COLLEGE OF AGRICULTURE & LIFE SCIENCES
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Ten Years of Bagrada Bug on Desert Cole Crops

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The bagrada bug, *Bagrada hilaris,* became a major pest of cole crops in the fall of 2010 where widespread outbreaks of the invasive stinkbug pest were reported throughout the desert SW. The resulting yield losses in broccoli, cauliflower, cabbage and other *Brassica* crops were economically significant. To document the impact of annual infestations, we surveyed produce growers and PCAs from Yuma Co., Maricopa Co. and Imperial Co., CA on an annual basis since 2010 to estimate the severity of bagrada bug on direct-seeded and transplanted cole crops, and the intensity of chemical management required to control it.

In the surveys, PCAs and growers were anonymously requested to estimate the fall acreage (August-November) they managed, and of those acres, the percentage where bagrada bug populations were present, what percentage required insecticide treatments and how often. In addition, they were asked to estimate the average percent stand losses and plant injury caused by bagrada bug infestations. Finally, PCAs and growers were asked to list the insecticide products they found to be effective in controlling bagrada bug adults when applied as either sprinkler chemigations or foliar sprays. Information was collected separately for direct-seeded and transplanted cole crops. Beginning in 2015, we asked for information specific to the use of Nipsit® seed treatments in conventional production. Table 1 shows the number of PCAs who participated in the surveys each year and the acres their estimates represented.

Table 1. Number of PCA respondents and acreage estimated in bagrada surveys, 2010-20.

Season	No. PCAs responding	Acres Estimated in Survey		
		Direct seeded	**Transplanted**	**Total**
2010	17	9310	4610	13,920
2011	13	6210	3450	9660
2012	19	6290	4595	10,885
2013	21	7255	5435	12,690
2014	19	6080	8080	14,160
2015	20	6700	6400	13,100
2016	22	4423	7985	12,408
2017	27	10,245	9170	19,415
2018	27	8980	7488	16,428
2019	15	5740	5140	10,880

Impact of Bagrada Bug Based on Insecticidal Control

Since the initial outbreaks in 2010 the bagrada bug has become an important, established pest on desert cole crops. Although numbers have declines in the past few years, studies of seasonal abundance infesting non-treated brassica plants at the Yuma Ag Center (Fig 1) show that bagrada bug infestations were higher last season relative the previous four growing seasons. Similarly, bagrada bug population abundance during the fall on non-treated broccoli plots has consistently declined since 2013 (Fig. 2) but populations in the fall of 2019 were noticeably higher. To further support this observation of increased activity, results from the PCA surveys indicated that bagrada populations were up in 2019. Prior to 2016, bagrada bug infestations were present on greater than 90% and 85% of the direct seeded and transplanted cole crop acreage, respectively (Fig 3). In the previous two fall seasons, the percentage of acreage treated for bagrada adults in direct-seeded and transplanted crops was less than 40% of the total acreage. However, in 2019 bagrada adults were present on almost 60% of the direct seeded crops. Unlike previous years, PCAs treated a lower percentage of acres than where the pest was present, suggesting a more responsive approach to bagrada management, as opposed to preventative approaches taken in previous years. The percentage of acres treated for bagrada in transplanted crops was comparable to the previous three seaspons.

It is important to prevent bagrada feeding during stand establishment to avoid stand losses and plant injury. This is reflected historically by the proportionately large number of acres prophylactically chemigated in direct seed crops during the initial outbreaks (Tables 2 and 3). In 2019, slightly more than 50% of the direct seeded acreage was chemigated, whereas about 25% of the transplanted acreage was chemigated. Once sprinkler pipe is removed from the field, management for bagrada adults can remain intensive. For example, greater than 80% of the reported acres were sprayed an average of 2.2 times in direct seeded-crops and over 76% of transplanted crops were sprayed almost 2 times from 2010-2015. However, in 2019, the number of spray treatments in direct seeded crops were higher in direct seeded crops, and in transplanted crops remained low. When the number of chemigations and foliar sprays are combined, PCAs treated direct seeded crops almost 2 times, but made less than 1 application in transplanted crops. More importantly, significantly fewer chemigations and sprays were applied in 2019 compared to when bagrada first showed up in 2010.

We're uncertain why populations have been declining over the past few years but may in part be a due to aggressive preventative control measures (particularly from 2010-2014), use of insecticide seed treatments, changes in the cropping system (fewer cotton acres), improved bagrada control in nurseries and greenhouses, local drought conditions, and impact of natural enemies (e.g., predators, pathogens) in non-crop landscapes. Slightly higher numbers observed last fall were likely due to the wet winter experienced in 2019.

Impact of Bagrada Bug Based on Crop Losses

Estimates of stand losses from bagrada bug infestations at stand establishment in both direct-seeded and transplanted crops have decreased considerably over the past 10 years (Table 4). Although stand losses in 2019 were quite low relative to initial outbreak, feeding damage was higher in direct seeded crops in 2019 compared to the pervious 2 seasons. Stand losses in transplants was very low, comparable to 2018. This is consistent with the reduced presence of bagrada bugs in commercial crops. Plant injury, defined as plants with multiple heads, forked terminals, and/or blind terminals resulting from bagrada feeding, was also low relative to 2010 for both direct-seeded and transplanted crops. However, plant injury was slightly higher in direct seeded crops in 2019. Similarly, total losses for direct seeded and transplanted crops were low, and down significantly compared with the initial outbreaks in 2010. These reported losses are consistent with stand losses and plant injury measured in trials conducted at the Yuma Ag Center over the past ten years.

Effective Insecticides:

Over the past 10 years, growers and PCAs reported using pyrethroids almost exclusively to control bagrada bugs during stand establishment via sprinkler chemigation (Figure 4). Among the insecticide active ingredients (AI) that PCAs reported as effective, bifenthrin (*Brigade, Bifenture, Fanfare, Sniper, Hero and Discipline*) has been the most commonly reported, followed by lambda-cyhalothrin (*Warrior II, Silencer, Lambda-Cy*), zeta-cypermethrin (*Mustang, Hero*), esfenvalerate (*Asana*), and permethrin (*Perm-Up*). In 2019, esfenvalurate, bifenthrin, and zeta-cypermthrin were the most commonly used pyrethroids. In general, comments provided on the survey suggested that a single pyrethroid chemigations appeared to provide effective knockdown control of adults, compared to 2010-2012 when heavy bagrada bug pressure often required re-application after 2-3 days.

In contrast, a broader array of AIs has been reported for use against bagrada bugs when applied as foliar sprays on established stands. Pyrethroids were reported as the most effective chemistry used by PCAs (Figure 5). Bifenthrin has historically been the most commonly used AI, followed by lambda cyhalothrin, zeta-cypermethrin, esfenvalerate and permethrin. Among the alternative chemistries used in the past 10 years, dinotefuran, methomyl and chlorpyrifos were reported to be effective against bagrada adults by PCAs. Neonicotinoids and OP/carbamates have not been reported for bagrada control since 2017, consistent with fewer sprays reported (Table 2). These estimates are consistent with results from efficacy trials conducted at Yuma Ag Center where products that have contact activity (i.e., Pyrethroids, OP/Carbamates) have provided the most effective control against bagrada adults on both direct-seeded and transplanted cole crops.

Nipsit® Treated Seed

Since 2015 when it first available on broccoli, we asked PCAs and growers about their experiences with the insecticide seed treatment, NipsIt® (*clothianidin*). The percentage of acreage planted with the seed treatment peaked in 2016 with almost 70% of acreage planted to NipsIt® (Table 4). In 2018, we observed a significant decrease in the Nipsit® acreage and number of PCAs using the product. Usage was up in 2019, but still well below 2015-2017 estimates. Based on the performance rating criteria, PCAs have historically reported that Nipsit® provided good-excellent control of bagrada adults at stand establishment. These results are consistent with multiple years of research at YAC evaluating Nipsit® broccoli against bagrada during stand establishment.

Insecticide Susceptibly

In 2010, field collected bagrada adults from the Yuma Ag Center were evaluated for susceptibility to two pyrethroids (Bifenture and Warrior II), a carbamate (Lannate) and a neonicotinoid (Venom). LC_{50} values were generated in laboratory bioassays and provided a measure of baseline susceptibility for each insecticide *(Palumbo et. al. 2015, J. Econ. Entomol. 108:672-682).* After ten years of exposure to these chemistries, we were curious whether bagrada had begun to develop resistance to any of the active ingredients. Thus, in May 2020 we collected a bagrada population from the Yuma Ag Center and exposed them to insecticides using the same bioassay methods. Based on a comparison of LC_{50} values and 95% confidence intervals generated in 2010, the results of the 2020 bioassays showed that there was no significant change in bagrada susceptibility to Bifenture, Warrior II, Lannate and Venom (Fig 6). It should be noted that bifenthrin had the largest decrease in susceptibility (~7 fold) in 2020 but was not significant different from 2010 population. These data are consistent with PCA reports that these products still provide consistent control in commercial Cole crops.

Acknowledgement: *Special thanks go out to all the PCAs and growers who took time away from their busy schedules to participate in these surveys over the ten years. Without your efforts, this historical data would not exist.*

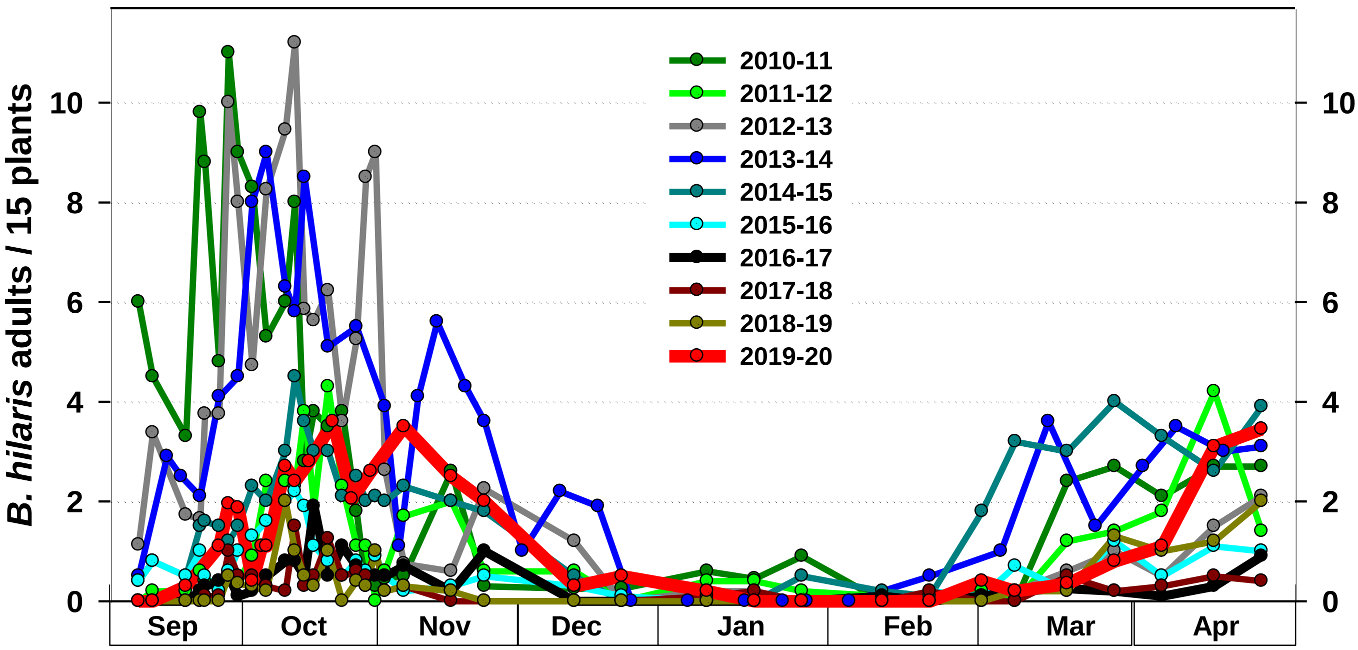

Figure 1. Seasonal bagrada bug abundance (adults/15 plants) in non-treated broccoli at the Yuma Agricultural Center from September 2010 through April 2020.

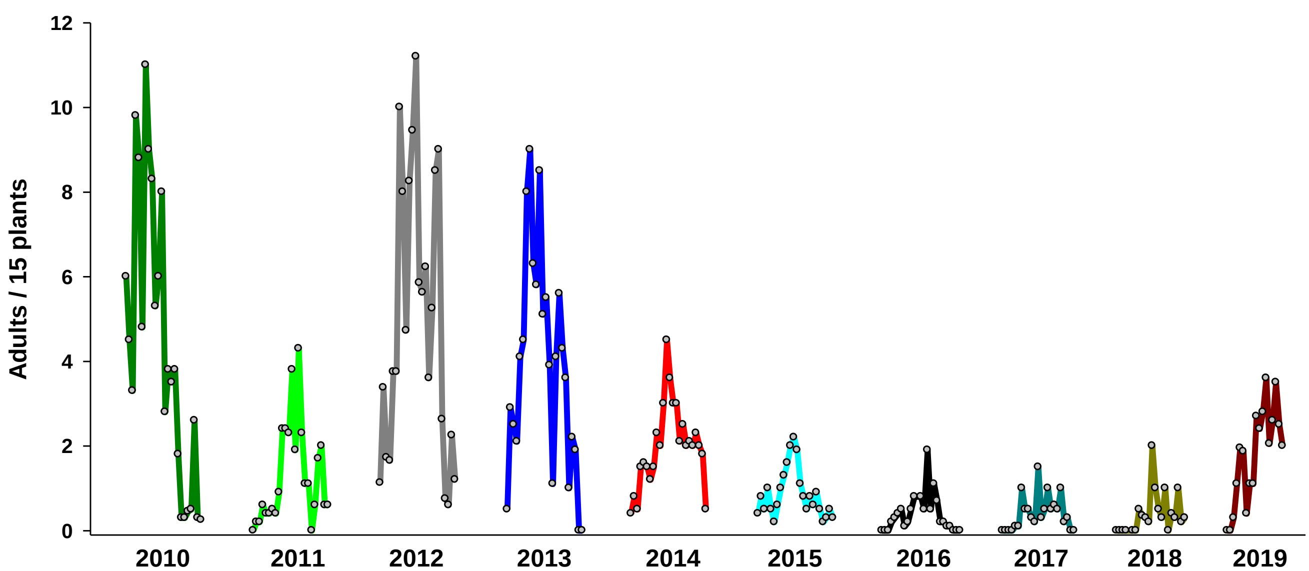

Figure 2. Fall bagrada bug abundance (adults/15 plants) in non-treated broccoli at the Yuma Agricultural Center during Sep-Nov, 2010-2018.

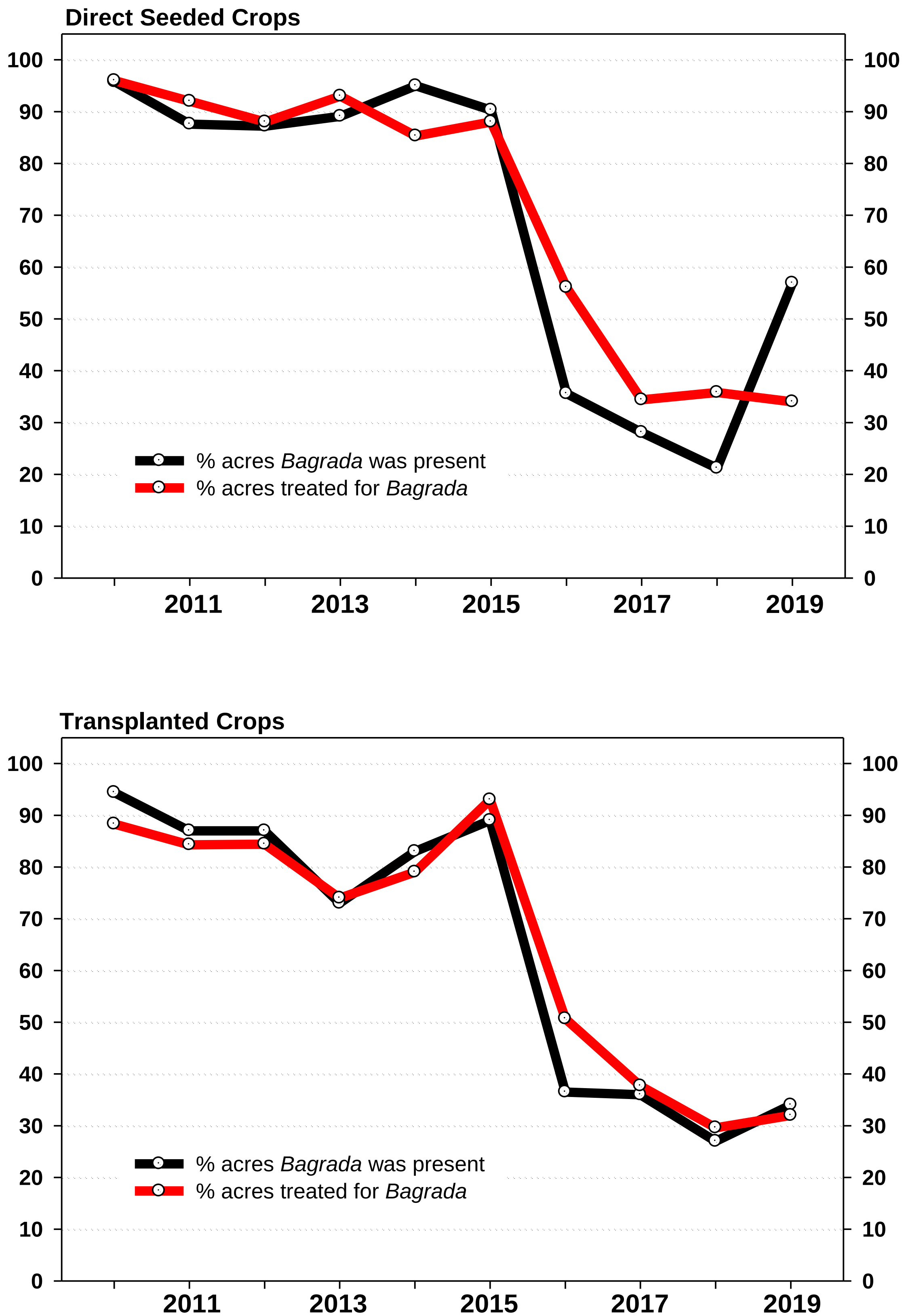

Figure 3. Percentage of acres where bagrada bugs were present and acres that required insecticide treatment for their control in direct seeded (top) and transplanted Cole crops (bottom), 2010-19.

Table 2. Impact of Bagrada bug on direct seeded Cole crops- based on chemical control.

	Direct seeded									
Chemical Control	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***
% acres chemigated	73.8	75.2	85.5	87.1	75.6	85.9	52.3	54.8	44.7	51.0
Avg. no. chemigations	1.6	1.6	1.6	1.5	1.6	1.3	1.2	1.0	0.7	1.0
% acres sprayed	90.0	87.0	86.8	88.5	76.3	60.1	34.7	24.1	18.7	32.7
Avg. no. sprays	2.7	1.8	2.5	2.5	2.2	1.4	1.0	0.6	0.5	0.9
Total no. applications	4.3	3.4	4.1	4.0	3.8	2.7	2.2	1.6	1.2	1.9

Table 3. Impact of Bagrada bug on desert Cole crops- based on chemical control.

	Transplanted									
Chemical Control	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***
% acres chemigated	60.6	72.0	65.1	67.4	64.8	79.3	55.1	49.3	41.5	26.0
Avg. no. chemigations	1.4	1.3	1.1	1.3	1.4	1.3	1.0	0.9	0.5	0.5
% acres sprayed	85.6	80.8	82.8	67.9	70.8	71.4	34.6	24.0	8.9	11.6
Avg. no. sprays	2.1	1.8	1.8	1.9	1.5	1.8	0.9	0.7	0.3	0.3
Total no. applications	3.5	3.1	2.9	3.2	2.9	3.1	2.0	1.6	0.8	0.8

Table 4. Impact of Bagrada bug on direct-seeded and transplanted crops- based on feeding injury.

	Direct seeded Crops			Transplanted Crops		
Season	***Avg Stand loss (%)***	***Avg plant injury (%)***	***Total crop loss (%)***	***Avg Stand loss (%)***	***Avg plant injury (%)***	***Total crop loss (%)***
2010	6.3	8.0	14.3	3.1	4.6	7.7
2011	2.5	4.2	6.7	1.5	3.9	5.4
2012	2.8	3.2	6.0	1.4	2.1	3.5
2013	3.9	7.9	11.8	1.7	5.8	7.5
2014	3.2	5.5	8.7	1.6	3.1	4.7
2015	2.6	2.9	5.5	1.6	3.6	5.2
2016	1.6	3.0	4.6	0.6	2.0	2.6
2017	0.3	1.0	1.3	0.6	1.4	2.0
2018	0.4	0.8	1.2	0.3	0.7	1.0
2019	0.7	1.8	2.5	0.3	1	1.3

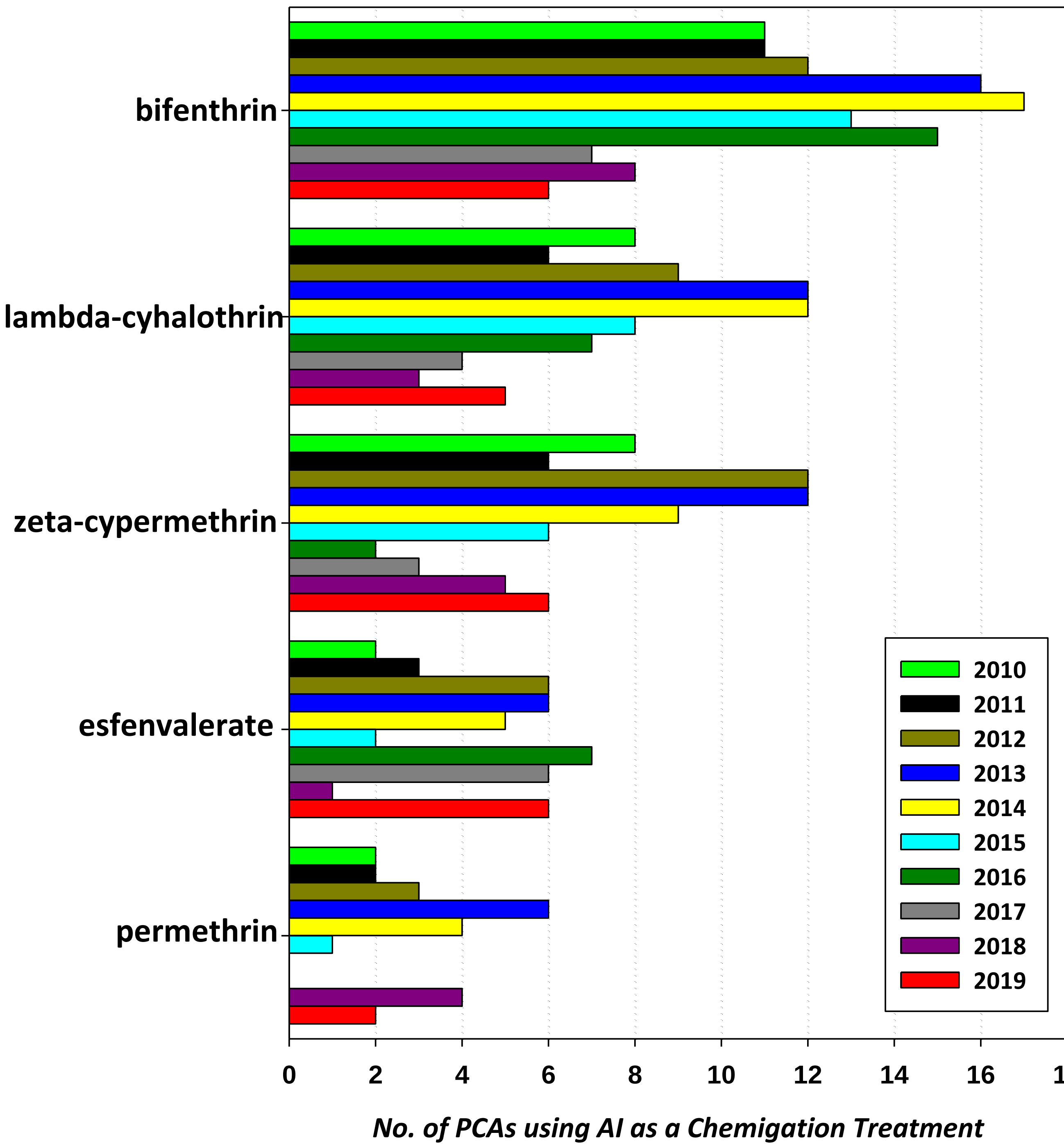

Figure 4. Insecticide AIs reported as effective against bagrada adult infestations when applied as chemigation treatments during stand establishment on Cole crop fields in Yuma, Imperial and Maricopa Cos. in 2010-2018.

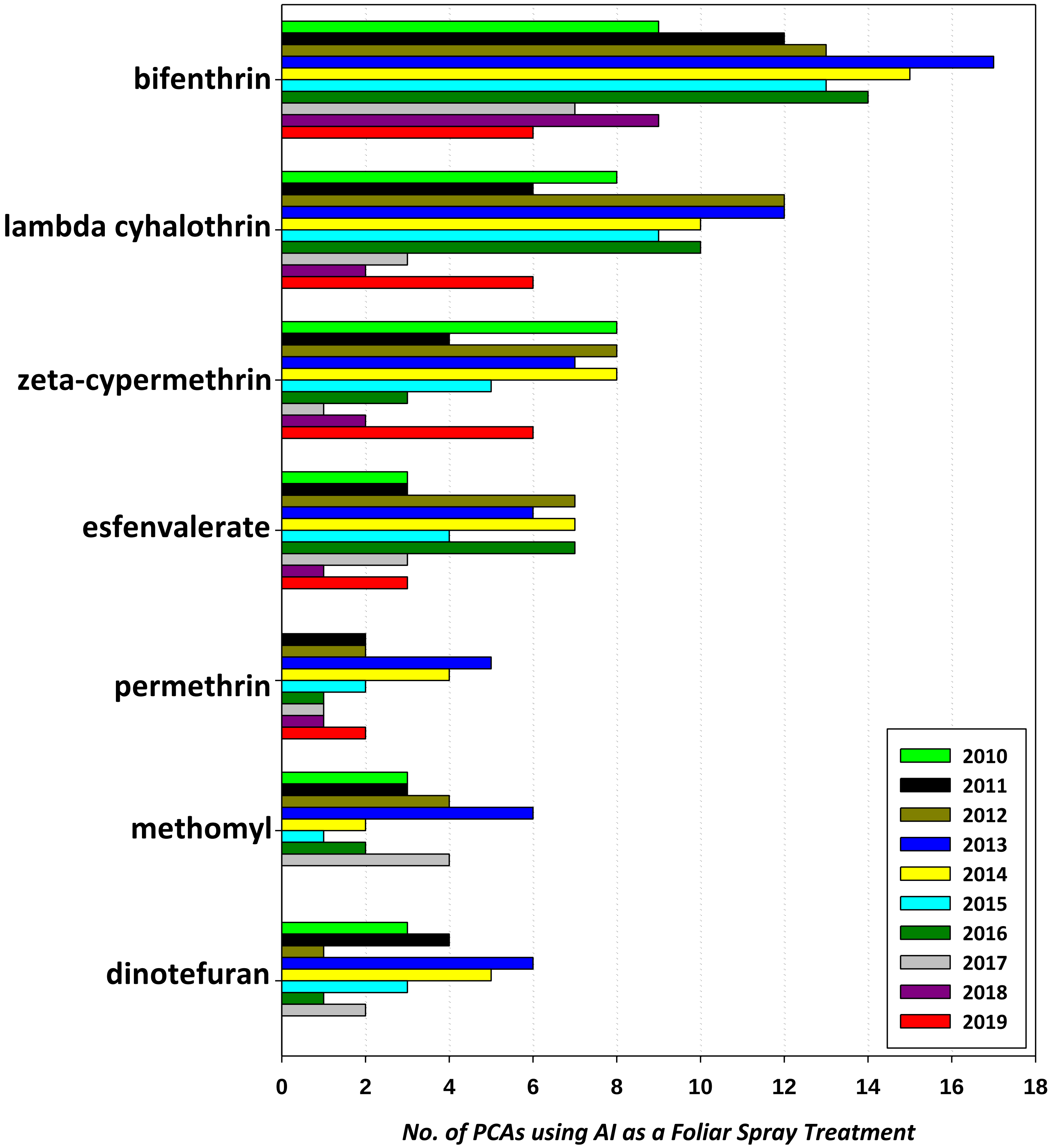

Figure 5. Insecticide AIs reported as effective against bagrada adult infestations when applied as foliar spray treatments on Cole crop fields in Yuma, Imperial and Maricopa Cos. in 2010-2019.

Table 4. Estimated usage of the Nipsit® broccoli seed treatment (clothianidin) and its performances against bagrada bugs, fall 2015-18.

Fall Season	No. Growers using Nipsit	Acres planted with Nipsit	% of Total[1] Acres Reported	Performance[2] Rating
2015	8	2760	41.2	4.5
2016	7	2950	66.7	4.4
2017	9	5750	56.1	4.1
2018	2	1100	12.2	4.5
2019	3	1200	20.9	4.5

[1] Total acres of broccoli reported in surveys from 2015=6700; 2016=4423; in 2017=10,245; 2018=8980.; 2019=5740

[2] Rating based on a scale of 1-5; with 1=no control; 2= poor control; 3=fair control; 4= good control; and 5=Excellent control.

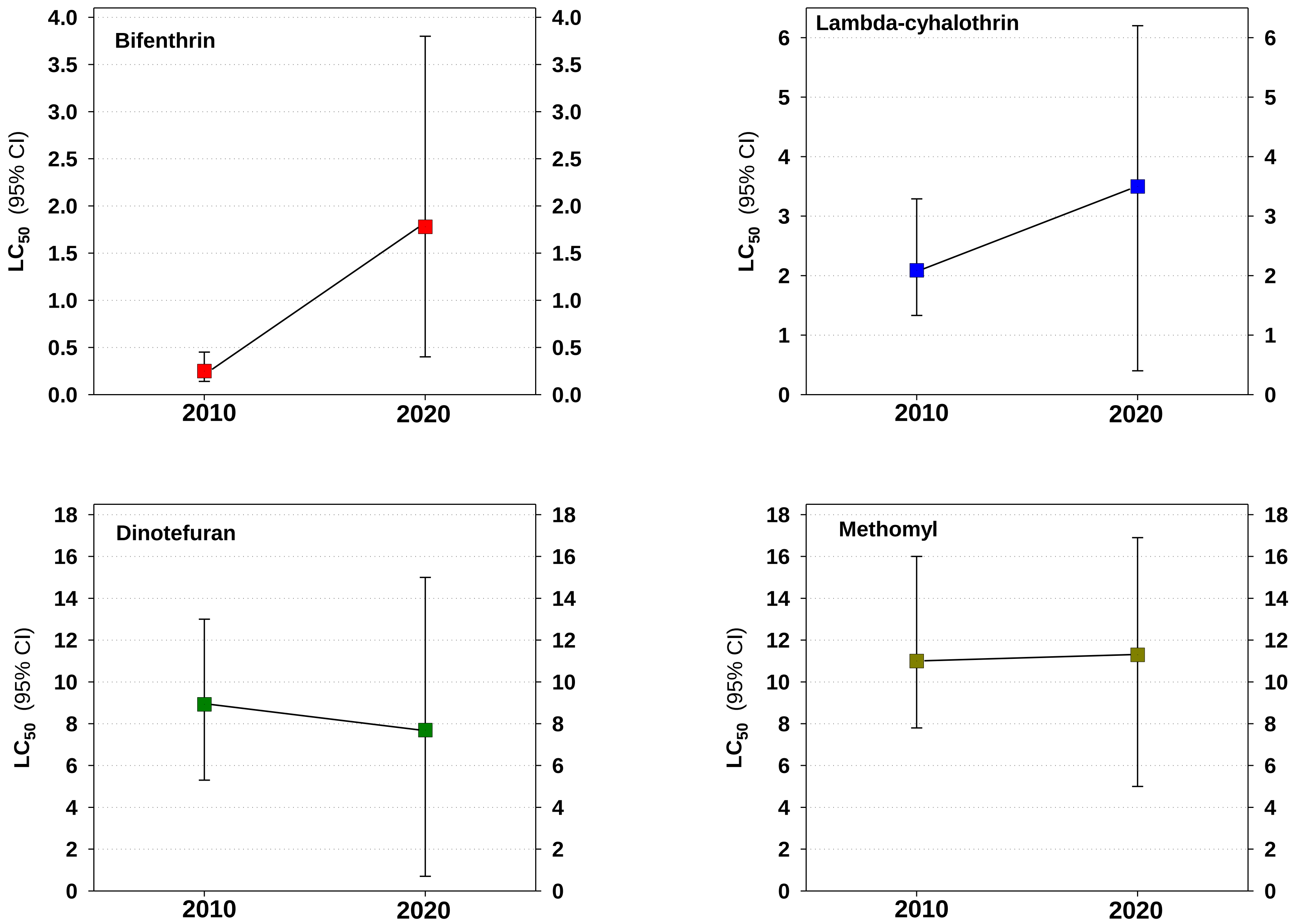

Figure 6. Susceptibility of Bagrada to bifenthrin (Bifenture), lambda-cyhalothrin (Warrior II), dinotefuran (Venom) and methomyl (Lannate) in laboratory bioassays conducted in 2010 and 2020.