COMPARISON OF SAMPLING TECHNIQUES FOR TARNISHED PLANT BUG AND PREDACEOUS ARTHROPODS

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Abstract

The relative efficiencies of beat sheet, sweep net and a hand-carried pneumatic keep-it-simple sampler (KISS) for sampling the tarnished plant bug and predaceous arthropods in cotton were examined in 1999. We used variance/mean ratio ($\sigma^2/\bar{x}$) as the criteria for comparing sampling techniques. KISS and beat sheets collected similar numbers of tarnished plant bugs which were significantly greater than those collected by sweep nets. All three sampling methods had similar $\sigma^2/\bar{x}$ ratios for the tarnished plant bug. KISS collected significantly more beneficial arthropods than beat sheets which, in turn, collected significantly more beneficials than sweep nets. Variance/mean ratios of beneficial arthropods were similar for KISS and sweep nets which were significantly smaller than those for beat sheets. We found that beat sheets and KISS effectively captured the tarnished plant bug while sweep net was less effective especially at low population densities. KISS appears to be the method of choice for sampling beneficial arthropods.

Introduction

Accurately sampling destructive and beneficial arthropods in row crops is an essential component of integrated pest management programs. Researchers have always been searching for the "best" sampling technique that would provide sound and informative data with the least amount of needed efforts. The method of choice used to sample for destructive or beneficial arthropods can be very critical. Great considerations are given to selecting the most suitable method that is rendered acceptable for a given situation. In statistical terms, an acceptable method maximizes precision while minimizing costs (Cochran 1977). Data on sampling variability and labor requirements are essential to select the superior method for sampling. Some work has been done to investigate the efficiencies of various methods used to sample for cotton insects and their natural enemies. A simple and a basic method to sample for arthropods is the visual examination of individual plants but that can be very tedious and labor intensive. Beat sheets and sweep nets are common methods for sampling cotton insects and both are inexpensive, quick, and easy to use. However, sweep nets have been criticized for their inefficiency in sampling crop ecosystems (Ellington et al.1984). Drop cloth was reported by Smith and Stewart (1999) to catch more insects than suction sampling for total predators. A new sampling method labeled KISS (Keep It Simple Sampler) has been recently introduced to sample arthropods in row crops. KISS was reported by Beerwinkle et al.(1997) to hold considerable promise as a mechanical sampling aid for quantifying boll weevil infestations in early season cotton. Limited research has been conducted to compare KISS to the other sampling techniques commonly used in cotton. Sparks and Norman (1998) reported that the blower appeared better than sweep net at detecting arthropods at low population densities and generally collected more individuals at higher population densities. Beerwinkle et al. (1998) reported that sampling efficiency of KISS was greatly superior to that of the hand sampling method.

The tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) is a major concern of Arkansas and other Mid-South cotton growers. Cotton field in Arkansas also support a diverse fauna of predaceous arthropods that play an important part in suppressing pest population outbreaks. It is imperative that tarnished plant bug infestation levels are frequently checked in order to make any informed pest management decisions. Beat sheets and sweep nets, both useful for arthropods inhabiting the foliage, have been commonly used to sample for plant bugs and beneficials in cotton. We initiated this study to compare the effectiveness of beat sheets, sweep nets, and KISS (Keep It Simple Sampler, a modified leaf blower) for sampling the tarnished plant bug and predaceous arthropods and to determine which technique results in the least variability. That is, which of the three techniques would be best for data that will be analyzed with an ANOVA?.

Materials and Methods

This study was conducted in 1999 on the Southeast Branch Experiment Station near Rohwer, AR. Standard production practices were used to maintain plots. DPL NuCotn 33B was planted on 5-13-99 in 38-inch rows at typical plant densities. Two sites were established in the cotton field and in each site 4 plots were assigned at random for arthropods sampling. Plots were 4 rows wide and 40 feet long. Mustard was planted between plots to ensure strong plant bug populations in the cotton plots. Plots used for sampling did not receive any insecticide applications for the duration of the study.

Each plot was used to collect arthropods by all three sampling techniques compared in this study: beat sheets, sweep nets, and KISS (keep-it-simple sampler). A 3-foot beat sheet (6 row feet per plot) sample was taken by beating plants from the two middle rows of the plot. Sweep net samples consisted of 10 sweeps of a standard 15-inch diameter sweep net using the single-row cross sweep on an outside row of the plot. KISS samples were taken by using the leaf blower on the

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other outside row of the plot (40 row feet per plot). The KISS sampling device is a portable unit that is constructed by modifying a conventional engine-driven leaf blower with the addition of a metal rod frame (a rectangular hoop, 7 inches high and 11 inches wide) to support an insect collection net (12-inch diameter by 28-inch length) in front of the blower outlet nozzle. The KISS is hand-carried along a row of plants with the blower outlet positioned so that plants (top portion) pass between the blower nozzle and the inlet of the insect net. High speed air at about 150 mph (at full throttle) from the blower dislodges insects from the plants and carries them into the net. Sampling was done once weekly for four weeks and was carried out simultaneously using all three sampling techniques. Arthropods were identified in situ, counted, then released.

The variance/mean ratio ($\sigma^2/\bar{x}$) was used as an index of precision for each sampling method. An analysis of variance (Proc GLM, SAS Institute 1998) was computed on the weekly mean counts and on the $\sigma^2/\bar{x}$ ratios for each arthropod sampled in this study. A small $\sigma^2/\bar{x}$ ratio indicates that variance is small compared with the mean, allowing for the detection of smaller differences among means in an analysis of variance. An inflated $\sigma^2/\bar{x}$ ratio suggests that one sampling technique engenders a more sizable sampling error to the variance. A Least Significant Difference (LSD) test was used to test for significant differences in arthropods counts and in $\sigma^2/\bar{x}$ ratios with the three techniques. Data were analyzed by regression analysis (Proc REG, SAS Institute 1998) for weekly means of arthropods from the three sampling techniques to determine the correlation among them. We used regression on $\log_{10}$ transformed means and variances to fit Taylor's power law relationship (Taylor et al. 1978). We used the slopes and intercepts from the regressions to calculate the number of samples needed for each sampling technique to collect insects in the range of their average weekly mean ± 3SE using the following equation:

$$Y = \text{intercept}.\text{mean}^{\text{slope}-2}/C^2 \text{ (Ruesink 1980)}$$

where Y= number of samples needed, intercept and slopes are Taylor's power law parameters, mean=arthropod abundance, and C = precision. A precision level of 25% of the mean was used given that we wished to estimate the mean within 25%.

Results and Discussion

Sampling Tarnished Plant Bug

The tarnished plant bug was collected with all three sampling techniques. However, the mean seasonal average number of plant bugs collected by KISS or beat sheets were significantly greater (< 0.05) than those collected by sweep nets (Table 1). Numbers of tarnished plant bugs collected with the sweep net were generally low and frequently equaled zero throughout the study. Only 6.2% of all tarnished plant bugs were collected in sweep net samples, while 50.5% and 43.3% of tarnished bugs were collected in KISS and beat sheet samples, respectively. Similar findings were reported by Sparks and Norman (1998) who noted that the number of arthropods collected by the blower was as many as or greater than the number collected by the sweep net. No significant differences in plant bug numbers existed between KISS and beat sheet samples (Table 1). All three sampling techniques had similar $\sigma^2/\bar{x}$ ratios for the tarnished plant bug (Table 2). Variance/mean ratios obtained with KISS or beat sheets for tarnished plant bug averaged 1.9 and 2.1 times those of sweep nets, respectively. However, KISS and beat sheets captured 8.2 and 7.1 times more tarnished plant bugs than sweep nets. Therefore, we conclude that both KISS and beat sheets are the sampling technique of choice for plant bug in cotton. The ineffectiveness of sweep nets in cotton has been reported by several researchers (Byerly 1978, Ellington et al. 1984, Race1960, Wilson and Gutierrez 1980). Our efforts to calculate sample sizes in this study were not very successful because only few of the regressions in Taylor's Power Law relationship were significant. Our data indicate that it would take 17 and 24 samples to estimate the average weekly mean number of the tarnished plant bug using KISS and beat sheet, respectively. Beat sheets are more economical than KISS and less time-consuming. KISS, however, seems to require fewer number of samples than beat sheets and can be used under conditions where using beat sheets is not feasible such as when field is wet. Beat sheets, generally, are also poor sampling techniques for detecting of arthropods at low density.

No significant correlation for plant bug counts existed among any of the sampling techniques used in this study. This indicates that sampling methods were not proportionally affected by variations in uncontrolled variables associated with the comparison experiments.

Sampling Beneficial Arthropods

Predaceous arthropods were collected in all three techniques, probably because they occur on all over the plants. However, counts of predators were significantly higher in KISS samples than beat sheet or sweep net samples (Table 1). KISS caught significantly more arthropods from all the predator groups than sweep net, but caught only more spiders than beat sheets (Table 1). Beat sheets caught significantly more ladybird beetles and big-eyed bugs than sweep nets (Table 1) which concurs with reports given by Byerly et al. (1978). Wilson et al. (1980) noted that more adults *Geocoris* spp. were found in the center of cotton plant canopies which explain the poor performance of sweep nets in cotton. Our data show that 54.2%, 34.8%, and 11% of all predators captured were collected in KISS, beat sheet, and sweep net samples, respectively. Beat sheets are generally best for slower moving arthropods that dislodge from plants when disturbed

such as immature hemipterans. KISS and sweep nets yielded similar variance/mean ratios for all predaceous arthropods caught (Table 2). Variance/mean ratios were significantly higher for big-eyed bugs using beat sheets than either KISS or sweep nets (Table 2). There was no significant correlation for predator counts among the sampling methods used in this study. The poor correlation between the sampling methods is partly due to their dissimilar manners in collecting insects.

Sampling Technique Selection

Two factors influence our decision in selecting sampling methods: reliability and costs. Reliability of the estimated density increases as the sample size increases but, obviously, cost is a limiting factor here. Thus, in addition to reliability, comparative efficiency of sampling methods is influenced by differences in costs in collecting sampling data The problem is to decide how much time and effort to put into sampling, that is, to find the proper balance between the reliability of the estimate and the cost of obtaining it. Costs can be compared in terms of human hour required to collect and process a single sample. Sampling times for the sampling methods included times for collecting arthropod samples and for visually inspecting the collected samples, identification, and counting. Beerwinkle et al. (1997) found that the sampling efficiency of the KISS, on the basis of time required per row-foot sampled, was about 10-fold better than that for hand sampling. Although KISS collected more tarnished plant bugs in our study than sweep net while both produced similar $\sigma^2/\bar{x}$ ratios, KISS samples required several folds more time to process than sweep net samples simply because more arthropods and plant materials and debris are collected. Also, KISS requires two individuals to operate efficiently. The factor that might make sweep nets more favored and appealing to some is the fact that it takes less time to gather data with sweep nets than with other sampling methods.

Summary

Estimating the abundance of arthropod pests and their natural enemies is a difficult task but it is essential for making informed pest management decisions. None of the sampling techniques tested will adequately sample all common arthropods in cotton because each technique samples only part of the habitat or only some of the life stages. Moreover, the effectiveness of each method may be affected by a wide array of factors such plant variety, weather, etc. For example, sweep nets may underestimate abundance if plants are wilted from drought. Also, beat sheets can not be used when the field is wet. The KISS, although requires more time and efforts to operate, seems to hold promises as a good sampling technique for arthropods in cotton fields.

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Table 1. Season mean count of tarnished plant bug and various predaceous arthropod groups collected by KISS, beat sheets, and sweep nets[1,2]. Rohwer, AR. 1999.

	Number of Arthropods / Sample		
Arthropod Group	**KISS**	**Beat Sheet**	**Sweep Net**
Tarnished P.Bug	2.8 a	2.4 a	0.34 b
Ladybird Beetles	8.7 a	6.4 a	1.6 b
Big-Eyed Bugs	3.8 a	2.4 a	0.81 b
Spiders	2.6 a	1.1 b	0.69 b
Lacewings	0.56 a	0.38 ab	0.2 b
Pirate Bugs	0.40 a	0.18 ab	0.04 b
Damsel Bugs	0.18 a	0.11 ab	0 b
Total Beneficials	16.3 a	10.6 b	3.3 c

[1]Means within rows followed by the same letter are not significantly different at the 5% level of significance.
[2]Beat sheet, sweep net, and KISS samples taken on 6-21, 7-1, 7-9, and 7-15-99.

Table 2. Variance/mean ratios ($\sigma^2/\bar{x}$) of plant bug and predaceous arthropods collected by three sampling techniques[1,2]. Rohwer, AR. 1999.

Arthropod Group	**KISS**	**Beat Sheet**	**Sweep Net**
Tarnished P.Bug	2.1 a	2.3 a	1.1 a
Ladybird Beetles	2.5 a	3.8 a	1.5 a
Big-Eyed Bugs	1.3 b	2.2 a	1.1 b
Spiders	1.5 a	2.3 a	1.3 a
Lacewings	0.71 a	0.75 a	0.94 a
Pirate Bugs	1.2 a	1.3 a	1.0 a
Damsel Bugs	0.18 a	0.11 ab	-[3]
Total Beneficials	2.2 b	4.4 a	1.3 b

[1]Means in rows followed by the same letter are not significantly different at the 5% level of significance.
[2]Beat sheet, sweep net, and KISS samples taken on 6-21, 7-1, 7-9, and 7-15-99.
[3]No damsel bugs collected in sweep net samples.