

# Insecticide Modes of Action on Desert Vegetable Crops

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COLLEGE OF AGRICULTURE  
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IRAC MOA <sup>1</sup> Group	Sub- group	Chemical sub-group or active ingredients	Common Products used on Desert Produce and Melon Crops
1	A	<i>Carbamates</i>	Lannate, Vydate, Sevin
	B	<i>Organophosphates</i>	Orthene, Diazinon, Dimethoate, Malathion, Metasystox-R Lorsban, Dibrom, and many generics
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> Acetylcholinesterase (<i>AChE</i>) inhibitors. Their toxicity occurs from the inhibition of <i>AChE</i> in the nerve synapse that leads to the accumulation and continued transmission of acetylcholine (<i>ACh</i>). While these chemical residues are still attached to the active synaptic site, the enzyme cannot hydrolyze <i>ACh</i> and thus is inhibited.</p> <p><b>Route of Activity:</b> Primarily toxic through contact activity; MSR and Orthene are known to have limited systemic activity.</p> <p><b>Spectrum of Activity:</b> Broad spectrum activity against a wide range of pests (e.g., flea beetles, aphids, thrips), but depends on compound. Many pests have locally developed high levels of tolerance over the past 20-30 years.</p>			
3		<i>Pyrethroids, Pyrethrins</i>	Asana, Baythroid, Ambush, Brigade, Mustang Max, Warrior, Danitol, Pyganic, and numerous generics
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> Voltage-dependent sodium channel activators. With Type I (e.g., Ambush, Brigade) pyrethroids a repetitive discharge occurs within the nerve membrane that has an excitatory effect that results in tremors, and lack of coordination leading to death. With Type II (e.g., Baythroid, Danitol) pyrethroids, the nerve membrane becomes strongly depolarized, and leads to a block of neurotransmission and to depression and paralysis in the insect.</p> <p><b>Route of Activity:</b> Contact activity via foliar applications, limited soil contact activity; short residual on most pests (3-5 d).</p> <p><b>Spectrum of Activity:</b> Broad spectrum knockdown activity, particularly useful for control of adult life-stages.</p>			
4	A	<i>Neonicotinoids</i>	Admire Pro (numerous generics), Platinum, Durivo, Actara, Assail, Venom, Scorpion, Belay
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> Neonicotinoids act by mimicking acetylcholine in its ability to stimulate <i>nicotinic ACh</i> receptors (<i>nAChRs</i>). Their effects start with excitation and lack of coordination, which rapidly results in partial paralysis as the extended stimulation of <i>nAChRs</i> leads to a block of synaptic excitability. Some of these compounds have shown anti-feedant activity at sublethal doses in some insects.</p> <p><b>Route of Activity:</b> Activity is primarily through ingestion via soil, systemic applications or translaminar action via foliar sprays. With the exception of Assail and Venom/Scorpion, most compounds have limited contact activity.</p> <p><b>Spectrum of Activity:</b> Selective activity against the adult and immature stages of whiteflies and aphid species. Residual efficacy varies with product and rates.</p>			
4	C	<i>Sulfoxamines</i>	Sequoia (sulfoxaflor)
<p><b>Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> Sulfoxamines interact with the <i>nicotinic ACh</i> receptors (<i>nAChRs</i>) as an agonist, but evidence suggests that they bind to these receptors differently than the neonicotinoids. Sulfoxaflor is not cross-resistant to imidacloprid resistant insects (i.e., aphids and whiteflies) due to differences in metabolism by monooxygenase enzymes which metabolically degrade neonicotinoids in most sucking insects.</p> <p><b>Route of Activity:</b> Activity is contact, and ingestion thru translaminar action via foliar sprays. Also has limited xylem mobility.</p> <p><b>Spectrum of Activity:</b> Excellent selective activity against most aphid species and Lygus bugs. Efficacy against adult and immature stages of whiteflies varies with rate. Marginal activity against Bagrada bug and other stink bugs.</p>			
4	D	<i>Butenolide</i>	Sivanto (flupyradifurone)
<p><b>Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> interact with the <i>nicotinic ACh</i> receptors (<i>nAChRs</i>) as an agonist, but evidence suggests that they bind to these receptors differently than the neonicotinoids. Similar to Sulfoxaflor, Sivanto is not cross-resistant to imidacloprid resistant insects (i.e., aphids and whiteflies) due to differences in metabolism by monooxygenase enzymes</p> <p><b>Route of Activity:</b> Activity is contact, and ingestion thru translaminar action via foliar sprays. Also has xylem mobility via soil application and root uptake</p> <p><b>Spectrum of Activity:</b> Excellent knockdown and residual activity against whiteflies as both a foliar spray (produce crops) and as a soil-applied systemic treatment (melons). As a soil systemic in fall melons, it has shown to be very effective against adult whitefly and CYSDV suppression comparable to Venom. Also provides good consistent activity against most aphid species. Easy on natural enemies and based on EPA reports it is practically non-toxic to adult honeybees and has been grant reduced-risk status.</p>			

5		Spinosyns	Success, Entrust, (spinosad) Radiant (spinetoram)
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> These products cause channel opening and an increased sensitivity to Ach in certain types of nicotinic synapses. The mechanism by which they cause excitability of nicotinic synapses is not currently known, but act differently from the neonicotinoids. Also their site of action is distant from the ACh binding site. Spinosyns also cause enhanced responses at some GABAergic synapses that may contribute to their insecticidal effects.</p> <p><b>Route of Activity:</b> Ingestion and contact translaminar activity via foliar applications.</p> <p><b>Spectrum of Activity:</b> Excellent selective activity against most Lepidopterous larvae, <i>Liriomyza</i> leafminers and western flower thrips</p>			
6		Avermectins	Agri-Mek (abamectin), Proclaim (emamectin benzoate) Minecto Pro (abamectin)
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> These compounds act as allosteric effectors on glutamate receptors, and increase the sensitivity of some nAChRs to ACh. This depresses activity in the nervous system, which often results in reduced movement and paralysis. The avermectins have a similar action on GABAergic receptors. These actions cause rapid paralysis and, eventually death.</p> <p><b>Route of Activity:</b> Ingestion and contact activity via foliar applications.</p> <p><b>Spectrum of Activity:</b> Selective activity against most Lepidopterous larvae (Proclaim), and leafminers (Agri-Mek) (Minecto Pro)</p>			
7	C	Juvenile Hormone Mimics	Knack (pyriproxyfen)
<p><b>Toxic Activity:</b> Insect Growth Regulator</p> <p><b>Mode of Action:</b> These compounds mimic the effects of juvenile hormone that regulates insect development from larva to pupa to adult. These compounds only affect immature stages at the time of molt. They have little effect on adult insects or immatures during the intermolt phases of growth. However, they may cause developmental problems by maintaining the immature form after the molt. Effects on insect reproduction also have been reported including decreased fecundity, decreased oviposition, or egg sterility.</p> <p><b>Route of Activity:</b> Primarily ingestion via translaminar action following foliar sprays</p> <p><b>Spectrum of Activity:</b> Excellent selective activity against whiteflies</p>			
9	B	Pyridine azomethine derivatives	Fulfill (pymethrozine) PQZ (pyrifluquinazone)
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> A.I. binds to the gating of Nan-lav TRPV channel complexes in chordotonal stretch receptor organs that lead to the disruption of feeding and other behaviors sucking insects.</p> <p><b>Route of Activity:</b> Primarily activity through ingestion via translaminar uptake following foliar sprays</p> <p><b>Spectrum of Activity:</b> Selective activity against whiteflies and aphids. PQZ has excellent activity against whiteflies and CYSDDV.</p>			
9	D	Pyropenes	Sefina, Versys (afidopyropen)
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> A.I. binds to the gating of Nan-lav TRPV channel complexes in chordotonal stretch receptor organs that lead to the disruption of feeding and other behaviors sucking insects.</p> <p><b>Route of Activity:</b> Primarily activity through ingestion via translaminar uptake following foliar sprays</p> <p><b>Spectrum of Activity:</b> Selective activity against whiteflies and aphids. Sefina has excellent activity against whitefly and CYSDDV.</p>			
11	B	Microbial disruptors of insect midgut membranes	Xentari, DiPel, Javelin, and other <i>Bacillus thuringiensis</i> products
<p><b>Toxic Activity:</b> Microbial biopesticide that disrupts feeding</p> <p><b>Mode of Action:</b> <i>Bacillus thuringiensis</i> (Bt) products have been formulated to mimic natural occurring crystalline toxins that disrupt the structure of the cells of the midgut leading to a cessation of feeding and destruction of the midgut, accompanied by a loss of body fluids and possible bacterial invasion. Different strains of Bt produce different crystals which have selective toxicity against various insects.</p> <p><b>Route of Activity:</b> Ingestion activity via foliar applications.</p> <p><b>Spectrum of Activity:</b> Selective activity against some Lepidopterous larval species (i.e., diamondback moth, cabbage loopers)</p>			
15		Inhibitors of Chitin Biosynthesis, Type 0	Rimon, Cormoran, (Novaluron)
<p><b>Toxic Activity:</b> Insect Growth Regulator</p> <p><b>Mode of Action:</b> Novaluron inhibits the synthesis of chitin at late stages, but the exact site is not known. As a result of this inhibition, the new exoskeleton lacks chitin and is thin and weak. It may split causing leakage of the body fluids, access for pathogens into the body and or prevention of normal muscle contractions.</p> <p><b>Route of Activity:</b> Excellent activity via ingestion.</p> <p><b>Spectrum of Activity:</b> Type 0I inhibitors are particularly active against early instar Lep larvae</p>			

16		<i>Inhibitors of Chitin Biosynthesis, Type I</i>	<b>Courier, (Buprofezin)</b>
<p><b>Toxic Activity:</b> Insect Growth Regulator  <b>Mode of Action:</b> Chitin is one of the main structural components of the insect exoskeleton. Buprofezin inhibits the synthesis of chitin at late stages, but the exact site is not known. As a result of this inhibition, the new exoskeleton lacks chitin and is thin and weak. It may split causing leakage of the body fluids, access for pathogens into the body and or prevention of normal muscle contractions.  <b>Route of Activity:</b> Excellent activity via vapor phase inhalation following foliar applications.  <b>Spectrum of Activity:</b> Type I inhibitors are particularly active against early-instar whitefly nymphs</p>			
17		<i>Molting Disruptors</i>	<b>Cyromazine (Trigard)</b>
<p><b>Toxic Activity:</b> Insect Growth Regulator  <b>Mode of Action:</b> Trigard specifically disrupts the larval and pupal molts in affected larvae. Normal cuticle development becomes disrupted causing difficulties with ecdysis. The biochemical mechanism of this action is unknown.  <b>Route of Activity:</b> Ingestion activity via foliar applications.  <b>Spectrum of Activity:</b> Selective activity against <i>Liriomyza</i> leafminers</p>			
18		<i>Ecdysone Receptor Agonists</i>	<b>Intrepid (methoxyfenozide), Confirm (tebufenozide)</b>
<p><b>Toxic Activity:</b> Insect Growth Regulator  <b>Mode of Action:</b> Intrepid mimics the effects of the primary molting hormone in insects by binding to the ecdysone receptor. This rapidly induces premature molting where feeding ceases, followed by the separation of the old cuticle and synthesis of the new one begins. Synthesis of the new cuticle is not completed, the old cuticle is not shed, and the insect remains trapped inside.  <b>Route of Activity:</b> Ingestion activity via foliar applications.  <b>Spectrum of Activity:</b> Selective activity against most Lepidopterous larval species</p>			
21	A	<i>MET inhibitors</i>	<b>Torac (tolfenpyrad)</b>
<p><b>Toxic Activity:</b> Metabolic toxin  <b>Mode of Action:</b> Exert their effects through the disruption of respiratory processes, specifically mitochondrial complex I electron transport (METI). Ultimately disrupt the flow of energy necessary for the synthesis of ATP.  <b>Route of Activity:</b> Contact activity via foliar applications.  <b>Spectrum of Activity:</b> Fair to good broad-spectrum activity against many key pests; particularly effective on western flower thrips.</p>			
22	A	<i>Voltage-dependent Sodium Channel Blockers</i>	<b>Avaunt (indoxacarb)</b>
<p><b>Toxic Activity:</b> Neurotoxic  <b>Mode of Action:</b> Avaunt is considered a voltage-dependent sodium channel blocker that acts differently from pyrethroids, both in mechanism and site. The compound locks (inactivates) sodium channels preventing axonal sodium influx. The production of nerve impulses is blocked resulting in a rapid cessation of feeding, decreased locomotor activity, and ultimately paralysis.  <b>Route of Activity:</b> Ingestion activity via foliar applications.  <b>Spectrum of Activity:</b> Selective activity against most Lepidopterous larval species</p>			
23		<i>Inhibitor of acetyl CoA carboxylase</i>	<b>Oberon (spiromesifen) Movento (spirotetramat)</b>
<p><b>Toxic Activity:</b> Lipid synthesis, Growth regulation  <b>Mode of Action:</b> These compounds are from the cyclic ketoenol or tetroneic acid derivatives class and are more active against immature stages than adults. The mode of action of these compounds is novel and involves the interference with the biosynthesis of lipids or fatty acids (inhibitor of acetyl CoA carboxylase) during immature development. Compounds are slow acting.  <b>Route of Activity:</b> Ingestion, translaminar activity (Oberon); and Xylem-Phloem systemic activity (Movento) via foliar applications.  <b>Spectrum of Activity:</b> Excellent selective activity against aphids (Movento) and whiteflies (Oberon and Movento)</p>			
28		<i>Ryanodine receptor modulators</i>	<b>chlorantraniliprole (Coragen, Durivo, Besiege) cyantraniliprole (Verimark, Exirel, Minecto Pro) cyclaniliprole (Harvanta)</b>
<p><b>Toxic Activity:</b> Neurotoxic  <b>Mode of Action:</b> These compounds are from the new diamide chemical class where the primary site of action of the compounds is the ryanodine receptor. The chemical action at these receptors causes prolonged activation of intercellular calcium channels, leading to overflow of calcium into muscle fibers that can result in sustained contraction of skeletal muscle, subsequent muscle paralysis and almost immediate cessation of feeding. Compounds can be slow acting.  <b>Route of Activity:</b> Activity is primarily through ingestion via soil, systemic applications (Durivo Coragen, Verimark) or translaminar ingestion action via foliar sprays (Coragen, Besiege, Exirel, Minecto Pro, Harvanta). Most have limited contact activity.  <b>Spectrum of Activity:</b> Selective activity against most Lepidopterous larvae, <i>Liriomyza</i> leafminers and whiteflies.</p>			

29		<i>Chordotonal organ modulators</i>	<b>Beleaf (flonicamid)</b>
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> Acts by disrupting the function of chordotonal stretch receptor organs, which can disrupt feeding and other behaviors in sucking insects. This MOA is different from Group 9, as they do not bind to the Nan-lav TRPV channel complex.</p> <p><b>Route of Activity:</b> Primarily activity through ingestion via translaminar uptake following foliar sprays</p> <p><b>Spectrum of Activity:</b> Effective against most aphid species and lygus bug; marginally active against whiteflies.</p>			
UN		<i>Unknown MOA</i>	<b>Azadirachtin (Aza-Direct, Azetra,</b>
<p><b>Toxic Activity:</b> IGR, repellent, anti-feedant</p> <p><b>Mode of Action:</b> Unknown</p> <p><b>Route of Activity:</b> Primarily activity through ingestion; potential contact activity</p> <p><b>Spectrum of Activity:</b> Activity against most aphid species and thrips; marginal activity against Leps</p>			

<sup>1</sup> Insecticide Resistance Action Committee (IRAC) modes of action groups; for more information on IRAC, insecticide modes of action and resistance management go to: <http://www.irac-online.org/>