K-STATE Research and Extension

Insect Growth Regulators

for Use in Greenhouses

Insect growth regulators are compounds that mimic the action of hormones to disrupt the molting process and modify growth of insect or mite pests. They do not kill insects directly, but interfere with normal development so insects die before they mature. Death occurs in 3 to 14 days depending on the product, target pest, and life stage. Insect growth regulators decrease populations over time. Some cause insects to stop feeding. Others affect egg, larval, nymphal, or pupal development. They inhibit metamorphosis and may negatively affect reproduction and egg viability. Insect growth regulators are primarily used to kill immature stages of plant-feeding insects, including caterpillars, fungus gnats (Figure 1), leafminers, mealybugs (Figure 2), scales (Figure 3), shoreflies, thrips (Figure 4), and whiteflies (Figure 5). Application timing is important. Products have a brief period of residual activity, and exposure to ultraviolet light can affect longevity, so repeat applications usually are warranted.

Insect growth regulators are most active on the early life stages of insects that undergo complete metamorphosis (egg, larva, pupa, and adult). They should be applied as soon as susceptible life stage(s) are noticed, thoroughly covering all plant parts. Population regulation may take longer when generations overlap. Because of their specificity, these products are less harmful to natural enemies such as parasitoids and predators than conventional broad-spectrum insecticides.

Insect Physiology

To understand how insect growth regulators work, it is important to understand some basic insect physiology.

Figure 1. Fungus gnat larvae.

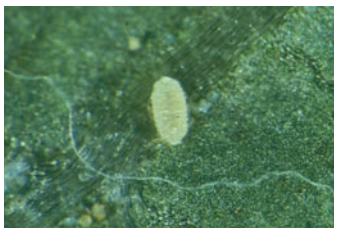

Figure 2. Mealybug crawler.

Figure 3. Scales.

Figure 4. Thrips nymph.

Figure 5. Whiteflies.

Insect growth and development is regulated by hormones. Produced by glands, hormones are chemical substances transported in the insect's body fluid (hemolymph) that influence physiological processes. Levels of the two main growth hormones, ecdysone and juvenile hormone, fluctuate countercyclically. Ecdysone regulates when the insect will molt, and juvenile hormone determines whether a pest will molt into a larger juvenile form or progress to the next stage. The absence of juvenile hormone initiates metamorphosis into the adult stage.

Ecdysone is secreted by the prothoracic glands located at the back of the insect's head, or thorax. It is the precursor to the major insect molting hormone 20-hydroxyecdysone (ecdysterone or 20E) and also plays a role in reproduction. When an insect is ready to molt, prothoracic glands release ecdysone, which is converted to 20E. An increase in this hormone begins the molting process that enables the insect to cast off its exoskeleton and build a new one.

Classification of Insect Growth Regulators

Insect growth regulators fall into three categories based on mode of action: 1) juvenile hormone mimics, or analogs, (agonists); 2) ecdysone antagonists; and 3) chitin synthesis inhibitors. Juvenile hormone analogs arrest development and cause insects to remain in an immature stage, preventing them from completing their life cycle. Ecdysone antagonists disrupt molting by inhibiting metabolism of the molting hormone, ecdysone. Chitin synthesis inhibitors interfere with enzymes that stimulate the synthesis and formation of chitin, which is an essential component of the exoskeleton. Without chitin, insect pests die in the immature stage or mature into sterile male or female adults.

Table 1. Commercially available insect growth regulators labeled for use in greenhouse production systems including common name (active ingredient), trade name, and mode of action.

Common Name	Trade Name(s)	Mode of Action
Fenoxycarb	Preclude	Juvenile Hormone Mimic
Kinoprene	Enstar II/AQ	Juvenile Hormone Mimic
Pyriproxyfen	Distance	Juvenile Hormone Mimic
Buprofezin	Talus	Chitin Synthesis Inhibitor
Cyromazine	Citation	Chitin Synthesis Inhibitor
Diflubenzuron	Adept	Chitin Synthesis Inhibitor
Etoxazole	TetraSan	Chitin Synthesis Inhibitor
Novaluron	Pedestal	Chitin Synthesis Inhibitor
Azadirachtin	Azatin, Ornazin, Molt-X*	Ecdysone Antagonist

* Additional trade names include: AzaGuard, Azatrol, Aza-Direct, and AzaSol.

Chitin synthesis inhibitors differ in effects on target pests. Diflubenzuron directly inhibits production of chitin, a protein-like compound responsible for the strength and resilience of the exocuticle (middle layer of cuticle). Buprofezin keeps 20E levels from declining during initial molting. When 20E levels are high, the old cuticle (skin) is not digested and the new cuticle fails to develop. Cyromazine causes the cuticle to become abnormally hard, decreasing elasticity and reducing the insect's ability to move and feed. A mite growth regulator, etoxazole, is also classified as a chitin synthesis inhibitor. Etoxazole inhibits molting during mite development. It is active on the eggs, larvae, and nymphs but has no direct effect on adult mites. Table 1 presents commercially available insect growth regulators in each category.

Side Effects of Insect Growth Regulators

Although insect growth regulators act on the young stages of insect pests, they may affect adults indirectly by suppressing reproduction (i.e., by inhibiting the formation of ovaries in the adult female and reducing egg viability). Applicators should read product labels to determine which ones affect adults. Such products are advantageous because suppression of adult female reproduction is an important long-term pest management strategy. It decreases the number of generations that occur during a cropping cycle so fewer insecticide applications are needed. Benefits include reduced insecticide and labor costs, less potential for insecticide resistance, and limiting workers' exposure to residues.

Summary

Insect growth regulators are a diverse group of compounds that can be classified into three distinct categories based on mode of action: juvenile hormone mimics, ecdysone antagonists, and chitin synthesis inhibitors. Application timing is important because susceptible life stage(s) must be present for these products to effectively regulate insect pest populations. Insect growth regulators should be applied early in the crop production cycle or when insect pests are first detected. They are less effective when insect pest generations overlap and different life stages are present. Insect growth regulators are effective in regulating populations of many types of insect and mite pests in greenhouse production systems and may reduce the number of individuals in future generations. Because of their broad activity, these products should be incorporated into insecticide rotation programs to delay the development of resistance.

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