A NEW SCOUTING TECHNIQUE FOR SAMPLING BOLL WEEVIL REPRODUCTION FOLLOWING THE USE OF INSECT GROWTH REGULATORS[1/]

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ABSTRACT

A new scouting technique was developed to monitor the efficacy of the sterility-inducing chitin synthesis inhibitor diflubenzuron on boll weevil, Anthonomus grandis Boheman, populations infesting cotton. By counting the number of one-third grown or larger squares that flared or fell from the plants as a result of weevil oviposition, and by monitoring the fruiting load of the plants, an estimate of the number of developing weevil larvae per acre may be obtained.

INTRODUCTION

The need for development of a new insect scouting technique is predicated on the occurrence of new pest problems or the development of new technology which dictates alteration of currently used techniques. The introduction of diflubenzuron (Dimilin®) for the control of boll weevil, Anthonomus grandis Boheman, populations in cotton is an example of changing technology which requires alteration of scouting techniques. Current techniques estimate the numbers of boll weevil oviposition punctures in a field; however, these do not provide an effective method of evaluating the impact of the ovicidal activity of diflubenzuron. Thus, as it is presently assessed, boll weevil damage may be substantially overestimated. Conversely, samples must be taken to determine if the diflubenzuron applications are maintaining egg sterility. With this in mind our purpose was to develop a scouting technique which would estimate the numbers of developing boll weevil larvae in diflubenzuron-treated fields.

MATERIALS AND METHODS

The present study was conducted in Tift County, Georgia. Coker 310 cotton was planted on 30 April 1981 with 91.44 cm. row spacings. Trifluralin and fluometuron were applied preplant and preemergence, respectively, at labeled rates. Mechanical cultivation was done as needed and remaining weeds were manually removed. Sampling began when ca. six one-third grown squares (0.64 cm diameter) per 30.45 cm were present (18 June 81) and was conducted twice weekly during the course of the study. No insecticides were applied in the test field.

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The study area was divided into eight plots, each measuring approximately 0.2 ha. Five 7.62 row-meter sections per plot were measured and flagged. Plant stands within flagged sections were uniform and averaged 2.3 plants per 30.48 cm. Each section was completely cleared of any flared or fallen squares during each sampling period. The term "flared squares" herein refers to squares with open bracts and/or yellow color that remained on the cotton plant after being damaged by the boll weevil. (Damaged squares may either flare or turn yellow without flaring depending on moisture conditions). "Fallen squares" refers to squares that abscised and fell from the plant after suffering boll weevil damage. Fruit counts were made in each section by counting three 0.9 row-meter sections in each 7.62 meter section of row that was cleared. A total of 13.7 meters of row was counted per field. Only one-third grown and larger squares were counted. Using the fruit counts and the number of flared and fallen squares, an estimation of damaged fruit/ha or percent damage was obtained.

During each sampling period the percent weevil damage was also determined in each field by examining 100 squares per plot. Squares were selected from the top, middle and lower branches. No flared squares or small bolls were included as per recommended procedure (Lambert and Herzog, 1982).

Four days after the sections were cleared, all flared and fallen squares (referred to collectively hereafter as flared) were removed from both sides of the row in each section. All squares were examined to determine the cause of damage; only squares damaged by boll weevil oviposition were counted. Data were collected at 4-day intervals until 24 July when reduced square numbers, intensive weevil damage and large populations of Heliothis spp. larvae caused almost total fruit loss.

Data were analyzed with the Statistical Analysis System general linear model (Rudd and Jensen 1977). A regression coefficient (or ratio) was calculated to relate the new flared square technique to the percent boll weevil damage estimated by the 100-square survey technique. A no intercept model was used to force the intercept through zero. This method produced a constant multiplication factor so that when multiplied by the percent flared squares, it would give the most accurate estimate of the 100 square survey method. The counts were analyzed for three different time periods and collectively so that differences attributable to growth stage could be detected. The ratios were calculated from data collected during three 10-day periods beginning 16 June, 26 June and 6 July, respectively.

In conjunction with the sampling study, the time required for oviposition and feeding-damaged squares to flare and fall was measured. Insect damaged squares were removed from the plants in 107 m of row between 1300 and 1800 h. After 24 h, the squares in the 107 meters of row were examined for boll weevil damage. Weevil oviposition and feeding damaged squares were tagged with 2.54 cm x 2.54 cm paper tags by looping a string loosely around the peduncle of the damaged square. Tagged squares were examined daily for 7 days and the number of flared and fallen squares was recorded. Examination and tagging was done between 1000 and 1400 h. This procedure was repeated five times between 19 June and 27 July.

RESULTS AND DISCUSSION

Data obtained by tagging damaged squares indicated that the best scouting interval would be four days or twice a week. Data from late June shows that only 14-21% of boll weevil oviposition damaged squares flared and fell by day 3 and that 42-53% of damaged squares flared by day 4 (Table 1). This indicates that the actual percentage of damage to the plant could be estimated by multiplying the flared squares percent damage by ca. 1.5 to 2.0. Thus, a 4-day sample interval was chosen to test the flared square sampling technique.

Tagging later in the season indicated that a higher percentage of squares flared by day 4 when a greatly increased weevil population produced several oviposition and feeding punctures per square. It was also shown that squares damaged by boll weevil feeding rarely flared or fell. Thus, this method of sampling measured only oviposition damage, and the tagging of feeding punctured squares was terminated in mid-July.

Table 2 shows three time periods in which the fallen and flared square sampling technique was tested. The first period produced a regression coefficient of 1.91 ± 0.098 with a correlation coefficient of 0.98. Thus, by multiplying the ratio by the flared percent, yields the approximate number of developing larvae per 100 squares. The counts were initiated very soon after squaring began and continued for 10 days. This is a very important period if the weevil is to be controlled efficiently. The high correlation coefficient achieved indicates that the number of flared squares provides a very good estimate of boll weevil reproduction with its resultant square loss.

The second time period also produced a high correlation between the flared square technique and the 100 square survey method with a of 1.90 ± 0.084 and a correlation coefficent of 0.98. This is quite similar to the ratio of the first period because similar weather and growth conditions occurred during both periods.

During the third period weather conditions were favorable for rapid growth of the cotton plant. Increased rainfall facilitated both plant and weevil development, thus causing faster flaring and abscission of squares (Fenton and Dunnam 1929). The regression coefficient generated during the third period was 1.75 ± 0.07 and the correlation coefficient was 0.98 which was similar to results from previous periods. The latter part of this period coincided with the time when _Heliothis_ spp. control measures would typically have been implemented. The slightly lower third period coefficient may have resulted from faster flaring (and abscission) of squares caused by damage from small _Heliothis_ spp. larvae. Squares that had already been damaged by boll weevils but that might not have flared without the _Heliothis_ spp. damage, were included in the data.

The third period was concluded on 16 July because weevil populations increased in the study field and most squares received at least two oviposition punctures causing them to flare sooner. Counts that included high numbers of multiple damaged squares were not included in the analysis because this level of damage would not occur under normal control practices. Table 1 shows that the squares tagged on 17 July flared and fell much faster than during other tagging periods. Most of these squares had at least two oviposition punctures and several feeding punctures. Squares damaged to this extent often become necrotic and turn yellow before flaring. Squares tagged on 21 July were not as heavily damaged as those tagged during the previous period and the rate of flaring returned to the previous levels when only one oviposition puncture per square was found.

Table 2 also includes data where all three time periods were analyzed together. This produced a regression coefficient of 1.82

± 0.47 and a correlation coefficient of 0.98 which is a high correlation between the flared square method and the 100 square survey method. The differences between the coefficients calculated for all three time periods is very small and damage levels calculated using each individual ratio would be very similar.

Several factors must be considered when employing the flared square method, including environmental conditions and differences between scouts. Both the cotton plant and boll weevil are greatly influenced by moisture and temperature. Under moist conditions conducive to square development, damaged squares flare and fall faster, and, with inadequate moisture, boll weevils perish by desiccation. Hot, dry conditions are the least favorable for weevil eclosion and thereby reduce the rate at which squares flare and fall (Fenton and Dunnam 1929).

In using the fallen and flared method, it is critical that only one-third grown and larger squares are counted in establishing the squaring rate. If smaller squares are included in the counts, the predicted percent damage will be far below the actual damage. Only the squares in each 0.9 m section of row should be counted, not the squares on branches extending out of the 0.9 m section. However, squares on branches extending into the 0.9 m section from other plants must be counted. If additional row section is counted the square counts will be inflated and the predicted damage value will be low. In addition, sampling sites should be located on flat land where fallen squares will not be washed away during heavy rains.

In summary, these results indicate a strong correlation between flared square counts and the percent damage detected by the 100 square survey method in an untreated field. Thus, by using the coefficient with counts of flared squares, effective monitoring of ovicidal efficiency may be achieved. To relate these values, the coefficient of 1.8 should be used during the entire period from first one-third grown square until peak blooming. This constant is similar to the coefficient produced for the three component time periods. This method can be employed to indicate whether the weevil control measure being used is maintaining damage at or below the established action thresholds. Although this method may be influenced by secondary factors, it provides a better estimate of the level of ovicidal control obtained from diflubenzuron than the currently used techniques.

TABLE 1. Daily Percentages of Tagged Oviposition and Feeding Damaged Squares That Flared, Fell to the Ground, or Were Retained by the Plant. Tift Co., Ga., 1981.

Date	Feeding Damage (%)				Oviposition Damage (%)			
	Lost			Retained[b]	Lost			Retained
	Flared[a]	Fallen	Total		Flared	Fallen	Total	
Tagged 19 June 81								
Checked 22 June	0	0	0	100	12	2	14	86
23 June	0	0	0	100	18	24	42	58
24 June	2	0	2	98	24	29	53	47
25 June	0	2	2	98	32	51	83	17
Tagged 26 June 81								
Checked 29 June	0	0	0	100	12	9	21	79
30 June	0	0	0	100	31	22	53	47
1 July	0	0	0	100	19	38	57	43
2 July	0	0	0	100	27	32	59	41
Tagged 3 July 81								
Checked 6 July	0	0	0	100	17	3	20	80
Checked 7 July	0	0	0	100	41	11	52	48
8 July	0	0	0	100	42	12	54	46
9 July	2	2	4	96	28	38	66	34
Tagged 17 July 81								
Checked 20 July					12	30	42	58
21 July					21	42	63	37
22 July					13	56	69	31
23 July					6	64	70	30
24 July					3	76	79	21
29 July					0	91	91	9
Tagged 21 July 81								
Checked 24 July					5	16	21	79
25 July					18	34	52	47
27 July					12	42	54	45

[a] Flared squares refers to squares that have flared and/or turned yellow and remain on the plant.
[b] Retained refers to squares that sustained boll weevil oviposition or feeding damage but continue to grow normally.

TABLE 2. Regressions of Boll Weevil Damaged, Flared and Fallen Squares to the Percent Damage Measured by the 100 Square Survey Method for Cotton in Tift Co., Ga. 1981.

Period	N[a]	b[b]	r[c]
I (16 June to 26 June)	45	1.91 ± 0.098	0.98
II (26 June to 6 July)	50	1.90 ± 0.084	0.98
III (6 July to 16 July)	50	1.74 ± 0.070	0.98
TOTAL (16 June to 16 July)	145	1.82 ± 0.047	0.98

[a] Sample size = number of 7.62 m sections sampled.
[b] Regression coefficient ± standard deviation.
[c] Correlation coefficient.

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