### COTTON APHID BIOLOGY AS AFFECTED BY CYHALOTHRIN (KARATE): APHID OR HOST PLANT MODIFICATION? M. N. Parajulee and J. E. Slosser Texas Agricultural Experiment Station Vernon, TX

# Abstract

A study was conducted to quantify the interaction among host plant, cotton aphid, and a pyrethroid insecticide, cyhalothrin (Karate), on cotton aphid population growth potential. Aphids from Karate-treated and untreated field plots were reared on cotton leaf discs from Karate-treated and untreated plots. Data on survival and fecundity were generated at 25 °C. Life table statistics were derived and compared among treatments. The rate of population increase, measured as the net reproductive rate, was significantly increased when aphids were reared on K-treated leaf discs compared to the aphids reared on untreated leaf discs regardless of the prior exposure of aphids to Karate insecticide, indicating a possible trophobiotic role of Karate on aphid population outbreak.

# Introduction

The cotton aphid, Aphid gossypii Glover, has been a consistent pest in Texas Rolling Plains cotton during the last two decades (Slosser et al. 1998). The known and potential factors that affect population dynamics of cotton aphids have been reviewed by Slosser et al. (1989), but the factors that trigger sudden outbreaks of cotton aphids are not clearly understood. Reports have indicated that some outbreaks of cotton aphids follow the application of pyrethroid insecticides for controlling cotton bollworm, Helicoverpa zea (Boddie), and tobacco budworm, Heliothis virescens (F.) (Leser 1994, Kidd et al. 1996). These outbreaks can be attributed to destruction of natural enemies, direct stimulation of aphid reproduction (hormoligosis), or indirect stimulation of aphid reproduction through hostplant modification (trophobiosis) (Slosser 1989). However, a clear relationship between insecticide application and aphid population increase is lacking. Slosser et al. (1989) noted that the aphid outbreaks in the Rolling Plains could not be attributed solely to the absence of natural enemies, but the rate of decline in aphid numbers after they attained peak densities was attributed to natural enemies. Kerns and Gaylor (1992) indicated that the aphid outbreaks following pyrethroid insecticide may be due to trophobiosis rather than hormoligosis, but they did not provide data to support this assertion.

The objective of this study was to quantify the effect of cyhalothrin (Karate) on cotton aphid biology, with particular emphasis on investigating the mode of action of cyhalothrin on cotton aphid population growth potential.

#### **Materials and Methods**

Experimental cotton plots were established at the Texas Agricultural Experiment Station farm in Chillicothe, Texas. The cotton variety 'Sphinx' was planted on April 26, 2000 in 40" rows, with a plot size of 10 rows wide by 75 ft. long. Within the large experimental set up with 36 such plots, some experimental plots were sprayed with Karate @ 0.04 lb AI/acre and some were kept untreated. Karate was applied on August 24, 2000 when cotton aphids began to increase in all plots. Forty-eight hours after the insecticide application, aphids were collected from both untreated control (C) plots and Karate-treated (K) plots, and brought to the laboratory for biological studies in controlled environment chambers. At the same time, cotton leaves (5th mainstem leaf below the terminal) were collected from both C and K plots and brought to the laboratory in a cooler. Cotton leaves

Reprinted from the *Proceedings of the Beltwide Cotton Conference* Volume 2:957-959 (2001) National Cotton Council, Memphis TN were washed to remove existing aphids, and leaf discs (9.62 cm dia.) were cut, using a modified cork borer. Several field collected aphids from each treatment were placed individually on leaf discs, floated on distilled water, in ventilated plastic petri dishes (60 mm x 15 mm) to produce F1 offspring; aphids collected from each treatment plot were reared on leaves collected from the same treatment plot to produce F1 offspring.

Newly born aphid nymphs (<18 h) from each treatment were individually reared on leaf discs (n = 20) from both treatments, with the following treatment combinations: a) aphids from C plot reared on leaves collected from K plot (C/C), b) aphids from C plot reared on leaves collected from K plot (C/K), c) aphids from K plot reared on leaves collected from C plot (K/C), and d) aphids from K plot reared on leaves collected from K plot (K/K). Individual aphids were inspected daily for survivorship and fecundity until the last aphid from each treatment died. Once aphids started reproducing, newly produced nymphs were counted and removed from the disc with a minimum disturbance to the mother aphid. Leaf discs were replaced weekly. This laboratory study was conducted in environmentally controlled chambers that were maintained at 25 °C and 14 h photoperiod. Four growth chambers were used, with 5 replicates of each of the 4 treatments in each of the 4 chambers.

Age-specific fecundity  $(m_x)$  and survivorship  $(l_x)$  schedules were constructed for each aphid, and life table statistics were calculated for each treatment regime. The calculated life table statistics included gross reproductive rate (GRR=  $\Sigma m_x$ ) and net reproductive rate ( $R_o = \Sigma l_x m_x$ ); intrinsic rate of increase ( $r_m$ ) was not derived because single generation data limits the attainment of a stable age distribution. The jackknife procedure (Meyer et al. 1986) was used to estimate the standard error of GRR and  $R_o$ values. The means from these analyses were compared using an analysis of variance and the least significant difference (SAS Institute 1995).

#### **Results and Discussion**

Age-specific fecundity varied among treatments. Aphids started reproducing in four days in all treatments. Daily fecundity was highest on C/C treatment for the first 2-3 days of reproduction, but the daily fecundity on C/C quickly declined to the lowest of all treatments during the period of peak reproduction, at 7-12 days of age (Fig. 1). The cumulative fecundity curve indicated that the K/C and C/K treatments, the two treatments in which the host substrate was switched between C and K collected aphids, resulted in lower fecundity compared to the C/C and K/K treatments during most of the active reproductive period (Fig. 2). The gross reproductive rate (GRR) was significantly higher on K/K compared to the other three treatments, whereas the GRR values were not significantly different among C/C, C/K, and K/C treatments (Fig. 3).

Age-specific proportional survivorship also varied among treatments. Survivorships were similar between C/C and K/K treatments during the first 12 days of the life cycle, but the survivorship in C/C treatment declined and remained below K/K treatment throughout the remainder of the life cycle (Fig. 4). Considering C/C and K/K treatments as two extreme checks to compare the effect of host substrate switching, aphids in K/C treatment started dying much sooner than in other treatments, and the survivorship on K/C remained lower than on C/K throughout the life cycle; survivorship on C/C and K/K were intermediate. As mentioned before, fecundity was similar between K/C and C/K treatments, but the survivorship schedules between these two treatments were distinctly different, indicating that K modified the host-plant and significantly improved aphid survivorship.

The net reproductive rate ( $R_o$ ) was significantly different among treatments. The  $R_o$  was highest for K/K, followed by C/K and C/C, and the lowest on K/C treatment (Fig. 5). The  $R_o$  decreased significantly when the K-treated aphids were reared on untreated leaf discs, whereas the  $R_o$  increased significantly when the untreated aphids were reared on K-treated leaf discs.

Because R<sub>o</sub> is the expected lifetime fecundity per newborn in the cohort, accounting for age-specific fecundity and age-specific survivorship, this statistic provides the most direct estimate of population growth rate over a single generation. Therefore, the R<sub>o</sub> values for these treatments indicate the rate of population increase per generation as affected by different treatments. It is apparent that the aphid population increase was significantly higher on the two treatments in which aphids were reared on K-treated leaves (host-plant factor) compared to the aphids reared on untreated leaves (aphid factor) regardless of the aphids' prior exposure to Karate. Moreover, the change in reproductive rate due to host switching after the insecticide treatment (K/K vs. K/C, C/C vs. C/K; Fig. 5) was opposite between C and K. That is, the rate of population increase for the aphids exposed to Karate decreased significantly when they were transferred to untreated host substrate, whereas the rate of population increase for the aphids that were not exposed to Karate increased significantly when they were transferred to K-treated host substrate. These data indicate that the mechanism for aphid population increase following Karate application is indirect through the effect of Karate on plant physiology (trophobiosis) rather than directly increasing fecundity (hormoligosis). Kerns and Gaylor (1992) suggested trophobiosis as a potential mechanism for aphid population outbreak following cypermethrin application, but they ruled out the possibility of hormoligosis involvement in their study. Slosser et al. (1989) also suggested a possible change in nutritional biochemistry of the cotton plant by insecticide, particularly leaf nitrogen and leaf carbohydrates, thereby impacting aphid survival and reproduction. Other studies are currently underway in our cotton aphid research program to validate these results under additional controlled research settings.

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Figure 1. Daily fecundity of *Aphis gossypii* as affected by the interaction of host plant and Karate application.



Figure 2. Cumulative fecundity of *Aphis gossypii* as affected by the interaction of host plant and Karate application.



Figure 3. Gross reproductive rate (GRR) of *Aphis gossypii* as affected by the interaction of host plant and Karate application. Bars with different letters are significantly different (P<0.05).



Figure 4. Proportional survivorship of *Aphis gossypii* as affected by the interaction of host plant and Karate application.



Figure 5. Net reproductive rate of *Aphis gossypii* as affected by the interaction of host plant and Karate application.