ACTION THRESHOLDS FOR WHITEFLIES IN ARIZONA

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Abstract

Three field tests were set-up for evaluation of action threshold levels for sweetpotato whitefly control with two different chemical combinations. The thresholds used to initiate treatments were ca. 1, 10, and 25 adult whiteflies per leaf designated as "early", "moderate", or "late". Immatures were present during these treatment initiation points at the rate of ca. 5 nymphs and ca. 10 eggs per sq.in. in the 'early' plots, 15.3 nymphs and 39.1 eggs per sq.in. in the 'moderate' plots, and 52.1 nymphs and 299.3 eggs per sq.in. in the 'late' plots. The insecticides used included a pyrethroid combination [Danitol®(.1 lb a.i./A) + Orthene®(.5)] and a non-pyrethroid combination [endosulfan(.75) + Ovasyn®(.25)]. Applications were by ground, broadcast, over-the-top, at 20 GPA. Populations were monitored as whitefly adults (leaf turns & net sweeps) and nymphs and eggs (leaf counts). Once applications were triggered, they continued ca. weekly. The early threshold required seven applications, starting 10 July, and produced yields (4038.8 lbs seed cotton/A) which were 2 or 3 times larger than the untreated check (1589.3 lbs seed cotton/A). Lint or leaf stickiness was not apparent; however, 2 or 3 sprays were required before any significant differences in whitefly populations could be found. Whitefly numbers were lowered significantly in both insecticide regimens, with somewhat lower numbers present in the pyrethroid treated plots. The late threshold was sprayed only twice, starting 12 August, and yielded no more cotton (1719.2 lbs seed cotton/A) than the untreated check (1395.0 lbs seed cotton/A). Lint and leaf surfaces were covered in stickiness and sooty mold. Whitefly populations were excessive and led to premature cut-out and poor fruit retention. The moderate threshold (10 adults per leaf) received five applications, starting 22 July, and produced high yielding and high quality cotton (3462.2 lbs seed cotton/A). Some stickiness and sooty mold growth was observable only on the lowest leaves. This was a result of limited honeydew production prior to the threshold and well before any boll opening. Lygus populations were extremely high and caused large differences in yields which favored the pyrethroid combination slightly and the earliest threshold significantly. Given commercial farm control realities (e.g., delays in sampling or application, differences in coverage or application, variable efficacy), the ideal threshold for initiation of treatments is likely between 1 and 10 adults per leaf.

Introduction

On-farm pest management decision-making is very dependent on appropriate action thresholds. That is, the insect population level at which some management action is required in order to prevent irrecoverable economic loss. The use of appropriate action thresholds ensures that insecticides are used only when necessary and when indicated by sampling. The sweetpotato whitefly (Strain B), *Bemisia tabaci* (Genn.), has only recently been considered a pest of cotton in Arizona (a.k.a. silverleaf whitefly). Little was known about its potential impact on yield or lint quality under the desert conditions of the Southwest. Losses in 1992 to this whitefly (SPWF) were extraordinary, and it was generally perceived that control efforts were initiated too late to achieve acceptable control. In addition, many believed that control was impossible or else achievable only with the combination of pyrethroid insecticides with an organophosphate insecticide. This study was designed to investigate the impact of three different action threshold levels on SPWF management. Furthermore, we sought to contrast a pyrethroid insecticide combination with a non-pyrethroid insecticide combination.

Materials & Methods

Cotton (DPL 5415) was field grown in plots (planted 14 Apr 1993) using a RCB design of 4 replications of 3 insecticidal treatments. This design was used for each of three different adult whitefly action threshold levels, i.e., three separate RCB designs. Each plot consisted of approximately 2000 sq. ft. (12 rows X 50 ft.) separated by bare ground areas (4 rows between reps or 7 ft. between plots).

Insecticidal treatments consisted of: 1) an untreated check, 2) a combination of endosulfan and Ovasyn® (0.75 lb ai/A & 0.25 lb ai/A respectively), and 3) a combination of Danitol® and Orthene® (0.10 lb ai/A & 0.5 lb ai/A respectively). Higher rates of Danitol® (0.2 lb ai/A) and endosulfan (1.0 lb ai/A) were used in the late threshold test (see below) and on 12 Aug (all tests) because of intense SPWF pressure (Table 1). Treatments were ground applied using tractor mounted TwinJet® 8003 spray nozzles at 20 gal/A, ca. 40 psi, and 2.5 mph. Insecticidal treatments were applied ca. weekly, beginning 10 Jul and ending 18 Aug.

Three treatment initiation (action) thresholds were used to initiate insecticidal applications, one for each test. The "Early Threshold" (ET) test began receiving applications at an infestation level of one SPWF adult per leaf on 10 Jul. The "Moderate Threshold" (MT) of 10 adults per leaf was started on 22 Jul. The "Late Threshold" (LT) triggered on 12 Aug with ca. 25 adults per leaf (Table 2). Plots within the ET regime received a total of 7 applications; MT plots received 5 applications; and LT plots had 2 applications. Nine leaves were examined per plot for the presence of SPWF adults. Plants were selected at random among three different rows excluding the two guard rows. For leaf turns, leaves from either the first, second, or third subtending position below the terminal were selected for adult counts. Mean counts of these numbers for all twelve plots per test (N=108) were used to determine initiation of applications.

In addition to leaf turns for adult monitoring, two sampling methods, sweeping and leaf counts, were used weekly for assessment. All material collected in either 100, 50, or 25 sweeps per plot were bagged, categorized, and counted for numbers of insects. For leaf counts, 10 leaves per plot from either the fourth or fifth subtending position below the terminal were collected, bagged and returned to the lab. A one inch square area based at the petiole and centered diagonally over the main vein of each leaf was microscopically examined, and the numbers of whitefly eggs and larvae tallied. For extremely dense populations either a 0.5 or 0.25 square inch area was used; however, these were

centered on only one side of the leaf main vein in sector number 2 or 3.

Harvesting was accomplished using a modified two row machine picker. On 10 Nov, four inside rows per plot were machine picked, and the seed cotton was then collected, bagged and weighed. Grab samples were taken for stickiness, turnout, and lint characteristics measurements.

Results & Discussion

Early Threshold (ET)

Adults: In this test, 1.21 SPWF adults per leaf (N=108) were measured on 8 Jul, and applications began on 10 Jul. The precount data indicated no significant differences among treatments or reps ($P>0.10$). The endosulfan+Ovasyn treatment had significantly fewer adults per leaf than the check on all post treatment dates except for 27 Jul ($P\leq0.10$). From 15 Jul to 23 Aug, the endosulfan+Ovasyn treatment ranged in adult samples from 0.39 to 8.08 adults per leaf. The Danitol+ Orthene treatment ranged from 0.31 to 7.36 adults per leaf over the same time period and had significantly fewer adults than the check on all but the first postcount sample date (15 Jul). There were fewer adults in the pyrethroid treated plots relative to the non-pyrethroid plots on all but the first postcount sample date (Fig. 1).

Eggs: A precount of eggs showed no significant differences among treatments or reps with a mean of 5.9 eggs per sq. in. for the entire test (N=120). No separation from the untreated check was detected until after the third spray, although ANOVA indicated a significant treatment effect after the second spray ($P=0.027$). Both chemical regimes significantly lowered egg counts on every sample date after 22 Jul with one exception. The endosulfan+Ovasyn plots were not significantly different from the check on 16 Aug with 93.4 eggs per sq. in.. Over all sample dates, endosulfan+Ovasyn ranged from 5.45 to 93.4 eggs per sq. in., and Danitol+Orthene ranged from 4.80 to 16.6 eggs per sq. in. (Fig. 2a).

Nymphs: Nymphal counts averaged 3.5 per sq. in. prior to spraying and did not reveal any significant treatment effects until after the third application ($P=0.026$). Both chemical treatments significantly depressed nymphal counts relative to the check thereafter with only one exception. Endosulfan+Ovasyn®, which ranged over the course of the test from 2.70 to 16.85 nymphs per sq. in., was not significantly different from the check on 16 Aug ($P>0.10$). Numerically Danitol®+ Orthene® had fewer nymphs per sq. in. than endosulfan+Ovasyn® on all but two sample dates, 28 Jul and 23 Aug (Fig. 2b).

Late Threshold (LT)

Adults: In this test, 27.78 SPWF adults per leaf (N=108) were measured on 10 Aug, and applications began on 12 Aug. All sample dates prior to spraying ($\leq$ 8 Aug) indicated no significant differences among treatments or reps ($P>0.10$). Both treatment regimes lowered the number of adults per leaf significantly relative to the check on each postcount sample date, with numerically fewer adults in the pyrethroid treated plots (Fig. 3). The crop had cut-out by mid-August, and the counts of adults precipitously dropped even in the check after spraying. These plants were severely stressed, covered in honeydew and sooty mold, and probably offered few attractive oviposition sites for the adults.

Eggs: All samples of eggs revealed no significant differences among treatments or reps, both pre- and post-

application (P>0.10). Egg numbers followed the same precipitous decline as the adults in all treatments late in the test because of crop cut-out (Fig. 4a).

Nymphs: Nymphal counts followed the same non-significant pattern depicted in the egg counts. No decline in nymphal populations was detected by the final sample date indicating the natural developmental time lag of nymphs relative to the eggs (Fig. 4b). The LT was clearly inadequate to control SPWF populations before crop cut-out, widespread stickiness, and yield loss.

Moderate Threshold (MT)

Adults: The MT was reached on 21 Jul with 9.28 adults per leaf over the entire test (N=108), and applications began the following day. Prior to this time, there were no significant differences among treatments or reps (P>0.10). The endosulfan+Ovasyn treatment had significantly fewer adults per leaf than the check on all post spray dates except for 10 Aug and 16 Aug (P≤0.10). The pyrethroid combination, Danitol+ Orthene, had even fewer adults per leaf and was significantly lower than the check on all post-application dates. In addition, the pyrethroid treated plots never reached the MT once applications were initiated, while the endosulfan+Ovasyn treatment exceeded the MT only once for the same time period (Fig. 5).

Eggs: A precount of eggs on 21 Jul showed no significant differences among treatments or reps with a mean of 39.1 eggs per sq. in. for the entire test (N=120). After one application, the pyrethroid treated plots had significantly fewer eggs relative to the check (51.7 vs. 131.0 per sq. in.), a trend which continued for all subsequent sampling dates. The non-pyrethroid treated plots had more eggs than the pyrethroid treated plots, but significantly less than the untreated check on three dates (4, 10 & 23 Aug). Over all post-treatment sample dates, endosulfan+Ovasyn ranged from 49.0 to 144.8 eggs per sq. in., and Danitol+Orthene ranged from 8.75 to 51.7 eggs per sq. in. (Fig. 6a).

Nymphs: Nymphal counts averaged 15.3 per sq. in. just prior to spraying (21 Jul) and did not reveal any significant treatment effects until after the second application (P=0.005), when both chemical treatments significantly depressed nymphal counts relative to the check. After this point, only the pyrethroid treatment was able to significantly lower the nymphal counts relative to the check. Furthermore, while the endosulfan+Ovasyn nymphal counts leveled off and then exploded on the last date, the Danitol+Orthene counts progressively declined with each successive application (Fig. 6b). This would seem to indicate that there might be some threshold variability according to the compounds used.

Yields

The pyrethroid treated plots out yielded all others; however, this difference was not significant in the LT test. Both insecticide regimes yielded significantly more than the check in the MT and ET tests. Use of the MT or ET easily doubled the yield relative to the check, while the pyrethroid treated plots were nearly 3X greater than the check (Fig. 7). Approximately 1000 lbs seed cotton separated the two different chemical regimes for both the MT and ET tests. At least a portion, if not all, of this difference is attributable to the superior level of *Lygus* control measured in the pyrethroid treated plots (unpublished data). Formal comparisons between tests cannot be made; however, the checks in all three tests were very similar, yielding around 1500 lbs of seed cotton. Furthermore, endosulfan+Ovasyn applied seven times according to the ET had very few whiteflies with no apparent losses to them. Yet, this treatment still yielded less than the five sprays of Danitol+Orthene applied on the MT, where slightly higher SPWF populations were being supported for a longer period of time. This is further evidence that the added yield "enhancement" observed in the pyrethroid treated plots was related to suppression of some other insect which in this

case was probably *Lygus*. Correlational analyses have yet to be completed to relate observed *Lygus* counts with yield and SPWF parameters.

Summary

These tests demonstrate the importance of timely control of whiteflies. Applications made according to the LT (≥25 adults per leaf) resulted in unacceptable levels of field control with widespread stickiness, fruit abortion, and stress. Applications made on the ET (1 adult per leaf) resulted in very clean cotton with no visible sootiness on lint; however, this initiation level required a total of seven sprays with two or three sprays needed before differences between the treated plots and the check could be quantified.

The MT (ca. 10 adults per leaf) resulted in apparently clean cotton too, but with only five sprays required. The data do show somewhat higher populations in the MT compared to the ET, but few differences in honeydew or sooty mold growth were observable in the field. There was some visible sootiness on the surfaces of the lowest leaves which resulted from early honeydew production prior to the first application and well before boll opening. These lowest leaves were nearly completely shaded and probably contributed little to the overall photosynthate production of the plant.

Both insecticide combinations performed reasonably well on weekly intervals for the ET and MT—neither was able to "rescue" the cotton produced in the LT. The Danitol+Orthene treated plots sustained fewer whiteflies (all stages) overall than did the endosulfan+Ovasyn treated plots. Furthermore, the Danitol+Orthene treatment yielded about 1000 lbs more seed cotton than did the non-pyrethroid combination. At least a portion, if not all, of this yield advantage is thought to be related to superior *Lygus* suppression in the pyrethroid treatment, though further analyses will be needed.

The cost of whitefly control in this study was substantial, but justifiable in view of the 2X–3X yields measured relative to the check. Though it should be noted that a potentially substantial proportion of this yield enhancement was due to *Lygus* suppression even in the less effective non-pyrethroid treated plots.

The ideal action threshold level is likely near 10 adults per leaf. However, given real world control and sampling realities—use of other compounds, delays in application, use of aerial or other less effective application methods, delays in or inadequate sampling—less than 10 adults per leaf may ultimately prove to be more appropriate. Further refinement of these thresholds is also necessary to include a feedback component rather than weekly scheduled applications.

Table 1. Dates and rates of applications for each threshold test. *On these dates 0.2 lbs a.i./A of Danitol and 1.0 lbs a.i./A of endosulfan were used in their respective combinations.

Early	**8/17**	**8/12***	**8/4**	**7/29**	**7/22**	**7/16**	**7/10**
Moderate	**8/17***	**8/12***	**8/4**	**7/29**	**7/22**		
Late	**8/17***	**8/12***					

	Ovasyn + endosulfan	**Danitol + Orthene**
# a.i. / A	**0.25 + 0.75**	**0.1 + 0.5**
Mix Rate	**21.3 oz. + 32 oz.**	**5.3 oz. + 8.9 oz.**

Table 2. Sweetpotato whitefly population levels near the times of initiation of applications (see Table 1) for each threshold. Adults / leaf were measured on 7/8, 7/21, & 8/10. Immature counts were measured on 7/9, 7/21, & 8/10.

Threshold	**Adults**	**Nymphs / sq. in.**	**Eggs / sq. in.**
Early	1.21	3.5	5.9
Moderate	9.3	15.3	39.1
Late	27.8	52.1	299.6

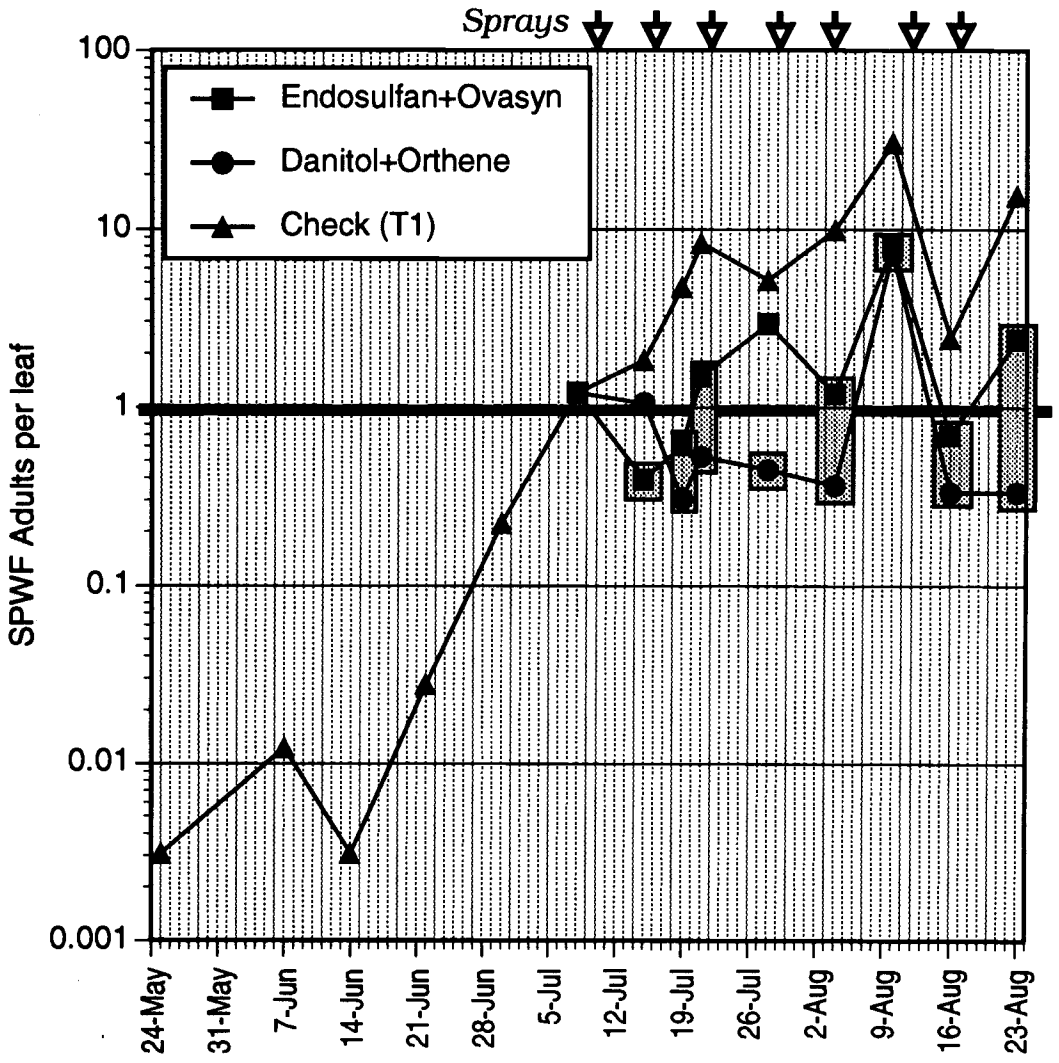

Figure 1: Numbers of sweetpotato whitefly (strain B) adults per cotton leaf for a pyrethroid and non-pyrethroid combination applied according to the early threshold of 1 adult whitefly per leaf. Arrows indicate spray dates. ▒ highlights samples which were significantly different from the check (Dunnett's Test, 0.10).

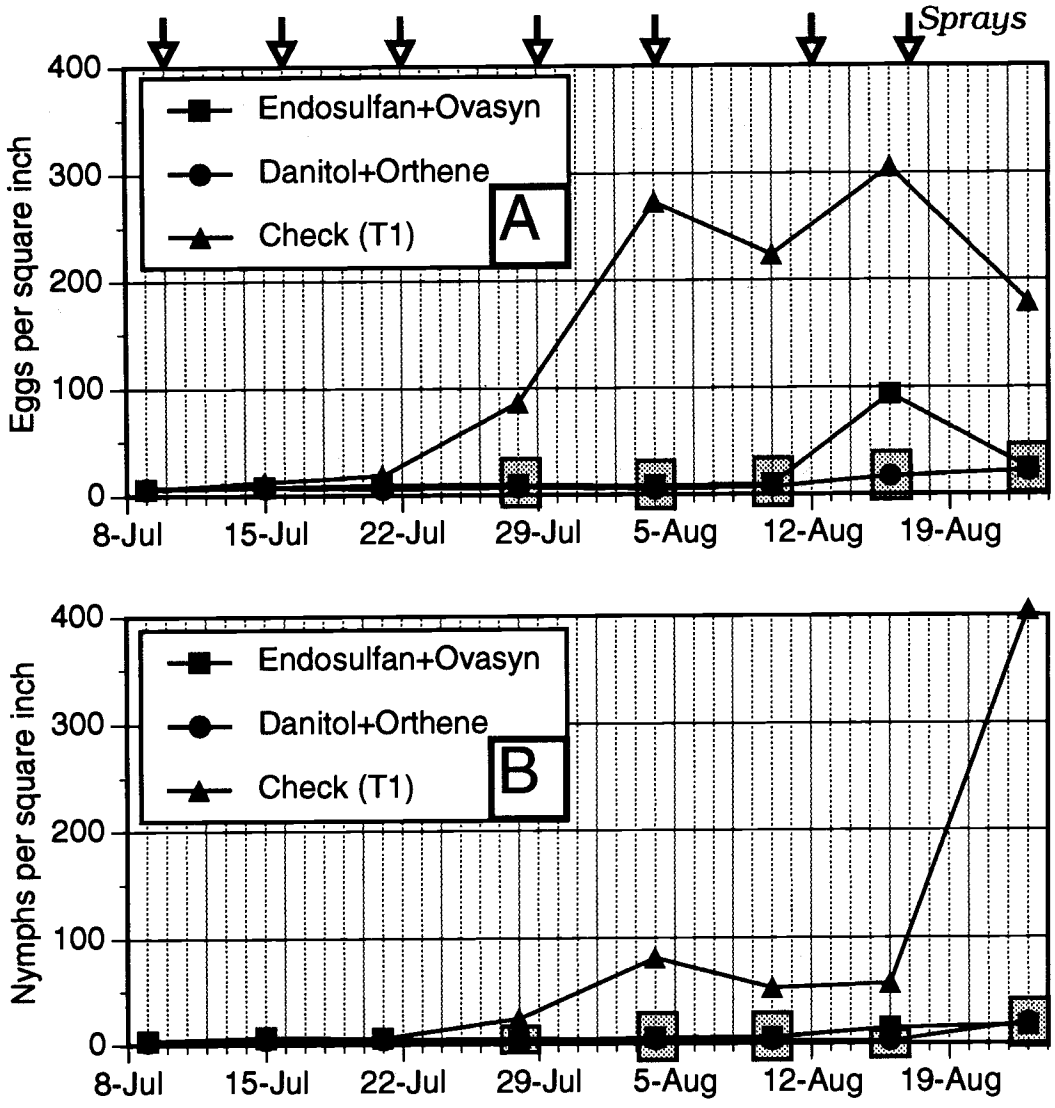

Figure 2: Plot of the number of eggs (a) and nymphs (b) per sq. in. of cotton leaf surface for a pyrethroid and non-pyrethroid combination applied according to the early threshold of 1 adult whitefly per leaf. Arrows indicate spray dates. ▒ highlights samples which were significantly different from the check (Dunnett's Test, 0.10).

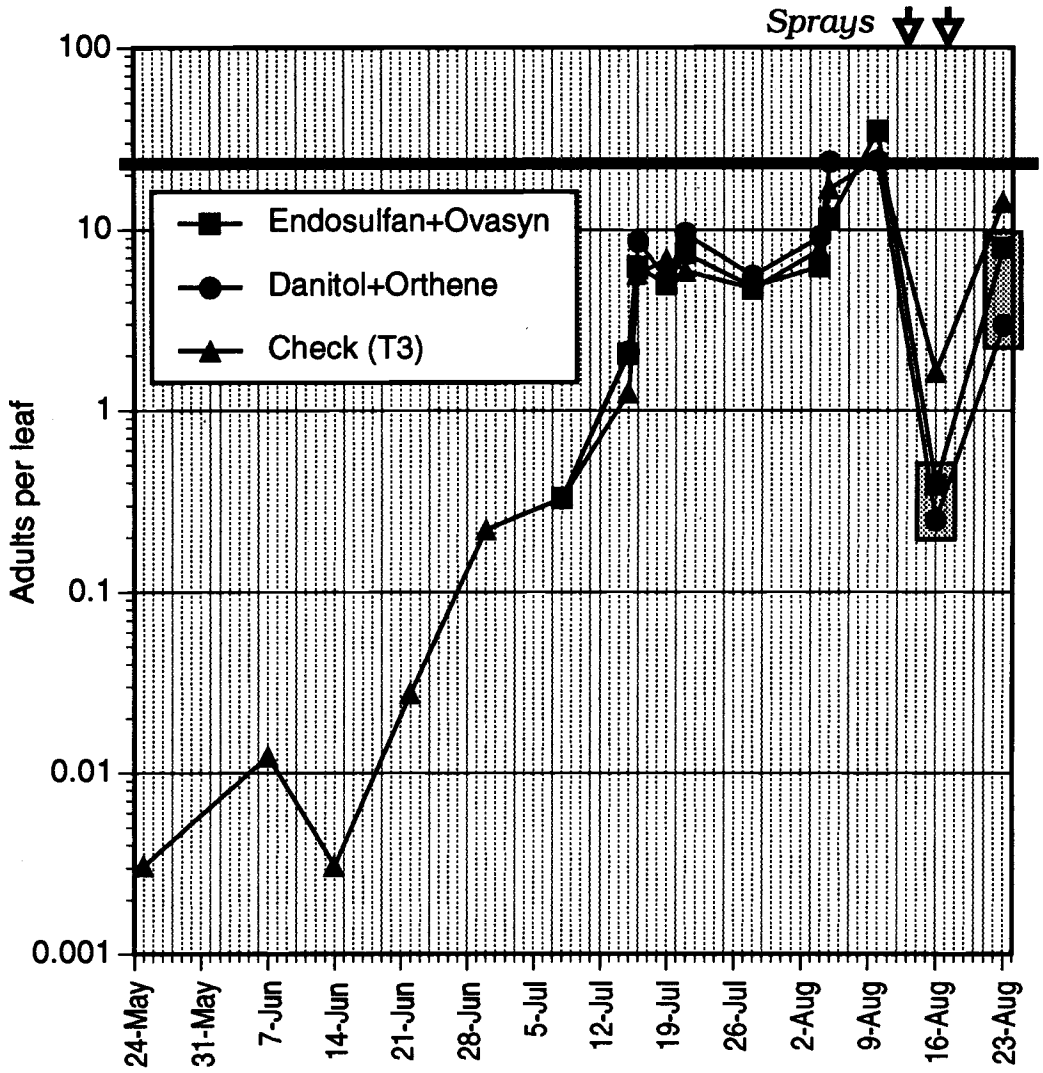

Figure 3: Sweetpotato whitefly (strain B) adults per cotton leaf for a pyrethroid and non-pyrethroid combination applied according to the late threshold of 25 adult whiteflies per leaf. Arrows indicate spray dates. ▒ highlights samples which were significantly different from the check (Dunnett's Test, 0.10).

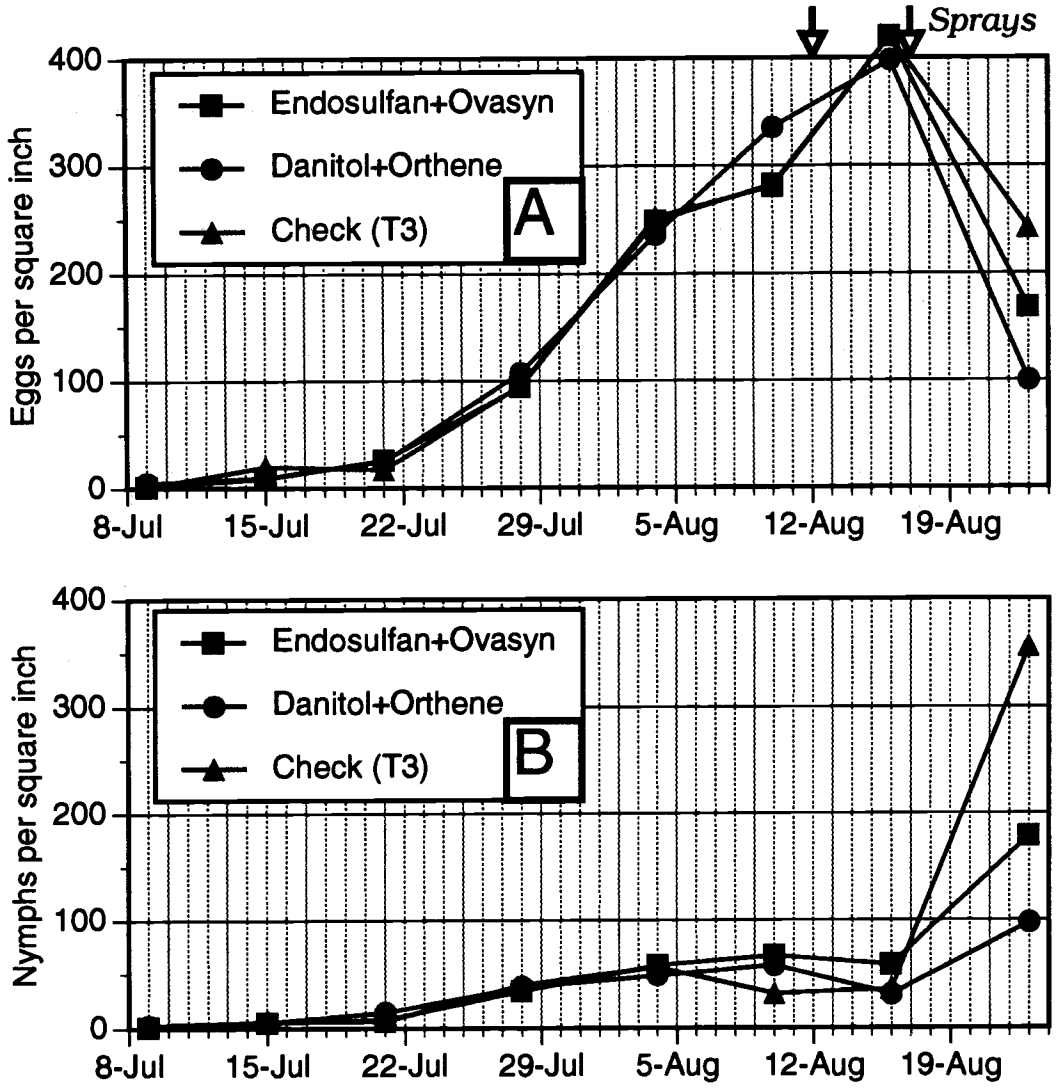

Figure 4: Number of eggs (a) and nymphs (b) per sq. in. of cotton leaf surface for a pyrethroid and non-pyrethroid combination applied according to the late threshold of 25 adult whiteflies per leaf. Arrows indicate spray dates. Significant treatment effects were found on the last date only ($P \leq 0.10$).

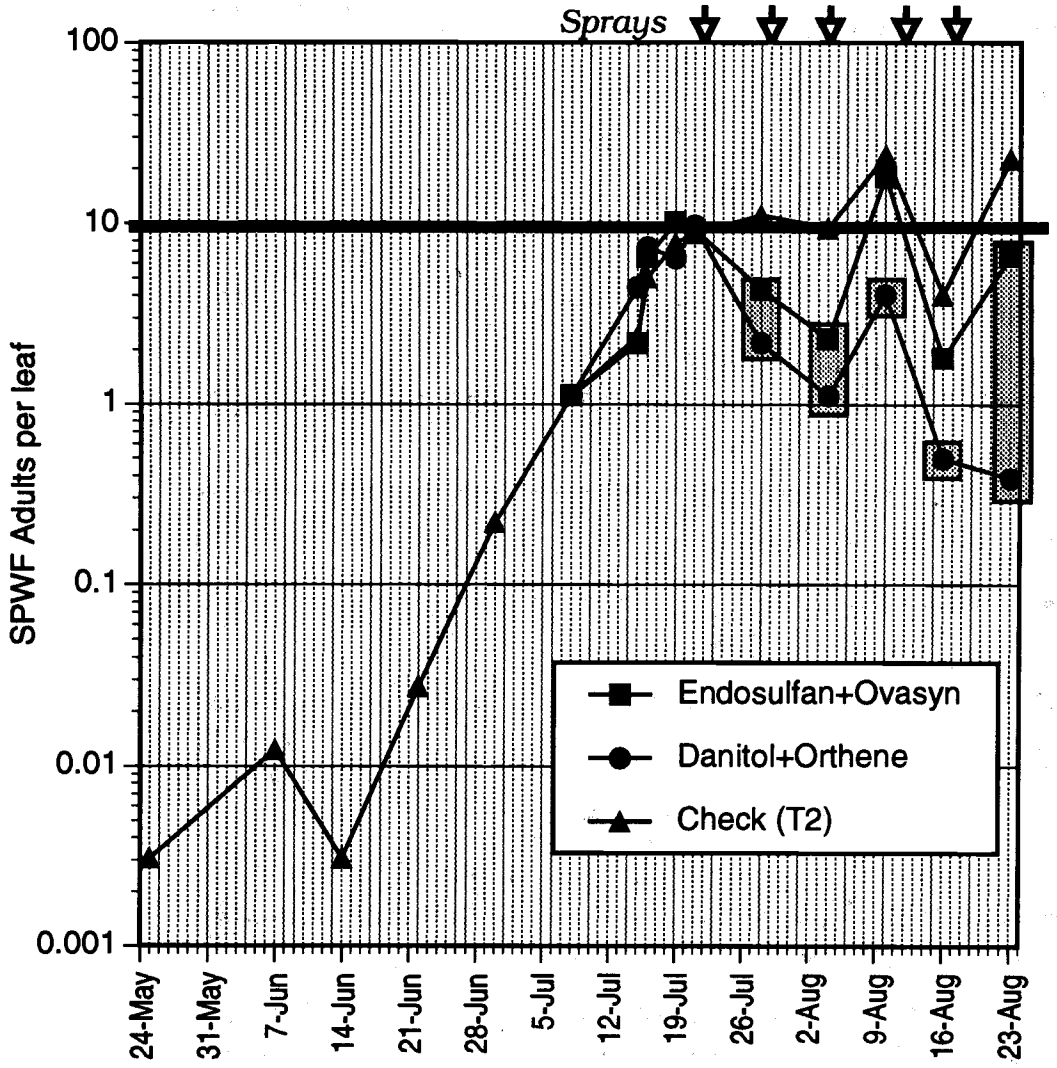

Figure 5: Numbers of sweetpotato whitefly (strain B) adults per cotton leaf for a pyrethroid and non-pyrethroid combination applied according to the moderate threshold of 10 adult whiteflies per leaf. Arrows indicate spray dates. ▒ highlights samples which were significantly different from the check (Dunnett's Test, 0.10).

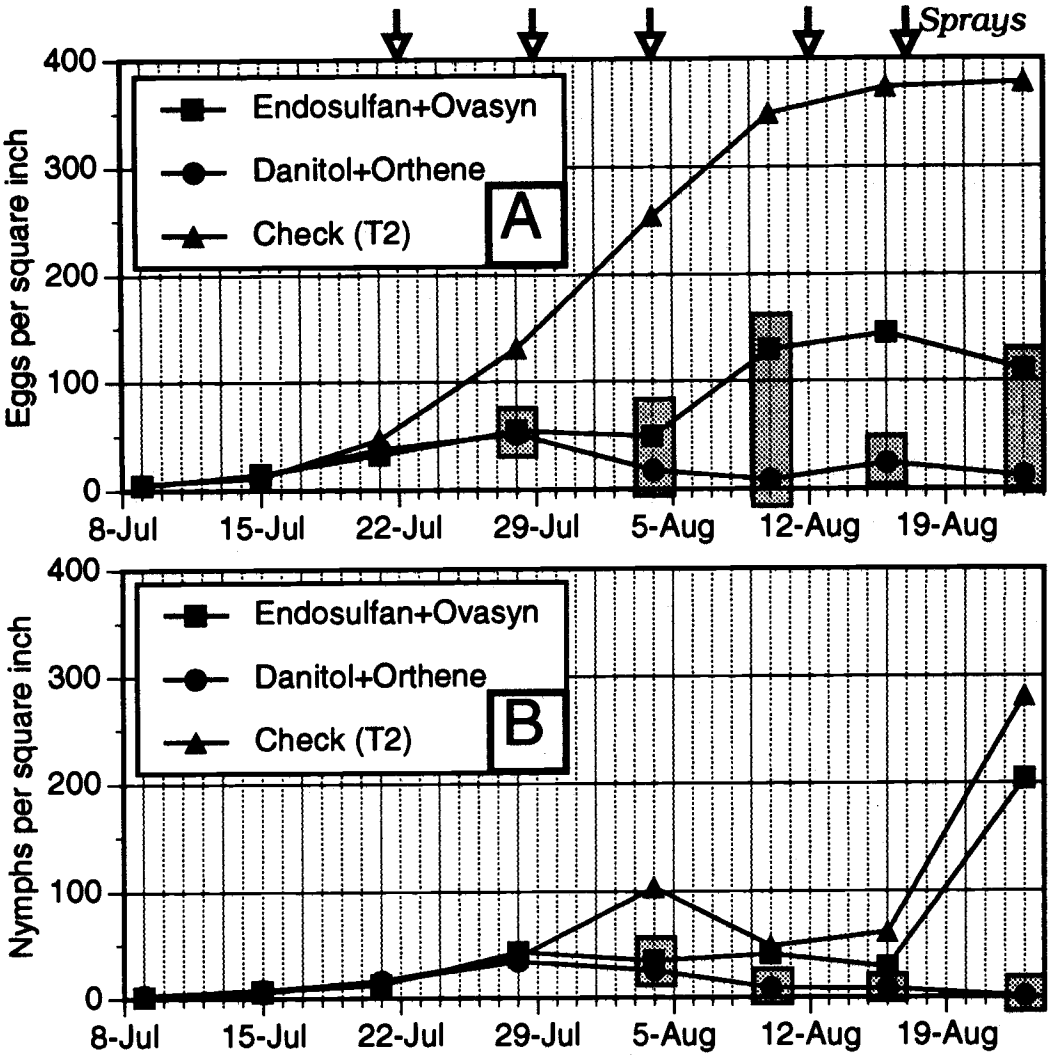

Figure 6: Number of eggs (a) and nymphs (b) per sq. in. of cotton leaf surface for a pyrethroid and non-pyrethroid combination applied according to the moderate threshold of 10 adult whiteflies per leaf. Arrows indicate spray dates. ▒ highlights samples which were significantly different from the check (Dunnett's Test, 0.10).

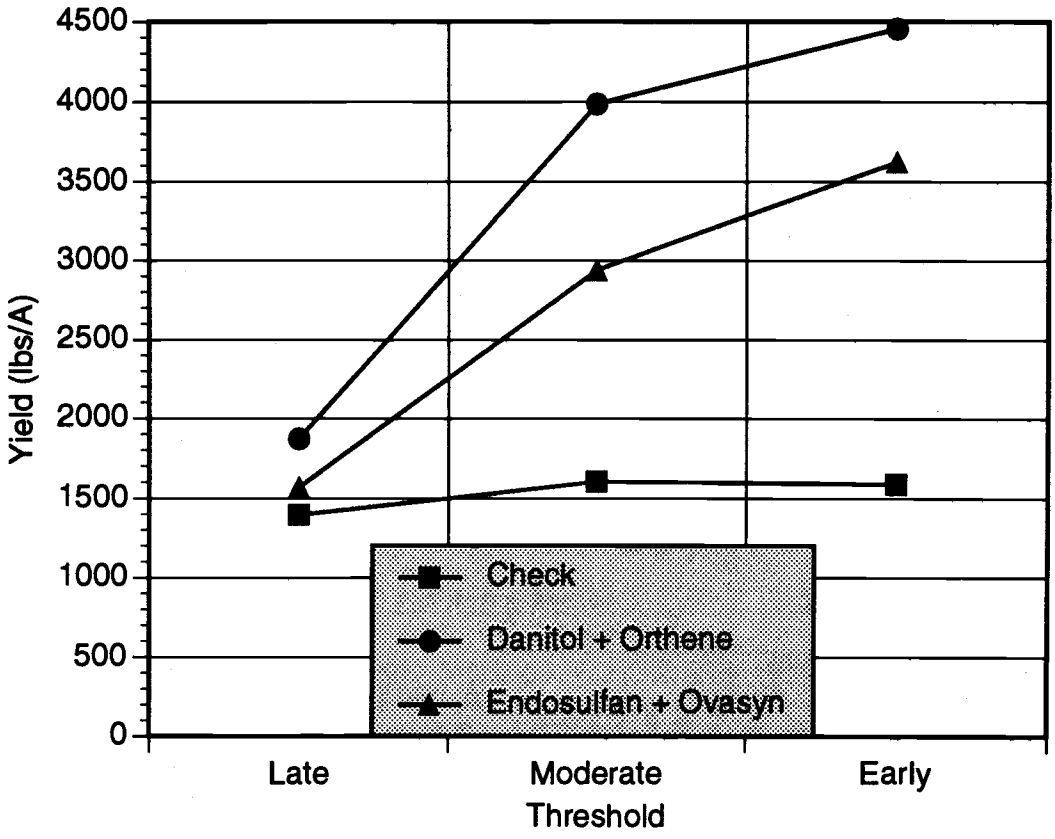

Figure 7: Seed cotton yields (per acre) for a pyrethroid and non-pyrethroid combination applied according to each of three action thresholds, early (1 adult per leaf), moderate (10 adults per leaf), and late (>25 adults per leaf). Both insecticide regimens when used on the moderate or early threshold yielded significantly more than their respective checks (Dunnett's Test, 0.10).