

Ovicidal Activity of Acetamiprid and Imidacloprid Against *Manduca sexta* (Lepidoptera: Sphingidae)¹

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Neonicotinoids are the most widely used class of insecticides, providing effective management of piercing-sucking insects through multiple application methods (Jeschke et al. 2011, J. Agric. Food Chem. 59: 2897–2908). In flue-cured tobacco (*Nicotiana tabacum* L.) and tomato (*Solanum lycopersicum* L.) production, the neonicotinoids acetamiprid and imidacloprid are used for management of *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) (Palumbo et al. 2001, Crop Prot. 20: 739–765), *Myzus persicae* (Sulzer) (Burrack and Toennissen 2017, NC State Extension AG-187: 145–162; Merchan and Burrack 2016, Int. J. Pest Manag. 63: 322–330), *Frankliniella fusca* Hinds (Groves et al. 2001, Crop Prot. 20: 439–445), and *Frankliniella occidentalis* (Pergrande) (Demirozer et al. 2012, Pest Manag. Sci. 68: 1537–1545) (Thysanoptera: Thripidae), the latter two vectors of tomato spotted wilt tospovirus.

Manduca sexta (L.) (Lepidoptera: Sphingidae) is a pest of tobacco (Madden and Chamberlain 1945, USDA Tech. Bull. 896) and tomato (Lange and Bronson 1991, Annu. Rev. Entomol. 26: 345–371), capable of defoliating entire plants. Insecticide-based management of *M. sexta* excludes the use of neonicotinoids, as tolerance to nicotine via induced detoxification and excretion by caterpillars (Wink and Theile 2002, Chemoecology 12: 29–46) confers tolerance to the nicotine mimics (Bai et al. 1991, Pestic. Sci. 33: 197–204). Although acetamiprid and imidacloprid are ineffective against *M. sexta* caterpillars, their toxicity against eggs is unknown and should be assessed to find targetable life stages, expanding the utility of the materials (Pedigo and Rice 2008, Entomology and Pest Management, 287–310).

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Thus, our goal was to determine the ovicidal activity of acetamiprid and imidacloprid against *M. sexta*.

We obtained day-old *M. sexta* eggs from a North Carolina State University colony. Serial dilutions of Admire 2F (imidacloprid) (Bayer Crop Science, Monheim, Germany) and Assail 70WP (acetamiprid) (United Phosphorus, Inc., King of Prussia, PA) were prepared immediately prior to use. We administered 0.5- μ l doses of six serial dilutions of either insecticide and a water control to the surface of 10 eggs, with a Hamilton repeating syringe (Hamilton Company, Reno, NV). Eggs were held in 10-cm diameter petri dishes (Corning Inc., Corning, NY) lined with moistened Whatman 1 filter paper (GE Healthcare Bio-Sciences, Pittsburgh, PA) and incubated at 30°C at 16:8 light:dark for 5 d. We recorded the number of successfully hatched eggs and removed them every other day. Insecticide assays were performed individually and were replicated at least nine times. We calculated lethal dose (LD₅₀) estimates, confidence limits, and χ^2 goodness of fit values in RStudio version 10.1.136 (RStudio Team 2017, RStudio, Inc., Boston, MA) using the DRC package (Ritz and Streiberg 2005, J. Stat. Softw. 12: 1–22).

Both neonicotinoid insecticides reduced *M. sexta* egg hatch as their doses increased, and their median lethal dose estimates differed by several orders of magnitude. The estimated LD₅₀ for Assail 70WP was 2.99×10^{-7} μ g/ml (2.09×10^{-7} acetamiprid μ g/ml) ($n = 700$), with confidence intervals (95%) of 2.41×10^{-7} to 3.71×10^{-7} μ g/ml (1.69×10^{-7} to 3.59×10^{-7} acetamiprid μ g/ml). The slope of the log-transformed Assail 70WP data was 1.12 ± 0.109 with a χ^2 value of 21.8 ($n = 700$; df = 4). The LD₅₀ value for Admire 2F was estimated to be 4.56 μ g/ml (0.976 imidacloprid μ g/ml) ($n = 630$), with upper and lower confidence intervals of 2.21 to 9.38 μ g/ml (0.473 to 2.00 imidacloprid μ g/ml). The slope of the log-transformed Admire 2F data was 0.444 ± 0.0830 and the χ^2 value was 9.377 ($n = 630$; df = 4). As the 95% confidence intervals did not overlap, LD₅₀ estimates for Assail 70WP and Admire 2F were significantly different.

Our results demonstrate that both acetamiprid and imidacloprid exhibit ovicidal activity against *M. sexta*, and acetamiprid in the formulation Assail 70WP is significantly more toxic than imidacloprid in the formulation Admire 2F. Ovicidal activity has been reported for both insecticides against lepidopteran pests in the families Crambidae and Plutellidae (Parrish et al. 2001, Proc. Beltwide Cotton Conf. 2: 904–906), Noctuidae (All et al. 2001, Proc. Beltwide Cotton Conf. 2: 802–803), and Tortricidae (Charmillot et al. 2007, Pest Manag. Sci., 63: 677–681); this is the first account of ovicidal activity against *M. sexta* or any member of Sphingidae. Insect egg morphology lends itself to protecting embryos from insecticides by creating a barrier that reduces penetration of toxicants (Campbell et al. 2016, Insecticides Resistance, 83–96). The baseline ovicidal activity reported herein could inform future research investigating factors, such as hydrophobicity (Grosscurt and Tipker 1980, Pest. Biochem. Physiol. 13: 249–254; Minakuchi et al. 2006, Bioorganic Med. Chem. Lett. 16: 4080–484), that cause differences in *M. sexta* ovicidal responses to the neonicotinoids acetamiprid and imidacloprid.