TASK 1.7: Final Report

Agreement No: 20-PMG-GR002

Project Title: Alternatives to chlorpyrifos for sugarbeet production in the Imperial Valley

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Task 1.7 Final Report: *Describe in detail how project goals and objectives have been fulfilled through the completion of project deliverables, summarize and evaluate project activities and accomplishments, and include recommendations for outreach and/or future research. The report must focus on how project results are explicitly related to project deliverables and must clearly describe any potential or actual effects on the deliverables. Also, include all relevant materials, documentation, and deliverables not previously submitted. The report may be submitted in the form of a publishable paper, with supplemental appendices as needed to correlate the findings in the paper with how project goals and objectives have been fulfilled through the completion of project deliverables, and to include recommendations for outreach and/or future research.*

Table of Contents

Tables

Figures

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1.0 Project Summary

Chlorpyrifos[1] was widely used in sugarbeet production in the Imperial Valley (IV), especially in fall to ensure stand establishment. It is now effectively banned for use in California. The California Department of Pesticide Regulation (DPR) created *an Alternatives to Chlorpyrifos* competitive grant program. This project was funded by that program for the 2020-2023 period to carry out research to identify alternatives to chlorpyrifos use and best management IPM practices for sugarbeets in the IV. Since chlorpyrifos is no longer registered for general use and no longer used by sugarbeet growers, this research focused on optimizing management and reducing risks from pesticide use while managing insect pests in sugarbeets. Seven stand establishment trials were carried out at the University of California's Desert Research and Extension Center (UC DREC, https://drec.ucanr.edu/) in Holtville during the 2020 to 2022 period and six complementary trials in cooperating sugarbeet growers' fields. At the UC DREC site, the use of chlorpyrifos was compared to seed treatments using clothianidin + cyfluthrin and other soil applied chemicals in current use by growers as stand establishment treatments. Additional trials compared the use and efficacy of chlorantraniliprole + imidacloprid soil treatments with seed treatments. Additional trials included the use of biostimulants as alternatives to post-emergence treatments. Planting dates and the value of pre-irrigation practices were evaluated. In growers' fields, seed treatments were compared to the preferred treatments recommended by their pest control advisors. Field scale plots were used. The majority of trials were also compared for final effects on yield and root quality. Insect observations were made at the UC DREC and selected growers' fields throughout the growing season. The costs and risks of the primary pesticides used were compared.

Results. The majority of insect pest management in sugarbeet production during these trials and in common practice in the Imperial Valley occurs in autumn when crops are planted established. Sugarbeet seedlings are slow to grow after emergence and subject to mortality from insect grazing. Inadequate and uneven populations of beets result in economic loss. Flea beetles and armyworms were the primary insects observed during fall.

Insect pressure declined between mid-September and late October in date-of-planting comparisons made at the UC DREC, holding all other factors constant. This was observed previously in earlier work funded by the Department of Pesticide Regulation in 2000 to 2003 (Godfrey et al, 200x). Later planting in October reduces insect pressure and the need for insecticides during stand establishment, and can be considered an IPM strategy.

Comparisons of pre-irrigation vs initial irrigation at planting for furrow irrigated plots provided no advantage from a pest management perspective in trials at the UC DREC site. None of the cooperating growers used pre-irrigation.

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[1] *0,0-Diethyl 0-(3,5,6-trichloro-2-pyridinal) phosphorothioate*; an organophosphate pesticide that acts as an acetylcholinase inhibitor. This material was marketed under many different tradenames, with the most commonly used ones being Lorsban and Dursban.

In UC DREC trials and growers' fields, clothianidin + cyfluthrin (PB) seed treatments were equivalent to other practices with respect to stand establishment and final yield, and to chlorpyrifos (L) soil treatment (used only at the UC DREC site).

Clothianidin + cyfluthrin (PB) was used at extremely low rates. PB seed treatment is effective against flea beetles and flea beetle larvae, the primary insect pest of emerging sugarbeets, and an effective substitute for chlorpyrifos (L). It is not as broad spectrum, however, and other materials may be needed to control post-emergence insect grazing by armyworms.

Post-emergence treatment comparisons of September planted plots at the UC DREC site (+/- esfenvalerate) were carried out in three separate years at UC DREC, all other experimental conditions being equal. Post- emergence treatments were ineffective or unneeded. Seedling mortality was small in all three years (approximately 5% or less of all seedlings), with or without treatment at that site. Yields of untreated plots at the UC DREC did not differ significantly from treated plots, indicating that post-emergence treatment may not always be needed. This was especially true for later-planted (October) plots.

No comparisons were possible with untreated (post-emergence) plots under farming conditions. In all of the cooperating growers' fields, irrespective of planting date, post-emergence application of pyrethroids and other compounds was considered necessary by PCAs for army worm control, and for supplemental control of flea beetles in addition to soil treatments applied at planting, or in addition to the use of seed treatments. This is common practice in the IV in fall. Where sprinklers were used, pyrethroids were applied with irrigation water to all plots.

There was no additional insect management during the remainder of the growing season in two cooperators' fields, but several treatments were applied in one cooperator's field during the first growing season (202-2021). Beets were harvested early (April) in the second growing season in all cooperators' fields. No insecticides were used past the fall establishment period that year.

Sugarbeet growers have adopted successful alternatives to chlorpyrifos use. Alternatives involve primarily chlorantraniliprole as s a soil amendment in combination with soil-applied imidicloprid, followed by post emergence control using esfenvalerate and sometimes additional use of imidacloprid and or chlorantraniliprole.

These grower practices were compared directly with chlorpyrifos use and to the use of clothianidin seed treatments in plot trials at the UC DREC site. PB seed treatments were comparable or superior to the use of chlorantraniliprole with respect to stand establishment and root and sugar yields in the majority of trials in this project.

Based on comparable results and on previous work in the IV and throughout California during previous years, seed treatment using neonicotinid insecticides appears to be a lower risk alternative to current growers' practices and to the historic use of chlorpyrifos on sugarbeets in the Imperial Valley.

Two of the grower-cooperators adopted their use during the trial (season two, 2021-2022) and seed suppliers report wide scale adoption of seed treatments currently in the Imperial Valley.

Pesticide risk was assessed using the IPM Institutes Risk Assessment tool.   Neonicotinid seed treatments are a low risk approach under the conditions of the Imperial Valley where there are few pathways to greater environmental exposure compared to their use elsewhere in the US and on other corps and in other cropping systems. These issues are discussed.

Fig 1.1. *Fall 2020 plantings_Trial 1, UCDREC*

2.0 Introduction

Sugarbeet production in Imperial Valley (IV) is highly vulnerable to insect feeding during two time periods: stand establishment when fields are planted in fall, and canopy damage in late spring and early summer prior to harvest, especially later harvests in June and July. Of the two time periods, loss of stand at establishment in fall (September and October) is the more common occurrence and greater risk because sugar beets develop slowly after emergence and insect damage can lead to loss of seedlings during the first weeks after emergence. Failure to emerge also is a significant and greater risk than post-emergence loss, and may in part be due to cryptic insect damage to germinating seedlings. *Chlorpyrifos* was applied during both these crop phases, but especially during fall, when slow-growing, emerging seedlings are vulnerable to loss from insect predation. It was used commonly because it was relatively inexpensive, broad acting, persistent and controlled the principal pests of sugarbeets (stripped flea beetle and armyworms) during the highly vulnerable stand establishment phase. Chlorpyrifos can no longer be used in California and has been restricted recently at the national level.

This research quantified insect damage during stand establishment in the IV in fall when chlorpyrifos had been used in the largest amounts. We also compared losses from untreated crops during spring and early summer at a site located on the University of California's Desert Research and Extension Center in Holtville in the Imperial Valley (**UC DREC**, https://drec.ucanr.edu/), and monitored and compared insect abundance and growers' treatments at the UC DREC site and selected cooperating growers' fields located across the Imperial Valley.

Insect pest management, commonly described as integrated (**IPM**), instead most often devolves to an individual pest-response approach, without effective integration with other crop and pest management practices. Here, an IPM approach was used to evaluate alternative chemistries in combination with staggered planting dates in fall, interactions with seed treatments, and irrigation management to promote control through escape and improved plant growth. In spring and early summer, insect control treatments in mature crops at differing harvest dates were documented and compared with observational data on insect occurrence and for treatment costs.

Research integrated experiments in growers' fields with trials at the UC DREC. Six site-year trials in growers' fields were carried out over two growing seasons (fall 2020 to spring/summer 2022). Cooperating growers' fields were used to compare available registered alternative pesticide treatments used during stand establishment to treatments used at the UC DREC site, including chlorpyrifos, used only for experimental comparisons at the UC DREC site. Pest management treatments varied in growers' fields depending on growers and their pest control advisors (**PCAs**) preferences and the site and year, but all growers' fields included at least one treatment that was also applied at the UC DREC to support comparisons across all sites.

Alternative irrigation management methods (pre-irrigation prior to planting compared to irrigation first at planting), and planting date interactions with irrigation and insecticide treatments (mid-September versus mid-October) were also evaluated in combination with alternative pesticide treatments at the UC DREC to identify a set of best pest management practices for fall stand establishment. Irrigation methods at UC DREC and in growers' fields included furrow (surface) irrigation or sprinkler irrigation during establishment followed by surface irrigation, depending on the year and field. Detailed, frequent observations during seedling emergence and early establishment were made at the UC DREC site to quantify cumulative emergence and the diverse causes of mortality affecting seedlings, including pre-emergence and post-emergence losses due to insects and pathogens. Seedlings were marked with small labels to allow observation of survival and loss (if any) over time during the establishment period. Trials at the UC DREC also included untreated controls to permit and observe the effects of greater levels of damage than were commonly tolerated or would be tolerated in growers' fields. Seedlings were sampled at approximately the 8 to 12 leaf stage (considered established) in all trials at all sites to evaluate differences among treatments in protecting seedling growth.

In growers' fields, stands were evaluated at approximately the 8 to 12 leaf stage to compare establishment success and seedling vigor. Similar measurements were made at the UC DREC site in year one (fall 2020), when a commercial air planter was used, (similar in kind with types used by growers), which allowed for comparison with growers' spacing results. Subsequently, a cone planter and measured seed amounts (100 seeds per plot) were used at the UCDREC to overcome problems with planter performance experienced in the first year. Cone planters are not precision planters so spacing cannot be directly compared with observations in growers' fields.

Additional complimentary trials consistent with *Objective 4* were carried out at UC DREC to evaluate a commonly used material (chlorantraniliprole[2]) in the Imperial Valley that was not part of the original experimental design used at the UC DREC for pesticide comparisons in year one to better compare its performance against seeds treated with clothianidin[3] and against untreated seed. Subsequently, chlorantraniliprole combined with imidacloprid was added to the primary UCDREC experiment in fall 2021 and 2022 to reflect growers' practices.

Biostimulants have been promoted increasingly in recent years (Malik et al., 2020; Sanders et al, 1990; Uppwala et al, 2022). Their use may allow seedlings to emerge more vigorously, and/or survive or outgrow insect damage in fall. A selection of these materials was evaluated in additional separate trials at the UC DREC as alternatives or supplements to conventional pesticides, used as foliar treatments (year 2) or soil applied (year 3).

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[2] 3-Bromo-N-[4-chloro-2-methyl-6-[(methylamino) carbonyl] phenyl]-1-(3-chloro-2-pyridinyl)-1H-pyrazole-5-carboxamide, an anthranilic diamide compound.

[3] (E)-1-(2-chloro-1,3-thiazol-5-ylmethyl)-3-methyl-2-nitroguanidine, a neonicotinid compound. PB also includes cyfluthrin.

Sugarbeet harvest in the IV occurs from April through July or early August. Throughout the growing season, observations were made of insects present in crops receiving different alternative pesticide treatments compared to controls at both the UC DREC site and in cooperating growers' fields. Sticky traps and wing traps were used to estimate insect presence and abundance. For late spring control in mature crops, harvest date relationships with the amount and types of pesticides required for adequate control were compared with observations of insect abundance and for costs.

The outcomes of all grower and research station treatments were evaluated finally by the root yield and quality of harvested roots from treated fields and research station plots. Efficacy, cost and the effects of insecticide treatments on yields are the criteria important to growers.

Pesticide risks are widely concerning to the public. The relative risks of the pesticides used at the research station and in growers' fields were evaluated and compared using the *Risk Management Tool* created by the Institute for Integrated Pest Management (https://pesticiderisk.org/).

2.1 Previous work

Project objectives, methods and expected outcomes were informed by previous work in the Imperial Valley and elsewhere in the state, some of which had been funded by the Department of Pesticide Regulation's Pest Management Alliance Program.[4] The previous *Pest Management Alliance* grant (Godfrey and Kaffka, 2000 to 2003), and (Haviland, 2002) also evaluated alternatives to chlorpyrifos and other insecticides in the IV and elsewhere in California. Working at Davis and in western Fresno County on mature beet canopies in summer, Haviland and Godfrey found that a pyrethroid (Esfenvalerate[5]) resulted in larger armyworm populations than untreated plots. Best control occurred with low impact materials like spinosids or a diacylhydrazine[6]. At the small plot scale used, yields were unaffected by the range of pesticide treatments compared, but root rot damage was greatest in the plots with the largest number of armyworms.

Kaffka and diverse cooperators worked on stand establishment issues in IV and elsewhere in California where beets were grown. There were 5 on-farm trials conducted in the IV in the late 1990s and early 2000s (this work is summarized in a publication on sugarbeet stand establishment-in preparation) and upcoming changes in the UC IPM guidelines for sugarbeet production. Most losses at the stand establishment stage were due to insects, especially flea beetles and armyworm larvae, but very little to pathogens. Pre-emergence losses were minimized equally using soil applied chlorpryrifos or a neonicotinid seed treatment

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[4] https://www.cdpr.ca.gov/docs/pestmgt/grants/alliance/index.htm

[5] (S)-cyano (3-phenoxyphenyl) methyl (S)-4-chloro-alpha-(1-methylethyl) benzeneacetate, a synthetic pyrethroid compound, common name: Asana

[6] Tebufenozide: benzoic acid, 3,5-dimethyl-,1-(1,1-dimethylethyl)-2-(4-ethylbenzoyl)hydrazide, common name: Confirm.

(imidcloprid[7]). The need for post-emergence insect control varied by site, year, planting date, neighboring crop (+/- alfalfa) and the use of pre-irrigation. The primary causes of poor stand establishment were poor seedbed conditions and failure to emerge (pre-emergence losses). Post emergence mortality was a lesser factor. Insect damage was greater when fields were planted in early in September, and more modest or absent when fields were planted later in October.

When trials were first initiated at that time, it was common grower practice to use large amounts of seed (100,000 seeds/ac), expecting only half or less to result in establish plants. Stands were hand-thinned to correct inevitable irregularities. By closely observing the establishment process in fields, we quantified that emergence was much better than growers and PCAs estimated at the time. Subsequently, seed amounts planted declined in the Imperial Valley and growers were able to stop hand thinning. Both changes saved money and are now standard practice.

The most damaging insect species observed during these trials was stripped flea beetle, which appeared on seedlings immediately on emergence (***Fig. 2.1***). Armyworm larvae appeared later after moths first identified seedlings, laid eggs, and larvae hatched. Damage to seedlings from both species was severe when seedlings were grazed intensively during the first two to three weeks after emergence in untreated controls in September plantings. In three years of on-farm trials, imidicloprid controlled damage from flea beetles similarly to a chlorpyrifos soil treatment, but not damage from armyworm larvae, which required post-emergence control in some fields. In two trials planted in October, post-emergence insect damage was minimal, requiring no treatment. Yields were not compared in these last two trials.

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[7] : 1-[(6-Chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine, A neonicotinid, common name as a seed treatment: Gaucho.

Pale-stripped flea beetle (*Systena blanda*) and western black flea beetle (*Phyllotreta spp.*).

Top: Beet Armyworm *Spodoptera exigua* (Hubner), Saltmarsh Caterpillar *Estigmene acrea,* Garden Webworm *Achyra rantalis (no photo),* Green Vegetable Bug *Nezara viridula,* Three-cornered Alfalfa hopper *Spissistilus festinus* (Say), *Based on visual inspection of plants. 30 plants per plot.*

***Fig. 2.1**. Common insect pests of sugarbeet observed during trials in the Imperial Valley.*

***Fig. 2.2.** Southern garden leafhopper (Empoasca solana), observed commonly in late spring/summer*

In relevant work carried out at Davis during the same time frame, several neonicotinids were compared. There were no significant differences among imidicloprid, thiamethoxam and clothianidin in the Davis trial (***Fig. 2.3***) and similar trials elsewhere (primarily Europe) in direct comparisons (IIRB_67th Congress, Brussells; 2004). Clothianidin now has displaced imidacloprid as a seed treatment for sugarbeets and is considered comparable to imidicloprid used in earlier trials.

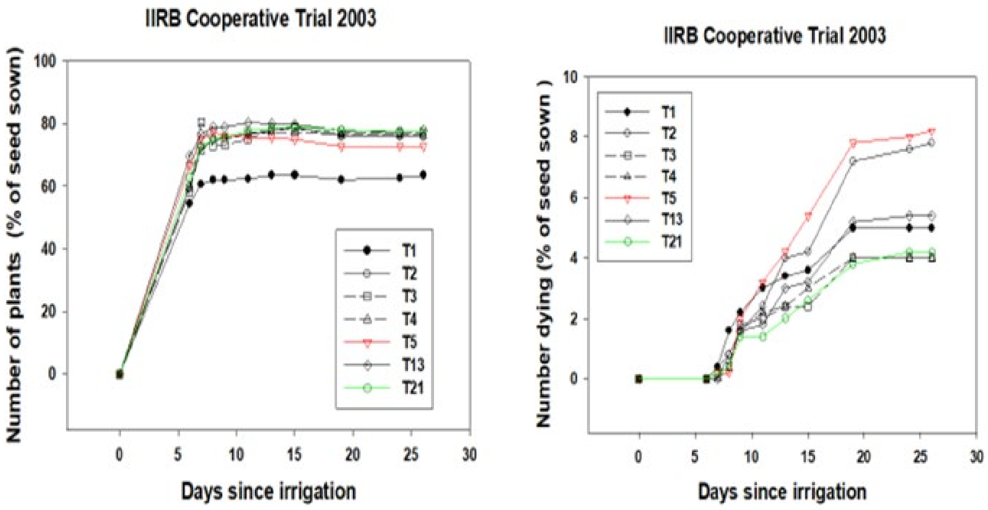

Fig. 2.3. *Comparison of effectiveness of diverse neonicotinid insecticides as seed treatments for sugarbeets. UC Davis trial. Left: % of plants emerging, right: number o seedlings dying post-emergence. T1: no treatment (control); T2: imidicloprid (90 g ai/100K seeds); T3: Imidicloprid + tefluthrin (4 g ai/100K seeds); T4: thiamethoxam (60 g ai/100K seeds); T5: Ti435 (unnamed compound, 60 g ai/100K seeds; T13: Tefluthrin (g g ai/100K seeds); T21: clothianidin (60 g ai/100K seeds).*

In additional older work, Empoasca sp. leaf hoppers were studied in cotton and beets (Hilgardia, 1972), and in limited trials since in the IV in beets and alfalfa (Eric Natwick, mostly reported in IV UCCE newsletters). More recently, work has been initiated with support from the Imperial County Board of Supervisors in 2018 conducted by Bachie and Kaffka[8]. Their trial was planted mid-October. Damage during both stand establishment and harvest stages was modest, treatments were ineffective, and yields similar, supporting the hypothesis that later planting in fall minimizes risk to seedlings. They suggested that small plots may not reflect pest pressures in growers' fields, but later planting dates likely also influenced trial outcomes. Small plot trials should be linked to sampling and experimentation at the farm scale.

3.0 Objectives

Obj. 1 (Tasks 2 and 3[9]). Quantify the effects of alternative stand establishment practices, including irrigation and seed treatments using systemic neonicotinid insecticides.

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[8] http://ceimperial.ucanr.edu/ news_359/Ag_ Briefs/?newsletteritem=81576

[9] *For the sake of clarity and more logical narration, tasks separated in the original contract language are included together in this report. The original contact language is cited here for comparison*:

Task 2.1: Stand Establishment: Carry out field trials in growers' fields, collect and analyze the data, summarize and report the results.

Obj. 2 (Tasks 2 and 3). Quantify the effects on pest abundance and crop performance of differing alternative pesticides and application strategies during the spring to summer period through crop scouting, and root yield and quality analyses at harvest.
Obj. 3. (**Tasks 2 and 3**) Relate the amount of treatment required to preserve yield and quality to differing harvest dates (over the May to July period).
Obj. 4. (**Task 4**[10]) Compare the effects of alternative and/or unregistered chemistries with chlorpyrifos on sugarbeets on pests and on crop growth and yields.
Obj. 5. (**Task 5**[11]) Identify and extend to growers and PCAs best alternative management strategies that rely on less broadly toxic pesticides, together with alternative IPM methods. Modify the UC IPM guidelines.

To achieve these goals and objectives, At the UC DREC we quantified seedling emergence, loss and final establishment, and measured seedling vigor by weighing established plants collected at the 8 to 12 leaf stage during fall when planting occurs and when chlorpyrifos was used in the largest amounts. We compared the performance of currently used pesticides with seed

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Task 2.2: Spring-Summer Period: Carry out field trials in growers' fields, collect and analyze the data, summarize and report the results.
Task 2.3: Harvest Period: Carry out field trials in growers' fields, collect and analyze the data, summarize and report the results.
Objective 3: UC DREC Enhanced IPM Experiments: Research station trials at the UC DREC comparing insecticide alternatives at two different planting dates and with and without pre-irrigation treatments (IPM practices) will be carried out. Data on insect occurrence and crop damage under different insecticide, planting date, and irrigation treatments will be collected from stand establishment to harvest. Yield, root quality, crop value, and treatment costs will be collected for each treatment replicate.
Task 3.1: Stand Establishment: Carry out research station experiments at the UC DREC, collect and analyze the data, summarize and report the results.
Task 3.2: Spring-Summer Period: Carry out research station experiments at the UC DREC, collect and analyze the data, summarize and report the results.
Task 3.3: Harvest Period: Carry out research station experiments at the UC DREC, collect and analyze the data, summarize and report the results.

[10] **Task 4. At UC DREC: New, Alternative and/or Unregistered Chemistries Experiments:** Research station trials at the UC DREC will be conducted over two seasons comparing the effects of new, alternative and/or unregistered chemistries with chlorpyrifos on pests and on crop growth and yields. Data on insect occurrence and crop damage under different insecticide treatments will be collected from stand establishment to harvest. Yield, root quality, crop value, and treatment costs will be collected for each treatment replicate.
Task 4.1: New, Alternative and/or Unregistered Chemistries Experiments: Carry out research station experiments at the UC DREC, collect and analyze the data, summarize and report the results.

[11] **Objective 5: Outreach and Extension of Results:** Identify and extend to growers and PCAs best alternative management strategies that rely on less broadly toxic pesticides, together with alternative IPM methods. Modify the UC IPM guidelines for sugarbeet production to reflect the findings of the project.

Task 5.1: Year 1 Meetings, Field Days, and Events: Project results will be reported at annual meetings of the sugarbeet industry in El Centro in February of each year, at the annual grower's meeting in February each year, at field station field days, CAPCA meetings and other events in the Imperial Valley and elsewhere. Reports will be distributed at county and statewide websites.

treatments used at low rates of active ingredient (Obj 1, 2 3). Interactions with planting and harvest dates and irrigation practices were compared. Yields and treatment costs of all treatment comparisons were compared and used as criteria for evaluating success based on crop yields (Obj 3), while considering the toxicity of treatment combinations to non-target organisms, people and ecosystems (Obj. 4/5). Separate trials at UC DREC compared the use of chlorantraniliprole and imidicloprid with and without seed treatments and the effects of bio-stimulants to seed treated with clothianidin (Obj. 4). There have been several presentations of results to date. Publication and additional outreach events related to these outcomes are ongoing (Obj. 5).

4.0 Methods

4.1 Project Design and Analysis (Objectives 1, 2, 3)

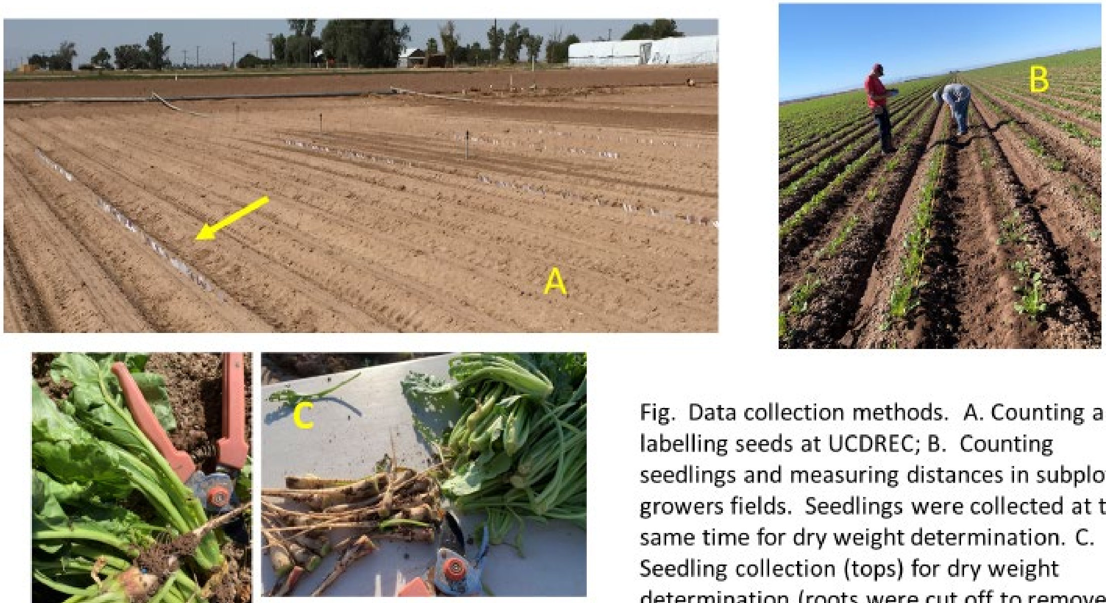
Complementary experiments were carried out at the UC DREC in Holtville and in 3 growers' fields each year. A neonicotinid seed treatment (clothianidin), hypothesized as a reduced toxicity practice, was common to all experiments. Data collected included seedling emergence and loss at the UC DREC site collected using marked seedlings, stand establishment at the 8 to 12 leaf stage measured by counting seedlings and distance between seedlings in plots, seedling dry weight at that stage as a measure of seedling vigor among treatments, season-long monitoring of insect pest abundance and damage at the UC DREC site and selected growers' fields, root and gross sugar yield and root quality at all sites, and comparative costs of differing treatments at all sites. Details about each trial are summarized in ***Table 4.1.***

Trials at the UC DREC contrasted potential IPM practices (planting dates and irrigation practices), and their interaction with differing insecticide treatments. Alternative irrigation management methods (pre-irrigation prior to planting compared to irrigation at planting), and planting date interactions with irrigation and insecticide treatments (mid-September versus mid-October) were evaluated in combination with alternative pesticide treatments to identify a set of best pest management practices for fall stand establishment. Irrigation methods at UC DREC and in growers' fields included furrow (surface) irrigation or sprinkler irrigation during establishment followed by surface irrigation, depending on the year and field. The practices preferred by each grower and their PCAs were used as a control treatment at field sites. Clothianidin seed treatments were common at all sites and compared to untreated seeds. Post emergence control in growers' fields depended on the recommendations of their PCAs and were used across all treatments in their fields, including experimental plots. Insect treatment costs were collected from cooperating PCAs and growers and compared among growers' fields.

In fall at planting at the UC DREC site, cumulative emergence, uniformity and post-emergence losses were compared by labeling emerging seedlings and quantifying survival and loss over the first two to three weeks from the beginning of emergence. Post-establishment, plots were monitored frequently and insect observations using sticky traps and wing traps (year two) were recorded. At the UC DREC site, plots were divided with half being treated with esfenvalerte and half left untreated. In general, more damage was tolerated and encouraged intentionally at the UC DREC site than would normally be allowed in growers' fields under standard practices.

Harvests at UC DREC were carried out in year one by hand and in year two using a two-row research plot harvester provided by Spreckels Sugar. One harvest was made in June in each year to allow untreated plots more time to develop insect damage for the sake of comparison with treated plots. Root samples were analyzed at the Spreckels Sugar quality lab in Brawley for sugar content and other measures of quality.

To be compelling to growers, treatment differences must be significant at the scale of concern to growers. In growers' fields, 4 to 6 row wide strips were collected at harvest using commercial harvesters, sufficient to fill a standard truck. The harvested area was measured (~ ½ acre/replication) to calculate yield. Each truckload was weighed and sampled for quality at the Spreckels Sugar factory. The timing of harvests in growers' fields varied from April to June over the two years, providing a representative sample of the range of conditions experienced by commercial sugarbeet growers in the Imperial Valley. *Table 4.1* summarizes key data for all the trials carried out in this project.



Weighing seedling tops. 20 plants per measured area were collected and topped, then dried and dry weights were compared as a measure of the amount of insect grazing that occurred.

Fig. Data collection methods. A. Counting and labelling seeds at UCDREC; B. Counting seedlings and measuring distances in subplots in growers fields. Seedlings were collected at the same time for dry weight determination. C. Seedling collection (tops) for dry weight determination (roots were cut off to remove soil and correct for breakage).

***Fig. 4*.1.** *Data collection during stand establishment in fall.*

Table 4.1 Trial comparisons

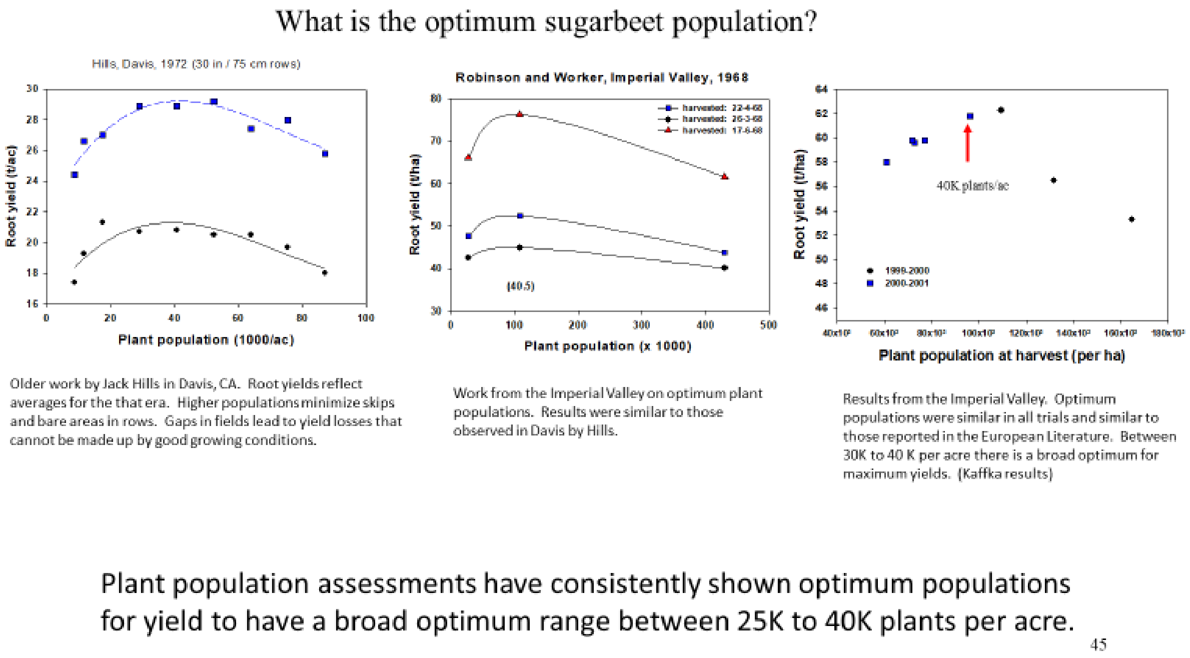
								At planting					Post-emergence and in-season				Biostimulant trials		
Location	Lat/Long	soil type	Year	Planting date Fall	Harvest date Spring-summer	Irrigation type (at planting)	Type	UTC	Chlorpyrifos 2 pints/ac	Clothianadan 30-40 g a.i./ac	Chlorantraniliprole 7.5 fl oz/ac	Imidicloprid variable	Esfenvalerate 5 fl oz/ac	Carbaryl 48 fl oz/ac	Methoxyfenozide	Methomyl	S	V	CY
								Year 1											
UC DREC		Holtville silty clay	2020-2021	16-Sep	16-Jun	furrow	research station	■	■	■			■						
				15-Oct	16-Jun			■	■	■									
UC DREC		Holtville silty clay	2020-2021	16-Sep	17-Jun	furrow	research station	■		■	■								
ASH 24		Imperial-Glenbar silty clay	2020-2021	7-Oct	May	sprinkler	Grower's field			■	■	■	■		■				
Mulberry 7			2020-2021	26-Sep	May	sprinkler	Grower's field			■	■	■	■	■					
Mulberry 13			2020-2021	14-Oct	may	furrow	Grower's field			■	■		■						
								Year 2											
UC DREC		Holtville silty clay	2021-2022	13-Oct	25-Jun	sprinkler	research station	■	■	■	■			■	■				
UC DREC		Holtville silty clay	2021-2022	13-Oct	25-Jun	sprinkler	research station			■	■								
UC DREC		Holtville silty clay	2021-2022	13-Oct	25-Jun	sprinkler	research station	■									🟩	🟩	🟩
Plum 20		Holtville silty clay	2021-2022	19-Sep	April	sprinkler	Grower's field			■		■	■	■	■	■			
Mulberry 15		Imperial-Glenbar silty clay	2021-2022		April	furrow	Grower's field			■	■	■	■	■	■				
Marigold 8		Imperial-Glenbar silty clay	2021-2022	27-Sep	April	sprinkler	Grower's field			■	■	■	■						
								Year 3											
UC DREC		Holtville silty clay	2022	15-Sep	not harvested	furrow	research station	■	■	■	■		■	■	■				
UC DREC		Holtville silty clay	2022	15-Sep	not harvested	furrow	research station	■									🟩	🟩	🟩

Notes: UTC = untreated control; L: Chlorpyrifos; both treatments only applied at UC DREC Herbicides and fungicides are not listed but appear in tables bleow cataloguing treatment used at all sites.

Application rates of materials applied to individual fields varied. Rates listed in the table were those used in trials at the UC DREC. Imidicloprid in diverse formualtions was used in growers fields. Amounts are presented in separate tables for each grower's field trial.

These experiments depend on observational data. Data were collected to support more predictable stand establishment. Using complementary techniques across all trials allowed us to observe and quantify losses to insects or pathogens during fall when seed is planted. Two years of field experiments were planned for UC DREC, but extended to year three due to the abandonment of the September planting at UCDREC in year two (fall 2021). This was the result of inadequate site preparation, in part due to stresses on research station staff due to Covid-related restrictions and illness that year. A modified late October planting at an alternative site on the station was substituted in year two. In year three, the September planting trial was repeated as originally designed. Budget constraints did not allow planting an October trial that year or harvest in late spring 2023. Three trials were carried out each year in cooperating growers' fields in diverse locations across the Imperial Valley (Table 1.1).

4.1.1. Stand establishment. Stand establishment is the most challenging agronomic task in sugarbeet production. Seeds are small, must be planted at relatively low population levels and are slow to grow and establish. Optimum sugarbeet populations vary from 30K to 40K uniformly spaced plants per acre (***Fig 4.2***). To know how many seeds to plant, growers must have a reasonable idea of the number of seeds that will emerge (pre-emergence losses), and the number of seedlings that will die post-emergence. To predict these values, the causes and timing of seedling mortality must be understood.



What is the optimum sugarbeet population?

Older work by Jack Hills in Davis, CA. Root yields reflect averages for the that era. Higher populations minimize skips and bare areas in rows. Gaps in fields lead to yield losses that cannot be made up by good growing conditions.

Work from the Imperial Valley on optimum plant populations. Results were similar to those observed in Davis by Hills.

Results from the Imperial Valley. Optimum populations were similar in all trials and similar to those reported in the European Literature. Between 30K to 40 K per acre there is a broad optimum for maximum yields. (Kaffka results)

Plant population assessments have consistently shown optimum populations for yield to have a broad optimum range between 25K to 40K plants per acre.

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Fig. 4.2*. Optimum plant populations determined in older research.*

In growers' fields, emergence was measured at several subplots within each treatment replication at the 8 to 12 leaf stage, when emergence and establishment were assumed to be final. The distance between seedlings and total seedling number was measured, and seedling dry weights collected by harvesting 20 seedlings at random and weighing dried plant tops to compare treatments for seedling vigor. Seedling dry weights at 8 to 12 leaves can differentiate among treatments if seedlings are damaged by insect grazing in some treatments compared to others, if all other conditions are equal.

Similar measurements were made at the UC DREC site in year one (fall 2020), when a commercial air planter was used (similar in kind with types used by growers), which allowed for comparison with growers' spacing results. A target spacing of 3.5 inches was used, though actual planter performance varied. In subsequent years, to better reduce uncontrolled variance in stand establishment counts due to concerns about the uniformity of the older air planter's performance in year one, a cone planter and 100 seed units were used for all subplots at the UC DREC, such that spacing data could not be collected. To compare performance in all UC DREC trials, data is expressed as percent emergence.

4.2 Experimental Design

4.2.1. Trial 1 at the UC DREC used a nested split-split plot design with planting date as main plots and irrigation treatments nested within planting dates. A chlorpyrifos soil treatment (labelled L) was compared to a seed treatment (clothianidin[12], labelled PB) or an untreated control (C or UTC) within irrigation plots and planting date plots[13]. Large plots were split further to allow for a comparison of post-emergence insect control and untreated plots. Emergence was monitored starting at approximately 5 to 7 days post planting and irrigation. Seedlings were marked with small stakes on emergence in six 25-foot rows and observed for damage and loss up to 12 leaves.

The experimental units for UC DREC trials were 25-foot subplots selected at random from the middle two rows (rows 2 and 3) of beets, nested within larger four row plots (60 feet long) (see diagrams attached). This corresponds to the capacity of a sugarbeet plot harvester and minimizes edge effects. All UC DREC plots included additional untreated rows of beets between and around replications to encourage pest pressure. Variety, irrigation, fertilization, weed management and mildew control were held constant.

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[12] E-1-(2-chloro-1-3-thiazol-5ylmethyl)-3-methyl-2-nitroguanidine; Poncho-Beta was used. Its formulation includes 34.3 % clothianidin and 4.6% of beta-cyfluthrin. It belongs to the neonicotinid group of insecticides. Typically 60 g a.i. per 100,000 seeds are applied with seed coatings. Commonly, 50,000 seeds are planted per acre, so application rates are approximately 30 g/ per acre a.i., depending on seed amounts actually planted.

[13] Initials for common names were used to simplify communication with growers, PCA and others familiar with the sugarbeet industry and crop production in general.

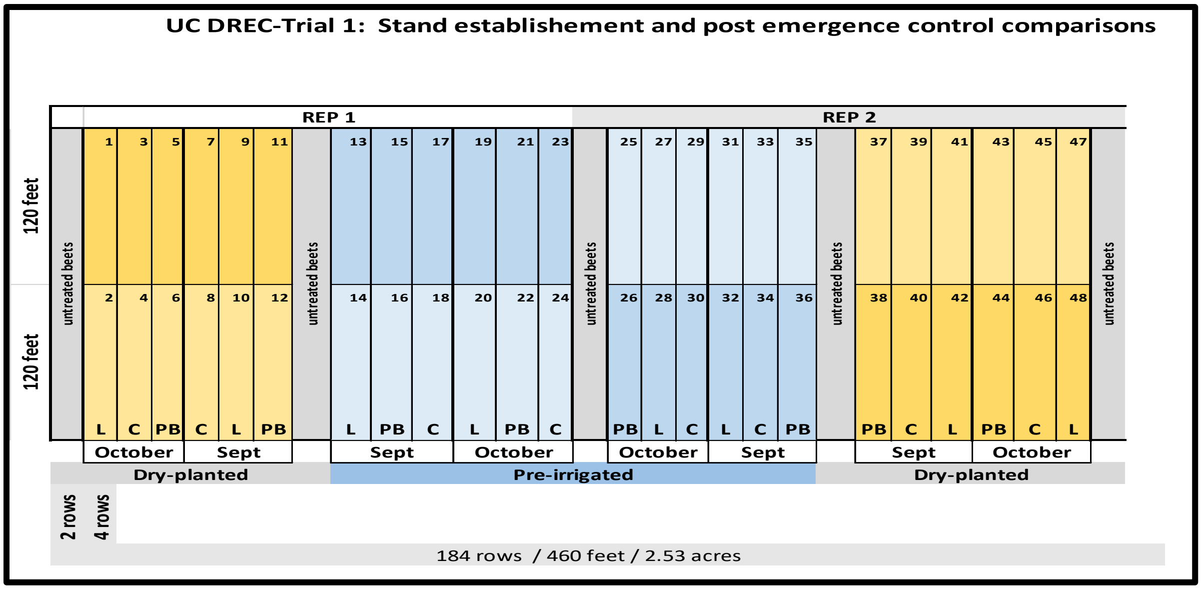

***Fig. 4.3**. Plot plan for trial one in 2020-2021 at the UC DREC site. Abbreviations used refer to common names of insecticides recognized by growers and PCAs. These are used for purposes of conveying results to these audiences. **L**: chlorpyrifos; **C or UTC**: untreated control; **PB**: clothianidin. Darker shaded plots received post emergence control (commonly Esfenvalerate), the lighter shaded plots were not treated. Treatment designs for trial one were similar in subsequent years.*

Granular, soil-applied chlorpyrifos was compared to seed treatments or an untreated control nested within main plots (***Fig. 4.3; Table 4.1***). In the second iteration of this trial in fall 2021 and fall 2022, an insecticide combination commonly used by grower cooperators (chlorantraniliprole[14] plus imidacloprid; COR+WR) was added for additional comparisons. After emergence, large plots were split again and controls applied for post-emergence protection If and when feeding damage was observed. The other half of the plot was left untreated. Esfenvalerate[15] was used, similar to practices commonly applied by grower-cooperators and their PCAs. The portion of the plots previously unsprayed in fall after establishment were left untreated during the remainder of the growing season, allowing for greater opportunity for insect damage than a standard pest control program would tolerate. Subplots (25 feet long) were harvested in June, to allow more time for insect damage to accumulate and have an effect on crop growth and yield. After harvest, the cumulative set of pest interventions was summarized and is reported.

In previous work on sugarbeet stand establishment in the Imperial Valley (REF), less insect damage was observed associated with later planting dates. There was also a tendency for increased emergence to occur. Temperatures (including soil temperatures-***Fig 4.4***) decline in fall with increasing Julian Day. The ideal temperatures for sugarbeet germination are approximately 74 to 85 Fahrenheit. Soil temperatures depicted in the graph are measured at six inches below the surface of a grass sward. Soil temperatures at the surface in bare soil are

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[14] An anthranilic diamide.

[15] A pyrethroid.

higher still, so temperatures in September commonly are above ideal. Arrows in Fig x. indicate approximate planting dates for DREC trials. Temperatures differ between dates by approximately 15 degrees F.

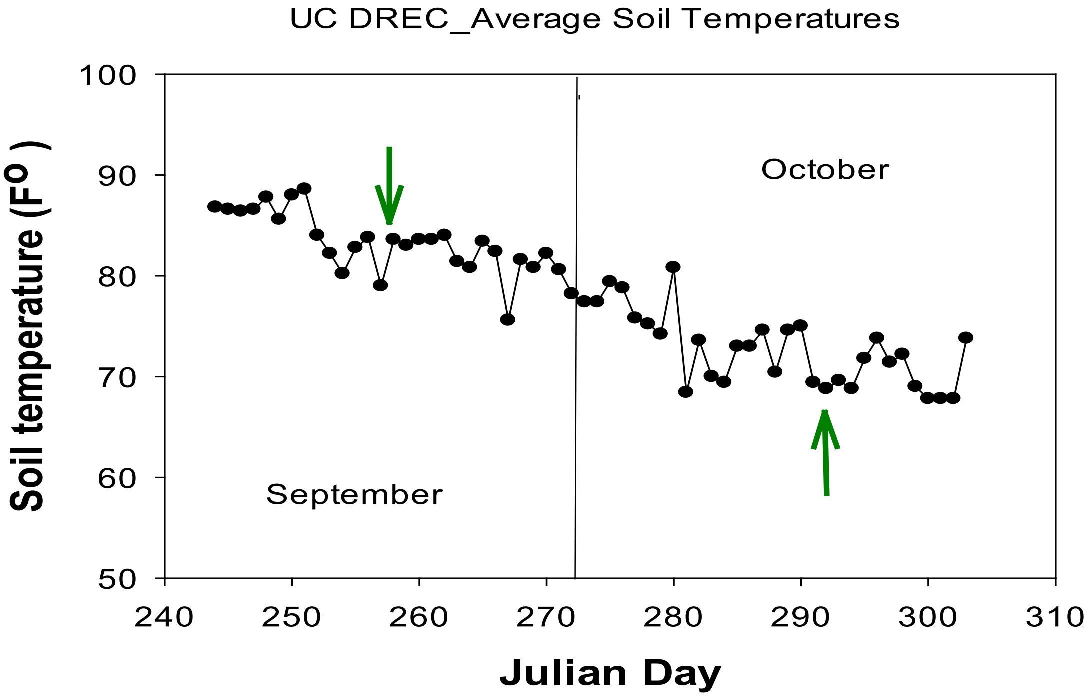

Fig 4.4*. Average measured soil temperatures (6 inches) at UC DREC in September and October (CIMIS data). Planting dates at the UC DREC site were mid-September and mid-October. Planting dates in growers' fields varied throughout the September-October period (Table 1).*

4.2.2. Tests of additional materials. Trial 2 at the UC DREC (2020-2021) focused on another material commonly used by grower-cooperators (chlorantraniliprole) and used a modified Latin Square design (***Fig 4.5***). These treatments included the seed treatment protocol from Trial 1 as a common element. All plots were surround by untreated beets to increase pest pressure, and as a source of data for untreated beets for comparison. One harvest was carried out, similar to trial 1. In year two (2021-2022) chlorantraniliprole was added to trial 1 to directly compare treatments in year 1 with current grower practices.

An additional trial was included in year two and modified and included again in **year 3 (fall 2022; see Table 1**) that screened selected bio-stimulants as a post-emergence treatment applied to seeds treated with clothianidin (discussed below). Bio-stimulant trials were not part of the original proposal, but were added as part of the larger effort to evaluate IPM alternatives to traditional pest management of beets in the Imperial Valley (Obj. 4).

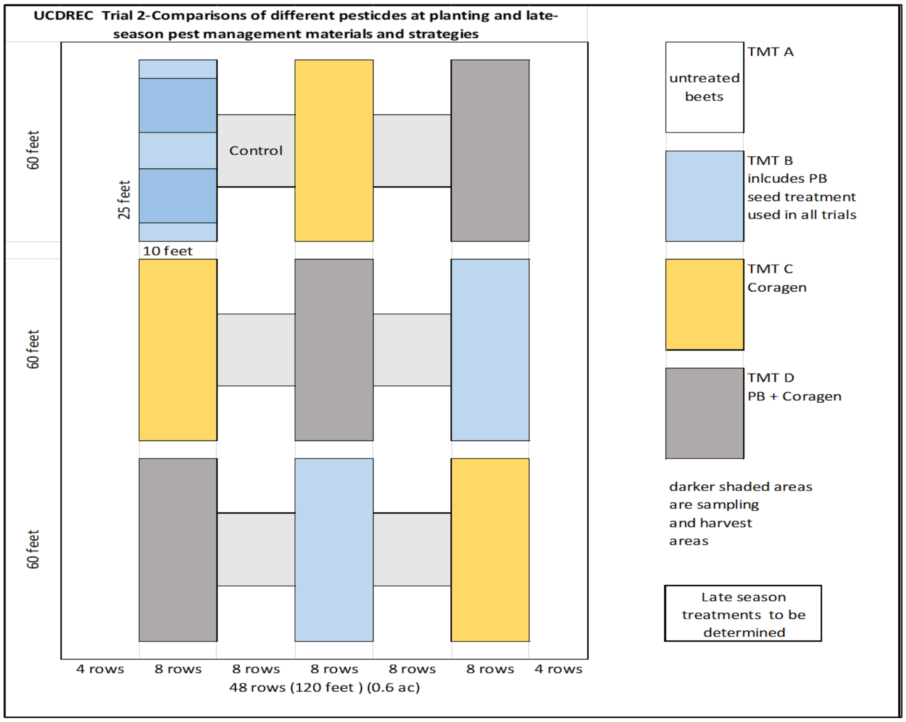

Fig. 4.5*. Plot plan for Trial 2 at UC DREC (2020-2021). PB: clothianidin seed treatment; COR: chlorantraniliprole soil treatment*

4.2.3. Trials in growers' fields. There were six trials in cooperating growers' fields over the two-year period, three each year (*Table 4.1, **Fig. 4.6***). A randomized complete block design was used in growers' fields with three treatment comparisons in most instances. Strips (plots) varied from 25 to 50 feet wide. The common practice used by each grower comprised the control, and seed treatments and combinations of seed treatments with growers' preferred practices were used as a third comparison. Post emergence controls in growers' field were applied at the discretion of their PCAs and common across all treatments. The experimental unit in growers' fields for intensive stand establishment observations were four to five 10 m (33 foot) long rows selected at random within each replicated treatment strip, depending on field length. Seedling numbers and the spacing between seedlings was measured in each subplot per replication. Twenty seedlings were collected at random in each subplot to compare seedling dry weights. Roots were removed to avoid soil contamination and to reduce variance associated with partial root loss when seedlings were removed.

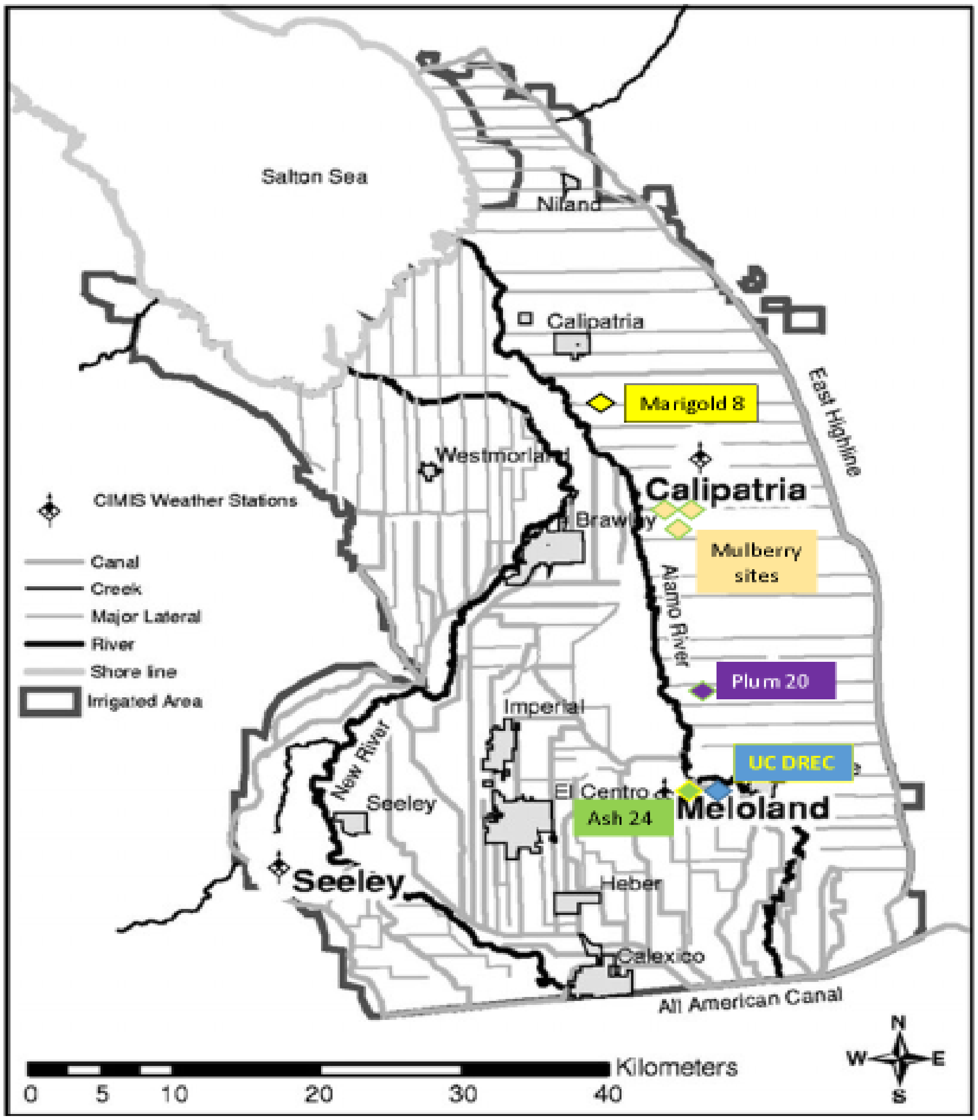

Fig. 4.6. Approximate location of research sites in the Imperial Valley

Map Source: https://www.researchgate.net/publication/241410912_Prediction_Accuracy_for_Projectwide_Evapotranspiration_Using_Crop_Coefficients_and_Reference_Evapotranspiration/figures?lo=1

For yield estimation, a truck load of beets was harvested within each strip (replication) (***Fig. 4.7***). The length of field harvested to fill the truck was measured and the number of rows (typically four 30-inch rows) used to estimate area. Depending on time of harvest and average yield, this area varied from 1/3 to ½ an acre per replication. Truck weights (approximately 20 tons) were determined at the Spreckels sugar factory and each load was sampled for root quality when weighed. Samples evaluated at the Spreckels Sugar tare lab.

All data were collected by the project leaders (PI and co-PIs) with the help of a full-time project staff research associate and staff assistants working for UCCE and at the UC DREC. Spreckels Sugar generously assisted with truckload data and sample quality analysis. Two PCAs working with cooperating sugarbeet growers provided input on project design and observations on field behavior for study sites. Pesticides were applied by licensed research personnel at the UC DREC and by farm personnel at study sites

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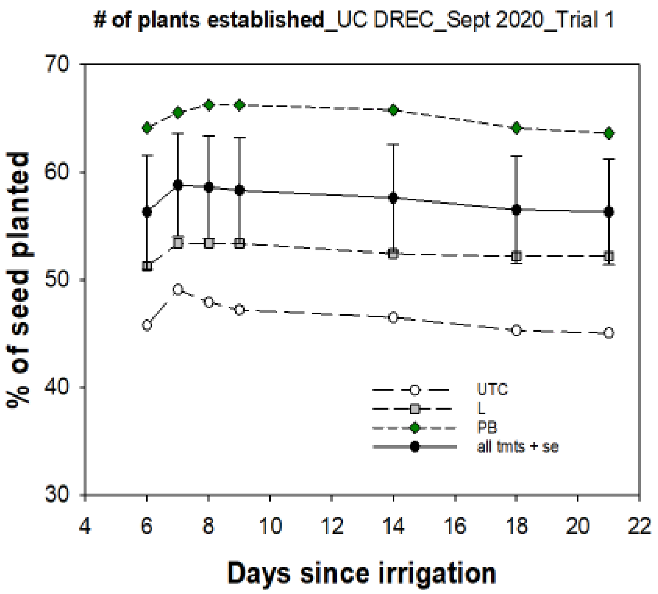
Fig. 4.7. *Harvest of field-scale plots in growers' field. Plot harvest at Ash 24, May 2021. Truckload weights from measured areas in the middle of large field plots were used in all cooperators' fields to determine yields associated with different treatments. Commercial harvest equipment was used. Trucks were weighed and sampled for quality at the Spreckels Sugar Factory in Brawley. This allowed for the detection of treatment differences, if any, at the scale of interest to IV sugarbeet growers.*

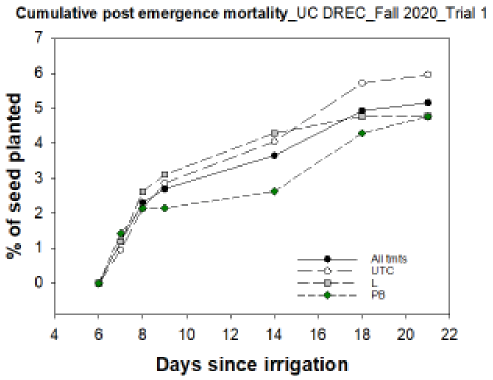
5.0 Results

Trials were conducted at the UC DREC each year during 2020-21, 2021-22, and fall 2022. Six trials were carried out in cooperating growers' fields during 2020-21 and 2021-22, three each year, at diverse locations (Table 1). Results are presented first by year and location (research station and growers' fields), and then analyzed and discussed cumulatively. Each year and location included a number of different conditions among cooperators' fields and at the UC DREC. Many farming practices and conditions varied among the grower cooperators, including irrigation, planting date, soil types and preferred pest management practices varied among the growers and their PCAs and between years in cooperators' fields. Adjustments in the pest management treatments evaluated also occurred at the UC DREC in response to suggestions from growers and PCAs and observations in the trials themselves. This provided a diversity of conditions under which to make observations, but also meant that pooling or combing data across sites and years presented inference and analytical challenges. Results are first presented for each year for trials at UC DREC, and then for growers' fields. Next insect observations are presented. Then analysis of data combined across years are presented and discussed where considered feasible. Final inferences combine both data analysis and judgement about how best to interpret pooled results. Lastly, pesticide risk is discussed.

5.1 Year one: 2020-2021 Growing Season

<u>5.1.1. UC DREC Location_Stand Establishment_Trial 1</u>. ***Figure 5.1*** shows data from the first planting date in the UC DREC trial. Untreated seed without plant protection was compared with chlorpyrifos (L), the traditional protective treatment used in the Imperial Valley, and with a neonicotinid seed treatment using clothianidin (PB). Irrigation treatments are combined in the figure. Plant numbers reached a peak at 6 to 8 days after the first irrigation and then declined slightly due to seedling loss. Post-emergence loss was a few percent of seed sown (4 to 6%) and is shown in *Fig. 5.1* as well. In general, post-emergence loss was a minor source of total mortality in this and all other trials that were part of this project. This is similar to observations from earlier work in the Imperial Valley and elsewhere in California. Average emergence for all treatments for the September planting date was 54 % (*Table 5.1*). Approximately 36 % of seed planted failed to emerge and establish plants. In this trial, the PB treatment supported the largest emergenc5e compared to the L and UTC treatments, and resulted in the lowest post-emergence loss. The PB treatment was significantly greater than the L and UTC means in the September planting, but differences were less in October (***Fig. 5.2***), reflecting more favorable conditions for sugarbeet germination and emergence. Variances in these data were large so differences in post emergence mortality were not significantly different.





Left: Number of plants established by days since the first irrigation. Right: **Cumulative post emergence losses.**

Fig. 5.1. *Emergence and establishment results, and cumulative mortality; September 15th planting date; Trial 1, UC DREC (2020-2021). UTC: untreated control, L: chlorpyrifos; PB: clothianidin + cyfluthrin. Error bar for all treatment is standard error.*

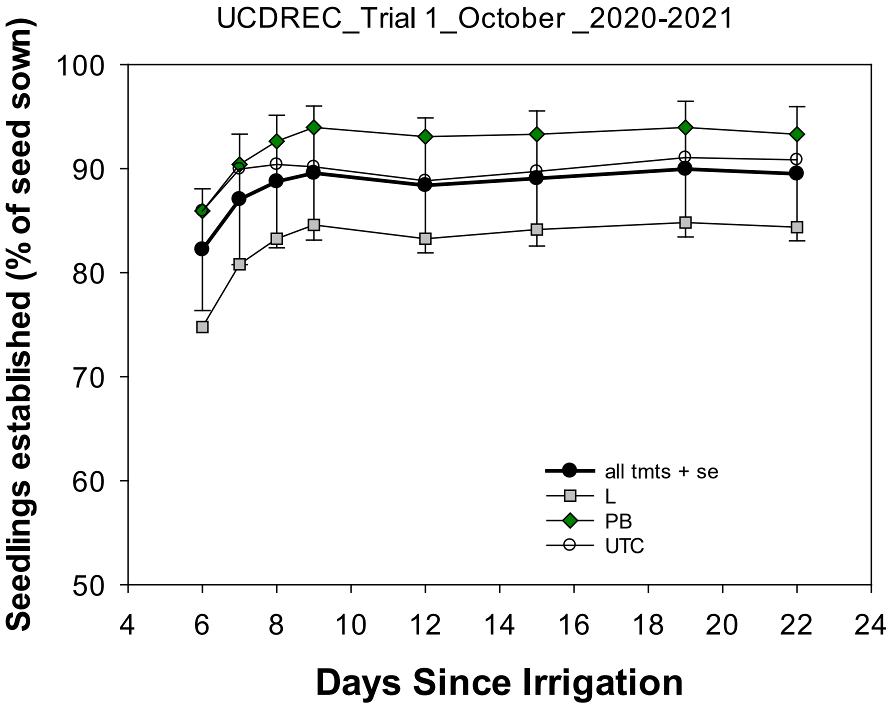


Fig.5.2. *Emergence and establishment results, and cumulative mortality; October 13th planting date; Trial 1, UC DREC (2020-2021). Error bars = standard error (treatment average)*

Figure 5.2 reports data from October 13th planted plots with similar treatments as the September panted plots. Overall emergence was 30 to 40 % larger in October than in September. At this date, the L treatment resulted in the lowest overall emergence, compared to UTC and PB treatments and PB resulted in the largest emergence. At 80 % emergence, the L treatment was still resulted in an excellent level of performance from a stand establishment perspective. There was almost no post-emergence loss (not shown).

Data in ***Table 5.1*** includes final plant spacing at the 8 to 12 leaf stage, sorted by treatments and planting dates. These data reflect the population of viable plants achieved in each set of treatments and are similar to the types of data collected in cooperating farmers' fields. They are a second type of measurement used to evaluate relative performance among treatments. These are compared to overall trial means for each planting date. We had hypothesized that pre-irrigation of plots would result in better seed bed preparation and more uniform moisture conditions for planting than seed planted into non-pre-irrigated plots. This was not observed at the UC DREC site at either planting date. Plant spacing and plant populations were significantly larger in dry planted plots at both planting dates. Based on spacing data, there were no differences among pesticide treatments at either planting date. Pesticide treatments were also non-significant at this site. Post-emergence insecticide treatments applied to half of each plot (*Fig. 4.3*) did have a significant effect on total populations. The most significant factor affecting stand establishment in fall 2020, however, was planting date, with a difference of approximately 2K plants per acre in treated plots. Total overall emergence was significantly greater in mid-October than mid-September. Experimental conditions at the UC DREC may have minimized the effects of IPM-focused treatments compared to growers' fields, which are much larger and more variable, and surrounded by commercial crops that may also harbor sugarbeet pests. Inference from small-scale plots at a research station to field-scale conditions must consider these differences.

Table 5.1*. Plant spacing and final emergence and establishment (%) for September and October planting dates. UC DREC (fall 2020). Itmt = pre-irrigation (Pre-I) vs no pre-irrigation (Dry); Post emergence = use of esfenvalerate after emergence vs no use. C: untreated control; L: chlorpyrifos; PB: clothianidin.*

DREC Trial 1 (2020)_September planting date_ Final spacing at establishment_(Values are inches)								
Measure	**overall**	**by Itmt**		**By pesticide tmt**			**Post emerg tmt**	
		Dry	**Pre-I**	**C**	**L**	**PB**	**Y**	**N**
AVE	**7.3**	**7.2**	**7.4**	**7.1**	**7.3**	**7.5**	**7**	**7.6**
SD/SE	5.2/0.15	5.2/0.21	5.3/0.2	4.4/0.21	5/0.24	6.2/0.3	4.9/0.24	5.6/0.18
plants/ac	**28600**	**29000**	**28220**	**29410**	**28600**	**27840**	**29830**	**27470**
% emerg	**54**							
DREC Trial 1 (2020)_October planting date_ Final spacing at establishment_(Values are inches)								
AVE	**4.2**	**3.9**	**4.5**	**4.2**	**4.2**	**4.1**		
SD/SE	3.4/0.05	2.7/0.05	4/0.09	3.9/1.0	3.2/0.08	3/0.08		
plants/ac	**50130**	**53700**	**46620**	**49870**	**49340**	**51270**		
% emerg	**95**							

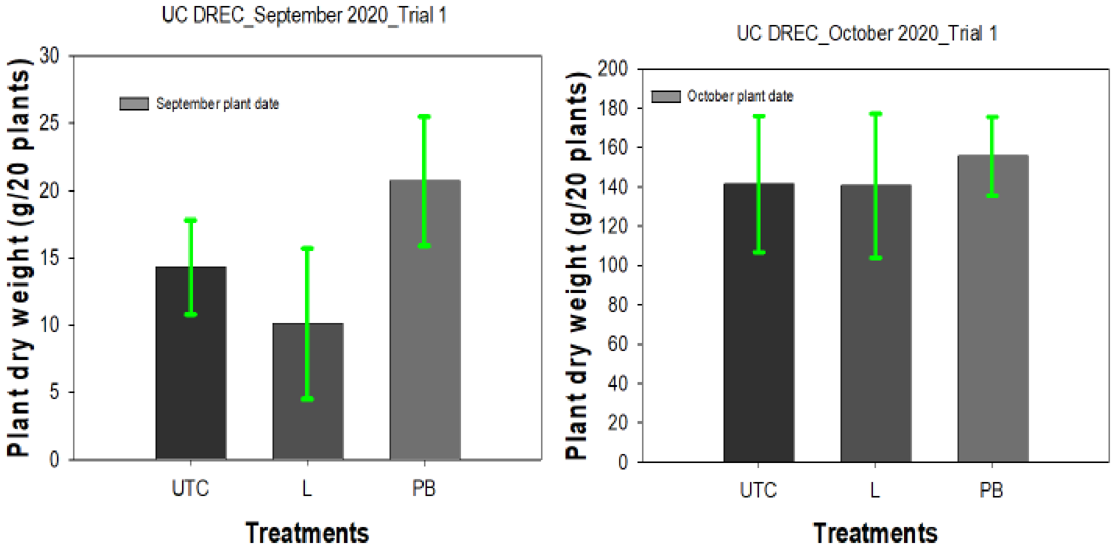


Fig. 5.3. *Seedling dry weights in Trial 1, UCDREC fall 2020. Left: September 15 planting dates; collected at 30 days post-emergence. Right: October 16 planting date; collected at 45 days post-emergence. Error bars are standard deviations.*

Figure 5.3 includes data on seedling dry weights harvested from plots. Twenty plants per plot were collected at random and roots cut off at the crown (*Fig. 4.1*). Post-emergence treated and untreated plots are combined in this data. Seedling dry weights should reflect variable levels of damage and the effectiveness of treatments if post-emergence damage was occurring. PB treated seeds were larger in the September planting date compared to the L treatment, but no differences were observed at the October planting date. In the October planted plots, no post-emergence treatment was applied due to a lack of any observed insect activity after seedlings emerged in late October. Large differences in seedling dry weights between September and October reflect differences in the number of days of growth when seedlings were collected (September = 30 days; October = 45 days) and in growing conditions.

At both planting dates, using several sources of comparison, PB treated seed was at least equivalent, if not superior to L treatments in this first set of trials at UC DREC as a plant protection strategy. These data suggest, however, that under more favorable conditions (October), the need for insecticides is less, and minimal treatments like PB seed treatment, may be sufficient.

Yields for trial 1 (harvested June 30-July1) are reported in **Tables 5.2 to 5.4**. Similar to fall establishment data, there were no significant treatment differences apart from planting data effects. Yields were lower in plots that had one month less time to grow. Irrigation treatments in fall did not result in significant differences in root and sugar yield the following summer.

Similarly, post emergence treatment in fall did not confer a yield advantage the following summer.

Table 5.2. *Insecticide treatments and root yields and quality at harvest (UC DREC_trial 1_2020-2021)*: C-untreated control; L-chlorpyrifos; PB-clothianidin.

DREC_2021_Pesticide contrasts				
(planting dates combined)				
Treatments	**Root yld**	**Sugar %**	**Sugar yld**	**% rotted**
	(t/ac)		*(lb/ac)*	
C	**49.4**	**16.4**	**16180**	**4.9**
(SD)	*9.96*	*0.51*	*3340*	*3.5*
L	**50.2**	**16.2**	**16220**	**6.6**
	7.74	*0.82*	*2360*	*6.1*
PB	**52**	**15.9**	**16560**	**4.7**
	6.47	*0.78*	*2150*	*3.7*
September planting				
C	**53.1**	**16.3**	**17340**	**5.2**
	12.5	*0.5*	*4190*	*3.6*
L	**53.5**	**16.2**	**17310**	**9.5**
	8.3	*0.7*	*2680*	*7.6*
PB	**54.9**	**16.2**	**17870**	**4.4**
	2.7	*0.4*	*955*	*4.2*
October planting				
C	**45.7**	**16.4**	**15025**	**4.6**
	5.1	*0.6*	*1820*	*3.6*
L	**46.8**	**16.2**	**15130**	**3.7**
	5.8	*1*	*1440*	*2*
PB	**49.1**	**15.6**	**15240**	**5**
	7.9	0.9	2240	3.5

Root and especially sugar yields did not vary significantly among pesticide treatments applied at planting by the time roots were harvest 9 months later in mid-June, 2021 (*Table 5.2*). Plants grew through modest differences among treatment differences observed in fall 2020. Planting date mattered, with September-planted crops having more time to develop than plots planted a month later. This was expected and is commonly observed. With respect to yield, PB treated seeds were comparable to the previously standard chlorpyrifos treatment (L), but even untreated seeds resulted in equivalent yields after modest thinning in late fall to regularize spacing and subsequent management due to approximately similar plant populations established in fall (*Table 5.1*).

Irrigation treatments were included as a potential IPM practice. We compared pre-irrigated plots to non-pre-irrigated plots under the assumption that pre-irrigation would create a more uniform soil moisture environment and also facilitate improved seed bed preparation (***Table 5.3***). Improved conditions for germination and emergence might, in theory, reduce the need for pesticides to protect against losses by increasing the rate of seedling emergence and early growth, the better to avoid or withstand damage. Pre-irrigation, however, did not provide any advantages in this trial under the conditions occurring at the UC DREC. Within the relatively small plots used at the UC DREC (*Fig. 4.3)*, there were likely fewer differences in soil quality affecting soil moisture and germination conditions (like salinity) than occur in much larger growers' fields. Short furrow runs allow for uniform water application compared to up to ½ mile long furrows in commercial fields. These conditions may have limited our ability to create conditions similar enough to growers' fields to adequately reflect any benefits from pre-irrigation. Differences would have to be large at this scale to infer treatment benefits but were not observed.

Table 5.3: *Irrigation treatment effects on yields and root quality (UC DREC_trial 1_2020-2021)*

DREC_2021_Irrigation treatments				
(planting dates combined)				
Treatments	**Root yld**	**Sugar %**	**Sugar yld**	**% rotted**
	(t/ac)		*(lb/ac)*	
Dry Planted	**52**	**16.2**	**16770**	**4.4**
(SD)	*8.4*	*0.9*	*2680*	*3*
Pre-irrigated	**49.1**	**16.2**	**15870**	**6.4**
	7.7	*0.6*	*2525*	*5.6*

Table 5.4: *Post-treatment control effects on yields and root quality (UC DREC_trial 1_2020-2021_September date only). Esfenvalerate was used for treated plots after emergence.*

DREC_2021_Post-emergence pesticide treatments				
(September)				
Treatments	**Root yld**	**Sugar %**	**Sugar yld**	**% rotted**
	(t/ac)		*(lb/ac)*	
Y	**51.6**	**16.3**	**16805**	**5.1**
(SD)	*8.9*	*0.4*	*2840*	*3*
N	**54.1**	**16.2**	**17550**	**7.7**
	7.3	*0.7*	*2605*	*7.8*

Differences in post-emergence insect damage was observed in fall 2020 at the UC DREC (*Table 5.1; Fig. 5.3*). By the time harvest occurred, however, any benefits from treatments the previous fall were no longer observable (***Table 5.4***). This suggests that some constraint on the use of post-emergence insect control should be possible in commercial fields when seedlings have grown past their most vulnerable stages, provided armyworm damage is absent or modest. This would be especially true for later planted fields (October). No post-emergence treatments were applied in the October-planted plots in this trial (*Table 4.1*). There was no insect activity observed at that time which required treatment.

5.1.2. UC DREC_Trial 2-2020-2021. A second trial in fall 2020, planted in September simultaneously with Trial 1, evaluated the effects of using chlorantraniliprole (COR) to support stand establishment. COR was widely adopted by growers as a substitute for chlorpyrifos to support stand establishment in the IV after chlorpyrifos was restricted. The use of COR was not part of the original experimental design in Trial 1. To evaluate its effects, we compared COR treated plots with untreated plots and plots using PB treated seed (**Fig.5.4 and Table 5.5**).

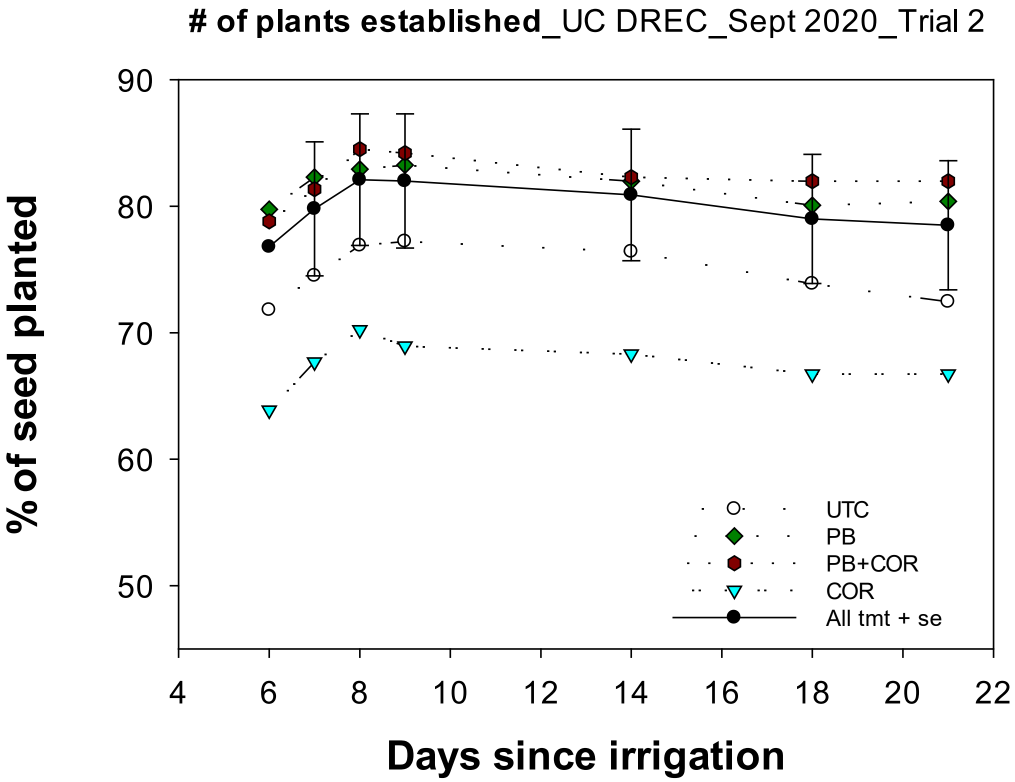


Fig. 5.4. *Chlorantraniliprole effects on seedling emergence and establishment. UC DREC_trial 2_2020-2021. UTC: untreated control; PB: clothianidin seed treatment; PB+ COR: PB + chlorantraniliprole; COR: chlorantraniliprole. All tmts: average of all treatments by DSI; error bars are standard errors.*

In this trial, emergence and final establishment (at DSI=21 days) was improved by the use of PB treatments, either alone or in combination with COR (***Fig. 5.4)***. Data in *Fig. 5.4* are from labelled seedlings marked as they emerged. The use of COR alone reduced establishment.

Similar to trial 1, seedling spacing at the 8 to 12 leaf stage was also measured in the different treatments as an additional method of comparison among treatments (***Table 5.5*** and ***Table 5.6).*** Treatments including PB resulted in improved stand establishment and larger plant populations compared to untreated plots, similar to the results observed for September in trial 1 (*Table 5.1*). Significantly smaller levels of emergence occurred in plots receiving only COR as a soil treatment. COR is not thought to be effective against flea beetles and other soil insects. Its use with PB treated seed added no advantage. Spacing measurements were converted to percent estimates for ease of comparison with growers' fields results where seedlings were not marked or observed daily during emergence in ***Table 5.6***. Results were similar to those resulting from the marked seedling data.

Table 5.5*. Plant populations and emergence in the chlorantraniliprole focused trial (UC DREC_Trial 2_2020-2021).*

UC DREC_Trial2_Sept 2020_Chlorantraniliprole comparisons on plant spacing (inches)and popluations (per acre)					
	Overall	**UTC**	**PB**	**COR**	**COR+PB**
AVE	**4.6**	**5.45**	**3.63**	**5.33**	**3.84**
sd	3.34	3.37	2.44	3.97	2.47
Mode	**2.36**				
Plants/ac	**45550**	**38280**	**57410**	**39190**	**54360**
% established	**51.5**	**43.3**	**65.1**	**44.3**	**61.4**
Data in inches or plants/ac; based on distances between seedling (n=2253); % of seed planted; UTC= untreated; PB: clothianidin					

Table 5.6*. Comparisons of plots with and without chlorantraniliprole on percent seedling emergence (UC DREC_Trial 2_2020-2021).*

Trial2-Yr 1: Chloranitriniprole effects			
Insecticide tmt	**Cumulative emergence**	**Cumulative Mortality**	**Established plants**
All tmts	**87.1**	**7.67**	**79.5**
SD	15	2.45	16.1
UTC	**86**	**9**	**77**
	12.3	2.33	12
PB	**91.7**	**6.3**	**85.3**
	18.9	1.11	19.8
COR	**78.7**	**7**	**71.7**
	15.6	1.33	14.9
COR+PB	**93.3**	**7**	**86.3**
	16.4	4.67	19.1

Seedlings were collected for dry weight determination at the same time as spacing data was collected (***Fig. 5.5***). Dry weights were largely similar due to large variance among seedlings, but there was a tendency for COR treated plot to produce smaller seedlings. Despite having no effect on emergence, the combination of PB+ COR produced slightly larger seedlings.

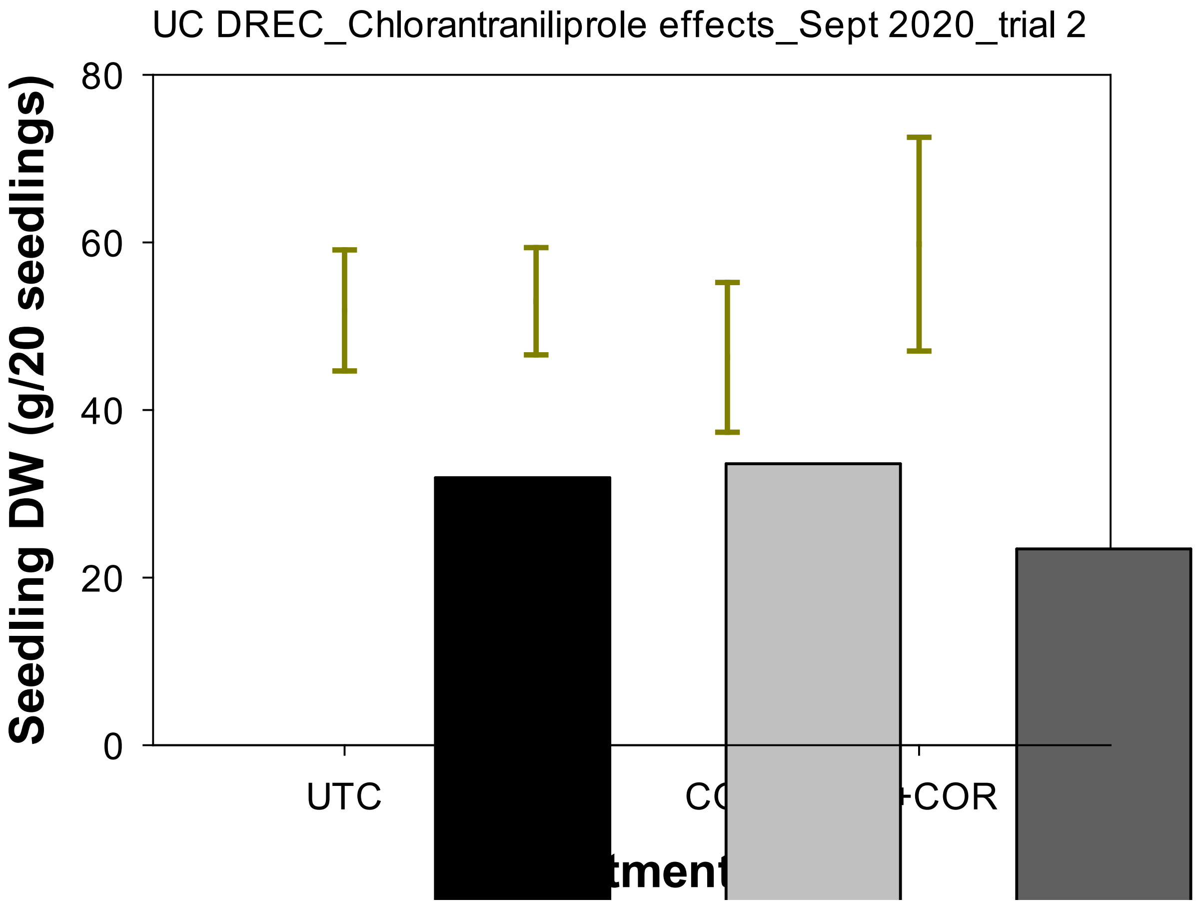


Fig 5.5. *Seedling dry weights. Error bars are standard deviations.*

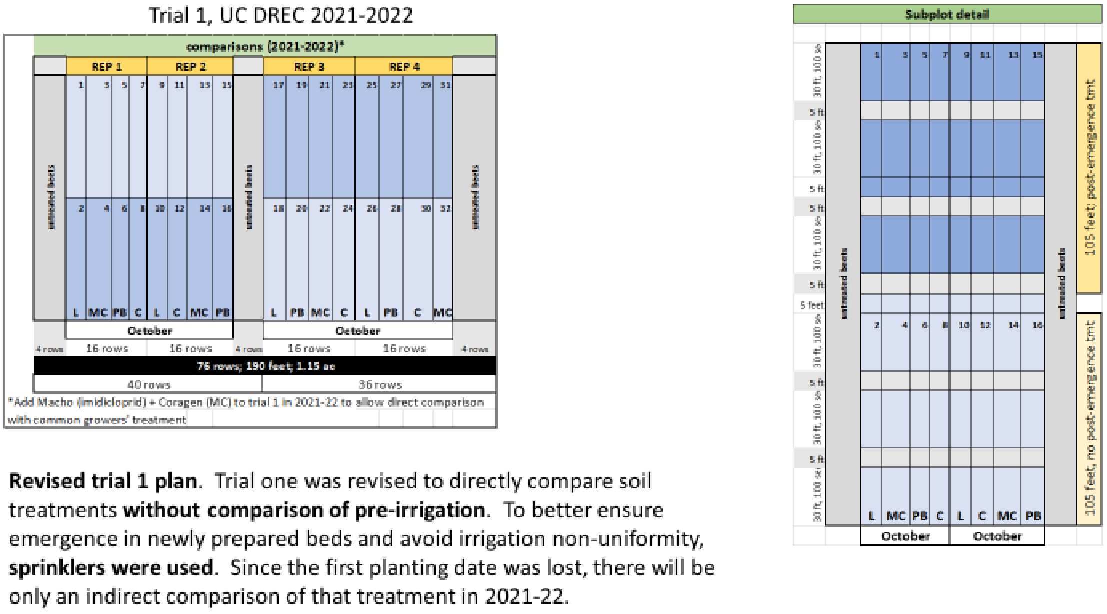
The following June, root yields were collected and analyzed for root quality (***Table 5.7***). There was no apparent benefit to using chlorantraniliprole (COR) in this trial with respect to root and gross sugar yield. Similar to trial 1, plants outgrew treatment differences in fall. Yields were similar to October-planted plots due to similar planting times. PB treated plots resulted in lower yields, but differences were not significant. It is unclear why this occurred. Because of differences in sugar %, sugar yields followed a different ranking. Growers are paid on a sugar basis.

Table 5.7. *Root and gross sugar yields (UC DREC_Trial 2_2020-2021)*

UC DREC_Trial 2_2020-21			
Treatment	Root yield t/ac	% sugar %	Gross sugar lb/ac
UTC	40.86	17.53	14290
sd	6.7	0.93	2150
PB	35.2	17.94	12670
sd	6.56	0.91	2640
COR	40.55	17.74	14350
sd	4.64	0.75	1210
PB + COR	38.15	17.59	13500
sd	4.44	1.27	2450

5.2. Year Two: 2021-2022 Growing Season

5.2.1. UC DREC Trial 1_Year 2: Four trials were planted at the UC DREC and three grower cooperators participated in evaluating alternative stand establishment practices complimenting the UC DREC trials. The first trial at UC DREC was similar in design to the trial in year one, with the addition of chlorantraniliprole (COR) plus imidicloprid (M) as a soil treatment at planting, consistent with growers' practices. Pre-irrigated and dry planted beds were created and both September and October planting dates were to be compared. The first plots were planted in mid-September, similar to year one. However, due to poor seedbed and soil conditions, uneven planter performance, and resulting uneven irrigation effects, the UC DREC trial was abandoned. Staffing at the UC DREC was affected that year by Covid limitations and these may have contributed to inadequate site preparation. After discussion with station staff, the research site was moved to a different station location for the mid-October planting. Pre-irrigation comparisons were no longer possible due to a lack of time between field preparation and planting. Similarly, land grading was not possible so furrow irrigation was judged to be risky. Sprinklers were used instead to overcome potential irrigation irregularities, and seed was planted in 100 seed lots using a cone planter to overcome unevenness in planter performance. Sprinklers were used for stand establishment in four of the growers' fields used in this set of trials and is increasingly common in the Imperial Valley. The planting plan is given in ***Fig. 5.6***. The October trial proved successful.



Revised trial 1 plan. Trial one was revised to directly compare soil treatments **without comparison of pre-irrigation**. To better ensure emergence in newly prepared beds and avoid irrigation non-uniformity, **sprinklers were used**. Since the first planting date was lost, there will be only an indirect comparison of that treatment in 2021-22.

Fig. 5.6*. Revised plot plan for trial 1, UC DREC_2021-2022*

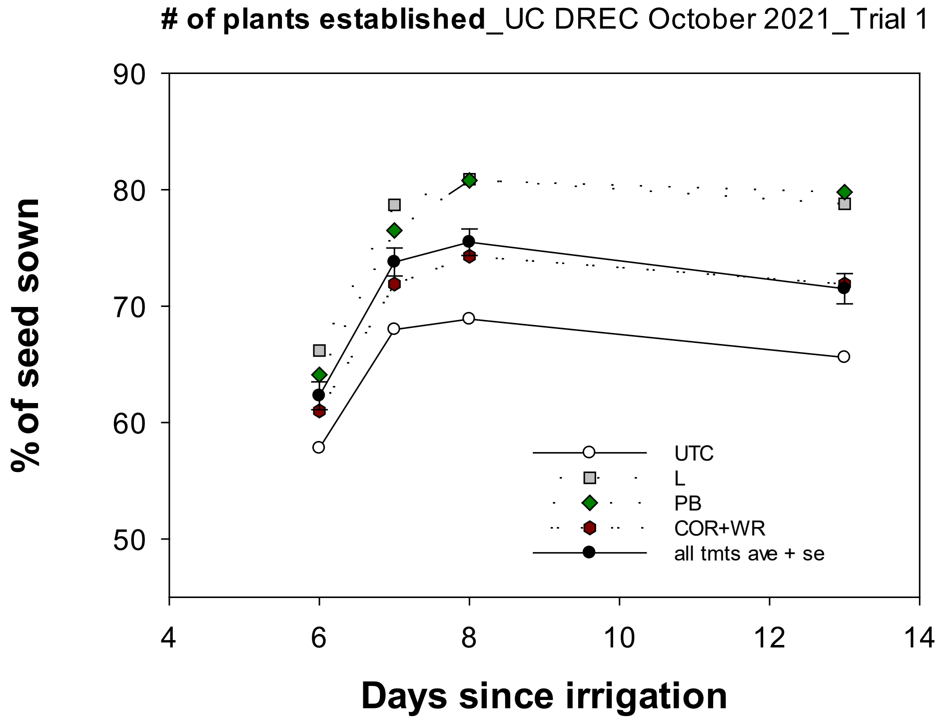


Fig. 5.7*. Seedling emergence and establishment. UC DREC-Trial 1, 2021-2022****.*** *All treatments average + standard error.*

Fig. 5.7 presents data on seedling emergence and establishment in Trial 1 at the UC DREC in year two of this project based on the revised plot plan in *Fig. 5.6*. Average emergence and establishment for all treatments combined were greater than 70 % in October. The PB and L treatments had similar and significantly larger rates of emergence and establishment. The COR +WR[16] treatment (chlorantraniliprole + imidacloprid) had fewer emerged and established seedlings. UTC plot had the smallest level of emergence and establishment indicating pre-emergence loss to insect pests that were not controlled. All treatments reflect good to excellent establishment, consistent with results in year one for October planted plots (*Fig. 10*). Because a cone planter was used with 100 seed plots (results = percent emergence), no spacing data were collected.

Fig. 5.8 reports seedling dry weights. The two treatments using neonicotinid insecticides (PB and COR+WR) resulted in the largest seedling dry weights at the 8 to 12 leaf stage. The chlorpyrifos treatment (L) resulted in the smallest seedling weights in this trial. Variance among untreated plots was larger than other treatments, indicating the variability associated with insect presence and predation that likely characterizes fields.

Table 5.8 includes yields from Trial 1 harvested at the end of June, 2022. Plots were thinned in fall after establishment to allow for uniform spacing, a compromise required by the use of a cone planter, so populations were approximately similar across all treatments. Most root and sugar yields were similar except for the COR+WR treatments, which were larger. Given that seedling emergence and establishment were similar (*Fig. 5.7*) and that plots were uniformly thinned in fall, this difference in yield is unexplained.

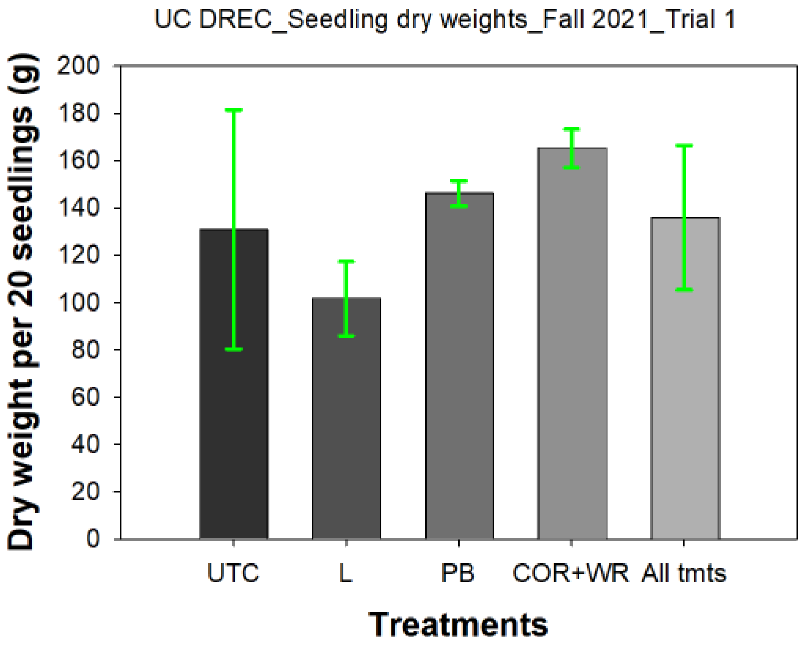


Fig. 5.8. *Seedling dry weights at 8 to 12 leaf stage. UC DREC-Trial 1, 2021-2022.*

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[16] In Fig 5.6, imidicloprid is labelled as M, but is identical to WR.

Table 5.8. *Root and sugar yields, UC DREC-Trial 1 (2021-2022, June).*

Treatment		Root yield (t/ac)	% sugar	Sugar yield lb/ac	Root wt (lb/root)
All tmts	**Ave**	**62.8**	**16.94**	**21260**	**9.86**
	SD	8.7	0.67	2910	1.8
UTC	**Ave**	**60.8**	**16.98**	**20605**	**9.35**
	SD	9.4	0.78	3030	2.3
L	**Ave**	**60.4**	**17**	**20550**	**9.24**
	SD	7.25	0.56	2420	1.36
PB	**Ave**	**62.74**	**16.88**	**21190**	**9.89**
	SD	8.6	0.74	2960	1.61
COR +WR	**Ave**	**67.3**	**16.88**	**22700**	**10.86**
	SD	8.3	0.74	2816	1.39

5.2.2. UC DREC Trial 2_Year 2. Two companion trials were also planted and observed: one focused on the efficacy of chlorantraniliprole (COR) as a soil treatment compared to PB treated seed (***Fig. 5.9***), the second on the effects of bio-stimulants on seedling growth after emergence (***Fig. 5.12***). COR was commonly used by cooperating PCAs and growers in last year's trials. This trial focused more narrowly on the benefits, if any, of COR when used with PB seed treatments (clothianidin). COR is applied for armyworm control primarily, since growers commonly apply post-emergence insect controls, COR at planting may not be necessary.

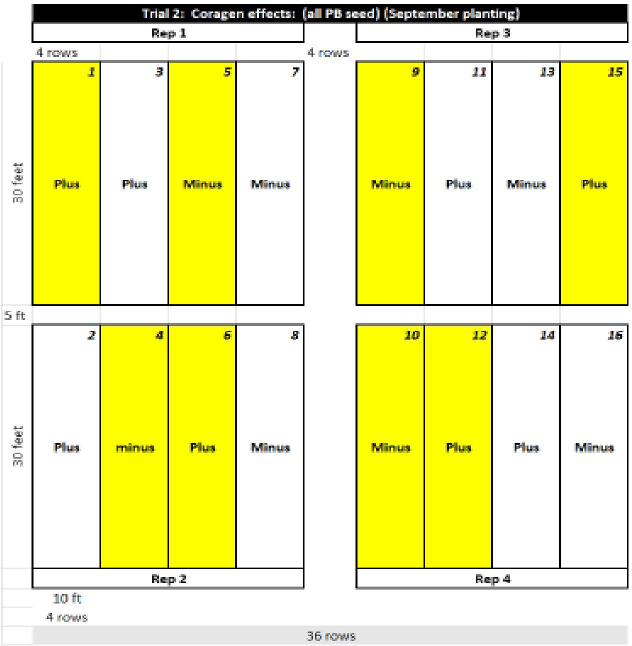


Fig. 5.9. *Plot plan for chlorantraniliprole comparisons with PB treatments. UC DREC Trial 2, 2021-2022. Plus includes chlorantraniliprole and PB seed, Minus includes only PB treated seed.*

Fig. 5.10 reports results for seedling emergence and established for trial 2. There was no difference and no benefit from adding COR as a pre-plant soil treatment in this trial. Seedling dry weights were also similar, though there was a non-significant increase in dry weight in the absence of COR use. This was similar to previously observed results in trial 2 in fall 2020 (*Fig. 5.5).*

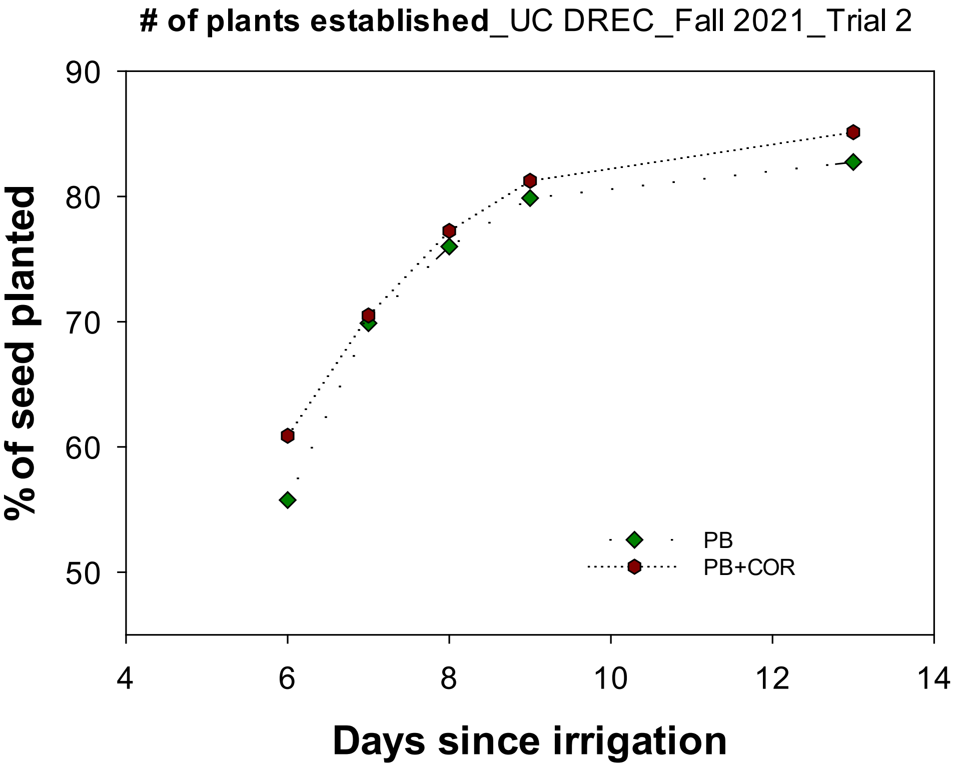


***Fig. 5.10**. Comparison of PB treated seed with and without COR soil treatments. Trial 2, 2021-2022. PB: clothianidin seed treatment. COR: Chlorantraniliprole soil treatments*

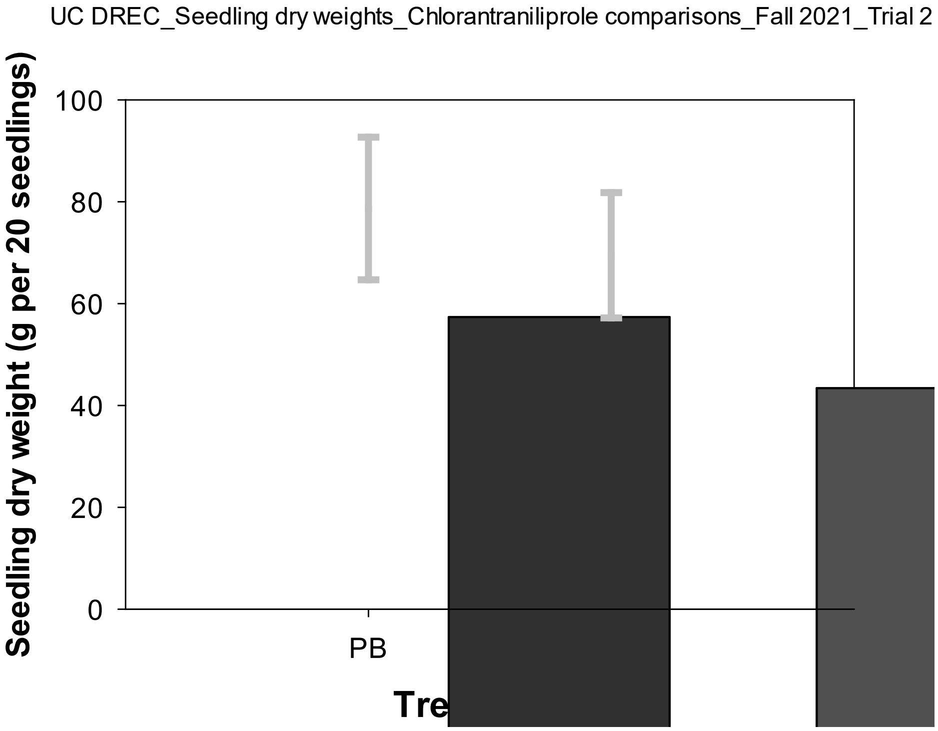


Fig. 5.11. *Seedling dry weights for COR comparisons. Trial 2, 2021-2022*.

5.2.3. Bio-stimulant Trial (UCDREC-year 2). A trial comparing bio-stimulants was added (**Obj. 4**) to test whether any of these materials would help sugarbeet seedlings escape or overcome insect damage (especially post-emergence) through increased growth and vigor resulting from the treatments (***Fig. 5.13***). Biostimulants are thought to improve plant growth by providing nutrients and phytoactive compounds to accelerate growth and development. If successful, they may act as substitutes for traditional pesticides, or at least reduce their use. Materials were applied to seedlings shortly after emergence. Plants were evaluated for damage and seedlings collected and weighed (dry matter) to compare growth. All treatments used PB treated seed.

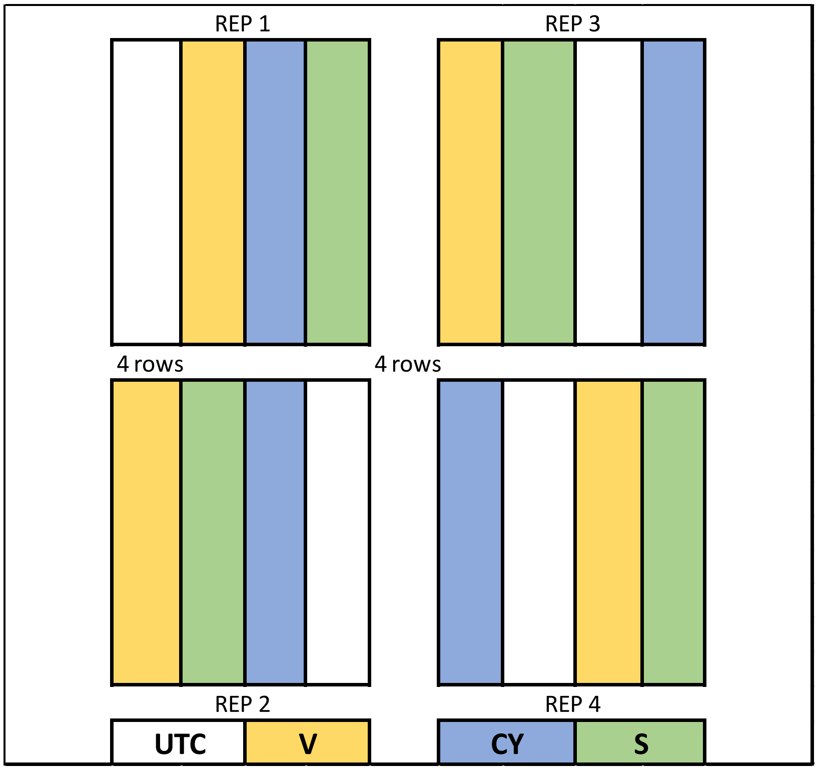


***Fig. 5.12**. Plot plan for bio-stimulant treatment comparisons. UC DREC_Year 2_2021-2022. Materials were applied shortly after full emergence. All treatments used PB-treated seed. Materials described in Table 5.9.*

***Table 5.9**. Bio-stimulant materials tested in trials in fall 2021 and fall 2022. All seed were treated with clothianidin.*

Biostimulant materials	
Treatment	**active ingredient(s)**
V	Brassinosteriod, triacontanol, glcosides, B vitamins
S	Seasweed extract & soluble potash fron *Ascophyllum nodosum*
CY	Algae extract, soluble potash, hydrolyzed vegetable proteins
UTC	no biostimulant

Average seedling dry weights after establishment were increased marginally by two of the treatments (C or CY, and S), but not significantly compared to the use PB seed treatments alone

(***Fig. 5.13***). Fall applied (October) treatment differences did not carry through to the next summer at harvest in late June (***Fig. 5.14***).

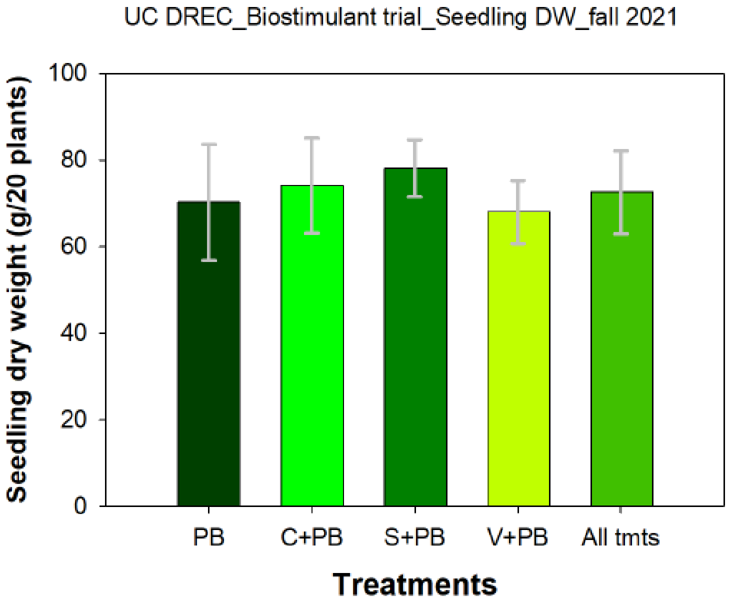


Fig. 5.13*. Seedling dry weights from bio-stimulant trial. Average of 20 seedlings per plot. UC DREC_Year 2_Fall 2021. PB = control (UTC) in Fig. 5.13. Error bars are standard deviations.*

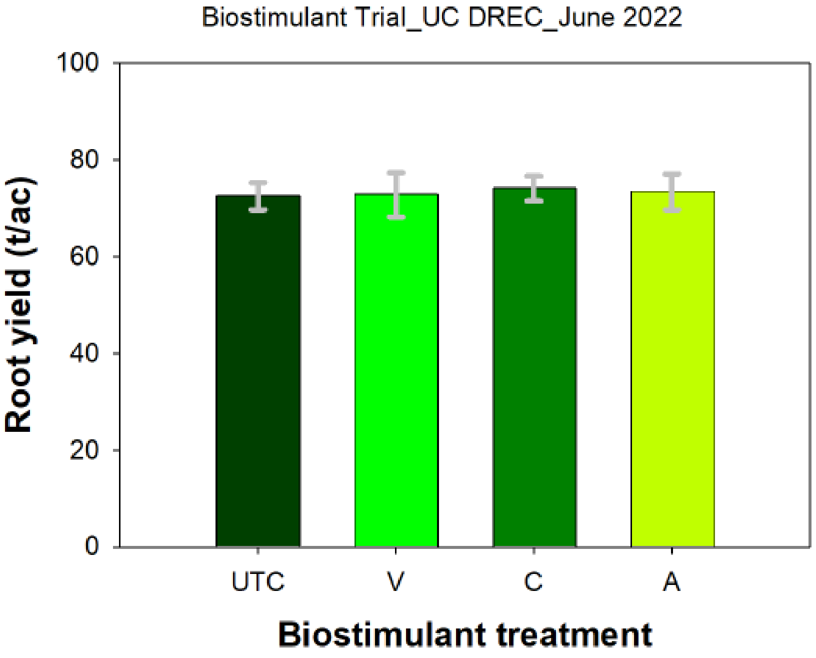


Fig. 5.14. *Root yields at harvest in June 2022, from bio-stimulant trial_UC DREC_Year 2. Average of four 25- foot, two-row plots.*

Year 3: Fall 2023

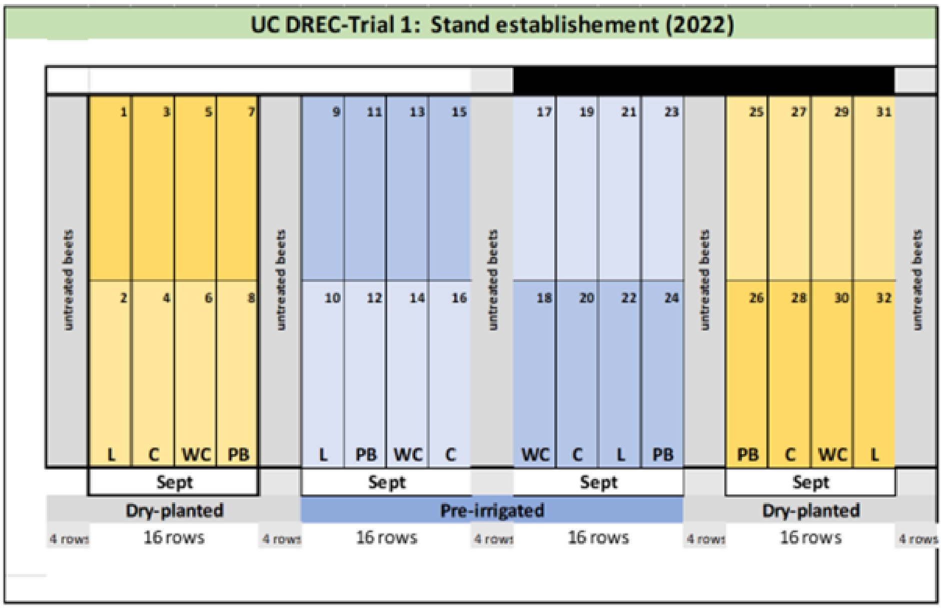


__Fig. 5.15__. Plot plan for trial 1_UCDREC_Fall 2022_Yr 3. This trial replaced the abandoned September trial in year two. C: untreated control; L: chlorpyrifos, PB: clothianidin seed treatment, WC: imidicloprid + chlorantraniliprole. Darker shaded areas received post emergence treatment with esfenvalerate. Lighter shaded areas received no post-emergence treatments.

5.3.1. Trial 1-year 3. ***Fig. 5.15*** is the plot plan for the trial 1 September planting date carried over from year two. This trial was planted in Fall, 2022 to replace the missing September trial from the previous year and provides a second replication at the UC DREC site of earlier planting dates. This is the second replication of September planted Trial 1. Emergence and establishment results are depicted in ***Fig. 5.16***. PB treated seed emerged and established at a significantly larger amount than UTC and COR+WR treatments. Similar to trial 1 in fall 2021 and to trial 2 in both fall 2020 and fall 2021, there was no advantage to using COR as a soil treatment even when combined with a soil-applied neonicotinid material (imidacloprid, WR) used as a soil treatment. Emergence was reduced compared using PB seed treatments suggesting that the immediate effects (absorption) of PB into seedling tissues resulting from application to seed coatings was more advantageous than waiting for absorption from soil applications of a similar type of insecticide (WR). Emergence rates were largely similar to September planted trial in year 1 and lower than both October-planted trials. Also like that trial, there was little to no post-emergence seedling loss.

There was no advantage, but an apparent disadvantage, from pre-irrigated plots in this trial (***Table 5.10***), similar to results in September 2020. All plots were furrow irrigated, but pre-irrigated plots were watered in August prior to final bed preparation. It was hypothesized that this would improve bed preparation and soil conditions for planting and improve the availability of moisture for seedlings, thereby acting as an IPM practice. It did not prove helpful under UC DREC conditions and appeared to be a disadvantage. It is not clear why this difference occurred. ***Table 5.11*** provides average seedling dry weight values for post-emergence treated or untreated plots. There were no differences between treatments at this site and year. These results were similar to results from year 1 (*Table 5.4*).

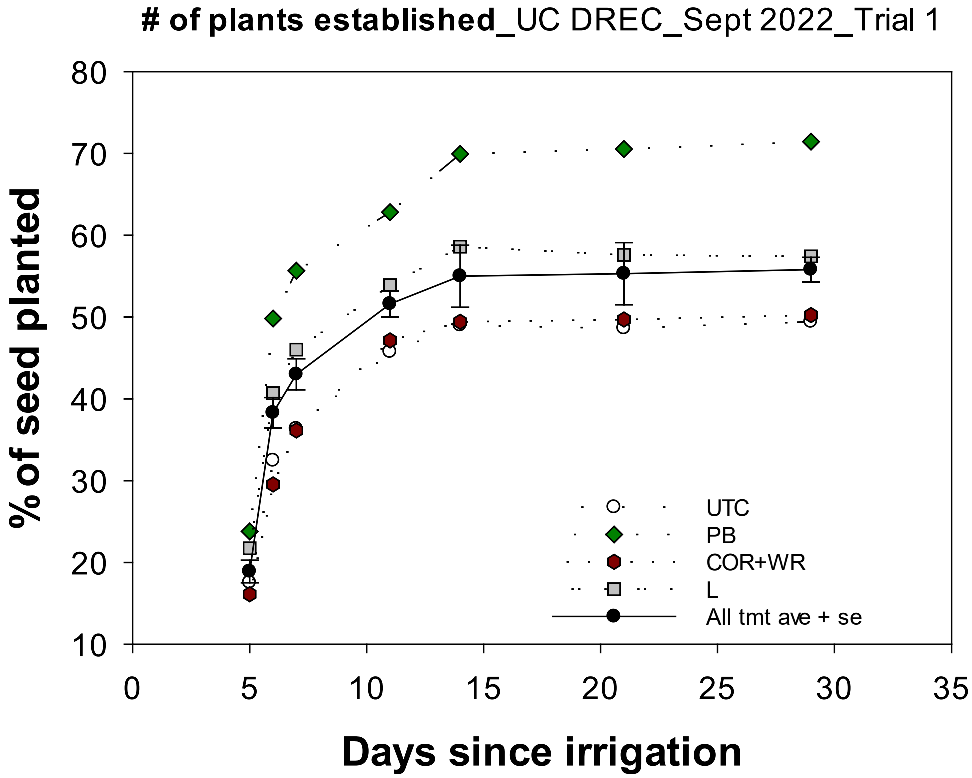


Fig. 5.16. Seedling emergence and establishment in September, 2022 at the UC DREC site.

Table. 5.10*. Cumulative emergence and cumulative establishment (% of seed sown) compared by irrigation treatment (UC DREC_Fall 2022_yr 3). DSI = days since initial irrigation.*

Irrigation effects_UC DREC_Trial 1_September 2022				
DSI	Pre-irrigated		Dry-planted	
(days)	Emergence	Established	Emergence	Established
29	**59.8**	**54.3**	**67.3**	**61.6**
SD	13.7	12.2	13.9	13.4

Fig. 5.17 illustrates differences in seedling dry weights collected at one month after planting (8 to 12 leaves. Seedlings were assumed to be securely established at this point. In this trial, treatments with neonicotinid materials, either as seed treatments (PB) or soil applied (WR) resulted in larger seedling dry weights, supporting a protective effect.

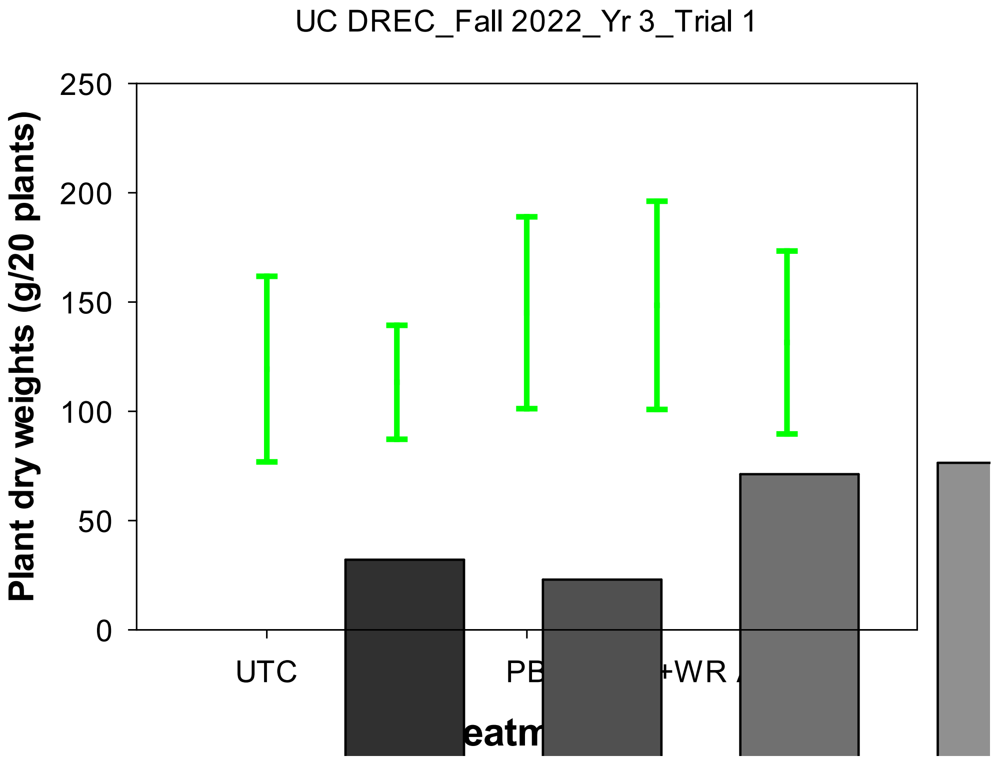


Fig. 5.17. *Seedling dry weights at establishment (8 to 12 leaves) in fall 2022, for September-planted plots. UC DREC_Trial 1_yr 3. Error bars are standard deviations.*

Table 5.11*. Post emergence treatment effects (esfenvalerate) on seedling dry weight.*

Post-emergence treatment effects_UC DREC_Trial 1_Sept 2022			
	All tmts	**Post-emergence tmt**	
		Y	**N**
AVE	**131.5**	**131.9**	**131.1**
SD	**41.9**	**41.3**	**43.8**

5.3.2. Bio-stimulant trial_UC DREC_Fall 2022-yr 3

In fall 2022, the bio-stimulants applied as post-emergence treatments in fall 2021 were applied as soil treatments to plots using PB-treated seed. Results are reported in ***Fig. 5.18***. There was no benefit with respect to seedling emergence and establishment or seedling dry weight at establishment (day 29) from the use of these treatments compared to PB treated seed alone. The S treatment appeared to inhibit emergence while the V treatment reduced seedling dry weight compared to other treatments.

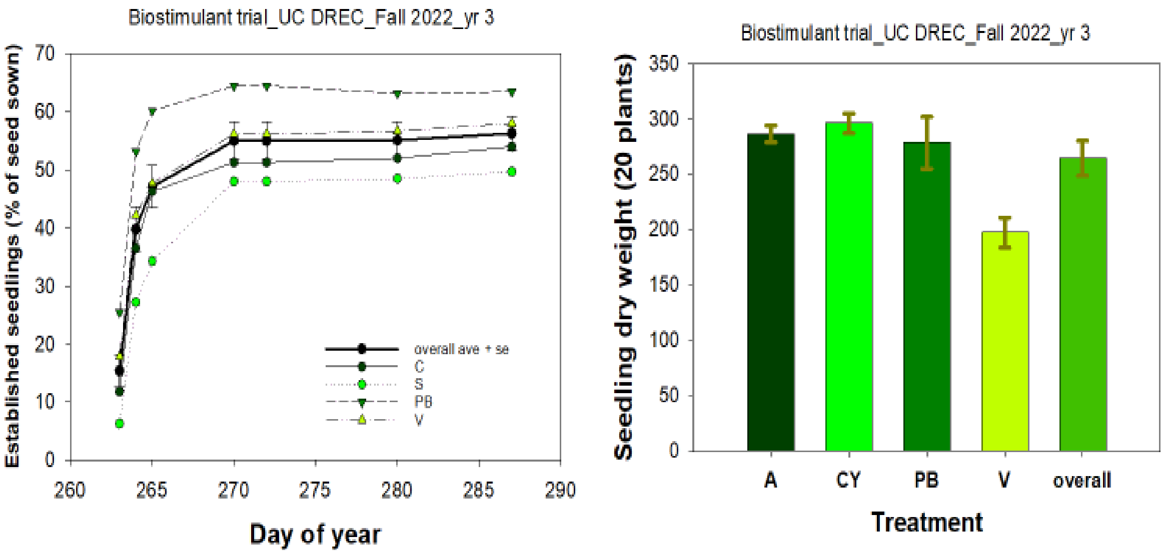


Fig. 5.18. *Results from the use of bio-stimulants applied as soil treatments. Left: Established seedlings. Right: Seedling dry weights at 8 to 12 leaf stage by treatment. Error bars are standard errors. All seed was treated with PB, PB = PB treatment only. Treatments in tis trial were soil (shank) applied in the seed row and are described in Table 5.9. Rates: V: 17 fl oz./ac; S: 82 fl oz./ac; CY: 5.5 lbs/ac.*

6.0. Cooperating growers' field trials

6.1. Year 1_2020-2021. Small plots like those used at the UC DREC are useful for detailed observations and for testing practices and materials that are not used currently in growers' fields. But especially for the study of insect behavior where scale and the influences of nearby fields and prior practices are important, field-scale trials in different IV locations are necessary for comparison with small plot outcomes. Three different growers cooperated in this project over the 2020-21 and 2021-22 growing seasons. There were three fields each year. In 2020-2021, one field, Ash 24, was directly adjacent to the UC DREC site in Holtville, while two other sites (Mulberry 7 and Mulberry 13) were located near each other, west of Brawley. Additional details about each site are provided in *Table 4.1*. Fields are identified by the nearest irrigation head gate. By convention, names increase alphabetically from south to north and numbers from east to west. Planting and harvest dates for these trials varied (*Table 4.1* and ***Fig. 6.1*** and ***6.2***), providing a range of times and locations across the Imperial Valley where sugarbeets are grown, reflecting actual farming practices. In 2020, the research team provided PB treated seed, and the growers used their own seed for the rest. All seed was the B5678 variety, but seed lots and seed size differed. As discussed, plots were monitored for seedling populations and spacing and for differences in seedling dry weights at the 8 to 12 leaf stage by collecting data in four to fine 10 m long subplots in each replication, depending on field length. Harvests were collected from each plot using commercial equipment. One truckload per plot was collected and the area harvested measured. Quality analysis for sugar content and quality parameters on each truckload was carried out at the Spreckels Sugar tare lab in Brawley, California.

Fig. 6.1. *Ash 24 plot plan. The Ash 24 location was second year beets. Irrigated on October 7, using sprinklers. PB: Clothianidin seed treatment. G: grower's treatment (imidicloprid + chlorantraniliprole. Grey plots are grower's treatments similar to G. All plots were treated with esfenvalerate via sprinkler irrigation. Season long materials applied and amounts are in Table 6.2).*

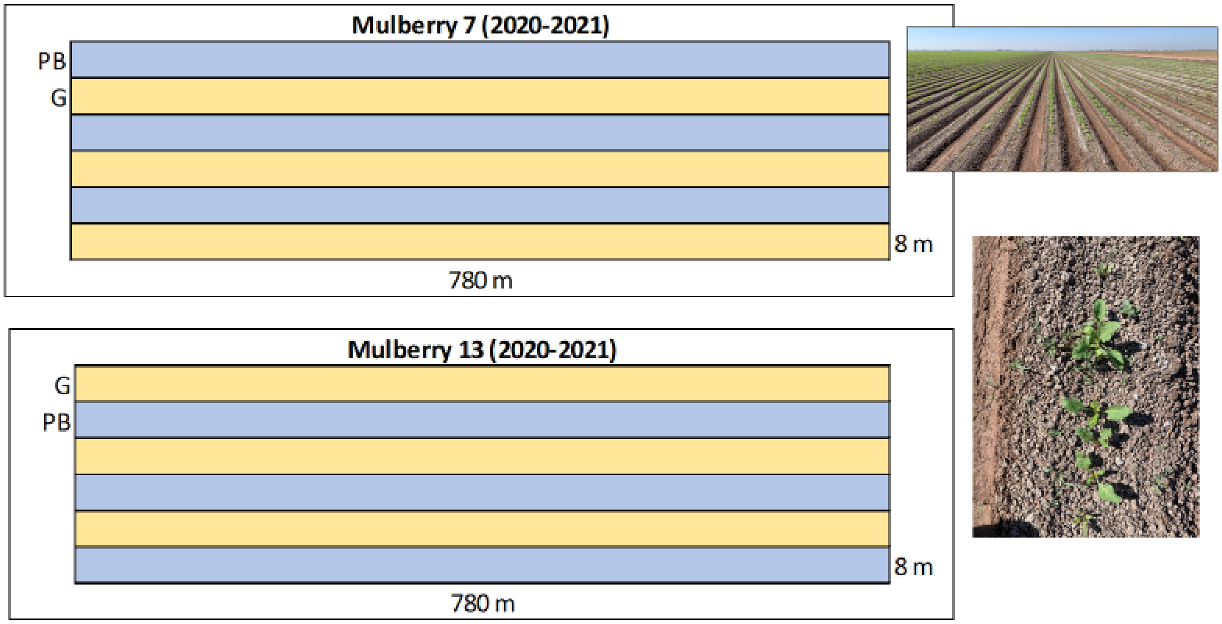


Fig. 6.2. *Mulberry 7 and Mulberry 13 plot plans. PB: Clothianidin seed treatment. G: imidicloprid + chlorantraniliprole. Mulberry 7 was planted in the most saline half of the field (irrigated September 26, using furrows), Mulberry 13 in the least saline half of the field (irrigated October 13, using sprinklers). Esfenvalerate was applied using sprinklers in Mulberry 13, but applied post-emergence using ground application in Mulberry 7. A complete list of materials applied during the growing season is provided in Tables YYY and ZZZ).*

Table (6.1). *Plant spacing and populations at growers' field sites.*

Growers trials 2020-2021						
Location	**ASH 24**		**Mulberry 7**		**Mulberry 13**	
Treatment	**Grower's**	**PB**	**Growers**	**PB**	**Growers**	**PB**
Ave. Spacing (in)	**6.6**	**7.2**	**7.1**	**5.1**	**6.1**	**6.3**
% emergence	**71.8**	**70.7**	**44.1**	**61.3**	**64**	**49.7***
Plants/acre	**31740**	**28830**	**29250**	**40600**	**33960**	**32940**
***closer seed spacing**						

Stand establishment was measured in 10 m rows in 4 to 5 subplots in each field plot. Results are presented in ***Table 6.1***. Average spacing per seedling, % emergence based on the use of modal distances among seedlings measured in all the subplots was used as an accurate estimator of planter performance, and calculated plants per acre and percent emergence are depicted. Spacing and populations in Ash 24 and Mulberry 13 were similar and successful from a commercial standpoint where 30K plants per acre is an economic population. In Mulberry 7, the growers reported a germination problem with the seed they purchased. There was a defective seed lot of the B5678 variety sold that year. The company acknowledged that problem and compensated growers, but it reduced emergence in the grower's treatment in that field. Larger amounts of seed were planted in Mulberry 7 than in the other fields. In general, PB treated resulted in commercially successful plant populations when combined with post-emergence treatment for army worm control and was similar to growers' treatments.

Seedlings were collected for dry weight determination at the same time and from the same subplot area as spacing measurements were made (***Fig. 6.3)***. Mulberry 13 was planted latest and seedlings were smaller on average at the time of collection. In general, seedling dry weights were similar, indicating no difference in early seedling growth.

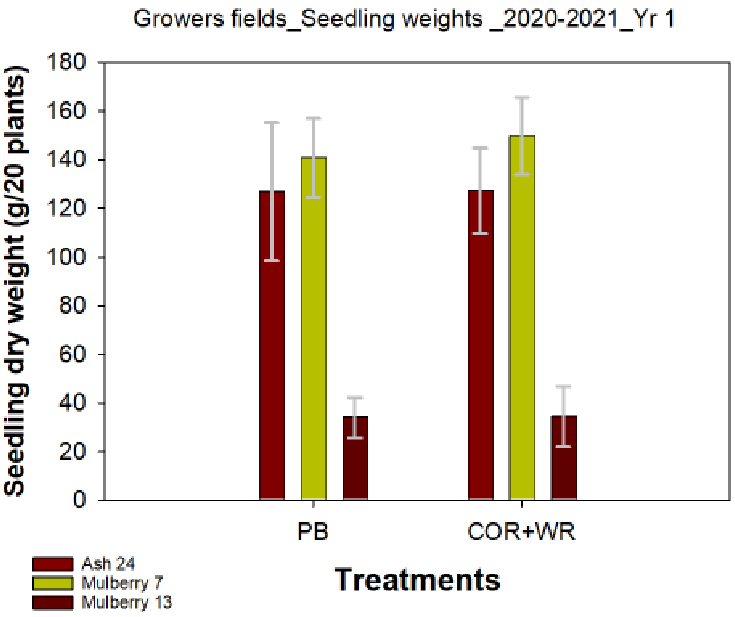


Fig. 6.3*. Seedling dry weights (average of 20 seedlings per plot) from growers' fields at the 8 to 12 leaf stage. Error bars are standard deviations.*

Fields were monitored for insect occurrence and abundance during the growing season (discussed below). Root and gross sugar yields are reported in ***Fig. 6.4*** for all three locations in 2020-2021. Treatment yields are averages of harvests (truck weights) from the three plots depicted in the plot plans (*Fig. 6.2, 6.3*). Field average data come from Spreckels Sugar records. There were no significant differences among stand establishment treatments at this scale in the growers' fields. PB treated seed with post emergence treatments for army worm control were comparable to the use of soil applied materials. All fields resulted in profitable outcomes. To be of interest to growers, treatment differences should be large enough to be observable at the scale that affects them economically. In these trials, both treatments performed adequately, so cost, ease of use and risk should be determinative of the best choice for insect control. Risk is discussed below. Overall costs and all the materials applied are reported in ***Tables 6.2, 6.3, 6.4*** respectively, for these three fields. All the materials applied, including fungicides and herbicides are included in the tables. A larger number of treatments and materials were used at the Ash 24 site than at the two Mulberry sites. In general, successful substitutes have been found for chlorpyrifos in sugarbeet production.

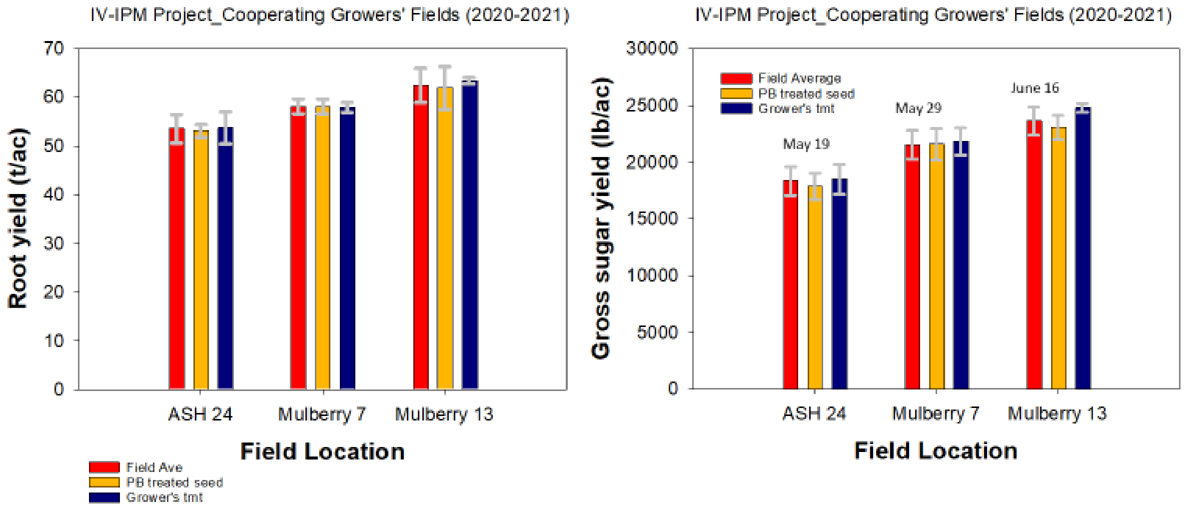


***Fig. 6.4**. Root and gross sugar yields in cooperating growers' fields (2020-2021). Harvest dates indicated in the figure. Error bars are standard deviations.*

Table 6.2. *Ash 24 (2020-2021). Pest management materials applied in grower's treatment, rates and costs*

Ash 24 (85 acres)					
date	**calendar day**	**method**	**active ingredience**	**rate**	**$ used**
9/24/2020	268	shank	Chlorantranilipole	7.11 oz/a	$5,925
9/24/2020	268	ground	Imidacloprid	5 oz/a	$670
10/6/2020	280	sprinkler	Esfenvalerate	9.6 oz/a	$488
10/9/2020	283	ground	Esfenvalerate	9.6 oz/a	$488
10/14/2020	288	ground	Methoxyfenozide	9.6 oz/a	$1,686
10/20/2020	294	ground	Methoxyfenozide	9.6 oz/a	$1,686
10/29/2020	303	ground	Glyphosate	32 oz/a	$1,381
10/29/2020	303	ground	Urea sulfuric acid complex, Trihydroxy carboxylic acid, Alkyl alkoxylated phosphate amine	128 oz/g	$514
10/29/2020	303	ground	Methoxyfenozide	10 oz/a	$1,753
10/29/2020	303	ground	Esfenvalerate	9.6 oz/a	$488
11/24/2020	329	ground	Glyphosate	30 oz/a	$1,295
11/24/2020	329	ground	Chlorantranilipole	5 oz/a	$4,167
11/24/2020	329	ground	carboxylic acid, Alkyl alkoxylated phosphate amine	128 oz/g	$514
11/24/2020	329	ground	Esfenvalerate	9.6 oz/a	$488
12/30/2020	365	ground	Sulfur	25 lbs/a	$723
2/11/2021	42	ground	Sulfur	25 lbs/a	$723
4/16/2021	106	air	Sulfur	10 lbs/a	$2,571
4/16/2021	106	air	Propiconazole	4 oz/a	$330
4/16/2021	106	air	Chlorantranilipole	5.38 oz/a	$4,484
4/16/2021	106	air	Pinene polymers, Petrolatum, Alkyl amine ethoxylate	8 oz/a	$265
			10 appl.@	$40	$400
				TOTAL	**$31,039.00**
				COST/A	**$365.00**

Table 6.3. *Pest management materials applied in grower's treatment, rates and costs; Mulberry 7, (2020-2021)*

Mulberry 7 (112 acres)					
date	**calendar day**	**method**	**active ingredience**	**rate**	**$ used**
9/26/2020	270	shank	Chlorantranilipole	7.5 oz/a	$8,236
9/26/2020	270	shank	Imidacloprid	5 oz/a	$963
9/30/2020	274	sprinkler	Esfenvalerate	9 oz/a	$603
10/9/2020	283	air	Carbaryl	47 oz/a	$3,091
11/6/2020	311	ground	Glyphosate	44 oz/a	$2,503
3/1/2021	60	ground	Sulfur	36 lbs/a	$1,371
3/25/2021	84	ground	Glyphosate	44 oz/a	$2,503
			6 appl. @	$40	$240
				TOTAL	**$19,510.00**
				COST/A	**$174.00**

Table 6.4. *Pest management materials applied in grower's treatment, rates and costs; Mulberry 13 (2020-2021)*

Mulberry 13 (145 acres)					
date	**calendar day**	**method**	**active ingredience**	**rate**	**$ used**
9/26/2020	270	shank	Chlorantranilipole	7.5 oz/a	$10,663
9/26/2020	270	shank	Imidacloprid	5 oz/a	$1,144
10/11/2020	285	aerial	Esfenvalerate	8.86 fl oz/a	$768
10/19/2020	293	aerial	Esfenvalerate	9.35 fl oz/a	$810
10/30/2020	304	ground	Glyphosate	2.77 pt/a	$3,263
10/30/2020	304	ground	Esfenvalerate	8.86 fl oz/a	$768
1/18/2021	18	ground	Glyphosate	3.07 pt/a	$3,618
3/21/2021	80	ground	Sulfur	35 lbs/a	$1,726
			6 appl. @	$40	$240
				TOTAL	**$23,000.00**
				COST/A	**$159.00**

More materials were applied at Ash 24 than for either Mulberry field. The same PCA managed both Mulberry fields; a different PCA managed the Ash field. The cost of the Ash field management program was twice as great as the two Mulberry fields, suggesting that apart from the possibility of much greater pest pressure at the Ash field than in the Mulberry fields, there was potential to reduce overall pest management costs and material use.

Year 2 (2021-2022)-Cooperating growers' trials.

Plum 20, a grower's field used in the trial, was planted in late September but irrigated using sprinklers in early October (***Fig. 30***). Two other grower trials were planted in late September (Marigold 8: 9-24-21; sprinkler irrigated), and early October (Mulberry 15: 10-2-21; furrow irrigated). Different treatments were used in strips in these fields and compared to the growers' preferred treatments. All plots were monitored for emergence and seedling performance (seedling dry weights) similarly to year one of this project. PB treatments were similar to all three fields, but the growers planting Marigold 8 and Mulberry 15 switched to the use of clothianidin seed treatments for the majority of their fields. The research team supplied untreated seed (B5678) for one of the treatments in both fields

The Plum 20 site compared PB treated seed with PB treated seed while also applying imidicloprid (Admire) as a soil treatment. The field average compared untreated seed plus imidacloprid. The Marigold and Mulberry field growers switched to all treated seed in fall 2021, so the field average reflected the use of PB treated seed throughout. The grower's treatment used untreated seed plus imidacloprid and chlorantraniliprole (WR+COR). Results are reported in ***Table 6.5*** and ***Figures 6.7*** and ***6.8***. Emergence and plant populations in the Plum field occurred at economically acceptable levels, with the PB treatment emerging at higher levels.

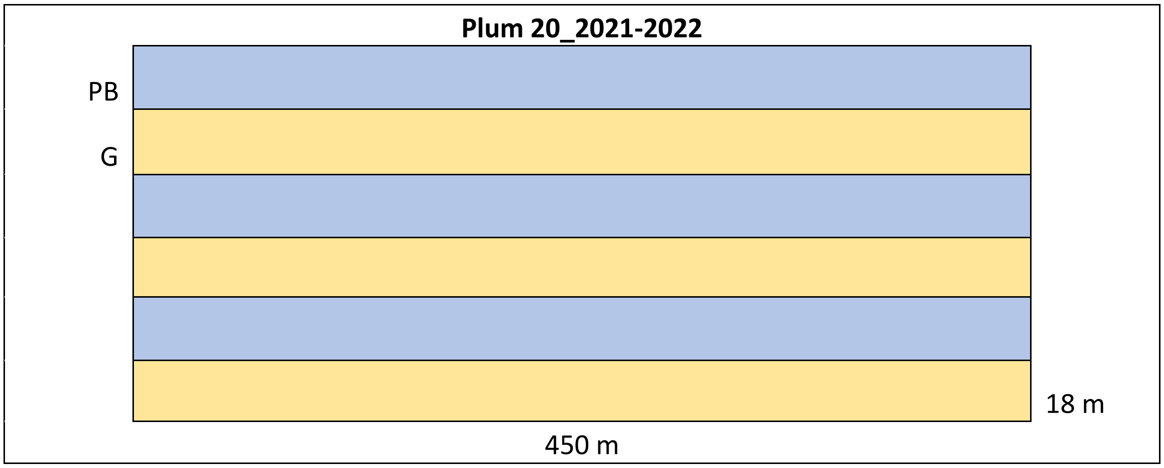


Fig. 6.5. *Plot plan for Plum 20 field (2021-2022). PB: chlothianidin seed treatment plus post-emergence control for armyworms (similar for all plots). G: soil applied imidacloprid. Different seed varieties were used in this field (PB: B5678; G: B4630).*

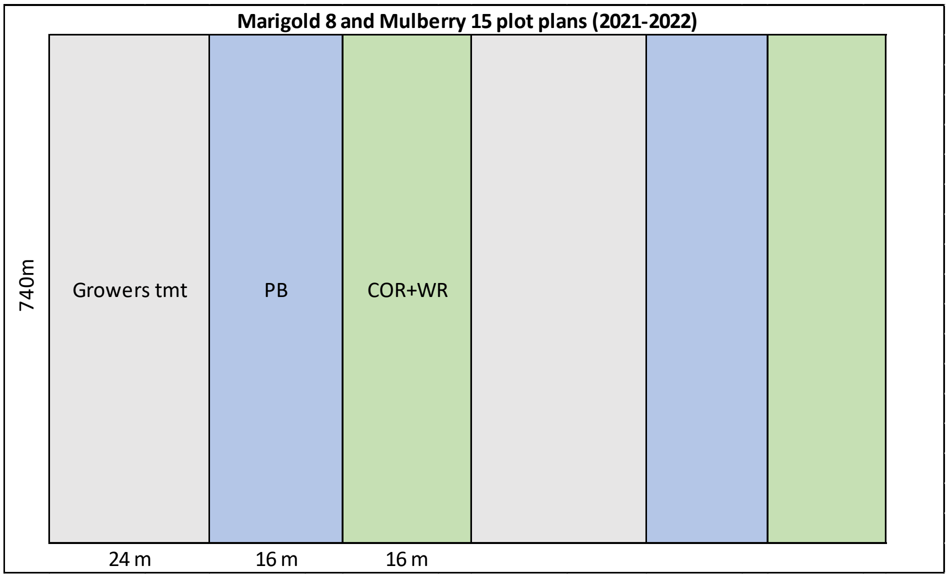
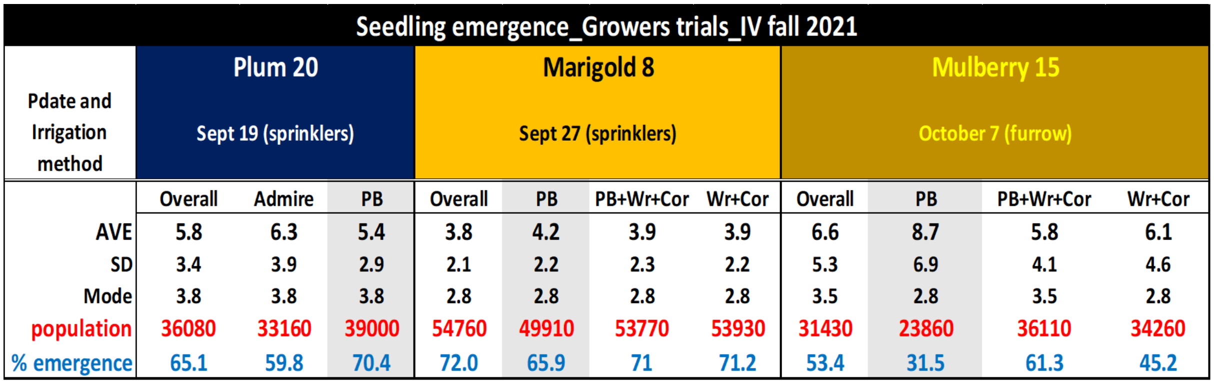


Fig. 6.6. *Plot plan for Marigold 8 and Mulberry 15 (2021-2022). PB: Clothianidin seed treatment; COR+ WR: untreated seed + chlorantraniliprole + imidacloprid (soil applied); Grower's: PB seed + COR+ WR.*

Populations were larger and uniform in the Marigold field with PB treated seed alone emerging at a marginally smaller amount but still more than adequate for a commercial crop. Emergence overall was less in the Mulberry field than the Marigold field but comparable to the Plum field and most of the fields in year one (2020-2021; *Table 6.1)*. In the Mulberry 15 field, however, the PB treatment emerged at a lower rate and had fewer plants per acre at the 8 to 12 leaf stage. Lower rates of emergence did not affect seedling vigor measured by seedling dry weights (***Fig. 6.7***). But lower plant populations did result in lower root and sugar yields at harvest the following April (***Fig. 6.8***). It is not clear why these differences occurred. This was the only instance of poorer performance by PB treated seed compared to other treatments compared to all other trials in growers' field and at the UC DREC. There was closer seed spacing in the PB treatment based on the most common spacing observed (mode = 2.8 inches, compared to 3.5 inches in the other plots measured). Planter performance may have differed and affected performance. This difference is otherwise unexplained. In the other growers' fields, seedling dry weights and root and sugar yields were similar.

Table 6.5. *Emergence and plant populations in cooperating growers' fields (2021-2022)*



Seedling emergence_Growers trials_IV fall 2021											
	Plum 20			Marigold 8				Mulberry 15			
Pdate and Irrigation method	Sept 19 (sprinklers)			Sept 27 (sprinklers)				October 7 (furrow)			
	Overall	Admire	PB	Overall	PB	PB+Wr+Cor	Wr+Cor	Overall	PB	PB+Wr+Cor	Wr+Cor
AVE	5.8	6.3	5.4	3.8	4.2	3.9	3.9	6.6	8.7	5.8	6.1
SD	3.4	3.9	2.9	2.1	2.2	2.3	2.2	5.3	6.9	4.1	4.6
Mode	3.8	3.8	3.8	2.8	2.8	2.8	2.8	3.5	2.8	3.5	2.8
population	36080	33160	39000	54760	49910	53770	53930	31430	23860	36110	34260
% emergence	65.1	59.8	70.4	72.0	65.9	71	71.2	53.4	31.5	61.3	45.2

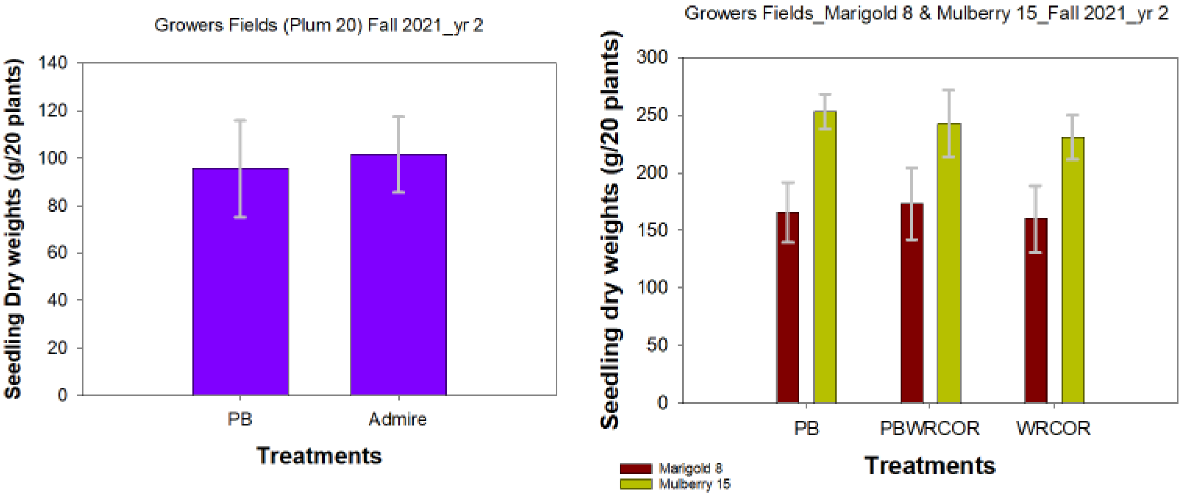


***Fig. 6.7**. Seedling dry weights in Plum 20; Marigold 8 and Mulberry 15 fields, fall 2021. Plum field is plotted separately due to the use of different seed varieties for each treatment. Error bars are standard deviations.*

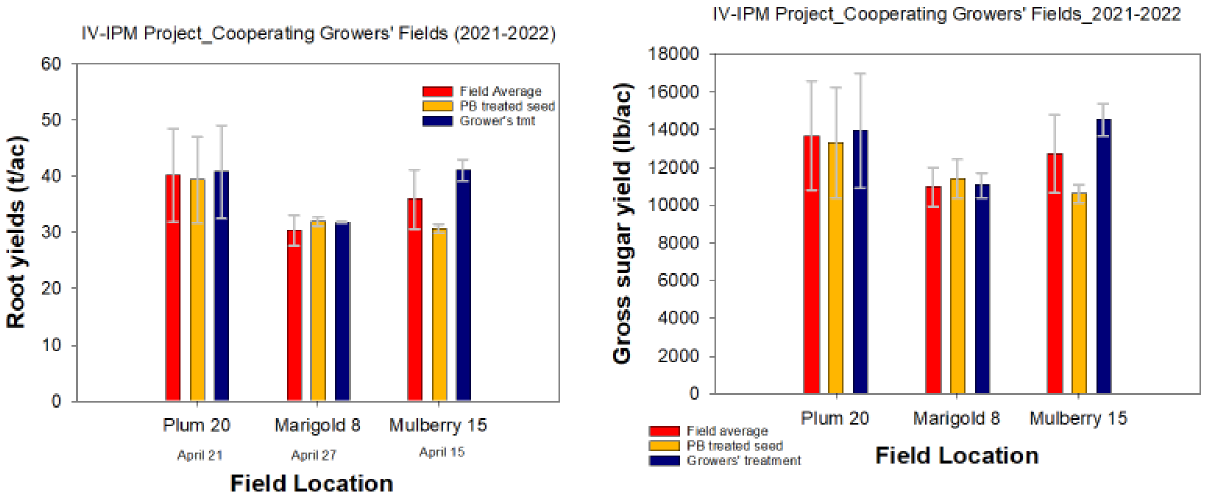


Fig. 6.8. *Root and gross sugar yields, Plum 20, Marigold 8 and Mulberry 15 fields, April 2022. Harvest dates are given in the figure. Error bars are standard deviations.*

Treatment costs in 2021-2022 were much smaller in grower's fields than in 2020-2021 (***Tables 6.6, 6.7,*** and ***6.8***. In part this was due to the shorter growing season in the second year for all three fields. There was very little pest management activity after December in these fields. In addition, these trials were planted later in the season (first irrigation in early to mid-October), which we observed in UC DREC trials to be an effective practice for reducing insect pressure on emerging seedlings. They were harvested in April compared to the previous year (late May and June) before significant insect activity occurred in spring. This was especially true for the grower managing the Plum 20 field compared to the previous year's site (Ash 24, *Table 15*). Overall, the six trials over two years provide an overview of pest management practices (insecticides, fungicides and herbicides) in common use currently in the Imperial Valley for sugarbeet production.

***Table 6.6**. Pest management materials applied in 2021-2022 to the Plum 20 field. Includes fungicides and herbicides.*

Grower 1 (Plum 20) 90 acres					
date	**calendar day**	**method**	**active ingredience**	**rate**	**$/a**
9/11/2021	254	shank	Imidicloprid	5.0 oz/a	$837
9/19/2021	262	irrigation	Esfenvalerate	9.6 oz/a	$516.44
9/25/2021	268	air	Methomyl	0.8 lbs/a	$2,487.60
9/25/2021	268	air	Methoxyfenozide	8.5 oz/a	$1,580.80
9/25/2021	268	air	Methyllesters, Alkylphenelethoxylate, Polyalkylenoxide modified polydimethlsiloxane	4.3 oz/a	$122.75
10/4/2021	277	ground	Glyphosate	32 oz/a	$1,462.50
10/4/2021	277	ground	Methoxyfenozide	10 oz/a	$1,859.77
10/4/2021	277	ground	Esfenvalerate	9.6 oz/a	$516.44
10/15/2021	288	ground	Methoxyfenozide	10 oz/a	$1,859.77
10/29/2021	302	air (1/3 field)	Chlorantraniliprole	4.3 oz/a	$1,265.40
10/29/2021	302	air (1/3 field)	Esfenvalerate	8.5 oz/a	$152.42
10/29/2021	302	air (1/3 field)	Methyllesters, Alkylphenelethoxylate, Polyalkylenoxide modified polydimethlsiloxane	4.3 oz/a	$40.92
11/9/2021	314	ground	Zeta-cypermethrin	4 oz/a	$570.77
11/9/2021	314	ground	Glyphosate	32 oz/a	$1,462.50
1/12/2022	12	ground	Sulfur	30 lbs/a	$1,215.00
2/10/2022	41	ground	Glyphosate	30 oz/a	$1,371.10
		cost/appl.	$40	8 appl.	$320
				total	**$17,641**
				$/a	**$196/a**

***Table 6.7**. Pest management materials applied in 2021-2022 to the Marigold 8 field. Includes fungicides and herbicides.*

Marigold 8 (130 acres)					
date	**alendar da**	**method**	**active ingredience**	**rate**	**$ used**
9/25/2021	268	shank	Chlorantraniliprole	7.5 oz/a	$9,564.00
9/25/2021	268	shank	Imidicloprid	5 oz/a	$1,024.40
9/29/2021	272	irrigation	Esfenvalerate	9.6 oz/a	$746.20
10/22/2021	295	ground	Glyphosate	44.3 oz/a	$2,137.20
10/22/2021	295	ground	Zeta-cypermethrin	3.89 oz/a	$821.60
10/22/2021	295	ground	Methoxyfenozide	14.6 oz/a	$3,922.10
		cost/appl.	$40	2 appl.	$80
				total	**$18,295.50**
				$/a	**$140.73/a**

Table 6.8. *Pest management materials applied in 2021-2022 to the Mulberry 15 field. Includes fungicides and herbicides.*

Mulberry 15 (65 acres) 2021-2022

date	calendar day	method	active ingredience		rate	$ used
9/27/2021	270	shank	Chlorantraniliprole		7.5 oz/a	$4,782.08
9/27/2021	270	shank	Imidicloprid		5 oz/a	$512.71
10/1/2021	274	air (1/2 field)	Esfenvalerate		9.2 oz/a	$175.97
10/6/2021	279	air	Esfenvalerate		9.6 oz/a	$372.99
10/14/2021	287	air	Zeta-cypermethrin		4 oz/a	$412.22
10/19/2021	292	air	Carbaryl		1.5 qt/a	$1,832.03
10/19/2021	292	air	Phosphoric acid, Alkylphenolethoxylate, Alkylpolyglcoside		.062 qt/a	$50.38
11/11/2021	315	ground	Glyphosate		48 oz/a	$1,157.81
11/18/2021	322	ground	Methoxyfenozide		15 oz/a	$2,014.75
11/19/2021	323	ground	Zeta-cypermethrin		4 oz/a	$412.22
1/6/2022	6	ground	Glyphosate		3 pt/a	$3,168.75
		cost/appl.		$40	8 appl.	$320
					total	**$15,211.91**
					$/a	**$234.03/a**

Cost estimates for all six fields were provided by cooperating PCAs and vary with method of application, grower and year to some extent. Using the most recent costs from the Marigold and Mulberry fields, chlorantraniliprole applied to soil at 7.5 oz/ac cost approximately $75/ac as applied in these trials. Imidicloprid cost approximately 8 $/ac. Combined, costs were greater than $80/ac. We assume they were applied with the planter as a tank mix. Clothianidin (PB) seed treatment is estimated to cost $45 per 100,000 seeds (called a unit). At planting rates commonly used (60,000 seeds per acre; 3.5 inches per seed), treatment costs are approximately $30/ac. There are no application costs, since it is applied with the seed coating. Since seed treatment was as effective at supporting emergence as other, more expensive soil applied materials, it would save growers money to rely on them in combination with post-emergence treatments to control armyworms. Seed treatment is more expensive, however, than the direct use of imidacloprid alone as a soil treatment (approximately $9.30 / ac in the Plum Field). Another $20/ac is needed for application costs for imidacloprid, if soil or plant applied.

7.0. Observations of insect activity during the growing season

7.1 Year one: 20202-2021. Trials were located at the UC DREC in Holtville in the southern area of the IV, and in cooperating growers' fields in diverse locations throughout the IV. Insect occurrence was monitored by field sampling using sticky cards, wing traps and visual damage ratings during stand establishment and for late season pest management at the UC DREC site (***Fig. 7.1, Fig. 7.2***). A limited amount of data was collected in grower's fields due to difficulty of access, field size and frequent pesticide applications. At the UC DREC site, a large set of observations about insect pest occurrence was collected.

Fig. 7.1. *Sticky card and wing traps used in trials.*

Flea beetle population sampling was done using 5X8 inch yellow and blue sticky cards. Two cards were stapled together, leaving the inner surface liners intact. The back-to-back stapled cards were slid on an eight-inch wooden stake placed in the plots within the plant row. The approximate height of the sticky traps was 2 inches above the soil surface. The outer liners were then removed. Counts were done using a hand-held lens. Both sides were counted. Plots were judged to be too small to meaningfully distinguish between treatment effects at the UC DREC, so all data are combined.

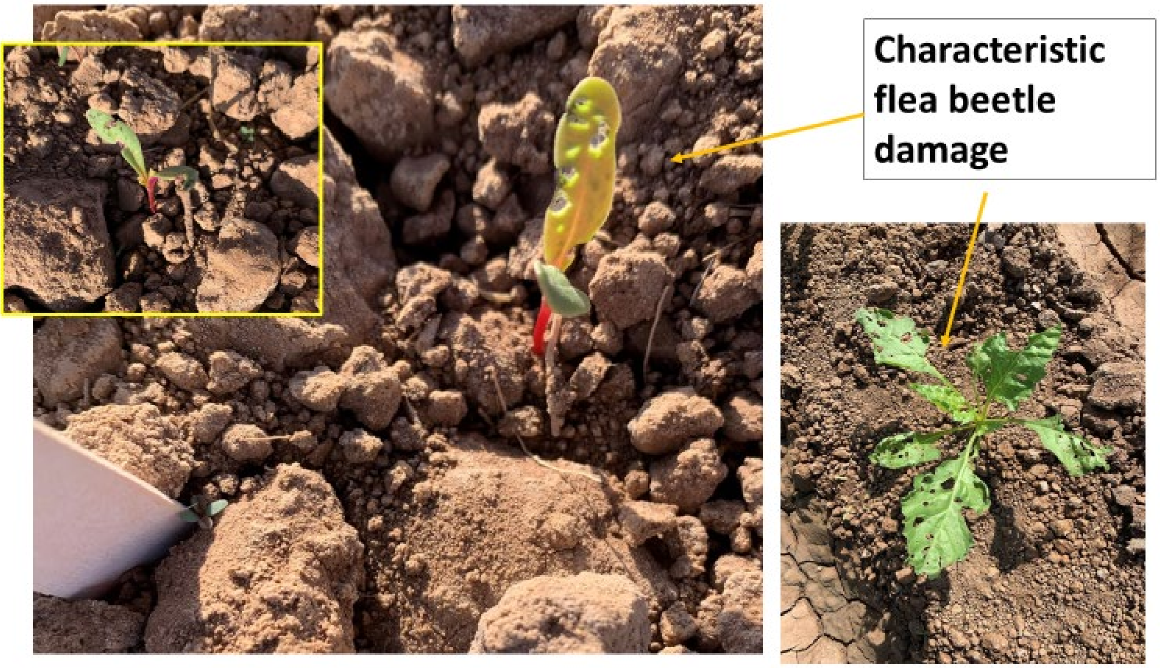


***Fig. 7.2**. Left: Characteristic flea beetle damage to emerging sugarbeet seedlings. Right: Older seedling outgrowing initial damage.*

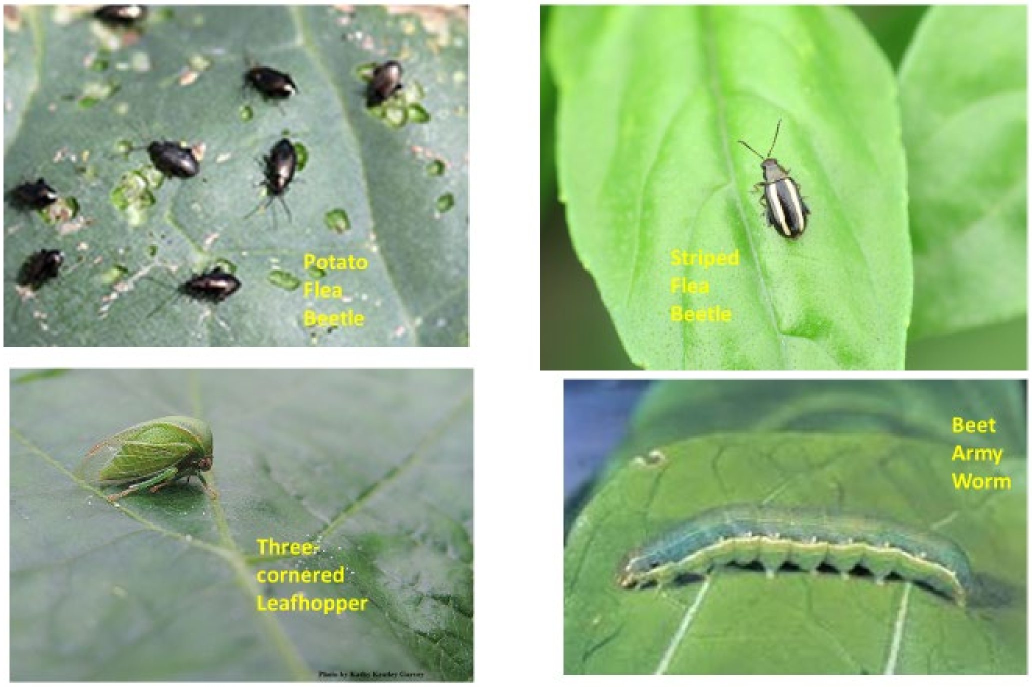


***Fig. 7.3**. Most common insect pests of sugarbeet observed in DREC trials and growers' fields.*

Cards were placed in plots starting after emergence in fall and repeatedly reset through the growing season. From December to June, 2021, work focused on insect monitoring at all research sites. Monitoring consisted in bi-weekly visual inspections of fields for the presence of key insect species like leaf hoppers and beet armyworms and associated insect damage. During fall, after emergence, 30 sticky cards were placed throughout the site corresponding with treatments and replaced at differing intervals depending on the number of insects caught and space on the cards. Intervals varied from 2 to 5 days for the September-planted trial and 4 to 15 days in the October-planted trial, due to fewer insects observed. Data reported are normalized by the number of days cards were left in the field (***Fig. 7.4***). In fall, two species of flea beetle were commonly observed, the Pale Striped Flea Beetle, *Systena blanda,* and the Potato flea beetle *Epitrix spp* ***(Fig. 7.3).*** Overall in September, more than 2,700 stripped flea beetles were captured in the September planted trial and 760 potato flea beetles, but less than 300 of either species in the October planted trial in fall.

In spring, insect activity increased during the warm months as expected. Leaf hoppers (Fig. 7.4 (36) were the primary insect observed, but not to damaging levels in any of the trials at UC DREC (***Fig, 7.5***). Data in the figure are from 9 sampling events during April to May prior to plot harvests. Numbers varied inconsistently over this period. Two of the grower-cooperators did not apply any controls for leaf hoppers in their fields that spring (*Tables 6.3, 6.4*). Chlorantraniliprole was applied in the Ash 24 field (*Table 6.2*), but likely primarily for armyworm control. Cooperating PCAs reported informally that spring 2021 was a light year for insect damage.

Post-emergence treatments for insects (flea beetles and army worms primarily) were common at all growers' sites, applied with irrigation water via sprinklers where they were used, otherwise via ground application or sometimes by air (*Tables 6.2 to 6.4* and 6.6 to 6.8). At the UC DREC, esfenvalerate (and sometimes carbaryl) was applied to half the plots that had been sprayed previously in the fall. The other plots received no pesticide treatments apart from soil or seed treatments at planting.

Other insect species were observed at non-damaging levels at the UC DREC site and in scouting in grower's fields. *Table 7.1* lists the species observed and the relative intensity of populations. Collectively, these diverse trials and observations demonstrate that the stand establishment period is the time of year when pest management is most challenging, especially for the earliest planed fields. Later-planted fields provide an opportunity to reduce use of insecticides.

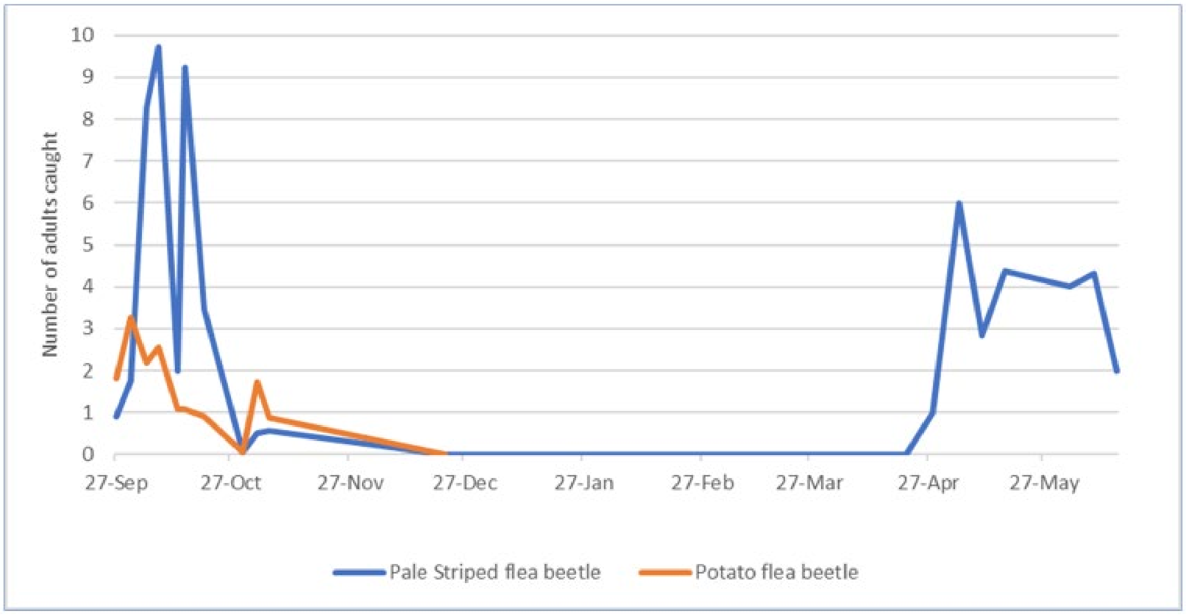


Fig. 7.4. *Average number per sampling event of flea beetles observed on sticky cards at the UC DREC site (Year 1_2020-2021)*

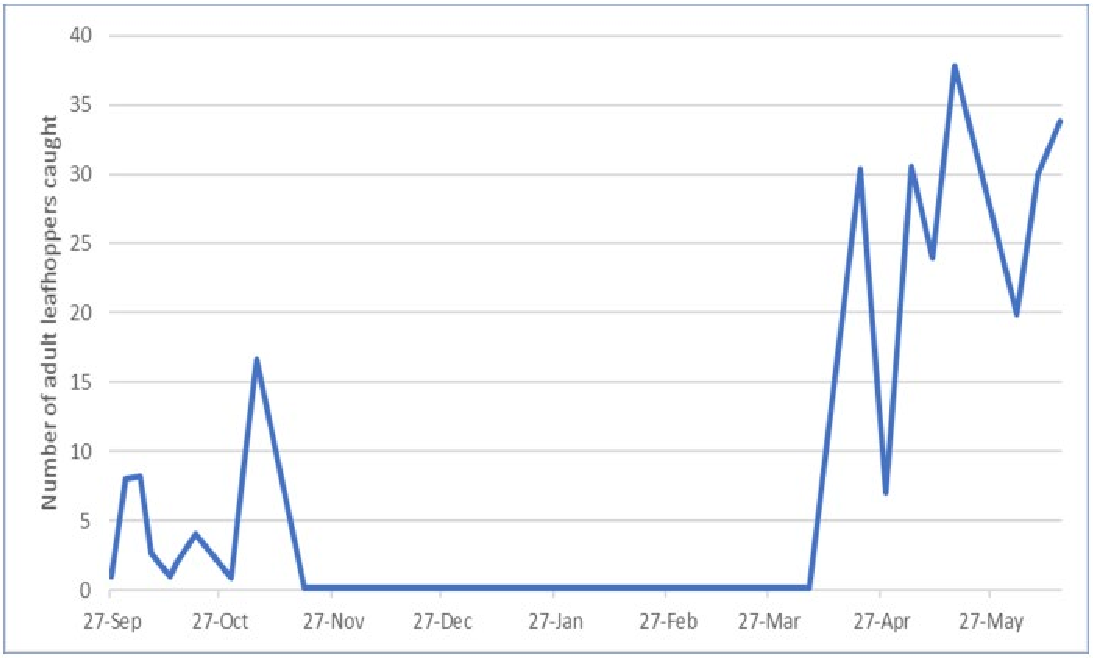
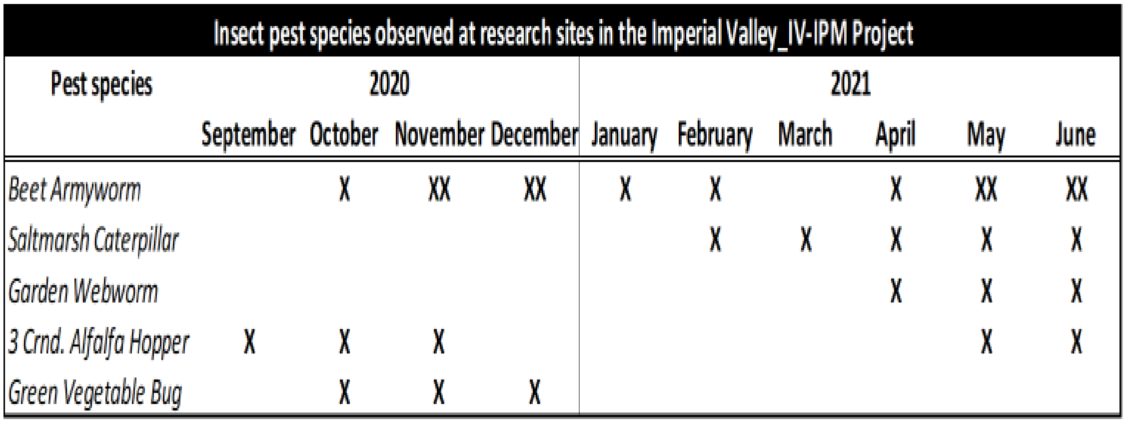


Fig. 7.5. *Average number of leaf hoppers observed on yellow sticky cards at the UC DREC site (year 1_2020-2021).*

***Table 7.1**. Relative abundance of insects observed in 2020-2021 at the UC DREC site and in growers' fields.*



Insect pest species observed at research sites in the Imperial Valley_IV-IPM Project

Pest species	2020				2021					
	September	October	November	December	January	February	March	April	May	June
Beet Armyworm		X	XX	XX	X	X		X	XX	XX
Saltmarsh Caterpillar						X	X	X	X	X
Garden Webworm								X	X	X
3 Crnd. Alfalfa Hopper	X	X	X						X	X
Green Vegetable Bug		X	X	X						

In the fall and spring after planting and establishment, leafhopper samples were collected on the same cards as the flea beetles. (See flea beetle sampling description above for details). In the spring, the sticky cards were placed at the canopy level of the beets using elevated holders. The sampling took place at the University of California Desert Research and Extension Center near Holtville, CA. Stripped flea beetles and potato flea were present predominantly. The beet leafhopper, *Circulifer tenelius* and Empoasca spp. leafhoppers were observed in lower numbers in fall.

7. 2. Year 2 (2021-2022). Two Sentry wing traps were set at each trial location. The trial locations include: 1) Desert Research Extension Center near Holtville, CA, 2) Plum 20 off Hartshorn Road, 3) Marigold 8 off Titsworth Road and 4) Mulberry 15 off Rutherford Road. One trap was baited with a garden webworm lure and the other was baited with a beet webworm lure. The traps were collected approximately once a week and the number of adults caught recorded. After three samples, it was determined that the garden webworm lure was getting more activity than the beet webworm lure. The beet webworm lure was abandoned and replaced with the beet army worm lure. Throughout the season, the beet army worm traps consistently had more adults trapped than the garden webworm trap. Additional data that was collected but showed no differences included: (1) Post emergent spray plots verse non-sprayed plots at Desert Research Extension Center, (2) yellow sticky cards placed in each replicate plot at Marigold 8 and Mulberry 15, (3) vacuum specimen sampling per replicate plot in Mulberry 15.

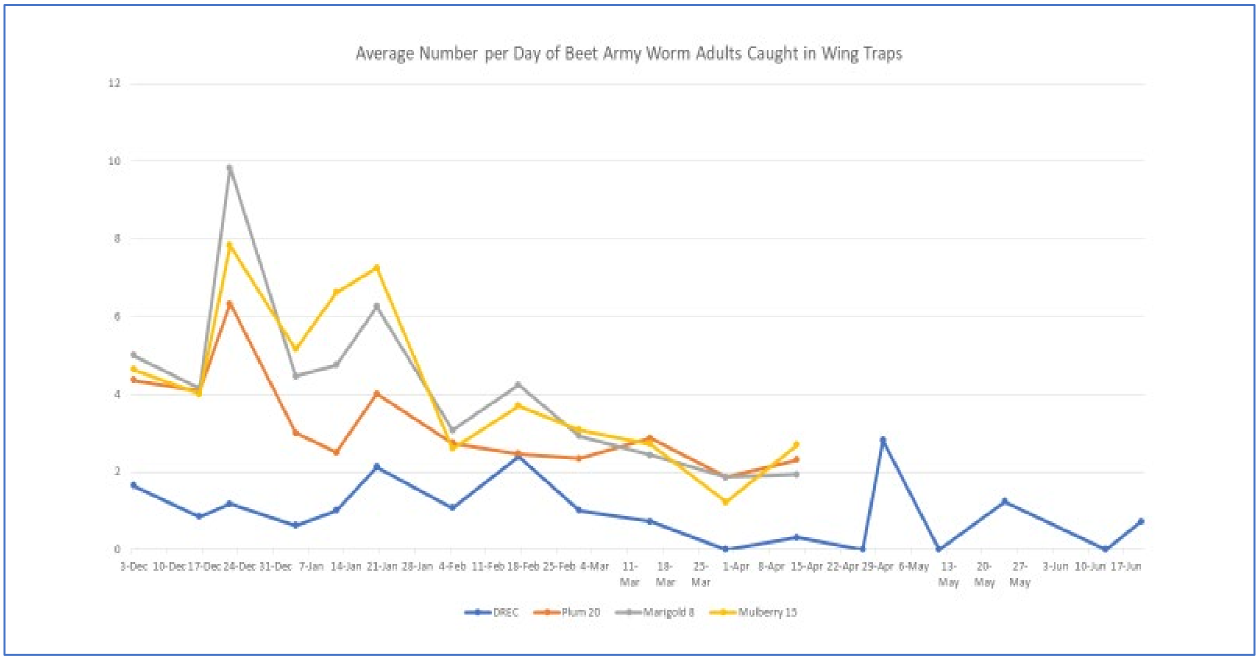
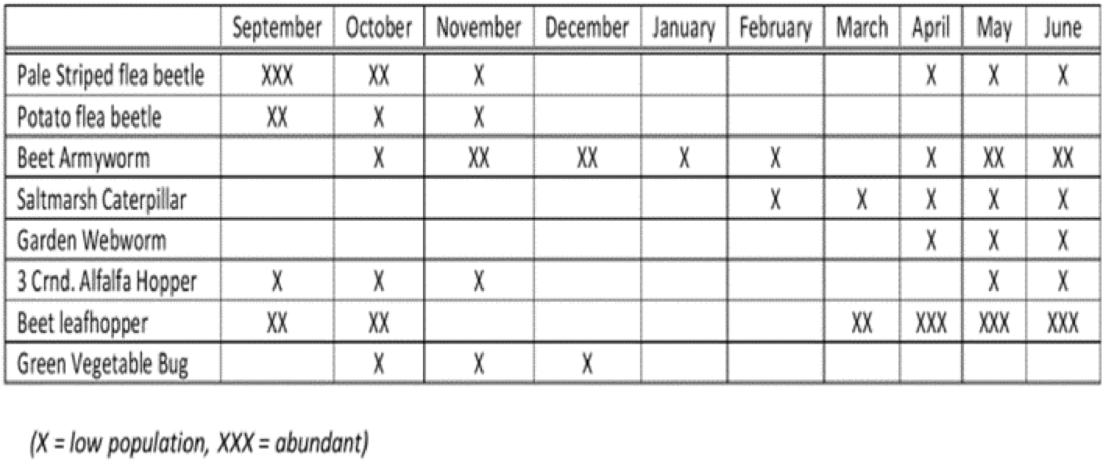


Fig. 7.6. *Average number of beet army worm adults caught per day in wing traps at diverse locations in the Imperial Valley (October 2021 to June 2022).*

Table. 7.2. *Insects observed in growers'sugarbeet fields and at the UC DREC in 2021-2022. May to June observations at UC DREC only*.



	September	October	November	December	January	February	March	April	May	June
Pale Striped flea beetle	XXX	XX	X					X	X	X
Potato flea beetle	XX	X	X							
Beet Armyworm		X	XX	XX	X	X		X	XX	XX
Saltmarsh Caterpillar						X	X	X	X	X
Garden Webworm								X	X	X
3 Crnd. Alfalfa Hopper	X	X	X						X	X
Beet leafhopper	XX	XX					XX	XXX	XXX	XXX
Green Vegetable Bug		X	X	X						

(X = low population, XXX = abundant)

7.3. Year 3_UC DREC_Fall 2022 . The September planting date in trail 1 that was lost in fall 2021, was repeated in fall, 2022 at the UC DREC. Only stand establishment was measured and correlated insect observations made from planting through the end of October. These are summarized in ***Figures 7.7 and 7.8***. Unlike in fall 2020, the number of stripped flea beetles trapped increased in number in October. That increase did not affect seedling size measured as seedling dry weights collected at the 8 to 12 leaf stage (*Table 13*). Seedlings had already reached a size where additional damage by beetles did not affect their growth. Armyworm grazing was not observed.

Post-emergence insecticides were used at the UC DREC site as an element of experimental design and are listed for all three years in ***Tables 7.3, 7.4*** and ***7.5***. Most treatments were applied to September-planted plots. As reported above, there were no yield or economic benefits from these treatments observed in the UC DREC trials in ether September or October plantings. In contrast, post-emergence treatments were common practice in all growers' fields, starting with irrigation occurring at emergence if sprinklers were used.

Observations in fall 2022 (year 3) align with those from previous years' trials, and reinforce a consensus understanding about insect pest pressure on fall-planted/summer harvested sugarbeet crops in the Imperial Valley. Insect pressure and the risk of economic loss is greatest in fall during planting during seedling emergence and establishment, especially fields planted in early to mid-September, but then declines as fall progresses and during cooler winter days. It then increases again as spring turns to summer, corresponding to insect life cycles and temperature responses. The trial in fall 2022 was not harvested. Doing so would have exceeded the end date for the project and the amount of funds available

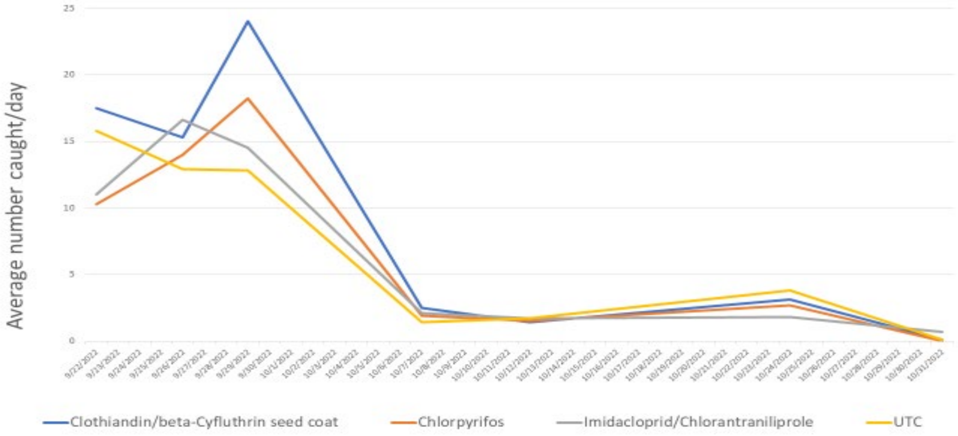


***Fig. 7.7**. Potato flea beetles captured per day using yellow sticky cards in trial 1, fall 2022 at the UC DREC. Average number of insects per day. September 22 to October 31. There were no significant differences overall among treatments.*

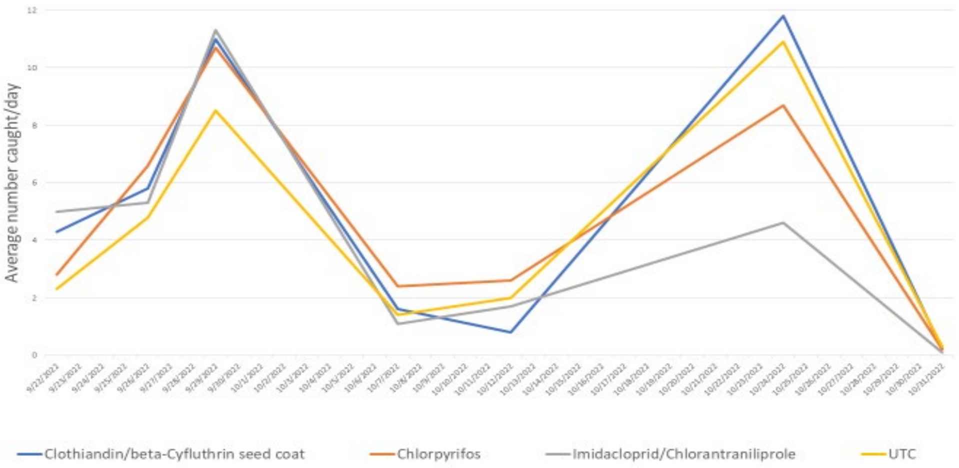


Fig. 7.8. *Stripped flea beetles captured per day using yellow sticky cards in trial 1, fall 2022 at the UC DREC. Average number of insects per day. September 22 to October 31. There were no significant differences overall among treatments.*

Table 7.3. *Pesticide applications in 2020-2021 at UC DREC site*

UC DREC Fall, 2020 to Summer 2021_(2.5 acres)						
date	**alendar da**	**method**	**acres appl**	**active ingredience**	**rate**	**$ used**
9/17/2020	261	shank	0.26	Chlorpyrifos	32 oz/a	$1.82
9/17/2020	261	shank	0.26	Chlorantranilipole	7.5 oz/a	$19.30
9/28/2020	272	ground	2.5	Glyphosate	48 oz/a	$9.09
10/14/2020	288	shank	0.26	Chlorpyrifos	32 oz/a	$1.82
10/6/2020	280	ground	1.25	Esfenvalerate	5 oz/a	$3.74
10/15/2020	289	ground	2.5	Glyphosate	48 oz/a	$9.09
11/19/2020	324	ground	1.25	Esfenvalerate	5 oz/a	$3.74
11/19/2020	324	ground	2.5	Glyphosate	48 oz/a	$9.09
4/5/2021	95	ground	2.5	Azoxystrobin	15 oz/a	$73
4/12/2021	102	ground	2.5	Sulfur	10 lbs/a	$30.25
6/3/2021	154	ground	1.25	Imidacloprid	9.6 oz/a	$24.80
				9 @	$20	$180
					TOTAL	**$365.74**
					COST/A	**$146**

Table 7.4*. Pesticide applications in 2021-2022 at UC DREC site*

UC DREC_2021-2022_ (1.54 ac)					
date	**alendar da**	**method**	**active ingredience**	**rate**	**$ used**
10/12/2021	285	shank	Chlorpyrifos	2 pt./a	$4.57
10/12/2021	285	shank	Chlorantraniliprole	7.5 fl oz/a	$19.11
10/12/2021	285	shank	Imidicloprid	5 fl oz/a	$2.05
10/27/2021	299	ground	Esfenvalerate	5 fl oz/a	$2.30
10/27/2021	299	ground	Glyphosate	48 fl oz/a	$5.60
11/16/2021	320	ground	Carbaryl	48 fl oz/a	$21.70
12/9/2021	343	ground	*Bacillus thuringiensis* , subsp. *Kurstaki*	2.0 lbs/a	$22.18
12/21/2021	354	ground	Sulfur	10 lbs/a	$18.63
2/1/2022	32	ground	Sulfur	10 lbs/a	$18.63
2/18/2022	49	backpack	Glyphosate	9.75 fl oz/a	$24.23
3/2/2022	61	backpack	Glyphosate	9.75 fl oz/a	$24.23
3/16/2022	75	backpack	Glyphosate	9.75 fl oz/a	$24.23
4/14/2022	104	backpack	Glyphosate	9.75 fl oz/a	$24.23
4/22/2022	112	backpack	Glyphosate	9.75 fl oz/a	$24.23
4/26/2022	116	backpack	Glyphosate	9.75 fl oz/a	$24.23
5/10/2022	130	backpack	Glyphosate	9.75 fl oz/a	$24.23
5/27/2022	146	ground	Azoystrobin	15 fl oz/a	$22.47
5/27/2022	146	ground	Spirotetramat	9 fl oz/a	$61.48
5/31/2022	151	backpack	Glyphosate	9.75 fl oz/a	$24.23
		cost/appl.		7 appl.	$140.00
				TOTAL	**$532.56**
				COST/A	**$345.80**

Table 7.5*. Pesticide applications in fall 2022 at UC DREC site*

UC DREC (1.76 acres)_Fall 2022					
date	**alendar da**	**method**	**active ingredience**	**rate**	**$ used**
9/13/2022	256	shank	Chlorpyrifos	2 pt./a	$1.83
9/13/2022	256	shank	Chlorantranilipole	7.5 fl oz/a	$19.30
9/13/2022	256	shank	Imidicloprid	5 fl oz/a	$2.05
9/14/2022	257	shank	Brassinosteroid,Triacontanol, Glycosides, B vitamins	17 fl oz/a	$0.88(est)
9/14/2022	257	shank	Seaweed extract & Soluble Potash derived from *Ascophyllum nodos*	82 fl oz/a	$1.87(est)
9/14/2022	257	shank	Algae extract, Soluable Potash, Hydrolyzed vegetable proteins	5.5 lbs/a	$14.33(est)
10/14/2022	287	ground	Glyphosate	48 fl oz/a	$6.40
10/17/2022	290	ground	Methoxyfonozide	16 fl oz/a	$35.35
11/9/2022	314	backpack	Glyphosate	9.75 fl oz/a	$5.50
		cost/appl.		4 appl.	$80.00
				TOTAL	**$150.43**
				COST/A	**$85.47**

Costs at the UC DREC research station are in part subsidized and differ from growers' fields and are not necessarily representative of the costs to commercial growers.

8.0. Multi-year, multi-site comparisons

8.1. Insect observations. The majority of insect pest management in sugarbeet production in the Imperial Valley occurs in autumn when crops are planted established. Sugarbeet seedlings are slow to grow after emergence and subject to mortality from insect grazing. Flea beetles, armyworms and leafhoppers were the primary insects observed and controlled during fall in all three growing seasons (years). Populations tend to large an active in the late summer in the Imperial Valley.

Insect pressure from flea beetles, leafhoppers and armyworms declined between mid-September and late October in date-of-planting comparisons made at the UC DREC, holding all other factors constant (**Figure 8.1**). This was observed previously in earlier work funded by DPR in 2000 to 2003. Planting from mid-October onwards reduces insect pressure and the need for insecticides during stand establishment, and can be considered an IPM strategy. Flea beetles captured later in fall when plants are established are not damaging.

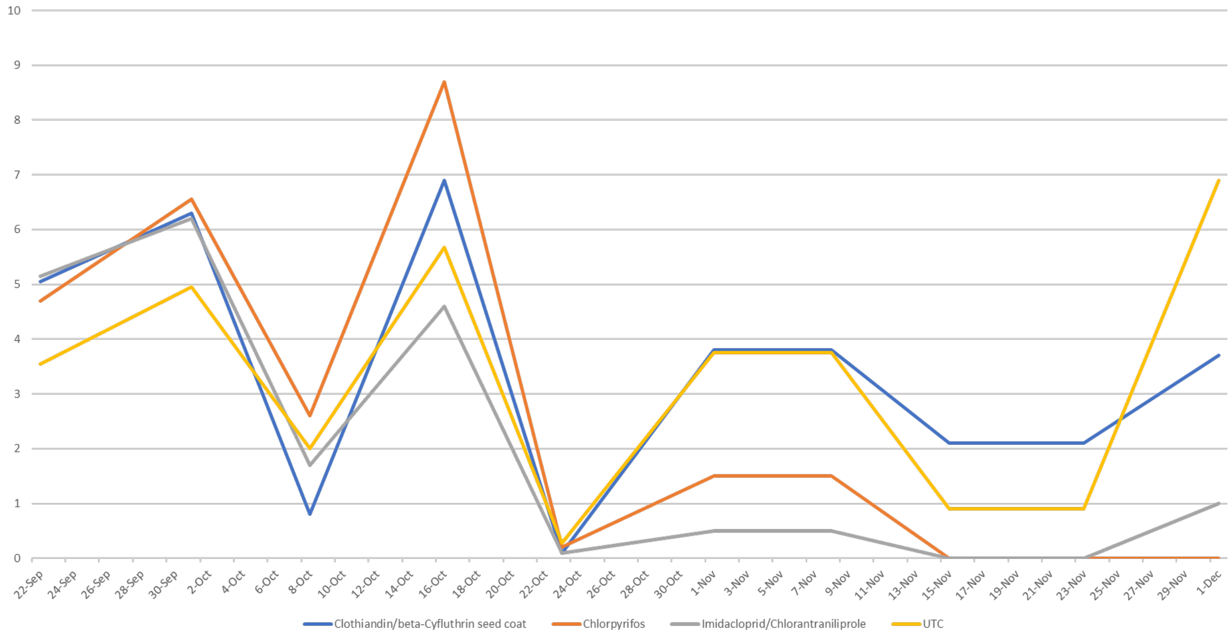


Fig. 8.1. *Multi-year average number of pale stripped flea beetles (Systena blanda) captured per day on yellow sticky cards at the UC DREC site over the 2020 to 2022 research period. Differences among treatments in small plots are largely insignificant.*

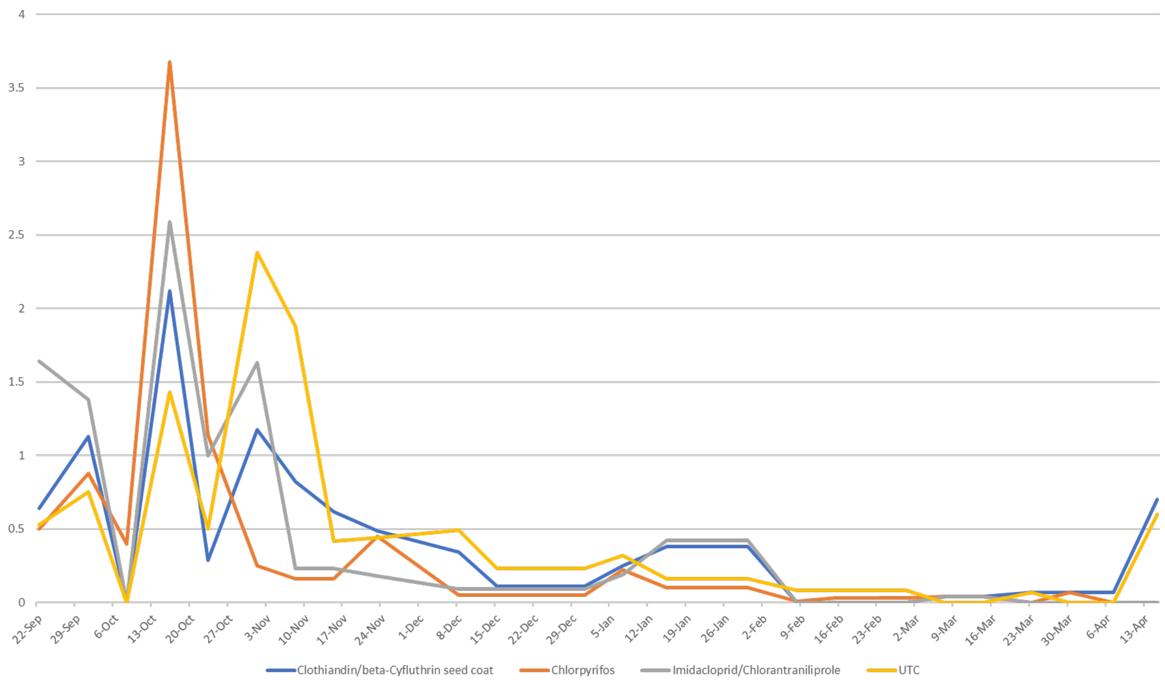


***Fig. 8.2**. Multi-year average of number of leafhopper (potato leaf hopper and beet leafhopper,* (Empoasca sp., and Circulifer *tenelius), caught per day on 3 X 5 yellow sticky cards in sugar beet plots at the UC DREC, 2020-2022. Differences among treatments are largely insignificant.*

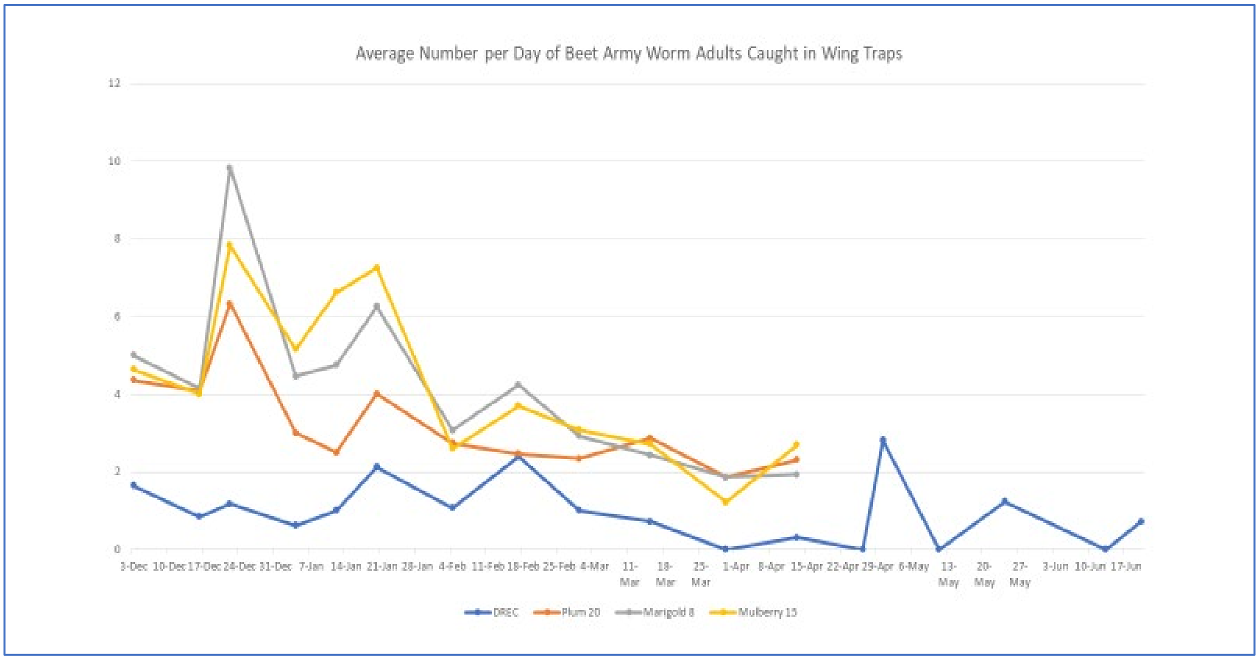


***Fig. 8.3.** Average number of beet army worm adults caught per day in wing traps at diverse growers' fields in the Imperial Valley (October 2021 to June 2022).*

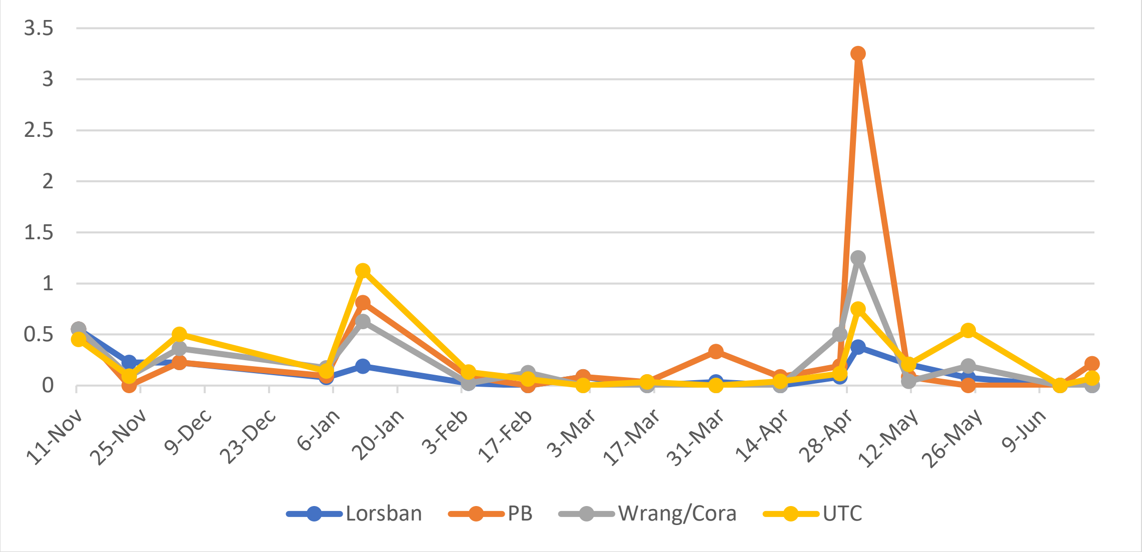


Fig. 8.4*. Average Number of flea beetles, leaf hoppers and armyworms (combined) caught on yellow sticky cards per day and treatment. UC DREC, 2021-2022.*

Armyworms were only monitored using wing traps in year two (***Fig. 8.3***). They were present and damaged seedlings in only one growers' field (fall 2020, Mulberry 13), reportedly due to a missed spray treatment, but otherwise were controlled in grower's fields or were present in low numbers at the UC DREC site.

Winter is a period of relative minor insect management (*Fig. 8.3,* ***Fig. 8.4****; Tables 7.1, 7.2, 7.4*). Early harvested beet crops require little to no insect control (*Tables 6.6 to 6.8*). The period of crop growth most suited to identifying and testing alternatives to traditional pesticides like chlorpyrifos was fall during planting.

8.2 Treatment comparisons across years. Table 8.1 compares results from UC DREC trials and growers' fields for all three years. Results are ranked by absolute values. Overall, PB seed treatments were largely superior to Chlorpyrifos applied as a soil treatment at UC DREC trials in all three years in supporting seedling emergence and establishment. In growers' fields, PB seed treatments were equivalent or superior to other treatments used by growers. The primary comparisons were with the use of chlorantraniliprole and imidicloprid as soil applications at planting. All growers' fields use post-emergence control (primarily with esfenvalerte starting with irrigation or shortly after emergence.

There were exceptions in the growers' trials to this general pattern. In fall 20202 in the Mulberry 15 field, seed quality for the grower's seed was poor and emergence was reduced. Plot areas were overplanted subsequently and yields were then similar at harvest among the treatments compared. In fall 2021, PB plots emerged less well than other treatments, resulting in lower populations closer to 20,000 plants per acre, compared to populations greater than

Table 8.1 . Imperial Valley IPM project_relative ranking of treatment outcomes by trial_Imperial Valley_2020 to 2022

					Comparison				
Location	**Year**	**Planting date** Fall	**Harvest date** Spring-summer	**Type**	**Emergence** %	**Population** *plants/ac*	**Seedling DW** *g/20 seedlings*	**Root yield** *t/ac*	**Sugar yield** *lb/ac*
Year 1									
UC DREC	2020-2021	16-Sep	16-Jun	research station	PB > L > UTC	PB = L = UTC	PB > UTC > L	PB > L = UTC	PB > L = UTC
		15-Oct	16-Jun		PB > UTC > L	PB > L + UTC	PB ≥ L= + UTC	PB > L > UTC	PB > L > UTC
UC DREC	2020-2021	16-Sep	17-Jun	research station	PB = PB + COR > UTC > COR	PB = PB + COR > UTC = COR	PB = COR > PB = UTC > COR	COR > COR + PB > UTC > PB	COR = PB > UTC > PB + COR
ASH 24	2020-2021	7-Oct	May	Grower's field	PB = ADM	AD + COR ≥ PB	PB = COR + ADM	PB = COR +WR	PB = COR +WR
Mulberry 7	2020-2021	26-Sep	May	Grower's field	PB > COR + WR*	PB > COR + WR*	PB = COR + WR	PB = COR +WR	PB = COR +WR
Mulberry 13	2020-2021	14-Oct	May	Grower's field	COR + WR + PB	COR +WR = PB	PB = COR + WR	COR + WR ≥ PB	COR + WR ≥ PB
Year 2									
UC DREC	2021-2022	13-Oct	25-Jun	research station	PB = L > COR +WR > UTC		COR + WR > PB > UTC > L	COR + WR > PB ≥ UTC=L	COR + WR > PB ≥ UTC=L
UC DREC	2021-2022	13-Oct	25-Jun	research station	PB = PB +COR		PB = PB +COR	COR > PB + COR > UTC >PB	COR ≥ PB > UTC > COR+PB
Plum 20	2021-2022	19-Sep	21-Apr	Grower's field	PB > ADM	PB > ADM	PB = ADM	PB = ADM	PB = ADM
Mulberry 15	2021-2022	2-Oct	27-Apr	Grower's field	PB + COR + WR = COR + WR > PB*	PB + COR + WR = COR + WR > PB	PB = COR + WR = PB + COR + WR	COR + WR > PB*	COR + WR > PB*
Marigold 8	2021-2022	27-Sep	15-Apr	Grower's field	PB + COR + WR = COR + WR > PB	PB + COR + WR = COR + WR > PB	PB = COR + WR = PB + COR + WR	PB = COR + WR	PB = COR + WR
Year 3									
UC DREC	2022	15-Sep	not harvested	research station	PB > L > COR +WR = UTC		PB = COR + W > L =UTC		

Notes: UTC: untreated control; PB seed treatment-chlothianidin + cyfluthrin; L: chlorpyrifos; COR: Chlorantraniliprole; WR: imidacloprid ; ADM: imidacloprid.

30,000 plants per acre. Increased growth of fewer plants could not overcome this population deficiency at harvest and yields were lower. There was no apparent explanation except for possible differences due to seed size and planter performance, but it is otherwise unexplained. In UC DREC trials, PB seed emerged as well as all other treatments in all three years (***Fig. 8.5***). This poor outcome for PB seed treatments differed from results in all other trials carried out during this project (*Table 27*).

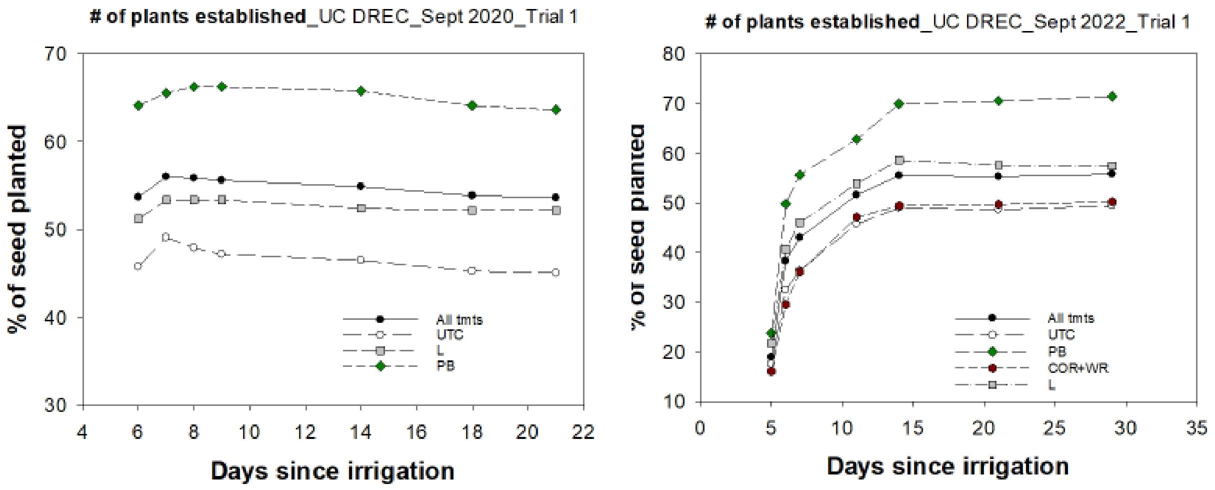


Fig. 8.5*. Comparisons of seedling emergence and establishment for two September trials at the UC DREC, from 2020-2021 (left) and fall 2022 (right).*

Fig. 8.5 compares Emergence in the two September planted trials at UC DREC. In both years, PB treated seed emerged more completely than L treated seed and untreated controls (UTC) that received no soil or seed treatments. Emergence and establishment for PB treated seed was slightly greater in the second trial but the relative relationship among treatments remained the same. In the second trial both the PB and L treatments emerged at greater rates than the COR+ WR treatment common in growers' fields.

October-planted trials at the UC DREC from 2020-2021 and 2021-2022 are compared in ***Fig. 8.6***. Both trials were planted approximately one month later than the September planted trials in *Fig. 8.5*. Differences reflect only planting date effects and differences between years. All other treatments were similar in both years. Average emergence ranged between 70 and 90 % of seed sown in mid-October, compared to 50 to 60 % of seed sown in mid-September. The October 2021 trial was sprinkler irrigated, but there appeared to be no advantage due to sprinkler irrigation compared to the year 1 trial.

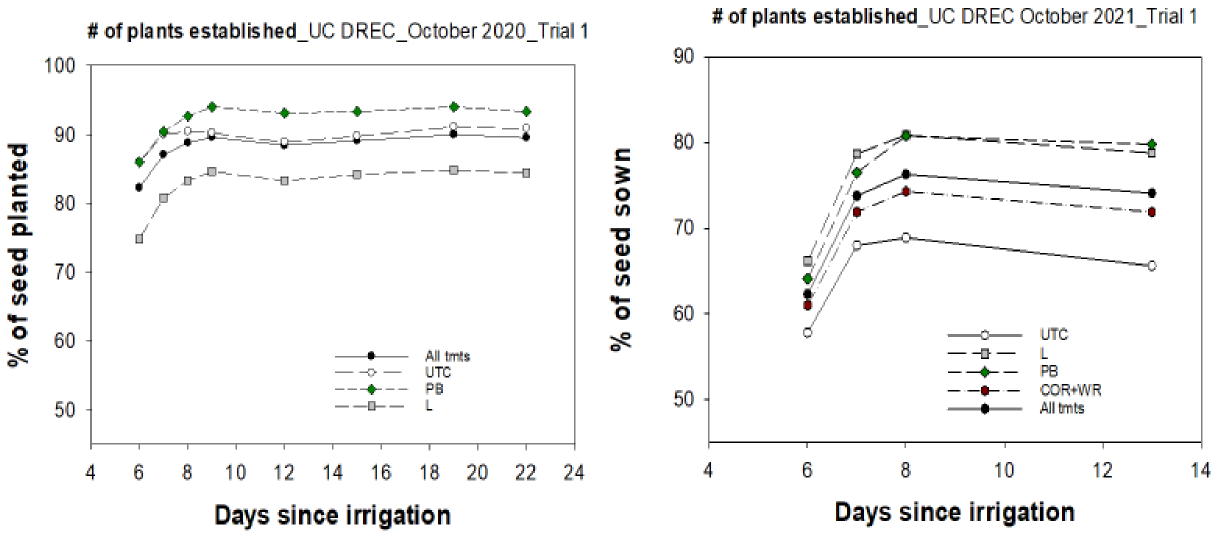


Fig. 8.6*. October-planted trial comparisons at the UC DREC. Left 2020-2021, right 2021-2022. Year one, plots were furrow irrigated and in in year 2, plots were sprinkler irrigated. Year 1 plots were furrow irrigated.*

Seedling dry weights were affected by treatments. September planting date comparisons similar to *Fig. 5.12* are shown in ***Fig. 8.7***. October plantings had less insect pressure and less response to treatments (not shown). There was large variance among seedling weights in both years. In general, seedling dry weights were larger in PB treated plots than in L or UTC plots in both years. Absolute differences in dry weights between the two years was due to later collection in year 3 when plants were larger, otherwise all other treatment conditions were similar.

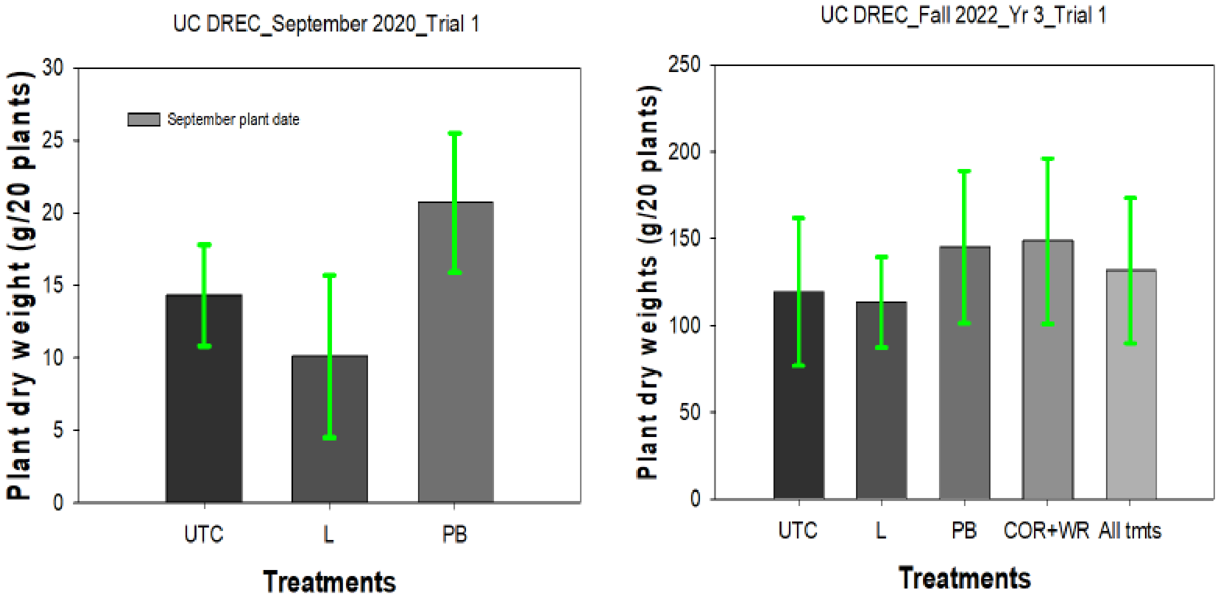


***Fig. 8.7**. Seedling dry weight comparisons in September-planted trials at the UC DREC. Left: 20200-2021, Right: fall 2022. Error bars are standard deviations. (Combined figures above).*

Chlorantraniliprole was evaluated in separate trials during the first two growing seasons. This material was used by grower–cooperators but not part of the original trial design. It was added to Trial 1 in 2021-2022 (year 2) to include a comparison between common grower practices and the use of chlorpyrifos (L). It was tested here to evaluate its effectiveness compared to seed treatments using clothianidin (PB). In year 2, since a PB + COR treatment was added to trial 1, trial 2 was used to evaluate whether COR increased the efficacy of PB seed treatment used alone. Grower-cooperators used both together. Emergence rates for PB and PB+COR treatments were similar both years. There was little armyworm pressure at the UC DREC site so the COR treatment provided no additional protection. There was no additional benefit in either year for including COR with PB seed treatments at planting. There was some indication that when used without PB seed, emergence was reduced due to greater pre-emergence loss (***Fig. 8.8***).

Seedling dry weights are compared for differences resulting from the use of chlorantraniliprole with PB treated seed and without treated seed, in ***Fig. 8.9***. PB and PB + COR treatments tended to differ in opposite ways in both trials, but not significantly. COR, by itself, resulted in lower emergence, likely because it is not protective against flea beetles or their larvae.

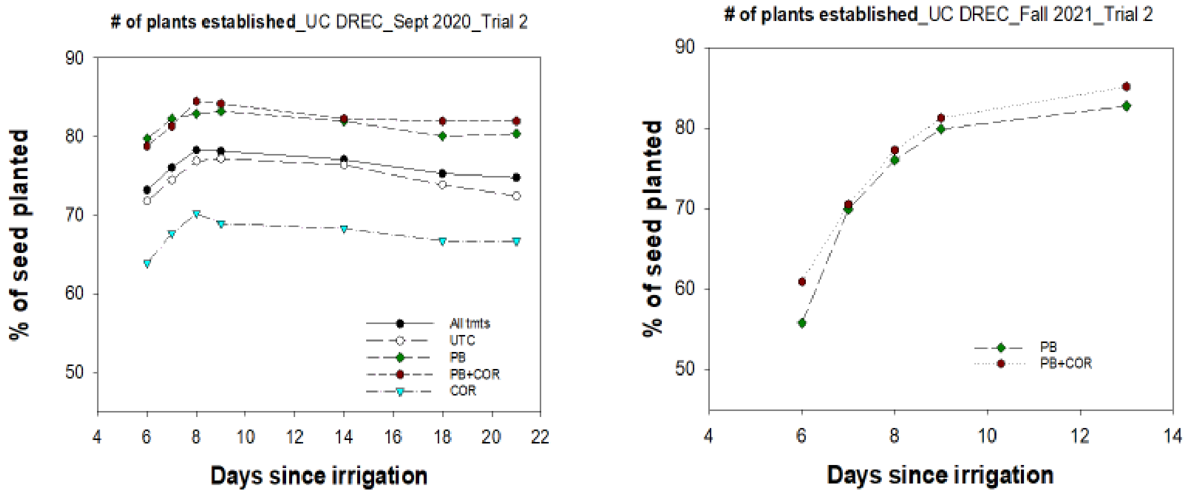


Fig. 8.8. *Comparison of soil treatments with and without chlorantraniliprole (COR) in secondary trials at the UC DREC during 2020-2021 and 2021-2022. Left: 2020-2021; right 221-2022. (Combined Fig. 12 and 15 above).*

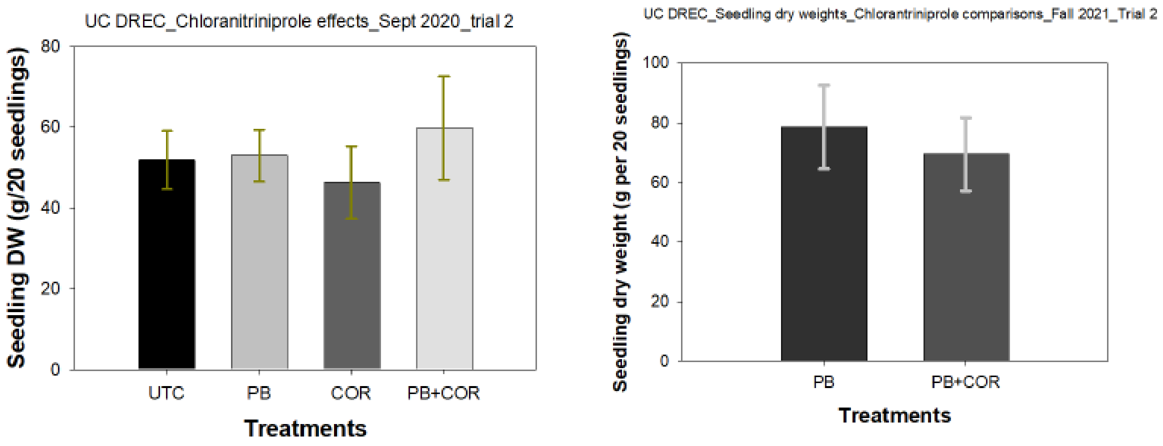


Fig. 8.9. *Chlorantraniliprole effects on seedling dry weights in two fall-planted trials at UC DREC. Left: September -planted trial in 2020-2021; Right, October-planted trial in 2021-2022. Error bars are standard deviations.*

Yields in the UC DREC trials were affected by the choice to use a cone planter in the 2021-2022 season (year 2, *Table 27*). The cone planter allowed for the planting of equal 100-seed amounts in plots, eliminating the variance due to planter performance observed in the first year's trial. Cone planters, however, do not distribute seed as uniformly as commercial planters like the air planter used in year 1, even accounting for planter variance. Seed is dispersed somewhat unevenly. After the 12-leaf stage, plots were hand thinned to create more uniform plant stands. This reduced the effects of fall treatments, if any, by the time harvest occurred in these trials. Results are reported in *Table 27* for completeness, but shaded to indicate this distinction, and to indicate that this trial did not provide useful information about fall stand establishment treatment effects on root and sugar yields. They reflect post-emergence treatment differences if any and random, unexplained effects among plots.

The trial in fall 2022 (year 3) was not harvested. In the previous two year's trials, harvests were carried out (*Tables 3, 4* and *8* and *9*). Harvest dates and season length were always latest/longest at the UC DREC. Harvests occurred in mid- to late-June in both years at the UC DREC site, with a season length of 9 + months. Growers' planting and harvest dates varied from mid-September to later in October for planting, and from mid-April to mid-June for Harvest across the six site/years (*Table 27*).

8.3. Pesticide use. Season length affected the use of insecticides and other pesticides. Practices varied among the fields and growers, and differed by year at the UC DREC site. But in all cases, pesticide application was largest during the fall cropping season. These data are reported in Tables Growers and their PCAs reported low insect pressure in spring 2021 when their fields were harvested in May and June. In spring 2022 (year 2), beets were harvested by the end of April before any insect pressure could be expected to occur in most years.

In planning these trials, we had expected more insect pressure to occur in late spring than was observed. Except to infer that less management may be needed in practice than was commonly thought, this limited the use of data from growers' fields to infer the need for and response to insect control in late spring/early summer.

There were differences in the amounts and types of materials applied by growers in this set of studies (***Table 8.2***). Over the two years, the Mulberry and Marigold fields were managed by the same PCA, the Plum and Ash fields by a different PCA. Pesticide expenditures were not correlated with gross sugar yields in any obvious way, suggesting that there is an opportunity to save money through prudent pest management. Differences in management in part may reflect pest management philosophy, and may or may not reflect actual insect pressure. Growers have varying levels of comfort with respect to pest management. In meeting with the grower-cooperator group and their PCAs, differences in costs of control were noted and discussed. Sharing this information appeared to be a valuable experience for all participants. It is unclear how much informal sharing of experience and practices occurs in the pest control community in real time during critical crop management periods, but encouraging such sharing and facilitating it in real time could be an important IPM practice.

Table 8.2 . Imperial Valley IPM project_Pesticide Expenditures_Imperial Valley_2020 to 2022

Trial information				Pesticide expenditures	Relative yield
Location	Year	Planting date	Harvest date	$/ac	lb sugar/ac
		Fall	Spring-summer		
Year 1					
ASH 24	2020-2021	7-Oct	19-May	585.15	18350
Mulberry 7	2020-2021	26-Sep	25-May	236.56	19210
Mulberry 13	2020-2021	14-Oct	16-Jun	243.03	22150
Year 2					
Plum 20	2021-2022	19-Sep	21-Apr	196	13670
Mulberry 15	2021-2022	2-Oct	27-Apr	140.73	10970
Marigold 8	2021-2022	27-Sep	15-Apr	234.03	12720

9.0. Pesticide Risks

Comparing risks of common pesticides used in sugarbeet production in the Imperial Valley.

Pesticides are yield preserving interventions in agriculture. Generally, they involve relatively low costs compared to the sum of all other investments in a crop, including both variable and fixed costs. Their use is prudent relative to the larger costs associated with crop production (De Wit,). Pesticide risk, however, is an important consideration for growers and workers who apply them, regulators, scientists (Frank and Tooker, 2020) and the general public (Xerses Society, 2018). Most crops, especially in the desert environment of the Imperial Valley, require some protection from insect damage. The alternative can be crop failure or reduced yields that are uneconomic. In addition to efficacy, risk is an important consideration in pesticide use.

To carry out risk assessment for pesticides used commonly in the Imperial Valley for sugarbeet production, we used the **Pesticide Risk Tool (PRT)** developed by *the IPM Institute of North America*[17]. From the website (https://pesticiderisk.org/): the PRT estimates risk to workers, birds, earthworms, small mammals, pollinators and aquatic ecosystems (receiving water bodies), and dietary risks to consumers. Scores are probability estimates of adverse effects in these broad general categories (***Fig. 50***). They are based on the technical risk assessment literature and consultation with a wide range of expert groups and individuals concerned with risk management, Including US EPA and several state agencies.

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[17] Pesticide Risk Tool_IPM Institute of North America, Inc.
211 S Paterson Street, Suite 380
Madison, WI 53703; Phone: 608 232-1410; Fax: 608 232-1440; https://pesticiderisk.org/

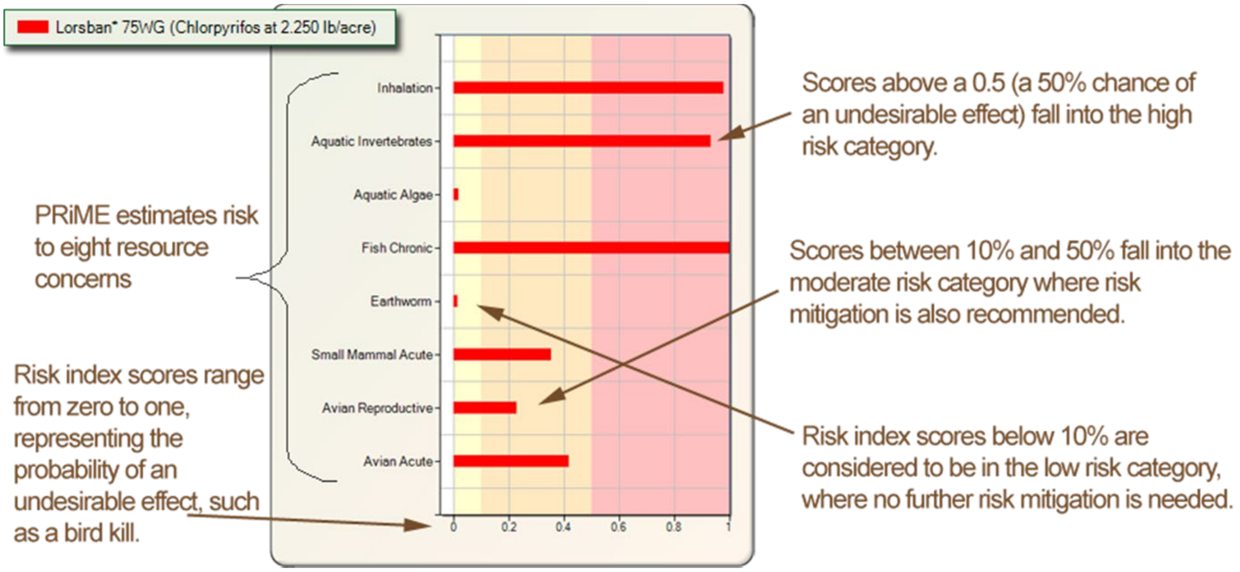


***Fig.** 9.1. Risk summary for generic use of Chlorpyrifos illustrating the rating system used. From the IPMI website: https://pesticiderisk.org/help/guided-tour*

***Fig. 9.2.** Northern Imperial Valley and Salton Sea. The Salton Sea is the receiving water body where surface runoff and drainage end up. Most transport occurs via field drainage systems (surface and tile drains) and is transported to the New and Alamo River and then to the Salton Sea.*

Pathways for risk exposure are important. Workers handling and applying pesticides work in close proximity to the materials when applied and are at higher direct risk from exposure than the general public. Seed treatments are considered safe to handle. Pesticides applied to plants or the soil surface may drift to other locations and directly affect any species in the path of application, including pollinators. If soil applied, soil organisms are exposed even if not direct pests of crops, such as earthworms. Pesticides applied in soils may migrate to groundwater through tile drains or via sediment movement to surface drains. Both pathways are possible in the Imperial Valley (***Fig. 9.2*** and **9.3**), but unlikely from this use.

Sediment is dislocated and transported from the sides of beds and furrow bottoms when surface irrigation is used, the common practice in sugarbeet production in the Imperial Valley. The tops of beds where seeds are placed are not affected. Subsurface transport through soils to tile drains occurs, but slowly over a multi-year period through largely clay dominated soils. Tile drains are 6 feet deep and widely spaced, requiring multi-year transit times. Pesticides are transported to receiving waters in the IV. Chlorpyrifos was detected in the Salton Sea (Anon, 2012; Sapozhinova et al, 2004; Crepeau et al., 2002). But it was applied cumulatively at large amounts across multiple crops and years, and directly to plants and soil surfaces, as well as soil applied, facilitating movement in runoff.

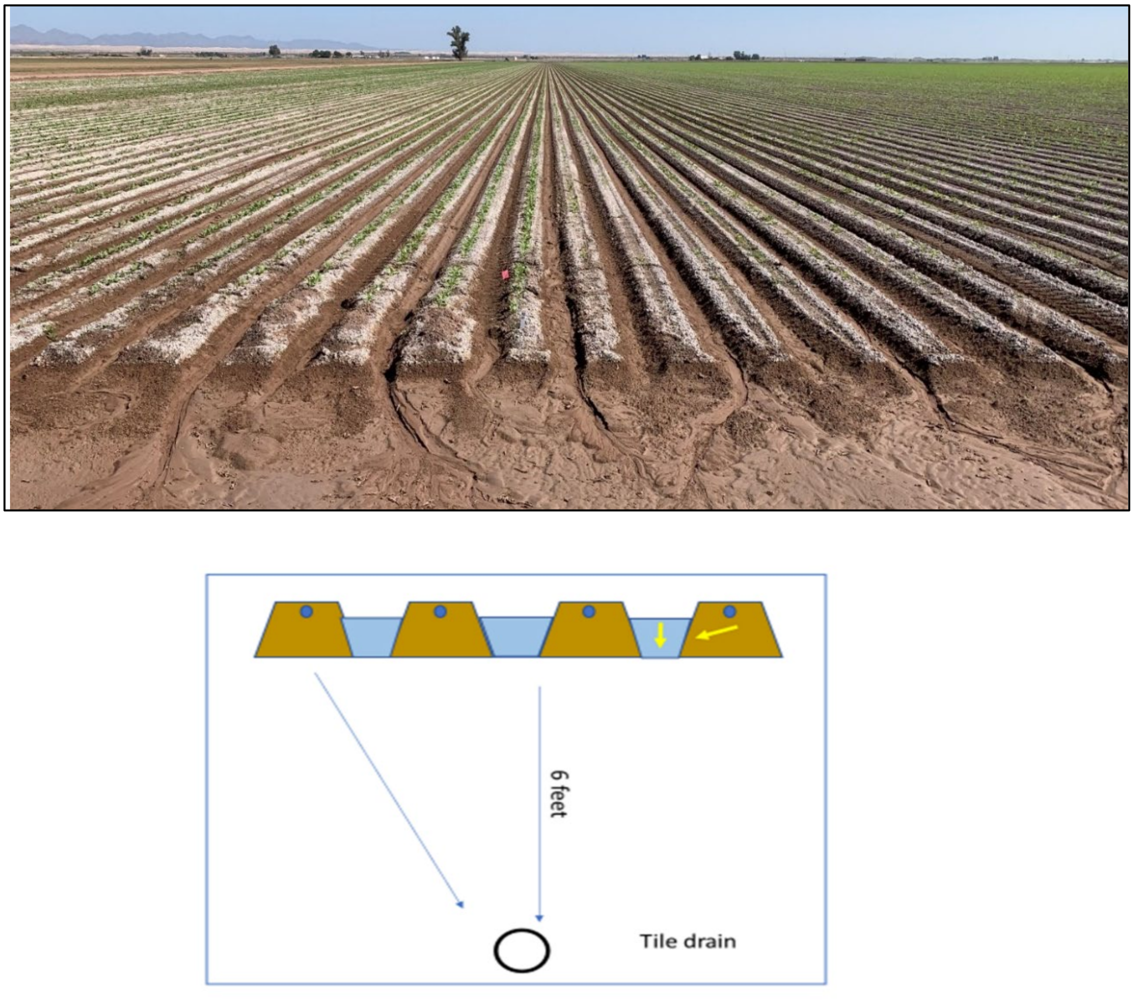
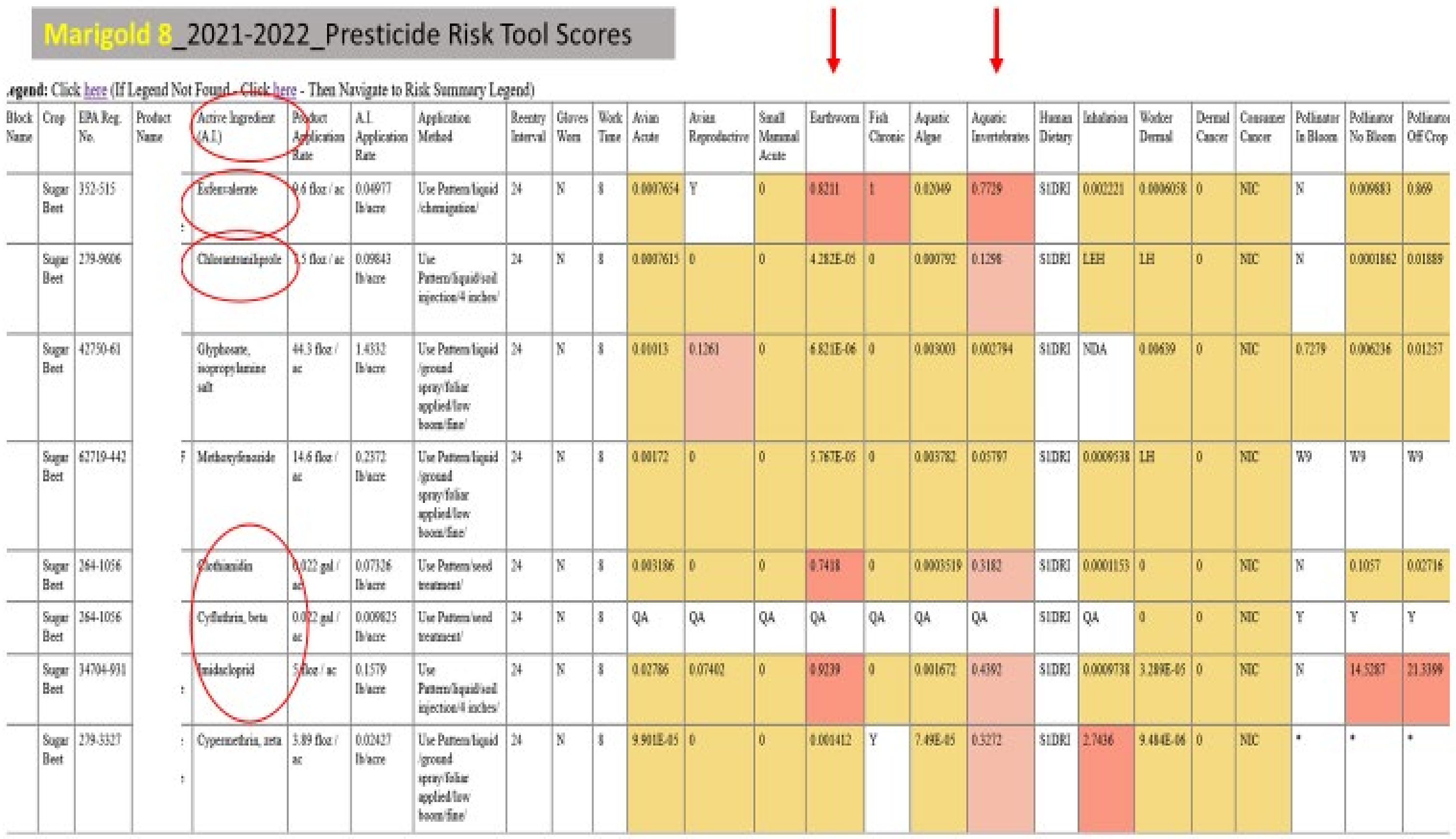


***Fig**. 9.4 (**52)**. Surface irrigation of emerging and established sugarbeet stand in Mulberry 13 (Fall 2020). Sediment runoff at the tail end of the field. Sediment is derived from the sides of the beds and furrow bottoms. Seeds are planted at 1-inch depth in furrow tops. Tile drains are 6 feet deep and widely spaced.*



Marigold 8_2021-2022_Presticide Risk Tool Scores

Legend: Click here (If Legend Not Found - Click here - Then Navigate to Risk Summary Legend)

Block Name	Crop	EPA Reg. No.	Product Name	Active Ingredient (A.I.)	Product Application Rate	A.I. Application Rate	Application Method	Reentry Interval	Gloves Worn	Work Time	Avian Acute	Avian Reproductive	Small Mammal Acute	Earthworm	Fish Chronic	Aquatic Algae	Aquatic Invertebrates	Human Dietary	Inhalation	Worker Dermal	Dermal Cancer	Consumer Cancer	Pollinator In Bloom	Pollinator No Bloom	Pollinator Off Crop
	Sugar Beet	352-515		Esfenvalerate	9.6 floz / ac	0.04977 lb/acre	Use Pattern/liquid /chemigation/	24	N	8	0.0007654	Y	0	0.8211	1	0.02049	0.7729	S1DRI	0.002221	0.0006058	0	NIC	N	0.009883	0.869
	Sugar Beet	279-9606		Chlorantraniliprole	[illegible].5 floz / ac	0.09843 lb/acre	Use Pattern/liquid/soil injection/4 inches/	24	N	8	0.0007615	0	0	4.282E-05	0	0.000792	0.1298	S1DRI	LEH	LH	0	NIC	N	0.0001862	0.01889
	Sugar Beet	42750-61		Glyphosate, isopropylamine salt	44.3 floz / ac	1.4332 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/fine/	24	N	8	0.01013	0.1261	0	6.821E-06	0	0.003003	0.002794	S1DRI	NDA	0.00639	0	NIC	0.7279	0.006236	0.01257
	Sugar Beet	62719-442		Methoxyfenozide	14.6 floz / ac	0.2372 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/fine/	24	N	8	0.00172	0	0	5.767E-05	0	0.003782	0.05797	S1DRI	0.0009538	LH	0	NIC	W9	W9	W9
	Sugar Beet	264-1056		Clothianidin	0.022 gal / ac	0.07326 lb/acre	Use Pattern/seed treatment/	24	N	8	0.003186	0	0	0.7418	0	0.0003519	0.3182	S1DRI	0.0001153	0	0	NIC	N	0.1057	0.02716
	Sugar Beet	264-1056		Cyfluthrin, beta	0.002 gal / ac	0.009825 lb/acre	Use Pattern/seed treatment/	24	N	8	QA	QA	QA	QA	QA	QA	QA	S1DRI	QA	0	0	NIC	Y	Y	Y
	Sugar Beet	34704-931		Imidacloprid	5 floz / ac	0.1579 lb/acre	Use Pattern/liquid/soil injection/4 inches/	24	N	8	0.02786	0.07402	0	0.9239	0	0.001672	0.4392	S1DRI	0.0009738	3.289E-05	0	NIC	N	14.5287	21.3399
	Sugar Beet	279-3327		Cypermethrin, zeta	3.89 floz / ac	0.02427 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/fine/	24	N	8	9.901E-05	0	0	0.001412	Y	7.49E-05	0.3272	S1DRI	2.7436	9.484E-06	0	NIC	*	*	*

Table 9.1 29. *Pesticide Risk Tool estimates for pesticide use for the Marigold 8 field in 2021-2022. Additional results in Appendix tables 1 and 2.*

Results from the use of the PRT are presented in Table X and Figure Y for the Marigold 8 field in 2021-2022. Marigold 8 and Mulberry 15 were managed similarly. Results for the Plum 20 field differed but not in substantial ways (data not shown). These fields were analyzed because they applied pesticides almost exclusively in the fall during stand establishment that year due to early (April) harvest dates that avoided late spring/summer pest management requirements. This reduced the detail in the tables and focused on the critical period for pest management in sugarbeet fields in the IV, fall during planting and establishment.

For clothianidin (the PB treatment), overall risk in *Table 9.1 29,* though small*,* likely is overestimated under IV conditions due to a lack of affected species and/or lack of pathways for risk to occur. Risk ratings are consensus-based on a wide range of locations and environments across the US and beyond where robust literature estimates are available (see below). Conditions in unique environments like the Imperial Valley are not ell represented in that literature. For example, earthworms are considered to be at risk from seed treatments with neonicotinids, but are rare or absent in desert soils in the IV, so that indicator is likely invalid. At ultra-low rates and slow rates of movement of any transportable material through the clays soils that dominate in the Imperial Valley to tile drains at 2 m depth, there is essentially non-existent risk to aquatic systems (fish), except perhaps through surface runoff (Fig. 52, Table X). Pollinators in particular are thought be at risk from general exposure to neonicotinid insecticides in agriculture (see below). Sugarbeets do not flower so there is no direct pathway for pollinators. Few to no pollinators were captured on stocky cards or in wing traps in late summer/early fall in bare fields in the IV, so pollinator risk is not rated as a concern (***Fig.*** **9.4 53**).

Post-emergence controls varied in the three fields observed in 2021-2022, so overall risk varied in small amounts among the fields (data not shown), but results were similar for Mulberry 15, and similar as well for the Plum 20 field (*Tables 15 to 17*). In general, the largest risk associated with stand establishment protection is from the use of esfenvalerate, accounting for the lack of clear transmission pathways for PB seed treatment residual as to natural systems or consumers.

Recommended best management practices resulting from this study involve the use of seed treatments using clothianidin, a neonicotinid insecticide used as a seed treatment. This use is recommended as a risk reduction strategy. When applied as a seed treatment, clothianidin is used in small amounts at standard seedling rates (60,000 seeds per acre). This is equivalent to applying 1.8 oz active ingredient per acre (36 g/ac). This is dispersed in a comparatively enormous soil volume and degraded over time, especially under the harsh conditions of the Imperial Valley. Risk was evaluated by using the Pesticide Risk Tool, created by the IPM Institute of North America (https://ipminstitute.org/ ; https://pesticiderisk.org/), and modified for the particular conditions of the Imperial Valley.

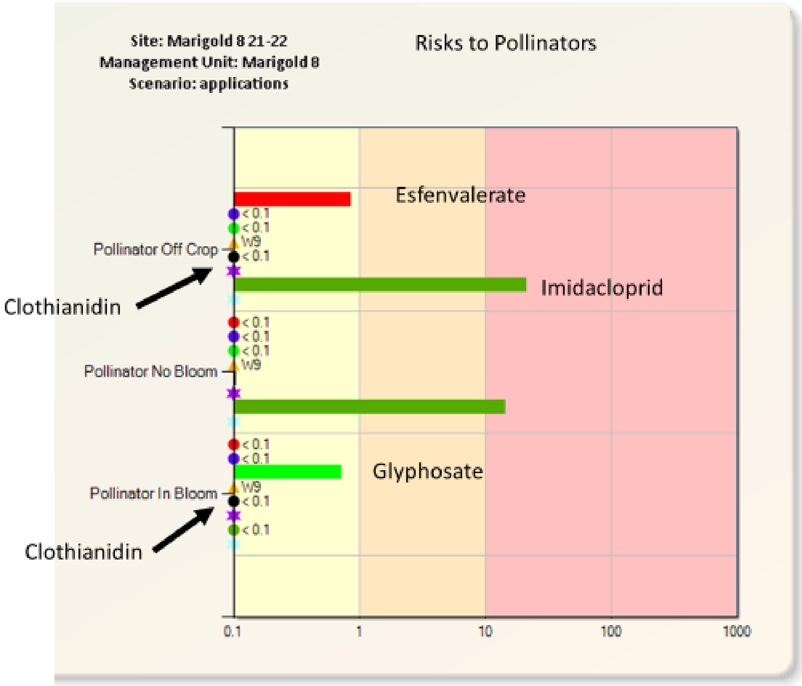


***Fig. 9.4**. Detailed results for pollinator risk from the use of diverse insecticide in the Marigold 8 field in 2021-2022. Pollinator risk from chlothianidin seed treatments was estimated to be inconsequential. Results from the Pesticide Risk Tool.*

Risks from neonicotinid use in sugarbeet production in the Imperial Valley

This recommendation runs contrary to much recent literature and regulatory actions which highlight concerns and non-target effects of neonicotinid use (Frank and Tooker, 2020; Thompson et al 2020; Wood et al., 2019; European Food Safety Authority, 2018). These compounds are widely used in the US, worldwide, and used broadly for a number of crops in the IV. A recent comprehensive literature review discussing benefits and costs is contained in Cornell (2020). The overall issues involved with the use of neonicotinid insecticides are discussed here briefly.

Pollinator risks. Fig. 9.4 are results from the use of the Risk Assessment Tool ranking risk from the pesticides used and compared in trials during this study. The largest risks to pollinators are from the use of neonicotinid insecticides applied to plants or to soils. The PRT indicates no risk to pollinators from seed treatments on beets. Beets do not flower in the Imperial Valley, and when they flower in seed producing regions (Oregon), are wind pollinated. We captured only a few bees of diverse species on sticky cards during the three years of monitoring crops, indicating that bees do not generally visit beet fields. There are no pathways for transmission of seed treatment insecticides to pollinators and thus no risks from this use.

Transport to surface waters. Transport of neonicotinid seed treatments to surface waters has been reported in a Canadian study from southern Ontario that resembles larger areas of the mid-west where corn and soybean rotations predominate (Schaafsma et al., 2019). There, shallow tile drains (1 m) combined with heavy drainage discharges in spring due to melting snow and thawing soils lead to drainage-based transport from tile drains and the appearance of chemical residues in surface ditches and creeks and other surface waters receiving drainage.

In the IV, commonly occurring sediment runoff is observed at the tail end of the field. Sediment is transported primarily from furrow bottoms and the sides of beds as water moves down furrows. Sugarbeet seed is planted at approximately 1 inch in depth in the middle of raised beds, so seed treatment insecticides do not come into contact with moving water and cannot become part of the sediment load at the end of the field (*Fig. 52*).

Any transport of seed treatment insecticides to receiving water bodies would have to occur via leaching and collection in tiles draining fields. Tile drains in the IV are widely spaced and commonly set at 2 m (6 feet) in depth. Tiles are widely spaced. Soils are clay dominated and internal transport to tile drains through clay soils occurs slowly.

A study from Switzerland reported transport via preferential flow to shallow tile drains (1m) is a sand and silt dominated soil. Amounts occurring in tile drains over the growing season (April-October) from a thiomethoxam seed treatment was 2.2×10^3 ng ha^{-1}. Rainfall was supplemented with sprinkler irrigation. Other studies from corn and soybean growing regions in the midwestern US also suggest transport to shallow tile drains (likely via preferential flow mechanisms) in spring.

Additionally, seed size and plant populations may influence the risk of dispersal. In the midwestern US, corn and soybean seeds are commonly treated[18]. Corn is planted at populations similar to sugarbeets but seeds are larger, likely requiring more active ingredient. Soybeans, in contrast, are planted at about 3 times the rate of sugarbeets and seeds are much larger. Corn and soybean rotations are common in large areas of the mid-west so amounts of neonicotinids applied to landscapes are much greater compared with use on sugarbeets in the Imperial Valley. Out of the nearly 450 K acres of planted area, beets are planted on approximately 25K acres per year (5 -6 % of the planted area), and cannot be planted in the same field more often than 4 years out of ten. Combined with extremely high soil temperatures in summer, leading to degradation (Chang et al, 2019), these factors reduce the risk of neonicotinid accumulation in soils and subsequent transport to surface waters, in contrast to corn and soybean rotations. (Frank and Tooker, 2020; Thompson et al 2020; Wood et al., 2019; European Food Safety Authority, 2018; US EPA, 2017; Krupke et al., 2017; Sanchez-

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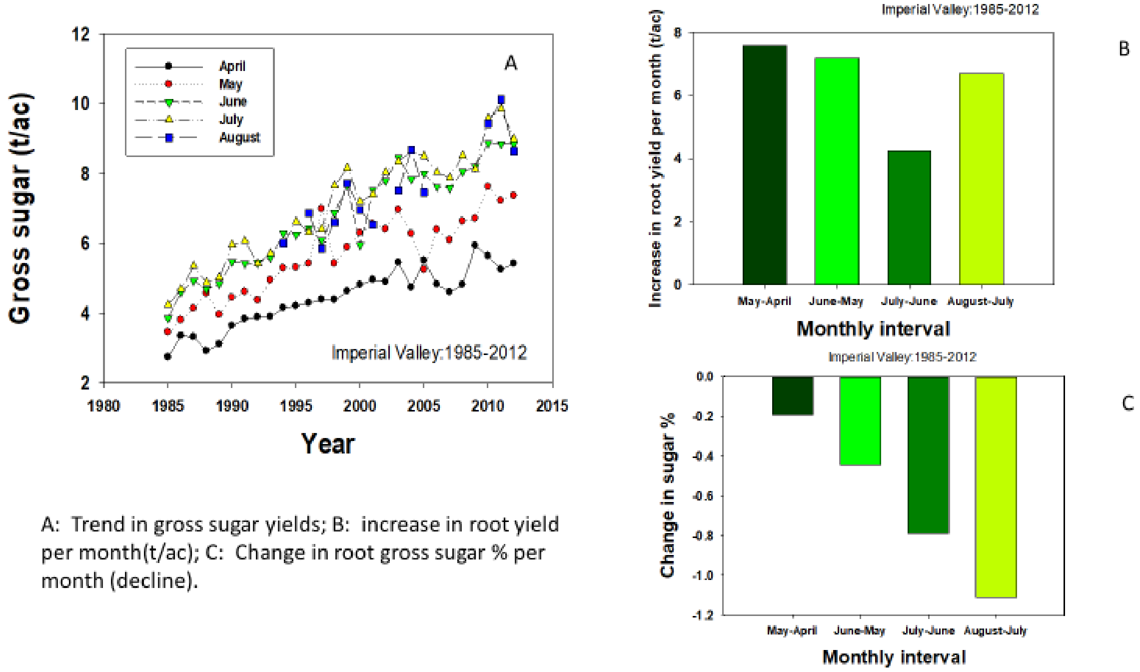
[18] Corn is planted at approximately 30K seeds per acre; soybeans at 90K to 120K seeds per acre. Corn is estimated to have 0.5 mg a.i. per seed treated with clothianidin, soybeans are estimated to have 0.15 mg/seed ai when treated with imidicloprid. On an acre basis, this is equivalent to 0.015 kg ai per acre for corn and a similar amount for soybeans. (Corteva data). In the US, approximately 90M ac per year are planted to both crops, though not all seed is treated. For sugarbeets in the IV, at 60K seeds per acre, and 0.6 mg/seed, 0.036 kg ai per acre are applied. Typically, 25K ac are planted to beets in the IV each year. These acres are approximately 6 % of all planted acres in the IV. If all acres used PB treated seed, approximately 900 kg per year would be applied in the IV for this use.

Bayo, 2014; and others in references cited below). The potential risk of transport to surface waters (the New and Alamo Rivers) in the Imperial Valley from treated sugarbeet seed and the amounts that might occur are unknown. To our knowledge, neonicotinid transport to surface waters in the IV has not been studied to date.

Cumulative risks from neonicotinid use, however, result from diverse uses on all crops, not just from sugarbeets. Use only on beets as seed treatments arguably would be impossible to detect quantitatively and likely is among the lowest risk uses in the region. Other uses of neonicotinids when soil or plant applied, may have the potential to reach receiving waters. Larger amounts of active ingredients may be used for these purposes, and if plants are sprayed, then contact with non-target organisms and some surface transport in furrows with irrigation water is possible. This particular use on sugarbeets is low risk compared to other that involve application to soils and plants. It can result in the reduction of other pesticide uses during stand establishment, especially for later-planted crops. It is a clearly superior substitute to chlorpyrifos from a risk perspective.

10.0. Discussion and Conclusions

10.1. Constraints on sugarbeet production in the Imperial Valley. The economic requirements of the sugarbeet industry in the Imperial Valley constrain options for reduced pest management interventions. Avoidance of peak insect activity periods in fall by planting later in October is only available for a portion of the total crop. A sugarbeet factory is a significant capital asset. For it to be viable financially, it must operate for the longest period possible in any given location. Climate limits farming seasonally and correspondingly curtails the operation of sugar factories all over the world. A number of ingenious methods have been developed to extend the processing season for beet refineries. In the Imperial Valley, beet harvest starts in early April and lasts until mid-July, and sometimes until early August. Mid-summer harvests are unfavorable due to increasing rates of loss to root rots during extreme summer temperatures. This limits the harvest campaign to 3.5 to 4 months per year. As the harvest season progresses, yields increase until about the end of June, and then remain static or decline with respect to yield and sugar content in beets due to high levels of respiration during hot weather (Kaffka and Tharp, 2015). End of season crops become increasingly uneconomic due to rising costs for water, labor and pest management, and losses in root quality and to root rots. The April starting date for first harvests is a compromise between the financial needs of growers and the needs of the factory. The growers need a factory to process and market their crop, and the factory needs willing growers to produce the crop. April harvests are often uneconomic for growers due to lower yields. The need for early April harvest, however, requires that some beets be planted starting in early to the middle of September when temperatures and insect activity remain high, an unfavorable time from an IPM perspective, to support early April harvests. Later planted beets, (mid-October onwards) avoid some insect pressure at planting and establishment, but these crops tend to be harvested last the following summer when insect pressure is again increased and losses to wet rots start to occur. Water and pest management costs rise, while root quality (sugar %) declines, limiting economic returns despite higher root yields. The risk of loss to wet root rots also increases with time, especially from mid-July to August, effectively limiting the growing season. The optimal time for planting and harvest is October to June, but not all acres can be planted and harvested at ideal times (Fig. XXX).



A: Trend in gross sugar yields; B: increase in root yield per month(t/ac); C: Change in root gross sugar % per month (decline).

Fig. 10.1. *Root yields by month, increases in sugar yield per month, and change in sugar % in roots by month. Root yields increase through June and then remain largely stable, while root quality tends to decline and risk of loss to wet root rots increases. (Kaffka and Tharp, 2015). Data is through 2012, but these relationships have not changed since that time.*

This project sought to improve overall insect pest management in sugarbeet production in the IV, while finding substitutes for chlorpyrifos, previously commonly used on sugarbeets. Given the well-defined characteristics of the production season and common location within the IV for producers, this research objective was considered reasonable and achievable. The outcomes included a more detailed understanding of the relationship between the amount of early season insect damage and crop yield, an understanding of the minimal treatments necessary to ensure adequate sugarbeet populations at planting, and which minimal treatments protect emerging seedlings when insect pressure is greatest. In addition, root yields and quality in spring and early summer were collected and compared with protection programs carried out the previous fall. The project was directed towards IV growers and their PCAs, several of whom participated, enhancing the effectiveness of outreach. Since profit margins for field crops like sugarbeets are often narrow, both cost and efficacy were considered when identifying best management practices. Pesticide risk was also evaluated. Additional outcomes included better informing the grower and PCA community about sugarbeet insect pest management, and new best management guidelines, including UC IPM guidelines (in preparation).

Insect pest management, commonly described as integrated, instead most often devolves to a pest-response approach, without actual integration with other crop and pest management practices. Here, a true IPM approach was used, with alternative chemistries combined with staggered planting dates in fall, and interactions with seed treatments and irrigation management to promote control through escape and improved plant growth.

The majority of insect pest management in sugarbeet production in the Imperial Valley occurs in autumn when crops are planted established. Sugarbeet seedlings are slow to grow after emergence and subject to mortality from insect grazing. Flea beetles, armyworms and leafhoppers were the primary insects observed and controlled during fall in all three growing seasons (years). Armyworms were present and damaged seedlings in only one grower's field, reportedly due to a missed spray treatment, but otherwise were controlled in grower's fields or were present in low numbers at the UC DREC site.

Insect pressure from flea beetles and armyworms declined between mid-September and late October in date-of-planting comparisons made at the UC DREC, holding all other factors constant (Figure 10.2). This was observed previously in earlier work funded by DPR in 2000 to 2003. Later planting in October reduces insect pressure and the need for insecticides during stand establishment, and can be considered an IPM strategy.

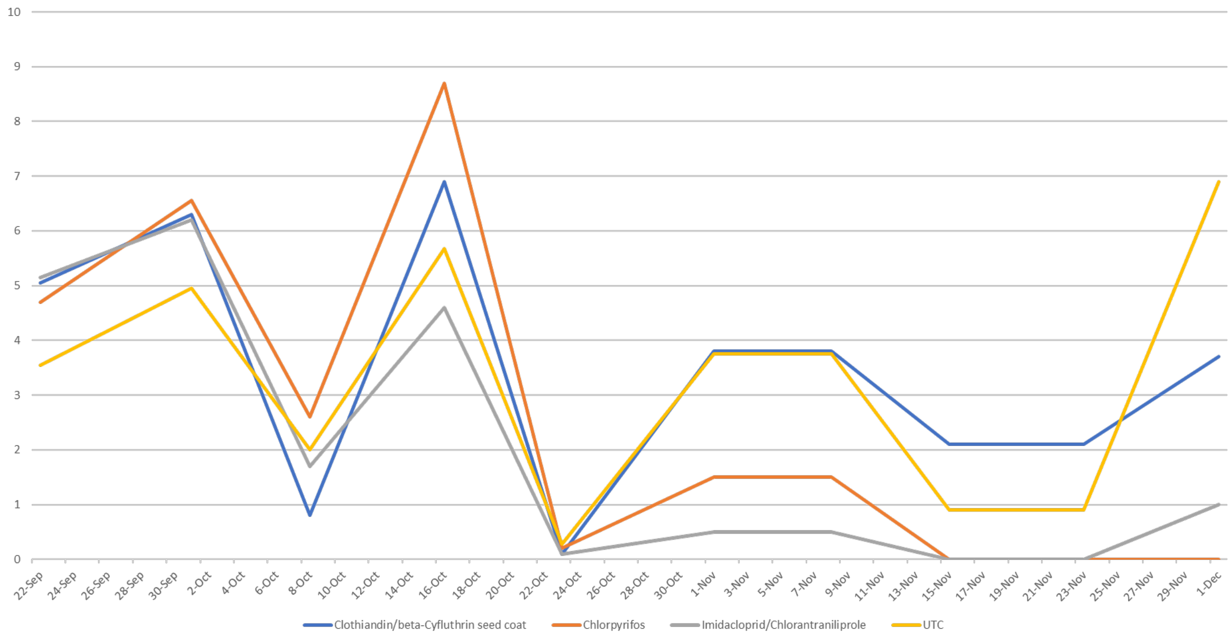


***Fig 10.2**. Multi-year average number of pale stripped flea beetles (Systena blanda) captured per day in fall on yellow sticky cards at the UC DREC site over the 2020 to 2022 research period. Differences among treatments in small plots are largely insignificant.*

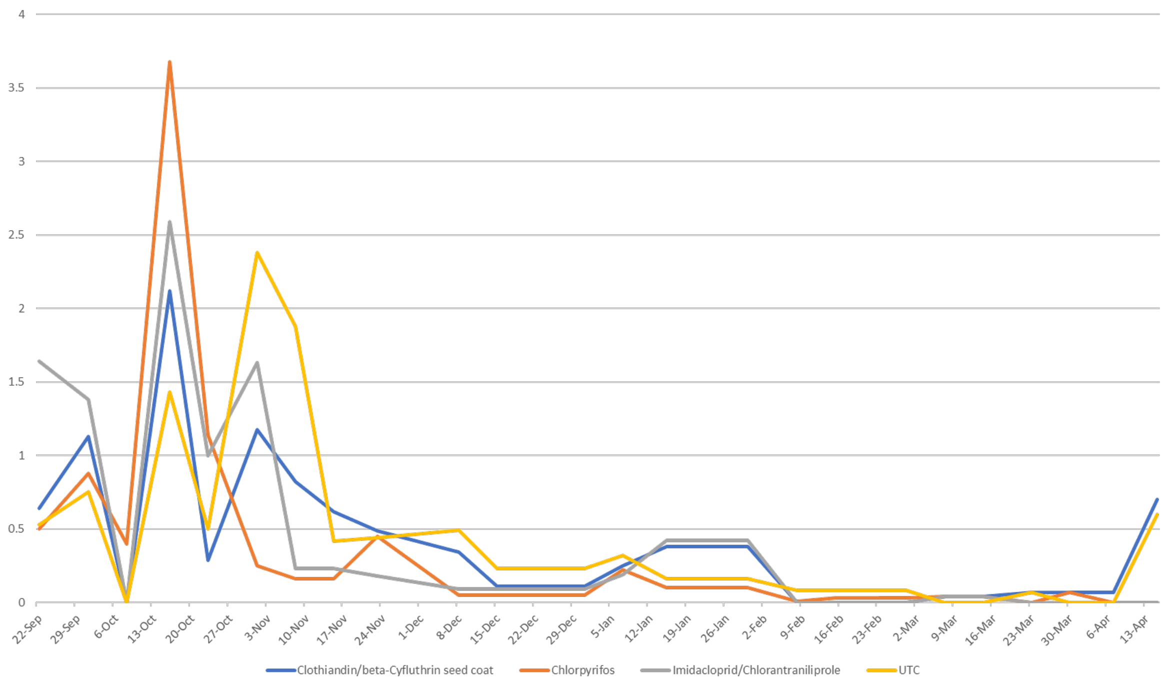


Fig. 10.3 *. Multi-year average of number of leafhopper (potato leaf hopper and beet leafhopper,* (Empoasca sp., and Circulifer *tenelius), caught per day on 3 X 5 yellow sticky cards in sugar beet plots at the UC DREC, 2020-2022. Differences among treatments are largely insignificant.*

Comparisons of pre-irrigation vs initial irrigation at planting for furrow irrigated plots provided no advantage from a pest management perspective in trials at the UC DREC site. None of the cooperating growers used pre-irrigation, so it seems to hold little promise as an IPM strategy.

In UC DREC trials and growers' fields, clothianidin + cyfluthrin (PB) seed treatments were equivalent to other practices with respect to stand establishment and final yield, and largely superior to chlorpyrifos (L) soil treatment in the trials at the UC DREC site.

Clothianidin + cyfluthrin (PB) was used at extremely low rates, and becomes ineffective after 40 to 60 days post-emergence as it becomes diluted in plants and degrades in soil and plant tissues (Chang et al, 2019). PB is effective against flea beetles and flea beetle larvae, the primary insect pests of emerging sugarbeet seedlings and newly emerged plants and is an effective substitute for chlorpyrifos (L) for this purpose. It is not as broad spectrum as chlorpyrifos, however, and other materials may be needed or likely are needed, especially for early-planted fields, to control post-emergence insect grazing by armyworms. Post-emergence treatment is standard practice for growers, most commonly using esfenvalerate, a pyrethroid insecticide, but also chlorantraniliprole and carbaryl.

Later planting in fall is a means of reducing or escaping insect damage on emerging seedlings with reduced or minimal pesticide use. Post emergence treatment comparisons of September planted plots at the UC DREC site (+/- esfenvalerate) was carried out in three separate years, all other experimental conditions being equal. Post- emergence treatments were ineffective or unneeded at the UC DREC site. Post-emergence seedling mortality was small in all three years, with or without treatment at that site (approximately 5% or less of all seedlings). Root and sugar yields of untreated plots at the UC DREC did not differ significantly from treated plots, indicating that post-emergence treatment may not always be needed. This was especially true for later-planted (October) plots.

Extrapolation from research station, small plot research, is not easily directly extrapolated to large scale growers' fields in diverse locations. No comparisons were possible with untreated (post-emergence) plots under farming conditions. In all of the grower cooperators' fields, irrespective of planting date, post-emergence application of pyrethroids was considered necessary by PCAs for army worm control, and for supplemental control of flea beetles in addition to soil treatments applied at planting and/or the use of seed treatments. This is common practice in the IV in fall. Where sprinklers were used, pyrethroids were applied with irrigation water to all plots.

There was no additional insect management during the remainder of the growing season (spring to summer) in two cooperators' fields, but several treatments were applied in one cooperator's field during the first growing season (2020-2021). Beets were harvested early in the second growing season (April) in all cooperators' fields. No insecticides were used past the fall establishment period that year.

Sugarbeet growers now have adopted successful alternatives to chlorpyrifos use. Alternatives involve primarily chlorantraniliprole as a soil amendment in combination with imidicloprid, followed by post emergence control using esfenvalerate, and sometimes additional use of imidacloprid and/or chlorantraniliprole or carbaryl.

Based on these results and on previous work in the IV and throughout California during previous years, seed treatments using neonicotinid insecticides appears to be a lower risk alternative to current growers' practices and to the historic use of chlorpyrifos on sugarbeets in the Imperial Valley. Two of the grower cooperators adopted their use during the trial (season two, 2021-2022) and seed suppliers report wide scale adoption of seed treatments currently in the Imperial Valley.

Pesticide risk was assessed using the IPM Institutes Risk Assessment tool. Neonicotinid seed treatments are a low risk pest management approach under the conditions of the Imperial Valley where there are few pathways to harmful environmental exposure compared to their use elsewhere in the US and on other corps and in other cropping systems. These issues are discussed.

10.2. **Limitations of these results.** Estimating the efficacy of pesticides under field conditions can be inexact, since so many conditions vary among research sites an across years, even in controlled experiments. The preponderance of outcomes in these diverse trials suggest that seed treatments are equally effective as common soil applied insecticides in controlling the primary pest of emerging sugar beet seedlings, stripped and potato flea beetles. They are a lower risk substitute for these other materials. They do not substitute for post-emergence pesticide applications to control beet armyworm grazing. Extrapolation from small plot trials at research stations to growers' fields and the larger IV region as a whole. Because conditions vary, statistical analysis is limited as tool for identifying effective treatments. In most instances, differences were not large enough to be significant, given the large amount of variance observed. The lack of significant differences implies that under actual field conditions, treatments are roughly equivalent, and can be substituted for each other. In that case, cost and risk become more important in deciding best management practices.

Risk tolerance differences exist among growers and PCAs. For the most part, growers try to avoid damage to seedlings altogether or tolerate only small amounts of damage. Once established, beets tend to grow through insect damage unless pest outbreaks are severe. Such outbreaks do not seem to occur in late fall or winter based on the outcomes of these trials and reported grower experience. But grower's preferences and the pest management philosophies of PCAs result in differ levels of treatments, as observed in these trials. The logic of pesticide use is difficult to dispute. It costs between $1200 and $2000 per acre to produce a beet crop in the Imperial Valley. Pesticide costs are 10 to 15 % of that total and protect against the loss of the rest of the grower's investment. Pesticide applications are almost always effective, and reduce financial risk, while withholding treatment poses risk of loss. Persuasive demonstrations are needed to support pesticide avoidance or reduced environmental risk strategies. This level of confidence was demonstrated for seed treatment efficacy and for benefits from delayed planting, but could not be equivalently demonstrated for reducing post-emergence treatment requirements in fall.

Large variance among years, growers' fields and experimental plots, and conditions and practices always limit inference. For the most part, differences observed were small or not significant. In part this was due to significant variance among plots at the UC DREC, and within Grower's fields. This variance is inherent in work of this nature, and common in commercial fields which commonly are large and may contain different soil types or significant gradients in properties like soil salinity. Replication was constrained by the willingness of growers to consign a large portion of their fields to experimental treatments, due to financial risk and the difficulty of managing multiple treatments in commercial fields. Additionally, budget limitations restricted the size of field plots and the number of replications in trials at the UC DREC.

To be of interest and value to growers, differences must be large enough to be detected at the scale of farming common to the IV, and account for the kind of variation at the field scale they experience. Here, we conclude that the lack of large differences across a range of growers' field conditions and within trials at the UC DREC support the equivalence of different insecticide use practices.

In that case, best management practices are those that cost least and reduce overall risk to the greatest general extent. Neonicotinid seed treatments fit those criteria and suggest a beneficial role for neonicotinid insecticides used as seed treatments with sugarbeets in reducing the use of other insecticide materials and reducing costs and risk for this minor crop use.

Based on these results and on previous work in the IV and throughout California, clothianidin seed treatment appears to be an effective, economic, and low risk alternative to current growers' practices and to the historic use of chlorpyrifos on sugarbeets in the Imperial Valley.

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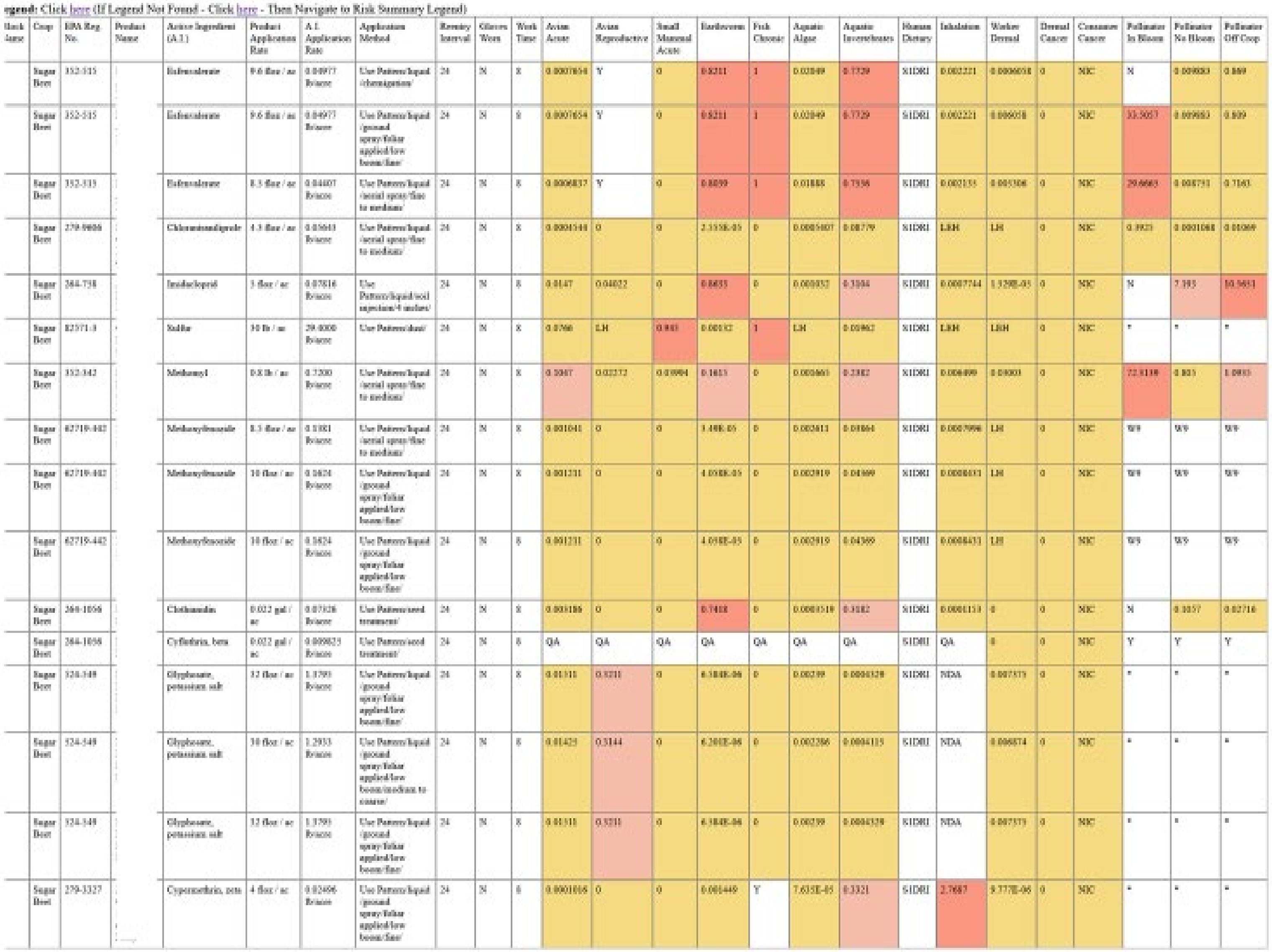
APPENDIX



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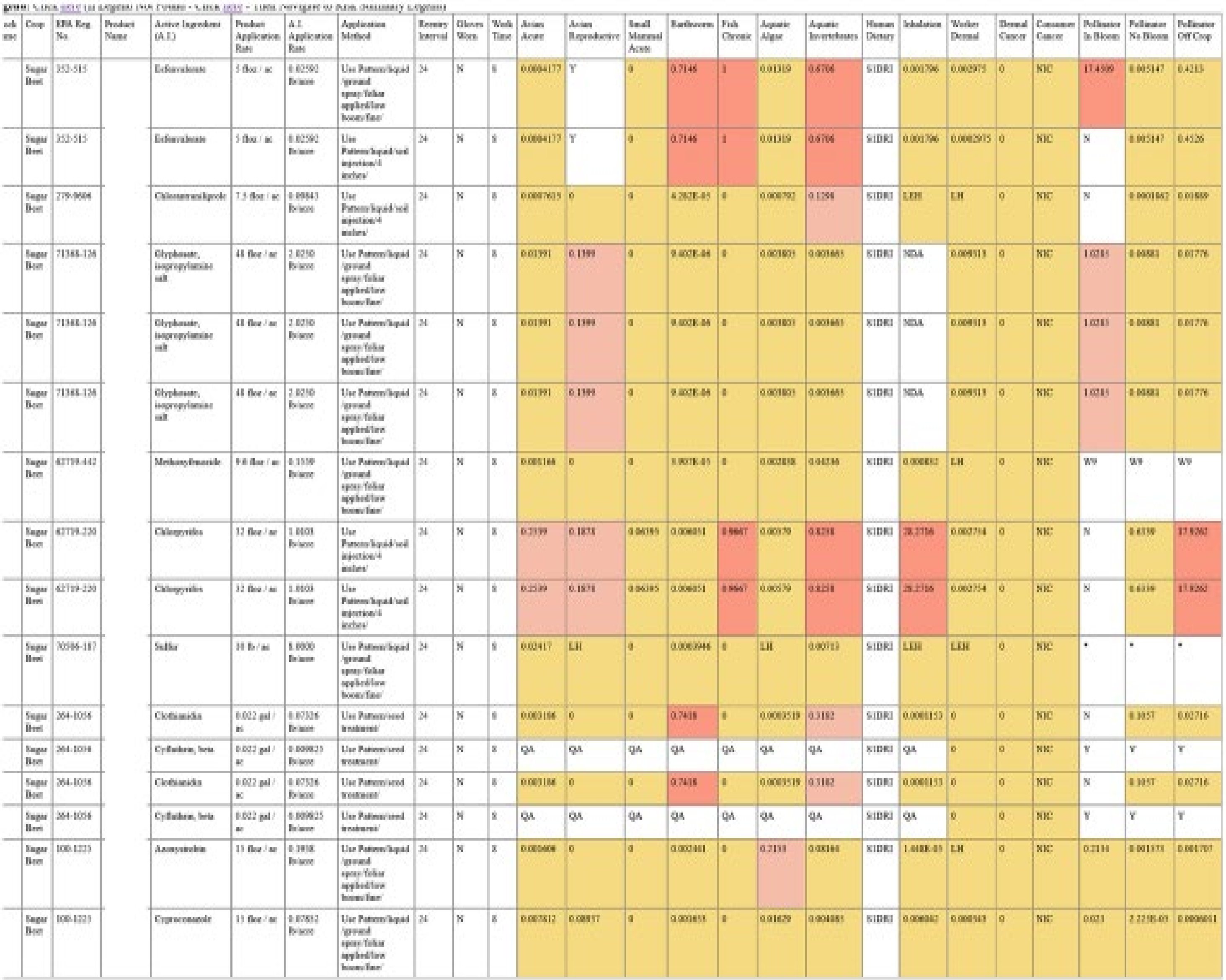
lock Name	Crop	EPA Reg No.	Product Name	Active Ingredient (A.I.)	Product Application Rate	A.I. Application Rate	Application Method	Reentry Interval	Gloves Worn	Work Time	Avian Acute	Avian Reproductive	Small Mammal Acute	Earthworm	Fish Chronic	Aquatic Algae	Aquatic Invertebrates	Human Dietary	Inhalation	Worker Dermal	Dermal Cancer	Consumer Cancer	Pollinator In Bloom	Pollinator No Bloom	Pollinator Off Crop
	Sugar Beet	352-515		Esfenvalerate	9.6 floz / ac	0.04977 lb/acre	Use Pattern/liquid /chemigation/	24	N	8	0.0007654	Y	0	0.8211	1	0.02049	0.7729	SIDRI	0.002221	0.0006058	0	NIC	N	0.009083	0.869
	Sugar Beet	352-515		Esfenvalerate	9.6 floz / ac	0.04977 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/fine/	24	N	8	0.0007654	Y	0	0.8211	1	0.02049	0.7729	SIDRI	0.002221	0.006058	0	NIC	33.5057	0.009083	0.809
	Sugar Beet	352-515		Esfenvalerate	8.3 floz / ac	0.04407 lb/acre	Use Pattern/liquid /aerial spray/fine to medium/	24	N	8	0.0006837	Y	0	0.8059	1	0.01888	0.7556	SIDRI	0.002153	0.005306	0	NIC	29.6665	0.008751	0.7163
	Sugar Beet	279-9606		Chlorantraniliprole	4.3 floz / ac	0.03641 lb/acre	Use Pattern/liquid /aerial spray/fine to medium/	24	N	8	0.0004544	0	0	2.155E-05	0	0.0005407	0.08779	SIDRI	LRH	LH	0	NIC	0.3923	0.0001068	0.01569
	Sugar Beet	264-758		Imidacloprid	3 floz / ac	0.07816 lb/acre	Use Pattern/liquid/soil injection/4 inches/	24	N	8	0.0147	0.04022	0	0.8655	0	0.000552	0.3104	SIDRI	0.0007744	1.329E-05	0	NIC	N	7.393	10.5651
	Sugar Beet	82571-3		Sulfur	30 lb / ac	29.4000 lb/acre	Use Pattern/dust/	24	N	8	0.0760	LH	0.803	0.00132	1	LH	0.05962	SIDRI	LRH	LRH	0	NIC	*	*	*
	Sugar Beet	352-342		Methomyl	0.8 lb / ac	0.7200 lb/acre	Use Pattern/liquid /aerial spray/fine to medium/	24	N	8	0.3067	0.02272	0.03904	0.1615	0	0.003661	0.2382	SIDRI	0.006499	0.03003	0	NIC	72.8138	0.803	1.0935
	Sugar Beet	62719-442		Methoxyfenozide	8.3 floz / ac	0.1081 lb/acre	Use Pattern/liquid /aerial spray/fine to medium/	24	N	8	0.001041	0	0	3.49E-05	0	0.002613	0.03864	SIDRI	0.0007996	LH	0	NIC	W9	W9	W9
	Sugar Beet	62719-442		Methoxyfenozide	10 floz / ac	0.1624 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/fine/	24	N	8	0.001231	0	0	4.058E-05	0	0.002919	0.04369	SIDRI	0.0008433	LH	0	NIC	W9	W9	W9
	Sugar Beet	62719-442		Methoxyfenozide	10 floz / ac	0.1624 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/fine/	24	N	8	0.001231	0	0	4.058E-05	0	0.002919	0.04369	SIDRI	0.0008433	LH	0	NIC	W9	W9	W9
	Sugar Beet	264-1056		Clothianidin	0.022 gal / ac	0.07326 lb/acre	Use Pattern/seed treatment/	24	N	8	0.003186	0	0	0.7408	0	0.0003519	0.3182	SIDRI	0.0001153	0	0	NIC	N	0.1037	0.02716
	Sugar Beet	264-1056		Cyfluthrin, beta	0.022 gal / ac	0.009825 lb/acre	Use Pattern/seed treatment/	24	N	8	QA	QA	QA	QA	QA	QA	QA	SIDRI	QA	0	0	NIC	Y	Y	Y
	Sugar Beet	524-549		Glyphosate, potassium salt	32 floz / ac	1.1793 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/fine/	24	N	8	0.01311	0.5211	0	6.384E-06	0	0.00239	0.0004329	SIDRI	NDA	0.007375	0	NIC	*	*	*
	Sugar Beet	524-549		Glyphosate, potassium salt	30 floz / ac	1.2933 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/medium to coarse/	24	N	8	0.01425	0.5144	0	6.201E-06	0	0.002286	0.0004115	SIDRI	NDA	0.006874	0	NIC	*	*	*
	Sugar Beet	524-549		Glyphosate, potassium salt	32 floz / ac	1.1793 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/fine/	24	N	8	0.01311	0.5211	0	6.384E-06	0	0.00239	0.0004329	SIDRI	NDA	0.007375	0	NIC	*	*	*
	Sugar Beet	279-3327		Cypermethrin, zeta	4 floz / ac	0.02496 lb/acre	Use Pattern/liquid /ground spray/foliar applied/low boom/fine/	24	N	8	0.0001018	0	0	0.001449	Y	7.635E-05	0.3321	SIDRI	2.7687	9.777E-06	0	NIC	*	*	*

Appendix Table. Plum 20 Field_2021-2022



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ick me	Crop	EPA Reg No.	Product Name	Active Ingredient (A.I.)	Product Application Rate	A.I. Application Rate	Application Method	Reentry Interval	Gloves Worn	Work Time	Avian Acute	Avian Reproductive	Small Mammal Acute	Earthworm	Fish Chronic	Aquatic Algae	Aquatic Invertebrates	Human Dietary	Inhalation	Worker Dermal	Dermal Cancer	Consumer Cancer	Pollinator In Bloom	Pollinator No Bloom	Pollinator Off Crop
	Sugar Beet	352-515		Esfenvalerate	5 floz / ac	0.02592 lb/acre	Use Pattern/liquid/ground spray/foliar applied/low boom/fine/	24	N	8	0.0004177	Y	0	0.7146	1	0.01319	0.6706	SIDRI	0.001796	0.002975	0	NIC	17.4509	0.005147	0.4213
	Sugar Beet	352-515		Esfenvalerate	5 floz / ac	0.02592 lb/acre	Use Pattern/liquid/soil injection/4 inches/	24	N	8	0.0004177	Y	0	0.7146	1	0.01319	0.6706	SIDRI	0.001796	0.0002975	0	NIC	N	0.005147	0.4526
	Sugar Beet	279-9606		Chlorantraniliprole	7.5 floz / ac	0.09843 lb/acre	Use Pattern/liquid/soil injection/4 inches/	24	N	8	0.0007615	0	0	4.282E-05	0	0.000792	0.1298	SIDRI	LEH	LH	0	NIC	N	0.0001862	0.01809
	Sugar Beet	71368-126		Glyphosate, isopropylamine salt	48 floz / ac	2.0250 lb/acre	Use Pattern/liquid/ground spray/foliar applied/low boom/fine/	24	N	8	0.01391	0.1399	0	9.402E-06	0	0.001803	0.001651	SIDRI	NDA	0.009513	0	NIC	1.0283	0.00883	0.01776
	Sugar Beet	71368-126		Glyphosate, isopropylamine salt	48 floz / ac	2.0250 lb/acre	Use Pattern/liquid/ground spray/foliar applied/low boom/fine/	24	N	8	0.01391	0.1399	0	9.402E-06	0	0.001803	0.001651	SIDRI	NDA	0.009513	0	NIC	1.0283	0.00883	0.01776
	Sugar Beet	71368-126		Glyphosate, isopropylamine salt	48 floz / ac	2.0250 lb/acre	Use Pattern/liquid/ground spray/foliar applied/low boom/fine/	24	N	8	0.01391	0.1399	0	9.402E-06	0	0.001803	0.001651	SIDRI	NDA	0.009513	0	NIC	1.0283	0.00883	0.01776
	Sugar Beet	62719-442		Methoxyfenozide	9.6 floz / ac	0.1539 lb/acre	Use Pattern/liquid/ground spray/foliar applied/low boom/fine/	24	N	8	0.005166	0	0	3.907E-05	0	0.002858	0.04236	SIDRI	0.000832	LH	0	NIC	W9	W9	W9
	Sugar Beet	62719-220		Chlorpyrifos	32 floz / ac	1.0103 lb/acre	Use Pattern/liquid/soil injection/4 inches/	24	N	8	0.2199	0.1878	0.06395	0.006051	0.9667	0.00179	0.8218	SIDRI	28.2716	0.002714	0	NIC	N	0.6339	17.8262
	Sugar Beet	62719-220		Chlorpyrifos	32 floz / ac	1.0103 lb/acre	Use Pattern/liquid/soil injection/4 inches/	24	N	8	0.2539	0.1878	0.06395	0.006051	0.9667	0.00579	0.8218	SIDRI	28.2716	0.002714	0	NIC	N	0.6339	17.8262
	Sugar Beet	70506-187		Sulfur	10 lb / ac	8.0000 lb/acre	Use Pattern/liquid/ground spray/foliar applied/low boom/fine/	24	N	8	0.02417	LH	0	0.0003946	0	LH	0.00713	SIDRI	LEH	LEH	0	NIC	*	*	*
	Sugar Beet	264-1056		Clothianidin	0.022 gal / ac	0.07326 lb/acre	Use Pattern/seed treatment/	24	N	8	0.003186	0	0	0.7438	0	0.0003519	0.3182	SIDRI	0.0001153	0	0	NIC	N	0.3057	0.02716
	Sugar Beet	264-1056		Cyfluthrin, beta	0.022 gal / ac	0.009825 lb/acre	Use Pattern/seed treatment/	24	N	8	QA	QA	QA	QA	QA	QA	QA	SIDRI	QA	0	0	NIC	Y	Y	Y
	Sugar Beet	264-1056		Clothianidin	0.022 gal / ac	0.07326 lb/acre	Use Pattern/seed treatment/	24	N	8	0.003186	0	0	0.7438	0	0.0003519	0.3182	SIDRI	0.0001153	0	0	NIC	N	0.3057	0.02716
	Sugar Beet	264-1056		Cyfluthrin, beta	0.022 gal / ac	0.009825 lb/acre	Use Pattern/seed treatment/	24	N	8	QA	QA	QA	QA	QA	QA	QA	SIDRI	QA	0	0	NIC	Y	Y	Y
	Sugar Beet	100-1223		Azoxystrobin	15 floz / ac	0.3938 lb/acre	Use Pattern/liquid/ground spray/foliar applied/low boom/fine/	24	N	8	0.005608	0	0	0.002461	0	0.2133	0.00166	SIDRI	1.448E-05	LH	0	NIC	0.2316	0.001373	0.001707
	Sugar Beet	100-1223		Cyproconazole	15 floz / ac	0.07812 lb/acre	Use Pattern/liquid/ground spray/foliar applied/low boom/fine/	24	N	8	0.007812	0.00857	0	0.003653	0	0.01629	0.004081	SIDRI	0.000842	0.000543	0	NIC	0.023	2.223E-03	0.0006051

Appendix Table. Mulberry 15, 2021-2022