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Arizona Department of Agriculture

AILRC Grants Program – Final Report for 2020

Project 20-02

Project title: **Impact of Antimicrobial Water Sanitizers on Insecticide Performance in Desert Lettuce**

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Location of Research: Yuma Valley Agricultural Center

Objectives: 1) measure the effect of antimicrobial water sanitizers on the acidification of spray solutions when used with commonly applied insecticides and;

2) determine whether the addition of sanitizers with common insecticide spray treatments effected their efficacy against beet armyworm, cabbage looper, diamondback moth, western flower thrips and green peach aphids.

Food safety issues have become increasingly important in the production of leafy vegetables in the desert. Recent concerns about microbial contamination of produce grown in the desert prompted the Arizona Leafy Greens Marketing Agreement (AZLGMA) to develop new Food Safety Guidelines for lettuce and leafy greens (1). Among the best practices recommended by the AZLMGA are guidelines focused on the sanitation of non-potable (Type B) water used for pesticide spray applications.

The guidelines specifically mandate that non-potable water (i.e., taken from canals, ditches, reservoirs) to be used for pesticide applications within 21 days of harvest must be treated with an anti-microbial sanitizer product with efficacy against *E. coli* and other coliform bacteria. Although the AZLGMA does not recommend a specific sanitizer, local growers have been using peroxyacetic acid (PAA) and sodium hypochlorite (NaClO) at low concentrations for this purpose. Last summer, growers and PCAs began questioning whether the use of these sanitizers in combination with commonly used insecticides would affect performance against key insect pests. To address these concerns, several field and lab studies were conducted to: 1) measure the effect of sanitizers on the acidification of spray solutions when used with commonly applied insecticides and 2) determine whether the addition of sanitizers to common insecticide spray treatments effected their efficacy against beet armyworm, cabbage looper, diamondback moth, western flower thrips and green peach aphids.

Methodology

I. Effect of PAA and NaClO on the Acidification of Insecticide Spray Solutions

Measurement of acidity of spray solutions associated with use of sanitizers was conducted in the laboratory at the Yuma Ag Center. Two water sources were used. Potable, Type A water was obtained from a residence in the city of Yuma, and non-potable, Type B water was obtained from the West Main Canal in the Yuma Valley. The most commonly applied insecticides used in lettuce were

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chosen for testing with the PAA products (Jet-Ag, Oxidate 2.0), and five common products were added to sodium hypochlorite (NaClO) (2). Sanitizer concentrations were based on label rates or shipper/grower recommendations for each product. Insecticide concentrations were based on standard applications rates.

Insecticides and sanitizers were placed in 1900 ml of water contained in 3-liter plastic bottles at a concentration equal to a 20 gal/acre spray mixture. First, three separate measurements of pH from each bottle were taken before addition of insecticides and sanitizers. Then, Jet-Ag at 30 ppm, Oxidate 2.0 at 22 ppm or Enviro Chlor at 3 ppm were added to bottles, shaken and allowed to sit for 5 min after which pH measurements for each bottle were taken. After 5 additional minutes, an insecticide and the adjuvant Dyne-Amic at 0.25% vol/vol was added to each bottle, shaken and pH measured 5 minutes later. Measurements of pH were taken at 1, 3, 6 and 24 hr intervals thereafter. The pH of each sanitizer* insecticide combination was measured with a handheld pH meter (pHTestr®20, Eutech, Highland Park, NJ). The pH meter was calibrated using a stock 4.0 and 7.0 pH solution prior to each measurement.

II. Effect of PAA and NaClO on Insecticide Efficacy

Lepidopterous Larvae - Field trials In the fall beet armyworm (BAW) and cabbage looper (CL) trials, head lettuce 'PYB7101A' was direct seeded on 5 Sep, 2019 at the Yuma Valley Agricultural Center (YAC), Yuma, AZ into double row beds on 42 inch centers. The spring diamondback moth (DBM) and CL trial was planted to cabbage 'Primo Vantage' on Jan 14, 2020. Stand establishment was achieved using overhead sprinkler irrigation, with furrow irrigation used thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Rates for each treatment are provided in the Tables 1-5. Sanitizers were applied at the following concentrations: Oxidate 5.0 at 22 ppm, Jet-Ag at 30 ppm, and Enviro Chlor at 3 ppm as per grower/PCA recommendations.

Foliar applications were made with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 50 psi and 21.5 GPA. In the Entrust and Entrust+Oxidate trial (Fig 1), two applications were made on 27 Sep and 13 Oct. In the other lettuce trials (Fig 2-5), a single application was applied to the Radiant and Proclaim+Bifenture treatments on 1 Oct; and in a third trial, a single application was applied to the Intrepid+Sniper and Coragen treatments on 15 Oct. In the spring cabbage trial (Fig 6), two applications were made on 10 and 28 Mar. Dyne-Amic was applied to each treatment at 0.25% v/v.

BAW, CL and DBM control was based on the examination of 5-10 whole plant at various intervals following each application (DAA). The presence of large (2^{nd} or > instar) larvae was recorded from each plant. Because of heterogeneity of mean variances, insect data were transformed using a log10 (x-1) function before analysis. All data were subjected to ANOVA; means were compared using Turkey's HSD test (P=0.05). Means from non-transformed data are presented in the tables.

Lepidopterous Larvae - Lab bioassays Mortality of beet armyworm and diamondback larvae exposed to several insecticide*sanitizer combinations were determined using a leaf-dip Petri dish technique adapted from an approved Insecticide Resistance Management Committee (IRAC) method (3). Larvae used in the assays were collected from laboratory colonies established from BAW and DBM collected from untreated plots at the Yuma Ag Center in November 2019 and reared on artificial diet for one generation prior to the bioassay. Spray concentrations (20 gpa) and rates for the insecticide*sanitizer combinations used in the bioassays were the same as those used for pH measurements.

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Whole leaves (8–9 cm in diameter) were detached from cabbage plants, dipped individually in each insecticide*sanitizer combination for 15 s with gentle agitation, and placed on paper toweling, where they were allowed to dry for 1 h. Control leaves were dipped individually in water alone. The treated leaves were placed on wetted filter paper within 90-mm Petri dishes. Six replicates of each insecticide (n=5 larvae/replicate; total n=30 larvae) were assayed. Mortality was assessed by counting the number of dead larvae (unresponsive to touch) at 96 or 144 hr following placement of the larvae onto the treated foliage. Feeding was also measured by estimating the total area of each leaf disk consumed after 96 or 144 hr. Analysis of variance was performed to compare the differences among insecticide treatments. The response variable (percentage mortality and feeding) was subjected to arcsine square root transformation before analysis. Means were compared using Turkey's HSD test ($P \leq 0.05$). Mean percentages from non-transformed data are presented in the figures.

Western Flower Thrips. Two trials were conducted to in the spring 2020. The first trial was planted to lettuce' Salute MI' on 5 Dec. 2019 and the second to 'Valley Heart' on Jan 24, 2020 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42-inch centers. Stand establishment was achieved using overhead sprinkler irrigation and furrow irrigated thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Radiant, 7 oz/ac and Lannate 0.8 lb/ac were compared with and without sanitizers in both trials. Two foliar sprays were applied on 4 and 20 Feb in the first trial; 17 Mar and 2 Apr in the second. The applications were made with a CO_2 pressurized boom sprayer that delivered a broadcast application at 50 psi and 21.5 gpa through 2 TXVS-18 ConeJet nozzles per bed. Dyne-Amic was applied to each spray treatment at 0.25% v/v. Numbers of western flower thrips (WFT) from 5 plants per replicate were recorded at various sample dates following each application (DAA). Relative thrips numbers were measured by removing plants and beating them vigorously against a screened pan (12-inch x 7-inch x 2-inch) for a predetermined time (10 s). A 6-inch by 6-inch sticky card was placed inside of the pan to catch the dislodged WFT. Sticky cards were then taken to the laboratory where adult and larvae were counted. Because of heterogeneity of mean variances, WFT data were transformed using a $\log_{10}$ (x + 1) function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the tables.

Green Peach Aphids For the aphid trial, cabbage 'Primo Vantage' was direct seeded on Jan 14, 2020at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42-inch centers. Stand establishment was achieved using overhead sprinkler irrigation, with furrow irrigation used thereafter. Plots were two beds wide by 45 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a RCB design. Sequoia at 2.0 oz/ac and Movento at 5.0 oz/ac were compared with and without Oxidate 5.0 (22 ppm) in this trial. Two foliar applications were made on 10 and 28 Mar with a CO_2 operated sprayer that delivered a broadcast application through 2 TXVS-18 ConeJet nozzles per bed at 50 psi and 21.5 GPA. Dyne-Amic was applied to each spray treatment at 0.25% v/v.

Green peach aphid (GPA) populations were assessed by estimating the number of aphids / plants in whole plant, destructive samples. On each sampling date, 6 plants were randomly selected from each plot and placed individually into large 5-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of apterous (non-winged) aphids present. Because of heterogeneity of mean variances, data were transformed using a $\log_{10}$ (x + 1) function before analysis and subjected to ANOVA; means were compared using Turkey's HSD test ($P \leq 0.05$). Means from non-transformed data are presented in the table.

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Results

I. Acidification of Insecticide Spray Solutions

In measuring acidity in Municipal (Type A) water, the initial pH readings of the water prior to addition of PAA and insecticides varied from 7.5-7.9 pH **(Table 1-2)**. Following the addition of Jet-Ag at 30 ppm, pH measured from 6.5 to 6.8, depending on insecticide mixture. For Oxidate 2.0 at 22 ppm, it dropped all insecticide solutions to a pH of 6.4. Very little change in acidity occurred with both sanitizers after 24 hr. The largest change in acidity was for Lannate and Movento, but both remained above pH 6 **(Table 1-2)**.

In canal (Type B) water, acidity varied between 7.8 and 8.1 pH prior to addition of sanitizer and insecticide **(Table 3-4)**. Following addition of Jet-Ag, acidity was consistently measured at pH values of 6.6 to 6.7. There were only subtle changes after the addition of insecticides. The lowest pH after 24 hrs included Lannate (6.3), Sivanto (6.3) and Movento (6.2) **(Table 3)**. Following the addition of Oxidate 2.0, pH values dropped to 6.5-6.6, and after 24 hrs, and the acidity for most compounds stayed relatively the same. The exceptions were Movento which changed from a pH of 8.0 to 5.9, and Lannate, 8.1 to 5.8. **(Table 4)**.

Canal (Type B) water used in the NaClO tests was highly alkaline, measuring 8.3-8.4 pH before addition of sanitizers. Addition of NaClO and insecticide solutions did not acidify the final spray solution over a 6 hr period. **(Table 5)**.

The acidity of the final spray solution can be important for many insecticide products. The motivation for measuring pH was based on past experiences with the impact of low acidity on the spinosyn chemistry (Entrust, Success, Radiant). In 2000-2002, we conducted field and lab studies to evaluate the knockdown and residual mortality of Success/Entrust against BAW and CL when applied in an acidic spray solution. Results showed that knockdown mortality was not affected, but residual efficacy was significantly reduced when Success/Entrusts was applied using acidic (<pH 5.0) spray solutions (4). This occurred when low acid conditions fractured the formulation exposing the active ingredient to UV degradation. Current Entrust and Radiant labels require the pH of spray solutions be maintained between 6 and 9 to achieve maximum performance. Results of our measurements show that maintaining acidity above pH levels that would be antagonistic for Radiant and Entrust spray solutions (~pH of 4-5) should not be a problem when PAA and NaClO are applied at concentrations used in these studies.

Finally, it does not appear that the PAA concentrations used in spray solutions changed after the addition of the insecticides. This was confirmed by estimating PAA concentrations in several sanitizer*insecticide mixtures using PAA test strips (Insta-Test Analytic Peracetic Acid Low Range Test Strips, LaMotte Co., Chestertown, MD). The PAA concentration of these mixtures did not drop below 30 ppm after 24 hrs (data not shown). We did not measure NaClO levels in sanitizer*insecticide mixtures.

II. <u>Impact on Insecticide Efficacy</u>

In our first fall lettuce field trial, the addition of Oxidate 5.0 with Entrust did not affect the residual efficacy of the insecticide against BAW and CL at 7 or 14 days following each application (**Fig. 1)**. In the spring cabbage trial, the addition of Oxidate 5.0 did not affect the residual efficacy of Radiant against DBM or CL at 7 or 14 days following each application **(Fig 6a and 6b)**. This was expected since the pH of the spray mixtures was between pH 6.0 – 6.4 for all applications and should not have negatively impacted the Entrust or Radiant formulations. In additional fall lettuce trials, spray

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mixtures of NaClO, Jet-Ag and Oxidate 5.0 did not significantly affect the efficacy of five key insecticides against BAW and CL **(Fig 2-5).** This included the single product sprays with Radiant and Coragen, as well as tank-mixtures of Intrepid or Proclaim with Bifenture.

We conducted several lab bioassays in order to determine if any of the sanitizers had an impact on the microbial insecticides Xentari and Venerate. Results clearly showed that BAW larval mortality for Xentari (a gram-positive bacteria) was not impacted by the addition of PAA and NaClO **(Fig 7 and 9),** while Venerate (a proteobacteria) was not effective against BAW at 2 qts/ac rate (**Fig 8).** All other conventional insecticides bioasayed for BAW mortality were not impacted by the addition of the sanitizers **(Fig 9-12).** Similarly, DBM mortality for Xentari and Entrust was not impacted by the addition of PAA and NaClO **(Fig 14 and 15**) and highlights the knockdown activity of Xentari against DBM. Oxidate 5.0 and NaClO applied solely with water, were not toxic to either BAW or DBM larvae in these bioassays. **(Fig 13 and 16).**

The impact of sanitizers on insecticide efficacy against WFT were tested in two field trials in the spring. In the both WFT trials, NaClO and Oxidate 5.0 did not significantly affect knockdown or residual control of larvae following 2 applications **(Fig 17-20).** Similar results were observed for adult WFT (data not shown). Again, not surprising since the pH of the spray mixture varied from 6.5-6.7 for Radiant and 6.0-6.2 for Lannate. Finally, a single lettuce trial was conducted to evaluate aphid efficacy with Oxidate 5.0 at 22 ppm +Sequoia at 2 oz/ac and Oxidate 5.0 +Movento at 5 oz/ac combinations. Again, no significant differences in residual control of green peach aphids was observed between the sanitized and non-sanitized spray treatments **(Fig 21).**

Conclusions

The results of this study clearly indicated that the use of PAA and NaClO as water sanitizers in foliar spray mixtures did not affect insecticide efficacy against key insect pests of lettuce. Furthermore, no crop injury or phytotoxicity was observed on lettuce foliage following any of the spray applications. Accordingly, given the fact that no complaints of poor insecticide performance were received last season, growers and PCAs should be confident in following the AZLGMA recommendations to include antimicrobial water sanitizers with their insecticide applications. However, a few questions remain concerning the impact of water sanitizers on pesticide spraying that were not addressed in this study.

First, for the most part only single insecticide products were evaluated in this study. What we don't know is how would pesticide performance be affected when multiple insecticides, fungicides and other foliar spray additives are combined with sanitizers in one tank mixture. Second, although we estimated that PAA concentrations were in the 30-ppm range using visual comparisons of PAA test strips, we did not actually quantify PAA concentrations in the spray solutions. Perhaps more importantly, we did not measure whether the sanitized insecticide spray mixtures would effectively kill colloform bacteria. We assume they will but have no data to support this.

Finally, the PAA products are also labeled as preventative and curative treatments for bacterial and fungal diseases in lettuce, but at much higher concentrations that used for water sanitizing. In some cases, use rates can be 3-fold higher or more for disease control. What we don't know, is do higher PAA concentration drive acidity of spray mixtures lower than pH of 5. If so, growers would be warned not to add insecticides like Entrust, Radiant, or Assail in with these sanitizer mixtures to prevent sub-optimal efficacy. Similarly, how do these products behave when mixed with insecticides during chemigation or irrigation?

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Acknowledgments

This research was funded by the Arizona Iceberg Lettuce Research Council under award AILRC 20-02. The lab and field research reported here would not have been possible without the tireless efforts from Leo Chavez, Javier Ruiz, Gerardo Villegas and Javier Chavez, UA-Yuma Ag Center. Special thanks to Charlie Narramore, Green Valley Farm Supply, Bill Fox, 7Ag Consulting, and Steve Alameda, TopFlavor Farms for their advice, and pointing this project in the right direction.

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Table 1. Effect of Jet-Ag on pH of Municipal Water *(Type A-potable)* and insecticide solutions.

		pH in Municipal Water *(Type A)*						
Insecticide	**Rate/ac**	**Water**	**Water + Jet-Ag**	**Water + Jet-Ag + Insecticide**	**1 hr**	**3 hr**	**6 hr**	**24 hr**
Radiant	5.0 oz	7.8	6.8	6.7	6.8	6.7	6.7	6.5
Sniper	5.0 oz	7.9	6.8	6.7	6.7	6.7	6.7	6.7
Coragen	5.0 oz	7.8	6.6	6.7	6.7	6.8	6.8	6.7
Exirel	13.5 oz	7.8	6.6	6.7	6.7	6.8	6.8	6.7
Intrepid	10.0 oz	7.8	6.7	6.7	6.6	6.7	6.7	6.7
Movento	5.0 oz	7.7	6.7	6.7	6.6	6.5	6.4	6.2
Sequoia	2.0 oz	7.7	6.6	6.7	6.6	6.7	6.7	6.6
Beleaf	2.8 oz	7.8	6.6	6.8	6.8	6.7	6.7	6.4
Sivanto	10.0 oz	7.8	6.6	6.7	6.5	6.5	6.4	6.7
Torac	21.0 oz	7.9	6.6	6.8	6.7	6.7	6.7	6.5
PQZ	3.2 oz	7.7	6.7	6.6	6.7	6.7	6.7	6.5
Versys	1.5 oz	7.7	6.5	6.5	6.6	6.6	6.6	6.5
Lannate	0.75 lb	7.7	6.5	6.4	6.5	6.4	6.5	6.1
Assail	4.0 oz	7.7	6.5	6.6	6.6	6.6	6.6	6.5
Proclaim	4.8 oz	7.7	6.5	6.6	6.6	6.6	6.6	6.5
Entrust SC	5.0 oz	7.7	6.7	6.7	6.7	6.7	6.7	6.4
Jet-Ag	**30 ppm**	7.7	6.6	6.6	6.6	6.7	6.6	6.6
	Temp. (°F)	78.3	79.0	79.3	79.8	80.1	80.2	77.5

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Table 2. Effect of Oxidate 2.0 on pH of Municipal Water *(Type A-potable)* and insecticide solutions.

		pH in Municipal Water *(Type A)*						
Insecticide	**Rate/ac**	**Water**	**Water + Oxidate**	**Water + Oxidate + Insecticide**	**1 hr**	**3 hr**	**6 hr**	**24 hr**
Radiant	5.0 oz	7.6	6.4	6.4	6.4	6.7	6.6	6.6
Sniper	5.0 oz	7.6	6.4	6.4	6.3	6.7	6.7	6.6
Coragen	5.0 oz	7.6	6.4	6.4	6.6	6.7	6.8	6.6
Exirel	13.5 oz	7.7	6.4	6.4	6.6	6.7	6.7	6.6
Intrepid	10.0 oz	7.7	6.4	6.4	6.6	6.7	6.7	6.6
Movento	5.0 oz	7.6	6.4	6.4	6.5	6.5	6.5	6.2
Sequoia	2.0 oz	7.7	6.4	6.4	6.6	6.7	6.8	6.6
Beleaf	2.8 oz	7.7	6.4	6.4	6.6	6.7	6.7	6.5
Sivanto	10.0 oz	7.6	6.4	6.4	6.5	6.5	6.5	6.3
Torac	21.0 oz	7.5	6.4	6.4	6.6	6.7	6.8	6.6
PQZ	3.2 oz	7.5	6.4	6.4	6.6	6.8	6.8	6.6
Versys	1.5 oz	7.5	6.4	6.4	6.6	6.7	6.8	6.6
Lannate	0.75 lb	7.7	6.4	6.3	6.4	6.5	6.5	6.3
Assail	4.0 oz	7.6	6.4	6.4	6.6	6.7	6.7	6.5
Proclaim	4.8 oz	7.7	6.4	6.4	6.6	6.7	6.7	6.6
Entrust SC	5.0 oz	7.7	6.5	6.5	6.4	6.4	6.4	6.4
Oxidate 2.0	**22 ppm**	7.8	6.4	6.4	6.6	6.6	6.8	6.6
	Temp. (°F)	79.2	79.3	80.1	79.2	79.3	80.1	74.0

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Table 3. Effect of Jet-Ag on pH of Canal Water *(Type B, non-potable)* and insecticide solutions.

		pH in Canal Water *(Type B)*						
Insecticide	**Rate/ac**	**Water**	**Water + Jet-Ag**	**Water + Jet-Ag + Insecticide**	**1 hr**	**3 hr**	**6 hr**	**24 hr**
Radiant	5.0 oz	7.8	6.6	6.6	6.6	6.4	6.6	6.5
Sniper	5.0 oz	7.7	6.7	6.6	6.7	6.7	6.8	6.6
Coragen	5.0 oz	7.9	6.6	6.7	6.7	6.7	6.8	6.5
Exirel	13.5 oz	7.9	6.7	6.7	6.7	6.8	6.8	6.6
Intrepid	10.0 oz	8.0	6.7	6.6	6.4	6.8	6.8	6.6
Movento	5.0 oz	8.0	6.7	6.7	6.4	6.5	6.4	6.2
Sequoia	2.0 oz	7.9	6.7	6.7	6.7	6.8	6.7	6.6
Beleaf	2.8 oz	7.8	6.7	6.7	7.1	6.8	6.8	6.7
Sivanto	10.0 oz	7.9	6.7	6.7	6.5	6.5	6.4	6.3
Torac	21.0 oz	7.9	6.7	6.6	6.7	6.7	6.7	6.4
PQZ	3.2 oz	7.9	6.7	6.7	6.5	6.8	6.7	6.3
Versys	1.5 oz	7.9	6.7	6.5	6.7	6.7	6.7	6.6
Lannate	0.75 lb	7.9	6.6	6.4	6.5	6.6	6.4	6.3
Assail	4.0 oz	7.9	6.7	6.6	6.6	6.8	6.7	6.6
Proclaim	4.8 oz	7.9	6.7	6.7	6.7	6.7	6.7	6.5
Entrust SC	5.0 oz	7.9	6.7	6.6	6.6	6.5	6.5	6.5
Jet-Ag	**30 ppm**	7.9	6.7	6.7	6.4	6.8	6.7	6.6
	Temp. (°F).	76.3	76.6	76.5	76.3	76.3	77.5	76.5

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Table 4. Effect of Oxidate 2.0 on pH of Canal Water *(Type B, non-potable)* and insecticide solutions.

		pH in Canal Water *(Type B)*						
Insecticide	**Rate (oz/ac)**	**Water**	**Water + Oxidate**	**Water + Oxidate + Insecticide**	**1 hr**	**3 hr**	**6 hr**	**24 hr**
Radiant	5.0 oz	7.9	6.6	6.5	6.5	6.4	6.4	6.3
Sniper	5.0 oz	7.9	6.6	6.5	6.3	6.4	6.4	6.5
Coragen	5.0 oz	8.0	6.6	6.5	6.5	6.5	6.5	6.5
Exirel	13.5 oz	8.0	6.6	6.5	6.5	6.5	6.5	6.4
Intrepid	10.0 oz	8.0	6.6	6.5	6.5	6.5	6.5	6.5
Movento	5.0 oz	8.0	6.6	6.4	6.3	6.3	6.2	5.9
Sequoia	2.0 oz	8.0	6.6	6.5	6.5	6.5	6.5	6.4
Beleaf	2.8 oz	8.0	6.6	6.5	6.5	6.5	6.5	6.4
Sivanto	10.0 oz	8.0	6.6	6.5	6.4	6.3	6.3	6.2
Torac	21.0 oz	8.0	6.6	6.5	6.5	6.5	6.5	6.5
PQZ	3.2 oz	8.0	6.5	6.5	6.5	6.5	6.5	6.5
Versys	1.5 oz	8.1	6.5	6.5	6.5	6.5	6.5	6.5
Lannate	0.75 lb	8.1	6.5	6.4	6.3	6.3	6.3	5.8
Assail	4.0 oz	8.1	6.5	6.5	6.5	6.5	6.5	6.4
Proclaim	4.8 oz	8.1	6.5	6.5	6.5	6.5	6.5	6.4
Entrust SC	5.0 oz	8.1	6.6	6.5	6.5	6.5	6.4	6.3
Oxidate 2.0	**22 ppm**	8.1	6.5	6.5	6.5	6.5	6.5	6.5
	Temp. (°F)	76.8	77.0	77.0	77.1	76.8	76.8	77.0

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Table 5. Effect Enviro Chlor on pH of Canal Water *(Type B, non-potable)* and insecticide solutions .

	Rate	NaClO in Canal Water *(Type B)*				
		Water	Water + Enviro Chlor	Water + Jet-Ag + Insecticide	1 hr	6 hr
Radiant	5 oz	8.4	8.5	8.3	8.3	8.3
Sniper	5 oz	8.3	8.4	8.3	8.3	8.3
Movento	5 oz	8.4	8.5	8.4	8.3	8.3
Lannate	0.75 lb	8.4	8.5	8.3	8.2	8.2
Entrust SC	5 oz	8.4	8.5	8.4	8.3	8.3
Enviro Chlor	**3 ppm**	8.4	8.5	8.4	8.4	8.4
	Temp. (°F)	75.7	75.8	76.0	76.5	78.3

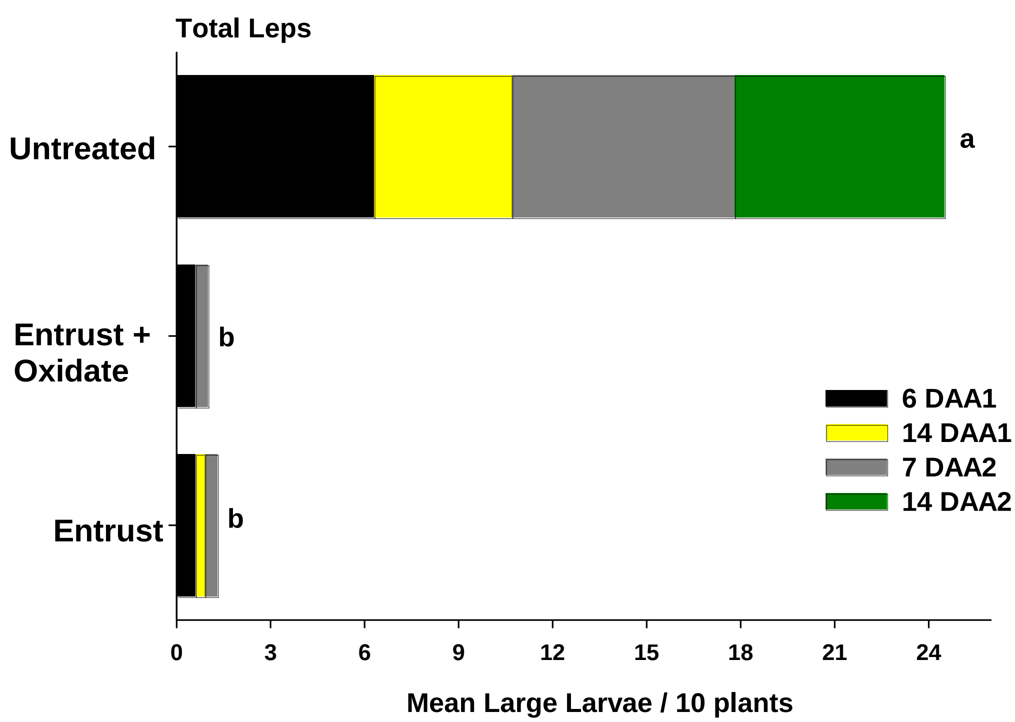

Figure 1. Efficacy of Entrust and Oxidate 5.0 against beet armyworm and cabbage loopers in lettuce, YAC fall 2019

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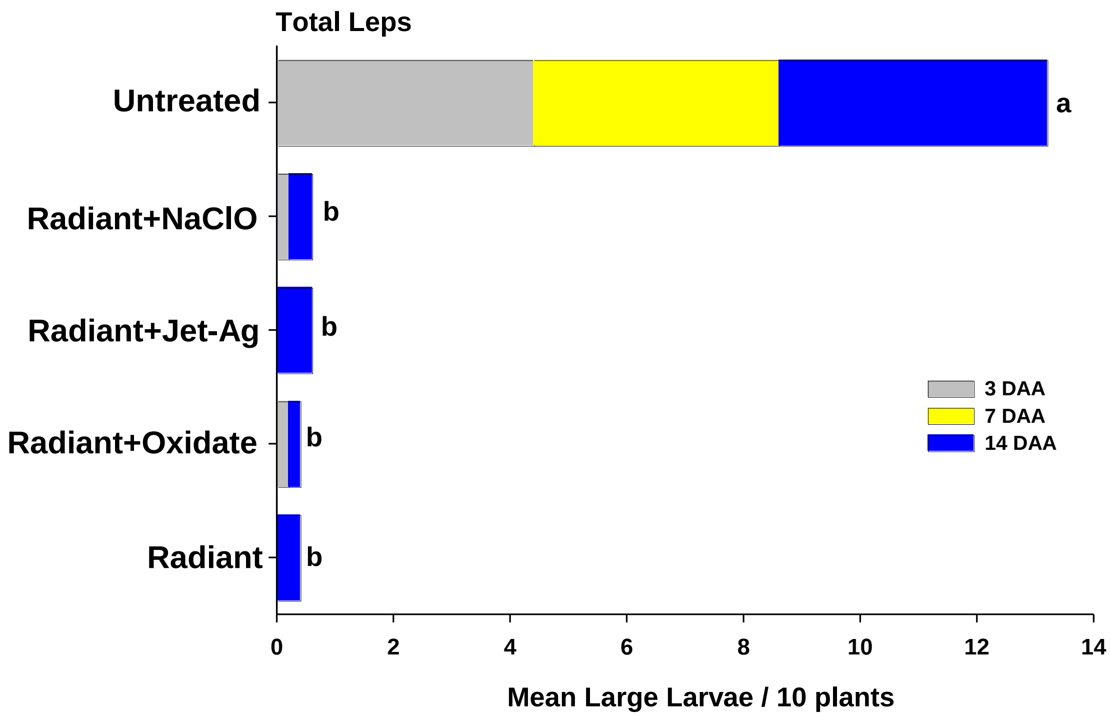

Figure 2. Knockdown and Residual Efficacy of Radiant and sanitizers against beet armyworm in lettuce, YAC fall 2019

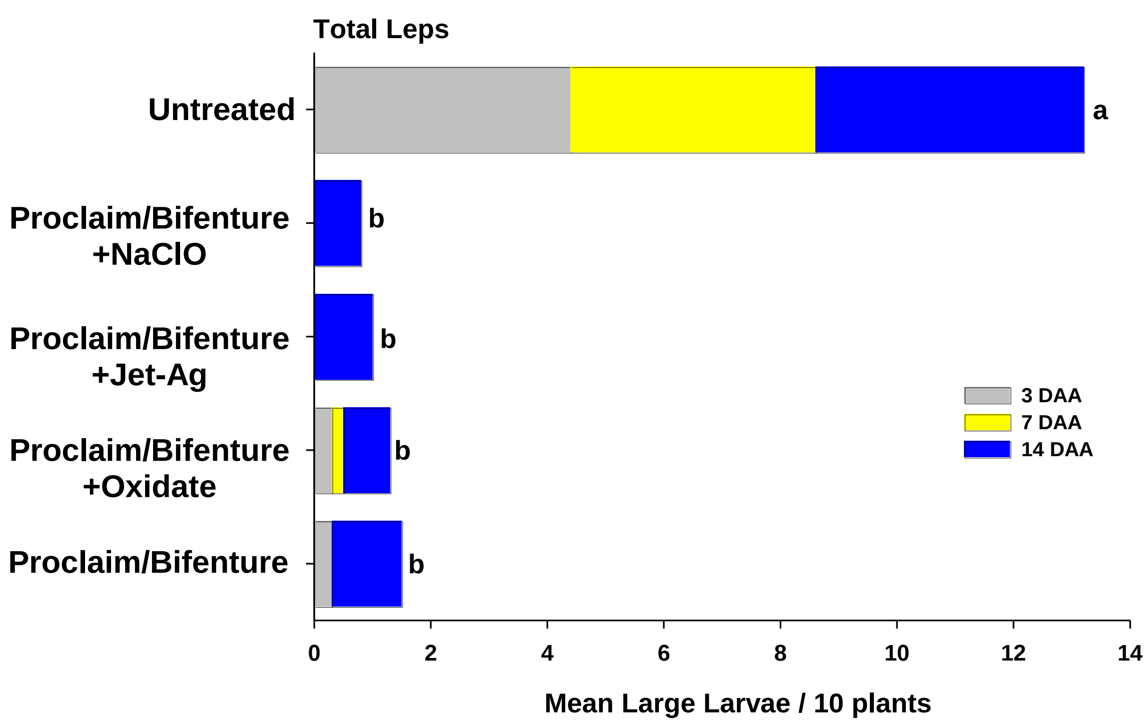

Figure 3. Knockdown and Residual Efficacy of Proclaim+Bifenture and sanitizers against beet armyworm in lettuce, YAC fall 2019

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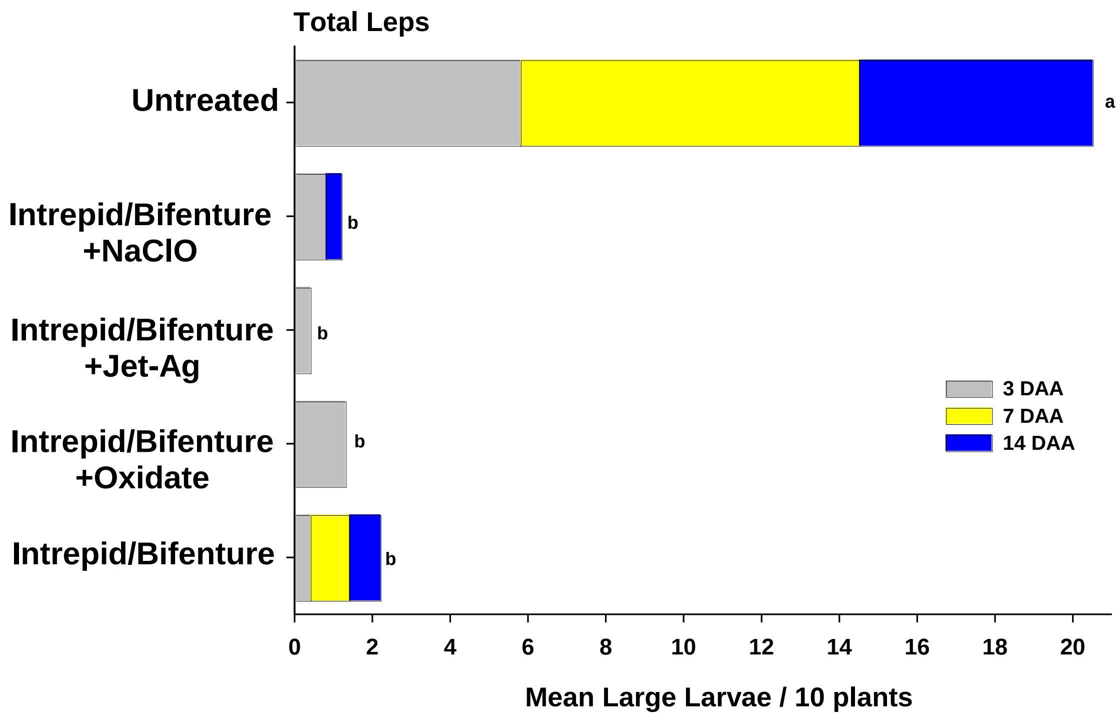

Figure 4. Knockdown and Residual Efficacy of Intrepid+Bifenture and sanitizers against beet armyworm in lettuce, YAC fall 2019.

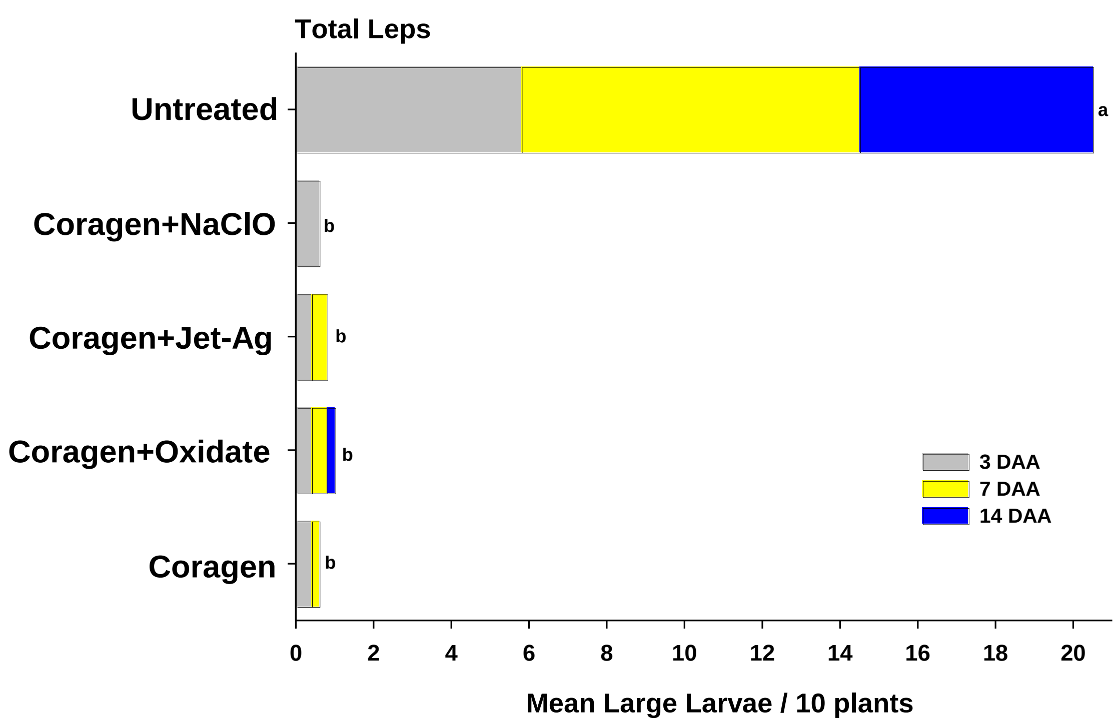

Figure 5. Knockdown and Residual Efficacy of Coragen and sanitizers against beet armyworm in lettuce, YAC fall 2019.

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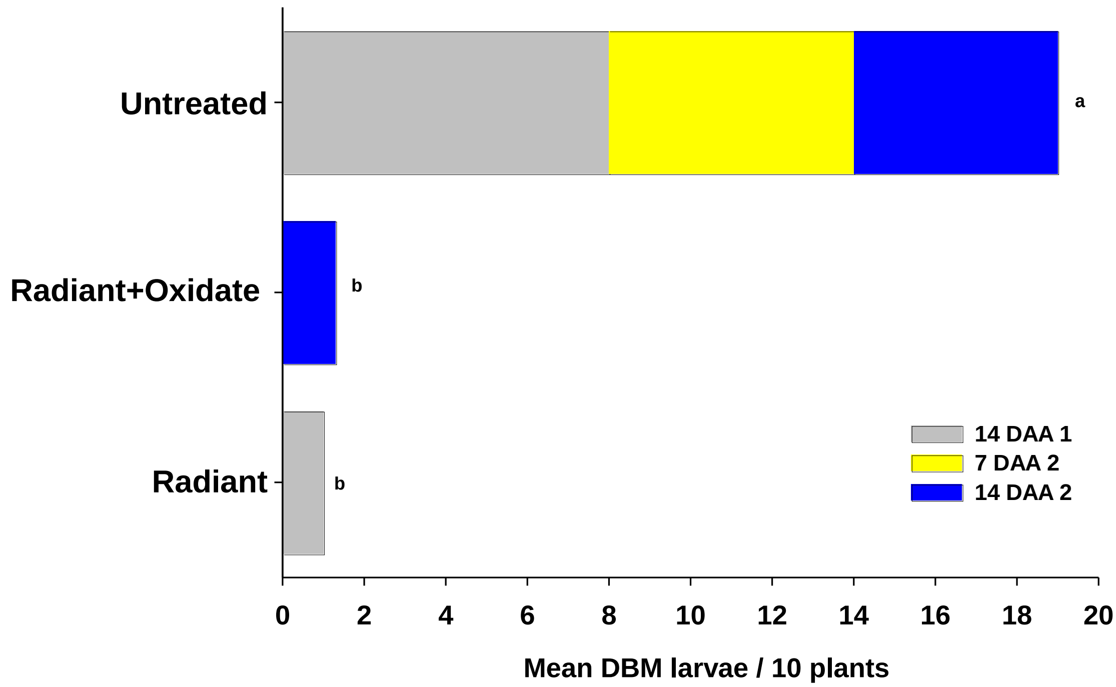

Figure 6a. Efficacy of Radiant and Oxidate 5.0 against diamondback moth in cabbage, YAC spring 2020.

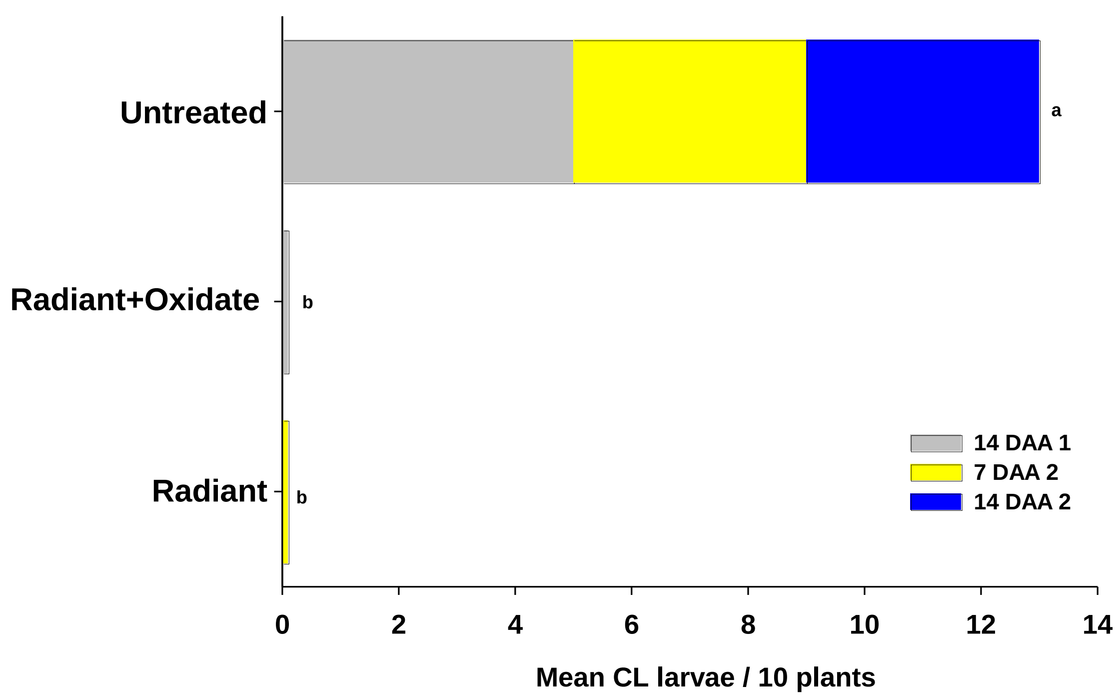

Figure 6b. Efficacy of Radiant and Oxidate 5.0 against cabbage looper larvae in cabbage, YAC spring, 2020.

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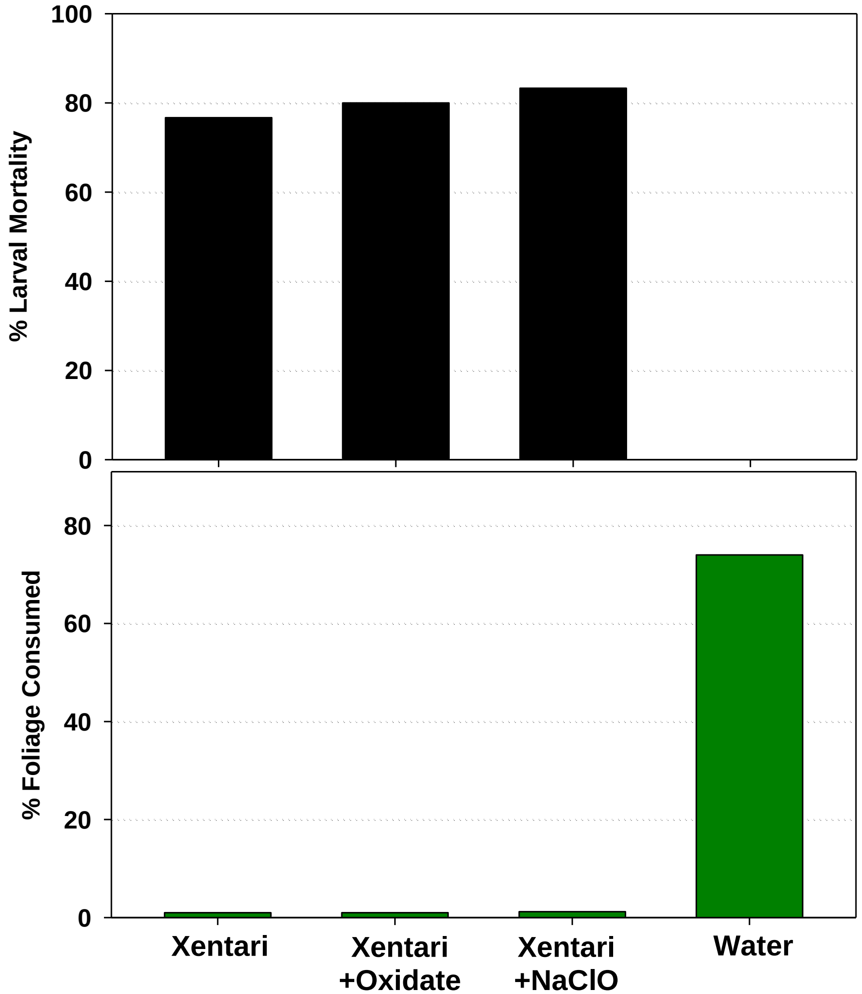

Figure 7. Mortality and Feeding of BAW larvae exposed to Xentari and Sanitizers for 144 hours in a Laboratory Bioassay, 2019

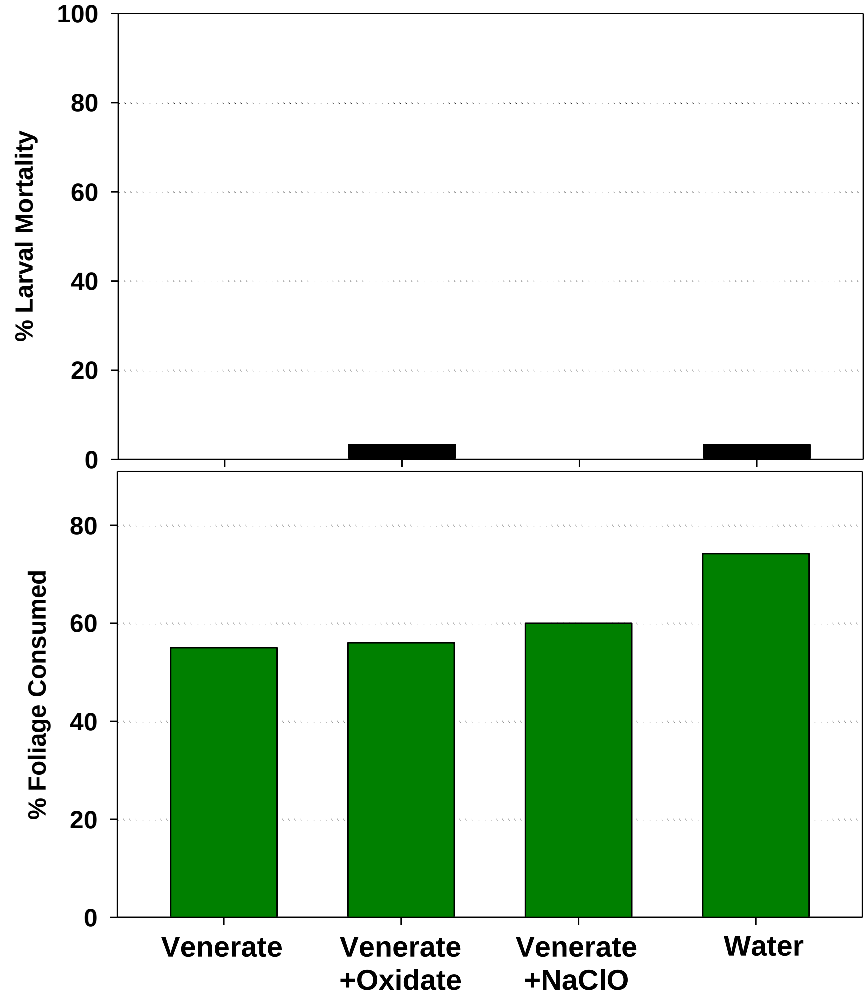

Figure 8. Mortality and Feeding of BAW larvae exposed to Venerate and Sanitizers for 144 hours in a Laboratory Bioassay, 2019

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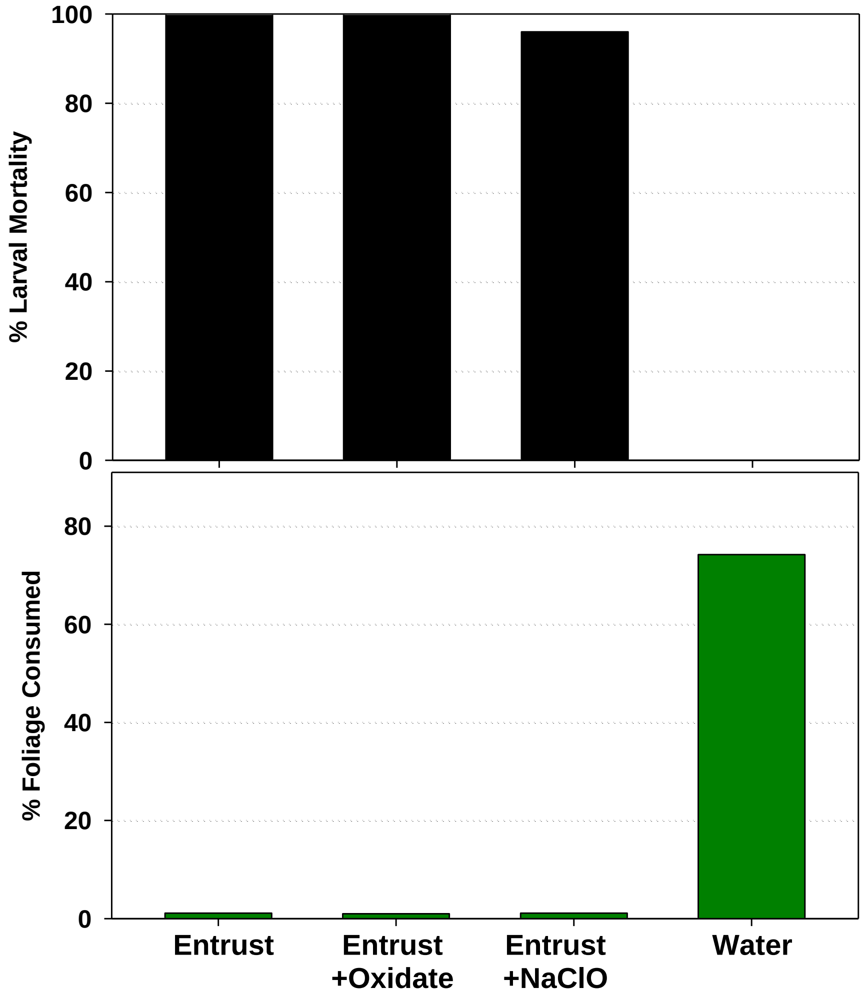

Figure 9. Mortality and Feeding of BAW larvae exposed to Entrust and Sanitizers for 144 hours in a Laboratory Bioassay, 2019

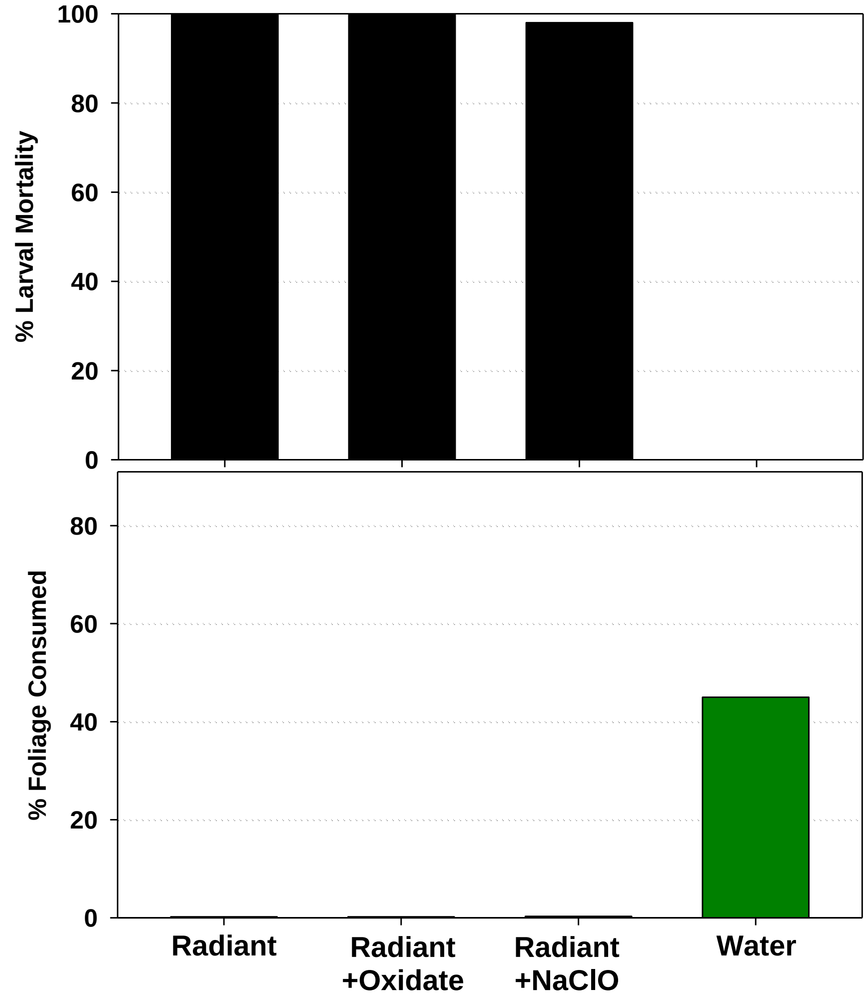

Figure 10. Mortality and Feeding of BAW larvae exposed to Radiant and Sanitizers for 96 hours in a Laboratory Bioassay, 2019

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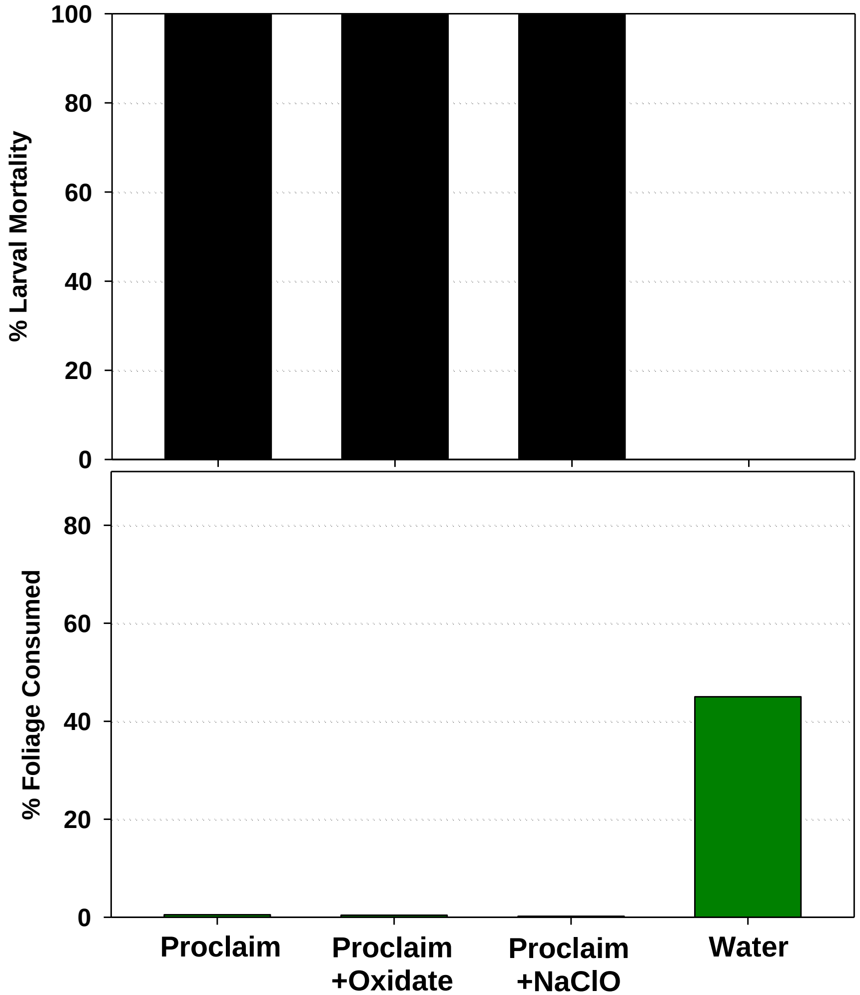

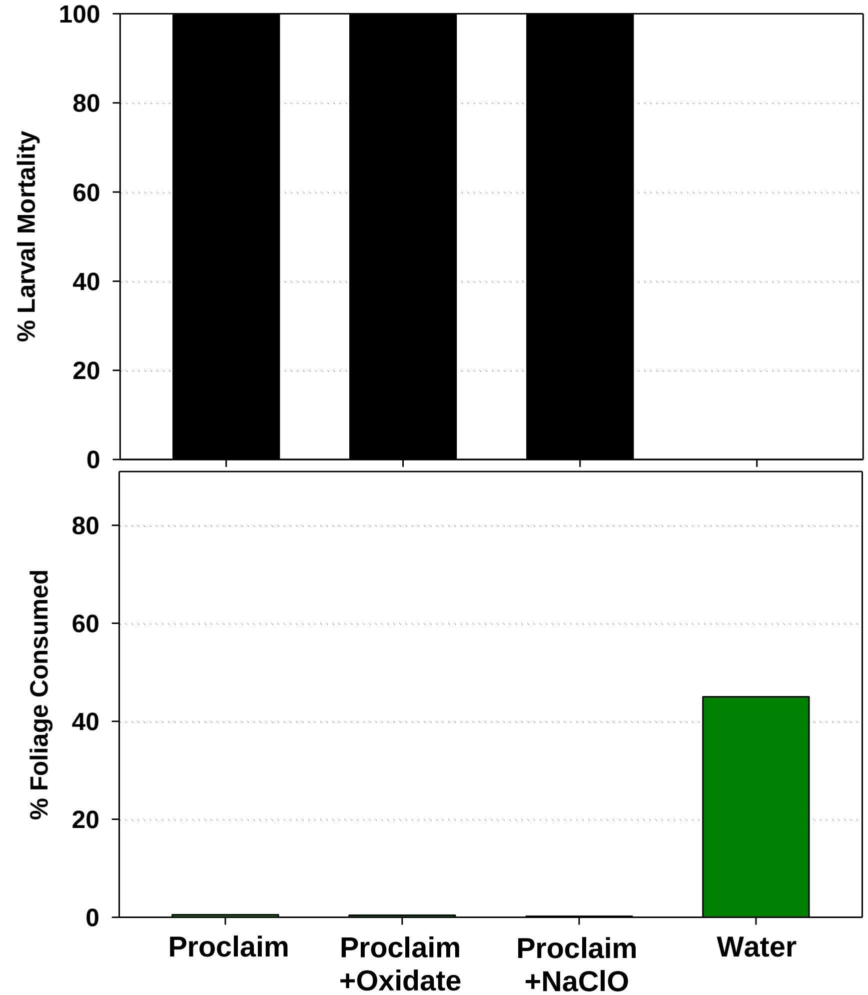

Figure 11. Mortality and Feeding of BAW larvae exposed to Proclaim and Sanitizers for 96 hours in a Laboratory Bioassay, 2019

Figure 12. Mortality and Feeding of BAW larvae exposed to Coragen and Sanitizers for 96 hours in a Laboratory Bioassay, 2019

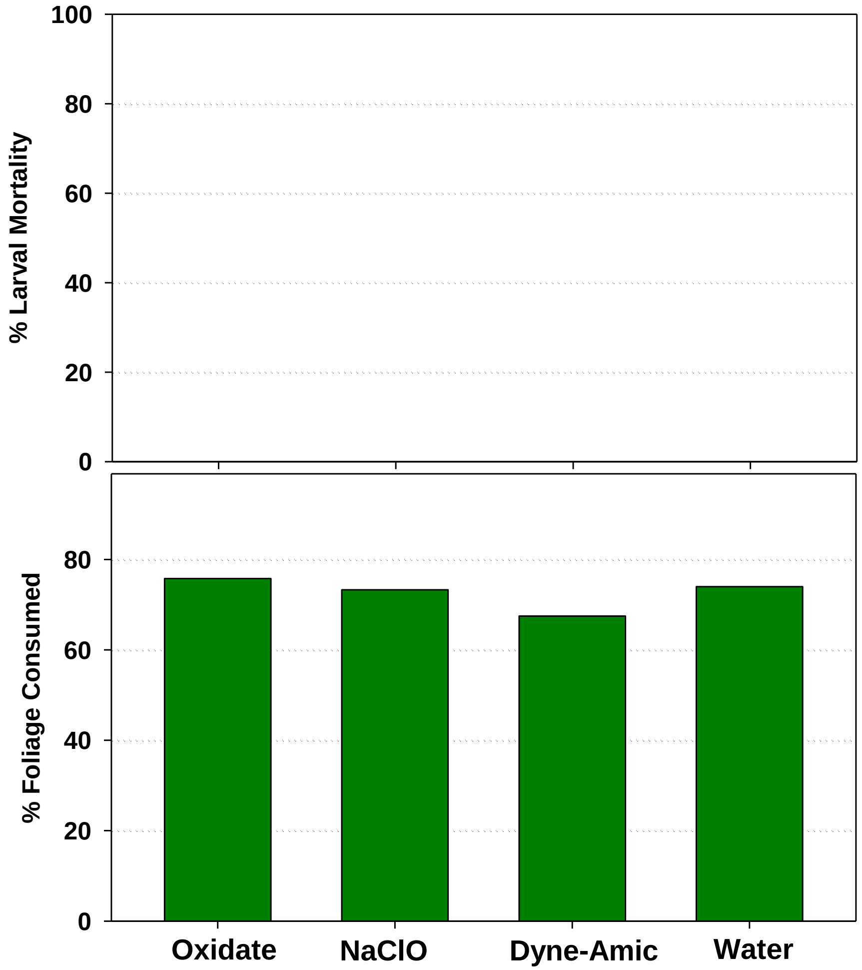

Figure 13. Mortality and Feeding of BAW larvae exposed to Sanitizers and an adjuvant for 144 hours in a Laboratory Bioassay, 2019

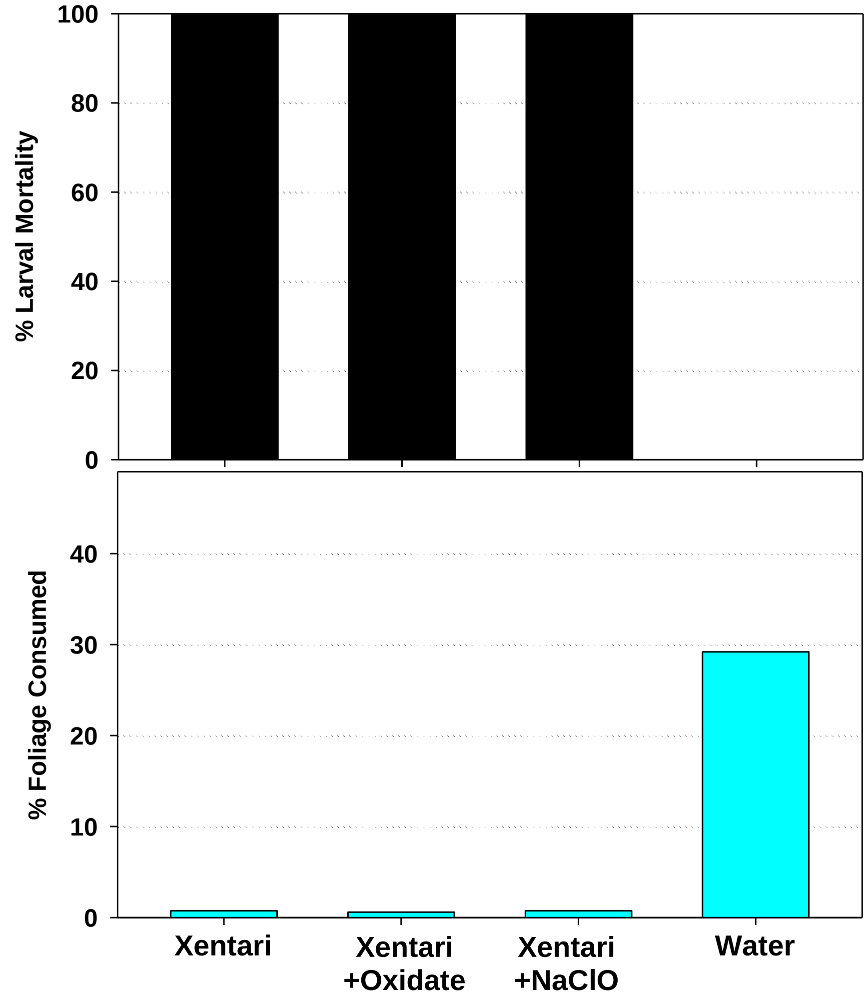

Figure 14. Mortality and Feeding of DBM larvae exposed to Xentari and Sanitizers for 96 hours in a Laboratory Bioassay, 2019

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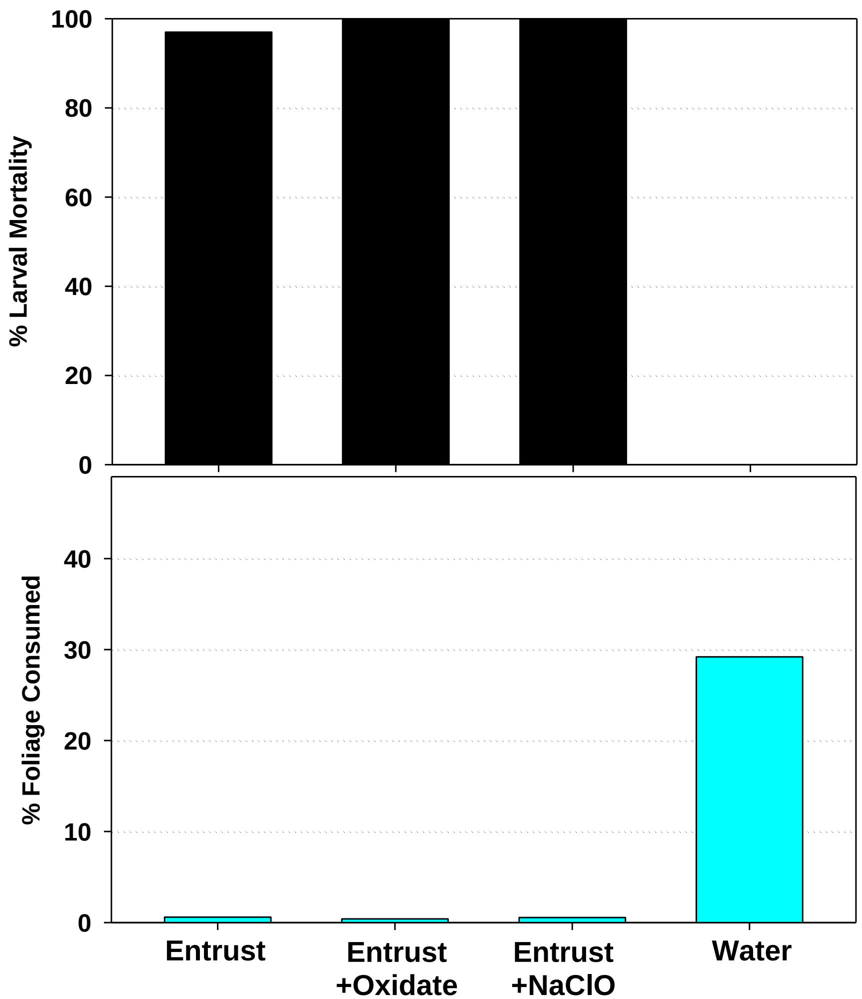

Figure 15. Mortality and Feeding of DBM larvae exposed to Entrust and Sanitizers for 96 hours in a Laboratory Bioassay, 2019

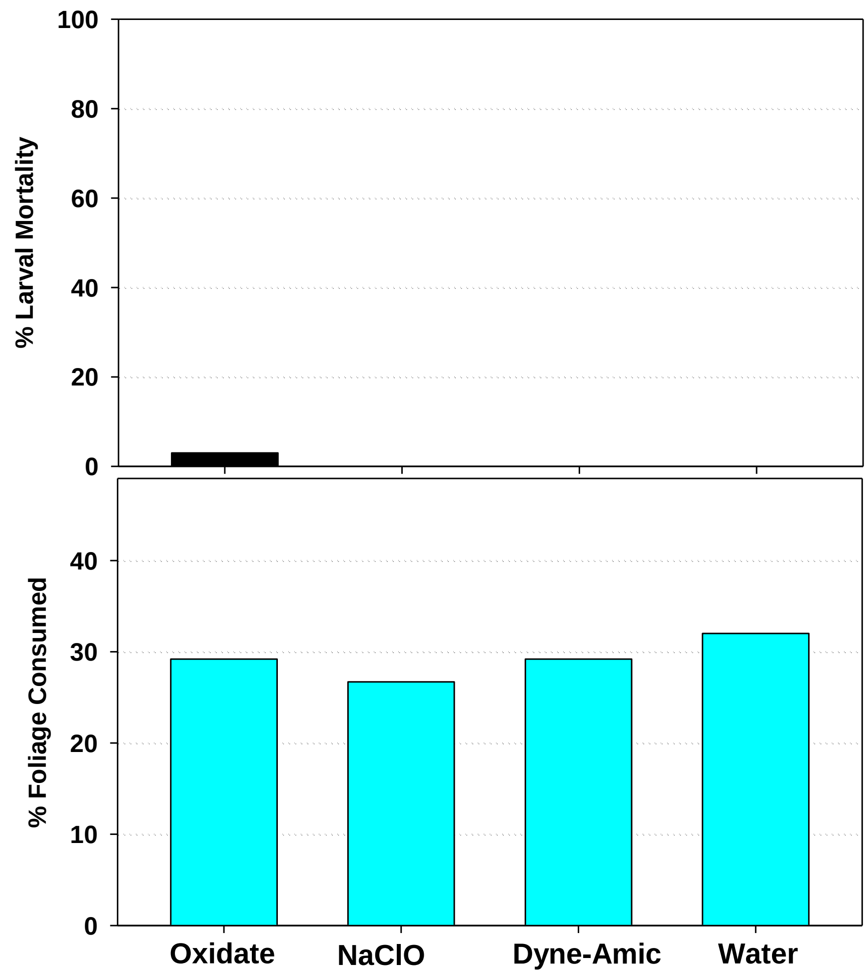

Figure 16. Mortality and Feeding of BAW larvae exposed to Sanitizers and an adjuvant for 96 hours in a Laboratory Bioassay, 2019

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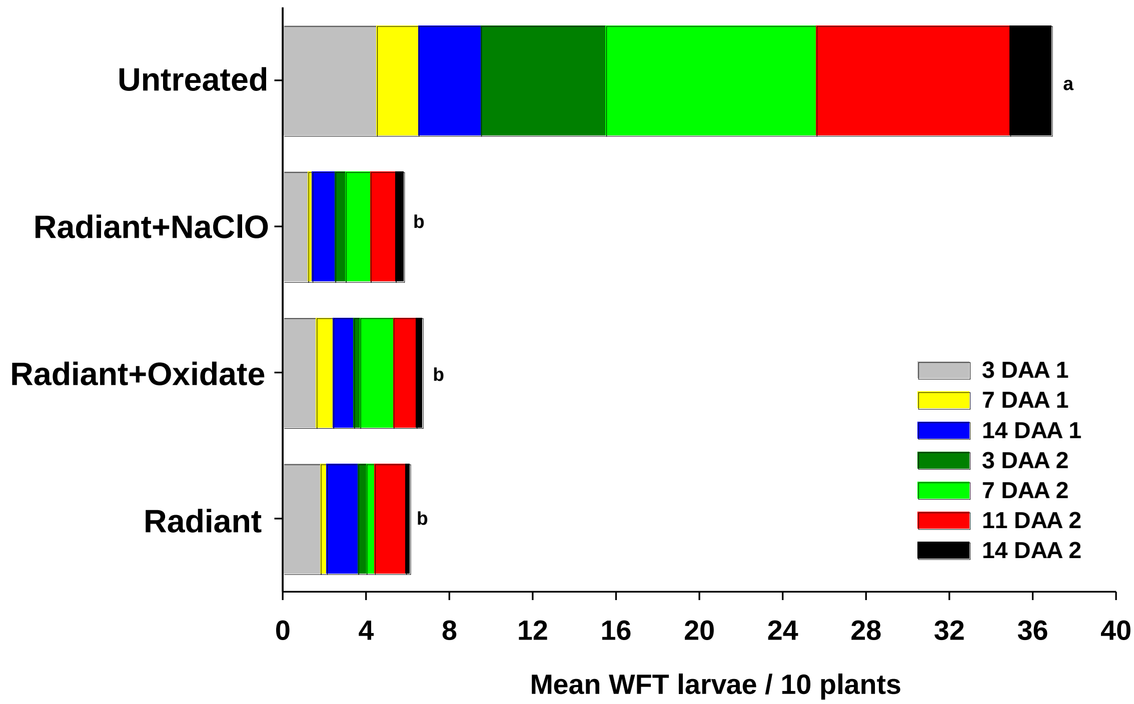

Figure 17. Trial I. Knockdown and Residual Efficacy of Radiant and sanitizers against WFT in lettuce, YAC spring 2020.

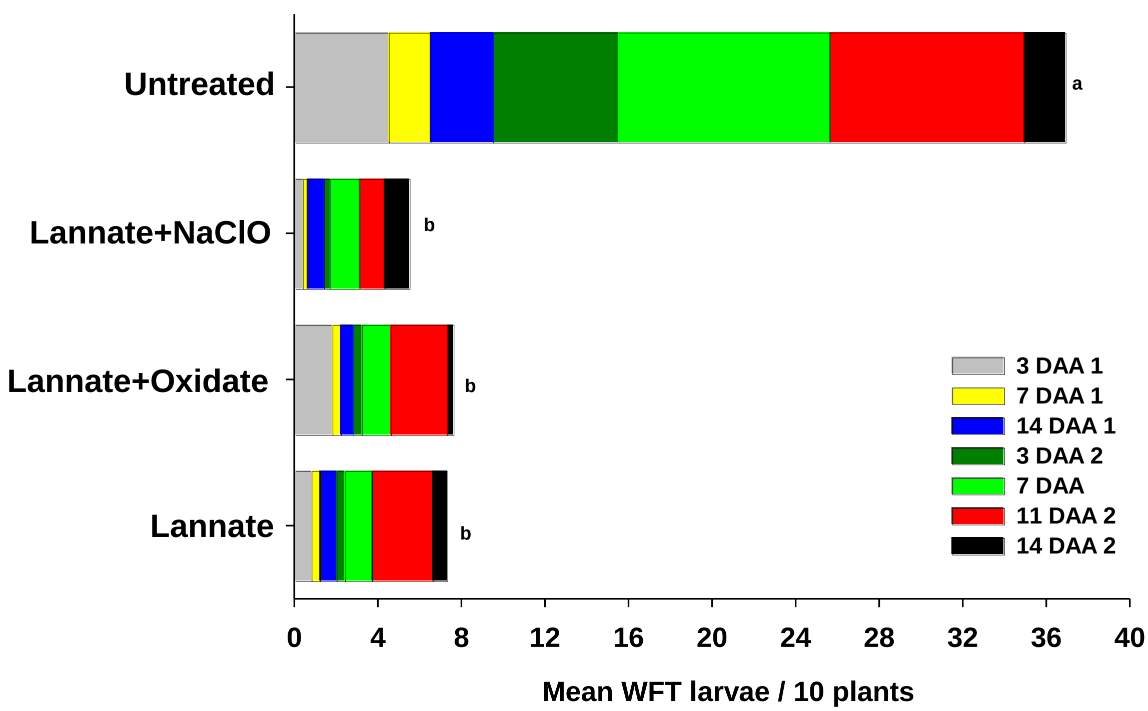

Figure 18. Trial I. Knockdown and Residual Efficacy of Lannate and sanitizers against WFT in lettuce, YAC spring 2020.

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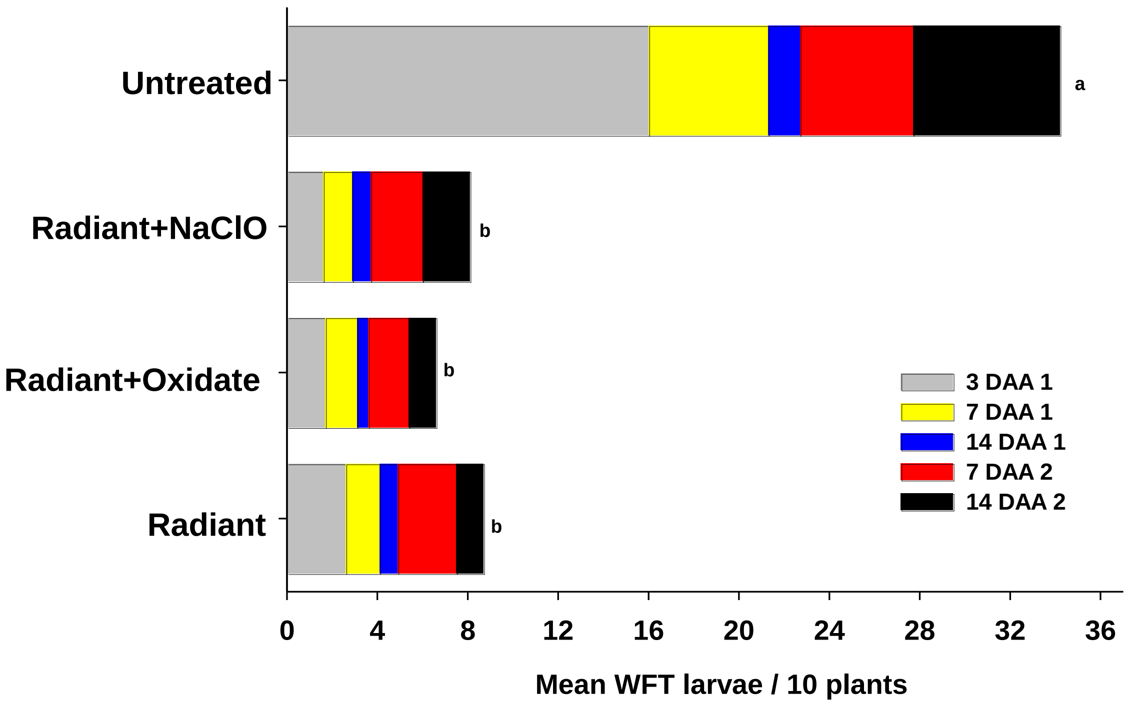

Figure 19. Trial II. Knockdown and Residual Efficacy of Radiant and sanitizers against WFT in lettuce II, YAC spring 2020.

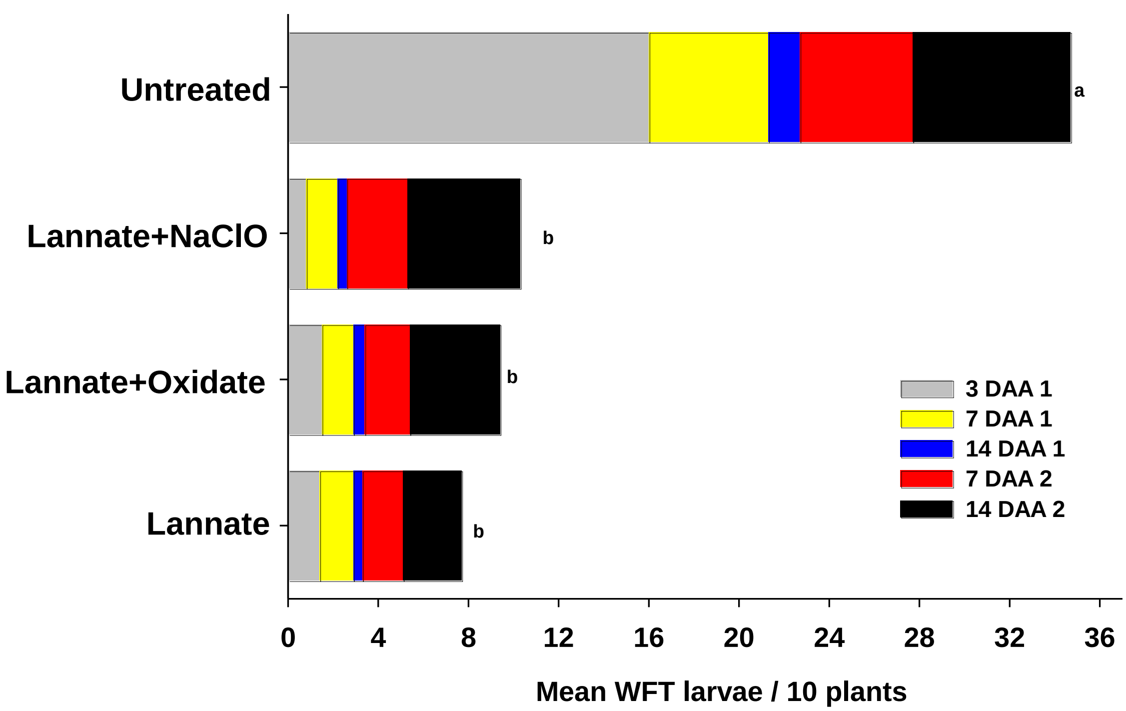

Figure 20. Trial II. Knockdown and Residual Efficacy of Lannate and sanitizers against WFT in lettuce II, YAC spring 2020.

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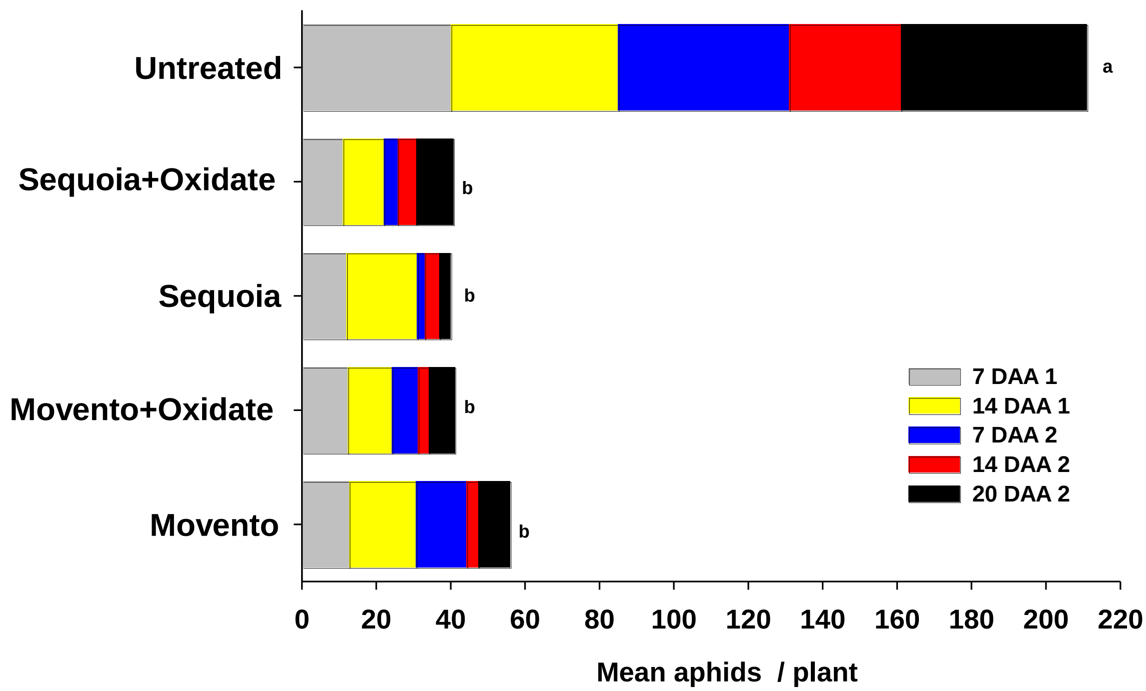

Figure 21. Knockdown and Residual Efficacy of Sequoia/Movento and Oxidate 5.0 against aphids in lettuce, YAC spring 2020.