SAMPLING IN AN AREA-WIDE BOLLWORM[1]/ MANAGEMENT COMMUNITY[2]/

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ABSTRACT

Procedures used to sample for the bollworm complex, the bollworm Heliothis zea (Boddie) and the tobacco budworm H. virescens Fabricus, egg and larval population in bollworm management communities (BMC) are presented. Bollworms were monitored weekly in a group of fields in a BMC near Portland, Arkansas during the 1979 and 1980 growing season. The data were pooled weekly and analyzed as a two-stage sampling problem.

Analyses of bollworm egg and larval counts were conducted on actual and transformed, $\sqrt{(X + 0.5)}$, data collected from four whole-plant samples in each field to determine if the sample unit size could be reduced from 14 row-ft (4.27 row-m) to 7 row-ft (2.13 row-m) at some time in the growing season, and to determine the optimum allocation of resources for both sample units.

Based on the data examined, four 7 row-ft samples per field were found to be an acceptable alternative to four 14 row-ft samples per field for the time in which the comparisons were made. The 7 row-ft sample units detected similar population trends, and gave comparable absolute or relative population estimates, lower estimates for the mean relative variation, and lower estimates for the mean coefficient of variation. The optimum sample size most often estimated for either sample unit was one sample per field; however, three samples of either unit size was found to be more appropriate in a BMC.

INTRODUCTION

An area-wide or community approach to management of bollworm populations, which includes the bollworm Heliothis zea (Boddie) and the tobacco budworm H. virescens Fabricus, on cotton was tested in Arkansas in 1976. The program objective was to make bollworm population management decisions for all of the cotton fields in a large land area (50+ mi^2) rather than on a field-by-field basis. A limited number of fields were sampled for the bollworm; management decisions were based on area-wide bollworm population trends; and, when necessary, most of the cotton in the area was treated within a 3 day period. The areas involved in this program were called bollworm management communities (BMC). The results of the program in the BMC at various locations in the state have been discussed (Phillips et al. 1977, Phillips 1978, Phillips and Nicholson 1978, 1979, Phillips et al. 1979, 1980, 1981, and Nicholson et al. 1983).

The purpose of this report is to describe the bollworm sampling program used in the development of BMC, to compare the optimum sample size (OSS) estimates for two sample unit sizes, 14 row-ft (4.27 row-m) and 7 row-ft (2.13 row-m), and to compare the relative variation (RV) and coefficient of variation

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(CV) for the two sample units. The data presented were collected from whole-plant observations in 1979 and 1980 in a BMC located at Portland, Ashley Co., Arkansas.

MATERIALS AND METHODS

Implementation of the sampling program in the BMC required development of a method of field selection. Boundaries of the BMC were delineated on ownership maps. The community was divided into quadrants of ca. equal size and the quadrants were subdivided into areas of ca. 2-mi^2 each. Coins were tossed onto a map of the BMC and the one field most fully covered by a coin in each 2-mi^2 area was chosen as the field to be sampled. Before sampling began, the fields were located and identified for the scouts. If a selected field was not planted to cotton, the nearest field of cotton was chosen as a replacement. A sampling schedule was established so that ca. the same number of fields were sampled from each quadrant each day. Sampling began during the week of June 11 and ended during the week of August 6 in 1979, and began during the week of June 16 and ended during the week of August 4 in 1980.

Whole-plant searches were made on 14 feet of row at four randomly selected locations in each field. The whole-plant sample was divided into two 7 row-ft subsamples. Scouts worked in teams of two and each scout was responsible for one of the subsamples. Data recorded were the numbers of bollworm eggs, and small ($\leq$1.25 cm) and large (>1.25 cm) bollworm larvae. In most years, when plant size prohibited completion of sampling, it was necessary to reduce the primary whole-plant sample unit size from 14 to 7 row-ft. Therefore, with the exception of optimum sample size estimates, comparisons are made only for the weeks of June 11 through July 23 in 1979 and June 16 through July 14 in 1980.

The data collected each week were pooled and analyzed as a two stage sampling problem. This analysis allows identification of among field variation (experimental error) and within field variation (sampling error). Because of numerous zero counts in the data and in order to stabilize the variance, data were transformed using $\sqrt{X + 0.5}$, and all analyses were conducted on both actual and square root transformed data.

Comparison of the 14 and 7 row-ft sample units was made on the basis of their ability to detect changes in population size, agreement between the two when converted to absolute or relative estimates, relative variation and the coefficient of variation. The RV was determined as RV = $(s_{\bar{x}}/\bar{x})$ 100, where $s_{\bar{x}}$ is the standard error of the field means from two stage analysis, and $\bar{x}$ is the mean. The value of $s_{\bar{x}}$ estimated in this manner is four times less than the value of $s_{\bar{x}}$ had the four subsamples been combined and $s_{\bar{x}}$ been estimated from field totals (see Wadley 1967). The CV was determined as CV = $(\sqrt{MSE} / \bar{x})$ 100 where MSE is mean square for samples within fields (sampling error) from the two stage analysis and $\bar{x}$ is the mean.

Optimum allocation of resources was determined for actual and transformed data for both sample units using standard techniques found in most statistical texts, e.g. Snedecor (1956), Steel and Torrie (1960), Wadley (1967), and others. The optimum number of samples per field was determined as OSS = $\sqrt{(C_F/C_S)(s_E^2/s_F^2)}$, where C_F is the cost (in minutes) of going to a new field, C_S is the cost (in minutes) of taking a single sample, s_E^2 and s_F^2 are the estimated variance components for samples within fields and among fields, respectively, from the two stage analysis. Time estimates used in the optimization procedure were obtained in a study conducted in 1981 (unpublished data). We estimated the average C_S for a 14 row-ft and a 7 row-ft sample as 22.4 and 12.5 minutes, respectively. The value for C_F was arbitrarily set to 5 minutes.

RESULTS AND DISCUSSION

Both sample units detected similar population trends (Fig. 1). The weekly means of the 14 row-ft sample units are ca. two times those of the 7 row-ft

units; therefore, the two were ca. equal when converted to absolute or relative estimates of the community means. These results are somewhat biased since one sample unit is a subsample of the other; however, these comparisons indicate that four 7 row-ft samples were acceptable alternatives to four 14 row-ft samples at the same sites.

Southwood (1978) noted that an RV of ca. 25 will detect a doubling or halving of a population being measured. An RV of 25 is often used in extensive sampling programs to evaluate sampling procedures (Pedigo et al. 1972, Hillhouse and Pitre 1974, Pieters 1978). An RV of 10 is generally acceptable in intensive studies (Southwood 1978) and is often set as a standard for comparison of sampling procedures. In our study the RV estimated weekly for the square root transformed data did not exceed four for bollworm eggs or larvae during either year of the study.

Both sample units, as indicated by their low $\overline{RV}$ and $\overline{CV}$, are acceptable for estimating the area-wide bollworm population in a BMC (Table 1). However, with one exception, the $\overline{RV}$ and $\overline{CV}$ for the 7 row-foot samples are slightly less than for the 14 row-foot samples. In 1979 the $\overline{RV}$ and $\overline{CV}$ estimates for large larvae from the 14 row-foot samples are less than those for the 7 row-foot samples. This is the result of a difference in the number of weeks over which the $\overline{RV}$ and $\overline{CV}$ estimates are made. The values were estimated for the 14 row-foot samples over 7 weeks and those for the 7 row-foot samples were made over 2 weeks. If the comparisons are made only for the 2 weeks in which large larvae were found in the 7 row-foot samples, the $\overline{RV}$ and $\overline{CV}$ for the 7 row-foot samples are less than those for the 14 row-foot samples.

TABLE 1. Mean Number of Larvae and Eggs per Field, Mean Relative Variation ($\overline{RV}$) and Mean Coefficient of Variation ($\overline{CV}$) of Bollworm Eggs and Larvae for Two Sample Units During 1979 and 1980.[a/]

VARIABLE	YEAR	14 row-ft			7 row-ft		
		MEAN	$\overline{RV}$	$\overline{CV}$	MEAN	$\overline{RV}$	$\overline{CV}$
EGGS	1979	3.55 (7)[b/]	0.71	7.72	3.23 (7)	0.54	6.29
	1980	3.75 (7)	1.05	9.06	3.32 (5)	0.72	7.80
SMALL LARVAE	1979	3.21 (7)	0.60	6.86	3.02 (7)	0.36	5.30
	1980	3.57 (5)	0.97	7.56	3.26 (5)	0.71	6.28
LARGE LARVAE	1979	2.86 (7)	0.15	2.24	2.88 (2)	0.18	2.70
	1980	3.26 (3)	0.71	6.23	3.06 (3)	0.48	4.92
TOTAL LARVAE	1979	3.24 (7)	0.62	7.09	3.03 (7)	0.37	5.39
	1980	3.78 (5)	1.03	7.74	3.38 (5)	0.78	6.54

a/ Statistics based on data transformed using $\sqrt{X + 0.5}$

b/ Number of weeks for estimates.

Transformation had little effect on OSS estimates for the two sample units (Table 2). The OSS most frequently estimated for each sample unit was one. The maximum OSS estimated for the 7 row-ft sample unit was three, and exceeded three only once for the 14 row-ft units. Three rather than four of either sample unit per field appear to be adequate for estimation of community means for bollworm eggs and larvae. However, within-field variation, which is responsible for the inability to estimate OSS in ca. 32% and 15% of the analyses in 1979 and 1980, respectively, should be considered before a reduction in the number of samples is considered.

TABLE 2. Frequency of Optimum Sample Size per Field (OSS) Estimates for Actual and Transformed[a/] Data During 1979 and 1980.

SAMPLE UNIT (row-ft)	YEAR	N[b/]	OPTIMUM NUMBER OF SAMPLES PER FIELD									
			ACTUAL					TRANSFORMED				
			1	2	3	≥4	NE[c/]	1	2	3	≥4	NE
7	1979	36	17	6	2	-	11	18	5	2	-	11
	1980	32	25	2	-	-	5	25	2	-	-	5
14	1979	28	15	5	1	-	7	16	4	1	1	6
	1980	20	17	-	-	-	3	17	0	-	-	3

[a/] Data transformed using $\sqrt{X + 0.5}$.

[b/] N = the number of OSS estimates made for each transformation.

[c/] No OSS estimate not possible.

Analysis of two-stage sampling data often indicates more variability among primary sampling units (fields) than among samples within primary units (samples within fields) (Snedecor 1956). The analysis of community data indicated more variation within fields than among fields. The estimated value of s_E^2 was usually greater than s_F^2, and s_F^2 was occasionally estimated to be zero or negative. In either case, the value of s^2 is set equal to zero and OSS cannot be estimated (see equation for OSS). Since we are interested principally in estimation of the community means, we are more willing to accept the within-field variation.

SUMMARY AND CONCLUSION

The 7 row-ft sample units, when compared to the 14 row-ft sample units, detected similar population trends, gave comparable absolute or relative estimates, lower $\overline{RV}$ and $\overline{CV}$. Four 7 row-ft samples are an acceptable alternative to four 14 row-ft samples in the estimation of the bollworm population means in a BMC.

The OSS most often estimated for either sample unit was one. OSS estimates for the 14 row-ft or 7 row-ft sample units exceeded 4 only once. The optimum allocation of resources indicates three samples of either sample unit per field are sufficient for the BMC sampling program.

The BMC sampling procedures have been adopted for use in both field-by-field and community bollworm management programs on cotton by the Arkansas Cooperative Extension Service (Johnson et al. 1982). Since other pests of cotton are managed in the conventional field-by-field manner, all fields in a BMC are sampled. This is more acceptable to growers, consultants, and extension service personnel. Also, in situations which warrant a return to field-by-field management (e.g. drought), the transition can be made without difficulty.

The data presented in this report were from a BMC in which only one field was sampled from each 2-mi^2 area. In the BMC as now operated, a reduction in both sample unit size and the number of samples per field will increase the $s_{\bar{x}}$ of the community means. However, based on the data presented, such a change should not affect community bollworm management decisions.

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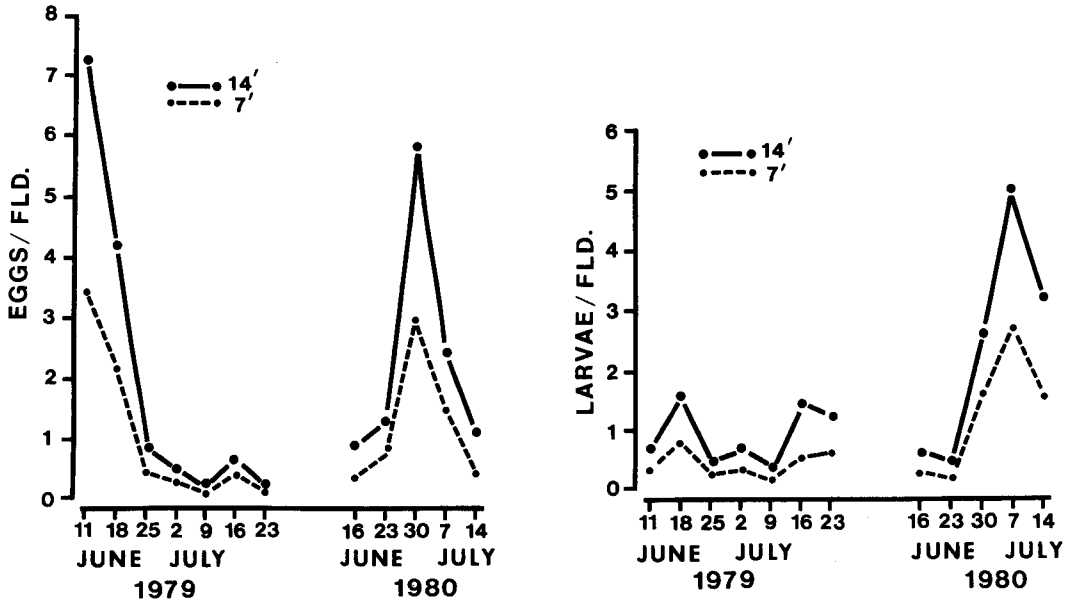

FIG. 1. Mean number of bollworm eggs and larvae per field per week

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