Effects of methoxyfenozide on the development, survival, and reproduction of the beet armyworm, *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae)

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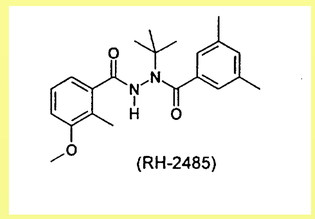
INTRODUCTION

Fifth instar *S. exigua*

Beet armyworm, *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae), a cosmopolitan pest and is an important pest of vegetable crops (CAB International 2000). Methoxyfenozide (MET) –an ecdysone agonist that represents a new group of insect growth regulators- which is a biorational insecticide potentially potent against larval Lepidoptera (Smagghe et al. 2003). Here we report the results of experiments that were performed to determine the susceptibility of third instars *S. exigua* to MET and the associated sublethal effects in surviving individuals when third instars were reared on methoxyfenozide-treated diet until pupation.



Methoxyfenozide molecular structure

MATERIALS AND METHODS

1) Larval toxicity bioassays

- *S. exigua* third instars: fed artificial diet containing 0.001-0.1 mg active ingredient [AI]/kg diet of the formulation Intrepid® (DowAgrosciences).
- Groups of 12 larvae into 2.5 cm^2 cylindrical wells containing ~1 cm^3 of diet.
- Untreated diet was provided to control individuals.
- Larval mortality was scored at 24-h intervals for pupation.
- The assays were performed four times.

2) Sublethal effects

- *S. exigua* third instars: fed artificial diet containing 0.018 mg AI/kg diet of MET (CL_{25}). Experimental conditions were identical to those of the toxicity bioassay .
- 49 and 15 replicates (12 larvae per replicate) for insecticide treatment and the control, respectively.
- Pupae were weighed and sexed three days after pupation.

2) Sublethal effects. Larval exposure to a sublethal concentration of MET resulted in a significant reduction in pupal weight compared to untreated larvae in both male and female insects (Fig. 1). The sex ratio was not significantly different between treated and control insects (data no showed).

The durations of larval and pupal development in insects that survived MET treatment were significantly increased compared with the control (Table 2).

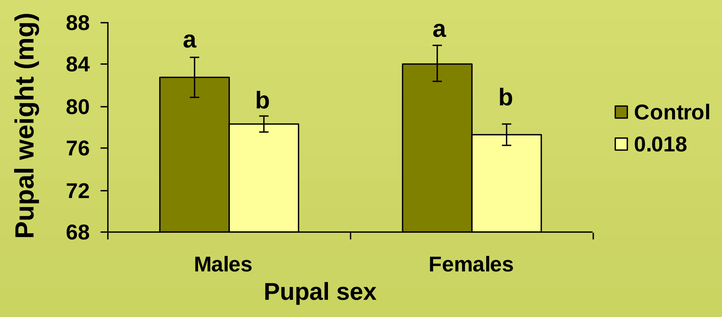


Figure 1. Effects of MET (0.08 AI/kg diet) on pupal weight (mg) ± SE of *S. exigua* (Student *t*-test, *P* > 0.05).

3) Effects on reproduction. The number of eggs laid by MET-treated insects (608.91 ± 25.52) was not significantly different compared with the control (532.57 ± 31.67) (t = 1.71, d.f. = 59, P = 0.09). Howerver, the percentage of eggs that hatched in the insecticide treatment (92.25 ± 1.36) was significantly reduced compared with the control (98.12 ± 0.71) (t = 4.81, d.f. = 47, $P < 0.001$).

Table 2. Effects of MET on larval and pupal development times of *S. exigua* exposed as third instar until pupation to an LC_{25} concentration through diet incorporation.

	Duration of larval stage (d ± SE) (N)		Duration of pupal stage (d ± SE) (N)	
Concentration (AI/kg diet)	Male	Female	Male	Female
Control	15.9 ± 0.4a (68)	15.5 ± 0.2a (82)	11.2 ± 0.1a (64)	10.1 ± 0.1a (81)
0.018	17.7 ± 0.2b (252)	17.5 ± 0.3b (168)	12.0 ± 0.1b (224)	10.8 ± 0.1b (150)

Within the same column, values followed by the same letter are not significantly different from each other (Mann-Whitney U, *P* > 0.05).

3) Effects on reproduction

- In total, 40 and 30 pairs of adults (< 24 h old) resulting from larvae that had been exposed to the insecticide and control were used, respectively.
- The total number of eggs laid by each female were recorded.
- % of eggs that hatched from those collected at 6 d after the first oviposition.

RESULTS

1) Larval toxicity bioassays. At 264 h post-treatment, the estimated LC_{50} value was 0.23 mg AI/kg diet (range of 95% C.I.: 0.17–0.37) (n = 5, b = 1.83 ± 0.35; a = 1.18 ± 0.33; χ^2 = 1.47).

Larval and pupal mortality. Third instars had significantly higher mortality compared with those in the control when examined until pupation (Table 1). Similarly, pupae from larvae treated with the insecticide had significantly higher mortality than untreated larvae (Table 1).

Table 1. Effects of MET on larval and pupal mortality, of *S. exigua* exposed from the third instar until pupation to an LC_{25} concentration through diet incorporation.

Concentration (AI/kg diet)	N	Larvae[a]	Pupae[b]	Total[c]
Control	177	10.88 ± 1.34a	6.05 ± 2.07a	16.95 ± 2.13a
0.018	585	24.35 ± 2.07b	17.79 ± 2.05b	37.66 ± 2.18b

Within the same column, values followed by the same letter are not significantly different from each other ([a]Mann-Whitney U, *P* > 0.05; [b-e]Student *t*-test, *P* > 0.05; [c]$\chi 2$ test).

CONCLUSIONS

- *Spodoptera exigua* larvae fed MET experienced lethal effects, whereas surviving insects suffered a wide range of sublethal effects, including reproductive effects, that have the potential to play a complimentary role in the overall pest control activity of this ecdysone agonist.

Acknowledgements

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