

To help grain growers manage their crop pests, the National Invertebrate Pest Initiative has been set up with the support of the Grains Research and Development Corporation. NIPI pulls together scientists from state government departments, universities, farmer groups and CSIRO and its coordinator is Dr Gary Fitt from CSIRO Entomology.

Australian Grain will be presenting articles reviewing the current knowledge of invertebrate pests – and their management in Australian grain systems.

Current and future aphid management in grain crops and pastures

Aphid outbreaks can severely damage Australian grain crops such as cereals, oilseeds and legumes. Feeding aphids damage plants in several ways, through direct feeding, transmission of plant viruses, injection of toxins and secondary fungal growth (sooty mould) on honeydew.

Although feeding aphids remove nutrients from plant cells, crops usually only sustain significant damage when aphids are present in large numbers. But low aphid numbers can cause substantial damage if they transmit plant viral diseases. Some species, such as Russian wheat aphid (*Diuraphis noxia*), inject saliva containing toxins into plants.

Last but not least, the honeydew aphids secrete, can lead to sooty mould which inhibits photosynthesis and can cause grain handling problems.

Aphids, with their piercing and sucking mouthparts, are specialised to feed from the cells transporting plant nutrients. Under the right conditions, their numbers build rapidly and, when the plant can no longer support large aphid numbers, the aphids produce winged morphs that disperse with the wind.



A ladybird larva. Predators such as ladybirds can provide significant control of aphids and improved strategies for monitoring and conserving natural enemies could enhance their effectiveness. (PHOTO: David MacClenaghan, CSIRO Entomology)

In agricultural monocultures, most of these individuals will find a suitable host thus letting aphid numbers build unhindered. Asexual reproduction and the telescoping of generations (females giving birth to live young in which embryos of the next generation are already developing) underpin aphids' ability to rapidly expand their numbers.

In areas such as southern Victoria and

Tasmania where plants grow year round, aphids are present all year. In Mediterranean climates, such as those of Western Australia, South Australia and southern New South Wales, aphid numbers plunge in summer with populations re-establishing after autumn rain. Many aphid species can also survive and reproduce at near freezing temperatures which lets them thrive in winter cropping areas.

CEREALS

The most common aphids in southern Australian cereal crops are oat aphids (*Rhopalosiphum padi*), corn aphids (*R. maidis*), rose-grain aphids (*Metopolophium dirhodum*, except in WA) and the grain aphids, *Sitobion miscanthi* and *S. frageriae*.

Direct feeding damage can occur on stems, leaves and heads, usually in the tillering and later stages of crop growth. During dry periods, *R. rufiabdominalis*, can build up on roots of winter cereals where it is difficult to control.

The primary source of aphid damage in cereals is through the transmission of viruses, in particular barley yellow dwarf virus (BYDV). But there is often little yield loss from BYDV because infection occurs late when plants are less susceptible.



Green peach aphid, which is common in the grainbelts of Australia, has developed resistance to more classes of insecticide than any other insect species.

(PHOTO: CSIRO Entomology)

...10▷

No wheat varieties have resistance to BYDV, but there is good resistance available in barley and some tolerance available in oats. Growers in high rainfall zones, which are generally high aphid risk areas, should consider using these.

Seed dressings containing imidacloprid can reduce the incidence of aphids and BYDV. But there should be a follow-up foliar spray of a synthetic pyrethroid seven weeks after crop emergence. If no seed dressings are used and BYDV is a risk, then two synthetic pyrethroid applications are recommended, at three and seven weeks after emergence.

In northern Australian growing areas (central New South Wales to Central Queensland), low numbers of the oat aphid and the corn aphid are always present in cereal crops.

Then, around every five to seven years, enormous numbers develop in early spring, particularly in barley, and these may reduce yield through feeding damage. But most populations will be reduced to sub-economic levels by natural enemies. If spraying is economic, growers generally use dimethoate, chlorpyrifos or pirimicarb.

CANOLA

Both the cabbage aphid (*Brevicoryne brassicae*) and the turnip aphid (*Lipaphis erysimi*) can cause considerable feeding damage to canola shoot tips. But as aphid colonies develop on flowering spikes, canola compensates by producing more

spikes.

Control should be considered if plants are drought stressed, as aphids target stressed plants which are less able to compensate for feeding damage. In marginal areas where drought stress is more likely, aphid damage can result in high yield losses.

Cultivars such as Hyden and Beacon appear to be the least susceptible to aphid colonisation.

Pirimicarb, the only chemical registered for use on aphids in canola, has the advantage of being kinder to beneficial insects. These build up in crops along with the aphids and can maintain aphid populations below threshold levels.

The green peach aphid (GPA), *Myzus persicae*, can sometimes cause significant early season crop loss. It is also the most important vector of beet western yellows virus, which could become a serious problem in southern Australia in the near future.

LUPINS AND PULSES

The blue-green aphid (*Acyrtosiphon kondoi*), the cowpea aphid (*Aphis craccivora*) and GPA commonly feed on cultivated lupins, usually during budding and flowering. Feeding can reduce yields, especially in low rainfall areas, when plants are stressed and less able to compensate for aphid damage.

Yield loss depends on lupin variety. Yellow lupin varieties, such as Wodjil, are usually very susceptible to aphids whereas most narrow-leafed lupin varieties, such as

Kalya and Tanjil, are not.

But there have been reports of GPA colonising resistant narrow-leafed lupins.

While chickpeas are not generally at risk from aphids, both faba bean and lentils are particularly susceptible to cowpea aphid.

There are thresholds for treatment against aphid damage on lupins and these have been extrapolated to other pulses. Dimethoate, methidathion, omethoate, and pirimicarb are among the recommended insecticides but registration varies between states.

In pulses, aphids transmit viruses such as cucumber mosaic virus (CMV) and bean yellow mosaic virus (BYMV). CMV can also cause big yield losses in lupins, but the risk depends on when the aphids arrive. Sowing lupin seed infected with CMV is the main source of infection so using clean seed is the best control method.

SORGHUM

The corn aphid is an occasional pest of sorghum panicles where their honeydew causes sticky grain, with consequent harvesting and handling difficulties. Natural enemies are very important in reducing panicle infestations.

SOYBEAN

The soybean aphid (*Aphis glycines*), first discovered in Australia in 2000, can be a problem in coastal New South Wales and Queensland. High populations reduce plant vigour and yield as well as leading to sooty mould growth. Again, predators play an important role in aphid suppression.

PASTURES

Aphids have been key pests of legume pastures – an important component of ley-farming systems of southern Australia – since the 1980s when a number of species were introduced. Depending on soil type and climate, these pastures are usually dominated by annual medics (*Medicago spp.*) or clovers (*Trifolium spp.*).

Cowpea aphid and blue-green aphid will colonise both medics and clovers.

Another species, *Therioaphis trifolii*, has two different forms – spotted alfalfa aphid (*T. trifolii f. maculata*) which attacks lucerne and some medics and spotted clover aphid (*T. trifolii*) which can severely damage clovers in some areas. Aphid-transmitted viruses can also be a problem, particularly BYMV in clover and alfalfa mosaic virus in medics.

Most varieties of the barrel medic (*M. truncatula*) have resistance to both blue-green aphid and spotted alfalfa aphid, with limited protection against pea aphid



In agricultural monocultures, most dispersing winged forms of the aphid will find a suitable host thus letting aphid numbers build unhindered. (PHOTO: Carl Davies, CSIRO Plant Industry)

and spotted clover aphid. There are also aphid-resistant lines for the strand medic, *M. littoralis*.

So far, resistant clovers have eluded breeders but moderate tolerance to blue-green aphid is available in some varieties of subterranean clover. No resistance exists against spotted clover aphid.

While organophosphate (dimethoate) and carbamate (pirimicarb) insecticides are registered for use against aphids in legume pastures, growers in high risk areas should first consider aphid-resistant varieties. Otherwise, seed treatments are a good option.

Before resorting to sprays, growers should check for natural enemies which could provide natural aphid control. More natural enemy friendly, 'softer' insecticides should be favoured. Because of their anti-feeding effects, pyrethroid insecticides are likely to be the most effective at preventing aphids from introducing viruses.

BIOLOGICAL CONTROL

Parasitoids and predators can help control aphids in cropping systems. One indicator that parasitoids are around is the presence of mummified aphids with their hardened and darkened cuticle. *Aphidius spp.*, *Lysiphlebus spp.* and *Diaratiella rapae* are the most effective parasitoids

in Australian grains, while *Aphelinus spp.* are generally restricted to summer crops such as sorghum.

Some exotic parasitoids such as *D. rapae* probably arrived in Australia with introduced aphids while others were introduced deliberately as biological control agents. Many parasitoids were introduced in the 1980s when the pea aphid, blue-green aphid and spotted alfalfa aphid were accidentally introduced.

Predators, such as ladybirds and hoverfly and lacewing larvae are also effective against aphids.

Crops should be checked for natural enemies before insecticides are used. Beneficials are generally more sensitive to insecticides than aphids so more are killed and this could result in an increase in aphids. If insecticides are needed, softer options should be used.

These include seed treatments which only affect the sap suckers and pirimicarb which is the softest of the registered contact insecticides.

In areas with consistent rainfall, both aphids and their predators are present all year. In Mediterranean climates, with wet winters and long, dry summers, aphid and natural enemy populations crash during

summer. When the weather cools, aphids reproduce faster than their natural enemies and so build their numbers.

With the arrival of warmer spring temperatures, natural enemies can catch up and become effective. But this is often too late to prevent significant crop damage.

PREDICTIVE MODELLING

In the Mediterranean-style climate of the Western Australian wheatbelt, aphids survive the summer in low numbers on perennial grasses, summer weeds or volunteer crops. The timing of aphid flights into crops in the winter growing season correlates with late summer and early autumn rainfall events. Alternative hosts take advantage of the rain and aphid numbers can build on these.

Because these hosts are often reservoirs for aphid-transmitted viruses, the same rainfall events are also linked to virus outbreaks.

Simulation models that forecast aphid and virus (BYDV, CMV and BYMV) outbreaks in the Western Australian wheatbelt are based on this association between rainfall and aphid/virus risk. Virus incidence and potential yield loss can be estimated from these models.

...12▷

INSECTICIDE RESISTANCE

Prophylactic spraying to control aphids increases the risk of insecticide resistance developing, in both target and non-target species.

GPA, which is common in the grainbelts of Australia, has developed resistance to more classes of insecticide than any other insect species. While it is a more serious pest of vegetables, it can damage canola and narrow-leafed lupins. GPA can also feed on resistant lupin varieties. In addition to sprays targeted at it, GPA is often exposed to sprays while feeding on broad-leafed weeds in other crops.

Insecticide resistance in Australian GPA has been present since the early 1990s.

A study of GPA from most of Australia's grain growing areas revealed that almost every aphid collected had organophosphate resistance caused by a mechanism that also provides some cross-resistance to pyrethroid insecticides.

This mechanism is unusual because it can be 'switched on' in response to pesticide exposure. As a result, aphid populations can quickly adapt to survive insecticides, particularly organophosphates such as dimethoate. This mechanism is so widespread that organophosphates are unlikely to be a useful control tool in the future.

Knockdown resistance (kdr) to pyrethroids is also common in GPA in Australian grain crops. In northern Victoria and southern Queensland, kdr was particularly frequent, perhaps as a result of recent exposure to pyrethroids used in vegetables in these areas. Because of this, it appears that any use of pyrethroids would quickly lead to resistance.

Unfortunately, prophylactic pyrethroid

sprays targeting cereal aphids in cereal crops will probably induce resistance in GPA feeding on broad-leafed weeds in these crops. This could lead to control problems in adjacent canola or lupin crops.

Prophylactic spraying can also select for resistance in non-target organisms. High level resistance to synthetic pyrethroids in the redlegged earth mite (*Halotydeus destructor*) in Western Australia almost certainly resulted from the use of synthetic pyrethroids for prophylactic aphid control, since pyrethroids have not been registered for use against it.

The mechanism conferring resistance to carbamates such as pirimicarb have not been found in Australian GPA so they should continue to be effective control tools for some time. Imidacloprid insecticides are very effective against aphids and no evidence for resistance to them was found in a recent survey.

FUTURE MANAGEMENT PRACTICES

In order to lower farm inputs and reduce the risk of insecticide resistance, aphid management practices should aim to reduce insecticide use. Aphid-resistant varieties are economical but not always available. Nor do they always prevent virus spread. Aphids can also evolve biotypes that overcome resistance thus reducing the useful life of resistant varieties.

Research on how aphids feed and how plants defend themselves could lead to more durable resistant varieties. It appears that plant resistance is often mediated by an immune factor that acts like an 'antibody', recognising a factor associated with aphid feeding and triggering the plant's defences.

Other research is looking at engineering plants so that the genes that allow GPA to feed on resistant varieties of narrow-leafed

lupins will be silenced. But these high-tech solutions will take at least 10 years to reach the market.

Meanwhile, aphid management should be based on the development and use of aphid- and/or virus-resistant varieties, natural enemy conservation and selective use of insecticides only when necessary.

Prophylactic treatment should be avoided because of the problems they cause. Seed treatments can also greatly reduce non-target effects.

Research is needed into more strategic methods of insecticide application. One promising approach is the use of border treatments to kill immigrant aphids but the greatest benefit could come from improved strategies for monitoring and conserving natural enemies.

It is difficult for growers to decide whether biological agents will suppress aphids to the point that insecticides are not necessary.

A combination of these approaches should provide Australian grain growers with effective options to manage aphids into the future.

This overview of aphids in Australian grain crops is a summary of a paper by Owain Edwards, Bernie Franzmann, Deborah Thackray and Svetlana Micic* on Insecticide resistance and implications for future aphid management in Australian grains and pastures: a review which appeared in the Australian Journal of Experimental Agriculture 48 (12): 1523-1530.

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