Optimum Sample Size of Bollworms on Cotton Plants in Burkino Faso

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ABSTRACT

Field experiments were conducted in cotton fields in 1997 in Burkina Faso, West Africa. Bollworms (Helicoverpa armigera, Earias insulana, E. biplaga, Diparopsis watersi) on cotton plants were sampled every week during the cotton growing season to assess the optimum sample size of bollworms in terms of the number of plants to randomly select. With a bollworm mean number of 0.60 per 25 plants in 1997, the results showed the need of sampling 73 and 105 cotton plants to achieve 70% and 75% precision level, respectively. The number of plant to sample decreases as the mean number of bollworms increases. For a bollworm mean number of 2 per 25 plants, the sample size drops to 15 and 22. A chart was designed which could be useful for agronomists, extension officers and scientists in determining the level of precision attainable at various numbers of bollworms for any sampling and monitoring program. Optimum sample size assessment is a prerequisite in developing sampling programs for IPM strategies in cotton growing.

Introduction

Cotton is grown during the rainy season in Burkina Faso, usually from May to October. National production increased from 150,000 in 1995 to about 340,000 metric tons in 1998. The lint produced is exported and represents the country's main export.

Among cotton feeding insects, *Helicoverpa armigera* Hübner (Noctuidae) is the most destructive in Burkina Faso. The bollworm complex is composed of lepidoterous pests feeding on buds, flowers and bolls. In addition to *H. armigera*, three other noctuids, *Earias insulana* Boisduval, *E. biplaga* and *Diparopsis watersi* Roths threaten cotton production every year with variable effect, depending on weather and region.

A calendar spraying schedule has been utilized for many years to address arthropod pest problems. Six to seven applications of chemical pesticides are carried out at fourteen day intervals from the 45^{th} day after plant emergence. It is now recommended to that spraying commences from the 30^{th} day after plant emergence because of the threat of cotton bollworm resistance to some of most frequently used chemicals.

Spraying insecticides based on economic thresholds (ET) and economic injury level (EIL) would benefit integrated pest management (IPM) in Burkina Faso. However, to ensure the success of this type of program, pest population levels must be monitored throughout the season (Boivin and Vincent, 1981).

Ruesink and Kogan (1975) describe sampling techniques for estimating population levels. First, the spatial distribution of the organism can be used to determine the optimal number of sample units that must be obtained to estimate the average density of the pest population within certain predetermined limits of error (Karandinos, 1976). As the purpose of sampling is to make recommendations for intervention, the aim is simply to determine whether the pest population is above or below a certain economic threshold.

To date, these recommendations have been based on empirical data. It is necessary to check if these decision-aids are appropriate. The objective of this study was to address questions concerning the optimum sample size of cotton bollworms in Burkina Faso in order to develop sampling programs to make recommendations for intervention less risky.

Material and Methods

Experiments were conducted from July to October 1997 in the western region of the country where the bulk of the crop is grown. Extension officers were selected to do the sampling by the chairman of the agricultural service of the national cotton company.

Each of the officers sampled weekly in a quarter of a hectare by checking 25 random cotton plants for caterpillars feeding on squares. Wherever possible, the number of individuals of each bollworm species was recorded individually.

Regression analyses

Dispersion patterns of cotton THE bollworms were determined by using Iwao's patchiness regression (Iwao, 1968, 1977; Iwao and Kuno, 1971). Iwao's regression method quantifies the relationship between variance (S^2) and mean density ($\bar{x}$) by calculating the Lloyd's (1967) mean crowding index ($\overset{*}{m}$) for each data set, where $^*m = \bar{x}\ [(S^2/\bar{x}) - 1]$. Mean crowding was regressed on $\bar{x}$ such that

$\overset{*}{m} = a + b\bar{x}$,

and least-squares estimates of a and b were calculated using a linear regression procedure (StatView, version 4 for the Macintosh Computer, Abacus Concepts Inc., 1992). A slope $\beta < 1$ indicates a uniform dispersion, $\beta = 1$ indicates a random dispersion and $\beta > 1$ indicates an aggregated dispersion. A τ-test was performed to determine whether the slope was significantly different from 1.

The intercept α is a measure of the basic unit of aggregation where α is the number of individuals that make up a "group" (Iwao and Kuno, 1971). When $\alpha > 0$, the population exists as groups of individuals (i.e., colonies), whereas the individual is the primary unit of aggregation when $\alpha = 0$. There is a positive or negative association between individuals when α is >0 or <0 respectively.

Optimum sample size determination

Iwao (1977) gives an optimum sample size (OSS) equation that incorporates α and β parameters obtained from a regression analysis.

$OSS = (\tau^2/D^2)[((\alpha + 1)/m) + \beta - 1]$,

where τ is Student's τ value at 5%, D is the desired precision level (set by the experimenter), *m* is the population mean, α is the index of basic contagion and β is the density-contagiousness coefficient. The precision level is defined as the standard error of the mean as a proportion of the mean (Iwao, 1977). A precision level D of 0.10 (90%) has been cited as a desirable level for "intensive" ecological research and a D of 0.25 (75%) as desirable for "extensive" management applications (Southwood, 1978). Precision levels (D) of 0.10 (90%), 0.15 (85%) and 0.25 (75%) may satisfy requirements for different types of field studies or monitoring (Ekbom, 1985; Elliott and Kieckhefer, 1986; Ward *et al.*, 1986). In this study, a range of D from 0.20 to 0.30 (by increment of 0.5) was calculated to provide a sampling tool for population density estimates of bollworms for pest management purposes.

Data were subjected to a square root transformation $\sqrt{Y}$ to stabilize error variance and were analyzed using StatView. When very small values are involved, $\sqrt{Y}$ tends to overcorrect so that the range of transformed values giving a small mean may be larger than the range of transformed values giving a larger mean. For this reason, $\sqrt{Y + \frac{1}{2}}$ is recommended as an appropriate transformation when some of the values are under 10 or even under 15 and especially when zeros are present. Regression analysis using the General Linear Model was performed to determine the association intensity of *H. armigera* with the remaining bollworms.

Results and Discussion

Figure 1 shows high correlation between counts of *H. armigera* and of all bollworms taken together. The coefficient of determination is 0.95, showing that the presence of the former predicts 95 times out of 100 the presence of the latter. Thus only the regression results for *H. armigera* are considered here.

Cotton bollworms were randomly distributed in fields with β not significantly >1 in Iwao's patchiness regression. Figure 2 shows the estimates when indices of dispersion and the coefficients of determination (r^2) for *H. armigera.* When all square feeding caterpillars were pooled together, the index of dispersion (Y) is 0.173 + 0.768*X and the coefficient of determination $R^2 = 0.811$.

When bollworm population averages about 0.6 per sampling unit (25 cotton plants), a sample size of 105 plants provided a 75% precision level whereas 295 plants provided a 90% precision level. The relationship between sample size and mean number of bollworms for precision levels ranging from 80 to 70% is shown in Figure 3.

Figure 3 is a tool to determine the level of precision according to the mean number of square feeding caterpillars. Before undertaking a sampling program, a few preliminary samples should be taken to estimate densities. For instance, based on a mean number of 0.6 bollworms present, the sample size is 73 for 70% precision, 105 for 75% and 165 for an 80% precision level. A 90% precision would be difficult to achieve for most sampling program without collecting large numbers of samples. However, the 75 and 80% precision level probably could be achieved most of the time with a sample number of 105 and 165 x 25 plants, respectively.

One attribute of OSS is that, at fixed precision level D, required sample size decreases with increasing population density (Karandinos, 1976). For instance, at a mean density of 2 bollworms per 25 cotton plants, the sample unit required drops to 15, 22 and 34 to get 70%, 75% and 80% precision level respectively.

The follow up of this study is to work on sampling programs that assume the assessment of ET and EIL in near future.

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Figure 1. Regression of *H. armigera* against total bollworm mean counts for predicting the presence of the latter, based on the presence of the former.

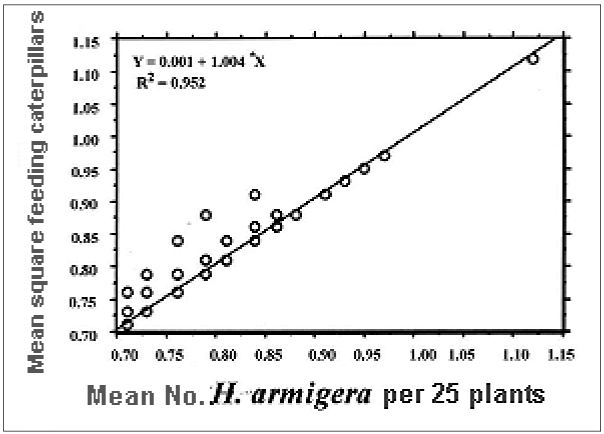

Figure 2. Regression of mean crowding($\overset{*}{m}$) on mean counts (X) of *H. armigera.*

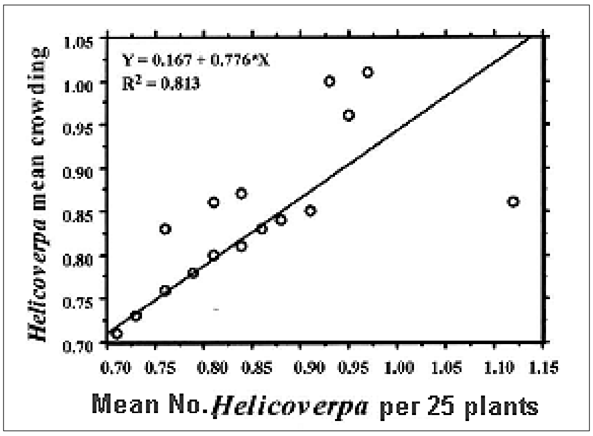

Figure 3. Number of plant samples required for estimates of H armigera density with precision levels from 70 to 80% for given mean numbers of *H. armigera* per 25 plants.