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LARGE FARM MANAGEMENT OF COTTON INSECTS VIA THE USE OF INSECT SAMPLES AND COTMAN INFORMATION

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Abstract

Over the past four years, we have studied historical cotton production records, insecticide use patterns, COTMAN information, and insect scouting reports on three large cotton farms in Northeast and Southeast Arkansas. Our intent was to examine temporal and field-to-field variation in the data and explore options for more efficient collection of insect management information. We have supplemented the study of these historical records with detailed trapping of heliothines moths across the landscape of each farm and COTMAN sampling of index fields at our Southeast Arkansas research site. Only recently have our databases matured to the point that we can begin to explore practical questions of data collection and strategic management across the scale of a large farm. More work is needed to finalize and archive the databases, and empirical experiments should be designed to directly test observations resulting from our study of historical records. A preliminary examination of COTMAN estimates of fruit shed and crop maturity suggested that year-to-year and farm-to-farm variation may be too high for practical management decisions across years and farms. However, variability among fields on a given farm and a given year was less and suggestive that understanding field-to-field differences and similarities may provide a mechanism for optimized scouting and management decisions. Heliothine eggs and plant bugs varied greatly across the different farms. At the Southeast Arkansas location, a significant reduction in heliothine eggs and a significant increase in plant bugs were observed over the past four years. Data were available for an 11-year period at the Northeast Arkansas location. Trends in increased plant bug densities and decreased heliothine egg densities were not noted. Overall densities of heliothine eggs were extremely low, with only 5% of the samples detecting eggs. Identification of the fields most prone to insect infestations may provide a key to optimized scouting across these large farms.

Introduction

Most traditional approaches to cotton insect management rely on management reactions to field-by-field assessment of pest densities and damage. Arkansas has a long history of innovative approaches to cotton insect management including organized insect scouting, community management systems, and indexing of crop development through COTMAN. Recent advances in insect control technologies, especially transgenic plants that express insecticidal proteins, and removal of boll weevil as a key pest of Arkansas cotton are providing historically unique opportunities to capitalize on more sophisticated management approaches. Precision agriculture and a wide range of evolving spatial management systems, including aerial and satellite imagery, are changing the traditional concept of the cotton management unit (Willers et al. 1999). Many researchers and farmers are now thinking about a range of different productivity zones within individual fields. Policy makers and regulators are thinking about tracking crop production inputs and environmental responses across large geographic regions that are spatially defined and quantifiable. The scale of the management unit is becoming less restrictive. To better understand how management unit variability may impact insect management decisions and how information collection may be better organized on different scales of management, we studied historical production records, insect scouting reports, and COTMAN information across three large cotton farms in Arkansas. Our rationale for this work and our reference to previous cotton insect management research in Arkansas is contained in McFall et al. (2003) and Luttrell et al. (2004). Allen et al. (2004 and 2005) describe heliothine moth capture studies related to the overall synthesis of this information.

Materials and Methods

Historical production records including information on field location, field size, yield, varieties, pesticide use, weekly COTMAN samples, and weekly insect scouting reports were obtained for Wildy Farms in Mississippi County, the Northeast Arkansas research site, for the period 1994 – 2005. Complete records on all data fields were not available for all years, but the total dataset is extensive and detailed. Additional refinement of the data may provide a larger data set as we better understand some of the incomplete or unknown records eliminated from preliminary analyses. These resulting data were organized in a database and studied by descriptive statistics. Most of the data fields included thousands of rows of information. For example, more than 10,000 individual insect samples were included in the analysis of insect scouting records. The COTMAN records are more elaborate and detailed, perhaps the most detailed farm-level dataset in the U.S. Cotton Belt.

Historical information at the Southeast Arkansas site was obtained from two large planting companies, R. A. Pickens and Son and Tillar and Company, located in Desha and Drew Counties. Detailed insect scouting records were available for R. A. Pickens and Son for the period 2001 – 2004. This included more than 6000 individual samples from different fields across the farm. Additional information on field locations, varieties, production inputs, and insecticide treatment records are being collected and organized, but they were not used in this study. COTMAN information is not methodically collected at the Southeast Arkansas research site. In 2004 and 2005, we monitored ~30 fields across the Southeast Arkansas area as index fields. Weekly COTMAN samples were collected in these index fields, and monthly or bi-weekly samples were collected in similar index fields in 2004. We used this information about fruit retention and crop to supplement the historical records provided by the planting companies.

For purposes of this preliminary examination of the collective data, we limited our observations to fruit shed and crop maturity information from COTMAN samples and average weekly samples of heliothine eggs and plant bugs. Sampling of insects varied at the two locations. Visual observations were relied on at the Southeast Arkansas locations. Drop cloth samples were used in addition to visual counts at the Northeast Arkansas locations. COTMAN sample procedures (Danforth and O'Leary 1998) were similar at both locations. In all data sets, we characterized variability graphically via the use of 95% confidence intervals.

Results

In 2005, fruit shed measured in COTMAN samples at the Southeast Arkansas location indicated that average fruit shed was below 10% until the second week in July (Figure 1). As late at the first week in August, plants were retaining 65% of all first position fruit. Variability across the region in estimates of % fruit shed generally ranged from 3 to 5%. Average % shed at the Appleberry farm was slightly higher that that for most of the other fields in June, but it was still less than 10%. The extremely large COTMAN data set at Wildy Farms indicated that fruit shed is historically less than 10% until the third week of July (Figure 2). Confidence intervals around the average estimated fruit shed only varied 3 to 4 % across the different fields on the farm during June and July. Year to year variation was slightly higher, as much as 5 to 7% during some years.

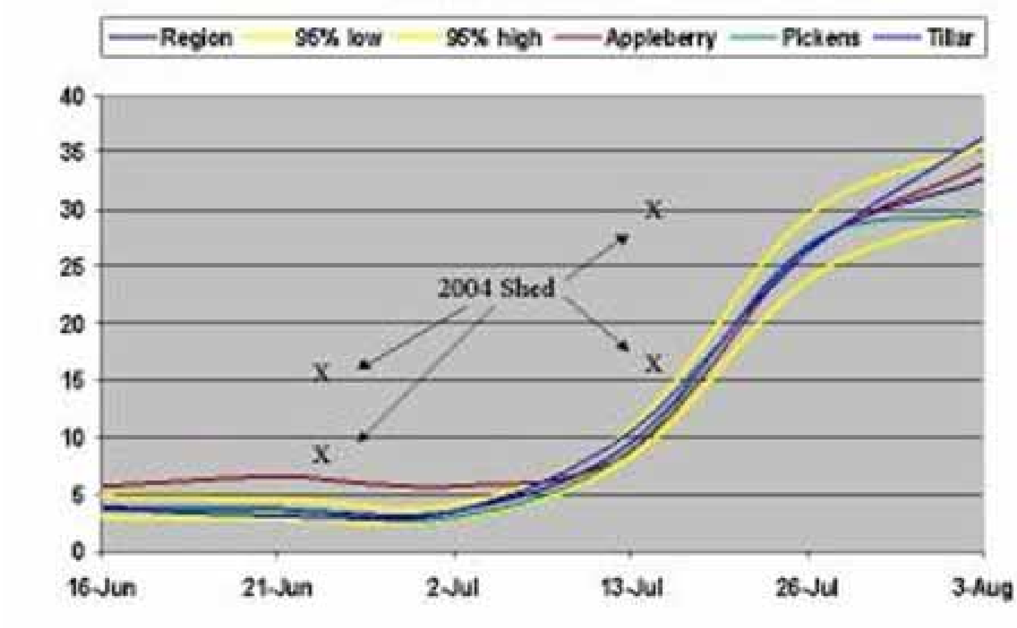
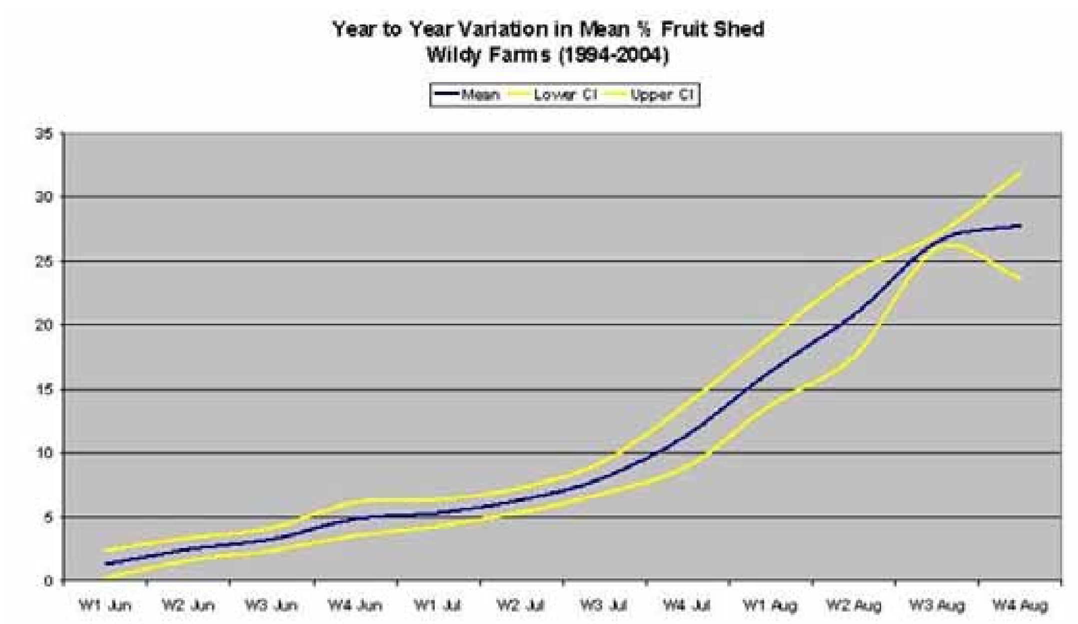


Figure 1. Percent fruit shed on farms in Southeast Arkansas as measured by COTMAN in 2005.



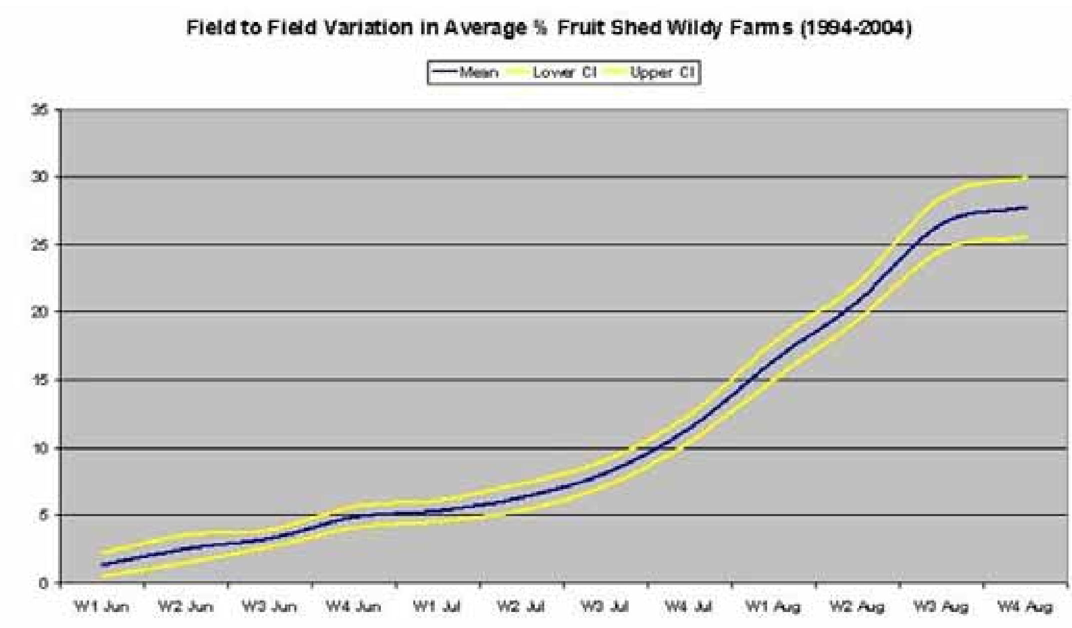


Figure 2. Year to year and field to field variability in average % fruit shed on Wildy Farms, 1994-2004. Upper and lower lines on each graph are 95% confidence intervals.

The detailed SquareMap information in the Wildy data allowed us to examine three different methods of estimating square shed: (1) monitoring retention of the top three fruiting nodes (S3PCTSHED), (2) monitoring retention of the third node from the terminal (3rdPOSSHED), and (3) monitoring retention of all first position nodes (SPCTSHED). In our field work, we typically use SPCTSHED, but others, including the Arkansas Cooperative Extension Service, often utilize these alternative methods to characterize fruit shed. In the Wildy data, average trends in fruit shed as a function of days from planting were highly correlated for all three sample methods (Figure 3). This suggests that seasonal trends could be characterized by either method. However, the magnitude of % shed varied at some time intervals (e.g. 63 to 69 days from planting). Crop managers should carefully describe the method used to determine square shed when communicating with others and estimating absolute magnitudes of shed rates.

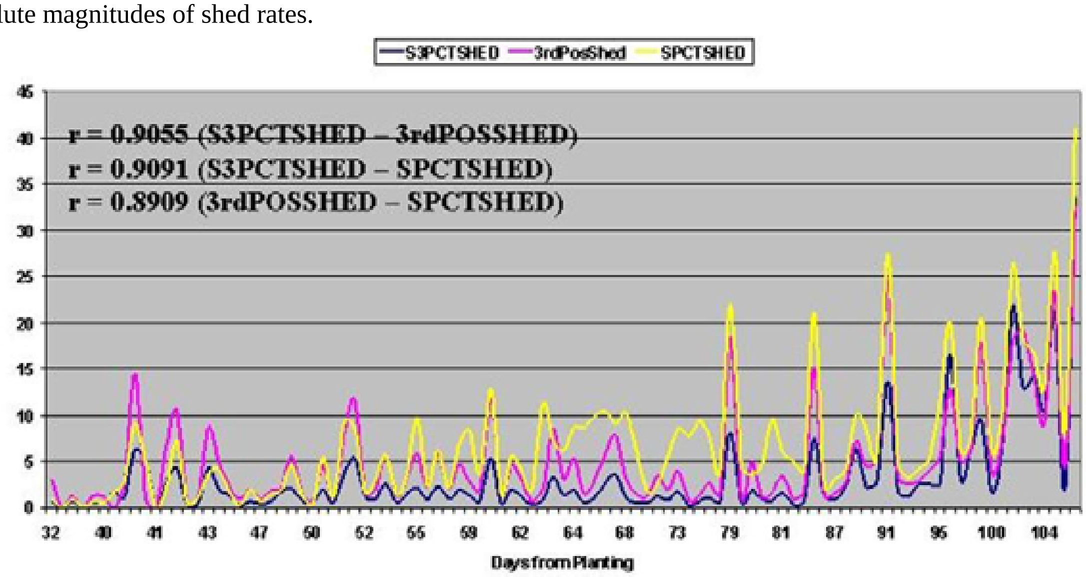


Figure 3. Average % square shed on Wildy Farms (1994-2004) estimated by three separate methods from COTMAN information: S3PCTSHED = shed of fruit from top three fruiting positions,

3rdPOSSHED = shed of fruit on the third position from the top, and SPCTSHED = shed of fruit from all first position fruiting sites.

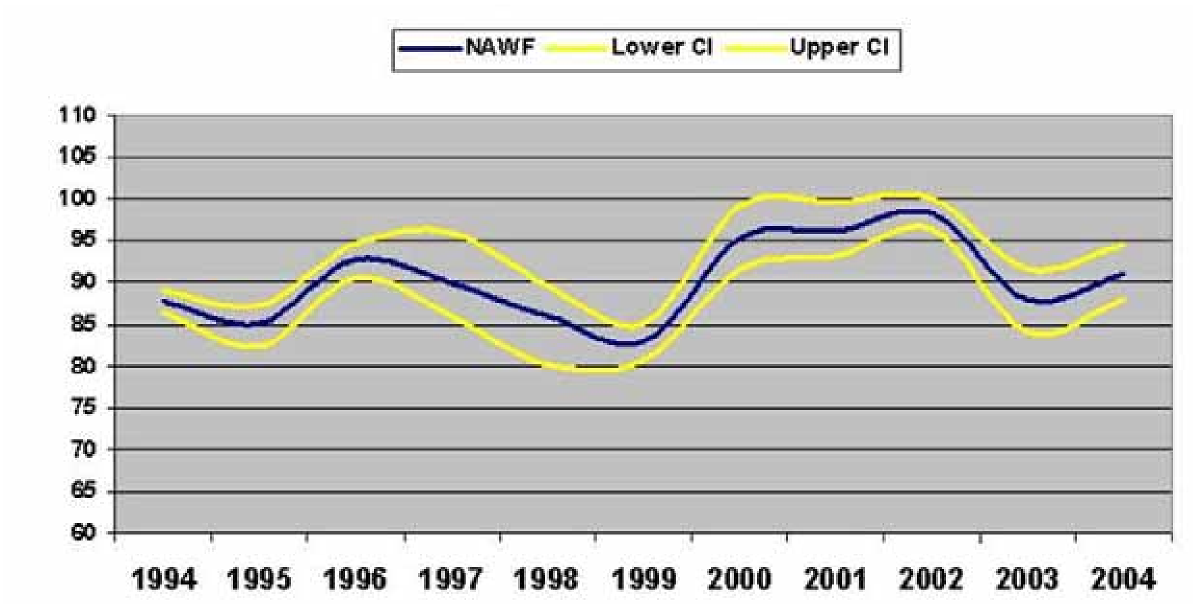


Figure 4. Average days from planting to NAWF = 5 on Wildy Farms, 1994-2004. Upper and lower lines are 95% confidence intervals.

Figure 4 provides a summary of 11 years of COTMAN information used to estimate cutout (NAWF = 5). Average days from planting to cutout ranged from 84 in 1999 to 97 in 2002. Confidence intervals around these average annual estimates ranged from 8 days in 1997 to 4 days in 2002. Length of time from planting to cutout seemed to be slightly higher in recent years, although the trend was not studied statistically. Estimates of NAWF = 5 were more variable in the smaller data set for Southeast Arkansas in 2005 (Figure 6). Across all index fields located on three farms, cutout ranged about 20 days. Average date of cutout was slightly later at Pickens (August 1) than at Tillar (July 24). Variation among fields on the different farms in Southeast Arkanasas indicated a range of 10 days for cutout on the Appleberry farm (Figure 6), a range of 5 days on Pickens (Figure 7), and a range of 8 days on Tillar (Figure 8).

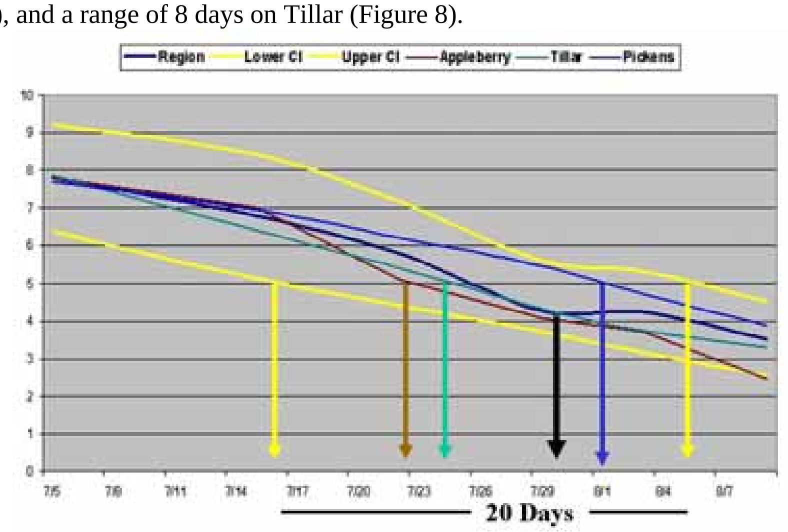


Figure 5. Average date of NAWF on three farms in Southeast Arkansas in 2005. Upper and lower lines represent 95% confidence intervals. Arrows indicate date of NAWF = 5.

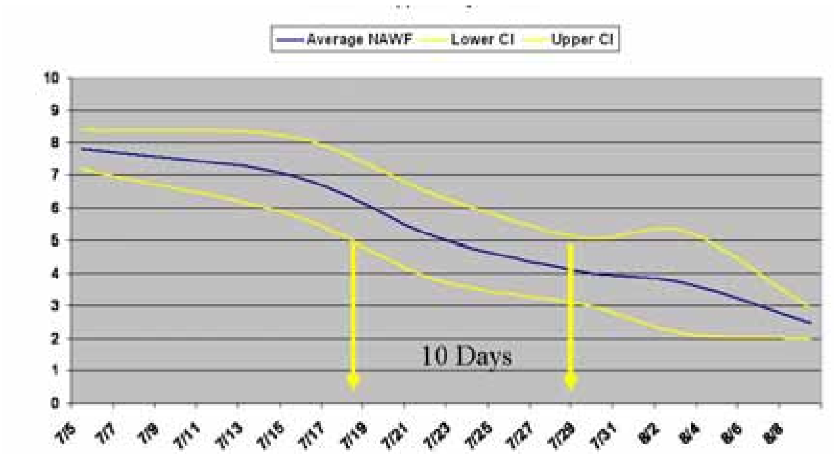


Figure 6. Average date of NAWF in fields sampled on the Appleberry Farm in Southeast Arkansas in 2005. Upper and lower lines represent 95% confidence intervals. Arrows indicate range in NAWF =5.

Figure 7. Average date of NAWF in fields sampled on R. A. Pickens and Son in Southeast Arkansas in 2005. Upper and lower lines represent 95% confidence intervals. Arrows indicate range in NAWF =5.

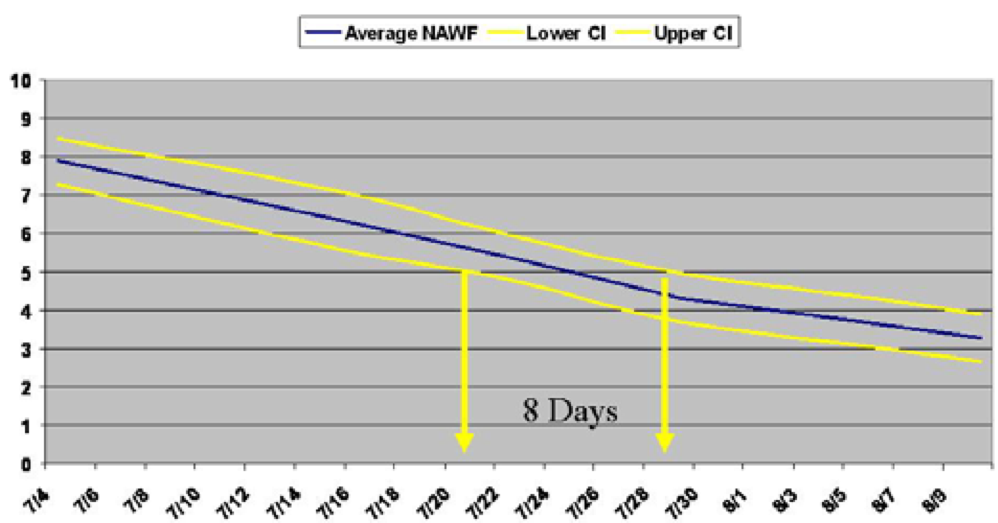


Figure 8. Average date of NAWF in fields sampled on Tillar and Company in Southeast Arkansas in 2005. Upper and lower lines represent 95% confidence intervals. Arrows indicate range in NAWF =5.

Seasonal average number of heliothine eggs per 100 plants declined from 2001 to 2004 at the Pickens research site (Figure 9). Plant bug numbers per 100 plants increased (Figure 10). Variability from year to year and week to week was high, but variability from field to field within a given week was small (Figure 11). When all data were averaged for each year of the study and plotted across the four-year period (Figure 12), a significant trend in reduction of heliothine eggs and in increased densities of plant bugs was observed. This was a summary of a very large data set (n = 6442 samples). To illustrate options to optimize sample size for various questions, subsamples of the entire data set (n=3221 samples) were analyzed and plotted. The subsamples reveal the same trends obtained with the entire data set, but with expanded confidence intervals.

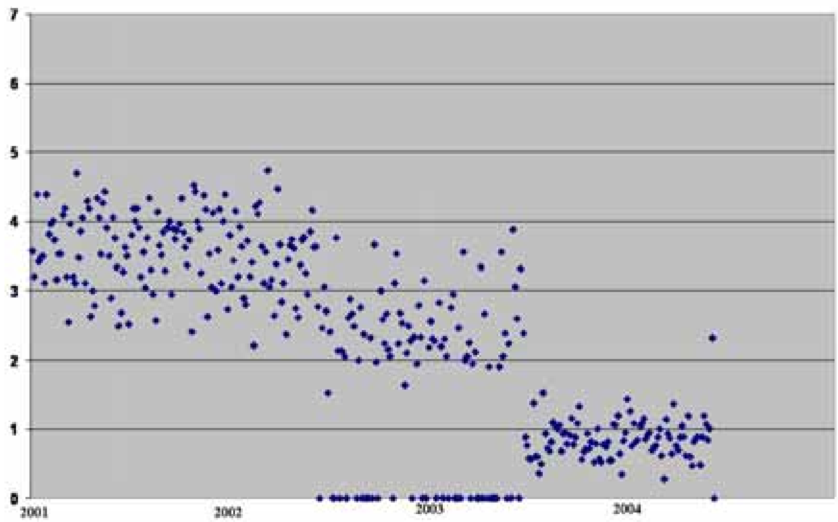


Figure 9. Seasonal average number of heliothine eggs per 100 plants in individual fields on R. A. Pickens and Son in Southeast Arkansas, 2001 – 2004.

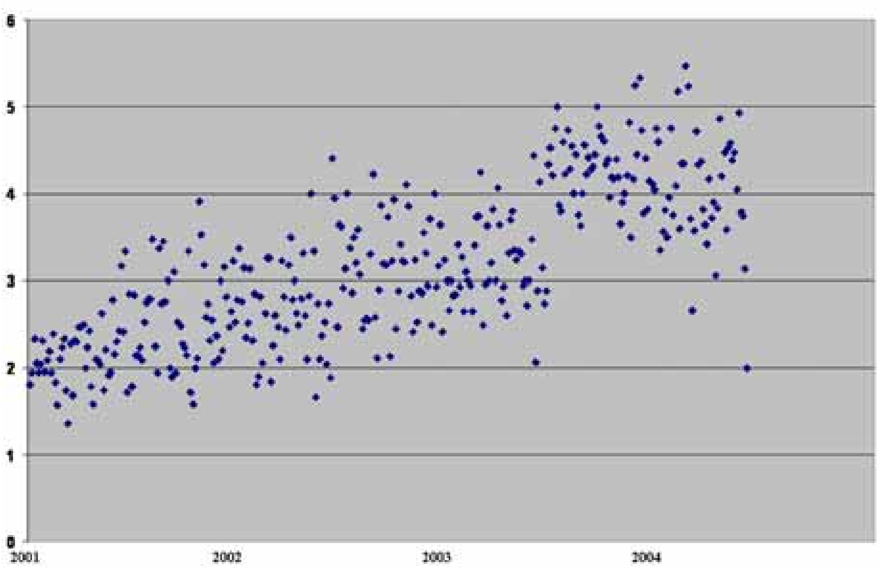


Figure 10. Seasonal average number of plant bugs per 100 plants in individual fields on R. A. Pickens and Son in Southeast Arkansas, 2001 – 2004.

No obvious trend in heliothine egg densities were detected in the elaborate Wildy dataset that included 11 years of sample information. Heliothine eggs are extremely rare in these samples. More than 95% of the samples collected over the 11 year period (10,262 samples) included no observations of heliothine eggs (Figure 13).

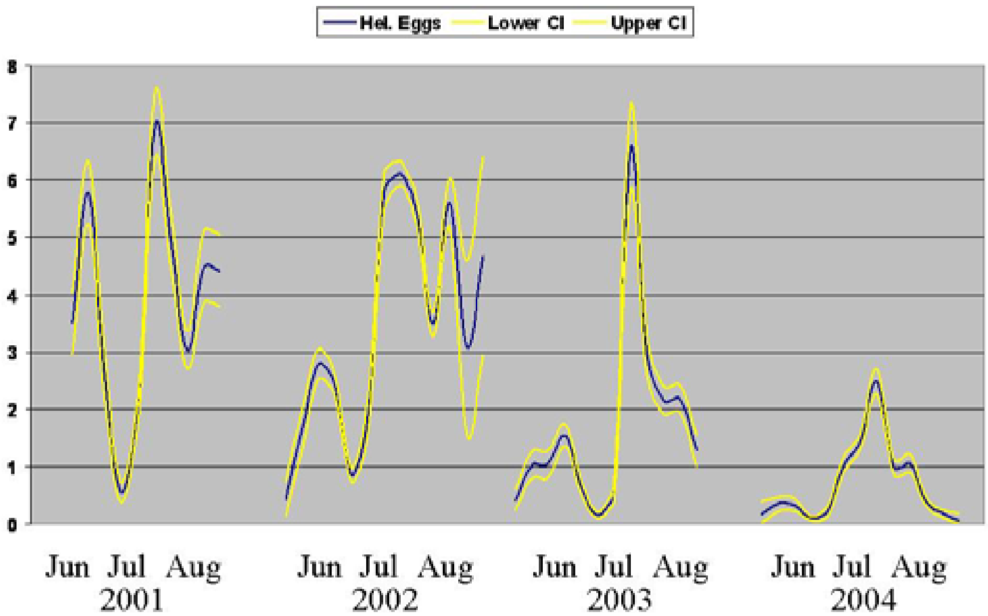


Figure 11. Field-to-field variability in weekly averages of the number of heliothine eggs per 100 plants, R. A. Pickens and Son, Southeast Arkansas, 2001-2004. Upper and lower lines are 95% confidence intervals.

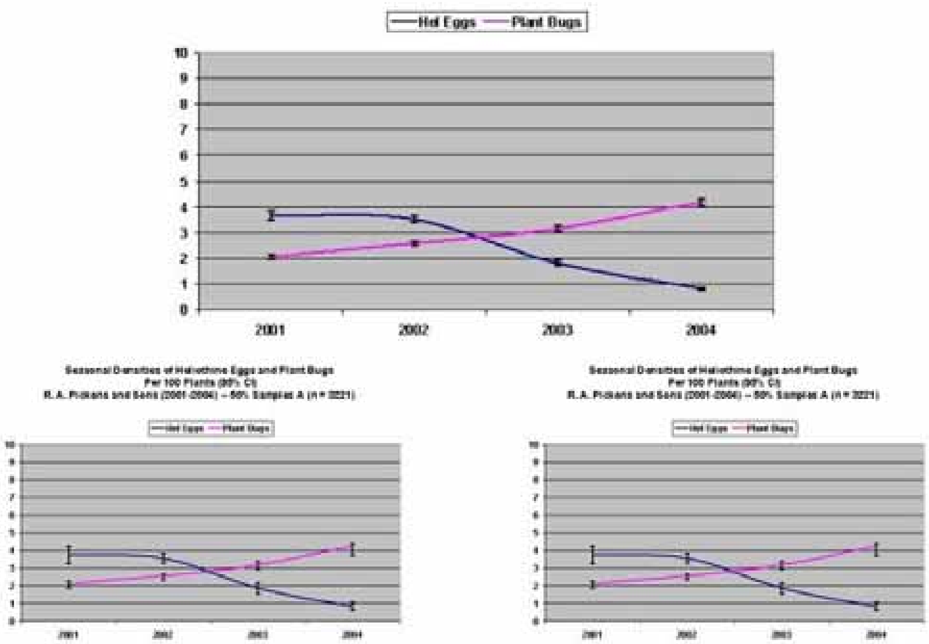


Figure 12. Annual average densities of heliothine eggs and plant bugs per 100 plants using all samples (top graph with 6442 samples) and half of the samples (lower graphs with 3221 samples).

When these data were averaged by individual field and sorted from least to greatest density of eggs, 60% of the fields had no recorded egg densities over the study period (Figure 14). Only 6% had average populations approaching treatable densities. A similar analysis of plant bug numbers at the Wildy site indicated that 58% of all samples had at least one plant bug detected (Figure 15). There was no obvious trend for increased densities, but more recent data (i.e. since 2000) need to be carefully studied in a separate analysis. Most of the fields averaged 1 to 5000 plant bugs per acre over the study period. Less than 10% of the fields had no detectable plant bugs and 6% had average numbers greater than 5000 per acre (Figure 16).

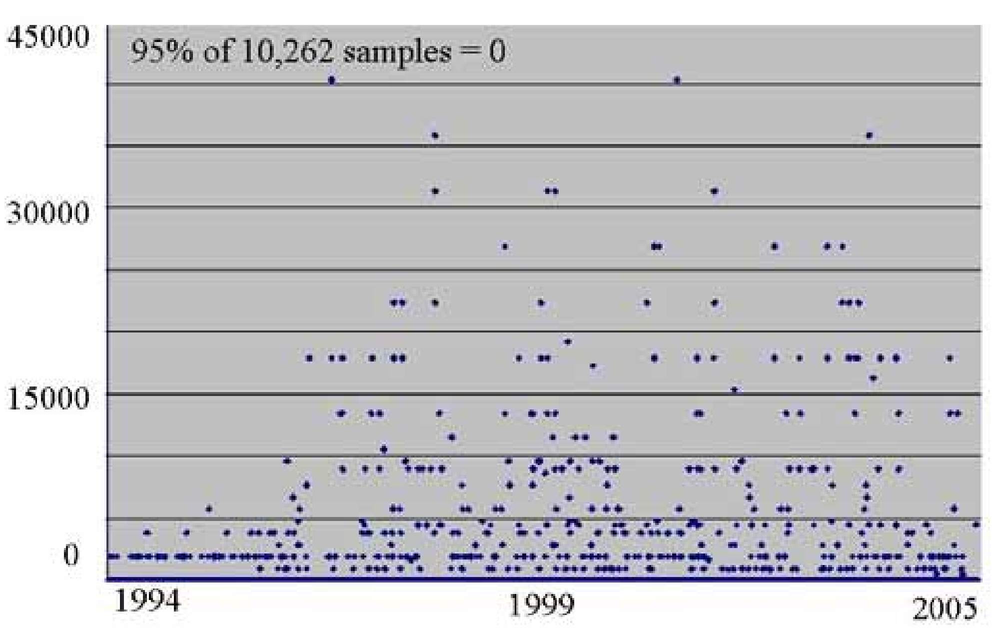


Figure 13. Heliothine eggs per acre in individual samples on Wildy Farms, 1994 -2005.

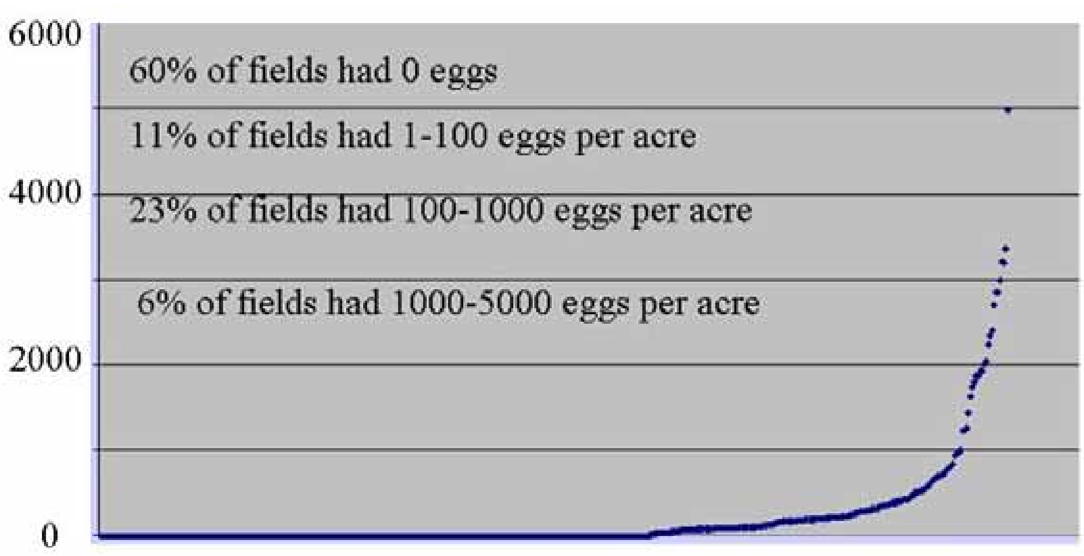


Figure 14. Average number of heliothine eggs per acre in individual fields on Wildy Farms, 1994 -2005.

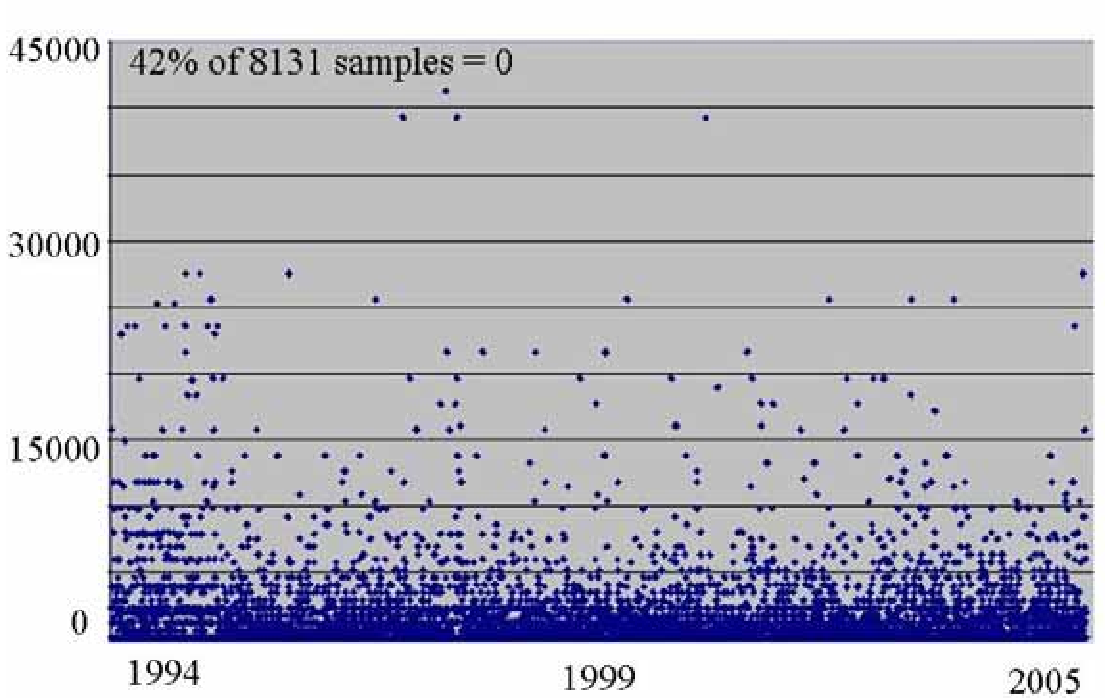


Figure 15. Plant bugs per acre in individual samples on Wildy Farms, 1994 -2005.

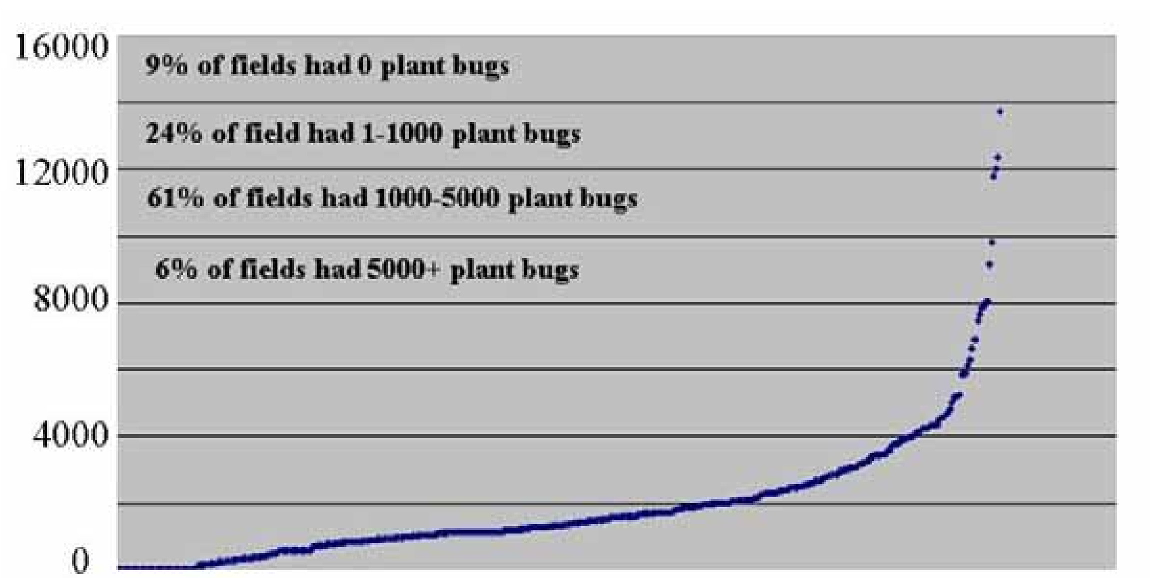


Figure 16. Average number of plant bugs per acre in individual fields on Wildy Farms, 1994 -2005.

Discussion

Collectively, these data illustrate a potential for characterizing production units on historical information. Coupling a database of historical information with strategic sampling across a large commercial farm could bring some efficiency to traditional field-by-field data collection. More work is needed to optimize the size of insect management units. Similarities in our preliminary summaries of COTMAN data and insect sampling information suggest that crop and insect management decisions based on fruit retention, crop maturity, and densities of heliothine eggs and plant bugs can be partially estimated from known field-to-field relationships.

Organization of this historical information with real time data collection may provide insight into the optimum scale of cotton insect management in Arkansas. Current efforts to spatial define different productivity zones within given fields will further expand opportunities to optimize collection of insect management information across entire farms. Benchmark information being compiled in this project will provide important insight into spatial and temporal variability of insect infestations, fruit retention, and crop maturity that will help design insect management systems with dynamic management units.

Acknowledgements

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References Cited

Allen, K. C., R. G. Luttrell, Marvin Wall, John Smith, Dick Hardee, and Richard Voth. 2004. Influence of surrounding crop structure on heliothine trap captures in Arkansas. Proc. Beltwide Cotton Conf., pp. 1417-1421.

Allen, K. C., R. G. Luttrell, and M. J. Cochran. 2005. Using farm records to explore spatial and temporal patterns of heliothine distributions on cotton in heterogeneous cropping environments in southeastern Arkansas. Proc. Beltwide Cotton Conf., pp. 1762-1768.

Danforth, D. M., and P. F. O'Leary (Eds.). 1998. *COTMAN Expert System 5.0 User's Manual*. Ark. Agric. Expt. Stat., Fayetteville, AR, 198 pp.

Luttrell, R. G., Tina Gray Teague, Diana Danforth, Bryce Blackman, Dale Wells, David Wildy, Steven Wall, Thad Freeland, and Patricia O'Leary. 2004. Further examination of COTMAN and grower production records as a basis for farm-wide management of cotton insects. Proc. Beltwide Cotton Conf., pp. 1395-1403.

McFall, Mandy, R. G. Luttrell, Tina Gray Teague, William Baker, Diana Danforth, David Wildy, Dale Wells, and Patricia O'Leary. 2003. Examination of production and COTMAN records on a large Arkansas farm: A foundation for area-wide insect management. Proc. Beltwide Cotton Conf., pp. 1385-1392.

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