

**EFFECTS OF WHITEFLY INSECT GROWTH
REGULATORS KNACK® AND APPLAUD®
ON COTTON APHID REPRODUCTION
AND SURVIVAL**

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Abstract

Cotton aphid, *Aphis gossypii*, and silverleaf whitefly, *Bemisia argentifolii* are two sucking insect pests that frequently occur in the San Joaquin Valley at economically damaging levels. Whitefly growth regulators Knack® and Applaud®, which were registered under Section 18 in 1997 in California, were being tested in 1996 in some large-scale field tests where it was observed that the insect growth regulators (IGRs) were possibly providing some aphid control in addition to the whitefly control. In order to evaluate the IGRs' effects on cotton aphids a series of controlled greenhouse experiments were done that examined the efficacy of applications before and after aphid infestation on aphid nymphs and adults. Knack was effective at reducing the number of offspring produced by adult cotton aphids as well as reducing the survival of nymphs to adulthood, particularly of the very youngest of aphids. Applaud also reduced the number of offspring produced by adult aphids but the magnitude of this effect was much less than it was with Knack. Knack was effective at reducing survival and reproduction when applied to cotton aphid nymphs at one tenth the label rate.

Introduction

Insect pests, particularly sucking insects, have increased in importance for California cotton production during the 1990's. Cotton aphid, *Aphis gossypii*, and silverleaf whitefly, *Bemisia argentifolii*, populations have increased to damaging levels throughout much of the San Joaquin Valley (SJV). These pests not only reduce cotton lint yields, but also have the potential to deposit honeydew on exposed lint and cause sticky cotton. These pests have significantly effected cotton production in California; in 1991, insects and mites caused an estimated 0.4% cotton crop loss in California and control costs averaged <\$10/A (Head, 1992) compared with a 6.7% loss in 1997 and a average of \$95.84/A in control costs (Williams 1998).

The silverleaf whitefly was first found in SJV fields in 1992 in the southern end of the valley. From 1993-96,

populations spread throughout the SJV with the most severe infestations being found on the southern, eastern, and western sides of the SJV nearest the foothills (Wood *et al*, 1997; Godfrey *et al*, 1996; Godfrey *et al*, 1995). In 1996 and 1997, whitefly populations developed throughout much of the southern half of the SJV. The cotton aphid has been present in the SJV for many years; prior to the mid-late 1980's populations were very low and this insect was a non-pest. Over the last 10 years, the cotton aphid has evolved from an early- and late-season pest, to a mid-season pest, to a pest during the entire cotton growing season (particularly mid to late-season).

In 1997, Knack® (pyriproxyfen; Valent U.S.A. Corp.) and Applaud® (buprofezin; AgrEvo) were registered under a Section 18 in the SJV for silverleaf whitefly control. These products were field tested in large plots in 1996. Knack and Applaud are insect growth regulators that kill whiteflies by disrupting the development and natural processes of the insects. Knack's mode of action is by suppressing embryogenesis within the insect egg as well as inhibiting metamorphosis and adult emergence in target insects. The mode of action of Applaud is by causing nymphs to die at molting stage, causing adults to suppress the oviposition, and/or to ovipose unhatchable eggs. (Technical information from Valent and AgrEvo)

During the large-scale field tests in 1996, it was observed that these products also provided some cotton aphid control. Godfrey, Wynholds, and Wright had conducted small plot field tests targeted against cotton aphid with these products in 1994 and found minimal activity. The objectives of our 1997 studies were to evaluate the activity of Knack and Applaud on cotton aphid in controlled greenhouse tests. Specifically, we examined the efficacy of applications before and after aphid infestation on aphid nymphs and adults.

Materials and Methods

These characteristics were common to all the experiments unless noted otherwise.

- Maxxa cotton plants with 3-4 true leaves
 - Greenhouse temperature range 75-95 degrees Fahrenheit
 - 2 aphids per leaf on each of two leaves per plant. (Except experiment #2 which was 1 aphid per leaf on each of three leaves per plant)
 - Tanglefoot on petioles to prevent wandering
 - IGRs applied at rates of 8 oz product/A (Except Experiment #4 which was 0.8 oz product/A)
 - Data collected daily
 - IGRs applied with hand held spray bottle
 - Each experiment had two treatments.
1. IGRs applied and allowed to dry completely before aphid infestation

2. IGRs applied one hour after aphid infestation
- Aphids came from greenhouse colony started from aphids collected from a cotton field at the U.C. Cotton Research Station, Shafter, CA.

Experiment #1

Applaud and Knack were applied to plants that were infested with newly-eclosed cotton aphid adults in order to look at the effects on the aphid reproduction rates and the duration of time of their ability to reproduce. Twenty plants were infested with four aphids each for a total of eighty aphids per treatment.

Experiment #2

Applaud and Knack were applied to plants that were infested with cotton aphid first instar nymphs to examine the effects on the number of days the aphids took to reach adulthood (*i.e.* reproduce) and survival to adulthood. Ten plants were infested with three aphids each for a total of thirty aphids per treatment.

Experiment #3

Knack was applied to plants that were infested with aphids of various ages (one, three, five, & seven day(s) old) to examine the effects on the number of offspring produced upon reaching adulthood. Ten plants were infested with four aphids each for a total of forty aphids per treatment

Experiment #4

Knack was applied at one tenth the label rate to plants that were infested with first instar nymphs in order to examine the effects on the number of offspring produced upon reaching adulthood and the percentage that reached adulthood. Eleven plants were infested with four aphids each for a total of forty-four aphids per treatment.

Results

Experiment #1

The Knack and Applaud treatments showed reductions in the average number of offspring per aphid in both the pre-infestation and post-infestation treatments. The reductions shown in the Knack treatments were much larger than the Applaud. The aphids on the plants treated with Knack before infestation produced 45.4% fewer aphids than the untreated. The aphids on the plants treated after infestation produced 52.1% fewer offspring than the untreated. The Applaud treatments resulted in a 7.8% reduction in the number of offspring for the pre-infestation treatments and a 19.4% reduction in the number of offspring for the post infestation treatments (Figure 1).

Both Knack and Applaud appeared to have some effect on the number of days that the treated aphids produced offspring. The aphids on the plants treated pre-infestation produced offspring for an average of 6.8% less time (6.9 days) for the Applaud treatments and 17.6% less time (6.1

days) for the Knack treatments when compared to the untreated (7.4 days). The aphids on the plants treated post-infestation produced offspring for an average of 10.0% less time (6.3 days) for the Applaud treatments and 20.0% less time (5.6 days) for the Knack treatments compared to the untreated (7.0 days) (Figure 2).

Experiment #2

The two IGRs applied to cotton aphid first instar nymphs produced very different results. The average number of days to first reproduction was very similar for the IGR treated aphids and the untreated aphids but only a small percentage of the Knack-treated aphids ever reached that milestone. Reproduction was almost completely inhibited in the Knack-treated aphids as only 10.0% of those aphids ever reproduced. Applaud appeared to have little effect on the aphid's ability to reach adulthood as both the pre-infestation and post-infestation phases of the experiment had 100% of the Applaud-treated aphids reaching adulthood (Table 1).

Experiment #3

Knack appears to have the greatest effect on the youngest of aphids (*i.e.* first instars). Averaging the data of the pre and post-infestation treatments showed that there was a 95.5% reduction in the number of offspring produced by aphids that were treated with Knack when they were 1 day old. The effects were somewhat diminished as the aphids were treated at later stages of life. The percent reduction in the number of offspring for the aphids treated at three days old, five days old, and seven days old were relatively similar at 49.6%, 42.5%, and 58.7% respectively (Figure 3).

Experiment #4

Applying Knack at one tenth the label rate to the first instar aphids was very effective at reducing the average number of offspring the aphids produced. The aphids on the plants treated pre-infestation produced 96.4% less offspring than the aphids on the untreated plants. The aphids on the plants treated post-infestation produced 89.5% less offspring than the aphids on the untreated plants (Figure 4).

One reason the Knack-treated aphids had such low numbers of offspring was that there were only a small percentage of them that ever reached adulthood. Only 18.2% of the aphids on the plants sprayed before infestation and 9.1% of the aphids on the plants sprayed after infestation ever reproduced compared to 50% for the aphids on the untreated plants (Figure 5). (All the treatments here lost a number of aphids to such factors such as aphids falling off the plants or getting caught in the Tanglefoot which is why even the percentage for the untreated is as low as 50%).

Discussion

Insect growth regulators targeted for silverleaf whitefly appear to have the potential to also have effects on cotton

aphid. In a greenhouse study, Knack significantly reduced the number of nymphs produced by adult cotton aphids and the survival of cotton aphid nymphs to the adult stage. The latter effect was the most obvious and also was greater on the younger compared with older nymphs. Knack was equally effective with an application before aphid infestation or directly on the aphid infestation. Knack applied at 1/10 the label rate was also effective. In the same greenhouse study, an Applaud application caused a slight reduction in the number of offspring produced by aphid adults, but the magnitude of this effect was much less than with Knack. The reduction in the fecundity of cotton aphid with Knack would appear to have potential for reducing field infestations and providing control of this significant pest. However, in 3 small plot field tests, Knack has provided 18, 58, and 25% aphid control at 14 days after application to high, moderate, and low aphid densities, respectively, at the time of treatment. The inability to affect aphids immigrating into cotton fields, the exposure time needed to affect aphid reproduction, the lack of IGR on new leaf tissue (where the aphid infestations usually begin) are possible reasons for the lack of significant field control. The effectiveness of the lower use rate in the greenhouse test bodes well for making the treatment more cost effective. However, this low rate would likely be detrimental for delaying the onset of resistance, especially for whiteflies, which is the primary target pest for Knack in cotton. Additional research is justified to attempt to develop use strategies for Knack on cotton aphids and to maximize control efficacy.

Acknowledgments

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Table 1. The effects of IGR application on survival to adulthood and the length of time until adulthood of cotton aphid first instar nymphs.

Timing	Treatment	Num. Of days to Adulthood	% reaching adulthood
Pre-inf.	Untreated	6.7	100
Pre-inf.	Applaud	7	100
Pre-inf.	Knack	7	10
Post-inf.	Untreated	6.9	100
Post-inf.	Applaud	6.6	100
Post-inf.	Knack	----	0

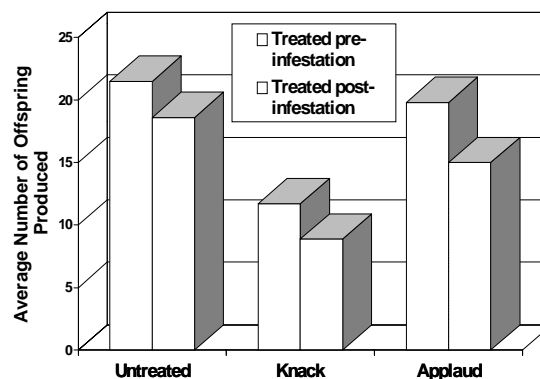


Figure 1. The effects of IGR application to the average number of offspring produced by cotton aphid adults.

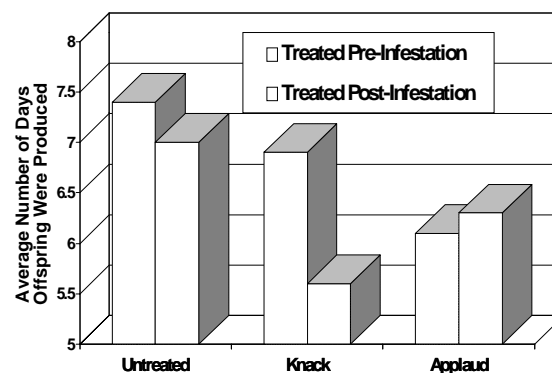


Figure 2. The effects of IGR application to the average number of days that cotton aphid adults produced offspring.

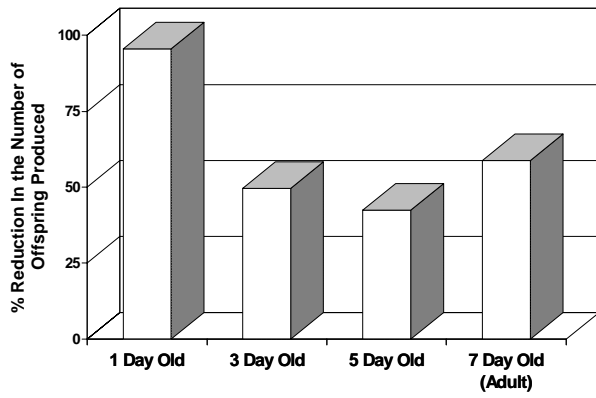


Figure 3. The effects of Knack application to cotton aphids nymphs of various levels of development.

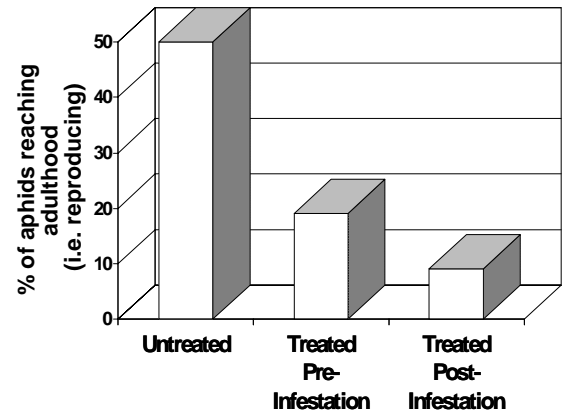


Figure 5. The effects of Knack application at 1/10 the label rate on survival to adulthood of cotton aphid first instar nymphs.

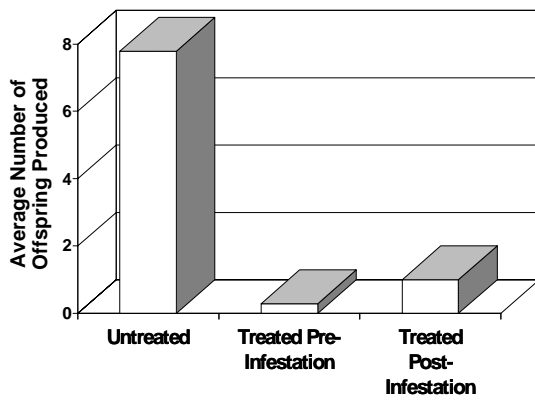


Figure 4. The effects of Knack application at 1/10 the label rate on the average number of offspring produced by cotton aphid first instar nymphs