

GEMSTAR® LC BIOLOGICAL INSECTICIDE FOR BOLLWORM AND TOBACCO BUDWORM

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Abstract

A new bioinsecticide, GemStar LC, is based on an insect-specific baculovirus which causes a lethal infection in bollworm and tobacco budworm larvae. It is produced by Thermo Trilogy Corporation (which purchased this and other biopesticide product lines from biosys, Inc. in January 1997), and became commercially available in 1996. It provides a safe and effective means of controlling young larvae without disrupting natural control of cotton pests by natural enemies. Recommendations are given for using GemStar LC in management of cotton pests.

Introduction

GemStar LC is a new liquid concentrate biological insecticide for management of *Heliothis* and *Helicoverpa* species on cotton and other crops. The active ingredient, *Helicoverpa zea* nuclear polyhedrosis virus (HzNPV), is a naturally-occurring pathogen of the cotton bollworm. This baculovirus has been studied intently by insect pathologists for over 60 years and appeared in several commercial formulations (notably Elcar® from Sandoz) in the 1970's and early 1980's (Ignoffo, 1973; Ignoffo and Couch, 1981). HzNPV is specific to caterpillars in the genera *Heliothis* and *Helicoverpa*, with no effects on other insects or on nontarget organisms such as fish, birds, and mammals. HzNPV is exempt from EPA residue tolerance, and GemStar LC carries the minimum 4 hour reentry interval. It is currently labeled for use in most cotton-growing states and is distributed in the USA exclusively by Helena Chemical Company. It is expected to become available in Mexico and Australia in 1997.

Structure and Mode of Action

The mode of action of GemStar involves infection and replication of a living pathogen, resulting in a fatal disease in the target pest. The infectious virus particles (virions) in GemStar are naturally microencapsulated in proteinaceous occlusion bodies (OB's), about 1 or 2 microns in diameter. The OB protects the virus from degradation by harsh environmental conditions and serves as the vehicle for transmission of the disease from one larva to the next or between larval generations. Upon ingestion by a host larva, OB's dissolve rapidly within the alkaline midgut, releasing virions which penetrate the nuclei of the midgut cells and begin to replicate. The progeny virus

from this initial round of replication enter the bloodstream of the larva, causing massive infection of nearly all major organs. At this stage the infected larvae become sluggish and stop feeding. As the infected insect dies (3 to 5 days after infection), its internal organs disintegrate into liquid containing billions of OB's. Virus-killed larvae can often be recognized by their characteristic head-down or inverted V posture. The fragile integument of the cadaver is easily ruptured, releasing OB's to contaminate surrounding plant material and infect other larvae.

Production and Quality Control

GemStar LC is manufactured by infecting bollworm larvae with HzNPV under controlled conditions of mass rearing. Virus-killed larvae are harvested and processed into an aqueous slurry rich in OB's. Formulated GemStar LC contains 200 billion OB's per liter, or 0.64% a.i. by weight. Each batch of GemStar LC is subjected to rigorous Quality Control testing before it is released for distribution. Microscopic OB counts, and standard plating assays are used to ensure that the product contains the required OB concentration, is potent against *H. zea*, and does not contain excessive load of microorganisms that might cause spoilage or inactivate the virus. A sample from each batch is also tested for the presence of mammalian pathogens by injection into laboratory mice.

Efficacy

GemStar LC has been tested extensively since 1994 on cotton and vegetable crops in the USA, Mexico, and Australia. The results from cotton trials have demonstrated effective control of *Heliothis* and *Helicoverpa* comparable to or exceeding levels achieved with *Bacillus thuringiensis* products, and in some cases also outperforming chemical insecticides, particularly in areas where resistance is common (Table 1).

Recommendations for Use

GemStar LC should be applied at 10 fl. oz. per acre (750 ml per hectare), by ground sprayer or airplane (either conventional or ultra-low volume). It is equally effective against bollworm and tobacco budworm. One 2.5 gallon container is sufficient to treat 30 to 40 acres of cotton, at an end user price of approximately \$7 per acre depending on the total area treated. Because the virus must be ingested by larvae to be effective, thorough coverage is essential and the inclusion of a spreader-sticker or similar surfactant in the spray mix is likely to enhance the results. Like Bt's, the virus is more effective against small larvae than large larvae. Large larvae infected with the virus may cause significant crop damage before they stop feeding. Therefore, GemStar is best applied against newly-hatched larvae (less than ¼ inch in length) and should not be used as a rescue treatment against an established infestation of mature larvae. Similarly, virus-infected larvae may still

cause damage to fruiting structures before the disease causes them to stop feeding. For this reason, GemStar is most appropriately used on cotton prior to flowering.

A GemStar LC application is relatively short-lived on cotton in the field (1 or 2 days residual activity) due primarily to inactivation of the virus by solar UV radiation. Repeated applications therefore may be necessary under sustained periods of egg lay. Efforts are currently underway to develop improved formulations of GemStar and other viral insecticides with longer residual activity. However, each infected larva becomes in essence a factory producing billions of new virus particles, so a single, well-timed application of virus may have a lasting effect not directly related to persistence of spray residue on the crop.

GemStar LC and Management of Cotton Pests

Because of its host specificity, GemStar does not harm the beneficial insects that can provide significant levels of natural control of early-season pests in cotton. Alone or in a tank mix with ovicidal rates of chemical insecticides such as thiodicarb, GemStar provides control equal to or better than that of conventional Bt products used in similar fashion and thus provides an additional tool for early-season management of bollworms and tobacco budworms with minimal danger of inducing secondary pest outbreaks.

Virus outbreaks are common in field populations of many Lepidoptera late in the growing season, often too late to provide economic benefit. GemStar should be used with the goal of shifting this disease outbreak to a point earlier in the season when it can play a more significant role in crop protection. An example of successful manipulation of HzNPV epizootiology already exists in US cotton. Areawide suppression of *H. zea* and *H. virescens* has been conducted since 1990 by USDA-ARS in the Mississippi Delta by aerial ULV application of a low rate of HzNPV to weed hosts in the Spring. Normally, these wild host serve as incubators of large flights of moths that lay their eggs in neighboring cotton fields. Broadcast application of the virus over thousands of acres has resulted in high incidence of disease in the spring generation of larvae developing on the wild hosts, leading to fewer moths migrating into the new cotton crop and thereby reducing the need for early season insecticide applications. (Bell and Hayes, 1994; Hardee and Bell, 1996; see also Streett et al., in these proceedings). GemStar LC was used to treat 50,000 acres at one-third the recommended cotton rate under this program in May 1996. GemStar LC applied at full rate on cotton at pinhead square, as a follow-up to the Spring areawide program, is being examined by USDA-ARS as perhaps the optimal strategy for early-season management of bollworm and tobacco budworm in areas where preservation of beneficial insects and resistance management are prime concerns.

Because of its unique mode of action, GemStar is a valuable tool for insecticide resistance management, as either a tank-mix partner or a rotation option. Insects resistant to chemical insecticides are still susceptible to virus infection, and viral insecticides have succeeded where chemical insecticides have been rendered ineffective by resistant pests (Fig. 1). Although insect populations may vary in susceptibility to viruses (ref), and low levels of resistance to some have been induced through laboratory selection, the baculovirus is living pathogen that has coevolved with its host, and can itself be selected for enhanced virulence toward a non-permissive or resistant host strain.

GemStar and is the only microbial insecticide currently approved in the US for use against bollworm and tobacco budworm on transgenic Bt cotton or on conventional cotton grown under the 25% refuge option. GemStar is equally effective against bollworm and tobacco budworm and therefore can be a useful tool for management of bollworm outbreaks as occurred on Bt cotton in some areas in 1996. Due to its safety toward beneficial insects, GemStar can be used without flaring secondary pests, helping to maintain the value of Bt cotton in overall IPM (particularly in areas where eradication of the boll weevil has eliminated or reduced the use of chemical insecticides that preclude reliance on natural enemies to hold other pests in check).

References

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Table 1. Summary of GemStar LC performance trials in US cotton (1994). Number of applications varied from 1 to 3 (although all treatments within a trial were applied with the same frequency). Percent control relative to untreated check, based on counts of larvae.

Location	Percent Control		
	GemStar LC*	Bt [†]	Pyrethroid [‡]
<i>Heliothis virescens</i> :			
Alabama	70	-	17
Alabama	31	21	43
Louisiana	48	-	40
Texas	43-60	-	3-22
<i>Helicoverpa zea</i> :			
Arkansas	58	-	66
North Carolina	46-53	22-49	83-87
Georgia	64	-	71
Texas	43	-	3
Louisiana	36	-	82

*10 fl. oz. (300 ml) per acre. [†]Applied at cooperator's standard label rates.

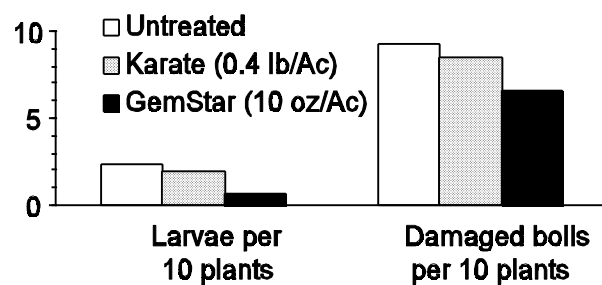


Figure 1. Performance of GemStar LC against pyrethroid-resistant *Heliothis virescens* on cotton in Prattville, Alabama in 1995. Applications were made Aug. 28 and Sep. 2, and plots were evaluated Sep. 9. Columns within a group bearing the same letter represent means that are not significantly different ($P > 0.1$).