insects

Using NPV to manage helicoverpa in field crops

NPV stands for nucleopolyhedrovirus. NPV is a disease of helicoverpa (or heliothis) caterpillars that occurs naturally in the Australian environment. Australian farmers have access to commercially produced formulations of NPV for the treatment of helicoverpa infestations in crops. NPV is safe and environmentally friendly. It is ideally suited for inclusion in an integrated pest management (IPM) approach to controlling *Helicoverpa armigera* and *H. punctigera*, the major insect pests in our cotton/grain farming systems.

NPV can be used in a variety of field crops, including sorghum, chickpea, cotton and maize.

In sorghum, NPV is the preferred product for helicoverpa management, not only because it is effective (frequently giving over 90 per cent control) but because it preserves the full range of beneficial insects in the crop (e.g. *Microplitis* and *Trichogramma* wasps).

In crops other than sorghum, it is important to have realistic expectations of what NPV can achieve. In these crops, control varies and depends on a range of factors. A key aim of this brochure is to help identify those factors that contribute to the successful management of helicoverpa with NPV.

Figure 1. *An NPV-infected helicoverpa larva that has ruptured, releasing millions of infectious virus particles (Photo: C. Hauxwell, DPI&F)*

Queensland Government
Department of Primary Industries and Fisheries

What is NPV?

NPV belongs to a group of insect diseases called baculoviruses that infect and kill the larvae of moths and sawflies (sawflies are a kind of wasp with plant-eating larvae).

In this brochure, NPV refers to the commercial formulations of helicoverpa NPVs currently available for the control of *H. armigera* and *H. punctigera* larvae (marketed as Gemstar® and Vivus Gold®).

The commercially available NPVs only kill helicoverpa larvae. They do not harm humans, wildlife or other insects.

One of the key differences between NPV and a conventional insecticide is that NPV is applied as a live disease. Therefore it is important to understand the NPV lifecycle to understand how it works.

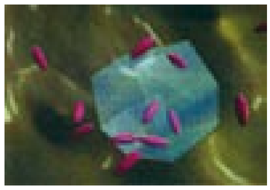
How NPV kills – NPV life cycle

Helicoverpa larvae have to eat NPV particles to become infected. These particles are called polyhedral inclusion bodies (PIBs). A dose as low as one PIB can be enough for NPV to successfully infect and kill it. Once the PIB is ingested, the virus infects the caterpillar's gut cells, spreading to the blood within 24 hours, and then to almost all the tissues in the body.

NPV can kill young larvae within 4 days of ingestion, older larvae within 5 to 7 days, depending on dose and temperature. The higher the dose and/or temperature, the faster is the rate of infection and death. However, cool to cold temperatures can prolong the time NPV takes to kill its host to more than 10 days.

In nature, infectious virus particles (virions) are embedded in a crystalline protein structure called a polyhedral inclusion body (PIB). PIBs are very small, with an average diameter of one micron (1 µm=one-millionth of a metre). Each PIB contains hundreds of virions.

Caterpillars ingest the PIBs along with their food.



Within seconds, the PIBs dissolve in the caterpillar's highly alkaline midgut, releasing the virions.

The virions pass through the midgut lining into the caterpillar's haemocoel (blood) and subsequently invade the cytoplasm and nuclei of susceptible cells. Virtually all the tissue cells are susceptible.

Virions and PIBs assemble and form within the cell nuclei.

The cells eventually disintegrate and release the PIBs back into the environment for reinfection.

Figure 2. *Life cycle of helicoverpa NPV. (Images: Courtesy of BASF Australia Ltd)*

Symptoms of NPV infection

Diseased larvae typically crawl to the top of the plant to die. Shortly after death, an infected larva's body becomes flaccid and its skin (integument) ruptures, releasing millions of PIBs (the infectious virus particles) back into the environment. When larval numbers are high, waves of natural infection can develop as more larvae become infected, die, and spread the infection, resulting in an outbreak (epizootic).

How long can NPV last in the environment?

NPV can persist for years in a protected environment such as the soil, but is rapidly killed by exposure to ultraviolet light in sunlight, and high temperatures.

Biopesticides – What are they?

NPV formulations belong to a group of pest control products called biopesticides. Other names for biopesticides are bioinsecticides, biological pesticides, biological insecticides, or even just biologicals.

Biopesticides are insect diseases (fungal, bacterial and viral) that have been isolated and mass reared for use against insect pests. One of the advantages of biopesticides is that they are usually very selective – that is, they only kill a single pest species or distinct group of insects – whereas many chemical insecticides are broad spectrum.

DPI&F is developing and testing biopesticides for use against several major crop pests (helicoverpa, green mirids, green vegetable bug, cotton aphid and silverleaf whitefly).

Control - What can you expect?

Sorghum. NPV is ideally suited for use in sorghum and should afford greater than 90 per cent control against all population levels provided the timing guidelines are followed (see page 6).

Chickpeas and cotton. NPV is best used against pest populations that are at or near economic threshold. If helicoverpa population levels are much higher than threshold, the percentage control from NPV may not be enough to reduce the population below threshold.

Chickpeas. Populations in excess of 6 larvae/m^2 may not be reduced below the economic threshold. For example, 70 per cent control success is required to reduce a population of 6 larvae/m^2 below an economic threshold of 2 larvae/m^2. However, a population of 10 larvae/m^2 would require greater than 80 per cent control to reduce pest levels below this threshold. Low predator and parasitoid numbers in chickpeas mean that you cannot rely on them to make an additional contribution to the results of an NPV spray.

Cotton. NPV control levels of 40–90 per cent (average 60 per cent) are possible on young cotton up to early flowering with good spray coverage. In flowering cotton, larvae can shelter in squares and flowers, which makes good control difficult. Beneficial insects are not affected by NPV so they can make a significant additional contribution to pest control if present.

Maize. NPV will not control larvae sheltering in maize cobs but should give good control in silking maize if applied via a ground rig fitted with droppers targeted at the cob and silk area of the plant. The use of droppers with spray booms improves target coverage.

Figure 3. *Spray boom fitted with droppers to apply biopesticides in maize (Photo: B. James)*

Spray application – Getting it right

Good control with NPV occurs when sprays:

- **are well timed** to coincide with larvae hatching, before larvae become entrenched in sheltered feeding sites
- **are targeted against small larvae,** preferably less than 7 mm in length. Larvae up to 13 mm in length may be targeted in sorghum. Larvae larger than this do not generally succumb to NPV infection.

Instar	Actual larval size	Length (mm)	Size category
First		1-3	Very small
Second		4-7	Small
Third		8-13	Small-medium

Figure 4. *Preferred target size range for NPV applications.*

- **achieve good coverage over the plant surfaces:** this is very important for ingestion-active products that must be eaten to kill. Application and nozzle selection needs to target the fine/medium droplet size range with a minimum droplet density index of 60 droplets/cm^2. A light wind (4–15 km/h) at application is important to distribute the spray on the target, including the underside of the leaves.
- **always include an additive,** such as Amino-Feed®. Adding 1 L/ha of Amino-Feed® significantly improves the performance of NPV in all crops. Amino-Feed® can be used at the same rate in ultra low volume (ULV) applications. Amino-Feed® possibly acts as a feeding attractant or stimulant, encouraging the larvae to eat more NPV PIBs. It may also improve distribution of the spray formulation over the plant surface, or help activate the virus in the insect gut.

The following factors also need to be considered to achieve the best results with NPV.

Rates

Gemstar® and Vivus Gold® are registered for use on several field crops in Queensland.

In chickpeas and sorghum, the registered rate for NPV is 375 mL/ha, and 500 mL/ha is the registered rate for cotton and maize. The higher rates in cotton and maize are because it is more difficult to achieve the necessary coverage in these crops, due to the presence of sheltered feeding sites and/or a more complex plant structure.

Water Volumes

For high-volume, water-based sprays, a minimum of 30 L water/ha is recommended for aerial application, and 100 L water/sprayed ha for ground rig application, always with 1 L/ha of Amino-Feed® or another effective additive.

Pressures of 300 kPa (3 Bar), or higher, should be used to provide the right application volume. Check that the pressure required to give the appropriate volume per hectare with your nozzles will still deliver spray droplets in the desired fine or medium droplet spectrum. Check that this is achievable according to the nozzle manufacturer's guidelines.

ULV aerial applications use oil-based carriers. DPI&F trial results show that ULV spray volumes as low as 3 L/ha are effective.

Adjusting droplet size and water volumes for dry conditions: Finer spray qualities, which improve coverage under good spraying conditions, are often associated with a more rapid uptake of the virus by the target larvae, due to the increased probability of the larvae encountering the product. However, under conditions of very low relative humidity (a Δt value more than 10) it may be necessary to increase the droplet size to a medium spray quality, which will require larger application volumes to ensure thorough coverage and rapid uptake of the NPV.

Note: Δt = difference between wet and dry bulb thermometer temperatures. The drier the air, the higher the Δt value.

Nozzle selection

DPI&F trials with NPV in chickpeas have shown that increasing the percentage of the target covered has a greater impact on efficacy (infection) than increasing the number of droplets per square centimetre. Standard flat fan type nozzles consistently outperform hollow cone nozzles because the nozzle design gives greater droplet penetration and improved deposition resulting in better spray coverage.

Water quality

Water pH should be neutral (pH 7.0) for best NPV performance.

A KEY ISSUE

Good control will only be achieved by good spray coverage targeted at the correct larval size: very small-small larvae (less than 7 mm).

Aerial applications - ULV versus EC

High temperatures and low relative humidity in summer are often unsuitable for high volume water-based emulsifiable concentrate (EC) applications. Research and grower experience have shown that aerial ULV applications of NPV (with the addition of spray oils) are effective against helicoverpa in sorghum and cotton during very hot, dry conditions. Amino-Feed® can be included in the ULV mixture, but in sorghum is not necessary to achieve good results with NPV.

ULV application of NPV at 3 L/ha total spray volume reduces the expense of carting the large water volumes required for EC treatments, though these cost savings are cancelled by the extra cost of the oil carriers used. However a key advantage is that aerial ULV sprays enable prompt treatment of large areas.

Figure 6. *Aerial application of NPV against helicoverpa in sorghum (Photo: D. Murray, DPI&F)*

Is ULV use of NPV registered?

Under Queensland's *Chemical Usage (Agricultural and Veterinary) Control Act 1988* (Sections8D. 8), a person does not contravene a label instruction by mixing another chemical product, or fertiliser or another substance with a chemical product, unless the instructions of the chemical product makes a statement prohibiting such mixing. Therefore, the addition of oil as an additive for ULV application may be permitted, even though it is not formally registered.

These details were correct at the time of printing. Conditions are subject to change. **Always read the label.**

Split-rate applications

Low rate application of NPV is not recommended for controlling helicoverpa infestations, as the percentage kill may be less than is needed to reduce larval numbers below the economic threshold for that crop.

DPI&F research with multiple low-rate (or split-rate) applications of NPV has suggested that these may increase the persistence of effective virus on the plant. Further field tests are needed to confirm the results. Early season applications of NPV may help to start an outbreak of virus in the pest population via secondary infection (see below).

What is secondary infection and is it useful?

'Secondary infection' refers to when caterpillars pick up virus released from the bodies of larvae killed by an earlier NPV application. Secondary infection is very common in sorghum, and is a key reason why NPV works so well in that crop.

Some growers routinely apply NPV in early season applications of other products (e.g. fungicide sprays). There is no reason not to do this other than cost, however there are no data available to support any benefits.

Does spraying before rain improve NPV performance?

Grower and research experience suggests that when NPV is applied just before showery weather, the results are better than when spraying during very dry conditions. This may be because light rain disperses the NPV particles more thoroughly over the plants, including into more concealed feeding sites. Heavy rain after application is not a problem because most NPV infection occurs within an hour of application.

Timing NPV sprays in sorghum to achieve maximum control

Applications in sorghum should be timed for 3 days after 50% of heads in the field have completed flowering (brown anthers to the base of the head). This timing is aimed to target the correct size of helicoverpa larvae and to conserve *Microplitis* wasps, the most important larval parasitoid of helicoverpa.

Figure 7. *A sorghum head at the completion of flowering (note brown anthers). NPV sprays should be applied when 50% of the crop is at this stage. (Photo: R Lloyd, DPI&F)*

How does this timing work?

Helicoverpa moths lay their eggs in developing sorghum heads just before flowering commences. Waiting until after 50% of the heads are at the brown anther stage of flowering allows for a full range of larval sizes to be present, ranging from newly hatched larvae through to larvae just over 7 mm in length (early 3rd instars). Larvae in this size range are ideal targets for an NPV spray. Larvae between 3 and 7 mm are also susceptible to being parasitised by *Microplitis* wasps.

The 3-day delay after 50% brown anthers is to conserve *Microplitis*.

Provided there is at least 3 days between when a caterpillar is parasitised by *Microplitis* and when it is infected with NPV, a *Microplitis* larva will be able to complete its lifecycle inside its caterpillar host before the caterpillar dies of NPV infection.

Ignoring the 3-day delay means, not only killing helicoverpa caterpillars that would have died from parasitism, but also killing the majority of *Microplitis* larvae developing inside their hosts.

For more information on *Microplitis*, see the DPI&F brochure, 'Microplitis demolitor *and ascovirus: important natural enemies of helicoverpa*'.

Timing NPV sprays in sorghum crops with a large spread of flowering

In crops where there is a large spread of flowering, it is better to spray before 50% of the heads are at the brown anther stage.

In sorghum, secondary infection by NPV can kill a large proportion of the caterpillars that hatch after the NPV application.

Coverage is the key, not time of day

Trial data in sorghum show that helicoverpa larvae are rapidly infected with NPV within an hour of spray application – irrespective of whether applied in the morning or evening. These findings imply that the time of day when NPV is applied to grain sorghum is not critical, and emphasis should be placed on applying NPV when conditions are most suitable to achieve good spray coverage.

Earlier recommendations to always apply NPV in the late afternoon or early evening are no longer current. These recommendations assumed that, due to the breakdown of NPV under UV light, evening sprays would ensure that larvae feeding during the night had sufficient opportunity to ingest NPV before it was degraded. The data in Figure 8 prove this is not a concern.

A key issue with timing NPV sprays is therefore to spray when you will get the best coverage – in many cases, spray conditions may be better in the morning than the late afternoon or evening.

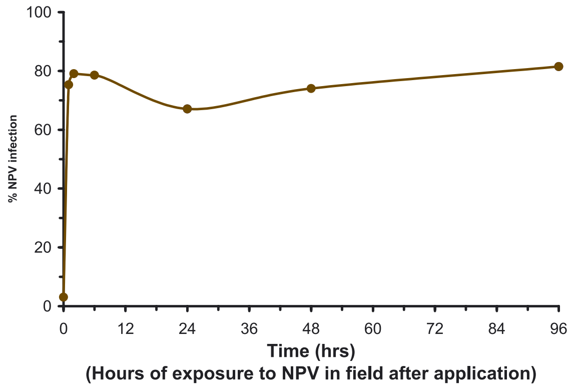


Figure 8. *The results from a DPI&F trial conducted in 2002 to assess the acquisition (uptake) of NPV by* H. armigera *larvae on grain sorghum following its early morning aerial application. This scenario of rapid infection is likely to be true for other crops where NPV is registered or there is a permit for use. However, further studies on NPV acquisition are still required in other crops.*

Could helicoverpa develop resistance to NPV?

Helicoverpa are unlikely to develop resistance to NPV. Resistance occurs commonly with conventional insecticides because they work in a relatively simple way. In contrast, viral infection is much more complex. Resistance to NPV is therefore much harder to develop. Both the naturally occurring viruses and the commercial products are a mix of many strains, each with a slightly different infection 'strategy'. Helicoverpa would find it difficult to become resistant to them all.

DPI&F research that monitored Australian helicoverpa populations for the development of NPV resistance over 3 seasons (2001–04) found no indication of resistance in any of the caterpillar populations studied.

Further information

DPI&F information products

To obtain copies of DPI&F publications, contact the DPI&F Call Centre on 13 25 23 or via the DPI&F website www.dpi.qld.gov.au.

Understanding helicoverpa ecology and biology in southern Queensland: Know the enemy to manage it better. DPI&F brochure 2005. QI07078

Microplitis demolitor *and ascovirus: important natural enemies of helicoverpa.* DPI&F brochure 2005. QI04079

DPI&F Summer and Winter Crop Management Notes on CD-ROM

Infopest – a DPI&F national database on CD-ROM, containing up-to-date information on all registered agricultural and veterinary chemicals.

Heliothis Stateline, DPI&F Newsletter. ISSN 1441-4244.

Crop Insects: The Ute Guide - Northern Grain Belt Edition. 2000. ISSN 0727-6273.

Other publications

Information relevant to NPV application in maize is contained in the Insect Pest Management in Sweet Corn Project (VG97036) final report available from Horticulture Australia Ltd. or from www.nre.vic.gov.au/agvic/ihd/projects/sc.

SPRAYpak. Cotton Growers' Spray Application Handbook. Cotton Research & Development Corporation. ISBN 1 876354 83 6. A guide to effective and safe pesticide application that is relevant for all crops.

Cotton Pest Management Guide (annual publication). NSW Department of Primary Industries, Australian Cotton CRC. ISSN 1442-8792.

Online Information

The DPI&F website www.dpi.qld.gov.au/fieldcrops is constantly updated with the latest pest management information.

Information on up-to-date pesticide registrations is maintained on the Australian Pesticides and Veterinary Medicines Authority (APVMA) Internet site www.apvma.gov.au.

The Australian Cotton CRC website www.cotton.crc.org.au has a variety of information related to integrated pest management including:

Impact of insecticides and miticides on predators in cotton

Current Insecticide Resistance Management Strategy

Integrated Pest Management Guidelines for Cotton Production Systems in Australia

About the authors

The DPI&F Entomology team is a leader in the science of managing insect pests and their natural enemies in broadacre farming systems.

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GRDC Grains Research & Development Corporation

Cotton CRC

Australian Government Cotton Research and Development Corporation