

# Insecticide Modes of Action on Desert Produce and Melon Crops

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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
<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 via foliar applications; 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>			
2	A	<i>Cyclodienes &amp; organochlorines</i>	Endosulfan, Thionex
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> <i>GABA-gated Chloride Channel Antagonists</i>. These compounds block chloride channels that depress the excitability of nerve tissue. Endosulfan toxicity occurs by blocking the chloride channels associated with <i>GABAergic</i> synapses which decreases the activity of these inhibitory inputs into the nervous system causing strong tremors and convulsions.</p> <p><b>Route of Activity:</b> Contact activity via foliar applications, short residual</p> <p><b>Spectrum of Activity:</b> Broad spectrum activity against a wide range of pests, but depends particularly effective against adult whiteflies and some aphid species. <b>Note: This class of chemistry is no longer available for use in Produce and Melons</b></p>			
3		<i>Pyrethroids, Pyrethrins</i>	Asana, Baythroid, Ambush, Brigade, Mustang Max, Warrior ( <i>Voliam xpress</i> ), 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</p> <p><b>Spectrum of Activity:</b> Broad spectrum knockdown activity, particularly effective on adult life-stages.</p>			
4	A	<i>Neonicotinoids</i>	Admire Pro, Alias ( <i>other generics</i> ), Platinum ( <i>Durivo</i> ), Actara ( <i>Voliam flexi</i> ), 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>	<i>Closer (sulfoxaflor)</i> <b>(currently pending registration)</b>
<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 aphids species and Lygus bugs. Efficacy against adult and immature stages of whiteflies varies with rate. Marginal activity against Bagrada bug</p>			

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5		<i>Spinosyns</i>	Success, Entrust, Radiant
<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, leafminers and western flower thrips</p>			
6		<i>Avermectins</i>	Agri-Mek ( <i>generics</i> ), Proclaim
<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 <i>nAChRs</i> 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), leafminers and thrips (Agri-Mek)</p>			
7	C	<i>Juvenile Hormone Mimics</i>	Knack
<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 when present during later molts, they may cause developmental problems by maintaining the immature form after the molt. Various negative effects on insect reproduction also have been reported including decreased fecundity, decreased oviposition, or developmental abnormalities in embryos (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	<i>Selective Homopteran feeding blockers</i>	Fulfill
	C		Beleaf
<p><b>Toxic Activity:</b> Neurotoxic</p> <p><b>Mode of Action:</b> Feeding inhibition in insects intoxicated by Fulfill is thought to be related to binding at the <i>ACh</i> site of some <i>nAChRs</i>, that is different from that of the neonicotinoids or spinosad. Feeding inhibition in insects intoxicated by Beleaf occurs by blocking the action of A-type potassium channels at pre-synaptic sites on nerve cells leading to uncontrolled release of acetylcholine into nerve synapses and overall loss of nervous control by 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 (Fulfill), aphids (Fulfill and Beleaf) and lygus bugs (Beleaf)</p>			
11	B	Microbial disruptors of insect midgut membranes	Xentari, DiPel, Javelin, other Bt products
<p><b>Toxic Activity:</b> Feeding disruption</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, or varieties, of Bt produce slightly 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, cabbage loopers, corn earworm)</p>			
16		<i>Inhibitors of Chitin Biosynthesis, Type I</i>	Courier, Vetica
<p><b>Toxic Activity:</b> Insect Growth Regulator</p> <p><b>Mode of Action:</b> Chitin is one of the main structural components of the insect exoskeleton. These compounds inhibit 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 vapor phase inhalation following foliar applications.</p> <p><b>Spectrum of Activity:</b> Type I inhibitors are active against whiteflies</p>			

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17		<i>Molting Disruptors</i>	Trigard
<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>	Intrepid
<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>	Torac (tolfenpyrad) <i>(currently pending registration)</i>
<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> Good-fair broad-spectrum activity against many key pest; particularly effective on thrips species.</p>			
22	A	<i>Voltage-dependent Sodium Channel Blockers</i>	Avaunt
<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>	Oberon, Movento
<p><b>Toxic Activity:</b> Lipid synthesis, Growth regulation  <b>Mode of Action:</b> These compounds are from the new cyclic ketoenol or tetroneic acid 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>	Rynaxypyr - Coragen, Durivo, Voliam Xpress, Synapse, Vetica Cyazypyr – Verimark, Exirel <i>(currently pending registration)</i>
<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, Voliam Xpress, Synapse, Vetica, Exirel). Most compounds have limited contact activity.  <b>Spectrum of Activity:</b> Selective activity against most Lepidopterous larvae, leafminers (Rynaxypyr/Cyazypyr) and whiteflies (Cyazypyr).</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/>