

Insecticide Resistance Management for Lepidopterous Larvae in Desert Produce Crops

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The figures below illustrate insecticide options available for chemical management of beet armyworm, cabbage looper, corn earworm and diamondback moth during the growing season. **Figure 1** provides a relative index of efficacy for insecticides currently labeled on lettuce for management of beet armyworm. The index is based on empirical data generated from local field trials. **Figure 2** offers guidance for each insecticide product and its most effective fit at various crop stages throughout the season. This guide applies to leafy and Brassica vegetables.

These charts should serve as a guide to PCAs and growers for avoiding the overuse of a single product based on its IRAC defined mode of action (MOA), and as a reference for selecting products/MOAs with which to rotate throughout the season for the purpose of maximizing and sustaining product efficacy. This management approach should not be difficult to implement given the number of insecticide products with distinctly different MOA available for management of lepidopterous larvae throughout the season (Fig 1 and 2).

Figure 1.
Lepidopterous Larvae Management in Desert Produce Crops, 2019

Product	IRAC ¹ MOA	Beet armyworm	Cabbage looper	Corn earworm	Diamondback moth **	Comments*
Lannate	1A	•••	•	•••	•••	Tank mix with another product for broad spectrum Lep activity; provides thrips control; PHI: 10 d on lettuce; Has activity against DBM adults
Acephate	1B	•	••	•••	••	Tank mix with another product for broad spectrum Lep activity; PHI: 21 d on head lettuce, celery; 14 d brussels sprouts and cauliflower.
Dibrom	1B	•	••	••	•••	Short residual product. For DBM use 2 pints / acre. Has good adult DBM activity also. PHI: 7-d on labeled cole crops.
Pyrethroids	3	•	•••	•••	•••	Tank mix with another product for broad spectrum Lep activity; PHI: varies with products; Has shown adult and larval DBM activity.
Radiant/Entrust	5	•••	•••	•••	•••	Stand alone Lep, leafminer, and thrips control; PHI: 1 day oncole crops and leafy vbeiges; Use rates at 5-7 oz depending on pest spectrum.
Proclaim	6	•••	••	•••	•••	Stand alone Lep control; PHI: 7 day on cole and leafy veg crops; use at rates above 3.6 oz; if cabbage looper present tank-mix with a pyrethroid.
Bt (Dipel/Xentari)	11B	•	••	•	••	Tank mix with another product for broad spectrum Lep activity, numerous Bt products available; PHI: 0 d; use rates of 1.5 lb or > for DBM
Cormoran	15+4A	•••	••	••	••	Tank mix with a pyrethroid for cabbage looper. Apply at 12 oz for best residual. Has whitefly adult knockdown activity. PHI: 7-d on cloe crops.
Intrepid	18A	•••	•••	••	••	Tank mix with another product for broad spectrum Lep activity; PHI: 1 day; good spray coverage desirable; use 16 oz rate for DBM
Avaunt	22	•••	•••	••	•••	Tank mix with another product for broad spectrum Lep activity; PHI: 1 day, use higher rates for best control of all Leps.
Coragen	28	•••	•••	•••	••	Stand alone Lep and leafminer control; PHI: 1 day for Leafy veg; 3-d for cole crops. Avoid use for DBM; resistance has been detected.
Exirel	28	•••	•••	•••	•••	Foliar only; Stand alone Lep, whitefly and leafminer control; PHI: 1 day for Leafy veg annd cole crops - Use at or above 15 oz for DBM.
Verimark	28	•••	•••	•••	•••	Soil only; Stand alone Lep, whitefly and leafminer control; Use at 13.5 oz. for best residual effectiveness. PHI: N/A
Harvanta	28	•••	•••	•••	•••	Stand alone Lep and leafminer control; PHI: 1 day for Leafy veg annd cole crops - Use at 16.9 oz rate for DBM.
Besiege	28+3	•••	•••	•••	•••	Stand alone Lep and leafminer control; PHI: 1 day forlettuce; 3 day for cole crops. Avoid use for DBM; resistance has been detected.
Durivo	28+4A	•••	•••	•••	•••	Soil only; Stand alone Lep and leafminer control; PHI: 30 day for leafy and cole crops; Avoid use for DBM; resistance has been detected.
Minecto Pro	28+6	•••	•••	•••		Stand alone Lep, whitefly and leafminer control; PHI: 7 day for leafy vegetables/celery. Use 10 oz rate. Not labeled on cole crops or spinach.
•••	Good residual control (7-14 d); For DBM - 7 d residual					
••	Marginal residual control (4-6 d)					
•	Poor residual control (1-3 d)					

¹ IRAC Mode of Action - for more infor go to - <http://www.irac-online.org/>

* always consult the label before applying any of these products

** Based on Fall 2018-19 research on local DBM populations

Figure 2.

Alternatives for Lep Larvae Control at Specific Crop Stages

Insecticide	IRAC MOA	At-plant Soil	Stand establishment		Thinning to Heading				Heading to Harvest		
			Coty-1 leaf	2-4 leaf	5-8 leaf	9-15 leaf	15-20 leaf	Pre-head	Early heading	2-4" head	4-6" head
Lannate	1A			•	•	•	•	•	•	•	•
Acephate	1B			•	•	•	•				
Dibrom	1B			•	•	•	•				
Pyrethroids	3		•	•	•	•	•	•	•	•	•
Radiant, Entrust	5							••			••
Proclaim	6							••			••
Bt	11B				••	••	••				
Cormoran	15+4A				••	••	••	••			
Intrepid	18						•	••	••	••	
Avaunt	22A						•	••	••	••	
Coragen, Soil	28										
Coragen, Foliar	28							••			••
Verimark	28										
Exirel	28							••			••
Harvanta	28							••			••
Durivo, Soil only	28+4A										
Besiege	28+3										
Minecto Pro	28+6							••			••

- to be used in combination with a different IRAC mode of action
- to be used in combination with a pyrethroid or Lannate

Tactics should be practiced avoiding the development of resistance of Lep larvae to any of these products/MOA as follows:

- Apply insecticides only when needed. Time insecticide applications based on UA recommended action thresholds (<http://ag.arizona.edu/crop/>).
- Ideally, the management strategy that presents the lowest risk to insecticide resistance is one where consecutive applications of the same product/MOA **are not** made in the same lettuce field.
- This can be achieved by rotating to an alternative product/MOA on each subsequent spray application to eliminate consecutive uses of the same MOA. Whenever possible, consider using any single product /MOA only once per lettuce field per crop season.
- In lettuce fields where a product/MOA is required more than once, limit the total usage of that product/MOA to 2 applications per field per crop season. (i.e., no more than 2 uses of any IRAC MOA or insecticide with the same color code), and avoid using it on consecutive applications.
- Use only recommended products and rates necessary to accomplish desired control (Fig 1 and 2).
- Do not apply any active ingredient below labeled rates as this may result in poor product performance, unacceptable insect damage and an increased risk of resistance.
- Apply insecticides by ground sprays to optimize spray deposition and coverage whenever possible.
- Do not apply tank-mixtures containing 2 or more of the newer chemistries (IRAC Groups - 5, 6, 18, 22 and 28) when controlling lepidopterous larvae. Not only is this expensive, but generally not necessary based on past performance trials (Fig 1).

Specific resistance management recommendations have been developed for the Diamides (IRAC group 28) for *beet armyworm* and *diamondback moth* on in the western U.S. Given the residual effectiveness of these compounds, along with their flexibility in application, it will be important to adhere to the guidelines below when using Diamide products as an effort to sustain the efficacy of this class of insecticide chemistry which contains many products.

- The Diamide products (IRAC Group 28) offer flexibility in application; they can be applied to plant foliage as a translaminar foliar spray, or systemically via a soil application.
- If a Diamide product is applied as a foliar spray, consider using this MOA only once per lettuce field per crop season. If a Diamide spray is required more than once, limit the total usage to 2 foliar spray per field.
- **Do not** apply a foliar Diamide spray **prior to** or **following** the use of a soil application of chlorantraniliprole (Coragen/Durivo) or cyantraniliprole (Verimark).
- If a Diamide product is soil applied prior-to or at-planting, as an in-furrow spray, shank injection, drip chemigation or transplant drench, **do not spray** a Diamide product on that crop for at least 60 days.
- If a Diamide product (IRAC Group 28) is applied as a post-emergence treatment through drip irrigation, **do not spray** any Diamide product on that crop prior to the Diamide chemigation, or at any time thereafter during the crop season.
- Do not apply more than **1** application of a Diamide product to the soil regardless if chemigated through drip irrigation, applied to transplant trays, or soil applied at planting. If additional beet armyworm or Lepidopterous larvae control is needed during the crop season, use a non-Diamide foliar alternative. See Figures 1 and 2 for alternatives products/MOA.
- Use a penetrating adjuvant (e.g., MSO/Silicone blends) with foliar Diamide applications to assist in spray atomization and penetration, and to provide uniform deposition of spray droplets on foliage; this is particularly important in Cole crops.
- To minimize selection pressure to beet armyworm:
 - In areas where alfalfa is grown in proximity to lettuce, **do not** apply any Diamide product (Coragen, Prevathon, Besiege) in alfalfa at any time.
 - In areas where cotton is grown in proximity to lettuce, **do not** apply any Diamide product (Prevathon, Besiege, Exirel, Minecto Pro) in cotton at any time.
- To minimize selection pressure to diamondback moth:
 - **Do not apply** any **foliar** Diamide products on nursery grown plants (e.g., cabbage or cauliflower) destined for field transplanting.
 - **Soil** Diamides (Coragen, Durivo and Verimark) can be applied on nursery grown plants as transplant drenches, but no earlier than 72 hrs prior to planting in the field.
 - Avoid using chlorantraniliprole (Coragen, Besiege, Durivo) on Cole crops because of known resistance in the desert. Instead, PCAs should use *cyantraniliprole* (Verimark, Exirel or *cyclaniliprole* (Harvanta) to control DBM.