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Imidacloprid Boosts TSSM Egg Production

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In the July 2001 issue of ***Agrichemical and Environmental News*** (***AENews*** No. 183), we reported the possibility of imidacloprid acting as a "fertility drug" for twospotted spider mite (TSSM). We now present a full report on this research, which was conducted during the last twelve months at Washington State University's Irrigated Agriculture Research and Extension Center (WSU-IAREC) in Prosser.

Background to Our Study

Imidacloprid, the first chloronicotinyl or neonicotinoid insecticide, was introduced in the early 1990s and is now widely used throughout the world for management of many pests on a host of diverse crops (see Allan Felsot's analysis of this insecticide as a candidate for reduced-risk status in the October 2001 issue of ***AENews,*** No. 186). This versatile, broad-spectrum, systemic compound exhibits activity against sucking insects (e.g. aphids, whiteflies, leafhoppers) and several species of beetles, flies, and moths, but is not toxic to plant-feeding mites (3, 4).

Imidacloprid has a mixed reputation regarding its safety to natural enemies of pests. It has low toxicity to spiders, some predatory beetles, and some predatory bugs (5, 6, 8, 13). However, other studies showed it to be highly toxic to other species within most of these same insect families (1, 9, 16, 19, 20). Similarly, some predatory mite species are tolerant of imidacloprid while others are susceptible (8, 9, 12, 16).

Australian predatory mite

Recently, increased egg production and population development was reported for the Australian predatory mite, ***Amblyseius victoriensis*** at sublethal doses of imidacloprid (8). The phenomenon of reproductive stimulation of pests (or beneficials) by sublethal doses of insecticides is known as ***hormoligosis*** (15). Examples include residues of azinphosmethyl increasing the fecundity of green peach aphids (14), citrus thrips producing more eggs on leaves containing residues of dicofol and malathion (17), and TSSM increasing egg production when exposed to carbaryl or DDT (2).

TSSM is the most important mite pest of horticultural and field crops worldwide and is exposed to imidacloprid in many crop systems, particularly those that have aphids or whiteflies as principal pests. One example is hop production in Washington where hop aphid (HA) and TSSM are the major pests. Imidacloprid is routinely used to control HA in late spring and is harmful to most predators of TSSM (9), contributing to mite outbreaks during summer (11). The usual severity of these outbreaks led us to consider the possibility of hormoligosis as an additional factor stimulating mite population development.

Twospotted spider mite

Study Methodology

We examined the effect of imidacloprid on TSSM egg production in the laboratory by exposing young adult TSSM to sprays of imidacloprid using a Potter Precision Spray Tower. We employed both formulations of imidacloprid (Admire 2 Flowable and Provado1.6 Flowable) and also sprayed a control group with a water-only treatment. After spraying, we placed mites individually on discs cut from bean leaves then placed the leaf discs on wet cotton wool in plastic boxes. We also placed another group of mites that had not been sprayed on leaf discs cut from a bean plant that was watered with Admire (i.e., systemically exposed). All imidacloprid formulations were used at their recommended rate for HA control in hop yards. Mites were stored at 82°F under constant illumination and ten discs were used per treatment in each of three experiments. We examined the leaf discs daily, recording the number of eggs present and removing the eggs until the mites died. Data were analyzed by Student's ***t*** tests or analyses of variance with means separated by Fisher's least significant difference (LSD) procedures (P < 0.05).

Egg Production Increased

Both foliar and systemic applications of imidacloprid resulted in significantly greater TSSM egg production than the water-only control treatment (Table 1). Increased egg production occurred immediately after exposure and lasted for about fifteen days in sprayed mites. In mites on the systemically-treated plants, the increase in egg production did not become apparent until the sixth day and lasted until the eighteenth day (Figure 1).

Mite longevity was not significantly different between those in the foliar spray and water-treatment groups, but females on the systemically-treated were significantly longer-lived (Table 1).

Implications for Hops

This study indicates that spray and systemic application of imidacloprid at rates used in Washington hop yards significantly increase the fecundity of TSSM. Female spider mites exposed to imidacloprid produced thirty to seventy more eggs during their lifetime (one to one and a half more eggs per day) than those not exposed to the insecticide. This represents an increase in fecundity of twenty to fifty percent, which clearly indicates a potential to dramatically increase the rate of population development in TSSM. The massive outbreaks of TSSM frequently seen on hops in Washington may be a consequence of imidacloprid stimulation of mite reproduction combined with suppression of natural enemies (9).

Greater Impact with Systemics?

The use of imidacloprid in hops systemically applied via drip irrigation systems is currently advocated in Washington because of presumed reduced risks to beneficial arthropods. However, the results from this study indicate that stimulation of mite fecundity is not lessened by this application method. In fact, systemic application may potentially have a greater impact because of imidacloprid's stability in the soil (4), demonstrated multi-year carryover in hop plants (21), and consequent season-long exposure to feeding mites. In contrast, residues from foliar-applied imidacloprid degrade within a few days (18). Given these facts, we also looked briefly at whether application of imidacloprid to TSSM eggs followed by those eggs' development on the treated leaves resulted in increased fecundity in resulting females. We saw no effect, supporting the idea that the residues of this insecticide are short-lived.

Fertile Ground for Future Research

A number of questions remain in the wake of this study.

- Is the fecundity response dose-dependent? The effect of different rates of this insecticide should be studied.
- Would other neonicotinoids have the same fecundity-stimulating effect? Imidicloprid is only one representative from this expanding class of insecticides.
- Does imidacloprid affect all mite species (pest and beneficial) in this manner? The range of mite species present in numerous affected crop systems should also be considered.

The imidacloprid-enhanced reproductive potential of ***A. victoriensis*** in Australian stone fruit orchards (8) may be counterbalanced to some extent by increased reproduction of TSSM, the target mite pest in that crop system. The major predatory mite species (***Galendromus occidentalis***, ***Neoseiulus fallacis***) important in hop mite management in Washington are both eliminated by foliar applications of imidacloprid at the recommended rate (9). However, one quarter of the rate is still effective against HA and does allow some survival of both predator species (7). Field evidence suggests that this rate may stimulate population development of ***G. occidentalis*** (10). If confirmed, this would open the possibility of using a reduced rate of imidacloprid to counterbalance the stimulatory effect on TSSM by stimulating its predator.

The stimulation of fecundity in TSSM by imidacloprid has great significance and importance to many crop protection and integrated pest management (IPM) programs throughout the world. The range of complex interactions between imidacloprid and mites, both pest and beneficial, requires further study, but useful application is imminent.

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Table 1

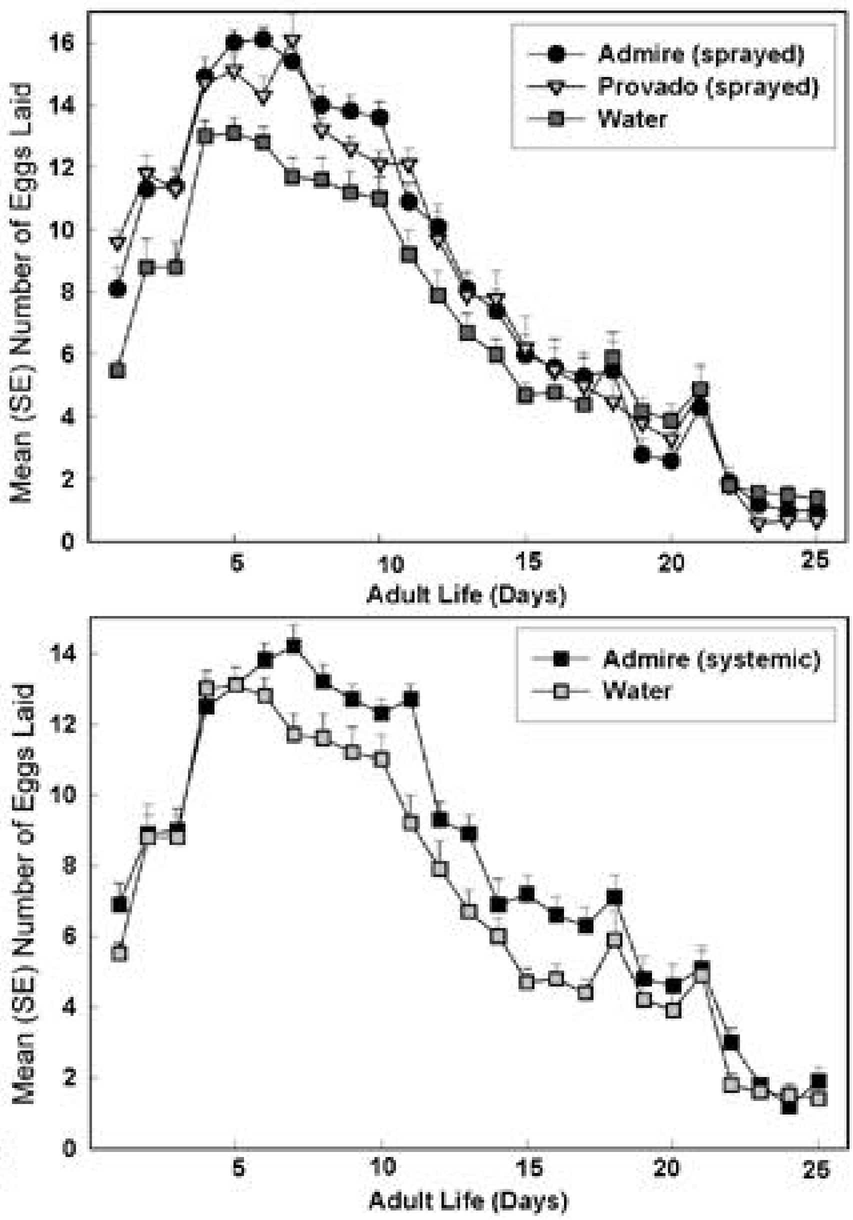
Effect of spray and systemically applied imidacloprid (0.013% a i. Admire™ 2 Flowable, 0.011% a.i. Provado™ 1.6 Flowable) on daily and lifetime egg production and longevity in twospotted spider mite compared to water only treatments.

	Mean (±SE) Egg Production		Mean (±SE) Longevity (d)
Treatment	Daily	Lifetime	
Admire™ (spray)	8.4 (0.4)a	204.9 (7.7)a	24.9 (1.0)a
Admire™ (systemic)	7.6 (0.2)a	205.5 (5.1)a	26.9 (0.5)a
Provado™ (spray)	8.6 (0.4)a	198.1 (9.3)a	23.4 (1.1)b
Water	7.1 (0.2)b	167.5 (6.6)b	24.0 (1.1)b

Means followed by different letters are significantly different (P < 0.05, LSD, Anova).

Figure 1

Effect of sprayed and systemic applications of imidacloprid on daily egg production of twospotted spider mite. Error bars represent standard error of the mean, 95% CL.



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