Chickpea insect pest management

Northern grains region

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Department of **Agriculture, Fisheries and Forestry**

This publication has been compiled by Melina Miles of Crop and Food Science, Queensland Department of Agriculture, Fisheries and Forestry (DAFF), and draws on previous publications and original research by Paul Grundy, Melina Miles, Sheree Short and Richard Lloyd. DAFF and GRDC funding for the IPM Workshops project (DAQ00179) has assisted the preparation of this publication.

Unless otherwise indicated, all photographs are provided by DAFF.

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Overview of chickpea insect pest management

The major insect pest of chickpeas is helicoverpa. Other less frequent pests include: locusts, aphids, cutworms, false wireworms, and blue oat mites.

Chickpea is quite unique in that it does not host significant numbers of beneficial insects. Small numbers of parasitic flies (tachinids) have been recorded from chickpea, but little else. Therefore, in relation to IPM, there are really no in-crop management opportunities. However, if chickpeas are poorly managed, they can contribute large numbers of helicoverpa to the local populations posing a threat to susceptible summer crops (sorghum, pulses, cotton) grown in the district.

To manage helicoverpa well, it is important to be able to sample and identify the different larval instars (very small, small, medium-large, large). Familiarity with these different lifestages is critical to determining the likelihood of damage occurring and optimising timing of control.

There are two species of helicoverpa, *Helicoverpa armigera* and *H. punctigera* that may occur in chickpea in the northern region*. H. armigera* is resistant to some insecticide groups (particularly the synthetic pyrethroids), whilst *H. punctigera* is susceptible to all products. While it is not always possible to do so, identifying which species is present, or knowing which predominate in your area, may help you avoid products that may not give good control. There are some tools that can help you make this determination.

Identifying helicoverpa

Why distinguish the two species of *Helicoverpa*?

Determining which species of helicoverpa are present in the crop is essential, principally because of the differing susceptibility of the two species to synthetic pyrethroids and carbamates.

Visual identification of the different species is sometimes possible from examination of larvae, however, it can be difficult and unreliable for small larvae about the size when control decisions have to be made. A hand lens, microscope or USB microscope is critical for examining small larvae.

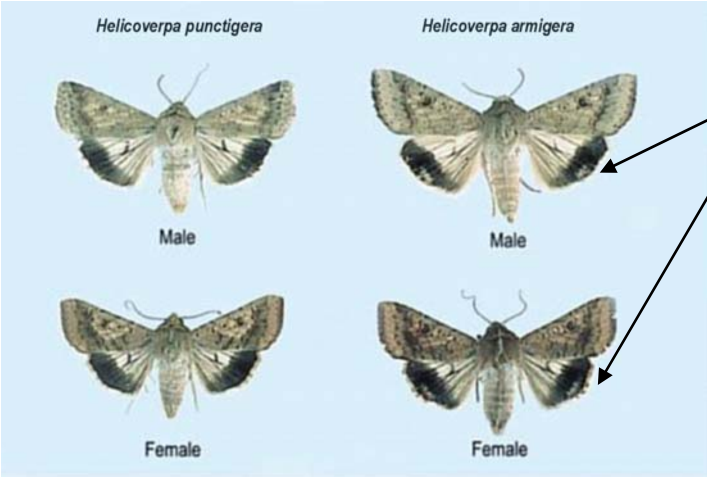
Small *H. armigera* larvae (3rd instar) have a saddle on the fourth segment and *H. punctigera* don't. This is often difficult to see in the field and this method isn't 100% accurate, but may be used as a guide.

In larger (5th and 6th instar) larvae, hair colour on the segment immediately behind the head is a good species indicator. These hairs are white for *H. armigera* and black for *H. punctigera*.

Medium *Helicoverpa armigera* (12 mm) showing the distinctive 'saddle' on 4th and 5th body segments (top), and *H. punctigera* without saddle (bottom).

Large *Helicoverpa punctigera* (left) and *H. armigera* (right) larvae showing the distinguishing dark and pale hairs behind their heads.

Helicoverpa species identification



H. punctigera* and *H. armigera* moths are distinguished by the presence of a pale patch in the hindwing of *H. armigera.

Helicoverpa larvae occur in a range of colours.

Species composition can vary between seasons and regions

Species composition in the crop will be influenced by a number of factors:

- Winter rainfall in inland Australia that drives populations of *H. punctigera*; and the occurrence and timing of wind systems that carry *H. punctigera* from inland Australia to eastern cropping regions,
- Winter rainfall in eastern cropping regions which drives the abundance of local populations of *H. armigera* through the generation of spring hosts. In regions where chickpea is grown, chickpea may serve as a significant spring host for *H. armigera* emerging from diapause, if these populations are not controlled (e.g. subthreshold populations across large areas of chickpea, or poorly managed crops).
- Relative timing of flowering – podding (attractive and susceptible) stages and the immigration of *H. punctigera* and emergence of *H. armigera* from overwintering diapause. Note: in Central Queensland, *H. armigera* does not enter winter diapause and will be the predominant species in chickpeas.
- Geographic location. In temperate regions (southern Queensland and further south) the majority of the *H. armigera* population over-winter from mid-March onwards and emerge during September/October. *Helicoverpa punctigera* is usually the dominant species through September when moths are migrating into eastern cropping regions. Seasonal variation can lead to *H. armigera*-dominant early infestations in some years, particularly in more northern districts. Pheromone trap catches can be used as an indication of the species present in a region. Note that pheromone traps are cannot be used to predict the size of an egg lay within a crop.

Monitoring chickpeas for insect pests

Helicoverpa is the main pest in chickpeas. Chickpeas are susceptible to significant yield loss caused by helicoverpa from pod set through to harvest. Whilst helicoverpa can cause reductions in both yield and quality, the economic threshold for minimising yield loss is much lower than that which would result in a reduction in grain quality.

Seedling insect pests, such as cutworm, can attack chickpeas, but are rarely an economic problem. Other infrequent pests include blue oat mites, false wireworms, cutworm and aphids.

Sampling with a beat sheet is best practice for monitoring helicoverpa in chickpeas. Establishment pests will be detected by visual inspection of seedling establishment and the pests.

Regular monitoring during the susceptible crop stages, is critical, particularly for helicoverpa where you may be dealing with insecticide resistant larvae and good control depends on small larvae being targeted.

Sampling strategy and technique

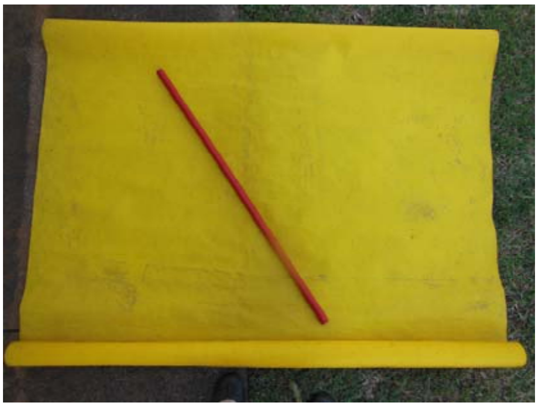
Both the beatsheet and sweep net are accepted techniques for monitoring helicoverpa larvae in chickpeas. The beatsheet is the recommended technique for crops grown on wider row spacings (>50 cm rows).

Economic thresholds are developed using a specific sampling technique, so it is important that you are aware of this when making management decisions. Thresholds for beatsheet and sweep net are presented in the 'Making management decisions' section.

Beatsheet vs sweep net

To date, the sweep net and beatsheet have not been calibrated in chickpea, so it is not yet possible to use the one threshold with an adjustment for relative sampling efficiency of the sweep net.

Using a beatsheet



Check crops regularly (at least once a week) with a beatsheet from flowering through to harvest. In addition to larval counts; visual observation of the crop growth stage, progress of flowering/podding, and the presence of eggs, diseased larvae (NPV) and moths all provide useful information for decision making.

Each time you inspect, check at least 5 x 1 row metre sections at a number of sites in the field. Start sampling at least 50 m into the field, and include samples from well into the field to enable a representative average field population to be calculated.

How to use a beatsheet

Watch a video of sampling chickpeas with a beatsheet (http://www.youtube.com/user/TheBeatsheet)

Place the beat sheet with one edge at the base of a row. On 1 m row spacing, spread the sheet out across the inter-row space and up against the base of the next row. Draping over the adjacent row may be useful for row spacing less than 1m, or where there is canopy closure. It also minimises larvae being thrown off the far side of the sheet. Using a 1 m long stick (dowel, heavy conduit), shake the row vigorously 10 times to dislodge larvae from the plants; size and count larvae on the sheet.

A standard beat sheet is made from plastic or tarpaulin material with heavy dowel on each end to weigh down the sheet. The beat sheet is typically 1.3 m wide by 1.5 m long. The extra 0.15 m on each side catches insects thrown out sideways.

Using a sweep net to monitor helicoverpa

Watch a video of a sweep net being used to sample barley for armyworm. (http://www.youtube.com/user/TheBeatsheet)

A standard sweep net with cloth bag and aluminium handle. With heavy use, the aluminium handle can shear off, so more robust wooden handles are often fitted by agronomists.

Where crops are sown on narrow row spacings, and it is not possible to get a beatsheet between the rows, a sweep net can be used to sample helicoverpa.

Hold the sweep net handle in both hands and sweep it across in front of your body in a 180 degree arc. Take a step with each sweep. Keep the head of the net upright so the bottom of the hoop travels through the canopy. Use sufficient force in the sweep to pass the hoop through the canopy and dislodge larvae.

Take 10 sweeps and then stop and check the net for larvae. Record the number and size of larvae in each set of 10 sweeps. Repeat at additional sites across the field.

Recording monitoring data for decision-making

Keeping records should be a routine part of insect checking. Successive records of crop inspections will show you whether pest numbers are increasing or decreasing, and help in deciding whether a control is necessary.

Insect checking records should include as a minimum:

- Date and time of day
- Crop growth stage
- Average number of pests detected, and their stage of development
- Checking method used and number of samples taken
- Management recommendation (economic threshold calculation)
- Post spray counts

The helicoverpa size chart is an essential reference for decision-making, particularly in chickpea where larval size is taken into account in the economic threshold (beatsheet-based) and is important in ensuring any control action is well targeted against susceptible larvae.

Eggs and very small larvae are not included in the economic threshold for helicoverpa (beat sheet threshold) due to high natural mortality.

***Helicoverpa* larval size categories and actual sizes**

Actual larval size	Larval length (mm)	Size category
	1-3	Very small
	4-7	Small
	8-23	Medium
	24-30+	Large

Eggs

There are no egg thresholds in chickpeas. Relying solely on egg counts for control decisions in chickpea is unreliable. This is largely due to the difficultly in accurately detecting eggs on the chickpea plant. Egg survival through to larvae can also be highly variable so making decisions based on egg numbers is less accurate than those based on larval density.

Use egg counts as an indication of an egg lay event and determine the potential development rate of the helicoverpa. Continue sampling to target small larvae for control

Eggs take 2-5 days to hatch (generally slower in winter than summer due to temperature differences). Newly laid eggs are white. They then turn a brown or off-white colour after a day or two. Eggs very close to hatching are in the 'black head' stage, where the egg is darker in colour and it is possible to see the black head capsule of the developing larva inside the egg. *See picture on page 14 of Insect Ute Guide (Northern Grain Belt).*

Very small larvae

The number of very small larvae, those which have hatched from the egg in the previous 24 hours, are difficult to estimate in the field. Often they are low in the canopy, and remain on leaflets when they fall onto the beatsheet, making them very difficult to see and count. Very small larvae do no economic damage to the crop, their feeding confined to leaves. Early research on helicoverpa has shown that the mortality of very small larvae is very high and their value in chickpea monitoring is probably more likely to be as indicators of an egg lay and potential activity of larger larvae in a week or two. There is a more detailed discussion of why counting and recording very small larvae does not contribute greatly to decision making in the 'Economic Threshold' section.

Economic thresholds for helicoverpa – the cornerstone of decision making

The economic threshold is classically defined as the pest population likely to cause a loss of yield and/or quality equal in value to the cost of control (chemical plus application). At threshold, the impact of the pest is equivalent to the cost of control, so there will only be an economic benefit from controlling the population if it exceeds the economic threshold.

The calculation of an economic threshold is based on these factors: (a) the cost of control, (b) crop value, (c) the average number of insect pests per sampling unit and (d) the potential loss per pest insect.

Economic thresholds for helicoverpa

Economic threshold based on beatsheet sampling (DAFF Queensland, 2007)

- **Vegetative to early flowering:** High populations have no impact on yield or quality. In rare situations, control may be warranted during the vegetative and flowering stages, when pest pressure is extreme and plants are defoliated.
- **Mid-flowering to early podding:** Based on the value of crop loss calculated by the following equation (or refer to the ready-reckoner table below)

$$Yield\ loss\ \ (\$/ha) = \frac{number\ heli\,cov erpa\ larvae\ per\ m^2 \times 2.0{*} \times chickpea\ price\,(\$/t)}{100}$$

* 2.0 g grain consumed per larvae

The equation above has been used to produce the following ready-reckoner table for a range of larval densities, and crop prices. Putting a dollar value on the predicted yield loss, if nothing is done to control the helicoverpa infestation, is a useful way to discuss the economic benefit (or not) of spraying.

Value of yield loss caused by helicoverpa larvae in chickpea, for a range of larval densities (determined by beatsheet sampling) and grain prices. Control is warranted if the cost of control is less than the value of the yield loss predicted.

Chickpea price ($/t)	Value of yield loss ($/ha)				
	1 larva/m^2	2 larva/m^2	3 larva/m^2	4 larva/m^2	5 larva/m^2
200	4	8	12	16	20
300	6	12	18	24	30
400	8	16	24	32	40
500	10	20	30	40	50
600	12	24	36	48	60

An on-line calculator for specific costs of control, larval density and crop value can be accessed from the calculators tab at the Beatsheet website (thebeatsheet.com.au)

To calculate a ready reckoner for economic thresholds (larval density), rather than the value of yield loss, use the following formula:

Economic threshold (# larvae/sampling unit) = C ÷ (D x V)

Where C = cost of control ($/ha)
D = yield loss per larva per sampling unit (kg/ha)
V = Chickpea price ($/t)

Cost of control ($/ha)	Crop value ($/t)							
	200	250	300	350	400	450	500	550
10	2.5	2.0	1.7	1.4	1.3	1.1	1.0	0.9
15	3.8	3.0	2.5	2.1	1.9	1.7	1.5	1.4
20	5.0	4.0	3.3	2.9	2.5	2.2	2.0	1.8
25	6.3	5.0	4.2	3.6	3.1	2.8	2.5	2.3
30	7.5	6.0	5.0	4.3	3.8	3.3	3.0	2.7
35	8.8	7.0	5.8	5.0	4.4	3.9	3.5	3.2
40	10.0	8.0	6.7	5.7	5.0	4.4	4.0	3.6

D = 20 kg/ha

Economic threshold based on sweepnet sampling (DAFWA)

Sweep net based ready-reckoner table (based on DAFWA estimate of potential yield loss per larva/ha of 30 kg). Control is warranted if the cost of control is less than the value of the yield loss predicted.

Chickpea price ($/t)	Value of yield loss ($/ha)				
	1 larva/10 sweeps	2 larva/10 sweeps	3 larva/10 sweeps	4 larva/10 sweeps	5 larva/10 sweeps
200	6	12	18	24	30
300	9	18	27	36	45
400	12	24	36	48	60
500	15	30	45	60	75
600	18	36	54	72	90

Value of yield loss ($/ha) =(# larvae (per 10 sweeps) x 30 x price ($/t))/1000

Dynamic economic thresholds for the northern region

There have been recent changes to the way we discuss economic thresholds for helicoverpa (beatsheet based threshold). The most obvious change in the recommended threshold is that it is no longer a set number of larvae per m^2. Rather it is dynamic, and is responsive to the value of the crop ($/t) and the cost of control ($/ha).

Research by DAFF Queensland entomologists has examined the impact of helicoverpa on chickpea yield and quality. As a result of this work, the potential yield and quality loss that larvae will cause under average field conditions has been quantified.

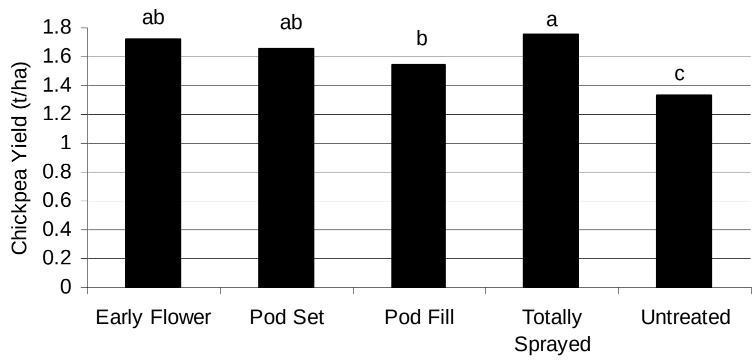
The research in Qld determined the consumption rate of helicoverpa larvae from hatchling to pupation to be 20 kg of grain per ha per larva per square metre (the outcome of the relationship between larval feeding and the compensation by the chickpea plant). Loss attributed to a particular larval density is calculated on the basis that they are large larvae doing maximum damage. The larval density in the relationship was determined using a beatsheet, and the threshold are only accurate for larval density estimates made using a beatsheet.

Making a decision about whether it is economic to spray, based on specific parameters for each management unit (field) is now possible.

Additional information on using the threshold to make a decision

Helicoverpa activity during flowering does not result in yield loss

Data from 6 trials in 2006 (DAFF Queensland) clearly shows that controlling helicoverpa at flowering does not result in a significant increase in yield or quality over delaying control until podset (expanded pods)

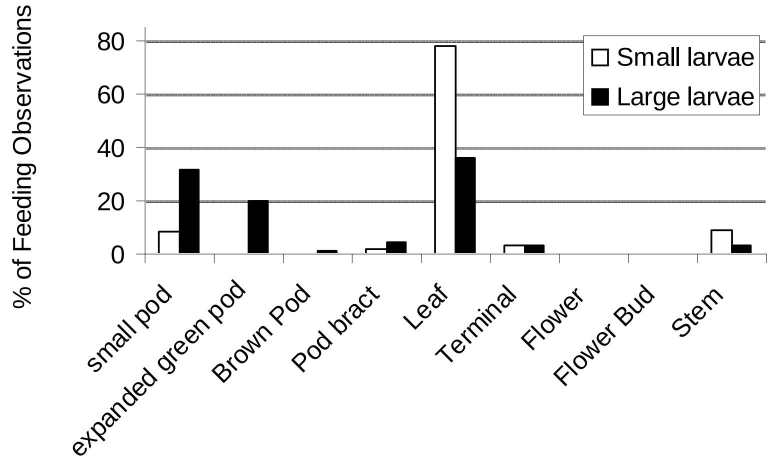


The impact of helicoverpa on chickpea yield when controlled at different stages of crop maturity. Bars with the same letter are not significantly different from each other.

In rare situations, control may be warranted during the vegetative and flowering stages, when pest pressure is extreme. If using products that are only effective against small larvae, it may be necessary to apply a spray during flowering to control a population of small larvae to prevent them causing damage as large larvae during pod set and podfill.

Larval feeding behaviour – how this influences crop damage

Extensive observational studies of small and large larvae in chickpea demonstrate that small larvae are primarily foliage feeders whilst large larvae feed on pods and foliage (see Figure). Neither small or large larvae were observed to have any preference for flowers which supports the data that show no yield loss is incurred when helicoverpa larvae are tolerated during flowering.

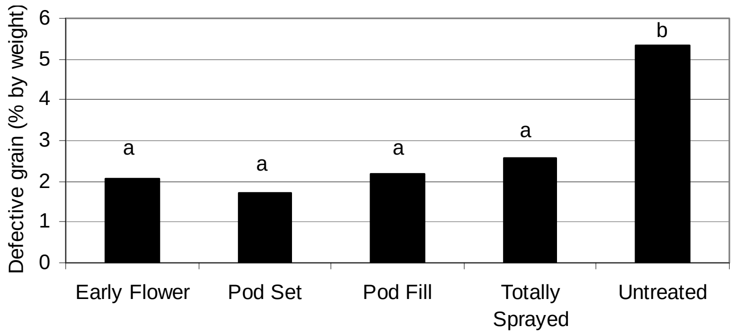


The feeding preferences of small and large helicoverpa larvae on chickpea when allowed to select feeding sites over a 4-6 hour period. Small larvae were third instar, large larvae were 4^{th}-5^{th} instar.

If using a product that is only effective against early instar larvae (e.g. NPV), then the application of control may be necessary during flowering to prevent damage by large larvae at pod set.

Grain quality

Grain quality is not affected in the range of larval densities for which it is currently economic to spray to prevent yield loss. Recent trials have shown that in the range of 1-4 larvae per m^2 defective grain is well below the level at which discounts/penalties apply (6% by weight, NACMA). Similarly, in the time of spraying trials, there was no significant decline in grain quality other than in the plots that were untreated. Given this result, we can be confident that within the range of larval densities for which it is economic to control, and with the recommendation to withhold treatment until late flowering or pod set, quality loss does not need to be factored in to the economic threshold.



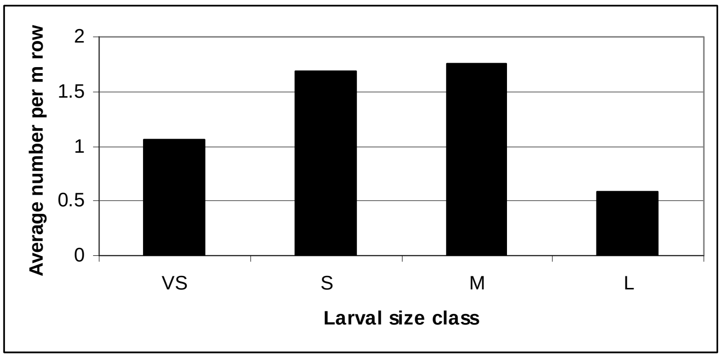
The proportion of defective grain (% by weight) did not increase when helicoverpa larvae were tolerated during flowering. Bars followed by the same letter are not significantly different from each other.

Helicoverpa larval densities in the range of 0-4 larvae per square metre (m^2) do not significantly reduce grain quality, measured in terms of the percentage of defective grain (NACMA, 2006).

It is worth keeping in mind that there is anecdotal information that suggests that larvae will cause significantly more pod damage in exceptional circumstances (e.g. extremely high temperatures, extreme crop moisture stress), however, there has been no trial work to determine to what extent this does occur.

The natural mortality of larvae is high

The number of large larvae recorded in unsprayed situations, is always considerably lower than the number of small larvae recorded in earlier checks. This indicates that there is significant mortality of small larvae. Recent trial work has shown that over 19 sites from CQ to the Downs, there was an average loss of 70% of larvae from small to large in the untreated plots. In other words, only one third of the number of small larvae recorded survived to become large. In previous studies of helicoverpa larval feeding behaviour, large larvae were found to do the majority of damage, in the order of 80%, with medium contributing about 15% and other instars the remainder. We would expect this to be similar for chickpea.



Average numbers of helicoverpa larvae in the different age classes in untreated chickpea. Data are averaged across 19 sites across central Queensland and the Darling Downs.

This natural mortality (most likely as a result of dislodgement from the plant, disease, cannibalism) is important because it means that there is a proportion of the population that will not survive to cause damage to the crop, even if they are not controlled. Conservatively, we estimate that the number of small (larvae <7 mm) found in a field sample can be adjusted for natural mortality by assuming 30% of them will not survive to cause significant damage as medium and large larvae. Estimating the number of very small larvae (VS) is very difficult and unreliable in the field, and we are suggesting that the inclusion of these larvae in estimates of the population is potentially misleading. Whilst our data show that there is overall an average 70% mortality across a large number of fields, the average is calculated from a range of mortality from 1% through to 99%; so we know that mortality will vary considerably from field to field – this is why we have been conservative in suggesting a 30% mortality adjustment rather than a 70% adjustment.

In practice this means that in calculating how many larvae per m2 are in a field, the following equation is used:

$$Number\ per\ m^2 = \frac{(S*0.7)+M+L}{row\ spacing\ (m)}$$

- Where S = small, M= medium and L= large larvae
- number of larvae is based on the number per metre of row, assessed with a beat sheet
- 0.7 multiplier = 70% surviving population
- Dividing by the row spacing (in metres) adjusts the density for different row spacing.

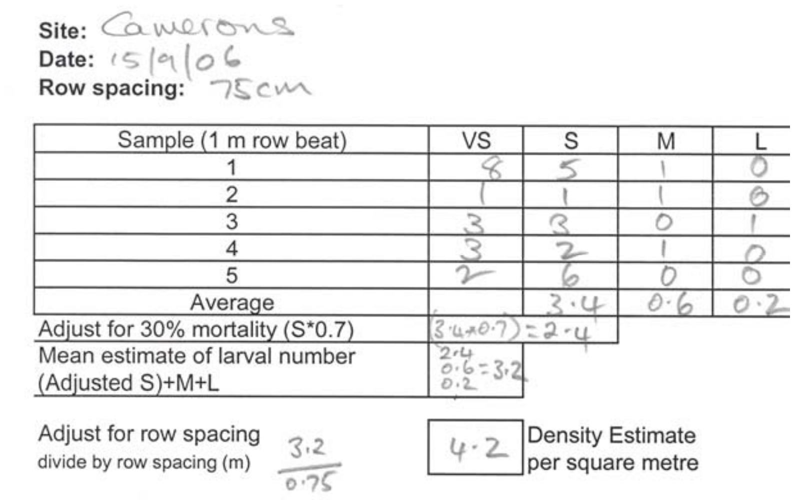
What we don't know

- At present there are no data on the behaviour of larvae in extremely moisture stressed crops versus crops with adequate soil moisture. This means that we cannot say with any certainty whether there is more, or earlier, flower and pod feeding when foliage appears to be less attractive.
- Nor do we have any data that compare the feeding behaviour of *H. armigera* with that of *H. punctigera* – The question remains as to whether the different species have differing preferences for leaves, flowers and pods.

Large helicoverpa larva feeding on a chickpea pod.

Using helicoverpa economic thresholds – an example

Example of a field check sheet with sampling data recorded for helicoverpa larvae in chickpea.



Site: Camerons
Date: 15/9/06
Row spacing: 75cm

Sample (1 m row beat)	VS	S	M	L
1	8	5	1	0
2	1	1	1	0
3	3	3	0	1
4	3	2	1	0
5	2	6	0	0
Average		3.4	0.6	0.2
Adjust for 30% mortality (S*0.7)	(3.4*0.7) = 2.4			
Mean estimate of larval number (Adjusted S)+M+L	2.4 0.6 0.2 = 3.2			

Adjust for row spacing
divide by row spacing (m) 3.2 / 0.75

4.2 Density Estimate per square metre

In this field there is an average of 4.2 larvae per m^2 (adjusted for mortality of small larvae). Assuming a chickpea price of $400/t the table of potential yield loss shows the cost of not controlling to be $32/ha.

In this example, if the cost of control is less than $32/ha then it is economic to spray.

Chickpea price ($/t)	Value of yield loss ($/ha)				
	1 larva/m^2	2 larva/m^2	3 larva/m^2	4 larva/m^2	5 larva/m^2
300	6	12	18	24	30
400	8	16	24	32	40
500	10	20	30	40	50
600	12	24	36	48	60

Making a decision to control

In making a decision whether to spray, there are a number of factors (in addition to number of larvae) that will influence the decision, timing and product choice. These include:

- Age structure of the larval population may need to be considered in relation to time to desiccation or harvest. For example, a late egg lay is unlikely to result in economic damage if the crop is 7-10 days away from harvest.
- Proportion of *H. armigera* and *H. punctigera* making up the total helicoverpa population. Visual identification, time of year, pheromone trap catches and local experience.
- Spray conditions and drift risk
- Insecticide options, resistance levels for helicoverpa and recent spray results in local area.
- Residual of the products

Selecting control options

We are very dependent on insecticides for the management of helicoverpa in chickpea, and the high usage of a limited group of compounds against successive pest generations imposes severe selection pressure. Invariably, we select individuals in a population that are not killed by normal application rates of insecticides. With continued insecticide application, the frequency of resistant individuals in the population increases, leading to field control failures.

The potential for natural enemies of helicoverpa (predators, pathogens and parasitoids) to limit the development of damaging larval populations is typically low in chickpeas, and also influences product selection.

'Spray small or spray fail'

Spraying should be carried out promptly once the threshold has been exceeded. Insects grow rapidly under warm spring conditions, and a few days delay in spraying can result in major crop damage and increased difficulty in control. This is particularly so for *Helicoverpa armigera*.

If a spray application is delayed for more than 2 days, for any reason, the crop should be rechecked and reassessed before any control action is implemented.

A helicoverpa larva inside a chickpea pod. Larvae that are not controlled when they are small can cause major crop damage.

Key considerations

Chickpeas provide the first host for *H. armigera* each season

Traditionally, control options were carbamates and pyrethroids. Resistance to pyrethroids is generally high and spray failures may occur if the population is predominantly *H. armigera*. Recent seasons have seen carbamates perform more reliably as their use in other crops (e.g. cotton) has declined. *Helicoverpa punctigera* is currently susceptible to all chemical groups. Both species are currently susceptible to indoxacarb and the biopesticides, NPV and Bt.

Beneficial insects make little contribution to helicoverpa control in chickpeas

Malic acid on the chickpea leaves has a repellent effect on many species, especially wasps such as *Trichogramma* and *Microplitis*. The group of parasitic flies called tachinids have been recorded parasitising helicoverpa in chickpeas. The tachinid fly lays its eggs on the helicoverpa larva, usually near the head capsule (see pages 124-125 in the Northern region Ute Guide). The tachinid larva then feeds and develops inside the *Helicoverpa* larva, and the adult fly emerges from a cocoon in the mature helicoverpa larva or pupae. Tachinid flies usually kill late instar larvae, therefore larvae will cause crop damage before they die. For this reason, tachinids have no effect on the damage that larvae can do to a crop, and their presence does not influence the estimate of larval numbers in the crop.

Resistance management underpins product efficacy

The threat of resistance development to new products will influence their future use patterns. It is likely that chemical companies will avoid season-long use of a single product in a sequence of crops to minimise the likelihood of resistance developing.

The Australian cotton industry has a voluntary Insecticide Resistance Management Strategy (IRMS) that incorporates all insecticides registered for use in cotton. Currently the grains industry does not have an IRMS, although CropLife has insecticide resistance management strategies for a number of crops (http://www.croplifeaustralia.org.au/default.asp?V_DOC_ID=1952).

Steward™ and the IRMS

Until 2012, indoxacarb use in chickpeas was restricted to avoid lengthy exposure of helicoverpa in the farming system (cutoff of 15 October (for warm areas), for hot areas (September 15) and cool areas (October 30).

This restriction has now been lifted as use patterns in chickpea are, in most seasons, consistent with the recommended window for each region.

Broader management considerations

- **Close monitoring can pay off.**
  In many cases the larval infestation may not progress past the 'smalls' stage and therefore control is unwarranted. Regular close checking, and reference to records from successive checks, will enable you to determine larval survival.

Small larva feeding on exposed sites and vegetative growth as pictured are easily targeted with sprays.

- **Aim for one well-timed spray.**
  Chickpea can tolerate moderate to high numbers of helicoverpa larvae (10-20 larvae/m^2) through late vegetative and early flowering growth stages. Most yield loss will be sustained from damage caused during pod fill, and this is the most critical stage for crop protection. Larval infestations are likely to be of mixed ages by the time the crop is well into podding. Products like Steward™ and Larvin® will adequately control a wide range of larval sizes, and offer around 10-14 days residual protection if applied to plants that are not actively growing.
  - The presence of *H. armigera* will influence management decisions. The helicoverpa emergence model is available through the COTTASSIST website (http://cottassist.cottoncrc.org.au/DIET/about.aspx).
  - The use of pheromone traps in spring and close visual inspection of larvae provide information on the likely presence of *H. armigera* in chickpeas as the season progresses.
  - Biopesticides (NPV and Bt) must target smaller larvae (preferably less than 7 mm in length). Therefore, in situations with high larval densities across a range of size classes, biopesticides are not the preferred choice. For more information, see the DAFF Queensland brochure "Using NPV in field crops."(http://thebeatsheet.com.au/resources/)
- **Keep pod damage in perspective.**
  While larvae and their damage may appear very evident in a crop, counts of damaged and undamaged pods will give an estimate of actual yield loss accumulating (1 damaged pod per m^2 = 1.7 kg/ha yield loss). In most cases relative pod damage is far less than initial visual inspections suggest, so careful monitoring of damage, in relation to total pod load, is recommended. Once pods are damaged, the yield is already lost; pod damage is not useful in making control decisions to prevent yield loss.
- **Be aware of withholding periods.**
  Both Steward™ and Larvin® have long withholding periods (21 days), as do some other products. Be aware that late sprays of these products could delay the harvest date.
- **Resistance management is vital.**
  The grains industry is heavily reliant on a limited number of effective insecticides for helicoverpa, particularly *H. armigera*. Abiding by key insecticide resistance management strategies is good practice:
  - Target small larvae to maximise efficacy
  - Be aware of the probability that the population will contain *H. armigera* and select insecticides accordingly
  - If more than one application is made in a crop, rotate insecticide groups
  - Where spray failures are suspected, do not re-treat with the same product.
- **Check compatibility of insecticides with fungicides** if planning to use together. Mixing fungicides with insecticides is becoming more common due to the fungicide spray programs recommended for ascochyta control. There are some product formulations that are NOT compatible with available fungicides.

Area-wide management strategies for helicoverpa – the role of chickpeas

When assessing whether to control helicoverpa in a chickpea crop the decision is usually made only on the basis of potential yield loss in that crop.

Reducing the overall size of the helicoverpa population on a regional basis is the aim of an area-wide management strategy. It is a move from the paddock by paddock control of helicoverpa, to an approach where neighbours and their agronomists are communicating and co-operating to reduce helicoverpa numbers wherever they can.

Some tactics that may be considered in the context of an area-wide management (AWM) approach and that relate to helicoverpa management in chickpea are:

- Reducing the spring *H. armigera* generation in commercial chickpea crops, and minimising the carryover of moths from chickpeas to susceptible summer crops
- Insecticide resistance management

These are discussed below.

Chickpeas can host the first generation of *Helicoverpa armigera*

It is well recognised that chickpeas provide a host for the first generation of helicoverpa in spring. *Helicoverpa armigera* emerge from diapause from late September to October. Variations in temperature in temperate regions will mean a variation in emergence from year to year, and region to region; the warmer the temperatures the earlier helicoverpa moths will emerge. Commercial chickpea crops that are still at flowering and pod fill stages will be attractive to helicoverpa.

To avoid peak *H. armigera* pressure in commercial chickpeas, plant early and consider desiccation of the crop to avoid excessive regrowth and prolonged attractiveness to helicoverpa.

Most larvae developing during normal pod fill will emerge as moths before harvest, so pupae busting of these crops is of little benefit. Where there are late larval infestations, cultivation soon after harvest will kill many pupae. Using larvae checking records and the helicoverpa development estimates (see Appendix 1) it is possible to estimate the time frame for effective 'pupae-busting'. Left too long, the pupae will emerge as moths and move into other crops.

These strategies will help to reduce the build-up of the first generation of helicoverpa within a farming region.

Appendix 1 Predicted helicoverpa development times in temperate regions.

APPENDIX 1. Predicted heliothis development times based on HEAPS model simulations using long term average daily temperatures. Note that insects are presumed to begin at half-way through the initial stage on the starting date. Also note that in any given period temperatures may vary substantially from the long term averages, and therefore this table should be used as a guide only.

Starting date and stage		Central NSW Predicted days until...			North West NSW Predicted days until...			South West Qld Predicted days until...			Darling Downs Qld Predicted days until...			Central Highland Qld Predicted days until...		
		Large	Pupa	Moth	Large	Pupa	Moth	Large	Pupa	Moth	Large	Pupa	Moth	Large	Pupa	Moth
9 Sept	W. egg	34	53	78	34	52	74	29	45	64	32	50	70	22	35	51
	Small	13	38	64	12	35	62	12	30	52	12	34	59	9	24	42
	Medium	5	28	56	5	27	55	5	24	48	5	26	54	4	19	38
	Large	-	14	46	-	13	41	-	13	40	-	13	41	-	10	30
16 Sept	W. egg	32	50	75	32	49	69	27	42	60	30	47	66	20	31	47
	Small	12	34	61	12	34	59	10	28	48	12	32	56	9	22	39
	Medium	5	27	54	5	25	53	5	21	44	5	25	51	4	17	35
	Large	-	13	43	-	13	41	-	11	37	-	11	39	-	9	28
23 Sept	W. egg	30	47	70	30	47	66	24	38	56	27	44	63	19	31	46
	Small	12	33	59	11	32	56	9	26	46	11	29	51	7	20	36
	Medium	5	25	52	5	25	51	4	20	41	5	23	47	3	15	32
	Large	-	13	41	-	11	39	-	10	34	-	11	39	-	8	26
30 Sept	W. egg	29	47	64	28	43	62	22	35	52	27	42	61	18	29	43
	Small	10	30	55	12	31	53	9	25	43	9	27	47	7	18	34
	Medium	5	24	51	5	24	48	4	19	39	5	21	44	3	15	31
	Large	-	10	38	-	10	38	-	9	31	-	10	36	-	7	24
7 Oct	W. egg	27	44	63	26	42	60	21	33	49	25	39	58	16	27	41
	Small	11	29	54	10	27	48	9	23	41	9	26	45	6	18	33
	Medium	5	23	48	4	22	44	4	18	36	4	20	40	3	14	29
	Large	-	11	38	-	10	36	-	9	29	-	10	34	-	7	23
14 Oct	W. egg	26	41	59	24	39	57	19	31	46	23	37	56	16	26	40
	Small	9	26	49	10	27	46	8	21	38	9	25	44	6	17	31
	Medium	4	20	44	4	20	41	3	16	34	4	19	38	3	14	28
	Large	-	10	37	-	10	34	-	8	27	-	9	31	-	7	22
21 Oct	W. egg	24	39	55	23	36	53	19	30	44	20	33	52	15	25	39
	Small	9	27	46	9	25	43	7	19	35	9	23	42	6	16	30
	Medium	4	19	42	4	19	38	3	15	32	4	18	37	3	13	27
	Large	-	9	34	-	9	31	-	8	26	-	9	28	-	6	21
28 Oct	W. egg	23	37	54	20	33	49	17	28	42	19	32	49	15	25	38
	Small	9	25	44	8	23	41	6	18	33	7	21	40	6	16	30
	Medium	4	20	39	3	18	36	3	14	30	4	16	35	3	12	26
	Large	-	9	34	-	7	28	-	7	24	-	8	27	-	6	20
4 Nov	W. egg	22	35	50	19	31	46	17	27	41	19	31	47	15	25	37
	Small	9	25	41	8	21	38	7	18	32	7	20	39	6	16	29
	Medium	3	18	37	3	17	35	3	14	28	3	16	35	2	12	26
	Large	-	10	30	-	8	27	-	7	23	-	8	27	-	6	20
11 Nov	W. egg	21	33	49	18	30	44	15	25	38	19	31	45	15	24	36
	Small	9	23	40	7	20	36	6	17	31	7	20	37	6	16	28
	Medium	3	18	34	3	15	32	3	13	27	3	15	33	2	12	25
	Large	-	9	28	-	8	26	-	7	21	-	8	27	-	6	20