INSECTICIDE BASICS–101

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People and insects have more in common than you might think. Insects need to breath oxygen, convert food to energy and regulate their movement and body functions with a nervous system that is very similar to ours. It should come as no surprise the chemicals that kill insects by asphyxiation, stopping energy production or affecting nerves can be toxic to humans. Insecticides can function as stomach poisons, contact and residual contact poisons, and as gasses that are taking in during respiration (fumigants). For contact insecticides it helps to be lipo-philic (fat loving).Insects adsorb these liphilic compounds through their skin. Understanding how insecticides work is important to help select products that are less toxic and also prevent or slow down the development of insecticide resistance in insect populations.

Insecticides are defined as products that kill an insect. These products can be classified by chemical family, how they kill, or by their mode of action. The mode of action (MoA) is the "how and where" a product works. Chemicals may be unrelated but if they have the same mode of action, both can become ineffective when resistance develops. Since over 90% of the insecticides affect the nervous system, it is helpful to have some understanding of the how nerves work. In simple terms, nerves are composed of axons, neurotransmitters, and receptors. In order to transmit a message, an electrical signal or pulse must travel down the axon, release a neurotransmitter which travels across the synaptic cleft and attaches to a receptor on another nerve or muscle. These receptors can be stimulated or can be made less sensitive. There are also enzymes that degrade the neurotransmitters after they have completed their job. Without these enzymes, nerves would be stimulated continuously.

An analogy is to think of the axon as an arm, the neurotransmitter as a ball, and the receptor as baseball gloves. To get an impulse to travel you must throw the ball and capture it in the glove. Insecticides can prevent the arm (axons) from working-or close the baseball glove (tie up the receptors). The enzymes that breakdown the neuro-transmitters are the clean-up crew that pick up all of the "balls" when they have completed their job.

The sensitivity and type of receptors and neurotransmitters do differ in different parts of the body and in different animals. Neurotransmitters found in humans include acetylcholine, dopamine, serotonin, GABA and epinephrine. Insects can utilize different neurotransmitters or receptors than humans. It is like using different types of balls and gloves. If we can exploit the differences between humans and insects we can develop more selective and less toxic products. Much of the new chemistry has gone this direction, but it has also resulted in products that selectively kill only certain types of insects.

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Insects do have a number of biological properties that are different from us. They must molt their skin in order to grow. Many orders of insects including true flies, beetles and moths must transform from a worm-like larval stage to an adult creature that does not look like or behave like the immature. Insects control their development with unique hormones such as juvenile hormone (JH) or ecdysone. As with any animal, if we can disrupt the hormone system we can cause major problems and often kill or sterilize the insect. Insect skin is made from a plastic-like product called chitin which is unique to arthropods. Chemicals that prevent insects from making chitin will kill the insect yet are relatively non-toxic to other animals and humans.

In all 28 main groups or primary modes of action, sites have been identified in mites and insects. Some of these are specialized products and have not been developed for broad scale agricultural uses. The Insecticide Resistance Action Committee (IRAC)-Insecticide Mode of Action Classification has been developed to provide farmers, growers, consultants, and other crop protection professionals with a guide to select insecticides and acaricides for use in an effective and sustainable resistance management strategy. By rotating to different groups, you delay or prevent resistance problems.

Insecticides That Affect the Nervous System

Group 1 Acetylcholine enzyme inhibitors
- Organophospates (66 active ingredients, ai), carbamates (25 ai)

Group 2 GABA chloride channel antagonist
- Cyclodienes (3 ai), fiproles (2 ai)

Group 3 Sodium channel modulators
- DDT, Synthetic pyrethroids (46 ai), pyrethrin

Group 4 Nicotonic ACH Receptors agonist/antagonists
- Neonictinoids (cloronicotinyls) (7 ai)

Group 5 Nicotonic ACH receptors modulators
- Spinosyns

Group 6 Chlorine channel activators
- Avermectins (3 ai), mibemycins,

Group 22 Voltage dependend sodium channels
- Indoxacarb (Avaunt)

Hormonal Products That Affect Molting and Development

Group 18 Ecdysone agonist
- Tubufenozide, Azadiractin

Group 7 Juvenile Hornome mimics
- Fenoxycarb, methoprene (Flea products)

Cuticle (Skin/Chitin Synthesis)

Groups 15,16,17
- Benzoylurea(Lepidotera) , Buporfenzin(Homoptera)
- Cryomazine (Diptera)

Digestion

Group 11 Microbial disruptors of insect mid-gut
- Toxins of Bacillus thuringiensis-and Cry proteins

Metabolic Process (mostly baits)
Group 12 Inhibitors of oxidative phsophorylation
    Diafenthiuon and organotin miticides
Group 13 Uncouplers of oxidative phsophorylation
    Chlorfenapyr (Pylon), DNOC
Group 20 Site 11 electron transport inhibitors
    Hyramethylon and Dicofol
Group 21 Site l electron transport inhibitors
    Rotenone, METI acaracides
Insecticidal SOAPS
    Fatty acids that affect permeability and structure of cell membrane- contact only
Oils
    Act by asphyxiation (block spriacles)
    plus essential plant oils can act as poisons by affecting fatty acids and interfering with metabolism

The IRAC Insecticide Mode of Action Classification can be found at **http://www.irac-online.org/resources/guide.asp**

Resistance can develop in a number of ways. Target site resistance refers to biochemical changes that make a site less sensitive to a chemical. Non target site resistance refers to enzymes or other factors which prevent chemical from getting to the target site. Examples would be: insecticides no longer penetrate the insect skin, or insecticides that are broken down by enzymes before they get to the nerve. Behavioral resistance is also possible. An example would be cockroaches becoming repelled by sugar as a pesticide bait mix – if they do not eat, it cannot kill them. Other factors such as soil degradation also affect how chemicals work