Always read the product label prior to using Vivus Max *Helicoverpa* Biocontrol

ViVUS MAX
Advanced *Helicoverpa* Biocontrol

Vivus is a Trademark of AgBiTech Pty Ltd.
Vivus Max *Helicoverpa* Biocontrol is manufactured by:

AgBiTech Australia Pty Ltd
8 Rocla Court, Glenvale, Qld 4350

AgBiTech

AgBiTech – a company 100% owned and managed by farmers and agricultural scientists – is a leader in developing and manufacturing biological insect control solutions. Around the world, field crop and horticultural farmers rely on our registered products. They trust and use our products because they know AgBiTech will always deliver dependable, practical, easy to use, high quality and cost-effective solutions.

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ViVUS MAX

TECHNICAL MANUAL

AgBiTech

ViVUS MAX

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Contents

AUSTRALIAN MADE

ALLOWED INPUT 106724 BFA REGISTERED PRODUCT

Introduction

VIVUS MAX HELICOVERPA BIOCONTROL IS A BIOLOGICAL INSECTICIDE THAT CONTROLS HELICOVERPA ARMIGERA AND HELICOVERPA PUNCTIGERA LARVAE.

The active constituent of Vivus Max is occlusion bodies (OBs – see **Fig. 1**) of the nucleopolyhedrovirus (NPV) of *Helicoverpa* spp. This baculovirus is a naturally occurring, highly effective biological control agent for *Helicoverpa* control. It is specific to larvae of *Helicoverpa* spp. and therefore has no impact on beneficial and other pest species in the crop. For these reasons, Vivus Max has a unique fit as a preferred option for the integrated management of *Helicoverpa* in a wide range of crops.

Occlusion bodies are protein bodies that have baculovirus particles embedded in them; they enable NPV to survive outside its insect host – like the spores of a fungus. When *Helicoverpa* larvae feed on Vivus Max treated plants they ingest the OBs and become infected with the virus. The virus utilises the insect's metabolism to replicate itself. The replicating virus invades almost every cell in the insect and eventually causes its cells to rupture, killing the caterpillar and releasing an NPV-laden liquid. Healthy larvae that feed on this liquid will also become infected and die (secondary infection).

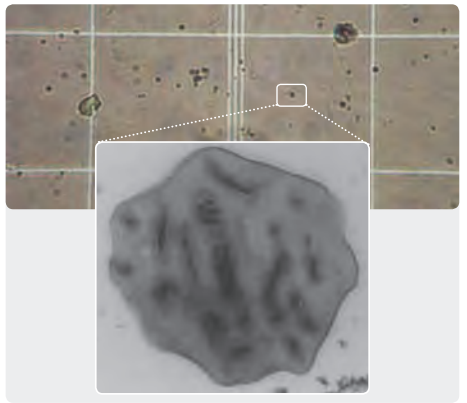

Fig.1 Grainy OBs as seen under a light microscope and a close-up of an OB using an electron micrograph.

How Is Vivus Max Made?

AUSTRALIAN MADE

Vivus Max is made in Australia by AgBiTech, a wholly Australian owned company.

The production process involves the mass rearing of huge numbers of *H. armigera* caterpillars (see **Fig. 2**), infecting them with a small amount of NPV, harvesting the resultant OBs from the dead caterpillars and formulating the final product. This process is conducted in climate-controlled facilities with highly specialised equipment. Vivus Max is available in 1 L and 5 L pack sizes. Each millilitre of Vivus Max contains 5 billion occlusion bodies.

The NPV in Vivus Max is a combination of a native Australian *H. armigera* isolate, (developed in conjunction with Queensland Department of Agriculture, Fisheries and Forestry (QDAFF)), that exhibits high laboratory potency, and a US *H. zea* isolate used in the original Vivus that exhibits a faster speed of kill. This combination is designed to maximise field performance.

Fig.2 Section of an AgBiTech larvae mass rearing tray.

Vivus Max Quality Control

THE MANUFACTURE AND FORMULATION OF NPV-BASED INSECTICIDES HAS SPECIFIC QUALITY ISSUES THAT REQUIRE SPECIALISED PROCESSES.

AgBiTech has strict quality control systems in place, developed through many years of experience. These include:

- **OB Counts –** The OB count defines the level of active viral particles in the final product. AgBiTech undertakes regular OB counts during and after formulation to ensure the appropriate virus loading; targeting a level 5% higher than indicated on the label. In addition to in-house testing, AgBiTech has Vivus Max independently tested to determine OB levels.
- **Potency bioassays –** The other key factor defining Vivus Max performance is the potency of the virus. AgBiTech uses a reference virus sample of known virulence and compares all batches produced to this reference sample. The Vivus Max specification requires that all product has equivalent or higher potency in comparison to this reference sample. AgBiTech also has Vivus Max independently tested for virulence.
- **Contaminant levels –** The production of NPV is a biological process involving the mass rearing and infection of huge numbers of *Helicoverpa* larvae. This process has the potential to allow bacteria and fungi to reach high levels in the final product. AgBiTech's manufacturing process minimises the risk of contamination and every batch of Vivus Max is tested in a food laboratory to ensure the final product meets food standards with respect to microbial contamination.
- **Storage and Transport –** To ensure long term stability of the virus in Vivus Max, the product should be stored at temperatures below 4°C. Temperatures above 30°C cause the virus to gradually degrade (over months) while above 40°C, degradation occurs more quickly (within 3 months). To ensure Vivus Max is readily available and reaches growers in perfect condition, AgBiTech has established a large cold depot and delivery network throughout all key areas where Vivus Max is used.

ViVUS MAX
Advanced *Helicoverpa* Biocontrol

Using Vivus Max early helps to maintain valuable beneficial species while allowing effective control of *Helicoverpa* larvae.

Vivus Max In Integrated Pest Management

VIVUS MAX HAS A KEY ROLE TO PLAY IN INTEGRATED PEST MANAGEMENT (IPM) IN CROPS THAT ARE ATTACKED BY HELICOVERPA SPP.

It provides effective and highly selective control of *Helicoverpa* larvae and has NO IMPACT on other pest or beneficial species in the crop. This means that natural predators and parasites in the crop are able to provide ongoing suppression of pests after Vivus Max is applied.

The use of less selective insecticides, while providing good initial knockdown control of larvae, can cause subsequent flaring of pests (including *Helicoverpa*) due to the removal of their natural enemies. This is a particularly important consideration in the first half of the season and in crops prone to pests normally kept in check by predation and parasitism, such as whitefly (**Fig. 3**), aphid and mites.

For growers releasing biological agents, such as predatory mites or *Trichogramma* wasps, using Vivus Max early helps to maintain these valuable beneficial species while allowing effective control of *Helicoverpa* larvae.

Fig.3 A whitefly parasite (Encarsia Formosa) on a whitefly pupa – actual size of wasp 0.6 mm.

Vivus Max In Resistance Management

RESISTANCE MANAGEMENT IS A KEY CONSIDERATION WHEN CHOOSING AN INSECTICIDE.

Helicoverpa armigera has developed resistance to a wide range of insecticidal groups such as carbamates (e.g. methomyl) and synthetic pyrethroids (e.g. cypermethrin).

Vivus Max is able to control larvae of *Helicoverpa* populations that have developed resistance to synthetic chemistry. It is also a valuable rotational product and mixing partner to help avoid resistance developing to synthetic insecticides.

Current scientific evidence shows that the chance of resistance developing to NPV is extremely low; with no known cases of resistance developing to NPV based insecticides anywhere in the world. This means that Vivus Max can be used throughout the season; early for use in IPM and later as a resistance break or mixing partner for synthetic insecticides.

Vivus Max is a valuable rotational product and mixing partner to help avoid resistance developing to synthetic insecticides.

How Vivus Max Works

A SCHEMATIC DIAGRAM AND DESCRIPTION OF THE LIFECYCLE/MODE OF ACTION OF NPV IS SHOWN BELOW.

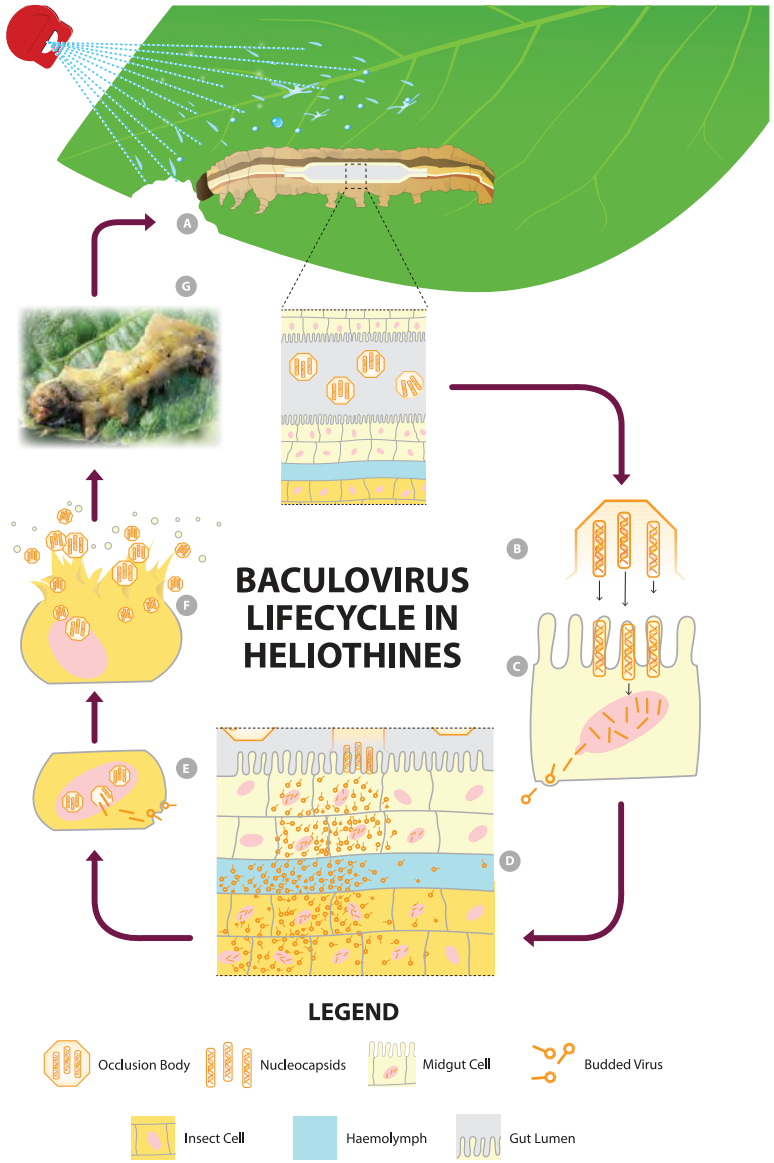

Fig.4 Nucleopolyhedrovirus lifecycle.

When Vivus Max is sprayed onto a crop, *Helicoverpa* larvae that are actively feeding on the crop will ingest OBs that are on the plant surface (A) (**Fig. 4**). Alkaline conditions in the insect's digestive tract cause the OB protein coating that encapsulates the baculovirus to dissolve, releasing virus particles that penetrate the cells lining the midgut (B). The virus enters the nucleus of the midgut cells (C) and utilises the insect's metabolism to replicate itself. The replicated virus, known as budded virus, is not in OB form and is how the virus spreads from cell to cell within the insect. Budded virus is transported via the haemolymph to invade virtually all of a larva's tissue (D). Prior to a cell rupturing from NPV infection, OBs form in the nucleus (E) to enable virus survival outside the caterpillar. The replicating virus eventually causes the larva's cells to rupture (F), resulting in death. Upon death, larvae liquefy and release an OB-laden liquid (G) (**Fig. 4**).

The OB-laden liquid can be spread around the crop by other insects and/or during rainfall or overhead irrigation. Healthy larvae that feed on this liquid will become infected and die – this is known as secondary infection. NPV infection cycles can provide ongoing suppression of *Helicoverpa* for many weeks to months, depending on conditions.

Larvae typically take 3-9 days to die from NPV depending on temperature and larval size at infection (i.e. warmer temperatures = faster kill; smaller larvae = faster kill). Dead and dying larvae are often seen near the top of the crop canopy.

Achieving Optimum Results With Vivus Max

Like other biological insecticides, a number of key environmental and biological factors can affect Vivus Max performance. Unfavourable conditions can lead to variable results and control levels that are below expectations. However, by adhering to a few important recommendations, maximum results can be consistently achieved.

Coverage, Coverage, Coverage

Thorough coverage is the key aspect in achieving consistently high mortality with Vivus Max.

Thorough coverage is vital because LARVAE MUST INGEST THE VIRUS for infection to occur.

Thorough coverage is best achieved by paying close attention to nozzle selection and boom setup, using optimum application volumes and considering environmental conditions at the time of application.

» **Nozzle selection and boom setup –** For ground-rig application avoid the use of flat fan nozzles, unless they are used in row crops with multiple nozzles per row (particularly if droppers are used) or when spraying a young crop without an established canopy. Flat fan nozzles used with a standard boom setup are likely to result in spray shadows due to the two dimensional nature of the spray pattern. Flat fans are primarily designed for herbicide application where maximum coverage is not as critical for performance. The use of TwinJet nozzles (**Fig. 5**) or hollow cone nozzles will significantly improve canopy penetration and spray coverage by reducing spray shadows, particularly when applying to a crop with a dense canopy. Nozzle selection should also consider droplet number and size. Fine droplets will penetrate dense canopies better however are more prone to evaporation.

Fig.5 Spray pattern from TwinJet nozzles.

In hot, dry conditions it is recommended to increase droplet size and number (and application volume – see below) to reduce droplet evaporation while maintaining coverage.

It is important to regularly monitor spray coverage using water-sensitive paper (**Fig. 6**).

» **Application volume –** For ground rig spraying in broadacre crops, a minimum application volume of 100 L/ha is recommended. In horticultural crops, use a minimum volume of 400 L/ha. The use of a wetter may also help to improve coverage in certain crops.

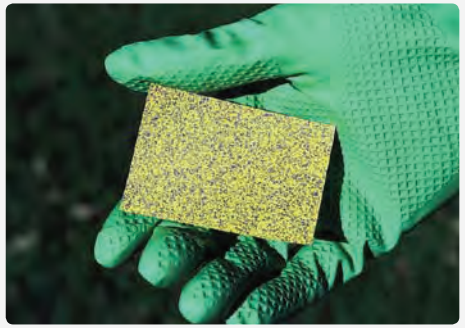

Fig.6 Use water sensitive paper to monitor spray coverage.

For aerial application using only water as the carrier, application rates of greater than 30 L/ha are required. In all situations, higher application volumes are recommended for more dense crops and where higher application volumes will result in improved coverage. Lower volumes may be possible if using band spraying and/or applying Vivus Max to early stage crops with a small leaf surface area.

In broadacre crops, Vivus Max can also be aerially applied in ultra-low volume (ULV) using a minimum of 3 L/ha of an oil carrier (such as D-C-Tron). ULV application produces a large number of very fine droplets, giving very good coverage. ULV droplets are not prone to evaporation during hot or dry conditions due to the oil carrier.

In sorghum only, Vivus Max can be aerially applied in 9 L water per ha plus 1 L Optimol per ha. This enables large areas to be treated quickly and cost-effectively during peak *Helicoverpa* control windows. Optimol is manufactured by AgBiTech and is a blend of molasses, sucrose and petroleum oil - for more information please refer to the Optimol Technical Manual.

» **Environmental conditions –** In addition to the spray parameters outlined previously, it is also important to apply Vivus Max when environmental conditions favour good coverage. Hot (above 35°C) and dry (below 40% relative humidity) conditions cause droplet evaporation and reduce coverage. This can be minimised by increasing spray volumes and droplet size and by using Optimol or other anti-evaporation products to reduce droplet evaporation. However, it is best to apply Vivus Max in humid (above 50% RH) and warm (25-35°C) conditions that favour good coverage.

During the warmer spring and summer months, these ideal conditions often occur during the early hours of the morning between 2 – 8am, particularly if there is a dew. Larvae tend to feed more actively during these hours and are less likely to be in protected feeding sites where they may avoid ingesting the virus. The higher humidity will also provide better spray conditions to give good coverage.

Temperature

Helicoverpa larvae must ingest NPV for infection to occur, so in addition to good spray coverage, it is important to apply Vivus Max when larvae are actively feeding. *Helicoverpa* larvae are most active at temperatures between 25-35°C, so applying Vivus Max in this temperature range increases the likelihood of a larva ingesting occlusion bodies (OBs) and therefore maximises the level of control achieved from the application.

Temperatures above 35°C will cause larval activity to rapidly decrease; below 25°C activity will decline gradually; below 18°C activity is reduced even further, and below 12°C larvae stop feeding.

It is preferable to delay application of Vivus Max until conditions reach 25-35°C, however control can still be achieved in cooler conditions provided temperatures have been at least 18°C for several hours prior to spraying. Where application cannot be delayed, or during extended cold spells (as often occurs in winter crops such as chickpeas), the addition of Optimol will improve the residual life of NPV on the crop and increase rates of infection.

A study by Queensland DAFF has shown that most virus is ingested within the first hour after application, therefore applying Vivus Max during active feeding is more critical than applying Vivus Max when longer residual effects may be expected (such as low UV light conditions). The 25-35°C temperature range also corresponds with higher insect metabolism, resulting in rapid infection by the virus once ingested.

A study by Queensland DAFF has shown that most virus is ingested within the first hour after application

Larval Size

Smaller *Helicoverpa* larvae are more susceptible to NPV infection than larger larvae because they need to ingest fewer OBs for infection to occur.

Smaller larvae are also more likely to be feeding on leaves and other unprotected areas, increasing the odds of ingesting NPV.

Larvae larger than 13 mm (4th instar and larger) should not be targeted with Vivus Max since control will be unsatisfactory (**Fig. 7**).

It is best to target very small to small larvae less than 7 mm in length (1st & 2nd instars) particularly in high value crops. Medium larvae between 8-13 mm (3rd instar) can be effectively controlled, however some damage may occur.

The addition of Optimol to Vivus Max sprays can improve larval control at the top end of the recommended size spectrum.

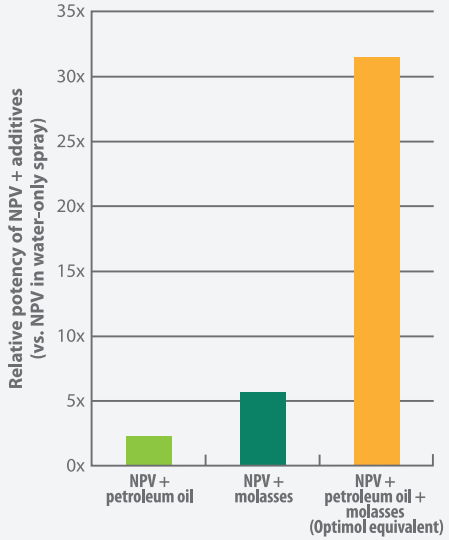

Fig.8 CRDC PROJECT DAQ 105C: Cotton leaf bioassay showing the effect of 3 additives on the relative potency of NPV.

Optimol And Sugar Based Additives

The use of molasses based additives can significantly improve mortality compared to Vivus alone (**Fig. 9**). Optimol improves the residual activity of Vivus Max, improves spray coverage and increases initial uptake and infection (see Optimol Technical Manual). The molasses, sugar and oil components in Optimol combine to greatly increase NPV infectivity (**Fig. 8**), however the mechanism for this is not fully understood. It may be due to a feeding stimulant effect from the sugars. However, research indicates it is more likely caused by interactions inside the gut of the larva. It is suggested that the Optimol components protect virus particles form inactivation by plant chemicals inside the gut, and may also increase larval susceptibility to NPV. Research in this area is ongoing. Mobait and various UV protectants have not been shown to improve Vivus Max performance and are not recommended.

Helicoverpa Growth Stage Identification

Showing the actual size of *H. armigera* larvae at a given age (days since egg hatch) when reared at 25ºC.

Instar	Age (days)	Size category	Length (mm)	Actual size	Vivus Max timing
1st	0 - 2	Very Small	1 - 3		✔✔
2nd	2 - 4	Small	4 - 7		✔✔
3rd	4 - 8	Medium (small)	8 - 13		✔
4th	8 - 11	Medium (large)	14 - 23		✘
5th	11 - 14	Large	24 - 28		✘
6th	14 - 18+	Large (snake)	29 - 40+		

Fig.7 *Helicoverpa* growth stage identification chart.

Field-lab Bioassay Showing The Impact Of Molasses

Trial 02-004: Field-lab bioassay showing the impact of molasses and D-C-Tron (ULV) on Vivus residual efficacy on cotton plants – Narrabri 2002.

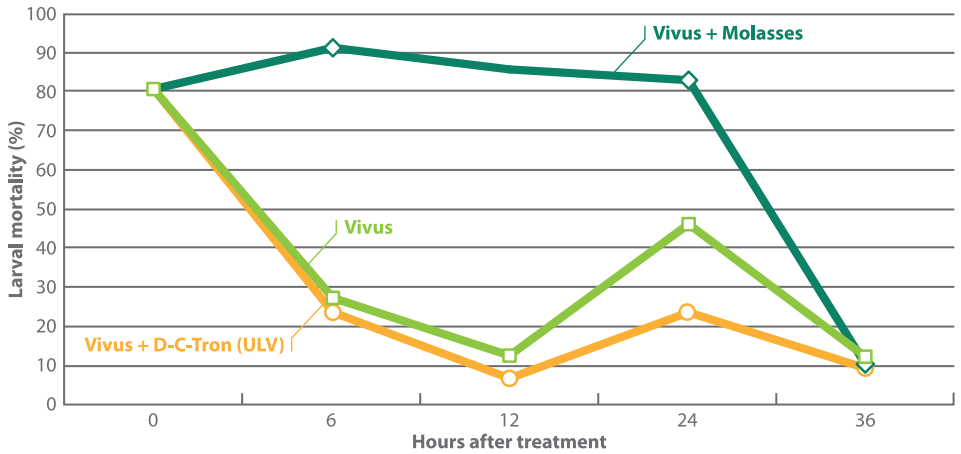

Fig.9 Field-lab bioassay showing the impact of adding molasses and petroleum oil to Vivus in cotton.

Spray Solution pH

The OBs in Vivus Max dissolve and release their virus particles in the alkaline (high pH) environment of a caterpillar's gut. Exposure to high pH (> 8) conditions in the spray tank prior to application can weaken OBs, damage the embedded virus particles and subsequently reduce Vivus Max performance. For this reason, it is important to only mix Vivus Max in water with a pH of 8 or less, or to lower the pH of alkaline water using an acidifier like citric acid or a buffer such as LI-700.

Care should also be taken when mixing Vivus Max with other products in the spray tank as some products (such as copper hydroxide and some foliar fertilisers) can increase the pH of the spray solution. Use pH strips to ensure the spray solution is at or below pH 8 before adding Vivus Max. It is also recommended to apply Vivus Max as soon after mixing as possible to minimise degradation of the virus in the spray tank.

Vivus Max Rain Fastness

The majority of larvae will ingest the virus within 1 hour of application (given optimum temperature and actively feeding larvae). For this reason, it is best to avoid applying Vivus Max if heavy rain is expected within one hour following application. However do not delay application if only moderate rain is expected, or heavy rain is not imminent.

Vivus Max Compatibility

When mixed in water, Vivus Max is highly compatible with the majority of pesticides and fertilisers. Vivus Max has no physical compatibility issues with other products, and is chemically very benign. Ensure that the mixture has a pH of 8 or less before adding Vivus Max as alkaline mixtures will damage the virus.

When applied in ultra-low volumes (ULV) with an oil carrier, Vivus Max should not be mixed with other products as the solvents in other pesticides can damage the virus in the concentrated ULV mixture. Vivus Max is compatible with Optimol in ULV mixtures.

Vivus Max Storage

Store in the closed, original container out of direct sunlight at or below 4°C. The product is stable for 2½ years if stored as indicated. Refer to label for additional storage conditions.

Vivus Max Performance

Vivus Max Laboratory Potency

The native Australian NPV isolate in Vivus Max was selected because it exhibits higher virulence in comparison to the US isolate used in the original Vivus product.

Laboratory bioassays, using caterpillars to evaluate the potency of different batches of NPV, have shown the isolate in Vivus Max has consistently improved potency compared to the US isolate.

It should be noted that differences seen in laboratory bioassays cannot be extrapolated to field differences, but provide a guide to the quality and virulence of a particular isolate or sample.

Vivus Max Field Performance

Data showing Vivus Max field performance and advice relating to specific crops and use patterns is presented in the following pages. In general, Vivus Max will provide between 60-90% control depending on a range of conditions.

Vivus Max will provide between 60 - 90% control depending on a range of conditions.

Larvae typically take 3-9 days to die from NPV depending on temperature and larval size at infection (i.e. warmer temperatures = faster kill; smaller larvae = faster kill).

Vivus Max has no physical compatibility issues with other products, and is chemically very benign

Fig.10 Vivus Max will not be effective against larvae in protected feeding sites.

Vivus Max CROP SPE CIFIC ADV ICE

Sorghum

Helicoverpa armigera in sorghum can be managed with one well-timed spray of Vivus Max during flowering, which reliably provides 90% or better control. Use lower rates of Vivus Max (75 mL/ha) when targeting larvae smaller than 7 mm (1st and 2nd instar) in length or under lower pressure (pre-threshold) situations.

Use higher rates of Vivus Max (150 mL/ha) when targeting larvae larger than 7 mm in length (3rd instar) or when larvae numbers reach threshold. Larvae larger than 13 mm (4th instar and larger) should not be targeted with Vivus Max since control will be unsatisfactory.

If using crop stage to determine application timing, Vivus Max will provide reliable control if applied when 50% of heads have reached 100% flowering (**Fig. 11**). In crops where there is a large spread of flowering, it is best to apply Vivus Max earlier than 50% flowering, as secondary infection is likely to be effective in controlling *Helicoverpa* that hatch after spraying.

Larvae up to 10 mm long largely feed on anthers and other flower parts, with larger larvae damaging the developing grain causing economic loss.

Fig.11 A sorghum head at 50% brown anther (L) and close-up of brown anthers (R).

During the vegetative stages of sorghum development, *Helicoverpa* may be found in significant numbers but their damage rarely warrants control. Crop inspection for midge should commence at early flowering, and monitoring for *Helicoverpa* can be done concurrently. *Helicoverpa* checking should continue throughout flowering on a weekly basis with twice weekly checks recommended as the crop approaches peak flowering.

» **Sorghum threshold calculation –** Research by Queensland DAFF has shown that *Helicoverpa* larvae will cause an average loss of 2.4 g of sorghum grain for each larva present in the crop. This and other information (cost of control, head density and grain price) allows the calculation of the threshold of *Helicoverpa* larvae that will cause economic loss if not controlled. This economic threshold is then used to determine if control using Vivus Max is warranted in a particular situation. The economic threshold formula for *Helicoverpa* in sorghum is:

$$\text{Economic threshold} = \frac{(C \times R)}{(N \times V \times 2.4)}$$

Where:
C = cost of control ($/ha)
R = row spacing (cm)
N = Number of heads per m row
V = Grain price ($/tonne)
2.4 = Grain damage (g/larva)

The economic threshold formula is used to determine if *Helicoverpa* control using Vivus Max is warranted in a particular sorghum crop.

For example, in a situation where the cost of control (C) is $32/ha (Vivus Max at 150 mL/ha + aerial application cost of $12/ha), with a 100 cm row spacing (R), 12 heads per metre (N) and a sorghum price of $200/tonne (V), the economic threshold will be 0.56 larvae per head.

This means that if monitoring showed an average *Helicoverpa* density of more than 0.56 larvae per head, control with Vivus Max would be warranted.

Higher yielding crops, a higher sorghum price or lower Vivus Max application costs would further reduce this threshold (and vice versa).

Vivus Max will provide reliable control if applied when 50% of heads have reached 100% flowering

Chickpeas

Vivus Max is a valuable tool for *Helicoverpa* management as part of an IPM approach in chickpeas. Queensland DAFF research has shown that the feeding activity of *Helicoverpa* larvae prior to pod set has little impact on yield. However, controlling very small and small larvae during flowering will minimise the number of large, difficult to control larvae during pod set and pod fill.

Trials conducted by AgBiTech have shown that using Vivus Max on pre-threshold larvae populations can delay larval numbers reaching economic threshold during podding and thereby delay the need for a chemical insecticide. This reduces the likelihood of requiring multiple larvicides in a season. Pod damage can also be significantly reduced when pre-podding chickpeas are inoculated with NPV (**Fig. 13**).

Lower rates of Vivus Max (75 mL/ha) can be used in pre-podding chickpeas and/or on pre-threshold larval populations. The high rate of Vivus Max (150 mL/ha) plus Optimol (1 L/ha) should be used when the pest population reaches economic threshold.

Fig.12 Small larva dead from NPV infection in chickpeas.

Vivus Max is a useful tool at flowering in chickpeas for a number of other reasons:

- It will not disrupt beneficial species in the crop.
- It preserves the single allowable application of indoxacarb (Steward) until the critical pod set/pod fill stages.
- It can be applied in conjunction with protectant fungicides (if required).
- It sets up the potential for an NPV infection cycle to occur.
- It avoids resistance building to synthetic insecticides.

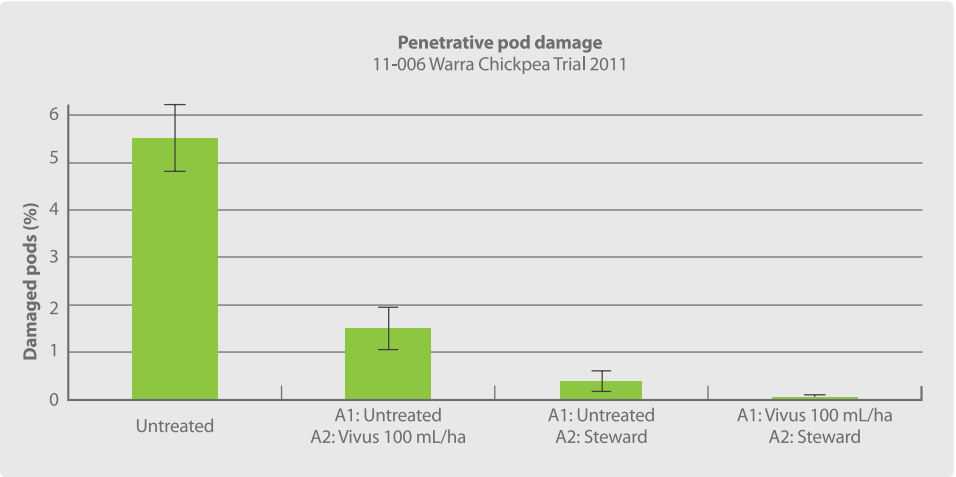

Fig.13 Trial 11-006: Field damage assessment results showing percent penetrative pod damage in chickpeas.

» **Specific recommendations in chickpeas –** In addition to the general recommendations for applying Vivus Max, there are some specific recommendations for maximising its performance in chickpeas:

- Molasses-based additives such as Optimol will improve the performance of Vivus Max in chickpeas. Add Optimol or molasses based additives at a rate of 1 L/ha. For more information refer to the 'Optimol and sugar based additives' section of this manual.
- *Helicoverpa* management in chickpeas will often be required during cool periods. At these times, ensure Vivus Max is applied during the warmest part of the day to maximise larval activity and increase the likelihood of virus ingestion. Ensure that temperatures have been at least 18°C for a minimum of 3 hours before applying Vivus Max. Ideally apply between 20-35°C where possible.
- If applying Vivus Max by ground rig, avoid the use of flat fan nozzles as they are likely to compromise coverage (except when the crop is young). Use TwinJet or hollow cone nozzles – these nozzles are also ideal if applying protectant fungicides.
- Vivus Max alone will provide around 70% control of *Helicoverpa* larvae in chickpeas, so should not be solely relied upon during and after pod set if larval numbers exceed 6 per m^2.

Cotton

Vivus Max can be successfully used for *Helicoverpa* control in conventional cotton (**Fig. 14**) as part of an integrated pest management program, however its performance in cotton can be highly variable.

Vivus Max must only be applied in cotton when larvae are less than 7 mm (1st & 2nd instars) AND are actively feeding because:

- NPV has a very short residual life (hours) due to cotton's alkaline leaf chemistry (pH 9+).
- Larvae will often be in protected feeding sites where they will not ingest the virus.

The addition of molasses-based additives such as Optimol will significantly improve the residual life and performance of Vivus Max in cotton (**Fig. 8**).

Due to the specific agronomic characteristics of cotton, infection cycles and ongoing suppression from NPV is less reliable compared to other crops.

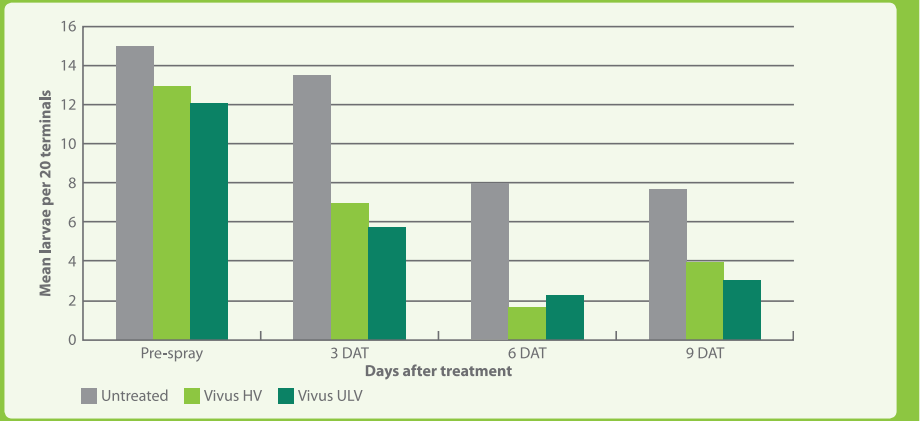

Fig.14 Trial 02-001: Field trial data showing performance of Vivus in cotton applied in high water volume (HV) (100 L/ha) and in ultra-low volume (ULV) – Brookstead 2002.

Sweet Corn

Vivus Max plays a valuable role in *Helicoverpa* management in sweet corn (**Fig. 15**). It is used to control larvae from the early vegetative stages through to tasselling and prior to the emergence of silks. At silking, contact synthetic insecticides with residual activity should be employed. Vivus Max has short residual activity so regular application may be required under consistent pest pressure. Where the crop is grown under overhead irrigation, Vivus Max is best applied in the irrigation water as excellent control can be achieved – refer to the *'Application via Overhead Irrigation'* section for more information.

Horticultural Crops

Vivus Max is registered for use in a wide range of horticultural crops for *Helicoverpa* management. Its high selectivity to *Helicoverpa* makes it the ideal IPM product during the early vegetative stages of production when some damage can be tolerated. Under high larval numbers or later when protection against damage is vital, it is an excellent mixing partner with synthetic insecticides as it will control resistant larvae and assist in controlling any larvae that may survive the synthetic insecticide. The virus has a relatively short residual effect, however regular applications will maintain background NPV levels in the crop, meaning the virus will be present to provide additional control of *Helicoverpa*. While Vivus Max is relatively slow to kill larvae, with peak control at 4-7 days, it will greatly assist in keeping crops free of the larger larvae that cause the majority of damage (**Fig. 16**).

Vivus Max has a rate range in horticultural crops of 150-300 mL/ha. The highest rate is only necessary for circumstances where there is a high demand on the product (such as very high larval numbers or when controlling larvae > 7 mm), and when other insecticide options are not available (such as in organic production, due to withholding period constraints of other insecticides or during rainy conditions – Vivus Max is highly effective during wet weather). For general use, the lower rate should be used, particularly if applying the product on a regular (4-7 day) schedule. In situations when even more regular applications of Vivus Max are possible (e.g. daily overhead irrigation in lettuce), it is recommended to use split rates proportional to the number of applications, e.g. instead of 150 mL/ha every 5 days, use 30 mL/ha every day. This approach will provide the maximum levels of control without increasing the total amount of Vivus Max used.

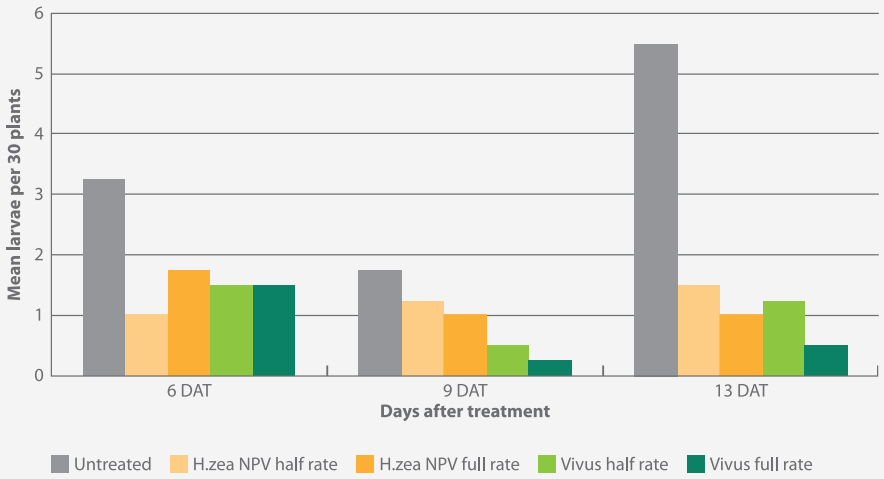

Fig.15 Trial 02-009: Field trial data showing the performance of 2 rates of Vivus in sweet corn – Bowen 2002.

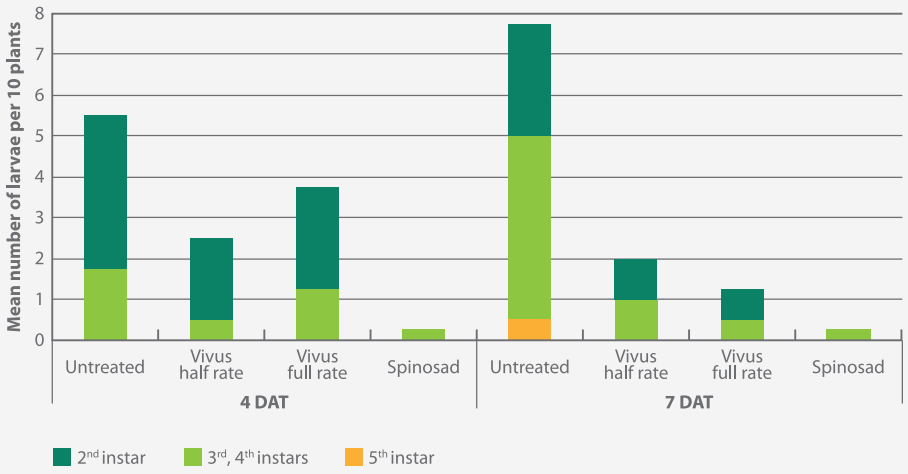

Fig.16 Trial 05-002: Field trial data showing the performance of two rates of Vivus in Capsicums – Bowen 2005.

Vivus Max Application Via Overhead Irrigation

VIVUS MAX IS THE FIRST INSECTICIDE REGISTERED IN AUSTRALIA FOR APPLICATION IN OVERHEAD IRRIGATION WATER.

By adding Vivus Max to irrigation water, growers can artificially inoculate their crop with NPV and achieve a high level of control of *Helicoverpa* larvae.

Vivus Max is unique among insecticides because applying the product via overhead irrigation provides excellent control of *Helicoverpa* larvae (**Fig. 18**). Rainfall is NPV's main natural dispersal mechanism throughout the crop canopy. Rain splash spreads the virus around the crop from the soil and NPV infected larvae, for infection of other larvae to occur (known as secondary infection). Applying Vivus Max in overhead irrigation mimics NPV's natural dispersal method.

Fieldwork has shown that applying Vivus Max in overhead irrigation water consistently achieves maximum control levels. While only a small proportion (< 20%) of the virus will remain on the plant, this amount is sufficient for a high level of control. This is because Vivus Max is known to work effectively at below label rates when coverage is optimised, and application in overhead water provides the maximum coverage achievable, including in protected feeding sites. It is also known that *Helicoverpa* behaviour changes during rainfall; including feeding in more exposed positions and wet larvae grooming themselves, increasing the likelihood of NPV infection. In addition, virus that does not remain on the crop but ends up in the soil is able to survive for significant periods, providing a source for re-inoculation of the plant with NPV at subsequent irrigations.

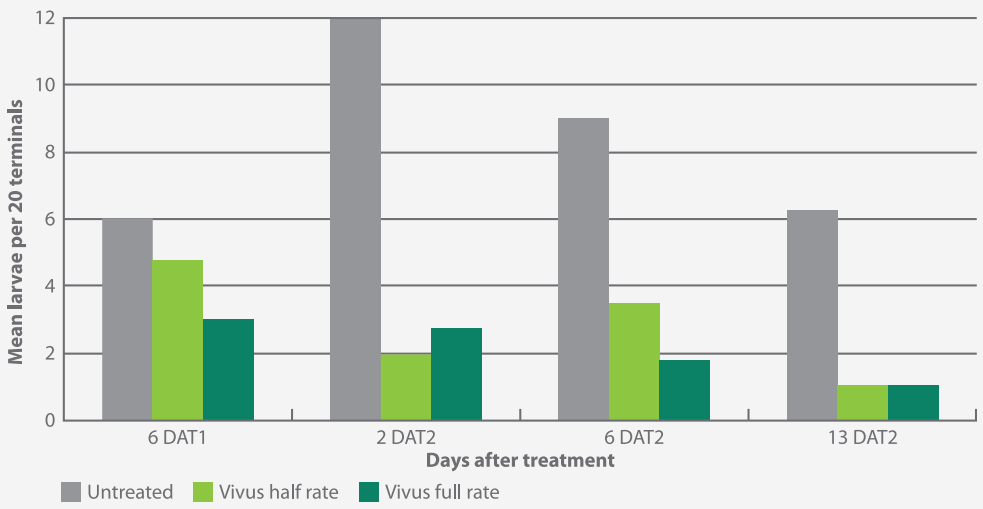

Fig.17 Trial 02-008: Field trial data showing the performance of two rates of Vivus in tomatoes – Bowen 2002. (NB: 0 DAT2 = 9 DAT1).

Label Directions For Overhead Irrigation

Vivus Max should be introduced to the irrigation water at the appropriate rate using fertigation equipment.

If the product is diluted in water prior to injection into the irrigation water, ensure that the dilution water is clean and not silty with a pH of 8 or less and ensure there is constant agitation. Preferably, rainwater should be used for dilution. Ensure any diluted Vivus Max is used within 10 hours of mixing.

For one-pass mobile irrigators such as centre pivots, laterals and travellers (guns) continuously introduce the required quantity of Vivus Max into the irrigation water over the course of irrigation. Apply in no more than 10 mm of irrigation water.

For stationary irrigators, introduce the required amount of Vivus Max into the irrigation water just prior to completion of the irrigation period, to maximise the concentration of Vivus Max applied and the amount that remains on the crop.

Commercial setup for applying Vivus Max through overhead irrigation.

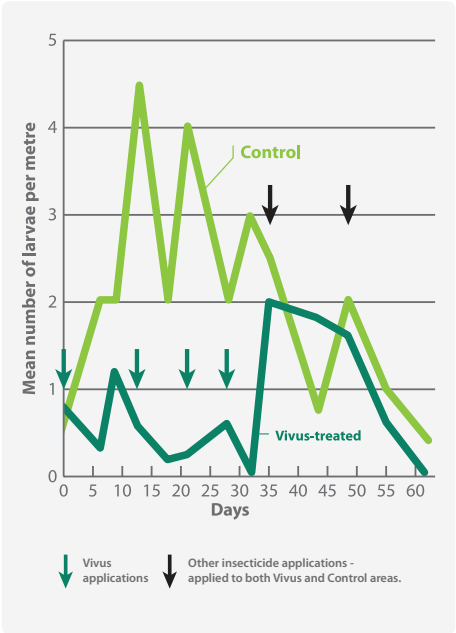

Fig.18 Trial 04-001: Typical control achieved from Vivus applied through centre pivot irrigation in Azuki beans.