THE UNIVERSITY OF ARIZONA | COLLEGE OF AGRICULTURE AND LIFE SCIENCES
COOPERATIVE EXTENSION
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Diamondback Moth on Desert Cole Crops in 2017

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Introduction

In the fall of 2016, widespread infestations of an invasive diamondback moth (DBM) population occurred in all vegetable growing regions in Arizona and continued throughout the remainder of the spring 2017 growing season. It was quickly determined that the source of the DBM populations originated from infested transplants grown in desert greenhouses. Within weeks of transplanting, PCAs and growers found that they could not adequately control the DBM infestations. It was later discovered that the invasive DBM population was very resistant to the diamide insecticides (Coragen, Beseige, Belt and Vetica) commonly used to control Lepidopterous larvae. Soon after the first transplanted fields began to harvest in November, several growers reported that seriously infested fields suffered significant yield reductions, and/or incurred extremely high control costs. By late December, DBM populations began to spread from the infested transplanted fields to direct-seeded crops throughout the region, causing further losses. By February, reports of infested broccoli, cabbage, kale and cauliflower fields were routine. The DBM infestations experienced by Arizona growers in 2016-17 were not anticipated, and overall, resistant DBM caused serious losses in cole crops. These losses were documented in a 2017 survey and can be found at: https://cals.arizona.edu/crops/vegetables/advisories/more/insect185.html.

Prior to the 2017-18 growing season, PCAs and growers were very apprehensive about resistant DBM reappearing on their fall crops. Fortunately, DBM populations were much lighter than the previous season, and we received no complaints from PCAs or growers of uncontrollable DBM infestations, crop damage or yield losses in 2017. Furthermore, PCAs reported having no difficulty controlling larvae or adults with commonly used insecticides, including the diamides. Field trials and lab bioassays conducted at YAC confirmed that the local DBM populations were susceptible to the these insecticides. Field inspections of transplants yielded no larvae on plants arriving from local and coastal nurseries. Thus, we have concluded that the DBM that appeared in 2017-18 were a distinctly different population than those that infested crops in the fall of 2016. In an attempt to document the differences in impact of the DBM on Arizona cole crops between the 2016-17 and 2017-18 growing seasons, we conducted another two-part survey of growers and PCAs from Yuma and Maricopa Co., AZ and Imperial Co., CA in May 2018 to estimate the severity of DBM on direct-seeded and transplanted cole crops.

Survey Methods

A two-part survey was conducted at the annual Lettuce Insect Crop Losses Workshop held at the UA Yuma Ag Center on May 15, 2018. A total of 25 PCAs and growers completed surveys. In the first part of the survey, respondents were anonymously requested to estimate the acreage they managed by commodity, and of those acres, the percentage where DBM was present. PCA and growers were then asked to estimate the acreage where DBM was considered problematic (i.e., they had difficulty in controlling DBM). They were asked to estimate the number of sprays that were applied to each specific commodity, and the average yield loss attributed to DBM.

In the second part of the survey, the intensity of chemical management required to control DBM, and the associated level of control provided by each insecticide product was estimated. Respondents were provided an extensive list of available insecticides used for DBM control, and asked to estimate the percentage of acers treated for each product and number of sprays applied. To estimate insecticide product performance, respondents were asked to rate the level of control that each product provided in controlling DBM using the following scale: 4-Excellent; 3-Good; 2-Fair; 1-Poor; and 0-No control.

Impact of DBM on Cole Crop Commodities

The population abundance of DBM in the desert last season was significantly lower than what was observed under widespread outbreak conditions in 2016. This is based on personal observations of experimental and commercial cole crops during both growing seasons. Results from areawide pheromone trapping that started in December 2016 show that DBM moth activity was 10-15 times higher in the spring 2017 compared to the spring of 2018 **(Fig 1)**. This is consistent with the significantly reduced DBM larval populations observed in fields within the Yuma copping system last season. Interestingly, trap catches during the summer months of both years show that DBM were essentially non-existent in July and August when suitable *brassica* host plants are not available to the pest. This supports our hypothesis that DBM disappear in the summer, only to reappear in the fall via transplant introductions or on wind currents. Following this summer inactivity in DBM trap catches, pheromone trapping data indicated moths started to appear in traps placed adjacent to recently transplanted and direct-seeded broccoli, cabbage, kale and cauliflower crops in early September (**Fig 2**). The initial spikes in moth populations at this time occurred soon after tropical storm Lidia (Sep 4) and a severe monsoon storm (Sep 12) occurred in Yuma, and suggest that these DBM populations migrated into the area on these storms. This is further supported by similarities in moth counts in traps placed in both transplanted and direct-seeded crops. Shortly thereafter, PCAs began reporting DBM larvae appearing on seedling stands and newly transplanted crops. We also began to pick up larvae at this time on direct-seeded broccoli crops at YAC. However, the DBM populations never reached outbreak status in 2017, and unlike 2016, we received no complaints from PCAs or growers of DBM infested transplants originating from local nurseries. Finally, DBM larvae were effectively controlled with both soil (Coragen, Verimark) and foliar (Radiant, Proclaim, Coragen and others) insecticides throughout the growing season.

Results from the first part of the survey clearly show that DBM had a minimal impact on both transplanted and direct-seeded commodities in 2017-18 (**Table 1**). A total of 25 completed surveys represented an estimated total of 25,827 acres of cole crops in Yuma, Maricopa and Imperial counties. Transplanted cauliflower and direct-seeded broccoli were the most reported commodities, and had the highest numbers of acres where DBM were present. Overall, the estimated average number of acres where DBM were considered problematic, the number of sprays applied to control DBM, and the average yield loss for all of the *brassica* commodities in 2017-2018 was extremely low relative to the previous season. For a direct comparison with estimates from 2016-2017 see https://cals.arizona.edu/crops/vegetables/advisories/more /insect185.html. When averaged across all commodities, the percentage of total acres where DBM were considered problematic was less than 2% in 2017 compared with almost 60% in 2016 (**Fig 3**). The reduction in problematic acres were similar when considering the major transplanted and direct-seeded commodities grown between the two seasons (**Fig 4 and 5**). Yield losses attributed to DBM in transplanted and direct-seeded commodities were negligible in 2017 (**Fig 6 and 7**) compared with unusually high losses in 2016. Consequently, in 2017, PCAs reported that 5-10 fewer spray applications were required to control DBM in these crops compared with 2016 (**Fig 8-9**). On average, PCAs required a single foliar spray to control DBM. These data clearly show how different the DBM infestations were in the two growing seasons.

Insecticide Usage, Efficacy, and Resistance

Estimated insecticide usage for DBM control on cole crop commodities in 2017-18 is shown in **Table 2.** Overall, significantly fewer acres were treated and fewer sprays were applied compared to 2016-17. Based on treated acres, Radiant, pyrethroids, *Bt*s and Proclaim were the most commonly applied insecticides used for DBM control last season. Radiant was used by the largest percentage of PCAs and was treated on the largest percentage of acres. Verimark applied as a soil treatment was used on a total of 7680 ac, and was applied as a transplant tray drench on greater than 50% of the transplanted cauliflower, cabbage and *Brassica* seed crops (**Fig 10, Table 4**). Among other products that were applied to a large percentage of acres for DBM control included Lannate, Intrepid, Coragen and Entrust. Overall the diamides (Belt, Vetica and Besiege) were used on fewer acres, but performed well compared to 2016. Surprisingly, Exirel, an effective 2nd generation diamide, was used on very few acres compared with 2016.

The PCA ratings on the insecticide field performance of insecticides used against DBM in 2017-18 are very consistent with research conducted at the Yuma Ag Center this past season. Based on the survey responses, the majority of the products used by PCAs performed *Good* to *Excellent* (rating of 3-4) in 2017, including the diamide products that were found to be resistant last year (**Table 3**). In contrast, survey results from 2016 showed that the highest any one product rated was a 3.0 (Verimark tray drench) and among foliar products in 2016, most products rated Fair-Good (rating of 2-3) with the exception of the diamides, Assail, Intrepid, and the older organophosphates. Field experiments conducted at YAC in 2017 showed that most products provided *good-excellent* activity consistent with PCA ratings (**Table 5**). Furthermore, Lab bioassays showed that a DBM population collected from YAC s in spring 2018 was highly susceptible to Radiant, Proclaim, Exirel, Coragen and Besiege. Again, these finding were consistent with PCA performance ratings.

Conclusions

We previously concluded that the 2016 DBM outbreaks were attributed to the establishment of a resistant population on developing transplants within local greenhouses that then dispersed into commercial cole crop fields at transplanting. This was unusual because in previous years PCAs easily controlled DBM with 1-2 well timed insecticide sprays as was the case in the fall of 2017 where DBM were much lighter and would be comparable to what a PCA would normally expect. Furthermore, the survey clearly indicates that control of the DBM populations in 2017-18 generally required a single spray on to prevent outbreaks or yield losses. Growers spent considerably less money controlling the pest and yield losses to DBM were negligible. We are still uncertain where the DBM population originated from in fall 2017 but it is likely the DBM adults (moths) immigrated in from Mexico, California or elsewhere last summer via storms. Regardless of origin, it is important to note that the DBM population we saw last season was not resistant to any of the insecticides commonly used in the desert for management of Lepidopterous larvae.

Acknowledgement

Special thanks go out to all the PCAs and growers who took time away from their busy schedules to participate in the surveys. Without your efforts, much of the data in this report would not exist.

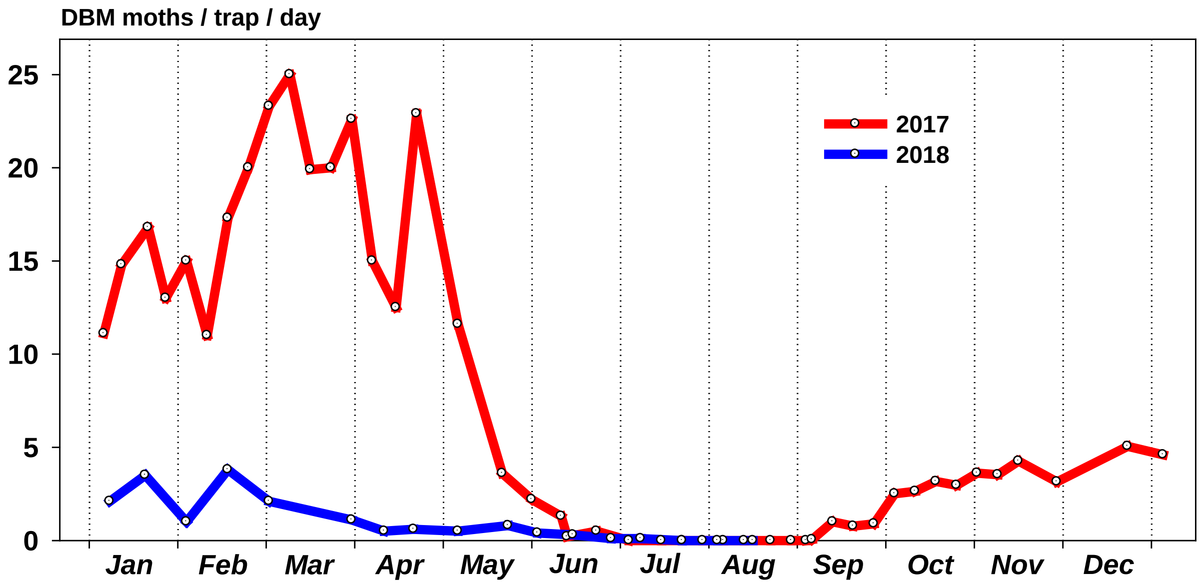

Figure 1. Relative DBM adult activity in Yuma county based on pheromone trap catches of moths in 2017 and 2018. Initial trapping was established on December 22, 2016.

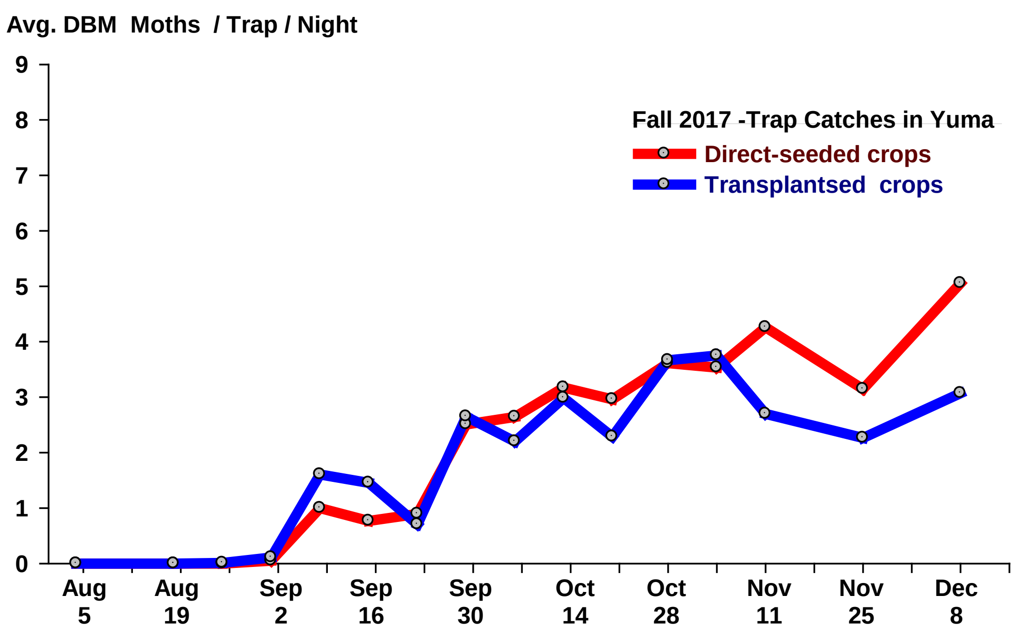

Figure 2. Relative DBM activity in Yuma county based on pheromone trap catches of moths during the fall on 2017 from traps located in transplanted and direct-seeded *brassica* crops

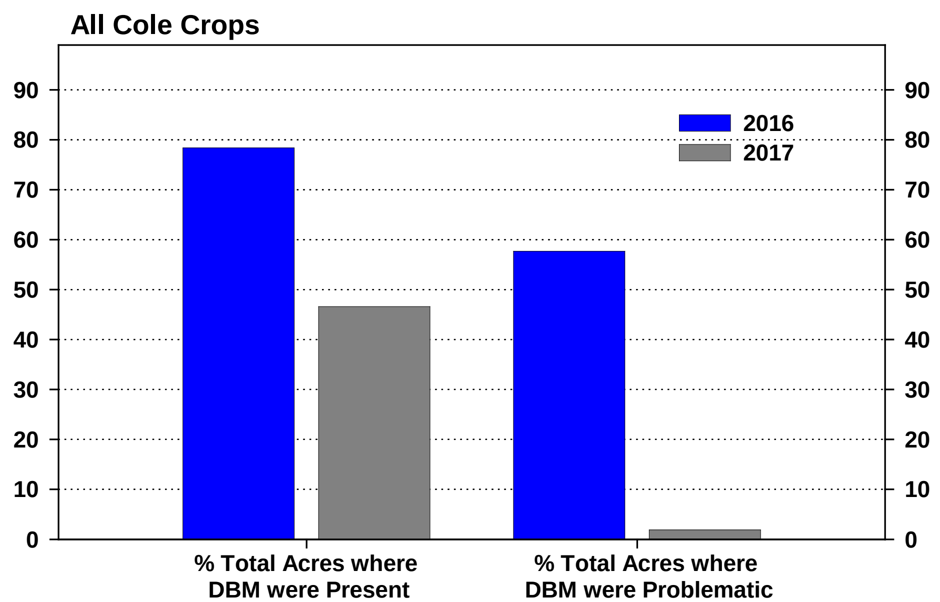

Figure 3. Comparison in the percentage of acres where DBM were present and problematic averaged across all cole crops in 2016 and 2017.

Table 1. Estimated impact of DBM on cole crop commodities grown in Yuma and Maricopa counties, Arizona in 2016-2017.

Crop	No. PCAs reporting	Total acres	Acres DBM Present [a]	Acres DBM Problematic [b]	No. Sprays	Max No. Sprays	Yield Loss (%)	Max. Yield Loss (%)
Broccoli-direct seeded	25	11,110	4,141	92	1.2	3	0.1	5
Broccoli-transplanted	8	1,550	730	3	1.0	4	0.1	1
Cauliflower-direct seeded	5	687	172	0	0.4	1	0.0	0
Cauliflower -transplanted	20	5,765	2,820	131	1.1	4	0.2	2
Cabbage - direct seeded	6	850	348	5	1.2	3	0.4	3
Cabbage - transplanted	12	3,490	2,030	170	1.3	3	0.3	5
Brassica seed crops	4	165	40	8	0.0	0	0.0	0
Kale -direct seeded	7	1,125	365	18	1.6	2	0.1	1
Kale-transplanted	8	575	325	30	1.1	3	0.1	1
Mizuna/Arugula	1	210	0	0	0.0	0	0.0	0
Brussel sprouts	1	300	300	30	6.0	6	1.0	0
Total Avg.		**25827**	**11271**	**487**	**1.4**	**2.6**	**0.2**	**1.6**

[a] Number of acres where DBM was present on plants in the field.
[b] Number of acres where DBM was considered a problem; PCAs had difficulty controlling larvae and adults.
[c] Average % yield loss in those acres where DBM was considered a problem (difficult to control).

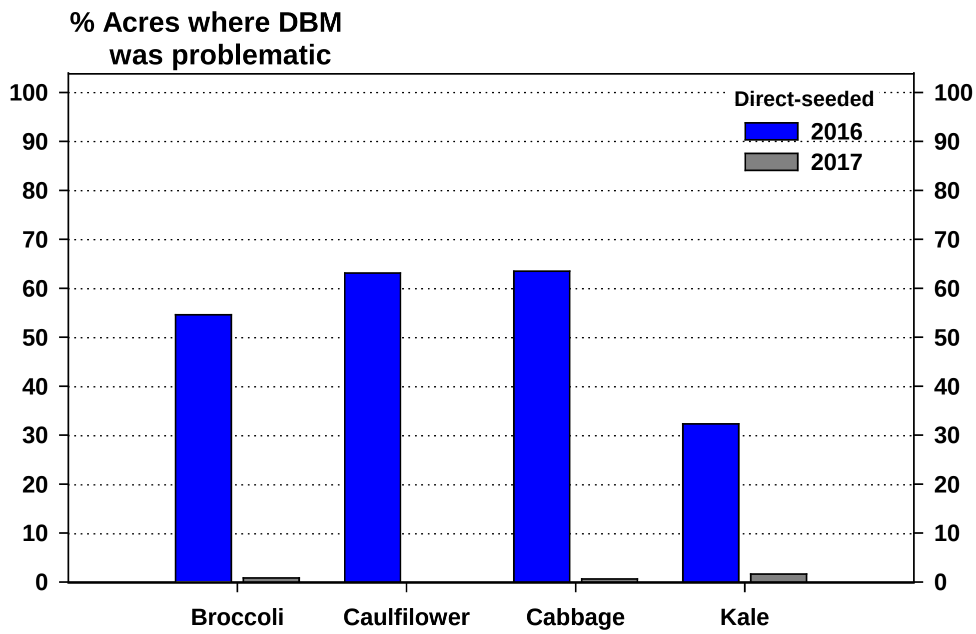

Figure 4. Comparison in the percentage of acres where DBM were considered problematic on direct-seeded cole crops in 2016 and 2017.

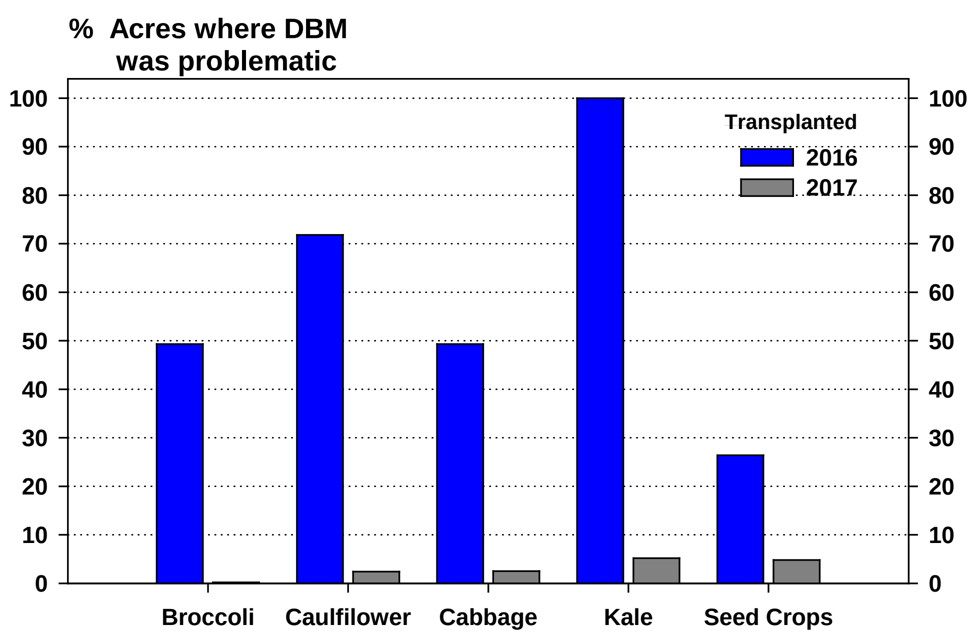

Figure 5. Comparison in the percentage acres where DBM were considered problematic on transplanted cole crops in 2016 and 2017.

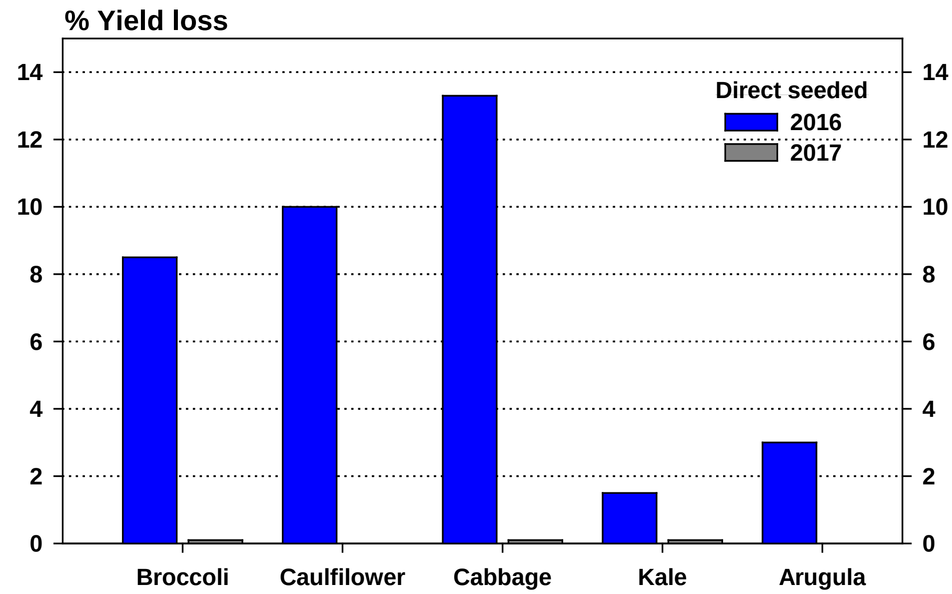

Figure 6. Comparison in the percent yield loss attributed to DBM on direct-seeded cole crops in 2016 and 2017.

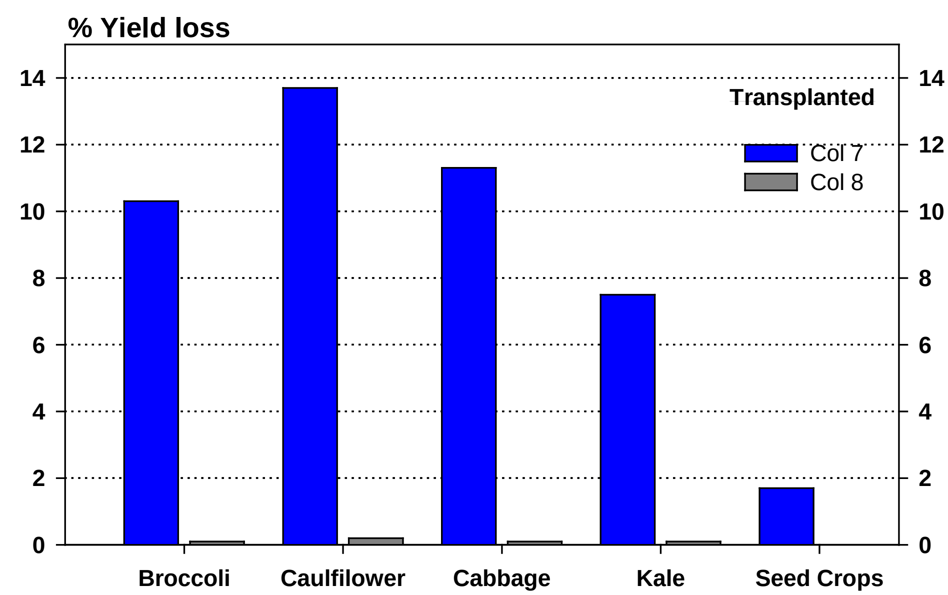

Figure 7. Comparison in the percent yield loss attributed to DBM on transplanted cole crops in 2016 and 2017.

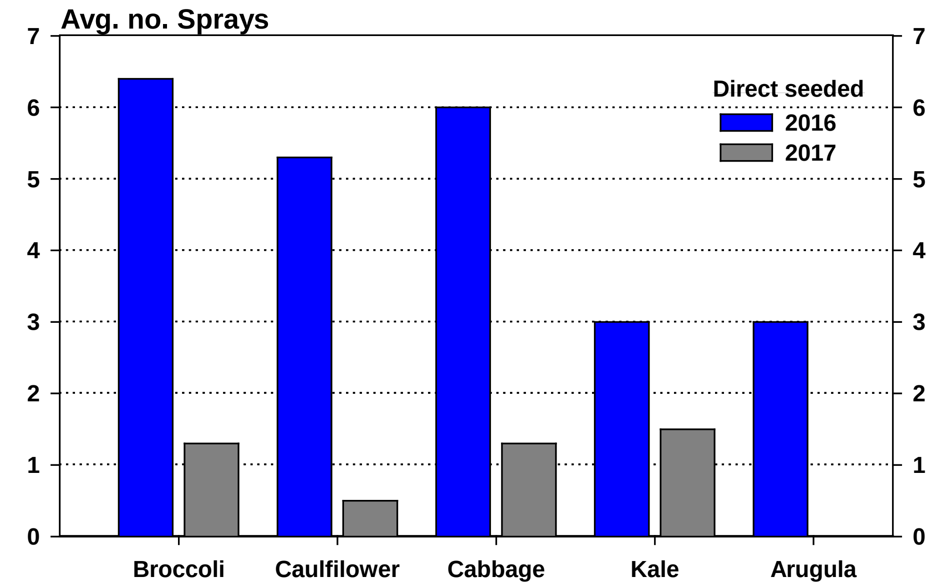

Figure 8. Comparison in the average number of sprays for DBM on direct-seeded cole crops in 2016 and 2017.

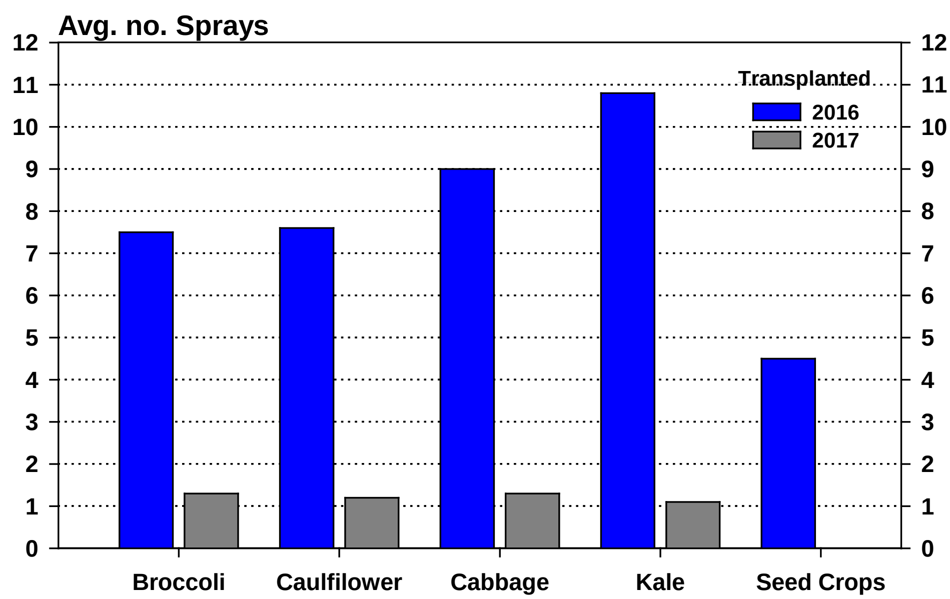

Figure 9. Comparison in the average number of sprays for DBM on transplanted cole crops in 2016 and 2017.

Table 2. Insecticide Usage for DBM Control on Desert Cole Crops in the 2016-17 and 2017-18 growing seasons.

	2017-18				2016-17			
Insecticide	**% PCAs using product**	**% Acres treated**	**Avg. no. applications**	**Treated acres [a]**	**% PCAs using product**	**% Acres treated**	**Avg. no. applications**	**Treated acres [a]**
Radiant	76	57.9	1.4	20,894	100	98.2	3.3	70,117
Pyrethroid	52	50.2	2.0	19,519	95	85.4	5.5	101,629
Xentari/Agree	38	32.4	1.8	14,150	75	49.8	2.5	26,938
Proclaim	57	29.4	1.2	10,412	95	83.9	2.9	52,645
Verimark	67	34.6	1.0	7,680	10	9.3	1.0	2,012
Entrust	24	17.0	1.8	6,854	55	32.5	2.2	15,470
Lannate	29	19.7	1.3	6,676	75	65.1	2.8	39,440
Dipel	19	12.7	1.8	5,605	-	-	-	-
Intrepid	24	20.9	1.0	5,051	15	14.1	1.4	4,271
Coragen (soil)	14	13.7	1.0	3,052	15	6.3	1.0	1,363
Coragen (foliar)	28	12.5	1.0	2,778	80	42.6	1.4	12,904
Avaunt	19	10.1	1.0	2,240	55	41.9	2.4	21,758
Belt	19	9.3	1.0	2,072	45	18.1	1.2	4,700
Malathion	10	5.2	1.0	1,150	20	6.4	1.0	1,385
Besiege	10	5.0	1.0	1,117	35	14.7	1.2	3,817
Dibrom	5	3.3	1.0	740	80	39.4	1.7	14,492
Cormoran	5	2.9	1.0	648	-	-	-	-
Acephate	5	1.9	1.0	420	15	5.0	1.0	1,082
Exirel	10	1.7	1.0	370	35	22.9	1.8	8,919
Vetica	10	0.7	1.0	150	30	15.1	1.2	3,921
Chlorpyrifos	5	0.4	1.0	81	25	5.0	1.2	1,298
Assail	0	0.0	0.0	0	45	25.7	1.2	6,673

A total of 25,452 ac were reported from 25 PCA surveys 2017-18, and a total of 22,115 ac were reported from 20 surveys 2016-17.

[a] Total treated acres estimated by multiplying: Avg. % acres treated * Avg. no. of applications * Acreage estimated by participating PCAs in the survey.

Table 3. Performance Rating [a] for insecticides used for DBM Control on Desert Cole Crops in the 2016-17 and 2017-18 growing seasons.

	2017-18		**2016-17**	
	No. PCAs using product	**Rating**	**No. PCAs using product**	**Rating**
Verimark	10	4.0	2	3.0
Dibrom	1	4.0	16	2.3
Cormoran	1	4.0	-	-
Acephate	1	4.0	3	1.7
Exirel	2	4.0	7	2.6
Vetica	2	4.0	6	2.0
Entrust	5	3.8	11	2.7
Radiant	17	3.7	20	2.5
Proclaim	12	3.7	19	2.3
Coragen (soil)	3	3.7	3	2.3
Coragen (Foliar)	6	3.5	16	1.1
Malathion	2	3.5	4	1.5
Besiege	2	3.5	7	1.0
Belt	4	3.3	9	1.7
Lannate	6	3.2	15	2.4
Xentari/Agree	8	3.0	17	2.6
Pyrethroid	11	2.9	19	1.3
Dipel	4	2.8	-	-
Avaunt	4	2.8	11	2.3
Intrepid	5	2.6	6	1.7
Chlorpyrifos	1	2.0	5	1.6
Assail	0	-	9	1.0

A total of 25 PCAs in 2017-18, and 20 PCAs 2016-17 completed Insecticide use surveys.

[a] Performance rating is based on the level of control achieved under field conditions for each product using the following scale: 4-Excellent control; 3-Good control; 2-Fair control; 1-Poor control; and 0-No control.

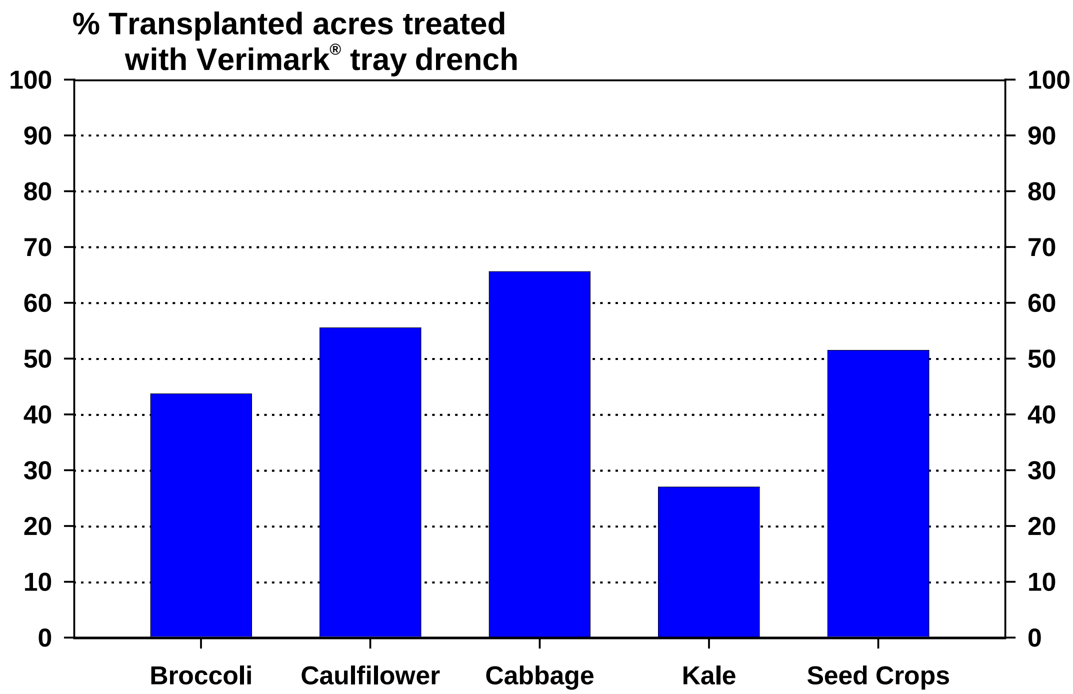

Figure 10. Comparison in the average number of sprays for DBM on transplanted cole crops in 2016 and 2017.

Table 4. Cole crop acres treated with Verimark® as a tray drench treatment in 2017.

	Verimark® Transplant Drench	
Crop	**Total acres transplanted**	**Total acres treated**
Broccoli	1555	680
Cauliflower	5765	3200
Cabbage	3490	2290
Kale	575	155
Seed crops	165	85

Table 5. Activity of insecticides against DBM larval populations based on PCA estimates of field performance, and local research that evaluated field efficacy and laboratory resistance in Yuma , Arizona, 2017-2018

	Insecticide Activity Against DBM Larvae		
	PCA Surveys	**Field Efficacy**	**Lab Resistance**
Radiant	Good	Good	Good
Proclaim	Good	Good	Good
Xentari /Dipel	Good	Fair	
Entrust	Good	Good	
Exirel	Good	Good	Good
Avaunt	Good	Good	
Dibrom	Good	Fair	
Lannate	Good	Good	
Coragen	Good	Good	Good
Besiege	Good	Good	Good
Pyrethroids	Good	Good	
Lorsban Adv.	Fair		
Cormoran	Good	Fair	
Vetica	Good		
Belt	Good		
Malathion	Good		
Intrepid	Fair	Fair	

Good (green)
Fair (yellow)
Poor (red)