Impact of Diamondback Moth Outbreaks on Arizona Cole Crops in 2016-17

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Introduction

The diamondback moth, *Plutella xylostella*, (DBM) is one of the most important insect pests of cole crops worldwide, and annually causes $ 3-5 billion dollars in economic losses due to direct yield losses and control costs. DBM larvae feed on leaves and marketable portions of all *Brassica* crops, and can cause significant yield losses if not adequately managed. Under outbreak conditions, controlling larvae and adults can be very difficult, often requiring multiple insecticide applications. In Arizona, DBM is typically considered a minor pest that occasionally builds up to damaging levels in the winter and spring. In most years, growers can easily control the pest with 1-2 well timed insecticide sprays.

However, beginning in October 2016 outbreaks of an invasive DBM population occurred throughout all vegetable growing regions in Arizona and continued throughout the remainder of the spring growing season. Cole crops that were affected included broccoli, cauliflower, cabbage, kale, mizuna/arugula, Napa cabbage, bok choy, Brussel sprouts and *Brassica* seed crops. It was quickly determined that the source of the DBM populations originated from infested transplants grown in local desert greenhouses. Apparently, the greenhouses were not able to control the DBM in their growing facilities, and transplants were delivered to fields infested with DBM larvae. Within weeks of transplanting, PCAs and growers found that they could not adequately control the DBM infestations.

To further complicate the situation, it was later discovered that the invasive DBM population was very resistant to a class of insecticides commonly used to control Lep larvae. After the first transplanted fields began to harvest in November, several growers reported that seriously infested fields suffered significant yield reductions, and 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 and cauliflower fields were routine. The DBM infestations experienced by Arizona growers in 2016-17 were not anticipated, and the resistant population that entered the desert caused serious losses in cole crops. It has been suggested that the DBM outbreaks this year were comparable in severity to the early sweetpotato whitefly outbreaks in 1992.

Survey Methods

In an attempt to document the impact of the DBM outbreaks on Arizona cole crops, we conducted a two-part survey of growers and PCAs from Yuma and Maricopa Counties in April 2017 to estimate the severity of DBM on direct-seeded and transplanted cole crops. 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 a problem (they had difficulty in controlling DBM compared with previous years). In these problem fields, 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 used was estimated. Respondents were provided an extensive list of available insecticides used for DBM control, and asked to estimate the % 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 Yuma county this past season was significantly greater than previously recorded. Results from areawide pheromone trapping beginning in January shows that DBM moth activity was 3-4 times higher than similar trapping conducted from 1999-2001 (Fig 1), and peaked by March in many locations. This is an indication of the outbreak intensity within the copping system and particularly in the Yuma Valley. It also indicates the spread of DBM from transplanted fields to direct seeded fields occurring during the winter and spring. During the fall when DBM problems were first reported, growers and PCAs indicated that entire fields were heavily infested with DBM and causing unacceptable damage to the crop. For example, plant samples collected from one cauliflower field in early November in the Yuma Valley were consistently infested with greater than 10 DBM larvae per head; the field was not harvested. At the time of the initial outbreaks, only fields that had been established with broccoli, cauliflower or cabbage transplants were infested with DBM, and PCAs were having difficulty controlling the pest. During November, ten separate PCAs reported having major problems with DBM on their transplanted crops. In contrast, PCAs were reporting that DBM were not present in direct-seeded crops, or in fields where transplants were brought in from greenhouses outside of the desert. Similarly, DBM was almost non-existent on direct-seeded broccoli plots crops grown for field experiments at the Yuma Ag Center during this same time.

Results from the first part of the survey clearly show the impact DBM infestations had on both transplanted and direct-seeded commodities (Table 1). A total of 23 PCA/growers completed surveys and estimates represented a total of 21,637 acres of cole crops in Yuma and Maricopa counties. Transplanted cauliflower and direct-seeded broccoli were the commodities most affected by the DBM outbreaks in 2016-17 based on the number of PCAs reporting, acres treated for DBM, and average yield losses. Similarly, direct-seeded cabbage and cauliflower, and transplanted broccoli and kale also experienced unusually high yield losses. Damage to a large percentage of the transplanted acreage occurred during November and December following the initial outbreaks, whereas damage to the direct-seeded crops occurred primarily during the spring season after DBM began to spread from recently terminated transplanted crops. Other minor acreage crops such as mizuna, arugula, baby kale and seed crops suffered considerably less damage, and were affected by DBM much later in the growing season. A single 20 acre Brussel sprouts field was grown in the Yuma Valley and sustained very high losses. The average number of sprays that PCAs made to control DBM also varied by commodity, but transplanted broccoli, cauliflower, cabbage and kale were, on average, the most heavily treated. There were individual direct-seeded fields of broccoli and cabbage that received 15 and 17 sprays, respectively, to control DBM. Rapidly growing, short-term crops such as mizuna, arugula and baby kale did not receive as many sprays.

Insecticide Usage, Efficacy, and Resistance

A total of 20 PCAs completed surveys estimating insecticide usage and field performance (Table 2). Based on treated acres, the pyrethroids were the most commonly applied insecticide used for DBM control, but were also one of the least effective. Radiant was used by all the PCAs and was the second most used insecticide, followed by Proclaim. Both of these products were top performers for PCAs with a fair to good rating for DBM control. Among other products that were used by a large percentage of PCAs included for DBM control included Lannate, Xentari/Agree, Avaunt, Entrust, Dibrom, and Coragen. All of these products performed fair to good for PCAs with the exception of Coragen. Other diamides such as Belt, Vetica and Voliam Xpress were used on fewer acres and also performed poorly. The 2nd generation diamides, Verimark (soil) and Exirel (foliar), were used on fewer acres, but performed good for PCAs. Older organophosphates such as chlorpyrifos, malathion, and acephate performed fair to poor based on PCA responses.

The PCA ratings on the insecticide field performance of insecticides used against DBM in 2016-17 are very consistent with research conducted at the Yuma Ag Center this past season (Table 3). Some commonly used products for DBM management were certainly less effective than expected. As we discovered in field and laboratory experiments, the invasive DBM population was very resistant to a commonly used class of insecticide. Lab bioassays conducted at the Yuma Ag Center showed that all of the DBM populations collected from transplanted fields in Yuma and Maricopa counties were highly resistant to chlorantranilprole (Coragen, Voliam Xpress), an anthranillic diamide insecticide that is normally very effective against this pest in Arizona. PCA performance ratings showed that a similar diamide active ingredient, flubendiamide (Belt and Vetica), also performed poorly in the field. This would be expected due to the common mode of action. A few of the populations that were collected from infested fields showed reduced susceptibility to spinetoram (Radiant) in lab bioassays, however Radiant was efficacious against DBM based on experimental field trials and PCA ratings. Products such as Lannate and pyrethroids also performed poorly in our field and lab trials, but this is not unusual given the long history of DBM resistance to these chemistries in most other growing regions. Consequently, resistance in the DBM population to chlorantranilipriole (and likely Lannate and pyrethroids) may have been one of the primary reasons PCAs and growers could not control the pest once the infested transplants arrived to the field. Prior to 2016, most of the insecticides shown in Table 3 would effectively control local DBM populations found in fields, albeit at much lower populations levels.

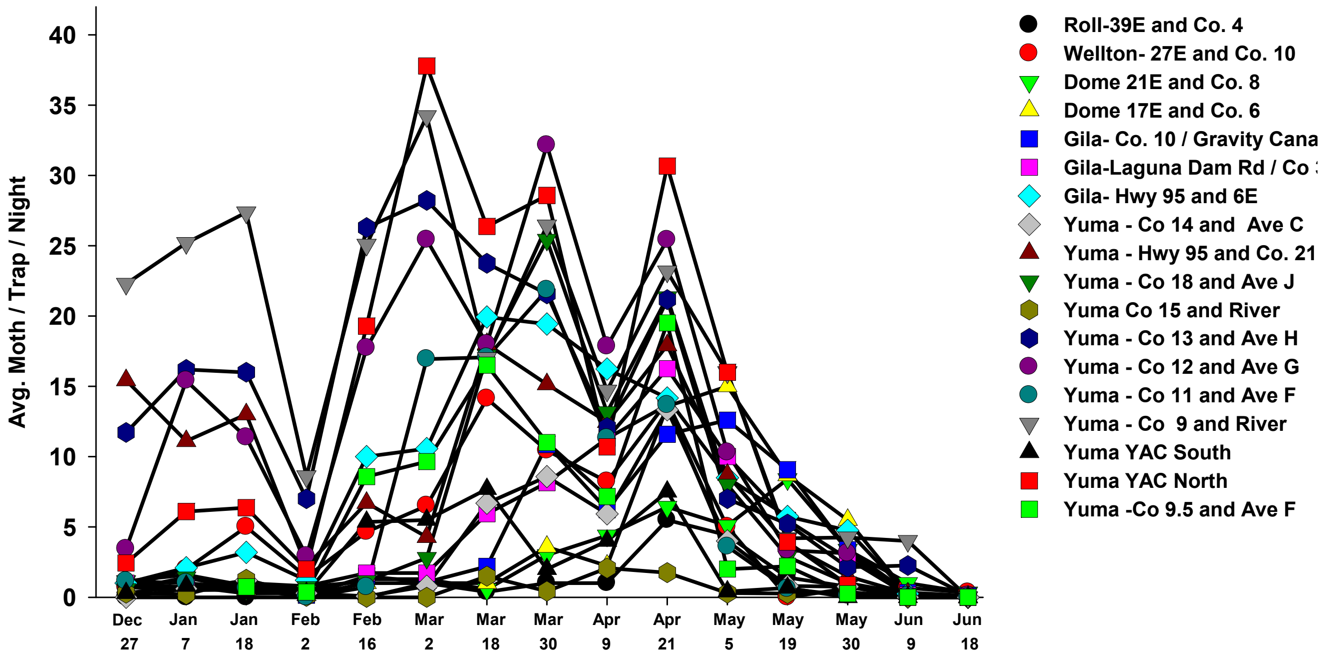
Conclusions

To a large degree, the DBM outbreaks in 2016 can be attributed to the establishment of the invasive DBM population on developing transplants within local greenhouses that then dispersed into commercial cole crop fields at transplanting. As noted above, in most years, growers can easily control DBM with 1-2 well timed insecticide sprays. However, PCAs that used a diamide insecticide (Coragen, Voliam Express, Belt and/or Vetica ~80% of the treated acreage [Table 2]) last fall to clean up the infested plants, likely failed to adequately control DBM. Unlike beet armyworms and cabbage loopers, early instar DBM larvae mine the leaves and can be hard to discover, and later instar larvae can be difficult to reach with sprays on the plant as they often infest the terminal growing points. By the time PCAs eventually realized the plants were infested, the DBM were well established and conventional control with insecticides was difficult to achieve, particularly on large plants where adequate spray coverage is very difficult to achieve. In addition, the warmer than average fall and winter temperatures certainly enhanced the biological activity of DBM once they became established in fields.

We are uncertain from where the resistant DBM population originated, or how it was able to so readily become established in the greenhouses. But given that DBM has never been a pest of this magnitude in the desert before, it is highly unlikely that this resistance was field evolved. It is more probable that the resistant DBM adults (moths) immigrated in from Mexico, California or elsewhere last summer via a monsoon storm. It is also possible that DBM may have been brought into local greenhouses on other plant material/transplants. Regardless of the source, local greenhouses and cole crop growers were not prepared to battle this resistant DBM population under desert growing conditions in 2016.

Acknowledgement

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



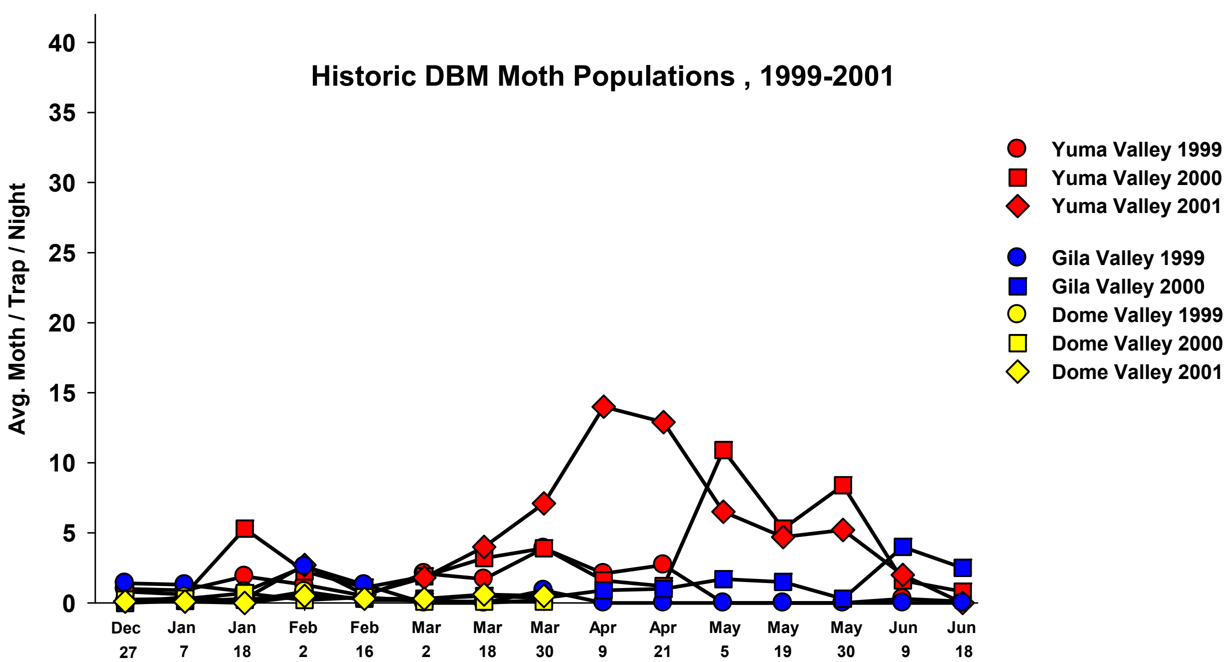


Figure 1. Relative DBM activity in Yuma county based on pheromone trap catches of DBM moths in the winter and spring 2017 compared to trap captures during years of non-outbreak conditions (1999-2001).

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 [a] DBM present	Acres [b] DBM treated	No. Sprays	Max. No. Sprays	Yield [c] Loss (%)	Max. Yield Loss (Range)
Broccoli-direct seeded	15	5623	4449	3071	6.4	15	8.5	4-50%
Broccoli-transplanted	8	2920	2380	1440	7.5	13	10.3	1-93%
Cauliflower-direct seeded	5	1220	800	770	5.3	8	10.0	0-45%
Cauliflower -transplanted	17	6400	5448	4593	7.6	13	13.7	0-100%
Cabbage - direct seeded	3	370	370	235	6.0	17	13.3	0-60%
Cabbage - transplanted	5	1865	1280	920	9.0	16	11.3	10-85%
Brassica seed crops-transplant	8	719	480	190	4.5	7	1.7	0-10%
Baby Kale-direct seeded	4	945	494	305	3.0	6	1.5	0-100%
Kale-transplanted	4	690	690	690	10.8	20	7.5	0-30%
Napa/Bok Choy -direct seeded	1	150	100	0	4.0	4	0.0	0%
Napa/Bok Choy -transplanted	1	150	112	75	4.0	4	2.0	2%
Mizuna/Arugula -direct seeded	1	565	339	170	3.0	3	2.0	50%
Brussel sprouts -transplants	1	20	20	20	11.0	11	20.0	20%

[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).

Table 2. Insecticide Use and Field Performance for DBM Control in Arizona Cole Crops, 2016-17.

Insecticide	% PCAs using Product	% Acres treated	Avg. no. applications	Treated [a] acres	PCA [b] Rating
Pyrethroid	95	85.4	5.5	101,629	1.2
Radiant	100	98.2	3.3	70,117	2.6
Proclaim	95	83.9	2.9	52,645	2.5
Lannate	75	65.1	2.8	39,440	2.3
Xentari/Agree	75	49.8	2.5	26,938	2.7
Avaunt	55	41.9	2.4	21,758	2.3
Entrust	55	32.5	2.2	15,470	2.6
Dibrom	80	39.4	1.7	14,492	2.4
Coragen (Foliar)	80	42.6	1.4	12,904	1.1
Exirel	35	22.9	1.8	8,919	2.6
Assail	45	25.7	1.2	6,673	0.9
Intrepid	15	14.1	1.4	4,271	1.7
Belt	45	18.1	1.2	4,700	1.4
Vetica	30	15.1	1.2	3,921	1.4
Voliam Xpress	35	14.7	1.2	3,817	1.0
Verimark (soil)	10	9.3	1.0	2,012	3.0
Chlorpyrifos	25	5.0	1.2	1,298	1.6
Malathion	20	6.4	1.0	1,385	1.4
Coragen (soil)	15	6.3	1.0	1,363	2.0
Acephate	15	5.0	1.0	1,082	1.7

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

[b] 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.

Table 3. Activity of insecticides against DBM larval populations based on PCA estimates of field performance, and local research that evaluated field efficacy and laboratory resistance, Yuma and Maricopa co., Arizona, 2016-2017.

Insecticide Activity Against DBM Larvae

	PCA Surveys	Lab Efficacy	Field Efficacy	Lab Resistance
Radiant	Good	Good	Good	Fair
Proclaim	Good	Good	Good	Good
Xentari	Good	Good	Good	
Entrust	Good	Good	Good	
Exirel	Good	Good	Good	
Avaunt	Good	Good	Good	
Dibrom	Fair	Good	Poor	
Lannate	Fair	Fair	Poor	
Coragen	Poor	Poor	Poor	Poor
Voliam Xpress	Poor	Poor	Poor	
Pyrethroids	Poor	Poor	Poor	
Lorsban Adv.	Fair			
Vetica	Poor			
Belt	Poor			
Malathion	Poor			
Assail	Poor			

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