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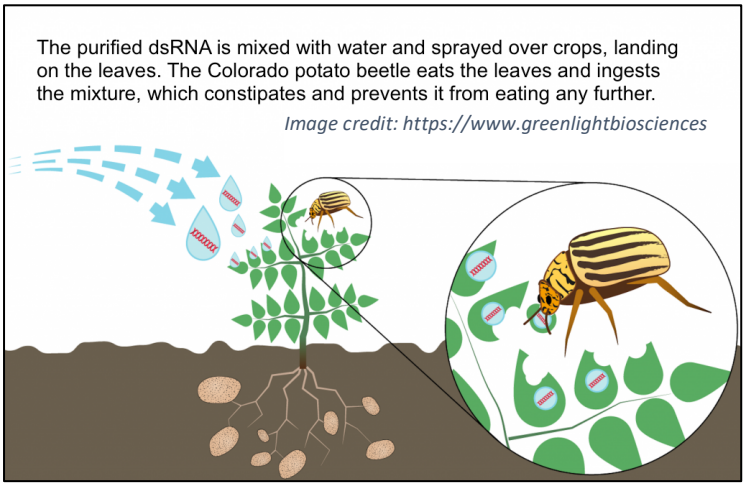
Update on RNA-based insecticides

- **What are RNA-based insecticides?**
  - RNA interference (RNAi) uses double-stranded RNA to block messenger RNA from sending out instructions to make proteins, thus *killing insects or reducing their ability to develop resistance to insecticides*
  - Plants can be genetically modified to produce it or it can be externally applied
  - It was first identified in 1990
  - Completely new mode of action, based on genes, not chemicals
  - EPA first approved an RNAi pesticide in 2017, called SmartStax Pro, a GM corn that has both transgenic insecticidal proteins and RNAi to kill corn rootworm. It's expected to be released in the United States in the next few years by Bayer.

- **How do they work?**
  - Specific to pest: blocks nucleotide sequences that are only found in the target pest
  - Can be designed for any pest species
  - Can be incorporated into the plant (systemic) or sprayed (ingested)
  - No contact / knock-down activity
  - Safe to beneficials and humans

- **Is RNAi being tested in potato?**
  - Greenlight Biosciences has a dsRNA insecticide for Colorado potato beetle
  - EPA is currently reviewing this product for experimental and commercial use
  - Applied by foliar sprays
  - Becomes active when consumed with plant tissue
  - Has no knock-down activity -> insect may take some time to die after application
  - Kills adults and larvae
  - Can provide similar efficacy to other foliar product currently used
  - Can be used combined with at-planting neonicotinoids, thus enhancing their activity
  - Breaks down quickly – short residual activity
  - Should be used in combination with other current pest management strategies, not a stand-alone "silver bullet"



- **Will RNA based insecticides get around insecticide resistance problems?**
  - In short, no
  - In a lab test, corn rootworm resistant to one trait was shown to be cross resistant to other dsRNA traits. The insect's gut walls did not absorb dsRNA, thus the larva was able to eliminate the toxin without it getting into its body. In the same test, insects resistant to the dsRNA insecticide were not resistant to the Bt insecticides.

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Products for Colorado potato beetle management

Colors represent different insecticide active ingredients

Treatment	Delivery	Product	Active Ingredient	IRAC
Early generation	In-furrow, seed	Admire Pro, generics	imidacloprid	4A
	In-furrow, seed	Platinum, Cruiser, etc.	thiamethoxam	4A
	In-furrow	Verimark	cyantraniliprole	28
	Foliar	Exirel	cyantraniliprole	28
	Foliar	*Coragen	chlorantraniliprole	28
	Foliar	Torac	tolfenpyrad	21A
	Foliar	Rimon[1]	novaluron	15
	Foliar	Agri-Mek, generics	abamectin	6
	Foliar	*Radiant	spinetoram	5
	Foliar	*Blackhawk, *Entrust	spinosad	5
Late generation	Foliar	Agri-Mek, generics	abamectin	6
	Foliar	Coragen, Voliam Xpress[2]	chlorantraniliprole	28
	Foliar	Exirel	cyantraniliprole	28
	Foliar	Admire Pro, generics	imidacloprid	4A
	Foliar	Avaunt[3]	indoxacarb	22A
	Foliar	Torac	tolfenpyrad	21A
	Foliar	Radiant	spinetoram	5
	Foliar	Blackhawk, Entrust	spinosad	5
	Foliar	Actara, Endigo ZC[2]	thiamethoxam	4A
Trap crop	Foliar	Avaunt[3]	indoxacarb	22A
	Foliar	Imidan	phosmet	1B

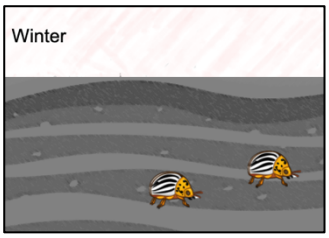
[1] Apply at 50% egg hatch, only kills larvae
[2] Mixed with pyrethroid, apply when potato leafhoppers are also problematic
[3] Avaunt has limited activity on larvae
*Registered on field corn, can be used for beetle management on volunteer potatoes in corn

3-year product rotation example for Colorado potato beetle management for "early" (overwintered) and "late" (summer) beetles

Year 1		Year 2		Year 3	
early	late	early	late	early	late
In-furrow + Foliar					
Verimark	Blackhawk	Platinum	Agri-Mek	Torac	Coragen
Full Foliar					
Torac	Voliam Xpress	Agri-Mek	Actara	Blackhawk	Exirel

Colorado potato beetle (CPB) management and warmer weather

Overwintering



- beetles enter overwintering diapause when day length begins to shorten
- beetles move short distances from potato field to field edges or woodlots and dig into the soil to overwinter
- survive best if soil temperatures stay around 32ºF
- overwintering depth depends on soil: beetles dig deeper in sandy compared to heavy soils
- beetles closer to the surface have a higher chance of freezing when soil temp drops
- warmer winters can lead to higher overwintering survival and larger populations of beetles emerging in the spring
- warmer than average summers can speed up the life cycle of beetles:
    - CPB need about 700 degree days to complete a generation
    - Check degree day accumulation at your location at MSU Enviroweather

Resistance management

Effects of weather on beetle resistance

- warmer winters = healthier beetles in the spring with stronger immune systems allowing them to combat the toxins in insecticide more effectively
- higher temperatures speed up development leading to greater selection for resistance
- some genes that underlie heat tolerance also provide resistance to insecticides
- higher temperatures in summer can make beetles more susceptible to insecticide

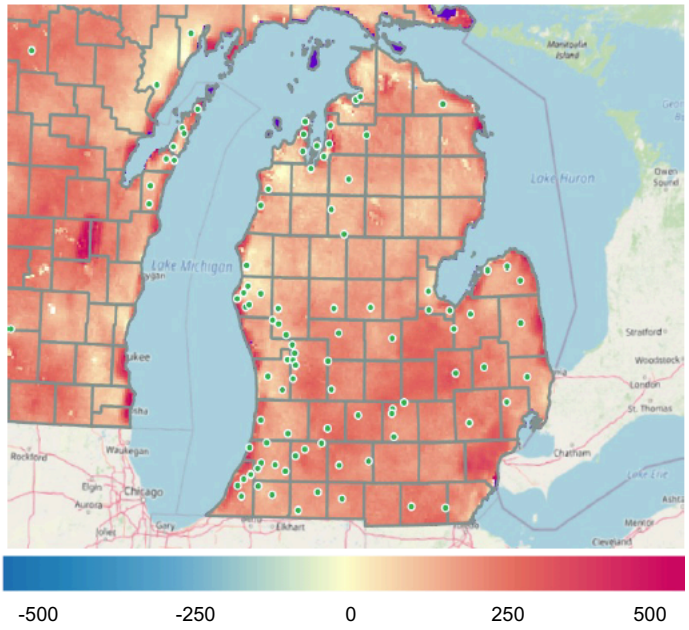
Effects of weather on insecticides

- some insecticides break down more rapidly in warmer temperatures, thus higher temperatures lead to a reduced efficacy window exposing beetles to sublethal doses

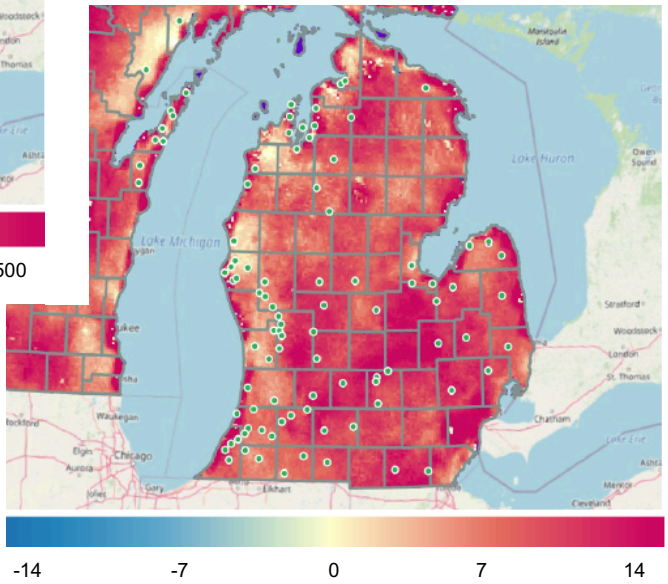
Recommendations to prevent insecticide resistance

1. Alternate insecticides: if a neonicotinoid was applied to the crop at planting (Group 4A), do not apply a foliar neonicotinoids later in the season
2. Crop rotation: potato needs to be rotated into fields with over ¼ mile between successive plantings to be effective
3. Only spray when necessary: before spraying, use scouting and action thresholds to determine that insecticides are not being sprayed unnecessarily
    - when spraying insecticides, try to spot treat or use a potato trap crop
    - use selective insecticides that will conserve natural enemies
    - apply insecticides at the recommended rate to prevent beetles from surviving and passing on resistance genes to the next generation

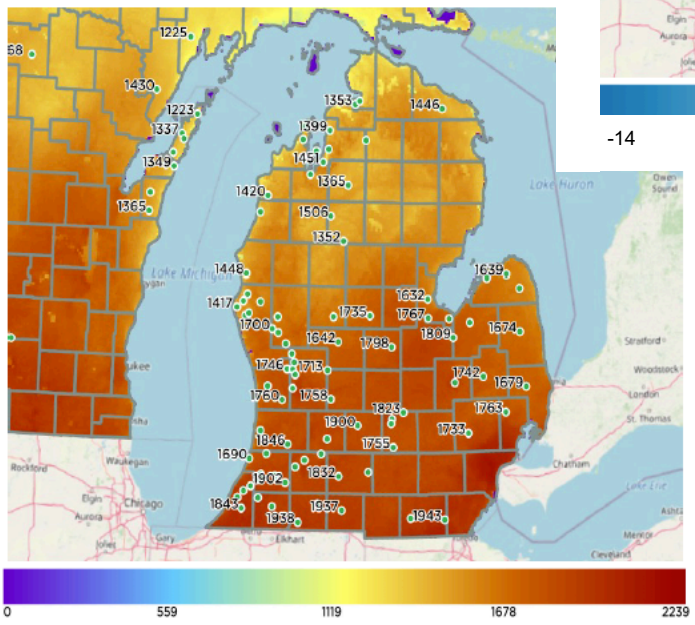
Heat Accumulation Compared with Normal (in degree days) April 1 - August 2



Heat accumulation compared with normal in DAYS (Apr 1- Aug 2)



Cumulative Growing Degree-Days (50F)March 1 – Aug 2



Source: https://alpha.enviroweather.msu.edu/weathermodels/latestobservations