2005 Beltwide Cotton Conferences, New Orleans, Louisiana - January 4 - 7, 2005

TARNISHED PLANT BUG RESPONSE TO CROP VIGOR AND DETECTION OF VIGOR DIFFERENCES VIA REMOTE SENSING

F. A. Harris, P. J. English, D. L. Sudbrink, Jr. and G. D. Wills
Mississippi State University
Stoneville, MS
J. E. Hanks
USDA, ARS
Stoneville, MS

Abstract

Three years of tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beauvois), infestation data and vegetation index data (calculated from remotely sensed imagery data) from two research fields on Delta Branch Experiment Station, Stoneville, Mississippi were subjected to linear regression analysis. Coefficients of determination (r^2) showed a strong functional relationship of cotton vigor (measured as plant height and canopy width) and the normalized difference vegetation index (NDVI) and five other vegetation indices. Lower r^2 values indicated a weaker functional relationship of TPB infestation and vegetation indices. Analysis of frequency distributions of above treatment threshold TPB infestations relative to partitioned vegetation indices (equal interval quartile classes) gave a better indication of the relationship between TPB infestation and crop vigor.

Introduction

Tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beauvois), has been reported to occur in abundance in vigorously growing portions of cotton fields - taller plants and greater canopy closure, a behavior that provides the basis for site-specific insecticide applications using prescriptions derived from remotely sensed imagery (DuPont et al. 2000, Sudbrink et al. 2001, Willers et al. 1999, Willers et al. 2000). Studies conducted at Stoneville, Mississippi between 2001 and 2003 were conducted to further show the functional relationship between imagery based vegetation indices, crop vigor, and TPB infestation density.

Methods

Two fields located on Delta Branch Experiment Station were used in remote-sensing and site-specific insect control studies for three years (2001 – 2003). Data from the fields were used in regression analyses to determine the influence of crop vigor and vegetation indices (calculated from remotely sensed imagery data) on TPB infestation. Thirty-two sample sites in each field were used for TPB infestation data and for processing of representative imagery data.

Insect observations and plant measurements (height and canopy width) were made at five to seven day intervals, if weather permitted, during the months of June, July and August each year. Sweep net (SW) (15 in.) samples and visual observation of terminals (TRM) were used in June and early July. Drop cloth (DR) (2 rows on 3 ft. cloth) samples and visual observation of terminals (TRM) were used in July and August. Dates for analyses were based on pretreatment dates when TPB infestation occurred at levels near, at, or above treatment threshold levels (Layton 2003) at one or more sites in a field.

Remotely sensed data were aerially acquired with a Duncan 2100 digital video-camera using three spectral bands - green (G) = 550 nm, red (R) = 600 nm and near infra-red (NIR) = 800 nm, where the cited frequency represents the apogee of each band's reflectance curve. Imagery pixels were 1 m^2. Each sample site was characterized for imagery representation by an area of interest (AOI), the center of which was geo-referenced and which consisted of 10 to 14 pixels around the center point. Radiance values expressed as digital integers ranging from 0 to 255 for each spectral band were used in Arcview® to calculate vegetation indices for each pixel in the AOI (Arcview® software, Environmental Systems Research Institute Inc., Redlands, California). ArcView® calculated the min. and max., the range, mean, and standard deviation for each index in the AOI of each site. The mean vegetation index value calculated for the AOI was used as the raw datum vegetation index for the site. Variation in number of pixels per AOI was caused by uncontrolled spatial orientation of imagery pixels relative to orientation of plots on the ground. When one-half or more of a borderline pixel was within the AOI, it was considered part of the AOI and its radiance values were included in calculations.

Imagery acquisition dates included in this study were: 11, 18 and 25 June and 2, 17, and 23 July in 2001; 18 June, 2 and 17 July, and 2 and 20 August in 2002; 16 and 24 July, and 7 August in 2003. Imagery acquisition dates were determined by temporal proximity to insect observation dates. Imagery data acquired on the date closest to a TPB insect observation date were used for regression analyses and for NDVI quartile classifications.

Six vegetation indices (VI) were derived from remotely sensed imagery data. The VI were calculated by forming ratios, differences, or ratios of differences, and sums of spectral band data (Jackson and Huete 1991). The VI were calculated as follows: normalized difference vegetation index (NDVI), where NDVI = (NIR – Red)/(NIR + Red); ratio vegetation index (RVI), where RVI = NIR/Red; green normalized difference vegetation index (GNDVI), where GNDVI = (NIR – Green)/(NIR + Green); green ratio vegetation index (GRVI), where GRVI = NIR/Green; green vegetation index (GVI), where GVI = (Green – Red)/(Green + Red); and Ashburn vegetation index (AVI) (Ashburn 1978), where AVI = NIR – Red.

The second approach used in this study was to partition TPB infestation levels (sweep net samples, terminal observations, and drop cloth samples) based on equal interval quartiles of NDVI data (done for each observation date in the 3-yr. study). The regression analyses of TPB infestation or plant measurements on other imagery indices (GNDVI, GVI, RVI, GRVI, AVI) indicate none were much different than NDVI as a basis for characterizing crop vigor or TPB infestation classes. Therefore, only NDVI data were used to partition TPB data sets. Quartile intervals were determined by $(I_{max} – I_{min})/4$, where I_{max} is the maximum NDVI value in a data set and I_{min} is the minimum NDVI value in a data set. NDVI values with associated TPB infestation and plant measurements were sorted and partitioned into quartiles from low to high. Average sites/quartile, average percent of sites/quartile with TPB infestation at or above treatment threshold, and average TPB infestation level were calculated and data sets for the three years were pooled for analysis of variance and separation of means by $LSD_{(p \leq 0.05)}$.

Data were analyzed by the PROC REG or the PROC GLM procedure, SAS 9.1, SAS Institute Inc., Cary, NC.

Results

The results of regression analyses are summarized in Tables 1 and 2 as means of coefficients of determination (r^2) and coefficients of variation (CV) for the multiple data sets acquired over the three years of the study. The r^2 and CV data were subjected to analysis of variance (ANOVA). This approach was taken to succinctly deal with the numerous data sets that had been subjected to regression analyses. The relatively high r^2 means and relatively low CV means shown in Table 1 for plant height (PH) and canopy width (CW) indicate that vegetation indices may have a close functional relationship to plant vigor (measured by plant height and canopy width), and that vegetation indices may have a predictive function relative to cotton crop vigor. On the other hand, the relatively low r^2 means and relatively high CV means shown in Table 1 for TPB infestation (three observation methods – SW, TRM, and DR) suggest that the linear regression model for vegetation indices may have a weak functional relationship to TPB infestation, and that vegetation indices may be useful in predicting trends in TPB infestation, but lack rigorous precision in predicting spatial characteristics of infestations. The relatively low r^2 means and relatively high CV means shown in Table 2 for tarnished plant bug infestation also indicate that the linear regression model for crop vigor measures may have a weak functional relationship to spatial characteristics of TPB infestation. An example of the close functional relationship (linear) of one vegetation index (NDVI) to crop vigor (plant height) is shown in Figure 1, and an example of the weak functional relationship (linear) of NDVI to TPB infestation is shown in Figure 2. Other curvilinear regression models and data transformations have not yet been studied. The positive trends in slopes in this study and the effective use of imagery based cotton field classifications for site-specific TPB control (Sudbrink et al. 2003) indicate an effective functional relationship of TPB infestation to imagery that may be better described by models other than the linear regression model.

A second approach used in this study was to partition TPB infestation data into classes of equal interval NDVI quartiles. These data were analyzed by ANOVA and results are graphically summarized in Figures 3 – 11. These data show that significantly higher incidents of above threshold levels of TPB infestation occur in the two higher NDVI quartiles (upper 50 percentile) than in the two lower NDVI quartiles (lower 50 percentile) (Figures 4, 7, and 10). The average TPB infestation levels are significantly higher in the two upper quartiles than in the two lower quartiles (Figures 5, 8, and 11). These results verify the usefulness of NDVI for classification of a cotton crop into high-risk infestation zones and low-risk infestation zones. Such zone classification provides efficiencies in insect scouting and provides the basis for site-specific insecticide application.

References

Ashburn, P. 1978. The vegetative index number and crop identification. The LACIE Symposium Proceedings of the Technical Session, pp. 843-850.

DuPont, K., R. Campanella, M. R. Seal, J. L. Willers, and K. B. Hood. 2000. Spatially variable insecticide applications through remote sensing. Proc. Beltwide Cotton Conf., National Cotton Council of America, Memphis, TN. 2:426-429.

Jackson, R. D. and A. R. Huete. 1991. Interpreting vegetation indices. Preventive Vet. Med. 11: 185-200.

Layton, B. 2003. Cotton insect control guide. Mississippi State University Extension Service. Publication 343, 35pp.

Sudbrink, D. L., F. A. Harris, J. T. Robbins, and P. J. English. 2001. Remote sensing and site specific management of cotton arthropods in the Mississippi Delta. Proc. Beltwide Cotton Conf., National Cotton Council of America, Memphis, TN. 2:1220-1223.

Sudbrink, D. L., F. A. Harris, J. T. Robbins, and P. J. English. 2003. Site specific management in Mississippi Delta cotton: experimental field studies and on-farm application. Proc. Beltwide Cotton Conf., National Cotton Council of America, Memphis, TN. 6pp.

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. Beltwide Cotton Conf., National Cotton Council of America, Memphis, TN. 2:1133.

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.

Acknowledgments

The authors would like to thank Brenda Yant, Boise Stokes, and Sean Horton for their assistance. We thank J. Gore, G. Snodgrass, and H. Pitre for review and help in preparation of the manuscript. We are especially grateful to Patrick D. Gerard (MSU, Division of Agriculture, Mississippi State, MS) for advice and assistance in statistical analyses of data. This research was funded in part by National Aeronautics and Space Administration through the Mississippi State University Remote Sensing Technologies Center, and the USDA, CSREES Advanced Spatial Technologies in Agriculture project at Mississippi State University.

Table 1. Mean coefficients of determination (r^2) and coefficients of variation (CV) for linear regression analyses of cotton plant height (PH), cotton canopy width (CW), and tarnished plant bug infestation sampled by sweep net (SW), terminal observations (TRM), and drop cloth (DR) - (dependent variables), summarized across six imagery indices (NDVI, GNDVI, GVI, RVI, GRVI AND AVI) - (independent variables). Analyses were across multiple data sets at Stoneville, Mississippi.

Dependent Variable (Observation method)	Number of Regressions Represented	r^2		CV	
		Mean (Std. Dev.)	Range	Mean (Std. Dev.)	Range
PH	156	0.71 (0.19)	0.01 - 0.93	10.9 (4.3)	0.67 - 44.6
CW	30	0.67(0.13)	0.29 - 0.83	9.8 (2.7)	5.1 - 14.4
SW	42	0.26 (0.17)	0.02 - 0.56	118.6 (39.2)	80.6 - 198.7
TRM	132	0.11 (0.12)	0.0 - 0.49	181.5 (113.7)	33.5 - 553.0
DR	120	0.22 (0.14)	0.0004 - 0.55	77.4 (34.1)	38.0 - 202.3

Table 2. Mean coefficients of determination (r^2) and coefficients of variation (CV) for linear regression analyses of tarnished plant bug infestation sampled by sweep net (SW), terminal observations (TRM), and drop cloth (DR) - (dependent variables), summarized across plant height (PH) and canopy width (CW) - (independent variables). Analyses were across multiple data sets at Stoneville, Mississippi.

Dependent Variable (Observation method)	Number of Regressions Represented	r^2		CV	
		Mean (Std. Dev.)	Range	Mean (Std. Dev.)	Range
SW	21	0.35 (0.23)	0.09 - 0.62	92.0 (5.3)	85.2 - 99.3
TRM	5	0.08 (0.10)	0.0003 - 0.37	202.7 (119.4)	66.0 - 594.9
DR	23	0.19 (0.14)	0.02 - 0.46	72.5 (22.9)	41.8 - 128.6

Figure 1:

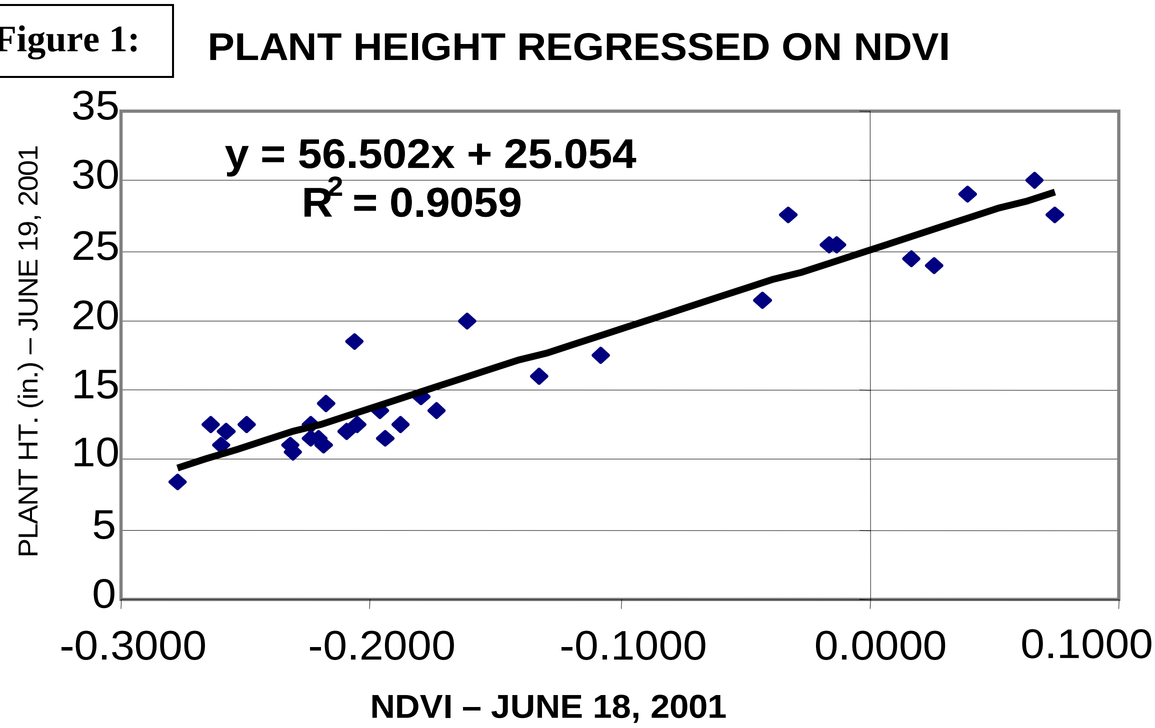
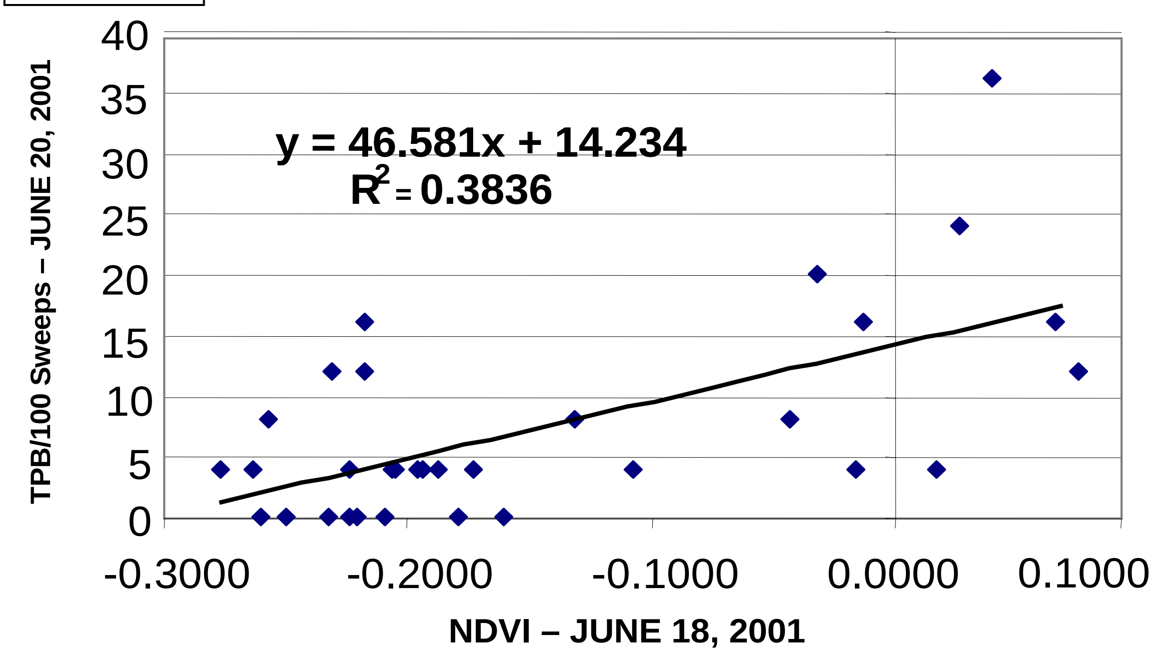


Figure 2:



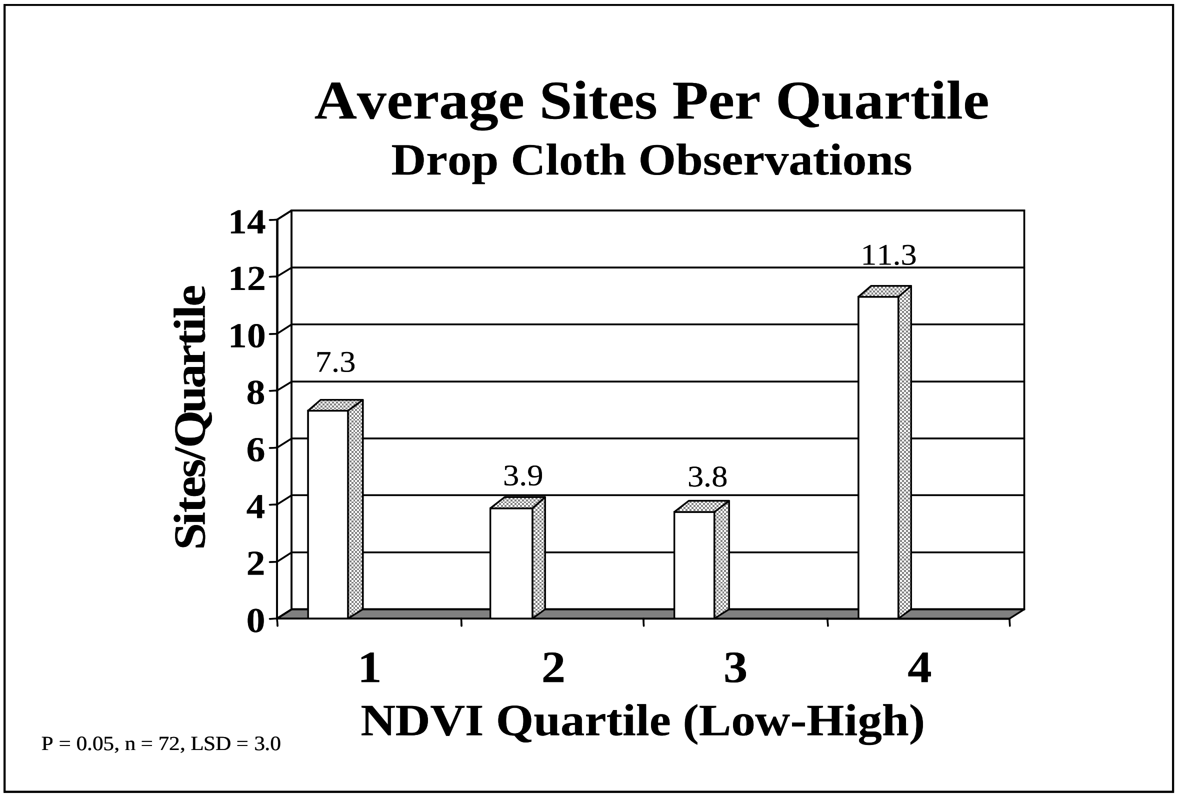


Figure 3:

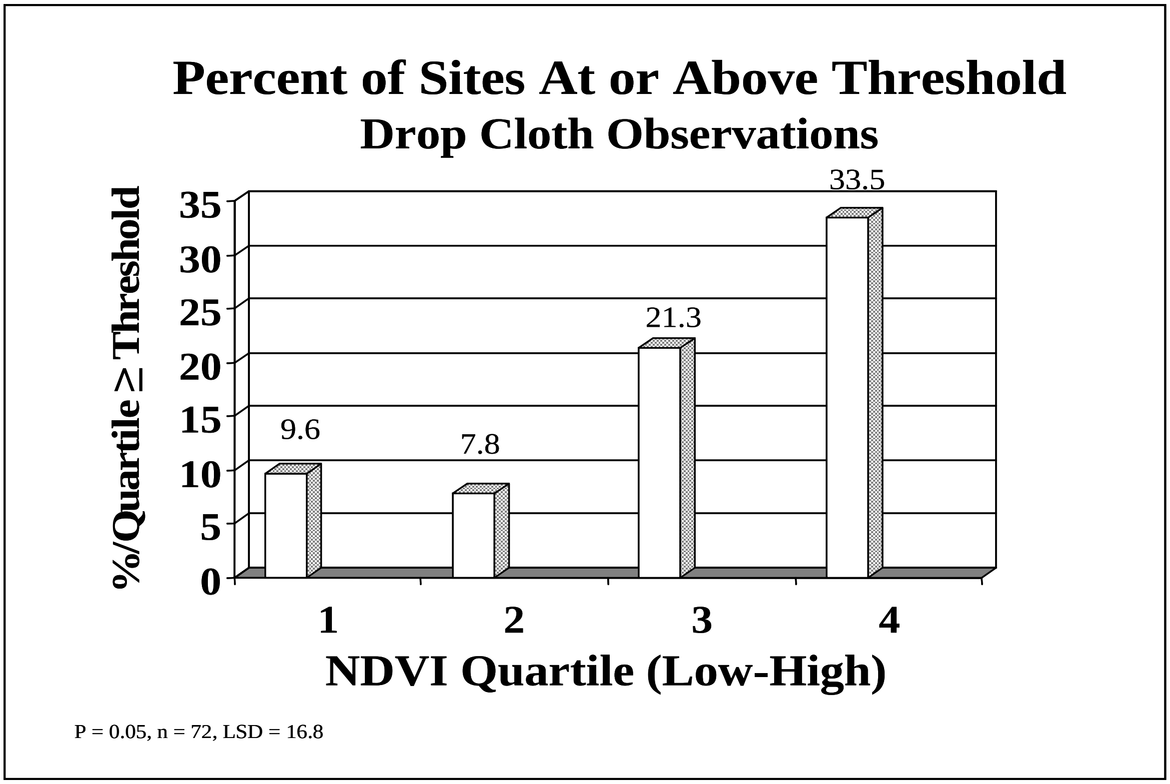


Figure 4:

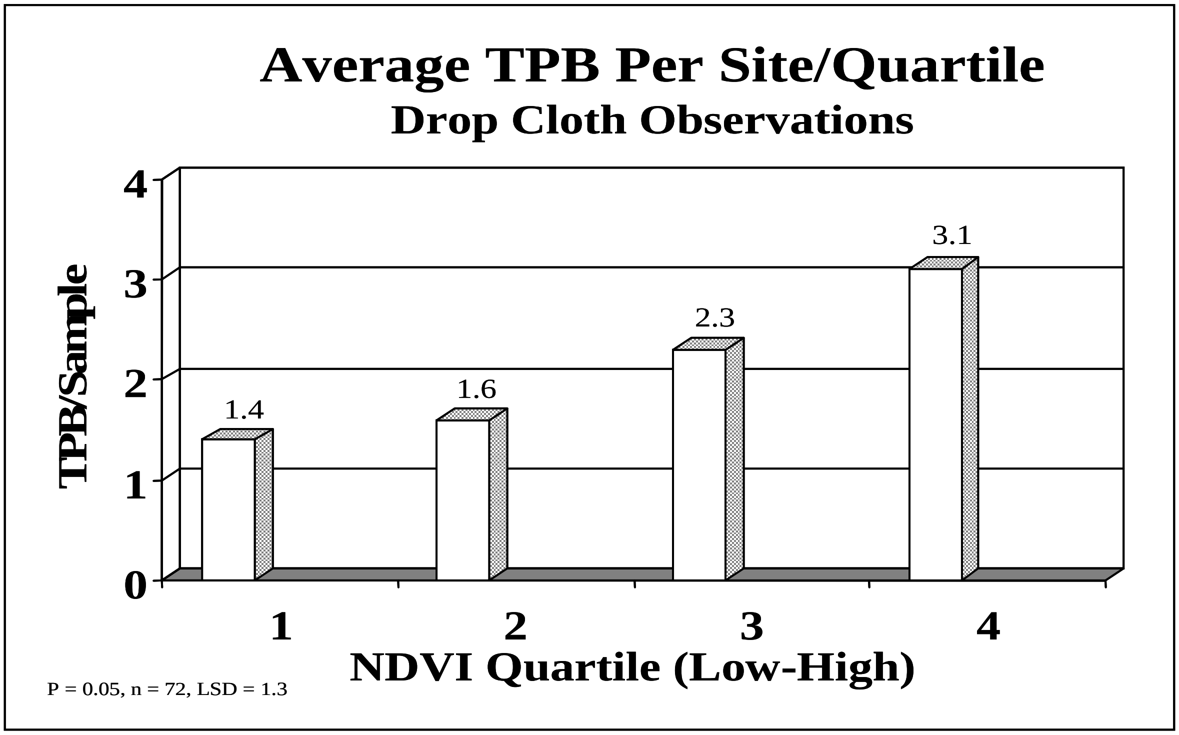


Figure 5:

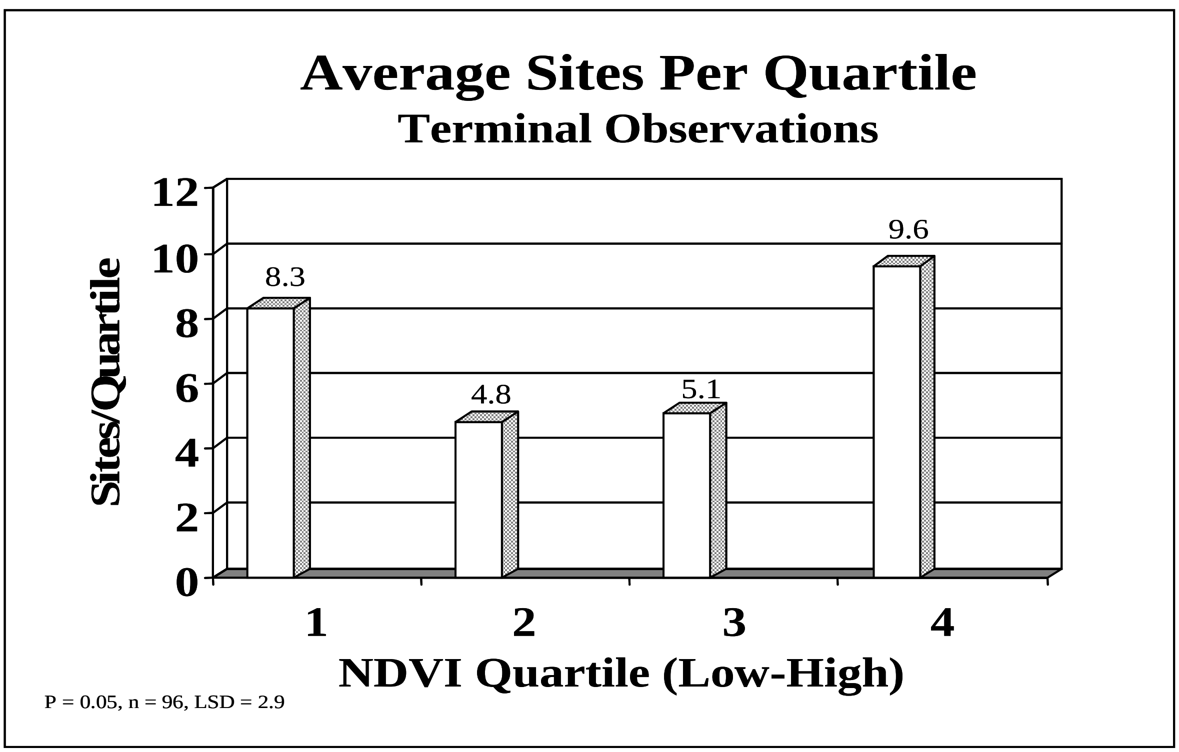


Figure 6:

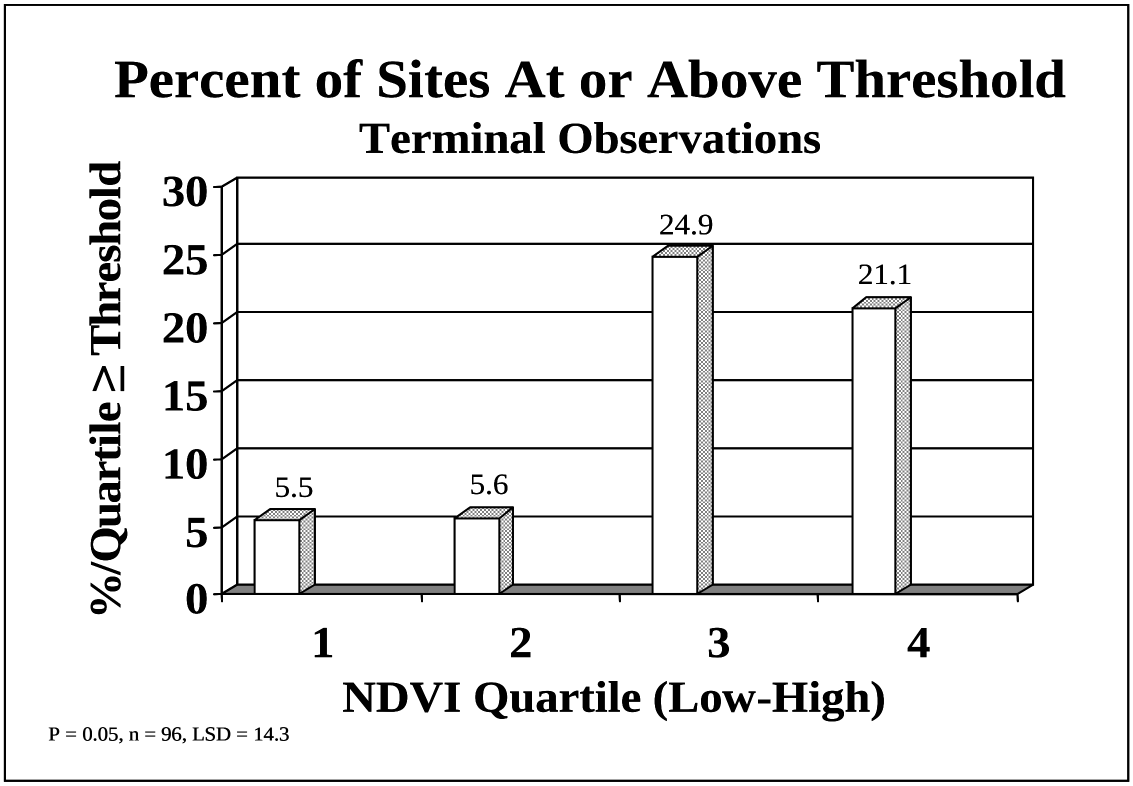


Figure 7:

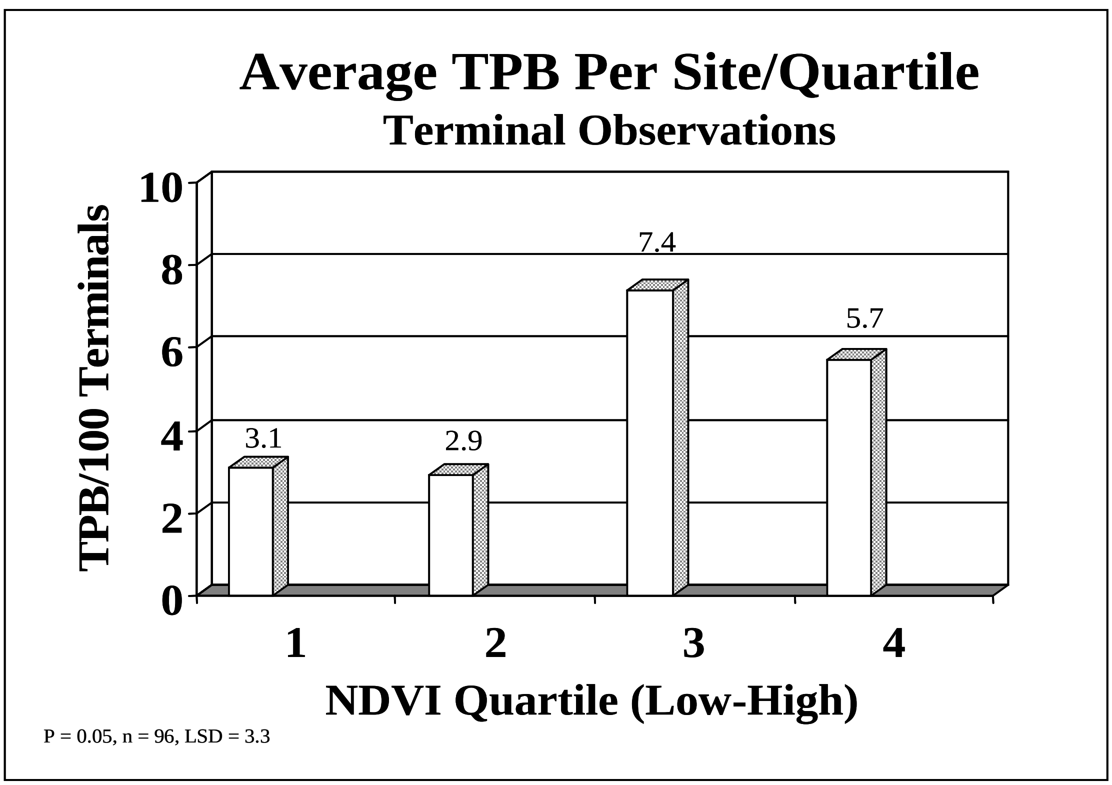


Figure 8:

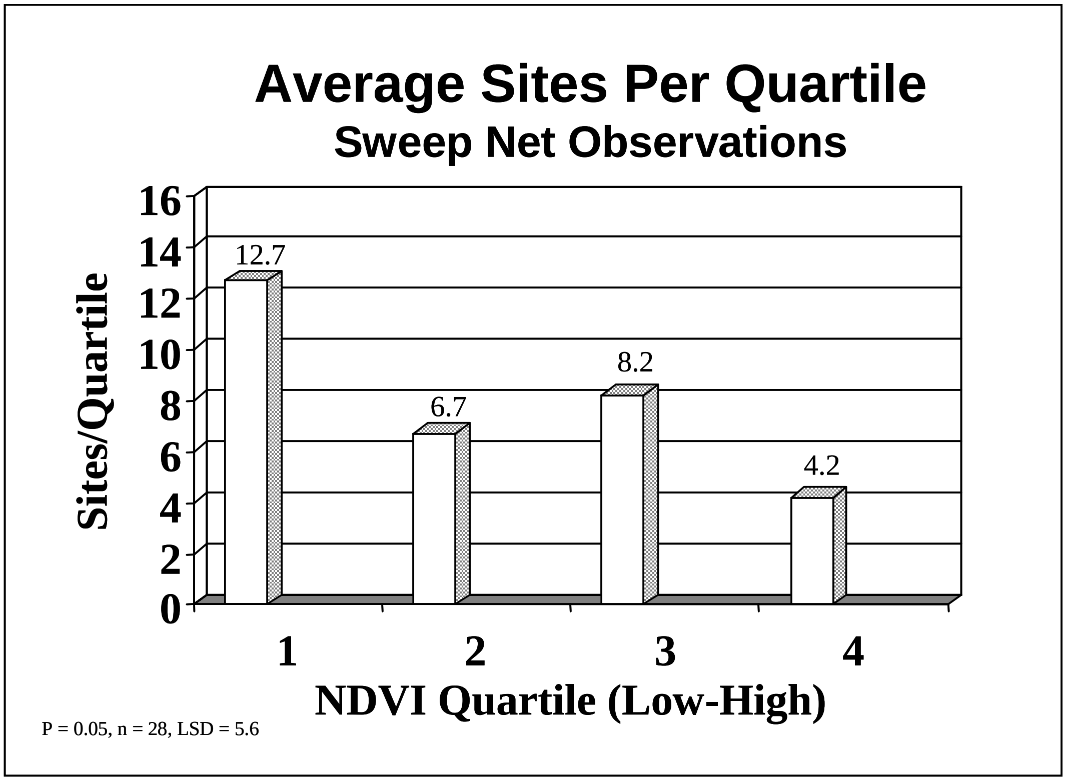


Figure 9:

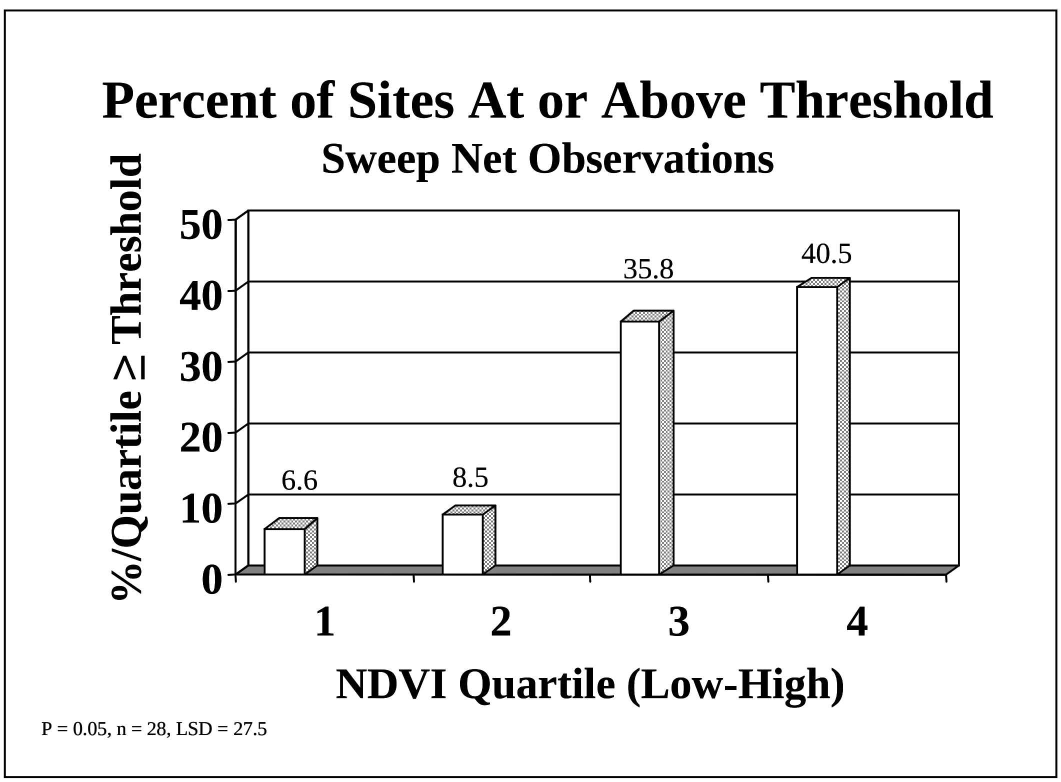


Figure 10:

2005 Beltwide Cotton Conferences, New Orleans, Louisiana - January 4 - 7, 2005

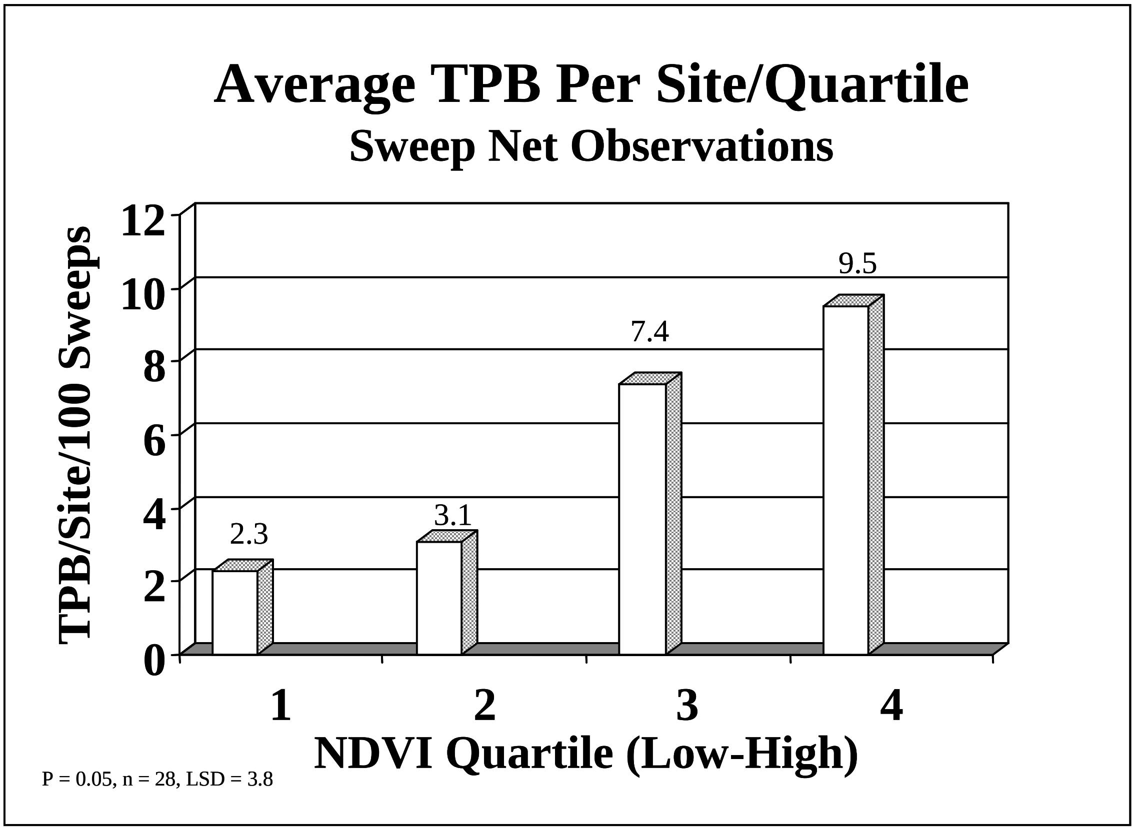


Figure 11: