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Background. The carrot weevil is the most destructive pest of carrots and parsley in Ohio and the Great Lakes region of the United States and Canada; yet its management remains an on-going battle. Given that Ohio ranks 3rd in the nation in fresh market production of parsley, losses in crop yield due to this pest (reported at 100% in some fields) are unacceptable and alternative management tools are desperately needed to help combat this pest. There are two novel insecticides on the market that have demonstrated some efficacy against carrot weevil in carrots (in Canada), and against annual bluegrass weevil, a close relative of the carrot weevil, in turf (in the US). These two products respectively are Exirel (active ingredient cyazypvr) and BotaniGard Maxx, a biological pesticide that is a pre-mix of an entomopathogenic fungus (*Beauveria bassiana*) and pyrethrins. Given the promising results from these studies, our goal was to test these two insecticides along with an industry standard (Baythroid XL) for reducing carrot weevil damage to parsley muck soil fields in Ohio. Furthermore, because these insecticides are contact insecticides, we wanted to further evaluate whether efficacy might be influenced by the ability to penetrate the crop canopy. Thus, we incorporated electrostatic sprayer (ESP) technology into our field experiment, which touts the benefits of improving coverage, and reducing pesticide drift and water usage.

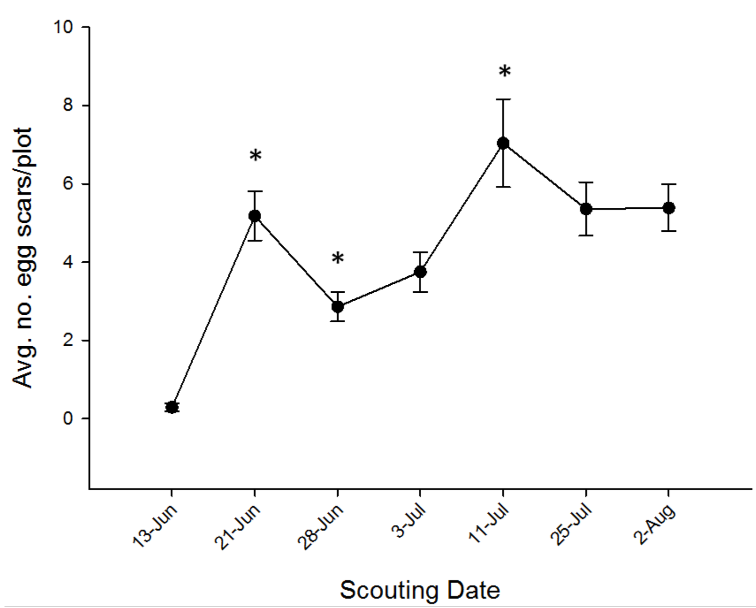
Objective. Evaluate the efficacy of three insecticides (one standard and two novel products) against the carrot weevil in parsley when applied with conventional versus electrostatic sprayer technology.

Methods. A small-plot field trial was conducted at OARDC's Muck Crops Agricultural Research Station in Celeryville, OH. This experiment included seven treatments with four replicates each, following a randomized complete block design. The insecticide treatments included three foliar insecticides (Baythroid XL, Exirel, and BotaniGard Maxx), and an untreated control. Experimental plots were 20 feet x 5 feet long and consisted of parsley beds that were three-rows wide and spaced 18 inches apart. We seeded parsley on May 2, 2018. To evaluate the impact of sprayer technology on insecticide efficacy against carrot weevils, each of the three insecticides were applied using both a conventional CK sprayer at 30 PSI, 36.4 gallons per acre (GPA), and 20" nozzle spacing moving at 2.73 mph, and an electrostatic sprayer at 15 PSI, 11 GPA, and 9" nozzle spacing moving at 2.44 mph.

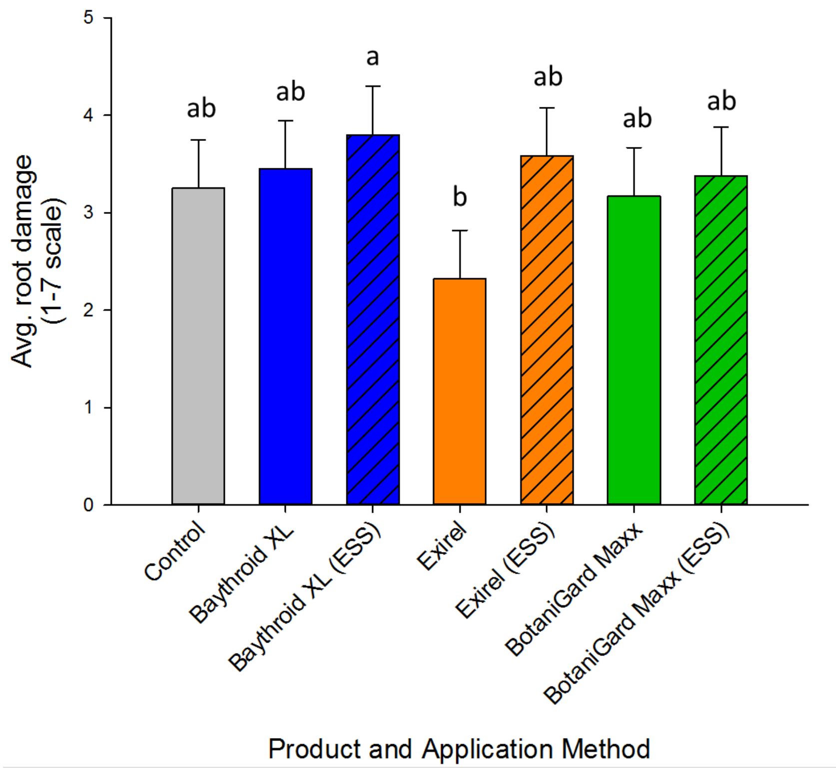
Beginning June 13, 2018, we conducted weekly scouting for carrot weevil egg-laying scars by randomly selecting 20 plants in each plot and recording the presence and number of scars present. Our final scouting for egg-laying scars occurred August 2, 2018. We evaluated insecticide treatment effects on the severity of root damage (tunneling) on 20 parsley plants per plot, pulled on July 19, 2018. We rated roots using a 1 – 7 scale where "1" indicates tunneling damage 1 cm below the root crown (least amount of damage) and "7" indicates tunneling damage 7 cm below the root crown (most severe level of damage). Finally, we estimated parsley yields on August 8, 2018 by harvesting three, one-meter lengths of row in each plot and recording the fresh weight of the foliage.

We made four insecticide applications at 7-10 day intervals, beginning June 18, 2018 and ending July 9, 2018. We evaluated Baythroid XL at the rate of 2.8 fluid ounces per acre, Exirel at 15 fluid ounces per acre (following label instructions to include an adjuvant, LI-700, at 0.25% volume/volume), and BotaniGard Maxx at 27.5 fluid ounces per acre. We tested the same rates for both conventional and electrostatic sprayer technology. We analyzed carrot weevil egg scar data using repeated measures analysis of variance (ANOVA) to determine if differences existed in the number of egg scars found among treatments over time. Parsley yield and root damage data were analyzed using ANOVA and mean comparisons by least significant difference (LSD) to determine if differences existed in the fresh weights and severity of root damage among treatments at the end of the experiment. All analyses were carried out in SAS version 9.3.

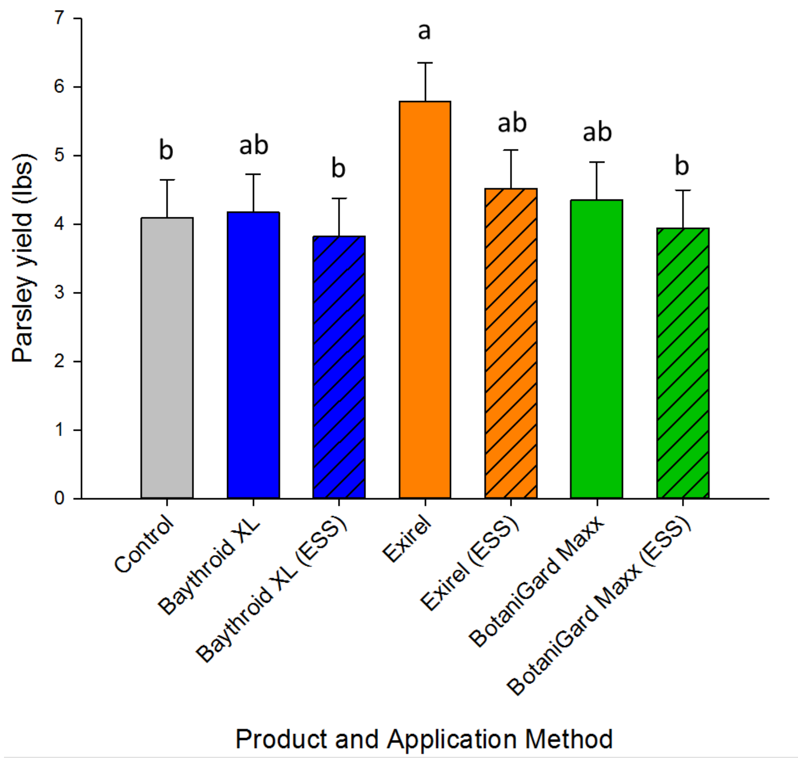
Results. ***Presence and number of egg scars on parsley.*** There was no effect of insecticide treatment on the number of egg scars observed over time. Rather, scouting date had a significant effect on the number of egg scars observed over the 7-week scouting period ($F_{6,27} = 40.28$, $P < 0.0001$). We observed the lowest number of egg scars early in the season, likely due to small plant size, which are not preferred by carrot weevils for egg laying. As the season progressed, there appeared to be two waves of egg-laying activity – the first occurring June 21st, followed by a significant drop in the average number of egg scars on plants, then growing steadily again until the second significant peak occurred on July 11th. Interestingly, there was no difference in the average number of egg scars observed on the two peak dates of egg-laying activity, even though they occurred roughly 3 weeks apart.



Root damage. Overall, there was no significant difference in the severity of parsley root damage across treatments ($F_{6,21}$= 0.89, P = 0.52). On average, all parsley roots exhibited tunneling damage roughly 3 cm below the crown. However, there was a trend for less severe root damage in parsley plots treated with Exirel using a conventional sprayer. In particular, parsley plots sprayed with Exirel using a conventional sprayer exhibited less severe root damage than plots treated with Baythroid XL using an electrostatic sprayer (ESS) (t = 2.09, P =0.04). In addition, there was a trend that plots treated with Exirel using a conventional sprayer had less root damage than plots treated with the same chemical using an electrostatic sprayer (t = -1.78, P = 0.08).



Parsley yield. There were no significant differences in parsley yield across treatments at the end of the experiment ($F_{6,21}$ = 1.42, P= 0.25). However, there was a trend whereby parsley plots treated with Exirel using the conventional sprayer exhibited the highest yield. For example, parsley yields were higher in plots sprayed with Exirel using the conventional sprayer as compared to: (1) untreated control plots (t = -2.16, P =0.04), (2) Baythroid XL-treated plots sprayed with the electrostatic sprayer (t = -2.50, P = 0.02), or (3) BotaniGard Maxx-treated plots, particularly when treated using the electrostatic sprayer (t = 2.35, P = 0.02).



Discussion. Carrot weevil egg-laying behavior increased during the season and hit peak levels on July 11, 2018. Although no single insecticide product stood out as having the highest efficacy, results from this experiment suggest that Exirel has potential as a crop protectant against the carrot weevil, particularly when applied using an adjuvant and conventional sprayer. For example, there was a general trend that plots treated with Exirel exhibited the highest yields and lowest levels of root damage. However, it is important to note that only four insecticide applications of the same products were made in this experiment at 7-10 day intervals. Therefore, we cannot rule out the possibility that these products and/or spray technology may yield stronger results when other active ingredients with different modes of action are incorporated and rotated into a spray program for the carrot weevil.

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