EFFECT OF IMIDACLOPRID ON WING FORMATION IN THE COTTON APHID (HOMOPTERA: APHIDIDAE)

Authors: Conway, Hugh E., Kring, Timothy J., and McNew, Ron

Source: Florida Entomologist, 86(4) : 474-476

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/0015-4040(2003)086[0474:EOIOWF]2.0.CO;2

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 16 May 2024
Terms of Use: https://bioone.org/terms-of-use

EFFECT OF IMIDACLOPRID ON WING FORMATION IN THE COTTON APHID (HOMOPTERA: APHIDIDAE)

HUGH E. CONWAY[1], TIMOTHY J. KRING[1] AND RON MCNEW[2]
[1]Department of Entomology, University of Arkansas, Fayetteville, AR 72701

[2]Agricultural Statistics Lab., University of Arkansas, Fayetteville, AR 72701

The cotton aphid, *Aphis gossypii* Glover, is considered one of the most important pests of many vegetable and field crops (Leclant & Deguine 1994). In 2002, aphids were present in 70% of US cotton fields, infesting 9.4 million acres of cotton (Williams 2003).

Imidacloprid is an effective systemic insecticide (Nauen et al. 1998) with a high degree of residual activity against cotton aphids although the compound is slow acting (Boiteau & Osborn 1997). Imidacloprid acts on the nicotinic acetycholine receptor, causing the insect to reduce or stop feeding, and reduces mobility (Gourment et al. 1994; Boiteau & Osborn 1997).

As a result of casual observations of an increased proportion of alate aphids in imidacloprid-treated fields compared to untreated fields, laboratory spray tests were conducted on apterous adult aphids to evaluate the extent of wing formation and fecundity in offspring due to exposure to imidacloprid. Increased wing formation due to insecticide treatment has not previously been reported.

Probit analysis using five application rates from 0 to 0.05 Lb ai/A imidacloprid (Provado® 1.6F, Bayer Corporation, Kansas City, MO 64120) were used to establish an LC_{50} for imidacloprid of 0.122 ppm (0.0125 Lb ai/A). In imidacloprid-treated fields, aphids may not obtain a lethal amount of insecticide because of insufficient dosage, inadequate coverage, or active avoidance of insecticide residues (Kerns & Gaylor 1992).

Each treatment was replicated eight times on greenhouse-produced four-leaf stage cotton (Deltapine 51 and Deltapine 428B; Delta and Pine Land Company, Scott, MS 38772). Ten pots (1 plant/pot) were used in each replication. Ten adult apterous cotton aphids were transferred onto each of the four true leaves of each plant with a fine camel hair brush. Treatments were applied to cotton plants in a spray booth (Research Track Sprayer SB6-079, DeViries Manufacturing, Hollandale, MN 56045). The aphids were allowed to settle and recounted to insure all leaves contained 10 aphids prior to treatment.

Five plants were randomly selected and sprayed with the LC_{50} solution of 0.0125 Lb ai/A imidacloprid and the other five plants were sprayed with water. Following spraying, plants were allowed to dry and placed in a chamber at 20 ± 3°C, (13:11, L:D). Aphids were counted on each of the four leaves/plant 48 h post-treatment to check mortality and to establish the number of surviving adults for fecundity assessment. The 48 h reading was selected based on mortality assessment from probit analysis. Ten days post-treatment, aphids on each leaf were examined and classified as either apterous or alate based on the presence or absence of wings or wing pads. All replicates were sampled using the same protocol with a total of 80 plants sampled (4 leaves/plant; 10 plants/replicate; 8 replicates). Data on wing formation with $\log_{10}$ transformed means and on fecundity were analyzed by analysis of variance with means separated using PROC GLM, ANOVA, and t-tests (SAS institute 1997, 1999).

Two days post-treatment 89.2% (±0.11) of the aphids survived in the control and 51.4% (±0.13) in imidacloprid treatments (±SE). No significant difference occurred among replications. A significant difference ($P \leq 0.0001$) in wing formation was observed between treatments (Table 1). Imidacloprid-treated plants had 12.0% (±1.30) alate offspring compared with 2.0% (±0.24) in the control plants. Further, a significant decrease ($P \leq 0.0003$) in fecundity of treated aphids occurred with aphids on control plants having 9.2 ± 0.97 offspring per adult and aphids on imidacloprid plants having 4.9 ± 0.50 offspring.

Alate aphids can migrate, have a longer developmental time, produce fewer offspring, and have

TABLE 1. EFFECT OF IMIDACLOPRID ON WING FORMATION OF OFFSPRING AND THE FECUNDITY OF SURVIVING ADULT COTTON APHIDS.

Treatment	Wing Formation ± SE (%)	Fecundity ± SE (offspring/adult)
Water control	2 ± 0.24 b	9.2 ± 0.97 a
Imidacloprid (0.0125 Lb ai/A)	12 ± 1.30 a	4.9 ± 0.50 b

Means in the same column followed by the same letter are not significantly different, df = 79, $P \leq 0.05$ (LSD, SAS Institute 1997). Wing formation data were $\log_{10}$ transformed. Percentage non-transformed data are shown in the table.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 16 May 2024
Terms of Use: https://bioone.org/terms-of-use

an increased risk of mortality when moving than apterous aphids (Noda 1959; Dixon 1977). Additionally, alatiform nymphs and adults are more tolerant than the apterous form to pesticides, possibly due to size difference, amount of sclerotization, and/or difference in behavior (Crafton-Cardwell 1991).

The formation of wings is influenced by prenatal (inside the mother), postnatal (early nymph), and a combination of both prenatal and postnatal conditions (Dixon 1998). *Aphis gossypii* has developmental flexibility as late as the second instar (Shaw 1970). The longer the delay, before wing development, the quicker the aphids respond to rapid environmental changes (Dixon 1998). Our results could be due to either prenatal or postnatal effects.

Crowding and nutritional factors are the two main forces involved with the production of alates in most aphids (Dixon 1998). Colonies with fewer than three aphids seldom produce alates, while colonies with three or more aphids often produce alate offspring (Reinhard 1927). Unfortunately, research has not identified the relative importance of nutrition versus crowding, and just two aphids can promote wing induction from tactile stimulation (Muller et al. 2001). Aphids on a more nutritious host produce more offspring and are less likely to move frequently. However, on poor quality hosts, aphids are more restless and more likely to contact other aphids, producing a crowding response (Tamaki & Allen 1969). The physical influence of spray likely induced movement and may have simulated crowding in some of the aphids in our tests, but this influence was controlled because the control plants received a water spray.

Imidacloprid treatment induced increased wing formation in the cotton aphid independent of aphid crowding and associated decline in plant quality due to aphids or plant senescence. Imidacloprid reduces aphid feeding and may lower plant nutrition; these effects may cause wing production. Further, the production of wings could be caused by the insecticide acting on the endocrine system in a way similar to that of precocenes (Hardie 1986; Hardie et al. 1996) or by the impact of the insecticide on the plant, or a combination of these or another unknown mechanism.

Summary

When treated with imidacloprid, cotton aphids produce a significantly higher percentage of alate offspring with significantly fewer offspring per adult. In addition to potential increased emigration by alate aphids, an increase in the proportion of alate aphids among survivors of an imidacloprid treatment may have further caused a decrease in the number of aphids in the treated field because alate aphids required a longer developmental time, produced fewer offspring, and had an increased risk of mortality. An increase in the proportion of alate offspring could ultimately decrease the overall number of aphids in the field and thus increase the apparent efficiency of the insecticide. Conversely, applications of imidacloprid could serve to worsen area-wide problems via increasing the dispersal of winged aphids to other fields, assuming the surviving alates are fit and disperse normally.

References Cited

BOITEAU, G., AND W. P. L. OSBORN. 1997. Behavioral effects of imidacloprid, a new nicotinyl insecticide, on the potato aphid, *Macrosiphum Euphorbiae* (Thomas) (Homoptera: Aphididae). Can. Entomol. 129: 241-249.

GRAFTON-CARDWELL, E. E. 1991. Geographical and temporal variations in response to insecticides in various life stages of *Aphis gossypii* (Homoptera: Aphididae) infesting cotton in California. J. Econ. Entomol. 84: 741-749.

DIXON, A. F. G. 1977. Aphid ecology: Life cycles, polymorphism and population regulation. Ann. Rev. Ecol. System. 8:329-353.

DIXON, A. F. G. 1998. Aphid Ecology, 2nd ed. Chapman & Hall, London, UK.

GOURMET, C., A. D. HEWING, F. L. KOLB, AND C. A. SMYTH. 1994. Effect of imidacloprid on nonflight movement of *Rhopalosiphum padi* and subsequent spread of barley yellow dwarf virus. Plant Dis. 78: 1098-1101.

HARDIE, J. 1986. Prococenes and morph differentiation in female aphids. *In* Holman, J. Pelikan, and J. Dixon (eds.), Population structure, genetics, and taxonomy of aphids and thysanopterons. The Hague: SPG Academic Publishing pp. 145-157.

HARDIE, J., G. NONG, T. TIMAR, P. SEBOK, AND D. HONDA. 1996. Precocenes derivatives and aphid morphogenesis. Arch. Insect Biochem. Physiol. 32: 493-501.

KERNS, D. L., AND M. J. GAYLOR. 1992. Behavior of cotton aphid exposed to sublethal doses of three insecticides. Southwest. Entomol. 17: 23-27.

LECLANT, F., AND J. P. DEGUINE. 1994. Cotton aphids, pp. 285-323, *In* G. A. Mathews and J. P. Tunstall (eds.), Insect pests of cotton, C. A. B., UK.

MULLER, C. B., I. S. WILLIAMS, AND J. HARDIE. 2001. The role of nutrition, crowding and interspecific interactions in the development of winged aphids. Ecol. Entomol. 26: 330-340.

NAUEN, R., K. TIETJEN, K. WAGNER, AND A. ELBERT. 1998. Efficacy of plant metabolites of imidacloprid against *Myzus persicae* and *Aphis gossypii* (Homoptera: Aphididae). Pestic. Sci. 52: 53-57.

NODA, I. 1959. The emergence of winged viviparous female in aphid VII. On the rareness of the production of the winged offsprings from the mothers of the same form. Jap. J. Appl. Entomol. Zool. 3: 272-280.

REINHARD, H. J. 1927. The influence of parentage, nutrition, temperature, and crowding on wing production in *Aphis gossypii* Glover. Texas Agric. Exp. Sta. Bul. 353: 1-19.

SAS INSTITUTE. 1997. JMP, Windows Version 3.2.1, SAS Institute, Inc., Cary, NC.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 16 May 2024
Terms of Use: https://bioone.org/terms-of-use

SAS INSTITUTE. 1999. SAS/STAT User's Guide, Windows Version 8, SAS Institute, Inc., Cary, NC.

SHAW, M. J. P. 1970. Effects of population density on alienicolae of *Aphis fabae* Scop. II. The effect of isolation on the development of form and behavior of alate in a laboratory clone. Ann. Appl. Biol. 65: 205-212.

TAMAKI, G., AND W. W. ALLEN. 1969. Competition and other factors influencing the populations dynamics of *Aphis gossypii* and *Macrosiphoniella sanbori* on greenhouse chrysanthemums. Hilgardia 39: 447-505.

WILLIAMS, M. R. 2003. Beltwide cotton insect loss estimates: 2002, *In* Proceeding of the Beltwide Cotton Conferences. Nat. Cotton Council Am., Memphis, TN.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 16 May 2024
Terms of Use: https://bioone.org/terms-of-use