SEQUENTIAL SAMPLING PLANS FOR *BEMISIA TABACI* EGGS AND NYMPHS IN COTTON

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Abstract

Fixed-precision sequential sampling plans are reported for egg and nymphal stages of Bemisia tabaci on cotton. These plans were developed based on detailed examination of within-leaf, within-plant, and within-field distributions of egg and nymphal (crawler through pupae) stages during the 1992 growing season in central Arizona. The most efficient sample unit for eggs and nymphs was determined to be a single 3.88 cm^2 circular plug taken from the basal portion of the 2nd sector of the 5th mainstem node leaf (counted from the terminal). Tentative plans are presented relating cumulative counts to sample size for fixed levels of precision.

Introduction

The development of efficient and reliable sampling methods is critical to the development of pest management strategies against *Bemisia tabaci*, the sweetpotato whitefly. Numerous methods have been employed by workers worldwide to provide estimates of immature *B. tabaci* population density in various crops (Butler et al. 1986, Ekbom and Rumei 1990). *B. tabaci* populations are known to be highly aggregated both within and between plants. Immature stages tend to be distributed vertically on the plant with more mature stages found on progressively older leaves (Ohnesorge et al. 1980, Melamed-Madjar 1982, von Arx et al. 1984, Bellows and Arakawa 1988, Abisgold and Fishpool 1990). Because densities of the immature stages can reach extremely high numbers, sampling can become a difficult and very time-consuming endeavor. Effort is needed to develop cost-effective sampling methods that will be adopted by the pest management community.

Material and Methods

Sampling data were collected from 17 June through 22 September 1992 from locations in Maricopa and Pinal Counties in central Arizona. Within-leaf, within-plant, and between-plant distribution patterns of nymphal and egg stages of *B. tabaci* were studied at the Maricopa Agricultural Center, Univ. of Arizona. Samples were taken from an established research plot area of DPL-50 and ST-506 about 2.4 ha in size. Approximately every other week two whole plants were randomly collected from each of 24 separate plots on 17 June and 12 separate plots approximately every two weeks thereafter until 25 August for a total of 24 or 12 plants per cultivar per date. Twelve plants were also randomly collected every two weeks from a nearby plot (0.2 ha) of Pima S-7. Plants were returned to the laboratory and mainstem leaves were collected from the first 7 nodal positions below the mainstem terminal. Individual leaves were subdivided into four sectors delineated by the three main leaf vein (see von Arx et al. 1984) and a 3.88 cm^2 circular plug (#14 cork-borer) was taken from the basal portion of each sector. The sectors were

denoted #1-4 with #1 being the far left sector with the underside of the leaf facing up and the petiole pointing down. Eggs and nymphs (all stages) were enumerated separately for each plug and sector under a binocular dissecting microscope.

Analyses of these within-plant and within-leaf counts revealed that the most efficient sampling unit was a single plug taken from sector #2 of the 5th mainstem node leaf (see below). This sample unit was used in subsequent studies to further examine within-field distributions in 15 commercial upland and Pima cotton fields from 20 August to 22 September. Ten sample sites were selected along a diagonal transect across each field and leaf plugs were collected from 5 consecutive plants at each site for a total of 50 plugs per field.

Results and Discussion

Distributional Pattern. Leaf area was equally distributed among the four sectors of the two upland cotton (DPL-50 and ST-506) leaves, but about 58% of the total area was subsumed by the center two sectors of Pima S-7 leaves. In general the distribution of eggs and nymphs on mainstem node leaves over the entire sampling period were proportional to sector area. In contrast, the 3.88 cm^2 plug averaged 4% of the whole leaf area but contained a significantly greater percentage (5-9%) of the eggs or nymphs on an entire leaf (G-test, $P<0.05$). Thus, eggs and nymphs were not uniformly distributed on the leaf.

We found that the 3rd-4th and the 5th mainstem node leaf consistently contained the greatest number of eggs and nymphs, respectively. Additionally, we found that coefficients of variation were consistently lowest for eggs on leaves from the 4th and 5th nodes and nymphs on the 5th and 6th nodes. Based on these characteristics we selected the 5th mainstem node leaf as the best location on the plant for sampling both eggs and nymphs. von Arx et al. (1984) found that the nodal position of the most infested leaf for pupae increased with time. However, these authors counted nodal position from the ground up, while we counted from the terminal down. Our approach greatly simplifies and speeds the collection of samples.

Analysis of data collected from smaller plots in Maricopa indicated that the between-plant (within-field) component accounts for the greatest portion of the variance in sampling for eggs and nymphs. Further analysis of data collected from commercial fields supported this conclusion. Based on the time required to collect consecutive individual plugs within a one sample site compared with the time required to move between sample sites (Cochran 1963), we determined the optimal sample allocation to be single plugs taken from multiple sites within the field.

Sampling Plans. Taylor's power law (Taylor 1961) was used to estimate mean-variance relationships for each of the various sample units. Coefficients of determination were consistently >90% Using these relationships to estimate expected variances for different egg and nymphal densities, we calculated the required sample size to achieve a fixed precision (SE/mean). Whole leaf counts were most efficient in terms of the number of samples required, especially at low population densities. However, taking into account the time (=cost) required to count immatures on the various sample units, leaf plugs, were found to be the most efficient sample units by at least one order of magnitude (Figure 1). We determined the most efficient sampling unit for eggs and nymphs to be a 3.88 cm^2 plug from the basal portion of sector #2 of the 5th mainstem node leaf.

Following Green's (1970) method we calculated the critical cumulative count, or "stop lines", for egg and nymphal sampling as a function of sample size. Results are shown graphically in Figure 2 for a fixed-precision of 0.2. Ideally, leaf plugs should be gathered from randomly selected plants throughout the field, however, a systematic collection of plugs along one or more transect that distributes the sample across the field may be more practical.

We stress that these sampling plans are tentative. They are based on pooled data from three separate cultivars and reflect *B. tabaci* populations during a fairly restrictive period of time in a single year and within a relatively small geographical area. Future work will emphasize validation of these sample plans over a wider range of conditions and the formulation of binomial sequential plans which should further reduce sampling effort. Finally, our sample plans can be tailored to specific action threshold values once these data become available.

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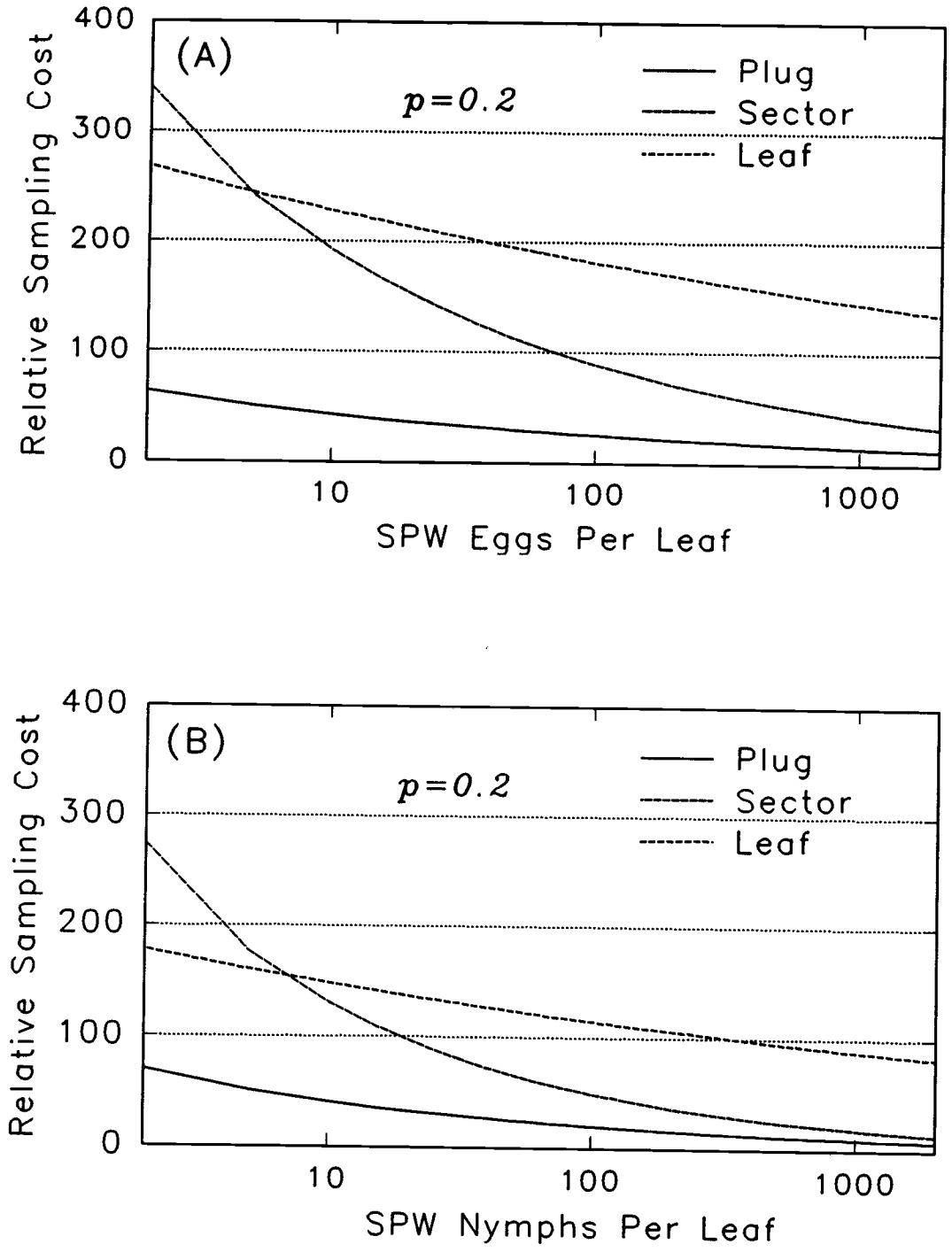

Figure 1. Relative cost of sampling *B. tabaci* eggs (A) or nymphs (B) as a function of population density and a fixed-precision of 0.2 (SE/mean). Relative costs were estimated assuming that the cost of counting one leaf plug was 1.0.

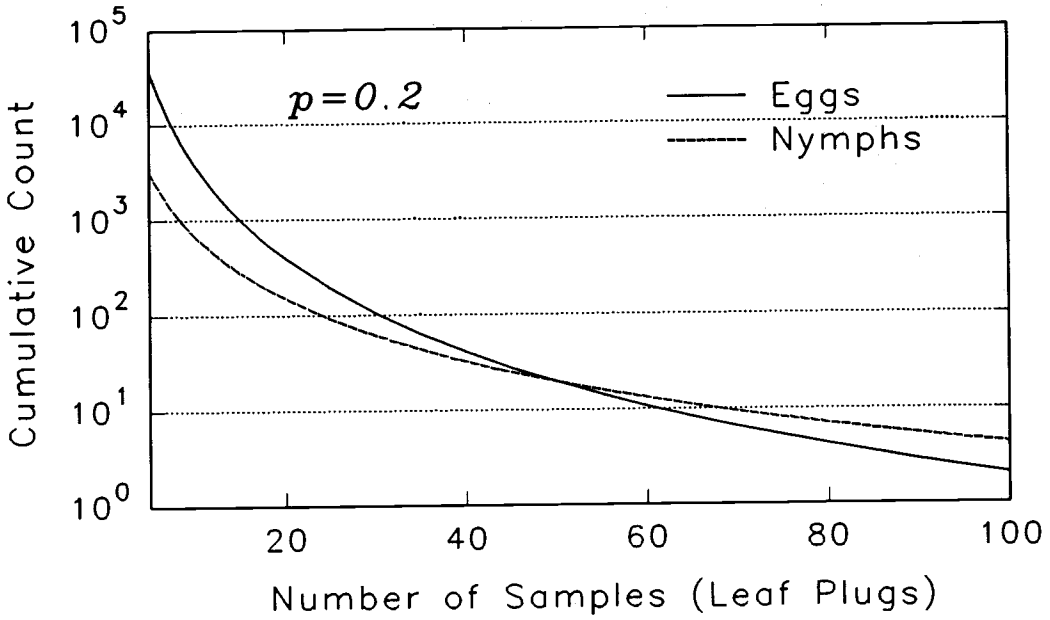

Figure 2. Sequential sampling plan stop lines for *B. tabaci* eggs and nymphs for a fixed-precision of 0.2. The sample unit is a 3.88 cm^2 plug from the basal portion sector #2 from the 5th mainstem node leaf.