed imagery was used to generate prescription maps to determine where insecticide sprays were to be applied on a site-specific basis. Required insecticides were sprayed in site-specific patterns in one experimental field and one farm field, while whole-field blanket applications were made in the other fields. Insect numbers were again counted after treatments to determine the effectiveness of the sprays.

Crop Maturity Study

After first bloom, sites were monitored using the BOLMAN component of the COTMAN expert system [which measures parameters such as cut-out; nodes-above-white-flower = 5 (NAWF = 5)]. Remotely sensed imagery was collected on a weekly basis as plants approached cutout and continued until the period of insecticide spray termination. A spectro-radiometer (GER 1500) was used to collect reflectance data of crop condition during this period.

When economic pest thresholds were reached, remotely sensed imagery was used to determine where insecticide sprays were to be applied on a site-specific basis. Required insecticides were sprayed in site-specific patterns in a farm field, while whole-field, blanket applications were made in the other fields. Insect numbers were again counted after treatments to determine the effectiveness of the sprays.

Results and Discussion

Experimental Fields

In mid-June in Field 7 at Stoneville, sample points in areas of vigorously growing plants (avg. ht.=23.25") had significantly higher NDVI values and TPB numbers than points in areas of slower growth (avg. ht.=12.65") (Table 1). Differences in plant vigor were visible in distinct zones in aerial imagery and there was a close correlation between taller plants and field zones with higher NDVI values (Figs. 1a and 1b) (Table 1). TPB populations occurred above economic threshold levels at 80% of points occurring in vigorous crop zones in mid June (Fig. 1b). Above threshold levels of TPB occurred at only 16% of points in the non-vigorous zones. The TPB population data indicated a possible preference for vigorous cotton zones. An NDVI-based prescription application map was created which saved approximately 35% of a site-specific application of dicotophos on 21 June (Fig. 1c). In post-spray counts, the application was determined to be successful as TPB populations were reduced to below threshold levels throughout the field. Later in July, another successful spray was made in field 7 which reduced sprays by approximately 25%.

Stink bug populations were monitored primarily by sampling plant terminals (economic threshold level = 5 stink bugs/100 terminals). Populations of stink bugs began to increase late in the season once bolls began developing and numbers reached economic threshold levels in portions of Field 7 at Stoneville in mid-August (Fig. 2a). On 15 August, stink bug numbers were found to be significantly higher in field zones where NDVI values were below 0.525 (these areas had experienced rapid growth during the unusually wet period late in the 2001 season) (Fig. 2b). A prescription spray map was created based on NDVI values (> or < 0.525). A site specific application was made on 17 August which saved approximately 50% of a dicrotophos insecticide spray (Fig. 2c). In post spray counts, the application was determined to be a success because stink bug populations were effectively controlled throughout the field (Fig. 2a).

Farm Fields

In mid June at Cumbaa Farm field 3, sample points with more vigorously growing plants (avg ht.=18.6") had significantly higher NDVI values and TPB numbers than slower growing areas (avg ht.=15.5") (Table 2). Plant vigor was visible in distinct zones in aerial imagery with a correlation between taller plants and field zones with higher NDVI values (Figs. 3a and 3b). In mid-June, TPB was found at >73% of points in vigorous zones and at none of the points in non-vigorous zones (Fig. 3b). TPB numbers were lower in farm vs. experimental fields possibly due to an improper herbicide application in the farm field which slowed crop development in May and June. Despite lower numbers, a potential preference of TPB for vigorous sites was indicated. An image-based prescription application map was created which required a buffer zone in the western third of the farm field due to infestation by TPB from adjacent cornfields (reducing the area of savings) (Fig. 3a).

Despite the required buffer zone, a site-specific application was made on 19 June that saved >25% of a dicrotophos insecticide spray (Fig. 3c). In post-spray counts, TPB populations were found to be controlled throughout the field. Later in July, another successful application was made which reduced sprays by approximately 20%.

Crop Maturity

Plants in portions of Cumbaa Farm field 3 began to reach cutout (NAWF = 5) in late July. Zones that had reached cutout by 18 July had significantly lower NDVI values than later maturing points in the rest of the field (Table 3) (Figs. 4a and 4b). TPB populations reached threshold levels at several sites in the field on 30 July and required insecticide treatment. TPB numbers were significantly lower in plots that had reached cut-out NAWF=5 +350 Degree Day 60 heat units (DD60s) (the preferred time for termination of pesticide applications for TPB in the Mississippi Delta) (Table 3). A prescription spray map was generated by masking out the areas that had reached NAWF=5 + 350 DD60s which was about 20% (Fig. 4c). A site specific application of acephate insecticide was applied aerially on 8/3/01 to control TPB in the pre-cutout portions of the field (or about 80% of the field) (savings = approximately 20%) (Fig. 4c).

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Acknowledgements

The authors would like to thank Dr. Jeff Willers, USDA-ARS-CSRL, Starkville, MS, for his assistance in experimental design and Johnny Williams, GPS Inc., for assistance with remote sensing. This work was funded in part by grants from Mississippi State University's Remote Sensing Technologies Center, Advanced Spatial Technologies in Agriculture program, NASA, and USDA.

Table 1. Plant parameters and TPB data for vigorous zones vs. slower developing zones, Field 7, Stoneville, MS, June 2001.

Zone data	**Plant ht." 6/19/01**	**Canopy gap width" 6/19/01**	**NDVI values 6/18/01**	**TPB/100 sweeps *Pre-spray* 6/20/01**	**TPB/100 sweeps *Post-spray* 6/25/01**
vigorous	23.25*	17.0*	-0.050*	13.90*	1.67ns (sprayed)
slower	12.65*	25.2*	-0.255*	2.86*	1.07ns

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

Table 2. Plant parameters and TPB data for vigorous zones vs. slower developing zones, Dean Cumbaa Field 3, Stoneville, MS, June 2001.

Zone data	**Plant ht." 6/19/01**	**Canopy gap width " 6/19/01**	**NDVI values 6/18/01**	**TPB/100 sweeps *Pre-spray* 6/20/01**	**TPB/100 sweeps *Post-spray* 6/25/01**
vigorous	18.6*	20.0	-0.0883*	3.85*	0.58ns (sprayed)
slower	15.5*	21.5	-0.1302*	0.00*	1.67ns

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

Table 3. Radiometry values and field data for cutout vs. pre-cutout zones, Dean Cumbaa Field 3, Stoneville, MS, late July-early August 2001. (cutout zones on 7/23/01 were also ≥ NAWF=5+350 hu. on spray date 8/03/01).

Zone data	**NDVI values 7/23/01**	**Days from planting to NAWF=5**	**DD60s past NAWF=5 8/03/01**	**TPB/12' row *Pre-spray* 7/30/01**	**TPB/12' row *Post-spray* 8/06/01**
Cutout	0.4496*	78	394	1.50*	1.64ns
Pre-cutout	0.4732*	83	276	4.00*	2.38ns (sprayed)

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

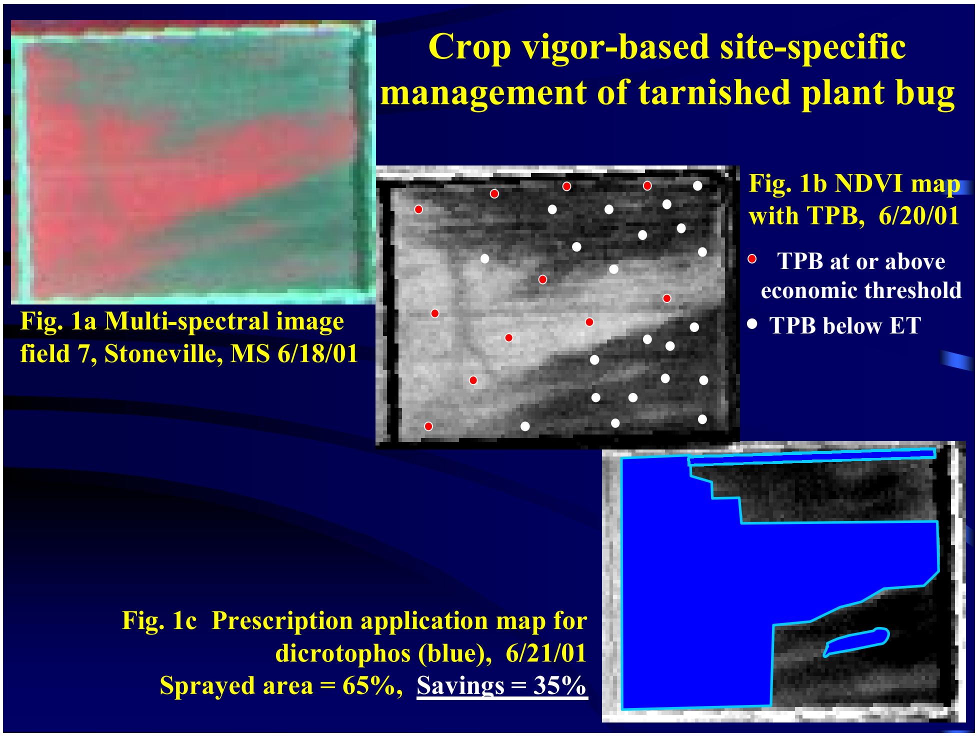

Figure 1a. Multi-spectral imagery of cotton crop, field 7, Stoneville, MS, 6/18/01; Fig 1b NDVI image with TPB sample sites (red points = TPB > economic threshold (ET), white points = TPB< ET), field 7, Stoneville, MS, 6/20/01; Fig. 1c Prescription spray map for site-specific dicrotophos insecticide application (0.4 lbs. a.i./acre) (blue) 6/21/01.

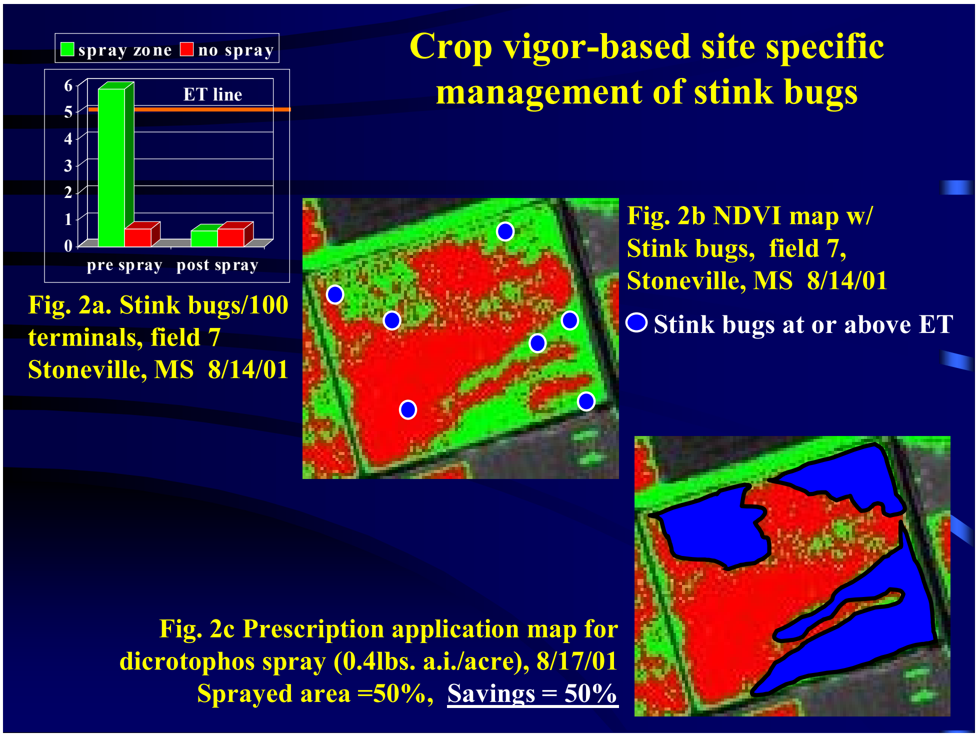

Figure 2a. Stink bugs/100 terminals, field 7, Stoneville, MS 8/15/01; Fig. 2b NDVI values <0.525) (green) and >0.525 (red); Stinkbugs at or above economic threshold level (blue dots), field 7, Stoneville, MS 8/14/01; Fig. 2c Prescription spray map for site-specific dicrotophos insecticide application (0.4 lbs. a.i./acre) (blue) 8/17/01.

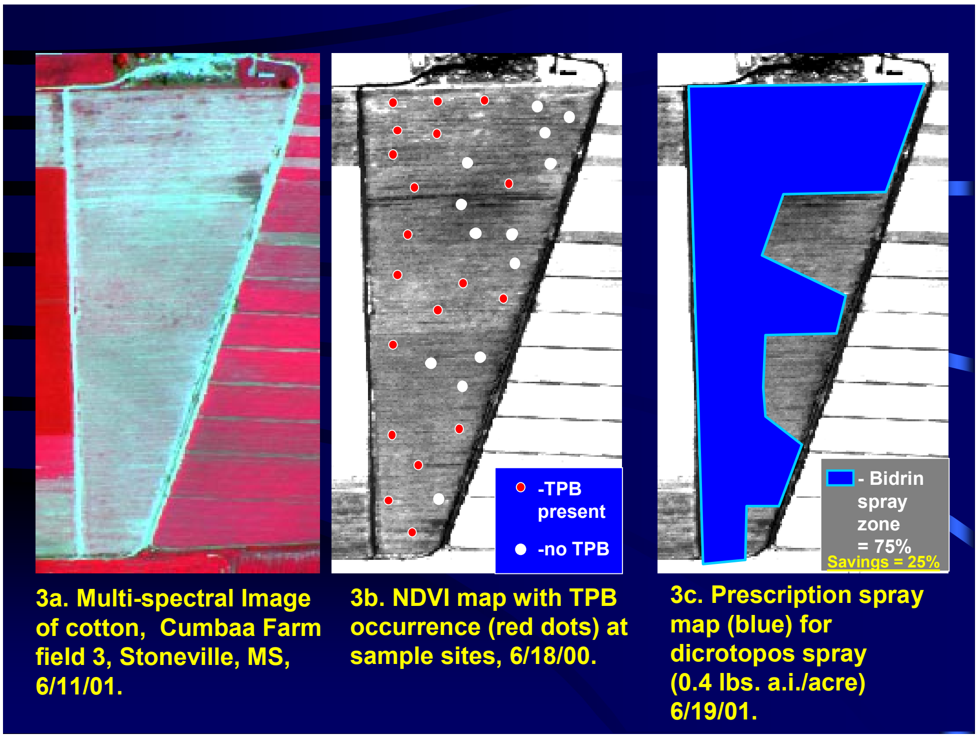

Figure 3a. Multi-spectral imagery of cotton crop, Cumbaa field 3, Stoneville, MS, 6/11/01; Fig. 3b NDVI image with TPB occurrence at sample sites. Cumbaa field 3, Stoneville, MS, 6/18/01; Fig. 6 Prescription spray map for site-specific dicrotophos insecticide application (0.4 lbs. a.i./acre) (blue) 6/19/01.

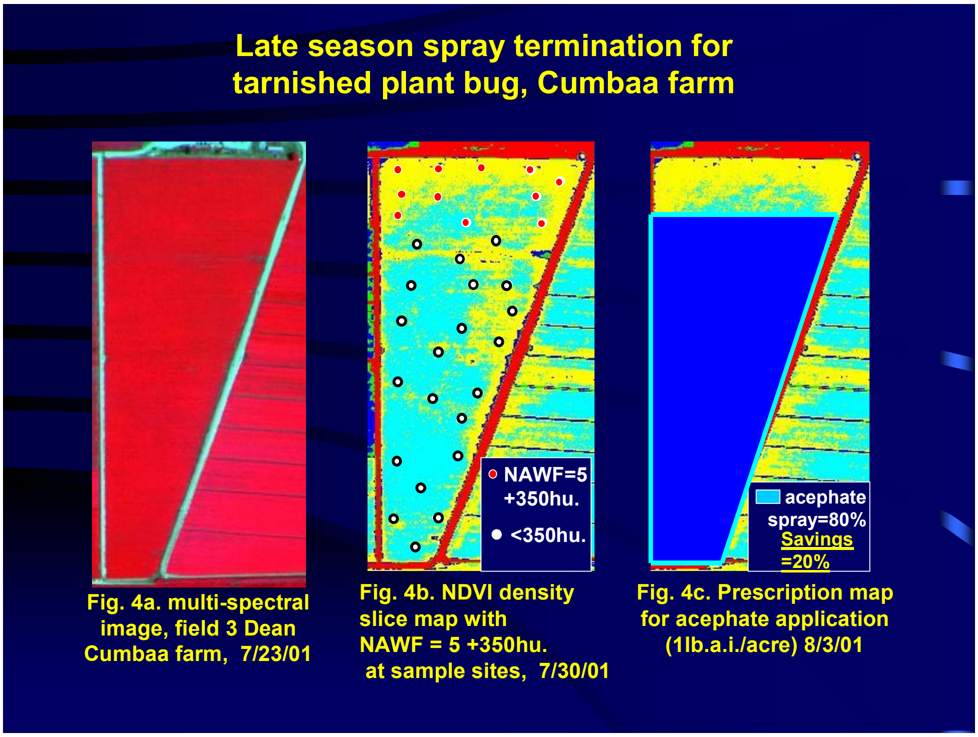

Figure 4a. Multi-spectral imagery of cotton crop, Cumbaa field 3, Stoneville, MS, 7/23/01; Fig. 4b. NDVI density slice image with cutout (maturing) zone (yellow) and points (red) 7/30/01; Fig. 4c Prescription spray map for site-specific acephate insecticide application (1.0 lbs. a.i./acre) (blue) 8/3/01.