

**STEWARD™ DISPERSION AND COTTON  
LEAF INTERACTIONS: IMPACT ON  
COTTON INSECT PESTS AND SAFETY TO  
BENEFICIAL ARTHROPODS**

**John T. Andaloro, Keith D. Wing,  
John H. Green and Edward B. Lang  
DuPont Agricultural Products  
Stine Res. Center  
Newark, DE**

**Abstract**

Steward™ 15SC is a new cotton oxadiazine insecticide from DuPont. It is a potent sodium channel blocker with a novel mode of action. Steward™ controls all major worms, tarnished plant bug, and fleahoppers at 0.09-0.11 lbs ai/a, mainly through ingestion and direct spray contact. Steward™ is neither soluble nor systemic. However, due to its lipophilicity and seed oil-based formulation, Steward™ disperses well over leaf surfaces and penetrates into the leaf's waxy cuticle optimizing control of certain sucking insects and providing rainfastness and good residual activity. The behavior of Steward™ alone and in tank-mixes in the application process and their interactions with the cotton leaf are being investigated; particularly as they apply to droplet flight, evaporation, droplet impact, leaf spreading, retention, leaf penetration, and residual. In addition to causing neural toxic effects, Steward™ is an effective antifeedant, providing quick crop protection despite the delay in insect mortality. The major mode of indoxacarb entry into the insect pest is through ingestion, followed by direct spray contact with exposure to a dried residual being the least effective. These differences in toxicity, based on the various modes of entry, allow Steward™ to exhibit differential selectivity against herbivorous vs insectivorous (predators/parasites) arthropods. This selective activity of Steward™ allows the conservation of beneficials in a commercial cotton ecosystem. In addition, Steward's safety to workers and the environment, consistent and reliable efficacy, low use rate, and unique mode of action make Steward™ an excellent fit in cotton IPM programs and a prudent choice to alternate, replace, or complement existing insecticide chemistries.

**Introduction**

Steward™ is a new cotton insecticide from the DuPont Company granted the status of reduced risk by the EPA. The product is on an accelerated registration timeline. Registrations on numerous crops have already occurred in a number of countries outside the United States. The active ingredient, indoxacarb, represents the novel insecticide chemical class oxadiazines and a different mode of action.

Indoxacarb is active at a biochemical site on the insect's nervous system blocking the flow of sodium ions. Indoxacarb is extremely potent on its biochemical target resulting in low field use rates (0.09-0.11 lbs ai/a) and excellent safety to workers and consumers. Indoxacarb is characterized by having low volatility, low solubility, and high lipophilicity. Indoxacarb is not systemic, and has moderate translaminar activity.

**Discussion**

Steward™ is a 15% suspension concentrate with the active ingredient suspended in seed oil. This formulation enhances dispersion and retention on the cotton leaf surface aiding in maximizing leaf penetration, which results in effective residual activity and rainfastness. Tank-mixing adjuvants (wettors, spreaders) are not required nor labeled. However, certain trials have indicated that under certain conditions the addition of surfactants may improve rainfastness, increase residual on treated leaves, increase speed of kill and improve contact activity of lepidopteran pests with dried residual on the leaf. The impact of surfactants to enhance activity is being evaluated, particularly in aerial applications.

Steward™ is compatible with commercial cotton pesticides, plant growth regulators and foliar fertilizers. However, as with other commercial insecticides a recommended mixing sequence is mandatory to achieve optimal tank dispersion and suspension, application and biological performance. The following order is recommended when tank mixing Steward™ with other products. Even though Steward™ is a liquid suspension concentrate it is recommended to be tank mixed in the same order as an EC due to the amount of oil in the formulation.

1. water soluble bags
2. water dispersible granules
3. wettable powders
4. liquid flowables
5. soluble concentrates
6. emulsifiable concentrates (Steward™ 15% SC)
7. surfactants, oils, adjuvants
8. soluble fertilizers
9. anti drift agents

The behavior of Steward™ alone and in tank-mixes in the application process and their interactions with the cotton leaf are being investigated; particularly as they apply to droplet flight, evaporation, droplet impact, leaf spreading, retention, leaf penetration, and residual. Understanding the relationship between formulation and application technology becomes more complicated when varying application modes and equipment and spray volumes are considered.

Steward™, mainly due to its oil-based formulation, is believed to be able to move across cell membranes into the waxy cuticle and between epidermal and palisade cells. The rate of leaf uptake is yet undefined but significant amounts slowly penetrate the leaf over time. This becomes highly advantageous for aiding in the control of sucking insects such as tarnished plant bug, *Lygus lineolaris*, leafhoppers and fleahoppers. Leaf partitioning is also conducive for defending against weathering, increasing rainfastness, and overall extension of residual in the leaf. The residual activity of Steward™ treated cotton leaves, squares and bolls at labeled rates appears to be about 7 days depending on the insect pest, population pressure, application and environmental conditions.

Insects exposed to Steward™ stop feeding within a few hours, become less mobile, and may show slight tremors and convulsions. Affected insects may stay alive for up to 48 hours depending on rate and susceptibility of the insect. The prolegs and posterior of the insect become paralyzed. Generally, the ability to diagnose a dying insect soon after application may be difficult since they remain still. However, within 24 hours after intoxication, insects appear smaller, shrunken, moribund, and severely desiccated. Some of these symptoms are a result of impairment to the sodium channel but also due to the cessation of feeding. Steward's strong antifeedant characteristic is a major component of its crop protection capability. Although it may take from 24 to 48 hours for the insect to die, feeding is negligible. In lab/field trials where field treated leaves are excised and assayed against tobacco budworm, beet armyworm, cabbage looper, and cotton bollworm larvae, minimal feeding often occurs even at sublethal rates.

The major mode of indoxacarb entry into the insect pest causing intoxication is through ingestion, followed by direct spray contact with exposure to a dried residual being the least effective. Indoxacarb is also ovilarvicidal on lepidoptera. When ingested, the LC50 range for indoxacarb on most third instar lepidopteran larval pests, ranges from about 0.2 to 2 ppm at 5 days post application. When insects are sprayed directly and then fed untreated leaves, the LC50 rises to about 2 to 10 ppm at 2-5 days post application. When larvae are allowed to walk over a dried residual film for an hour without feeding and then transferred to untreated leaf material and evaluated 5 days later, the LC50 is generally well over 100 ppm.

These differences in toxicity, based on the various modes of entry, allow Steward™ to exhibit differential selectivity against herbivorous vs insectivorous (parasites and predators) arthropods. In addition lepidopteran larvae have exhibited a much higher capacity and efficiency in bioactivating indoxacarb to its active metabolite compared to other insects. The bioactivated molecule is what allows indoxacarb to be

neuroactive. The foraging behavior of most predators and parasites exposes them only to dried residues of Steward™ thus providing a high level of safety. Beneficial arthropods are most vulnerable if they directly contact the spray and if some aspect of their behavior results in ingestion of the product: i.e., tarsal and antennal cleaning or occasional probing of leaves in the absence of prey (by hemipteran predators). However, toxicity to insects even in these instances may not occur if they are unable to efficiently bioactivate the compound.

The selective activity of Steward™ allows the conservation of beneficials in a commercial cotton ecosystem. In addition, Steward's safety to workers and the environment, consistent and reliable efficacy, low use rate, and unique mode of action make Steward™ an excellent fit in cotton IPM programs and a prudent choice to alternate, replace, or complement existing insecticide chemistries.