Sorghum insect pest management

Northern grains region

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Department of **Agriculture, Fisheries and Forestry**

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Overview of insect pest management in sorghum

Sorghum is susceptible to insect pests from emergence to late grain fill. Early sorghum pests include armyworms and soil insects. These pests are normally present in a grain sorghum crop in low numbers where their damage can be tolerated. However, seasonal conditions can sometimes stimulate the build up of a large population of one or more of these and they can cause significant damage.

Seed dressings to combat soil insects are now commonly available and may be the most effective control as well as the least disruptive to natural enemies.

The build up of pests, such as aphids and rutherglen bugs, can be reduced by choosing open-headed type sorghum hybrids. These insects appear to thrive in compact or closed panicle types where they are hard to control due to the difficulty of achieving good spray penetration; and may be protected from natural enemies.

It is now possible to implement an integrated pest management (IPM) strategy to control helicoverpa and midge on sorghum through the use of:

- the Nucleopolyhedrovirus (NPV) that is selective for helicoverpa, and preserves beneficial insects that further reduce the risk of pest outbreaks. Sorghum is a source of egg and larval parasitoids for the cropping system.
- strategic use of midge-tolerant hybrids
- an area-wide management approach to helicoverpa which minimises early buildup in chickpea and other winter hosts, and includes pupae busting late sorghum crops to reduce the carryover of pupae from one season to the next (particularly from summer to the following spring)
- management of non-crop hosts of sorghum midge (Johnson grass) in spring

Major pest - *Helicoverpa armigera*

Although larvae are often present in vegetative crops, helicoverpa rarely cause economic loss at this stage of crop development. The feeding activity can be highly visible, with 'shot holes' in the unfurling leaves and frass (caterpillar poo) in the whorls. However, in some seasons large helicoverpa larvae will move from feeding on foliage to heads; causing significant damage to developing grain.

The majority of helicoverpa eggs are laid on heads as they emerge, and before they flower. The larvae resulting from these eggs cause the economic damage to the sorghum crop from early grain fill.

Small larvae (less than 10 mm long) feed on the pollen sacs in the flower head where they cause little damage. Larger helicoverpa larvae feed on developing seed.

Larvae of helicoverpa may be confused with sorghum head caterpillar and yellow peach moth. Both these pests can be monitored along with helicoverpa. Sorghum head caterpillar is distinguished from heliocoverpa infestations by the presence of webbing. There are no thresholds for sorghum head caterpillar, and small infestations are likely to be controlled by predation. The yellow peach moth threshold is around 0.4x the helicoverpa threshold.

Helicoverpa damage to whorl and emerging leaf.

Characteristic 'shot holes' in sorghum leaf caused by helicoverpa feeding in the whorl.

Sorghum head caterpillar.

Yellow peach moth larva and moth.

Monitoring for helicoverpa

Monitor for helicoverpa from head emergence through to early grain fill.

Spinning a sorghum head into a bucket to determine

Monitoring for larvae

- Determine helicoverpa larvae numbers by beating five heads into a bucket hard enough to dislodge larvae. Count larvae in the bucket and work out an average per head. Repeat across the field.
- Determine larval sizes (important for control decisions).

Monitoring eggs and egg parasitism

In some instances it may be necessary to monitor eggs. For example, if there is egg lay, but few larvae eventuating it may be of interest to determine whether there is significant parasitism of eggs occurring. Eggs are not a good indicator of subsequent larval numbers because mortality highly variable.

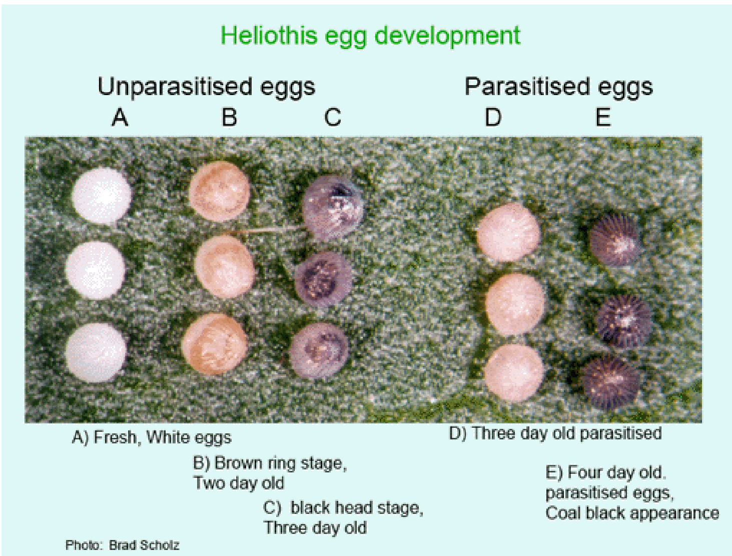
Helicoverpa eggs and 1st instar larva.

The majority of eggs are laid on heads as they emerge from the boot, before they start flowering.

- Cut heads hold in a bucket. Spin the stalk between your hands to dislodge eggs. Eggs will be easily visible against a dark background.
- Newly laid eggs are white. Unparasitised eggs develop a brown ring within 2 days, and then the head capsule of the developing larva is visible 1-2 days later.
- To assess parasitism, collect eggs and hold at room temperature for 4 days (in a container, or stuck to sticky tape). Parasitised eggs turn black, unparasitised eggs develop normally.

Egg and hatchling mortality can be extremely high in sorghum as a result of dislodgement by rain and wind, parasitism and predation Cannabalism by larger larvae can also be significant.

Minute pirate bug (*Orius* spp), a predator of helicoverpa eggs and small larvae.



Signs of helicoverpa activity in sorghum during grain filling

In addition to finding larvae, other visible signs of helicoverpa activity are usually evident. Larvae tend to 'shear' the top off developing grain, and frass (caterpillar poo) may be visible in leaf axils and on the ground around the base of plants. Early instar larvae (1-4th) feed on anthers, around 80% of crop damage is caused by 5-6th instar larvae (medium – large).

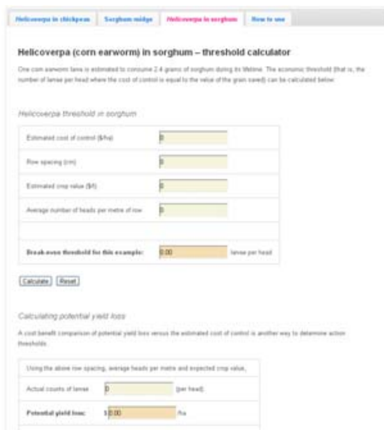
Helicoverpa damage to developing grain (left), caterpillar frass evident in and around helicoverpa-infested plants (centre and right).

Thresholds

- It is estimated that each helicoverpa larva will, from 1st to 6th instar cause a yield loss of 2.4 g (equivalent to 24 kg/ha at 1 larva/m^2. The majority of this damage is done by the 5th and 6th instars.
- The threshold for control varies with grain prices and cost of control. The critical number of insects per head is the number of insects that can eat more dollars worth of grain than the cost of spraying. Control is recommended when insect numbers are at or above the critical threshold level.
- The critical helicoverpa larvae number can be calculated with the following formula:

  No. larvae/head = (C x R) ÷ (V x N x 2.4)

  where
  C = cost of control ($/ha)
  R = row spacing (cm)
  V = value of crop ($/tonne)
  N = number of heads/metre of row
  2.4 = weight of sorghum (grams) lost per larva



An online threshold calculator (pictured right) is available at the Beatsheet website (thebeatsheet.com.au) to assist with making management decisions about helicoverpa in sorghum using parameters specific to your management units.

Alternatively, use the ready-reckoner table (next page) to estimate the economic break even point.

Helicoverpa yield loss in sorghum ready-reckoner. The economic break-even point is reached when potential yield loss (if no action taken) equals the cost of control.

Sorghum price ($/ha)	Value of potential crop loss ($/ha)*			
	0.25 larvae/head	0.5 larvae/head	1.0 larvae/head	2.0 larvae/head
100	6	12	24	48
150	9	18	36	72
200	12	24	48	96
250	15	30	60	120
300	18	36	72	144

*based on yield loss of 2.4 g per larva

Management considerations for helicoverpa in sorghum

Insecticide resistance is a major consideration in determining a management approach because *Helicoverpa armigera* is the only helicoverpa species that attacks sorghum.

- Persistently high levels of resistance to the synthetic pyrethroids means that these products cannot be relied on, and are not recommended for helicoverpa control in sorghum.
- The use of synthetic pyrethroids for the control of sorghum midge will incidentally select for resistance in helicoverpa
- The use of synthetic pyrethroids in sorghum will kill beneficial insects including predators and parasitoids of eggs and larvae. Killing beneficial insects will increase the likelihood of helicoverpa survival and crop loss.
- Carbamates have variable levels of resistance, and will often decline in efficacy as the season progresses. Carbamates have a useful fit in helicoverpa management as they can be effective against large larvae that have escaped an NPV, or where a product with short withholding period is required.

Crop uniformity has a big impact on pest management in sorghum. Uniformity influences the following:

- 80% of helicoverpa eggs are laid in heads as they emerge from the boot, and prior to flowering. In a uniform crop, there will be little spread of larval size as the majority of eggs will have been over jus a few days.
- Efficacy of NPV is greatest where it is well targeted at larvae < 7 mm in length. Where there is minimal spread in larval ages, the timing of a spray is a relatively simple decision. A spread in ages may necessitate more than one application, or the use of NPV and another product to control larger larvae.

Using NPV in sorghum

- NPV is most effective against small larvae (less than 7 mm). Avoid targeting larvae over 13 mm.
- NPV must be ingested by the larvae to kill them
  - Crop coverage is critical for an ingestion product to maximise the likelihood of larvae encountering treated leaf material.
  - Spray when larvae are actively feeding (temperatures between 25°C and 35°C). Feeding may not occur if temperatures are below 15 °C.
  - Maximum uptake of product occurs within 1 hour of application.
  - At temperatures below 18 °C, time to death will be extended (insect growth is dependant on temperature)


Helicoverpa larvae killed by NPV.

- Apply NPV when about 50% of the sorghum panicles have completed flowering (see label for instructions).
- As with any other insecticide, only 80-90% control will be achieved, so be aware when applying to extremely high populations (>20 larvae/head) that the population may still exceed threshold post treatment. In these situations, rechecking is essential to ensure significant crop loss does not continue to occur after treatment.
- NPV is does not have off-target impact on beneficial insects.

For more detailed information on the use of NPV on the DAFF Queensland brochure "Using NPV to manage helicoverpa in field crops" (http://thebeatsheet.com.au/resources/), or the AgBiTech website (http://www.agbitech.com/).

Natural enemies (beneficial insects)

The combined action of natural enemies can have a significant impact on potentially damaging helicoverpa populations. It is therefore desirable to conserve as many of the natural enemies as possible. Natural enemies of helicoverpa include predators of eggs, larvae and pupae, parasites of eggs and larvae and caterpillar diseases.

A large number of predatory bugs and beetles attack helicoverpa eggs and larvae, including damsel bugs, big eyed bug, ladybeetles, glossy shield bugs, spined predatory shield bug and assassin bugs. Other predators of helicoverpa eggs and larvae are ants, spiders and lacewings. Predatory earwigs and wireworm will feed on pupae in the ground.

Parasitoids and parasites include the wasp parasitoids *Trichogramma* spp (egg parasitoids), *Microplitis* and *Heteropelma* (larval parasitoids), *Ichneumon* (pupal parasitoids) and the parasitic tachinid flies that parasitise larvae.

Monitoring beneficial insects

The predatory species can be sampled along with helicoverpa – either through visual inspection or when beating/spinning heads into a bucket to assess egg and larval numbers. Parasitoids are sometimes visible flying in the crop, particularly the larger species (*Heteropelma* and *Ichneumon*). To make an assessment of the impact of parasitoids on the helicoverpa population it is necessary to assess the proportion of the population that has been parasitised. Helicoverpa eggs can be collected and held at room temperature for 4-6 days, checked for normal emergence of larvae or blackening (evidence of *Trichogramma* parasitism). See section on "egg parasitism" above for images of parasitised and unparasitised eggs. *Microplitis* parasitism can be assessed by splitting medium larvae (15 mm) and looking for the developing wasp larva inside the helicoverpa larva.

Parasitised helicoverpa larva 'split' to show developing *Microplitis* larva inside (circled).

See the DAFF brochures on helicoverpa parasitoids "Parasitoids: natural enemies of helicoverpa" and specifically *Microplitis demolitor* (http://thebeatsheet.com.au/resources/).

More detailed information on natural enemies of helicoverpa, including images of each and information on monitoring and identifying them, visit the DAFF IPM pages (http://www.daff.qld.gov.au/26_3510.htm).

Pupae busting

In some seasons, late sorghum can host large numbers of helicoverpa larvae that will overwinter as pupae in the soil, emerging the following spring. A basic rule of thumb for identifying fields at risk of harbouring diapausing pupae, is that any crop with larvae present past mid-March is likely to have diapausing puape. To be effective, pupae busting (cultivation to a depth of 10 cm) must be completed by the end of August, before moths start to emerge in spring.

There are several key benefits of pupae busting. First, it is a key tool in managing insecticide resistance in the *H. armigera* population. Preventing the carryover of helicoverpa that have been exposed to synthetic pyrethroid and carbamates in sorghum to spring chickpea, wheat and canola has major benefits. Second, pupae busting will reduce the overall *H. armigera* population in a region, reducing the pest pressure in spring crops.

Major pest - sorghum midge (*Stenodiplosis sorghicola*)


Sorghum head severely affected by midge (left) showing a large proportion of glumes without developing grain. Compare with a relatively unaffected head (right).

Management of sorghum midge requires an integrated approach to maximise effectiveness. Midge resistant hybrids offer benefit to growers, particularly in terms of increased flexibility that allows for late season crops when midge pressure is high. Midge resistance also offers benefits in a season when crop uniformity is affected and the crop is likely to have an extended flowering. Current midge resistant hybrids are bred to make it physically more difficult for female midge to lay eggs in the floret. The midge resistance rating scheme has been adopted by all sorghum breeding companies so growers know what the likely benefit will be, and can select a variety to suit their planting situation.

However, many growers elect to grow lower midge rated varieties with higher yield. Consequently, sorghum midge management is still heavily reliant on the use of synthetic pyrethroids to control midge in-field.

The midge lifecycle varies from 2-4 weeks, depending on temperatures. This allows many generations to occur in one season and accounts for the rapid build-up of extremely high midge densities especially where the flowering period of sorghum is extended by successive plantings. Adult female midge lay their eggs inside sorghum florets where chemicals cannot reach. Insecticides only target the adult midge as they move about the crop and do not kill the eggs or hatched larvae that are already present inside the sorghum florets.

Sorghum midge control may require several insecticide applications during flowering, particularly for late planted crops which flower when midge pressure is high or in crops where flowering is staggered and heads are susceptible to midge over a period of weeks.

Monitoring for midge

Often the first midge seen are caught in spiders webs in the field – a sign that midge are active. While midge adults only live for one day, they do most of their egg laying (and subsequent damage to the crop) in the morning. Generally, peak midge activity occurs between 9 and 11 am, and this is the best time to look. However changes in weather can bring midge into a field from surrounding areas (Johnson grass, earlier sorghum crops) at any time of day. Midge numbers can vary widely both within a crop and between plants. This variation makes the thorough sampling critical to estimating midge abundance.

Sorghum heads are most attractive to midge at mid flower. It is not uncommon to see double or triple the number of midge on panicles at early-mid flower compared with the end of flowering.

At lower midge densities, adult flies will move around and lay almost exclusively on the flowering portion of the panicle.

Female sorghum midge laying eggs in sorghum floret.

Midge flies are only 1-2 mm long, and it is very easy to underestimate midge numbers if you are not careful. The easiest way to 'get your eye in' is to look at the top half of mid flowering panicles and look for movement of the small red flies against a still sorghum panicle looking from side on and slightly above side on one section of the sorghum panicle at a time. Keep your eyes focused over a couple of branches of florets for several seconds at a time to detect female midge walking around the branch or bobbing up and down probing their ovipositor into each floret. On windy days you may have to hold each head still and shelter the panicle with your body before examining each panicle. Alternatively, beat heads into a bucket and count the number of midge dislodged per head.

Monitor for midge over 10 metres of row in at least 4 different locations in your crop.

To minimise the risk of economic damage, monitor very closely for midge numbers every day during head emergence and flowering, and know what your spray threshold for midge is before the midge turn up.

Sorghum midge damage is evident by white pupal cases that stick out of the tips of glumes.

As the season progresses, previous midge activity can be evident by the presence of pupal cases sticking out of affected glumes (see picture right). The pupal case is left behind as the adult midge emerges from the glume where it has completely consumed the developing seed during larval development. Looking for signs of midge activity can be important in determining causes of poor seed set.

Sorghum midge parasitoid, *Eupelmus* spp. May be confused with midge when monitoring sorghum.

In later crops you may also start to see the black midge parasitoid, *Eupelmus* spp. Whilst it can be present in reasonably large numbers, this parasitoid does not occur early enough to prevent midge from causing damage. It can also be confused with midge, so be sure to look for the reddish abdomen of the midge, not just little black 'flies'.

Economic thresholds

Thresholds vary with the resistance levels of the hybrids as well as commodity prices and the cost of insecticides. Threshold levels can be calculated using the factor of 1.4 g of grain destroyed per egg-laying adult. On susceptible hybrids this level is usually about one adult per head.

For your specific costs of control, midge rating and crop price you can use the on-line midge threshold calculator at thebeatsheet.com.au (pictured right) or refer to the ready-reckoner table below.

Estimate of the value of yield loss for a range of midge resistances and crop values. The estimate shows the likely economic loss if no control is implemented.

Midge rating of hybrid	Estimated yield loss (t/ha)*	Economic value of yield loss at a varying sorghum prices			
		$160/t	$200/t	$250/t	$300/t
1 midge per panicle					
Susceptible (rating 1)	0.52	42	104	130	156
3 Rating	0.18	14	36	45	54
5 Rating	0.10	8	20	25	30
7 Rating	0.08	6	16	20	24
8+ Rating	0.05	4	10	13	15
3 midge per panicle					
Susceptible (rating 1)	1.58	252	315	394	473
3 Rating	0.53	84	105	131	158
5 Rating	0.32	50	63	79	95
7 Rating	0.23	36	45	56	68
8+ Rating	0.12	25	24	30	36

Assumptions made in calculations: A crop of 75,000 heads/ha; damage over 4-5 days; all heads exposed to midge over the 4-5 days.

The yield loss estimates in the table assume that spraying results in a 100% kill and that there is no midge damage prior to chemical application. It also assumes that you will receive the same average midge pressures over 4-5 days. In reality research has shown that one well timed insecticide for midge (put on from panicle emergence and before midge even enter the crop) will still only prevent 70-80% damage protection in lower rated sorghum hybrids. In 8 rated hybrids, yield losses can be reduced by over 90% with this spray timing.

The midge resistance rating scheme

The most common means of controlling sorghum midge is through the use of resistant hybrids. Since 1993 all commercial sorghum hybrids have been assigned official midge resistant (MR) ratings from 1-7.

A 7-rated hybrid, when exposed to the same midge density as the susceptible hybrid (rated 1), sustains 7 times less damage. In 2002 the rating system was extended to a new 'open-ended' rating of 8+. Trials have shown that some 8+ hybrids contain levels of resistance that approach 'practical field immunity'. It is worth noting that for 8+ varieties, some are just a little better than 7 while others are 'practically immune'.

Current commercial sorghum hybrids and MR ratings assigned by the Sorghum Midge Tested Scheme (2012).

Hybrid	MR Rating	Seed Company
Enforcer	6	HSR Seeds
Pacific MR 32	6	Pacific Seeds
MR-Striker	6	Pacific Seeds
MR-Eclipse	6	Pacific Seeds
MR-Bazley	6	Pacific Seeds
MR Taurus	6	Pacific Seeds
85G33	6	Pioneer
Dominator	5	HSR Seeds
Venture	5	HSR Seeds
Pacific MR43	5	Pacific Seeds
86G56	5	Pioneer
84G99	5	Pioneer
Liberty White	4	HSR Seeds
MR-Buster	4	Pacific Seeds
84G22	4	Pioneer
85G08	4	Pioneer
Tiger	3	HSR Seeds
MR-Maxi	3	Pacific Seeds

Management considerations for sorghum midge

- Staggered flowering in a crop increases the risk of yield loss caused by sorghum midge. A spread of flowering over 3 weeks can mean midge emerging from early heads will attack later heads. It also means that determining the 'right' timing for treating midge is more difficult, and it will be necessary to treat more than once to protect the heads as they start flowering.
- Midge control is often done in conjunction with an NPV application for helicoverpa or to control Rutherglen bug. Be aware that synthetic pyrethroids will also kill beneficial insects that would otherwise contribute to the control of pest species; helicoverpa and aphids in particular. After treating midge, you may need to be more vigilant in terms of monitoring potential outbreaks of other pests.
- Application of synthetic pyrethroid will incidentally expose helicoverpa, and contribute to selecting for pyrethroid resistant individuals in the population. Consider pupae busting the sorghum crop if it had helicoverpa larvae present after mid March. Pupae busting reduces the size of the insecticide-resistant population carrying over from one season to the next.

Natural enemies

Three small black wasp parasitoids play a role in the control of sorghum midge. They are: *Eupelmus* sp. (pictured), *Tetrastichus* sp. and *Aprostocetus* sp. Their presence in sorghum crops may be recognised by their small round emergence holes in the spikelet.

Minor pests

Monitoring

At establishment

Young plants may be defoliated or killed by feeding caterpillars. Signs of damage include chewed leaf margins and faecal pellets at the base of young plants or in the throats of older plants. The northern and common armyworm feed at night and hide in vegetation during the day.

Conduct ground searches for larvae. Check along planted rows at the base of damaged seedlings and under soil and stubble. Distribution is patchy, so searches at a number of locations are needed. Average the larval count.

In vegetative crops

Larvae typically feed in the whorl, resulting in the 'shot hole' pattern similar to that caused by helicoverpa (see image in the helicoverpa section).

Checking for armyworm in vegetative sorghum is not necessary as they do not cause significant damage to plants at this stage. If there are large numbers of caterpillar larvae evident in late vegetative crops, and the risk of large larvae moving onto emerging heads, dissection of a number of plants across the field to determine which species is present may be warranted.

Natural enemies

Armyworm larvae are attacked by a number of parasitoids that may be important in reducing size of the population. Viral and fungal diseases are recorded as causing mortality of armyworm. Helicoverpa NPV does not affect armyworm.

Crop establishment pests

Soil insects

False wireworms, striate, eastern and southern *Pterohelaeus* and *Gonocephalum* spp.

Damage

Larvae feed on decaying vegetable and crop residues in the soil. They also feed on newly germinating seed and the growing points of seedlings, which results in patchy stands.

Damage is most common in early planted crops where crop residue has become scarce.

During summer, adults may damage young plants, by surface feeding or cutting of the plant at or near soil level. Damage by both larvae and adults may necessitate re-planting.

Risk period

The risk from adults is highest in summer. For larvae the risk is highest for early (September-October) planted crops. Damage may occur if early plant growth is slowed by cool damp weather allowing larvae to remain in the moist root zone. As soil dries they retreat below the root zone.

Monitoring and thresholds

Detection can be difficult - either hand sift 10 soil samples (30 x 30 cm) or place 10 germinating seed baits (GSB) throughout the paddock. One larva per sample warrants control.

Seed bait placed in field prior to planting, just starting to germinate.
The bait will be dug up and examined for wireworm and false wireworm larvae.

Management considerations for wireworm and FWW in sorghum

High mortality of false wireworms can be caused by cool wet weather from autumn to spring. False wireworm beetles are more damaging to seedlings where stubble is buried by cultivation than in crops that are directly drilled into the surface retained stubble. This is because the surface feeding beetles remain feeding on the stubble and not the crop.

- Prepare ground for even and rapid germination.
- Use of press wheels at planting provides some control.
- Clean cultivation during summer dries out topsoil and eliminates weeds that provide food for adults.
- Larvae can be controlled by insecticide applications at planting or insecticide treated seed.
- Control of adults is obtained by baiting with insecticide treated cracked grain broadcast evenly over the surface at or immediately after planting.
- Where broadcasting is not possible, the bait may be laid in trials spaced no more than 2 metres apart

Natural enemies provide little control in situations where the population is large enough to cause damage to crops. However, the activity of a range of predatory, ground dwelling species will impact on the population on an ongoing basis, and may reduce the likelihood of an outbreak.

Cutworms (*Agrotis* sp.)


Cutworm larvae curled in the characteristic C-shape when disturbed.

Several species of cutworm can occur in crops. Brown cutworm - *Agrotis munda*, Bogong moth - *Agrotis infusa*, Black cutworm - *Agrotis ipsilon* and Variable cutworm - *Agrotis prophyricollis*

The common name of cutworm is derived from the larval habit of severing the stems of young seedlings at or near ground level, causing the collapse of the plant. Cutworm larvae typically shelter in the soil during the day. They curl into a 'C' shape when disturbed.

Damage

Cutworm larvae can sever stems of young seedlings at or near ground level. Sometimes the young plant is partially dragged into the soil where the larvae feed on it.

Larvae may also climb plants and browse on or cut off leaves.

Crop areas attacked by cutworms tend to be patchy and the destruction of seedlings in one area may cause cutworms to migrate to adjacent fields.

Risk period is spring and summer - one generation per crop. A weedy fallow prior to sowing can lead to cutworm infestation.

Monitoring and thresholds

- Inspect emerging seedlings being alert to patchiness in the stand, particularly on field edges or weedy patches.
- Treat seedlings when there is a rapidly increasing area or proportion of crop damage (greater than 10% seedling loss).
- Treat older plants if more than 90% of plants are infested or more than 50% of plants have 75% or more leaf tissue loss.

Control

- Cutworms are attacked by a range of natural enemies such as parasitoids, predators and diseases.
- Controlling weeds prior to planting will reduce cutworm infestations.
- Insecticides are used when damage warrants their use.
- Spot spraying of identified patches may suffice. For best results, spray late in the afternoon when larvae are active, or will contact residue as they start to feed.

Black field earwig (*Nala lividipes*)

Black field earwigs are a sporadic pest of sorghum, usually in areas with heavy, black soils.

Damage

- Eat newly sown and germinating seed and the roots of crops below ground, resulting in poor establishment.
- Chew the stems of newly emerged seedlings above ground.

Monitoring and control

- Monitor crops after planting until establishment.
- Use germinating seed baits or digging and sieving to detect adults and nymphs prior to planting.
- Control if more than 50 earwigs in 20 germinating seed baits.
- Grain baits containing insecticide applied at sowing offer best protection.
- Insecticide seed dressings provide some protection.
- In-furrow sprays are not effective in protecting against dense populations.
- Earwigs prefer cultivated soils rather than undisturbed soil (zero till).
- Use press wheels at sowing.

Armyworm

- Northern armyworm - *Leucania separata*,
- Common armyworm - *Leucania convecta*, and
- Dayfeeding armyworm - *Spodoptera exempta*

The northern and common armyworm feed exclusively on grasses, including cereal crops. Armyworm outbreaks typically occur after periods of drought, perhaps because natural enemies that would otherwise keep populations in check are depleted.

Armyworm are active in autumn, feeding on seedlings at establishment and in the whorl of vegetative plants. During the day armyworms shelter in the throats of plants or in the soil and emerge after sunset to feed. The larval stages likely to be encountered are all similar in appearance. Armyworm caterpillars can be distinguished from other caterpillar species like cutworm and helicoverpa by the three white lines that run the length of the body. These white lines are most distinct on the 'collar' just behind the head.

Vegetative – Harvest pests

Corn aphid (*Rhopalosiphum maidis*)

Although other species of aphids may be present on sorghum, the corn aphid is the most common and, in some seasons, present in extremely high numbers. Large outbreaks are rare, and as can be seen from the thresholds, treatment is only necessary under extreme pressure.

Corn aphid in whorl and ladybird predator (*Hippodamia*)

Damage

Adults and nymphs suck sap and produce honeydew. It is rare for a corn aphid population to be high enough to cause direct damage to plants, but extreme numbers can cause plants to turn yellow and appear unthrifty.

The main issue with corn aphid is the production of honeydew in the heads that persists through to harvest. In most seasons the honeydew is washed off by rain, but when it isn't it can cause sticky grain that is difficult to harvest (clogging headers).

Monitoring and thresholds

Visually inspect a number of plants across the field. Inspect leaves and the whorl when vegetative, and the head on more mature plants. Aphid infestations often start on the edges of fields, so ensure to samples are taken from representative areas of the field.

Estimate the percentage of plants infested and the percentage of leaf area covered by aphids. Record the presence of parasitism (mummified aphids) and predators. Natural enemy activity can suppress low to moderate aphid populations.

Vegetative stage: 100% of plants infested with 80% of the leaf area covered by aphids.
On heads: 75% of heads infested, with 50% of the head covered by aphids.

Management considerations for corn aphid in sorghum

- Choosing hybrids with open heads can reduce aphid numbers as these are generally less infested than tight-headed hybrids.
- The application of broadspectrum insecticides (e.g. synthetic pyrethroids, carbamates) for helicoverpa/midge will kill natural enemies including predators and parasitoids of aphids. Early use of insecticides increases the likelihood of an aphid outbreak.

Natural enemies

A range of predators (including ladybird adults and larvae, damsel bugs, bigeyed bugs, lacewings, and hoverfly larvae) will help reduce aphid populations. Parasitoid wasps can be extremely effective in suppressing populations.

More detailed information on natural enemies of corn aphid, including images of each and information on monitoring and identifying them, visit the DAFF IPM pages (http://www.daff.qld.gov.au/26_3510.htm).

Rutherglen bug (RGB) (*Nysius vinitor*)

Until the 2000s, Rutherglen bug was considered a minor pest of sorghum, causing complications with harvest when present in large numbers at the end of the season.

In recent years, RGB has become a more abundant, and is occurring in sorghum earlier. It is now clear that RGB has the capacity to cause significant yield loss through direct feeding on developing grain from flowering to soft dough.

Sorghum head showing premature reddening of grain and dark spots as a result of Rutherglen bug feeding on developing grain from flowering.

Although not well understood, RGB infestations originate from both immigration (from inland regions) and locally generated populations. In some seasons, conditions may be more suitable for local generation, and in others for migration. In severe outbreaks, it may be that both sources contribute, resulting in extremely long periods of influx into susceptible crops.

Damage

- Above threshold infestations at flowering and seed initiation will result in poor seed set, and symptoms similar to midge damage.
- Direct feeding by RGB on developing and filling grain results in premature reddening of the grain and dark spots (feeding wounds). Affected grain may be small, shrivelled and the endosperm does not fill the grain.
- Under wet conditions, the feeding wounds allow bacteria and fungi to enter the seed, further degrading grain quality and severely affecting seed viability (germination).

Monitoring and thresholds

RGB numbers are difficult to estimate once the population exceeds about 50 per head. As the thresholds are lower than this, it is possible to reliably estimate RGB densities through monitoring.

Rutherglen bug adults (left) and nymphs (right).

Monitoring for RGB can be done at the same time as for helicoverpa and midge. Start checking for RGB from head emergence.

- Beat sorghum heads into a bucket and count the RGB. At flowering and early grain fill, the bulk of the population will be adult and extremely flighty. Beating into a ziplock bag is one way to contain the sample for counting before they fly away.
- RGB have a very clumped distribution, with some head having very large numbers, and others with no RGB. Take enough samples to be confident in your estimation of an average field population; at least 10 heads from each of 4 sites across the field.

Preliminary thresholds are proposed. Further field trials are required to validate these thresholds.

- Flowering and milky dough stage: 20-25 RGB/head
- Soft dough stage: 30-50 RGB/head
- Hard dough – harvest: no impact on yield

Thresholds are based on exposure of the heads to the RGB for 7 days. Longer exposure may result in additive loss e.g. 25 RGB for 14 days = 50 bugs for 7 days.

Infestations of adult RGB reduced seed set by 15-20% at densities of 50-100 bugs/head.

Adults and late instar nymphs cause feeding damage, small nymphs do not feed directly on developing grain.

Management considerations for RGB in sorghum

- RGB control, if warranted, should be applied when thresholds are exceeded between flowering and soft dough stages. Later infestations (large populations as a result of breeding) that typically build up prior to harvest do not contribute to yield loss and do not warrant control unless there are concerns about contamination at harvest.
- Sorghum is able to compensate for up to 20% reduction in seed number through the production of bigger seed near those that are lost. Above this level of damage, the crop is unable to compensate.
- There are no soft chemical options for the control of RGB. Repeated influxes of migrating adults can make repeat applications necessary, as will staggered flowering.
- The use of broadspectrum insecticides for RGB control will kill beneficial insects that contribute to the control of other pests including helicoverpa and aphids. Continue to monitor the crop for pest resurgence.

Natural enemies

Egg parasitoids are the most commonly recorded natural enemy of RGB. Their potential contribution to population control will be limited in seasons when there are large influxes of adults. Predation has rarely been recorded, but spiders may play a role.

Spider on sorghum

Sorghum head caterpillar (*Cryptoblabes adoceta*)

This pest in more prevalent in tropical and sub-coastal areas of north-eastern Australia. It may be confused with helicoverpa and yellow peach moth.

Damage

Larvae feed on developing seed, each larva destroys about 0.5 g of grain (approximately ¼ the amount consumed by helicoverpa). They web clusters of seed together.

Monitoring and thresholds

The presence of caterpillars is indicated by webbing of seed clusters, webbing of whole heads and presence of small white/pink excreta. Dislodge larvae for counting by beating heads into a bucket.

Action levels vary with commodity prices and the cost of insecticides. The threshold level can be calculated using the factor of 0.5 g of grain destroyed by the larva in the formula below.

No. larvae/head = (C x R) ÷ (V x N x 0.5)

where
C = cost of control ($/ha)
R = row spacing (cm)
V = value of crop ($/tonne)
N = number of heads/metre of row
0.5 = weight of sorghum (grams) lost per larva

Sorghum head caterpillar infestation showing characteristic webbing and retention of frass in the webbing.

Management considerations for sorghum head caterpillar

- Open-headed sorghum varieties are generally less infested that tight-headed varieties and also allow better penetration of insecticides.
- There are currently no registered products against sorghum head caterpillar but chemicals registered and used for helicoverpa are likely to be effective.

Natural enemies

Parasitic wasps provide some biological control, but are unlikely to control populations above 10 per square meter.

The avoidance of broad-spectrum pesticides prior to flowering may help conserve natural enemies.

Yellow peach moth (*Conogethes punctiferalis*)

This pest may be confused with helicoverpa and sorghum head caterpillar.

Damage

Larvae feed on developing seed. Each larva destroys about 1 g of grain.

Monitoring and thresholds

Count larvae during milky dough stage and by dislodging them from heads by beating into a bucket.

The threshold for yellow peach moth can be calculated using the following formula:

No. larvae/head = (C x R) ÷ (V x N x 1.0)

where
C = cost of control ($/ha)
R = row spacing (cm)
V = value of crop ($/tonne)
N = number of heads/metre of row
1.0 = weight of sorghum (grams) lost per larva

Yellow peach moth larva (top) and moth (bottom).

Management considerations for yellow peach moth

Open-headed sorghum varieties are generally less infested than tight-headed varieties as they allow better penetration of insecticides.

Natural enemies

The avoidance of broad-spectrum pesticides prior to flowering will help conserve natural enemies. Parasitic wasps provide some biological control.