# MULTISTATE EVALUATION

# of Tarnished Plant Bug Sampling Methods

## *in Blooming Cotton*

Fig. 1 - Immature tarnished plant bug.

Fig. 2 - Adult clouded plant bug.

Fig. 3 - Adult cotton fleahopper.

Fig. 4 - Adult green stink bug.

## Introduction

Cotton pest management has undergone significant changes since the mid 1990s. Extensive adoption of Bt cultivars and successful boll weevil eradication have greatly reduced insecticide applications targeting the once primary insect pests boll weevil, tobacco budworm and cotton bollworm. These applications, however, also were providing coincidental or collateral control of other insect pests, such as a complex of bug pests.

The primary complex of bug pests in cotton is composed of plant bugs and stink bugs. The tarnished plant bug (TPB, Figure 1) is the major bug pest in the mid-South while stink bugs are the major bug pest of the Southeast. Representatives of the plant bug pest group also include the tarnished plant bug (TPB, Figure 1), the clouded plant bug (Figure 2) and the cotton fleahopper (Figure 3). The most important members of the cotton stink bug pests include the green stink bug (Figure 4), southern green stink bug (Figure 5) and brown stink bug (Figure 6). Leaf-footed bugs (Figure 7) are becoming more of a problem in the southern mid-South area and would be considered members of the bug complex.

Many of these bugs are now the major insect pests of cotton. To compound the problem in the mid-South, TPB now have resistance to some insecticides (e.g., pyrethroids) that once provided collateral or coincidental control. All of these factors have contributed to increased control costs and crop losses for these pests since 1995.

Regardless of the species, members of the cotton bug pest complex cause similar types of damage to cotton. Both plant bugs and stink bugs cause direct yield loss by feeding on cotton bolls. No distinguishing differences in the boll damage are found among the different members of the bug complex. Plant bugs also will feed on squares, the damage from which may result in squares shed or anther damage that is visible during bloom.

The TPB is the predominant plant bug species found in mid-South cotton. TPB has historically been an important pest, and pre-bloom insecticide applications have sometimes been required to control infestations. Applications for TPB control in flowering cotton were less frequent because of the previously mentioned issues.

Research has shown that tarnished plant bugs can cause severe yield reductions during the flowering stages of cotton plant development. Figure 8 shows the yields of an experiment where insecticide applications targeting tarnished plant bugs were initiated from the second through seventh weeks of flowering and continued throughout the season. Yields in the untreated control were about half of those where insecticide applications were initiated during the second and third weeks of flowering.

Considerable work has been done to determine the most efficient and accurate methods for sampling TPB and their damage during the pre-bloom stages of cotton plant development. Consequently, agricultural pest managers have become comfortable with the sampling procedures in pre-bloom cotton where sweep-net samples along with square retention counts are used to determine the appropriate timing of insecticide applications. Unfortunately, no consensus has been reached on sampling methods for TPB during the blooming stages.

A dropcloth has typically been considered the best way to measure tarnished plant bugs, and many states have treatment thresholds based on dropcloth sampling. Consultants and pest managers, however, are reluctant to use dropcloths because of the perceived time and effort required for sampling. Many agricultural consultants base their control recommendations on visual observations, but methods of visual scouting are not standardized and vary considerably among individuals. Furthermore, accurate thresholds are not well established for visual samples, so many applications are based more on the experience of the consultant rather than on scientific research.

Several experiments have attempted to compare the accuracy and efficiency of dropcloth and sweep-net samples for tarnished plant bugs. These studies vary in their findings but generally concede that dropcloths are more effective at sampling immature TPB, and sweep nets are more effective at sampling adults. Plant-based monitoring procedures, such as numbers of damaged or frass-stained squares, also show promise as indices of plant bug populations.

Recommended sampling procedures for stink bugs differ from that of tarnished plant bugs. Boll injury thresholds for stink bugs have been adopted in much of the Cotton Belt. These thresholds call for treatment when 15 percent to 20 percent of bolls show internal evidence of injury such as warts on the boll wall and lint staining. This approach was developed in the Southeast where stink bug infestations in cotton are more common than TPB infestations. Tarnished plant bugs and clouded plant bugs, how-

*Fig. 5 - Southern green stink bug.*

*Fig. 6 - Immature brown stink bug.*

*Fig. 7 – Leaf-footed bug.*

*Fig. 8 - Lint yields from experiment of TPB insecticide applications.*

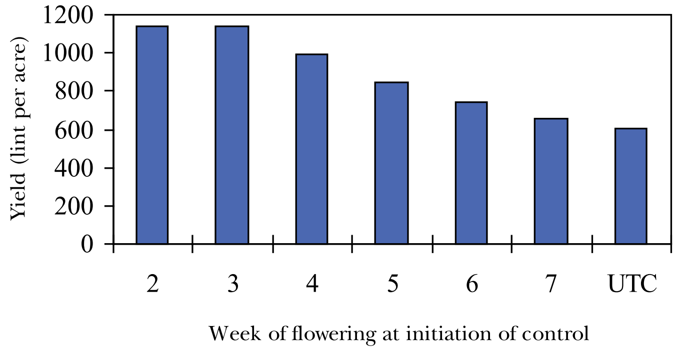


**Table 1. Description of the sampling unit for each method evaluated.**

**Direct Counts - Insects**

- Dropcloth - one 2.5-ft x 3-ft black dropcloth (5 row ft) placed between two rows with the cotton vigorously shaken over the cloth.
- Sweep Net - 25 sweeps using a 15-inch diameter sweep net.
- Whole Plant - inspection of the terminal (top 3 nodes), 2 squares, 1 bloom and 1 boll on 25 plants.

**Indirect Counts - Insect Damage**

- Dirty Squares - inspection of 25 half-grown or larger squares for external feeding signs (yellow staining) - Figure 9.
- Dirty Blooms - inspection of 25 white blooms for anther damage, Figure 10.
- External Bolls - external inspection of 25 medium-size bolls for dark sunken lesions characteristic of bug feeding, Figure 11.
- Internal Bolls- interior inspection of 25 medium-size bolls for wart-like growths on the boll wall or stained lint on one or more locks, Figure 12.

*Fig. 9 - Dirty square with external yellowing.*

*Fig. 10 - Dirty bloom with damaged anthers.*

*Fig. 11 - External boll damage from bug feeding (note sunken lesion).*

*Fig. 12 - Warts on internal boll wall resulting from bug feeding.*

ever, also will feed on small bolls and will cause injury symptoms similar to stink bugs.

This multistate evaluation of bug sampling procedures was initiated to identify the most accurate and efficient sampling methods for bug pests in blooming cotton. Multiple sampling methods were studied throughout the mid-South during 2005 and 2006.

## Procedures

Seven sampling methods were evaluated in commercial cotton fields in four states (Arkansas, Louisiana, Mississippi and Tennessee) representing the mid-South cotton production environment. These sampling methods included three direct estimates of bug density and four damage indices (Table 1). In each field, four locations were sampled using each method. Data recorded for each field included the date, the time necessary to take each sample, time of day, average plant height, average number of plant nodes, average number of nodes above the first position white flower (NAWF), temperature, wind speed, the presence of dew or other moisture, the person taking the sample and of course, counts of plant bugs and stink bugs.

During 2005, 120 fields were sampled. In 2006, only 60 fields were sampled, but the direct insect samples were taken at different times of the day in selected fields. Dropcloth, sweep-net and whole-plant samples were taken in the morning (7:00 a.m. - 9:00 a.m.), midday (11:00 a.m. - 1:00 p.m.) and afternoon (4:00 p.m. - 6:00 pm). Indirect samples were taken only during midday.

Tarnished plant bugs were the only bug pest found in densities sufficient for analysis. Thus, the following discussion will only consider TPB.

## Results

Among the direct sampling methods, sweep nets caught the most adults, and dropcloths caught the most nymphs (Figure 13). Sweep nets caught slightly more total TPB per sample unit than dropcloths or whole-plant methods. When considering the time required for collecting a sample, many more insects were collected with sweep nets and dropcloths than with the whole-plant sampling method (Figure 14). Among indirect sampling methods, the highest damage per sample unit was found in dirty blooms, which was also the most rapid indirect sampling method (Figures 15 and 16).

The precision of a sampling method determines the number of samples required to make a correct decision.

*Fig. 13 - Average number of adult and nymph TPB collected per sample unit.*

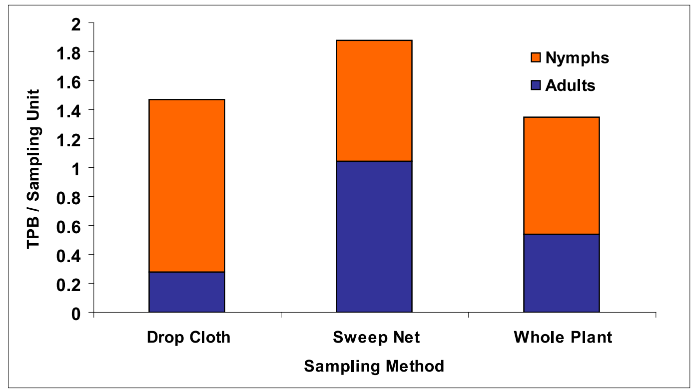



*Fig. 14 - Average number of adult and nymph TPB collected per minute of sampling.*

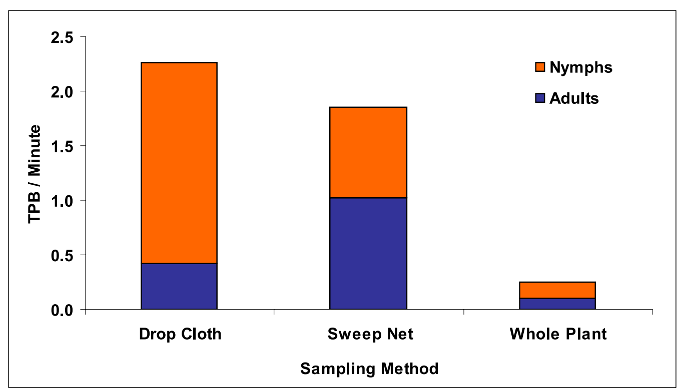



*Fig. 15 - Average percent damage observed per sample unit.*

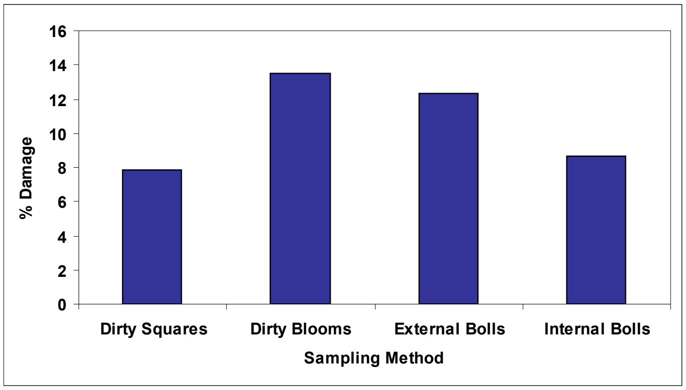



*Fig. 16 - Average number damage observed per minute of sampling.*

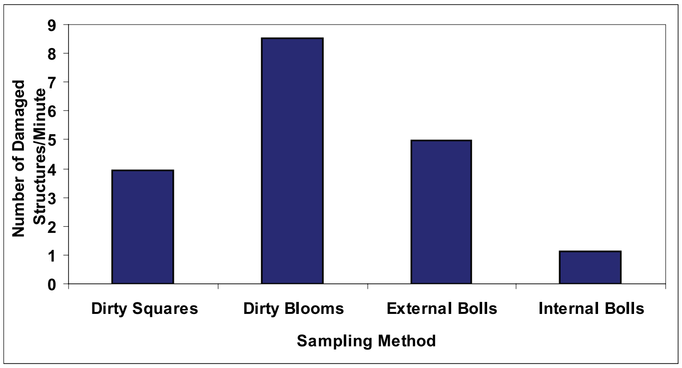



*Fig. 17 - Sampling precision - number of samples needed to make a correct decision 80% of the time when the population is 20% above threshold.*

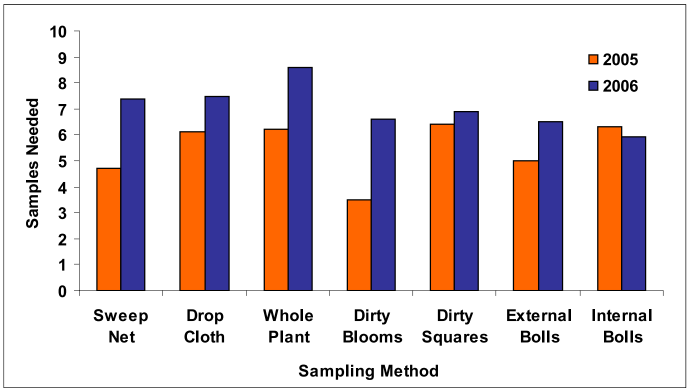
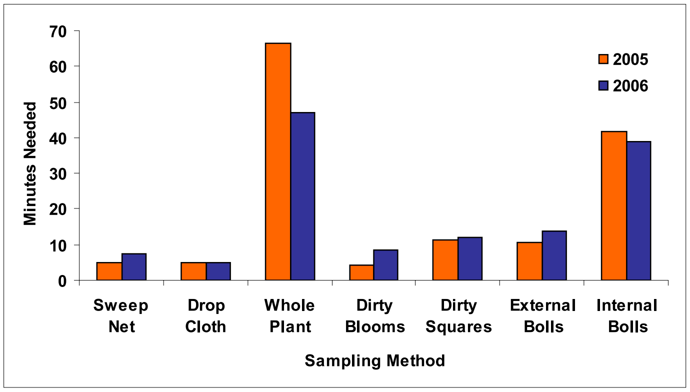



*Fig. 18 - Sampling efficiency - number of minutes needed to make a correct decision 80% of the time when the population is 20% above threshold.*




Differences in precision were relatively small among the different sampling methods. Comparison of methods for precision indicated that a similar number of samples are required by all sampling methods to make a correct decision 80 percent of the time if populations exceed the threshold by 20 percent (Figure 17). The total number of samples required for this level of precision ranged from about four to eight samples, with an average of five to seven sample units needed for each method when averaged across both years. Fewer samples would be needed if populations were well below or well above threshold.

Sampling efficiency is the total amount of sampling time required to make a correct decision. The sampling time required to make a correct decision 80 percent of the time varied considerably among samples when population densities were 20 percent above threshold (Figure 18). The sampling time required for the desired precision ranged from about 5-12 minutes for most methods, with the dropcloth, sweep-net and dirty-bloom techniques being the fastest. Sampling using the internal boll or whole plant technique, however, was much slower, requiring 30-60 minutes longer than the other methods to make a treatment decision with similar confidence.

The environmental conditions when samples were made marginally affected how many insects were found (Figure 19). The fewest TPB tended to be found in late afternoon samples, when average temperatures were the hottest, presumably because insects moved deeper into the canopy to avoid the heat. This decrease in efficiency was especially apparent for sweep-net and whole-plant samples where 20 percent to 25 percent fewer insects were caught in late afternoon compared with midday samples. A reduction in TPB numbers also was observed for the sweep net during early morning, at a time when the foliage was generally wet, compared with midday samples. It appears that a wet sweep net was about 15 percent less effective at catching TPB.

The person taking the sample also influenced the results, and although the dirty-square method was the least sensitive to sampler variation, all methods were statistically affected by the individual taking the sample. Unfortunately, no sampling method was immune to variation from one person to another.

## Discussion

Generally, our efforts indicate the many sampling techniques, both direct and indirect, can be used to estimate tarnished plant bug populations in cotton. The time required to take different kinds of samples, however, varied considerably, and this was the primary factor that influenced overall sampling efficiency. Whole-plant counts of insect numbers were effective but particularly inefficient. When plant bug numbers are near threshold, our data indicate that crop advisers would need to count TPB in about six sample units of 25 plants to make an accurate treatment decision. This sampling technique would take approximately 1 hour per field, whereas sampling with a dropcloth or sweep net would require about 5-8 minutes, excluding walking time, to achieve the same level of confidence.

Sweep-net and dropcloth sampling methods were about equally efficient but have different biases. Although sweep nets catch many more adults, more nymphs are found on dropcloths. Dirty blooms were the most efficient indirect sampling method tested and generally generated a recommendation consistent with the other sampling methods. The occurrence of dirty blooms, however, may respond slowly to changes in plant bug numbers (i.e., may be more indicative of previous pest densities than current infestation levels). We could not evaluate this possibility with these data. The dirty-square technique was relatively efficient compared with boll sampling methods, and it was easier to use when thumb-size bolls were not easily found (such as during early bloom). The dirty-square technique was also least sensitive to sampler variation.

Based on results across all fields, we calculated expected TPB counts for each sampling method when populations averaged 1, 2, 3, 4 or 5 insects per black dropcloth (5 row ft). Thus, when using a treatment threshold based on one sampling technique, an equivalent threshold can be estimated for another sampling method (Table 2). For example, if using a threshold average of 3 TPB per dropcloth, equivalent thresholds would be 15 TPB per 100 sweeps or 10 percent dirty squares.

Although many sampling techniques can be used to estimate tarnished plant bug populations, some methods are better than others based on sampling time and number of insects or damage observed. Traditional methods using a dropcloth or sweep net were confirmed as relatively reliable sampling techniques. Both the dirty-bloom and dirty-square techniques have promise as plant-based sampling indices for evaluating plant bug population densities. These techniques, however, would not be appropriate for monitoring stink bug populations and may be more influenced by other factors such as variety and crop maturity. Current and future research efforts are attempting to validate existing plant bug treatment thresholds and explore thresholds based on new, promising sampling techniques. ■

*Fig. 19 - TPB catches at different times of the day.*

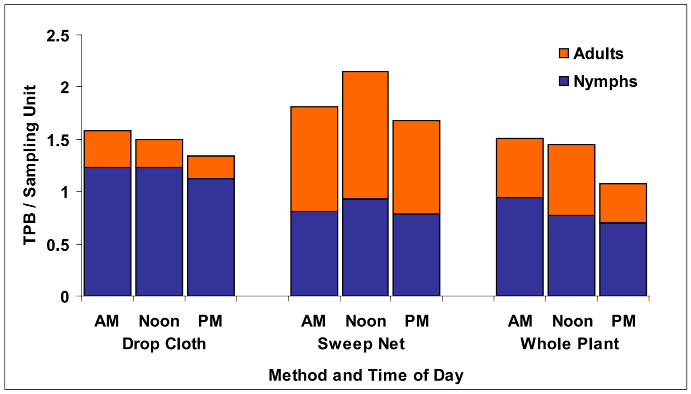



**Table 2. Expected tarnished plant bug counts for various sampling methods if populations average 1, 2, 3, 4 or 5 insects per black dropcloth (5 row feet).**

| Sampling Method (unit) | Expected TPB Counts for Different Sampling Methods | | | | |
|---|---|---|---|---|---|
| Dropcloth (5 row feet) | 1 | 2 | 3 | 4 | 5 |
| Sweep Net (100) | 5 | 10 | 15 | 20 | 25 |
| Whole Plant (100) | 4 | 7 | 11 | 14 | 18 |
| Dirty Squares (100) | 3 | 7 | 10 | 13 | 16 |
| Dirty Blooms (100) | 6 | 11 | 17 | 22 | 28 |
| External Boll Damage (100) | 5 | 10 | 14 | 19 | 24 |
| Internal Boll Damage (100) | 4 | 7 | 11 | 14 | 18 |

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