Heliothis Nuclear Polyhedrosis Virus for Bollworm Control

R.E. Teakle,
Entomology Branch,
Department of Primary Industries,
Indooroopilly, Queensland 4068.

Introduction

Heliothis armigera and Heliothis punctigera are the key insect pests on cotton in Australia and measures to control them are vitally important in cotton management. The computer-based management program for cotton, SIRATAC (Hearn et al., 1981) makes recommendations on the basis of regular and systematic monitoring of both pest and beneficial species on the crop and recommendations are designed to conserve the often considerable level of natural control present, where possible. In a precursor program named FLY, a commercial formulation of a virus imported from the United States, Elcar™, (Shieh, 1978) was used as the first option for controlling Heliothis species on cotton. In the first two season's trials, yields were maintained with fewer pesticide applications than in the conventionally managed cotton (Room, 1979). However, later results were not encouraging, but the reasons for the inconsistent performance of the virus insecticide were not established. Possibly, unfavourable comparison with the new synthetic pyrethroids at the time was involved. Elcar was provisionally removed as a pesticide option from the SIRATAC program in 1980-81, and production was recently discontinued owing to insufficient demand in the United States. Experience there had indicated that it was most effective against low or moderate infestations (Yearian et al., 1980).

An Australian firm, Biocontrol Ltd, based at Warwick, Queensland, is now preparing to produce an improved formulation of the virus for use on cotton, sorghum and grain legumes. Resistance to the synthetic pyrethroids and endosulfan has been recorded in Heliothis armigera (Gunning et al ., 1984), and no clear alternatives to these are in sight. In view of the threat posed by resistance and the proposed release of the new formulation, it is timely to reconsider the possible role of the virus in Heliothis control on cotton. SIRATAC Ltd has now accumulated data representing a considerable body of experience, and quantitative relationships between the virus and the Australian Heliothis hosts are now better understood (Teakle, 1986).

Characteristics of the Virus

Heliothis NPV is infective only for larvae of Heliothis species. Natural epizootics are observed in Australia on sorghum, lucerne and peanuts, where Heliothis control is not as rigorous as on cotton, and can also occur on unsprayed, experimental cotton (Wilson and Greenup, 1977). The infected larvae tend to move to the top of plants to die, after which they darken and flatten onto the plant substrate or hang vertically by abdominal legs. The newly dead larvae are typically soft and "squashy" and fragile. The skin ruptures readily releasing virus-laden body contents. The disease spreads to other Heliothis larvae which consume contaminated plant material or cannibalise the cadavers.

The virus was the first to gain registration as an insecticide and is notable for its virulence, safety and specificity, and relative ease of production and storage. It is produced commercially in infected, laboratory-reared Heliothis larvae (Ignoffo, 1973).

Factors which influence the efficacy of an NPV application

These include:
(i) the initial activity of the virus preparation,
(ii) its rate of application and distribution on the crop,
(iii) its persistence on the crop,
and (iv) the susceptibility of the target larvae.

Initial activity

The activity of the virus preparation is standardized by the manufacturer by bioassay using laboratory-reared Heliothis larvae. Its activity after storage depends on the storage temperature. If the material is stored under refrigeration (7°C) it should remain stable for at least two years. It degrades slowly at normal environmental temperatures and virus stored for long periods under these conditions should be reassayed for potency.

The virus would be quite thermostable during short-term storage on the farm and handling and application in the field (Teakle, 1986).

Rate of application

Calibration to determine dose-mortality responses on the crop is required in order to avoid waste through the use of unnecessarily high rates and the use of rates which are inadequate to achieve effective control.

The decision on the level of kill desired will depend on the farmer's objective:

either (a) to protect the first crop of bolls and thereby reduce the overall growing period and associated risks due to pests or weather,

or (b) to accept the loss to insect damage of a proportion of bolls which would be shed anyway, and to budget for compensation by the plant.

Distribution of the virus

The requirement for ingestion of the virus by larvae means that it must be uniformly distributed on the crop. Failure could be the result of this not being achieved, and also inappropriate timing (see later).

Persistence on the crop

The main cause of loss of activity of the virus is exposure to sunlight. The half-life in exposed locations is normally about 1 to 2 days, but this should be extended for the new Biocontrol Ltd formulation, which includes a sunscreen. Application in the late afternoon or evening is considered desirable. Treatment of shaded parts of the plants will also extend the "life" of the virus, and this may be achieved electrostatically by equipment such as the Electrodyne.

Susceptibility of target larvae

This depends on the inherent susceptibility and rate of virus acquisition of the larvae. Inherent susceptibility is influenced by the age of the larvae, and decreases about 150-fold during the first week of larval life (Teakle et al., 1985, 1986). However, this can be largely counteracted by the increase in feeding rate as the larvae increase in size. Large larvae are, however, virtually immune to the virus.

Larval feeding behaviour is also critical on cotton. Newly-hatched larvae tend to feed on the surface of the plant, whereas larger larvae tend to burrow in and feed in structures such as terminals, squares or bolls. In this event, the larvae acquire virus only during entry and exit. Baits included with the virus can increase mortality by encouraging the larvae to feed on exposed surfaces such as on foliage.

Secondary spread

One advantage of the virus disease is its capacity to spread to noninfected larvae. The amount of virus produced in a newly-hatched larva at death is equivalent to 4 million doses and this increases to 400 million doses in larger larvae. The biological potential of this amount of virus is consequently very large and increases with the proximity and density of the larvae at risk. The period to death is normally 4 to 7 days, and this would govern the rate of release of the virus. It should also be mentioned that infected larvae continue to feed at a reduced rate. Consequently it is highly desirable that the virus be applied to coincide with the presence of newly-hatched larvae, anticipated by monitoring. The relatively long incubation period would adversely influence acceptance of the virus by growers who might expect as early a response as with chemical insecticides. It is most important that the grower is well informed on the way the virus works and its limitations.

The virus can be used in conjunction with the ovicide chlordimeform and control can be superior to that achieved with the "Dipel"-chlordimeform mixture, currently recommended by SIRATAC (Yearian et al., 1980). Additionally, unlike the bacterium in "Dipel", the virus has the capacity to accumulate in the top surface layer of the soil and to be available to infect Heliothis on subsequent crops, particularly those in which epizootics are liable to occur.

The use of the virus would allow existing natural control to be exploited. Its use would decrease selection for resistance and consequently prolong the useful life of conventional insecticides. The solving of the conceptual and technical problems associated with the use of the virus should therefore be a priority for researchers in cotton protection.

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