Insecticide Resistance Management Guidelines for Lepidopterous Larvae in Lettuce

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The figures below illustrate insecticide options available for chemical management of beet armyworm, cabbage looper and corn earworm 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 crop season.

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, 2016

Product	IRAC [1] MOA	Beet armyworm	Cabbage looper	*Corn earworm*	Comments*
Lannate	1A	•••	•	•••	Tank mix with another product for broad spectrum Lep activity; provides thrips control; PHI: 10 d on lettuce; Use rates above 0.75 lb AI/ac.
Lorsban	1B	•••	•	•••	Tank mix with another product for broad spectrum Lep activity; For use on cole crops, PHI: 21 d; use top of label rates if possible.
Acephate	1B	•	••	••	Tank mix with another product for broad spectrum Lep activity; PHI: 21 d on head lettuce only.
Pyrethroids	3	•	•••	•••	Tank mix with another product for broad spectrum Lep activity; PHI: varies with products ; use high labeled rates
Radiant	5	•••	•••	•••	Stand alone Lep, leafminer, and thrips control; PHI: 1 day on lettuce; Use rates at 5-7 oz depending on pest spectrum.
Proclaim	6	•••	••	•••	Stand alone Lep control; use a penetrating adjuvant ; PHI: 7 day on lettuce; use at rates above 3.6 oz; if cabbage looper present tank-mixed with a pyrethroid.
Bt (i.e. Dipel)	11B	•	••	•	Tank mix with another product for broad spectrum Lep activity, numerous Bt products available; PHI: 0 d -good spray coverage desirable
Intrepid	18A	•••	•••	••	Tank mix with another product for broad spectrum Lep activity; PHI: 1 day; good spray coverage desirable; mix with a pyrethroid for best results
Avaunt	22	•••	•••	••	Tank mix with another product for broad spectrum Lep activity; PHI: 1 day, good spray coverage desirable, use higher rates for best control
Coragen	28	•••	•••	•••	Stand alone Lep and leafminer control; PHI: 1 day for lettuce- Use at or above 5 oz. for best residual effectiveness.
Exirel	28	•••	•••	•••	Foliar only; Stand alone Lep, whitefly and leafminer control; PHI: 1 day for lettuce- Use at or above 13 oz. for best residual effectiveness.
Verimark	28	•••	•••	•••	Soil only; Stand alone Lep, whitefly and leafminer control; Use at or above 10 oz. for best residual effectiveness.
Voliam Xpress	28+3	•••	•••	•••	Stand alone Lep and leafminer control; PHI: 1 day forlettuce; Use higher rates (8 oz or > for best residual effectiveness.
Volium Flexi	28+4A	•••	•••	•••	Stand alone Lep and leafminer control; PHI: 7 day for lettuce; Has aphid activity. Use higher rates for best residual effectiveness.
Durivo	28+4A	•••	•••	•••	Soil only; Stand alone Lep and leafminer control; PHI: 30 day for lettuce; Use at 13 oz. for best residual effectiveness. Has aphid activity.

•••	Good residual control (7-14 d)
••	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**

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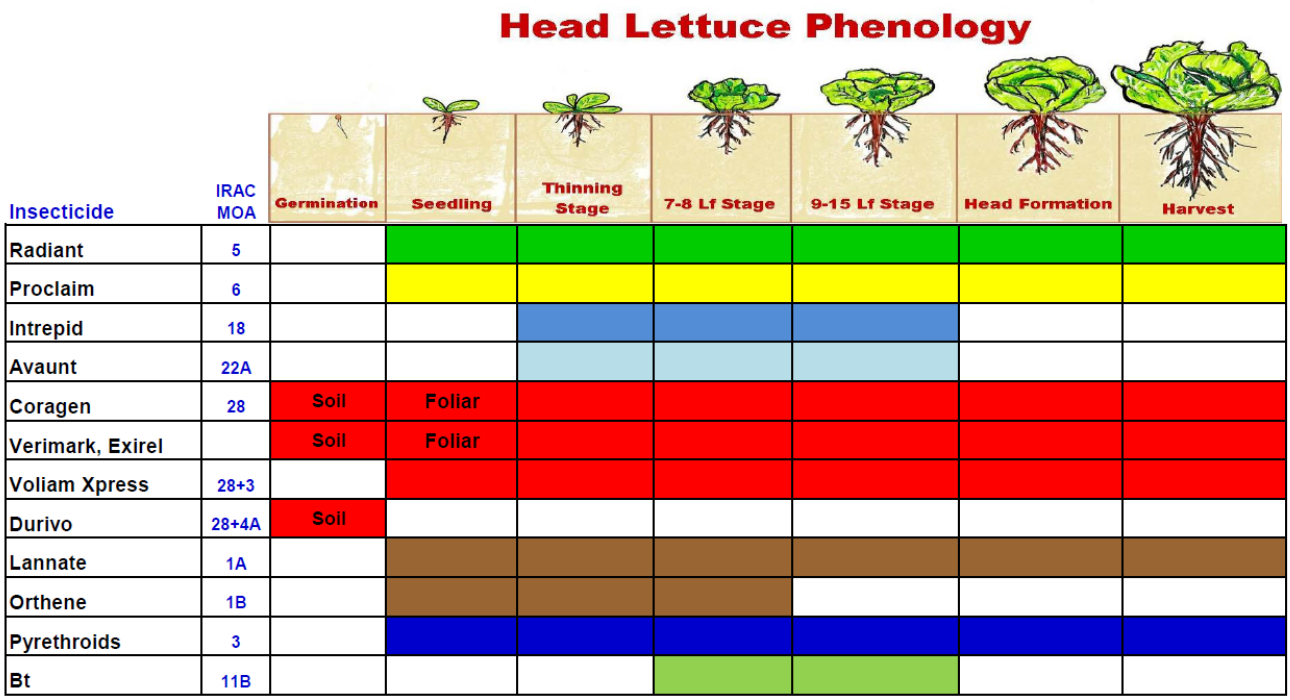
Figure 2.



Insecticide	IRAC MOA	Germination	Seedling	Thinning Stage	7-8 Lf Stage	9-15 Lf Stage	Head Formation	Harvest
Radiant	5							
Proclaim	6							
Intrepid	18							
Avaunt	22A							
Coragen	28	Soil	Foliar					
Verimark, Exirel		Soil	Foliar					
Voliam Xpress	28+3							
Durivo	28+4A	Soil						
Lannate	1A							
Orthene	1B							
Pyrethroids	3							
Bt	11B							

Additional tactics should be practiced to avoid the development of resistance by beet armyworm 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 (see examples in **Figure 3-5** below). 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 directed 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* on lettuce crops grown 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 new class of insecticide chemistry.

- The Diamide products (IRAC Group 28) offer flexibility in application; they can be applied to plant foliage translaminarly through foliar sprays, or systemically via soil applications.

- If a Dimide 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 and do not use them in consecutive applications (Figure 3).

- **Do not** apply a foliar Diamide spray **prior to** or **following** the use of a soil application of chlorantraniliprole (Figure 4 and 5).

- If a Diamide product is soil applied prior-to or at-planting, as an in-furrow spray or shank injection, **do not spray** a Diamide product on that crop at any time during the remainder of the crop season (Figure 4).

- If a Diamide product (IRAC Group 28) is applied as a post-emergence treatment through drip irrigation, **do not spray** any Diamide products on that crop prior to the Diamide chemigation, or at any time thereafter during the crop season. (Figure 5).

- Do not apply more than **1** application of a Diamide product to the soil regardless if chemigated through drip irrigation or soil applied at planting. If additional beet armyworm control is needed during the crop season, use a non-Diamide foliar alternative. See Figures 1 and 2 for alternatives products/MOA.

- Consider using an adjuvant 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.

- In areas where alfalfa is grown in proximity to lettuce, do not apply any Diamide product (Coragen, Voliam Xpress) in alfalfa at any time.

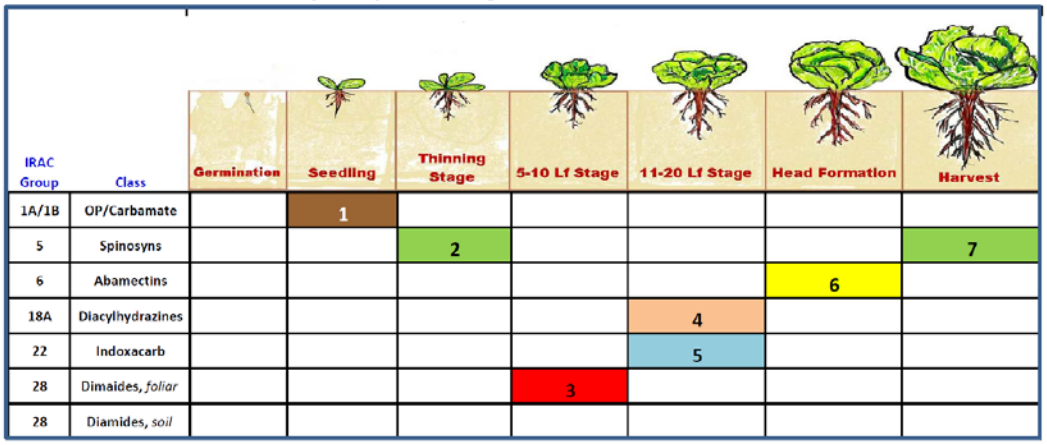
- In areas where cotton is grown in proximity to lettuce, do not apply any Diamide product (Coragen) in cotton at any time.

- **Do not use** any soil or foliar applied Diamide product on nursery grown plants (e.g., cabbage or cauliflower) destined for field transplanting.

Figure 3

Foliar IRM Programs

***Spodoptera exigua* in Head Lettuce - western U.S.**



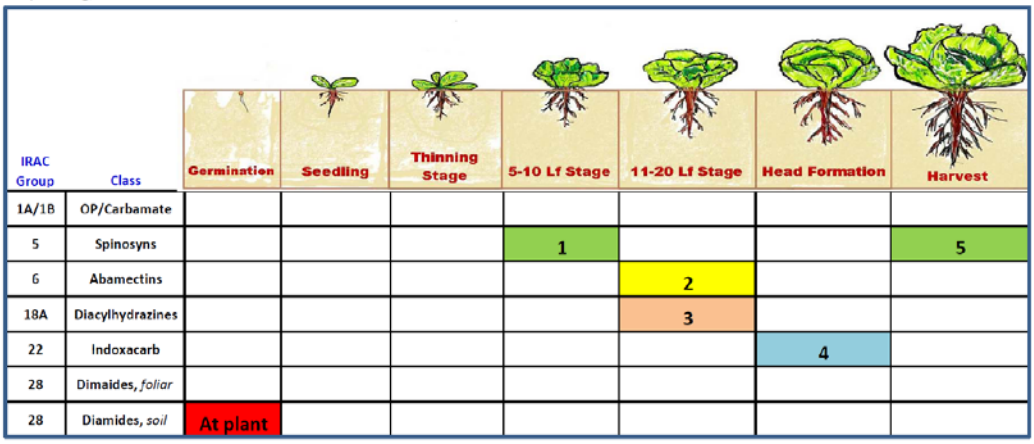
IRAC Group	Class	Germination	Seedling	Thinning Stage	5-10 Lf Stage	11-20 Lf Stage	Head Formation	Harvest
1A/1B	OP/Carbamate		1					
5	Spinosyns			2				7
6	Abamectins						6	
18A	Diacylhydrazines					4		
22	Indoxacarb					5		
28	Dimaides, *foliar*				3			
28	Diamides, *soil*							

Figure 4

Soil / Foliar IRM Programs

At planting, In-furrow

***Spodoptera exigua* in Head Lettuce – western U.S.**



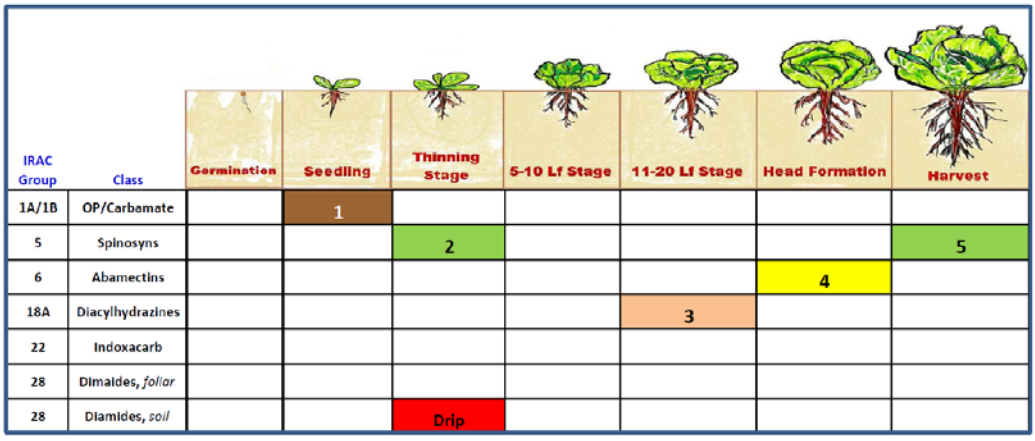
IRAC Group	Class	Germination	Seedling	Thinning Stage	5-10 Lf Stage	11-20 Lf Stage	Head Formation	Harvest
1A/1B	OP/Carbamate							
5	Spinosyns				1			5
6	Abamectins					2		
18A	Diacylhydrazines					3		
22	Indoxacarb						4	
28	Dimaides, *foliar*							
28	Diamides, *soil*	At plant						

Figure 5

Soil / Foliar IRM Programs

Drip chemigation

***Spodoptera exigua* in Head Lettuce – western U.S.**



IRAC Group	Class	Germination	Seedling	Thinning Stage	5-10 Lf Stage	11-20 Lf Stage	Head Formation	Harvest
1A/1B	OP/Carbamate		1					
5	Spinosyns			2				5
6	Abamectins						4	
18A	Diacylhydrazines					3		
22	Indoxacarb							
28	Dimaides, *foliar*							
28	Diamides, *soil*			Drip				