Pest and disease control – is it about reducing costs or increasing packouts?

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Costs - the first part of cost/benefits

Temperate fruit production is an old business. Consumers have high quality expectations and there is no room for blemished fruit. Unfortunately there are few natural pest and disease resistances in the current varieties and plant protection plays a big role in the production systems.

Yields can be high (apples 40 – 85 t/ha) and turnover can be very high ($95,000+/ha). This places great importance on everyone in the production system having good knowledge regarding the crops, the pest and disease regime and plant protection products.

Farm inputs are significant and although products may cost $4-5,000/ha on high input farms, the largest costs are still labour, post-harvest costs (packaging, storing, freights, commissions) and farm overheads. Farm inputs are usually only 6 – 9 % of the total costs of production and sale. So despite there being the usual pressures to minimise farm input costs, they should be kept in perspective and the emphasis should be on how farm inputs can maximise yield and quality rather than reduce costs.

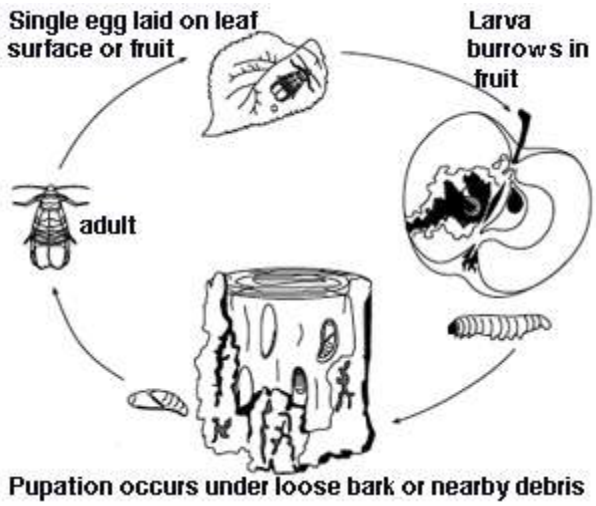
Prices differ for every insecticide and miticide used and usually there is a reason for this. The more expensive products do more or the cheaper products have some drawbacks. Occasionally there is an oversupply of a pesticide and prices fall (eg Dithane at present) or a shortage and prices rise (eg Polyram at present), but mostly prices reflect the job they will do.

In subsequent sections we can explore the challenges posed by the major insects and diseases of apple, the benefits offered by the different products and how IPM approaches can be best incorporated. I will provide examples from my trial work in Queensland but try and offer a national perspective regarding best practices as much as possible.

Five pests and three diseases are discussed;

Codling moth *Cydia pomonella*

The codling moth life cycle



Codling moth control options

IPM options include granulosis viruses, *Trichogramma* wasps, Bt and pheromone mating disruption. Mating disruption is a long-term successful 'soft' option and viruses are a recent addition to the arsenal. In Australia the area under mating disruption varies from 30 to 70% depending on district and year.

Regular cover sprays with insecticides were the mainstay of codling moth control for over 50 years. The main chemical used was Gusathion, firstly as a wettable powder and then as a suspension concentrate. However codling moth control went through a period of rapid change in the 1990's when low level resistance was reported to Gusathion, alternative chemicals become available (Insegar, Penncap-M, and Avatar), and mating disruption control was developed (Isomates). Since then additional other good new chemicals were developed and brought to market; Calypso (2002), Samurai (2007), Delegate (2008) and Altacor (2008).

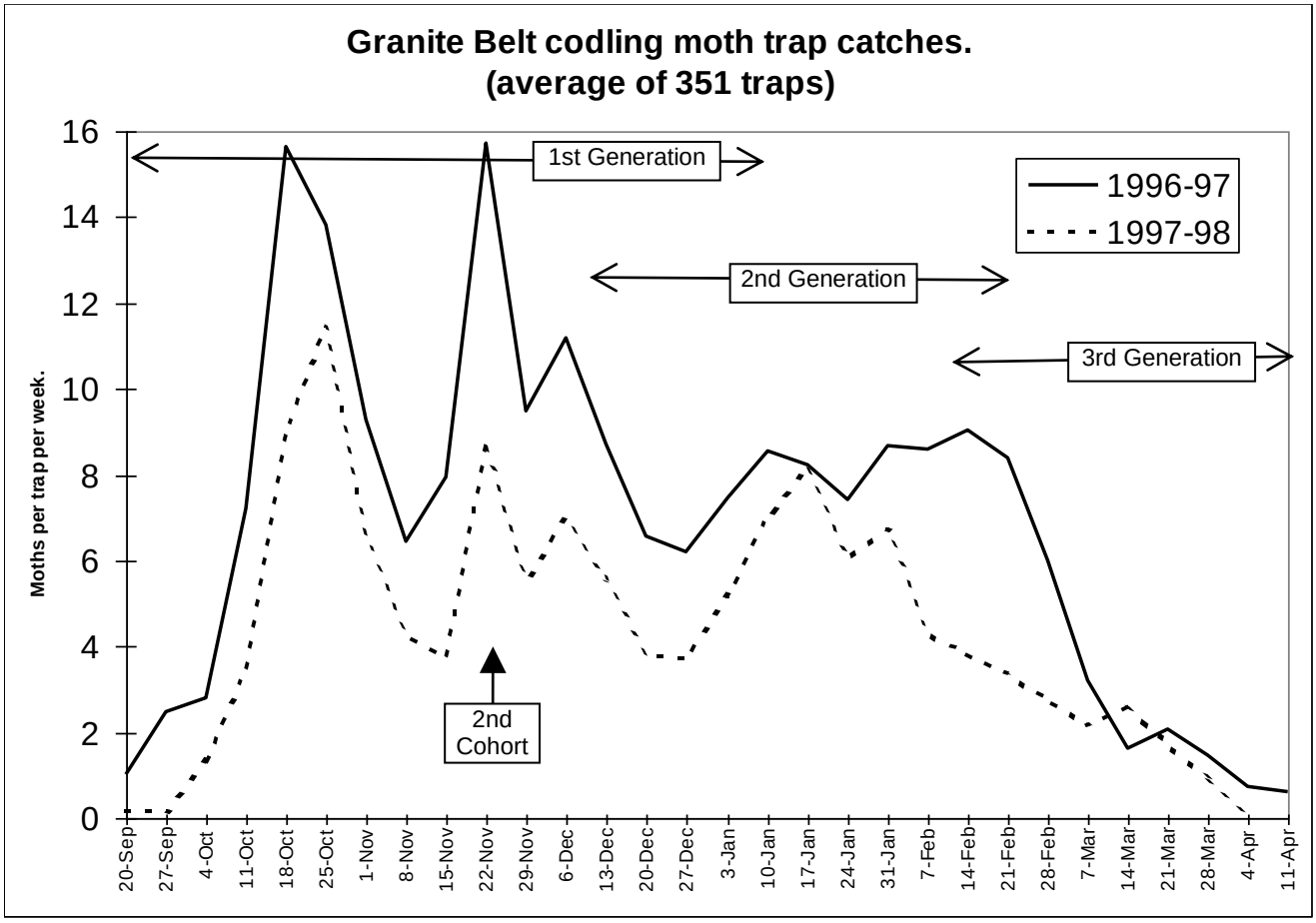
Codling moth monitoring. Because many of these newer controls are not as straightforward as traditional regular cover sprays, growers must know the level of codling moth infestation in their orchards and in particular blocks within their orchards. Pheromone baited sticky traps are used to catch male codling moths, and indicate the level and timing of the pest's activity.

When mating disruption (Isomates) are used the drawing power of the pheromone baited lure is over-run by the pheromone emitted by the dispensers (500-1,000/ha). Traps in pheromone treated orchards are baited with a 10X lure and/or a lure with a feeding attractant (kairomone).

Codling moth life cycle. Codling moth are dormant as larvae in silken cocoons until spring and moths emerge and lay eggs that hatch into larvae (grubs) that do the damage to fruit. This larvae-moth-egg-larvae cycle is repeated 1, 2 or 3 times a season depending on a district's climate. In an apple orchard where good commercial control is being achieved with insecticides the first moth flight is usually the greatest and the second and third are usually smaller. This is because insecticides are killing eggs and larvae and the population is decreasing.

The first moth flight from the first population has two peaks. This is because there are often two major emergences in spring. The second group is called the 'second cohort'. Ecologically the population has a better chance of survival if it has these two emergence times.

The second generation overlaps with the first and third generation so there are often a lot of moths in the orchard in mid season from mixed generations. In an orchard where control is not working the second and third moth flights can be higher than the first.



How many codling moths are too many ?

Orchard Category	Total Number of codling moths caught in a season*
Extremely High	600 +
Very High	301-600
High	176-300
Moderate	101-175
Low	51-100
Very Low	21-50
Extremely Low	0-20

* in a single trap in a non-pheromone treated block

A manageable population. The lower the better!! Low populations will allow growers to reduce sprays or turn to 'softer' controls Insegar, mating disruption, Madex or Mimic. To stay in the moderate range an orchard should have no more than 175 moths caught in a year. Experience has shown that in the warmer Australian climates approximately one third of the moths are caught by mid-November (this includes the first cohort of the first moth flight). This is also a practical time to make a decision about whether an orchard has too many moths. Hence if more than 55 - 65 moths are caught by mid-November then the

orchard will most likely be above the moderate category. This means that control within the current season will have to be intensive to prevent damage and overall numbers will have to be reduced before 'softer' controls can be used in following seasons.

What are some options for improved control ? Trap catch data can be used to improve pest control.

Situation A. You are not happy with the moth numbers and wish to reduce the moth population and reduce fruit damage.

Option 1. Stick to your present control method but increase the intensity.
Eg, instead of applying 8 insecticide sprays in a season and starting in November you could apply 12 sprays by reducing the intervals between sprays and starting in late October.

Option 2. Stick to your present control method but add another control.
Eg, apply 8 insecticide sprays as well as using pheromone dispensers;

Situation B. You are happy with your low moth numbers and want to reduce your chemical use.

Option 1. Change your control program. Eg, change from a program of 12 old style insecticides (Pencapp-M/Gusathion) sprays to a mating disruption program. Alternatively, use a combination of Calypso, Delegate, Samurai and Altacor sprays.

or **Use a combination program**. Eg use Mating disruption and apply Madex virus or insecticide for the just the first generation of moths as a transitional measure.

Option 2. Reduce your program. Eg, reduce the amount of chemical used late in the season if traps are showing consistently low numbers.

Mating Disruption is different to traditional control and points to be considered **;**

- Block size – larger the better
- Uniformity of trees – trees the same height
- Initial moth population – very low is best
- Border situation – apply insecticides to edges of blocks
- Earliness of application – pre bloom is best
- Correct rates – don't be tempted !
- Correct height – put them in top portion of canopy
- Use MD + insecticides to 'crash' a population in transition years
- Minor pests may flare when broad spectrum insecticides withdrawn
- Skip MD every few years?
- MD 'wasteful' on Gala apples?

Extra Considerations

Queensland Fruit Fly. Isomate-C, Altacor, Avatar, Calypso, Delegate, Insegar and Samurai treated blocks will require fruit fly treatments in late December - March. The timing and number of sprays depends on the weather and fly pressure. Bait spraying is effective, cheap and reasonably quick. Lorsban or Gusathion cover sprays will also suppress fruit fly and have been used successfully.

Heliothis. This caterpillar can be active at blossoming and when fruit are very small. Altacor, Avatar and Delegate are registered for heliothis control. Calypso showed some control in trials. If Delegate is used for western flower thrips control during blossoming then Heliothis damage is usually minimal.

Woolly Apple Aphid. Gusathion and Lorsban can suppress aphids in the crawler stages in November and December, but they also kill the beneficial wasps in summer and autumn. Altacor, Avatar and Insegar are known to be very safe to the WAA parasitic wasp. Delegate, Samurai and Calypso are moderately safe.

Light Brown Apple Moth. Altacor, Avatar, Delegate, Gusathion Insegar and Mimic control LBAM and Samurai & Calypso have some supersession of LBAM. This pest sometimes becomes a secondary pest in orchards that have been treated with pheromones. LBAM has increased as a problem as later maturing varieties have been planted (Pink Lady and Sundowner) as LBAM are most active in autumn.

Fuller's Rose Weevil. This is a minor pest that can become a secondary pest in orchards that have been treated with pheromones for consecutive years. Weevils are easily controlled by 1 or 2 strategic insecticide sprays.

Pest Mites. Broad spectrum , old style insecticides can suppress or kill mite predators. Use of softer insecticides or pheromones will allow predators the best chance to control pest mites.

Notes:

- Insegar is not suited to large trees and spraying should be timed from trap catches. However Insegar will also help control Heliothis and San Jose scale, is not toxic to the woolly aphid predatory wasps or several mite predators.

- If Gusathion and Pencapp-M/Folidol are replaced by pheromones the woolly aphid predators and mite predators will be encouraged.

- If using pheromones, Insegar or Madex for the first time some more detailed codling moth trapping will be needed. Also if there is a large carryover of woolly aphid then withdrawing Gusathion, Folidol and Penncap-M may lead to an initial flare up of woolly aphids because these insecticides do have some suppression activity on woolly aphid crawlers. Be prepared to enlist an extra control for woolly aphid eg Lorsban or Confidor.

Insecticides for codling moth control

	Altacor	Delegate	Samurai	Calypso	Gusathion	Insegar	Avatar
Group	28	5	4A	4A	1B	7B	22A
Codling Moth	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LBAM	Yes	Yes	Suppression	Suppression	Yes	Yes	Yes
Woolly Aphid			Yes	Suppression			
Mealy Bug			Yes				
Heliothis	Yes	Yes					Yes
Dimpling Bug				Yes			

Pest mites & predators

Mites are a small but important part of pest and disease control in apple and pear orchards. They breed very rapidly so should be monitored. TSM adults live for 3 – 5 weeks. They lay an average of 70 eggs at the rate of 3-14 eggs/day. So 1 female mite can develop into 24 million mites in 4 months! This is the reason they can seem to explode in population warm weather and why they mites become resistant to new chemistry quickly.

The Queensland Experience

- **Europen Red Mite (ERM)** was the main problem 20 years ago. Mostly now it is the minor pest mite because of the widespread distribution of the predatory mite, *T. pyri*. In some years ERM will flare if winter oil spraying for control of ERM eggs is not done well.

- **Two Spotted Mite (TSM)** is the main problem in most apple orchards. *T. pyri*, *Persimilis* and Stethorus beetles and larvae are useful predators, but are seldom enough to control TSM by themselves.

- **Apple rust mites (ARM)** has been seen in Stanthorpe since 2001, but was never very widespread until 2005-6. It is never the major mite and appears in hot-spots in different orchards each year. It can be an alternate food source for predatory mites. Large numbers of ARM will turn the foliage red (similar appearance to TSM damage) thus reducing the effectiveness of the leaf.

Pest mite lifecycles

Season	Where is it now?	What's it doing?	Comments
Winter	TSM in resting adult stage in trash on orchard floor, weeds, tree crotches ERM in eggs on wood ARM in buds and under bark	Waiting Developing Waiting	Hygiene possible Use winter oil
Spring	TSM moving up and off wood onto new leaves, building up on weeds; vetch, clover, etc ERM moving from wood to leaves ARM moving to foliage	Waking up and dispersing ERM hatching Laying eggs	TSM pop. starts low Use Vertimec in spring ERM pop. can start high if no oil or poor cover
Summer	TSM mainly on back of leaves ERM on both sides ARM on both sides	Many generations of breeding	Spray now with knockdowns
Autumn		Preparing for winter	Dropping temps or decline of food source

Integrated Pest Management (IPM)

Integrated pest management plays a big role in management of mites in apples. The industry is pretty proud of the pesticide reduction possible with IPM. Before IPM it was common for growers to use 4, 5 or 6 miticides a years and we would still see mite disasters on some orchards. The basics of IPM for mite control are;

- Hygiene for TSM
- Oil cover for ERM
- *T. pyri* mainly in wetter summer areas
- *T. pyri* prefer ERM
- *T. occidentalis* in dry areas
- *T. occidentalis* prefer TSM
- *P. persimilis* is hungry & fast but soft and doesn't survive the winter well.
- *Stetherous* is robust and useful but unreliable
- Rust mites hard to manage
- Resistance is a serious issue

Mites can never be eliminated by chemicals or IPM, they can just be managed. Two aims;

- Effective - to produce quality fruit mite management must be effective. Embracing IPM but failing to control mites is a bad strategy - there is no premium for smaller fruit or paler fruit and no rewards for early defoliation and weaker buds.
- Cost effective - Mite management must be cost effective as miticides can be expensive. This is because they have shorter sales lives than other pesticides. Growers usually use only 0, 1, or 2 a year and price is important. Compare this to pre-IPM when up to 6 miticides a year was not uncommon in hot years.

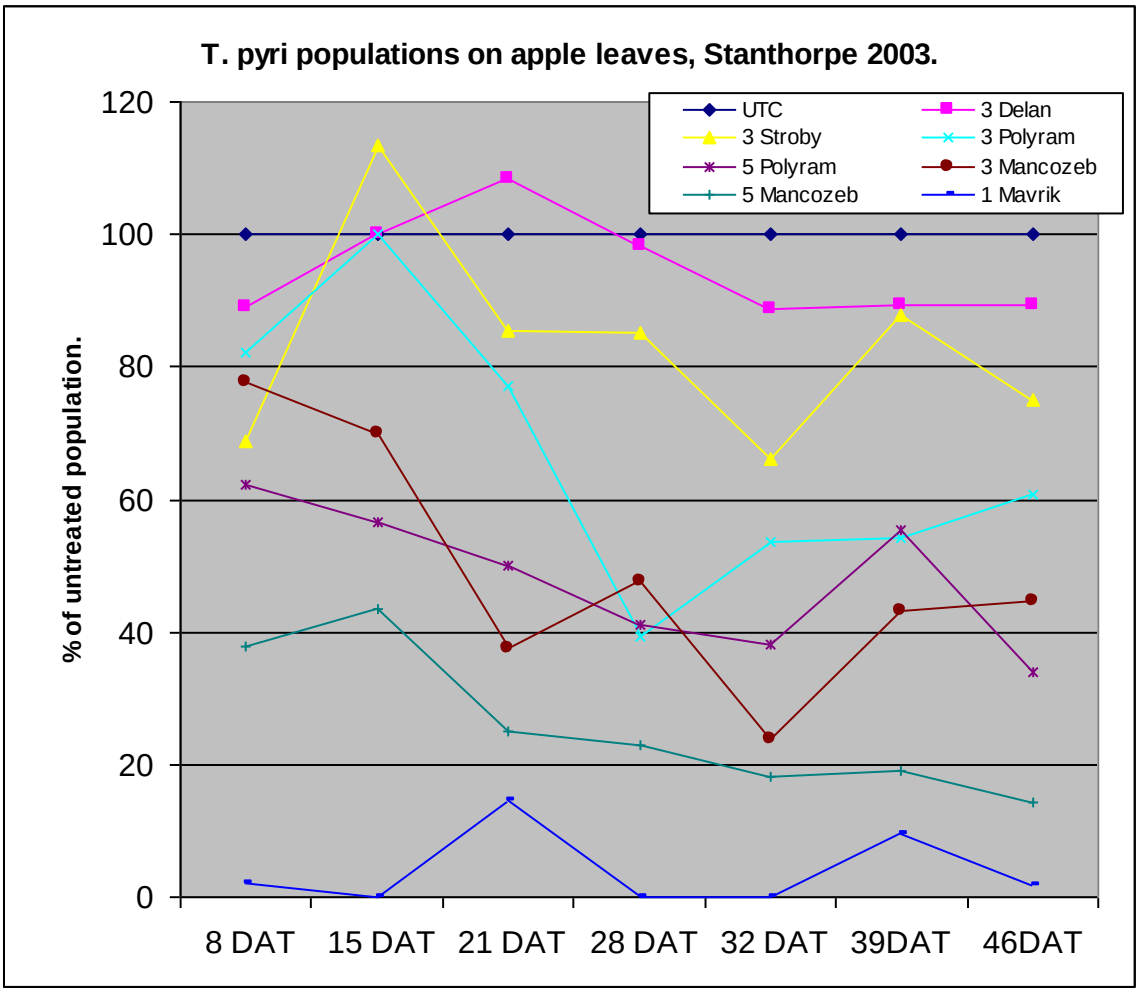
Mite predators

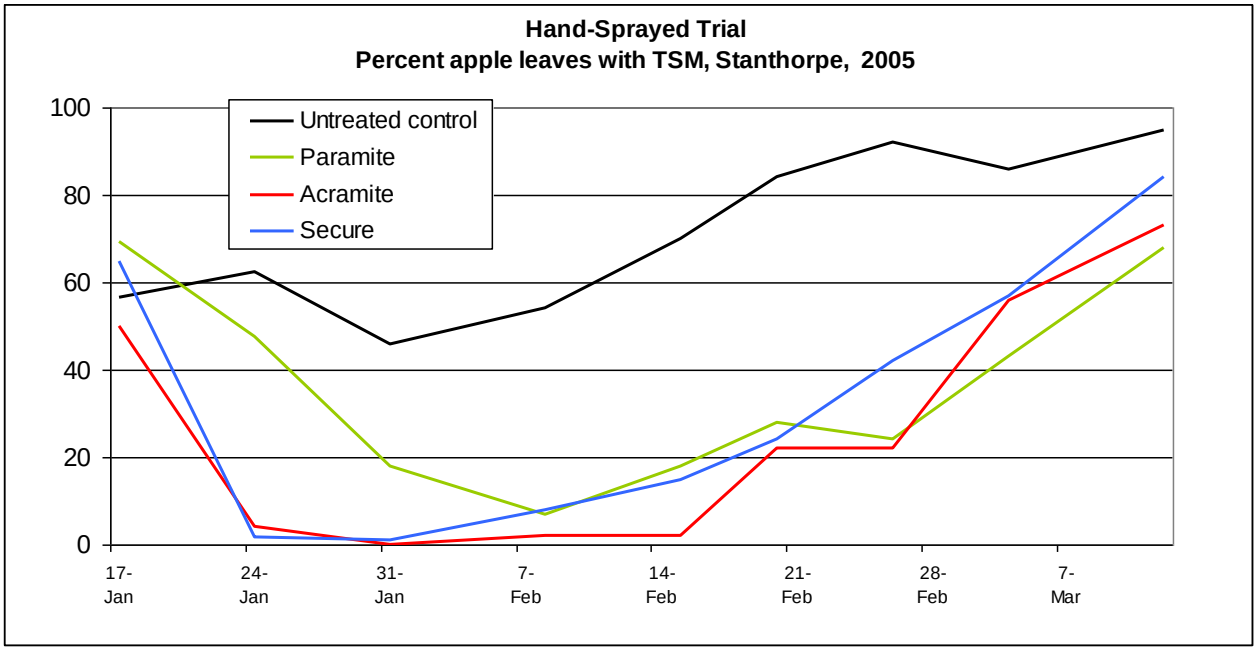
Miticides affect predators. Predatory mites are mites and are also affected by miticides, however usually not as much as pest mites are. Miticides also deprive predators of their major food source (mites). Predatory mites survive when no pest mites are around because they can also feed on grass pollen and microscopic moulds.

Fungicides affect predators. Mancozeb and Polyram are the most toxic fungicides with Mancozeb slightly more toxic than Polyram. Ziram is intermediate in its affect. Captan, Delan, Dodine, Flint, Stroby, Pristine, Nustar and Systhane are all of low toxicity. Hopefully the new fungicide Fontelis will prove to be safe to predatory mites with wider field experiences. Continual use is worse than occasional strategic use – see case study where five consecutive applications of Mancozeb and Polyram were worse than three applications.

Insecticides affect predators. Mavrik, Carbaryl, Lebaycid and Supracide are very toxic to predatory mites. Predator populations can survive Carbaryl used as a chemical thinner as it is usually only applied to the top portion of the tree and usually just to some varieties in some years. The Queensland strain of *T. pyri* has

some resistance to Lorsban, Gusathion and Penncap-M and some NSW strains have reported resistance to Mavrik.





Miticides

Miticides that presently work	Miticides that once controlled mites	Insecticides that once controlled mites
Acramite	Acaban	Acarol
Omite	Apollo	Gusathion
Paramite	Calibre	Malathion
Secure	Kelthane	Parathion
Vertimec	Plictran	Supracide
	Pyranica	Systox
	Sanmite	
	Torque	

Note that the first column in the table is the shortest list.

Many of these will move to the second column list before you retire. How we all behave will determine the longevity of these miticides (fruit growers and professional agronomists).

The two essentials are to; Do the correct rotations and look after the predators.

Miticide	Price	Features	Timing
Vertimec + Oil	$42/ha	Some knockdown and little residual unless absorbed Use with oil Use early on soft leaves	2 to 6 weeks after petal fall
Paramite	$136/ha	Knockdown Doesn't kill adults, sterilises them Kills eggs, nymphs and hatching nymphs	Use on threshold. Use earlier than other knockdowns
Omite Betamite	$230/ha (1 full + ½ rate)	Knockdown Kills most adults Kills most nymphs	Use on threshold Follow up 7-10 days later
Acramite	$366/ha	Kills adults, nymphs and eggs ?	Use on threshold Rec is to use early
Secure	$131/ha	Only kills TSM ERM can flare	On threshold

Paramite is the stand-out value for money miticide but because it acts differently to other miticides it should only be used if you have some good scouting going on.

- It doesn't kill adult mites
- It can kill eggs, and the residue kills nymphs as they hatch out of eggs
- It does kill nymphs when they are sprayed
- It causes adults that are sprayed to lay sterile eggs
- No new adults developing, so the adults present at spraying just die of old age.
- This takes 3-5 weeks, depending on the weather.

- Need to act 2-3 weeks earlier than other miticides.
- Need to know what you are doing!!

Miticide rotation

Vertimec cannot be used on the same orchard in two consecutive seasons. The exception being when Vertimec doesn't provide season-long control and an alternative miticide is used as well.

Secure, Paramite and Acramite should only be used once per season.

Omite can be used more than once a season - in fact a follow-up spray is recommended.

As Omite does not kill eggs and the residual action on hatching nymphs wears off before all the eggs present at spraying have hatched, a second application within 5-10 days is usually needed for control. The second application is usually at a lower strength (label IPM rate).

Alternatively Omite can be mixed with Paramite. Omite killing most adults and most nymphs. Paramite killing most nymphs. Paramite killing some eggs and causing remaining adults to lay sterile eggs and having enough residual action so that nymphs hatching from eggs present at spraying are killed. Can decrease the rate of Omite used to ½ or ¾ if some predators are also present. This mix will vary in price from $251 to $281/ha, which will always be cheaper than Acramite at $366/ha. Decision needs to be supported by good scouting.

Good Mite Control

- Winter oil for ERM (and TSM)
- Predators + miticides
- Softer options for codling moth control may promote predators. Some insecticides and fungicides softer than others on predators.
- Timing: when to start, how often to apply.
- Choice of miticide: rotation, match product/rate to pressure.
- Coverage: miticides work better at dilute volumes. Tops and insides need to be covered.

Mealybugs

The tuber mealybug (*Pseudococcus viburni*) is the main pest in Queensland apples and pear crops but the longtailed mealybug (*Pseudococcus longispinus*) is the species found in southern orchards. Behaviour and controls are very similar for the two pests. Tuber mealybug is also known as the obscure mealybug.

Season	Where is it now?	What is it doing?	Comments
Winter	Under bark on older wood	Over-wintering	Hard target
Spring	On bark and buds	Dispersing Laying eggs	Easy target to spray Need water volume
Early Summer	Crawlers move to back of new leaves and fruitlets	Dispersing	Easy target to spray Need water volume
Summer	In fruit calyx and stem-ends	Growing, feeding, breeding and making-a-mess.	Hard target
Autumn	In fruit calyx and stem-ends		Impossible target

Females are flightless, larger, and longer-lived than the winged males, who cannot feed and die immediately after mating.

Nymphs resemble adults in body shape, take six to nine weeks to mature, and are mobile their entire lives. Females will lay clutches of several hundred orange eggs in cottony sacs, from which nymphs will hatch and emerge after about 5–10 days in warm weather. They may complete 2-3 generations per year.

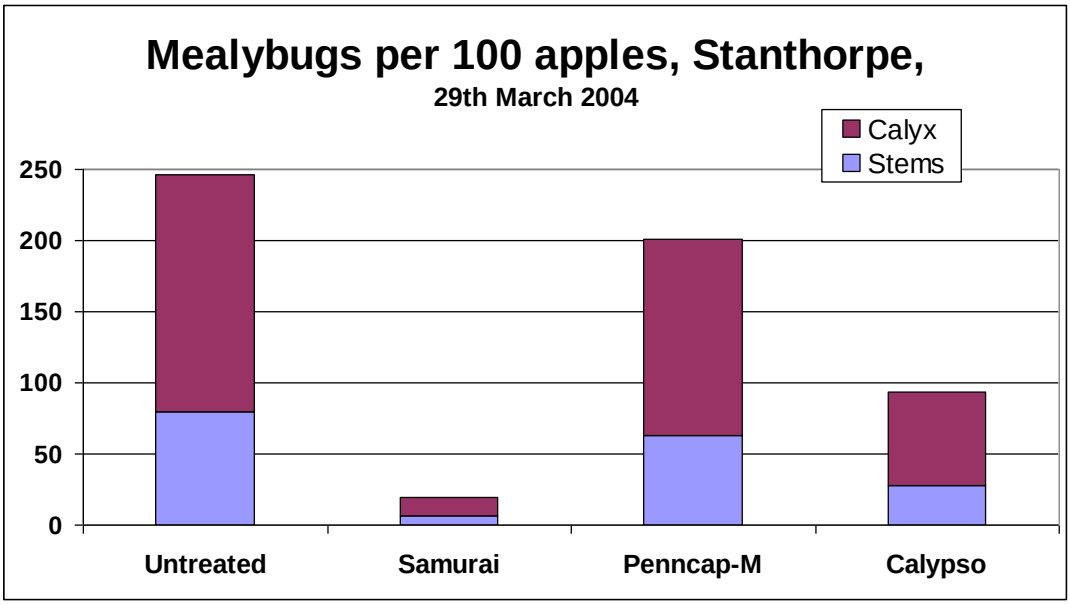
Mealybugs lay eggs all year long, and during winter, shelter under the bark of trees and vines (though there is no true dormancy). These overwintering populations include individual mealybugs from all stages of development, but are dominated by eggs and first instar nymphs; overwinter mortality for young nymphs is high.

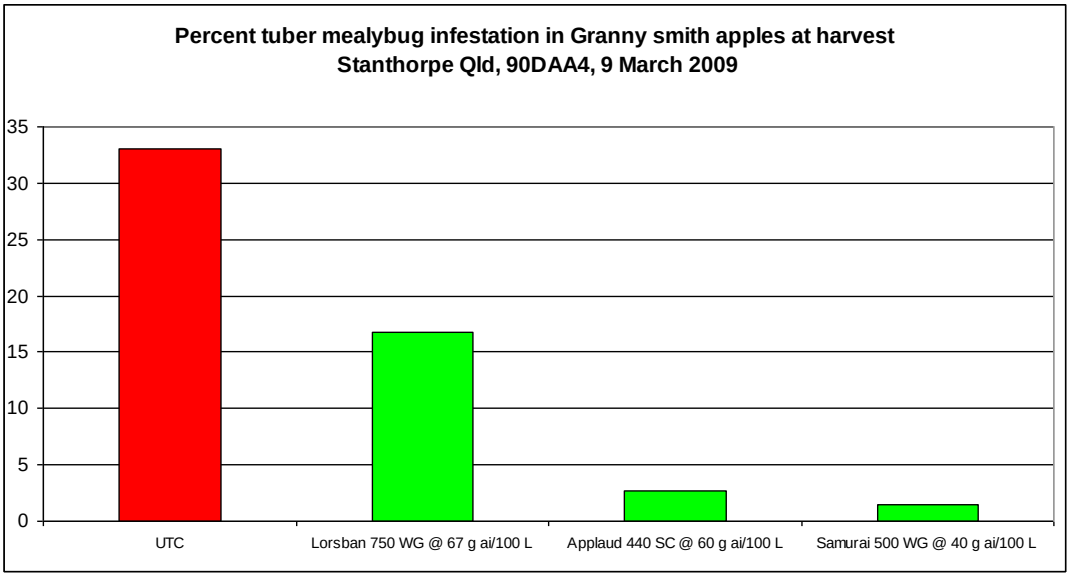
Mealybugs feed on the sap and excrete honeydew which blackens as sooty mould. They seek the sheltered sites of calyx and stem ends of fruit. Their presence, and the sooty mould downgrades fruit.

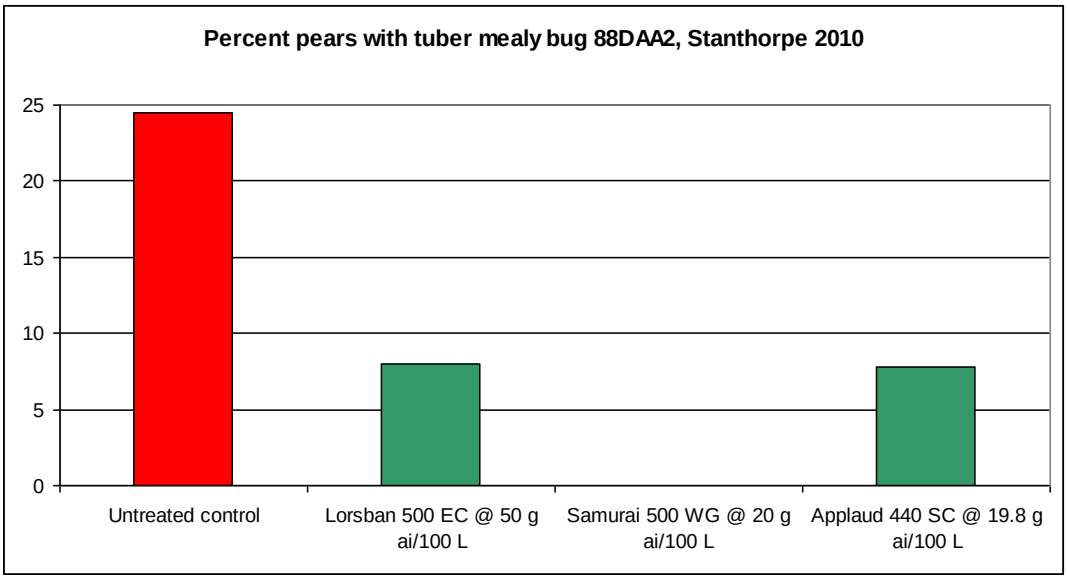
A successful IPM strategy isn't available for this pest just yet. There are some mealy bug predators that are useful in citrus and have been used in apple orchards, but they don't survive well or spread easily. Orchard hot spots have to be concentrated on with the present insecticides, but after 1 – 2 years attention the problem can be minimized.

Spray application is very important as our application techniques are aimed at putting a light mist cover onto flat leaves and smooth apples that are nicely presented outside of canopies. But mealy bug hide in the bark cracks and inside fruit calyx and stem cavities. Often the tops of tall trees are not treated well and become an ongoing reservoir of mealy bugs.

Mealybug research trials







Insecticides for mealy bug control

	Lorsban	Samurai	Applaud
Mealy Bug	Yes	Yes	Yes (pears)
Group	1B	4A	17A
Codling Moth		Yes	
LBAM	Yes	Suppression	
Woolly Aphid	Yes	Yes	
Heliothis			
Dimpling Bug	Yes		

Getting Good Mealy Bug Control

- Know your orchard hot spots and concentrate on them.
- Act early when adults are emerging and new crawlers are moving.
- Act early before leaves shield the wood/bark.
- Act early before mealy bugs have calyx and stem ends to hide in.
- Choose a good insecticide.
- Use high volumes of water to 'wash' into hiding places.
- Tops of tall trees may never be sprayed well enough.
- Predators may be useful, get your scouts to look for them.

Woolly Apple Aphid (WAA) *Eriosoma lanigerum*

WAA life cycle

Woolly apple aphid (WAA) gets its name from the woolly appearance of its colonies. Long strands of white wax is exuded from their back and help to protect the colony from predators and pesticide sprays. Aphids also produce honeydew amongst the waxy strands. The aphid itself is purple, but dead aphids appear black.

Aphid colonies appear as cottony masses clustered in leaf axils, wounds and pruning scars on the trunk and branches of the tree. These are the sites of the most tender and thinnest bark, and aphids can easily pierce it to feed on sap. Swollen galls can form at feeding sites on shoots.

WAA prefer shaded areas so colonise the underside of shoots and the inside of canopies. Hail-netting improves the environment for WAA by increasing shade, but also by causing etiolation of shoots, which are 'softer' and more prone to infestation.

Most of the population consists of wingless females which reproduce asexually and produce 100-200 live young per year. The first instar is a crawler that usually settles close to the mother, hence the dense colonies. However crawlers are also a dispersal mechanism within the tree and from the roots to the tree. Subsequent nymphs are similar in appearance to the adults only smaller. Winged aphids are also produced in late summer as a dispersal mechanism.

A significant portion of the population lives on roots, close to the soil surface. Especially in sandy soils (or soils that crack). Aphid infested roots gall, and as trees age these galls enlarge and can join up and form 'plates' of roots adjacent to the trunk.

The root infesting aphids are protected from parasitic wasps and extremes of weather and form a reservoir for infestation of the shoots in spring and summer. Crawlers move up the trunks as temperatures increase. Sticky tapes can indicate when this migration commences.

Trees can have above-ground infestations of woolly apple aphid but no root infestations as different rootstocks vary in susceptibility to woolly apple aphid. Any rootstock with a MM (Malling Merton) prefix has some WAA resistance eg MM.111 or MM.106. However rootstocks with just an M prefix (Merton) are susceptible to WAA eg M9, M26. The new range of rootstocks with a CG prefix (Cornell at Geneva) was also bred for WAA resistance.

There are several types of damage caused by WAA;

⇒ The sap sucking weakens trees and can cause leaf drop which affects the trees ability to size and colour fruit.

⇒ Fruit buds are damaged, so future crops are reduced

⇒ Root infestations reduce the ability to take up nutrients and water; older trees are less efficient and the growth of young trees can be retarded.

⇒ Honeydew and the wool that has fallen onto fruit will blacken and downgrade fruit.

⇒ Fruit pickers can be hindered by the white wool and the aphid bodies, causing sticky purple staining of hands, clothes and picking bags.

Season	Where is it now?	What is it doing	Comments
Winter	Mainly on roots	Resting/feeding	Majority of population
	In bark injuries; pruning cuts and broken limbs		Old trees worse
	On dormant shoots		Especially if warm/dry winter
Early Spring	Roots	Multiplying	Drenches applied now
	Trunks	Crawlers migrating	Indicator tapes now Oil + insecticides applied now
Spring	Leaf axils initially	Crawlers migrating Growing/breeding - many cycles	Ready sap source
	1 year old and new wood		Foliar insecticides effective now as easy target and small canopy
Late Summer	1 year old and new wood	Crawlers migrating Dispersal by winged forms	Insecticides just 'taking the top off' the colonies now.

WAA only became a problem in 'warmer' countries (Australia, NZ, South Africa) when broad spectrum spraying for codling moth commenced. This lead to rootstock breeding for 'the colonies' by the research stations in England

Hail-netting, longer pruning, improved agronomy, newer more vigorous varieties have increased the WAA pressure in the past 15 years.

How to Control WAA

1. IPM (WAA is not a problem in neglected or organic orchards because wasp is so good)
2. Treat above ground
3. Treat below ground
4. Combine all 3 is best approach

The best control is the free one – **The Wasp**! So get to know The Wasp.

⇒ Overwinters in the WAA bodies, protected from weather but still vulnerable to sprays.

⇒ Emerges later than WAA crawlers so there is a timing issue.

⇒ Easy to knock over with insecticides; Gusathion, Lorsban, Penncap-M, Carbaryl.

⇒ Calypso, Altacor, Samurai, Delegate are softer and Confidor very safe

Wasp populations can explode late in season **but** usually too late – that's why we need to establish early control with insecticides. Look for wasps hanging around WAA colonies trying to find an exposed spot

between the woolly exudate where they can lay an egg into an aphid body. Look for black, dead and WAA bodies with wasp exit holes.

If woolly aphid is in need of treatment in late summer with Samurai or Lorsban and the wasp is present, but not being totally effective then it needs to be protected. Growers can strip spray, which leaves some areas where the wasp is not killed, and will spread back into sprayed areas. Rain washes off the wool and assists spray effectiveness and the wasp's effectiveness.

Insecticides for WAA control

Several cover sprays for codling moth will control WAA (Samuari) or suppress WAA (Calypso and even Gusathion).

3 cover spray approaches;

- True systemics eg the old WAA product Kilval
- Knockdowns eg Lorsban and Folidol
- Partially systemic/knockdown eg Calypso, Samurai

Or . . . . . the **Magic Drenches**: Confidor and Samurai

When applying cover sprays;

- Go early in the season when colonies small & crawlers vulnerable.
- Dimple bug and mealybug sprays can overlap.
- Make use of rainfall which removes some wool and improve spray penetration
- Minimise the affect of toxic sprays on the wasp by strip spraying.
- Use high volumes of water, maybe wetter.
- Changing to pheromones can cause WAA flares in orchards on susceptible rootstsocks
- Short season varieties eg Galas can be source of wasp as cover spraying stops on them first.

IPM

- Confidor and Samurai drenches will have an effect for 2 or even 3 seasons and this allows wasp to work very well, if late season insecticides are managed (or use pheromones).
- Calypso can suppress WAA
- Cold storing the wasp to improve its timing is impractical
- Rootstocks - Northern Spy, the MM series (MM.106, MM.111) the CG series
- Pruning style, crop load-shoots, Regalis

Resistance

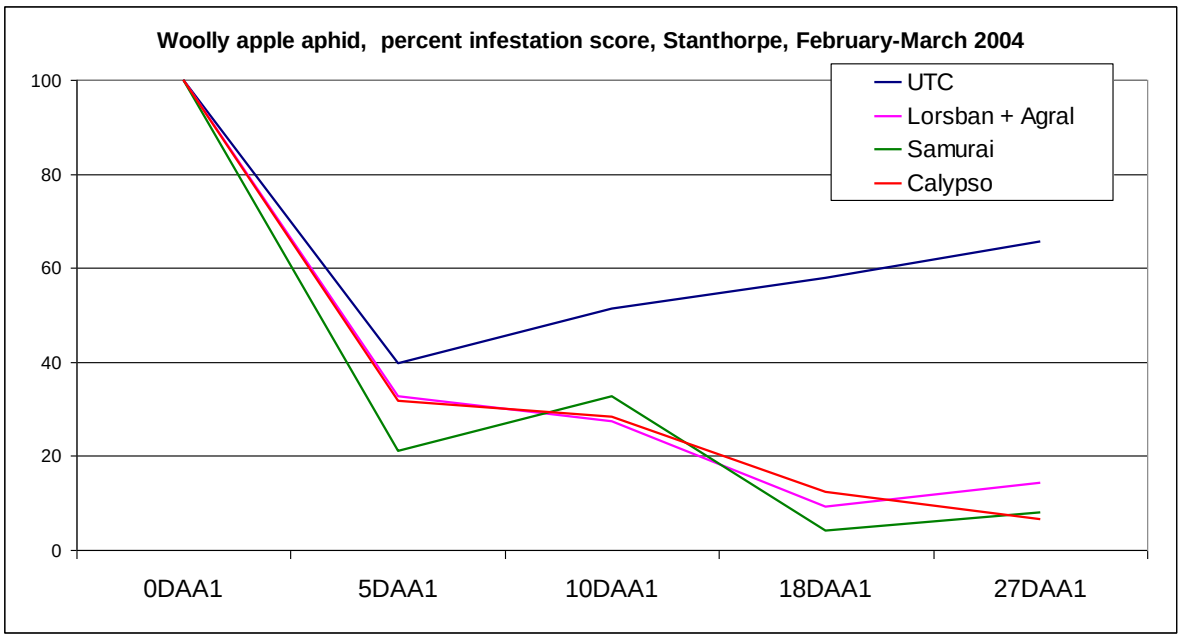
- Kilval fell over in Tassie then resistant WAA were distributed via nursery stock.
- Wasp + insecticides should delay resistance developing

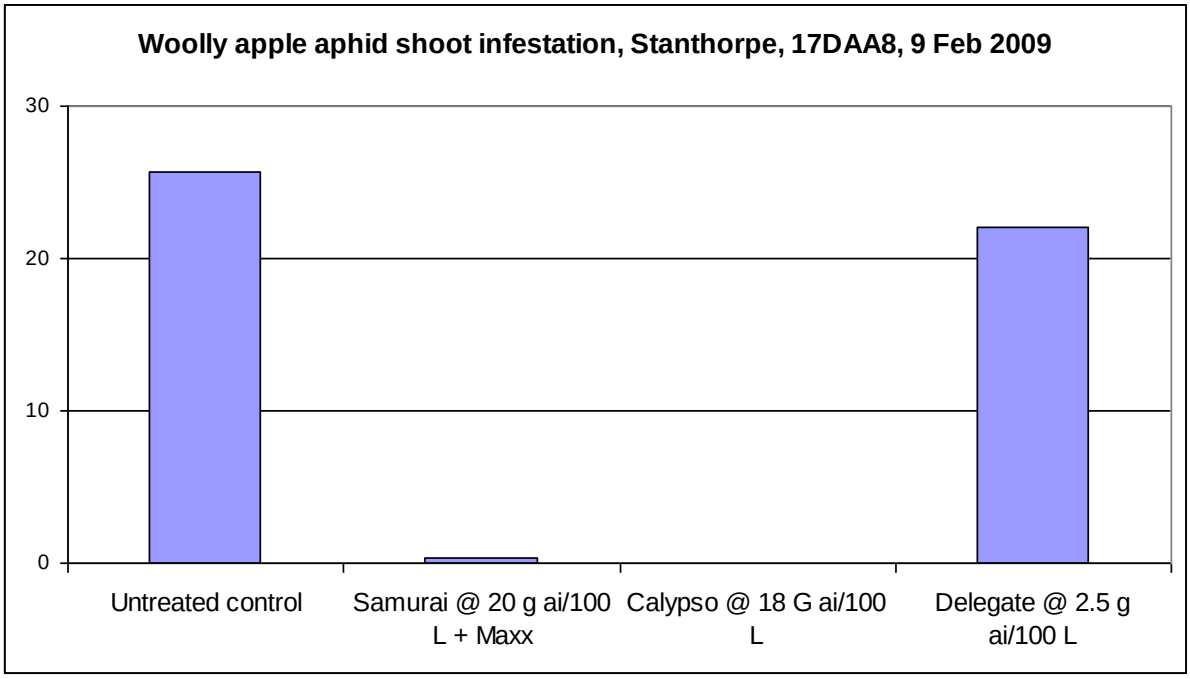
Getting Good WAA Control

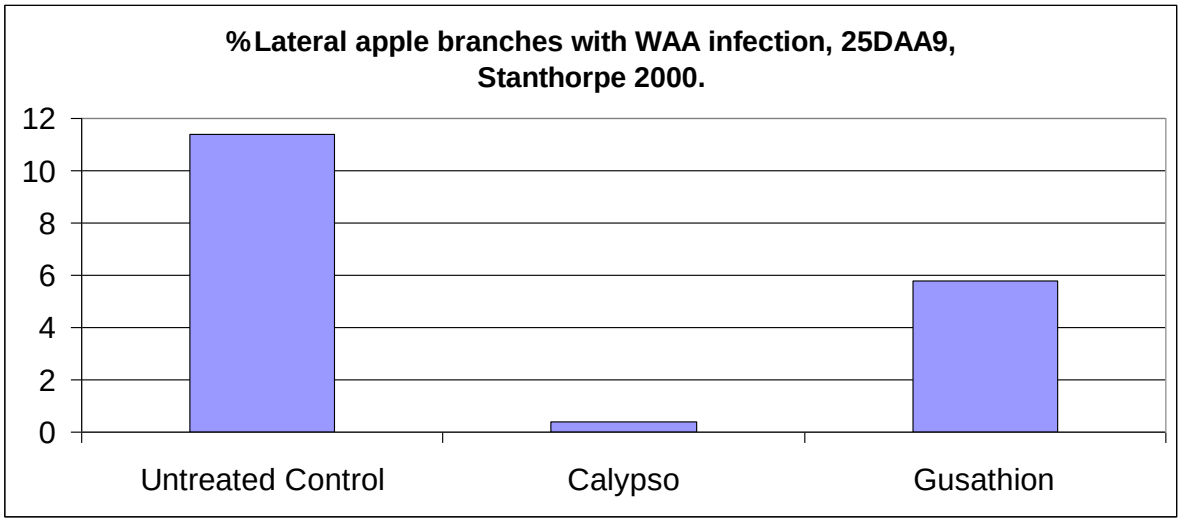
- Base strategy on resident WAA population
- Confidor and Samurai drenches essential if high pressure orchard
- Knockdowns must be early & high volume
- Some codling moth sprays can control/suppress WAA
- The WASP is the cornerstone of long term control

	Drench		Foliar Application							
	Confidor	Samurai	Lorsban	Samurai	Calypso	Gusathion	Altacor	Delegate	Insegar	Avatar
Woolly Aphid	Yes	Yes	Yes	Yes	Suppression	Suppression				
Group			1B	4A	4A	1B	28	5	7B	22A
Codling Moth				Yes	Yes	Yes	Yes	Yes	Yes	Yes
LBAM			Yes	Suppression		Yes	Yes	Yes	Yes	Yes
Mealy Bug			Yes	Yes						
Heliothis							Yes	Yes		Yes
Dimpling Bug			Yes		Yes					

.


Woolly apple aphid, percent infestation score, Stanthorpe, February-March 2004
100
80
60
40
20
0
UTC
Lorsban + Agral
Samurai
Calypso
0DAA1
5DAA1
10DAA1
18DAA1
27DAA1


Woolly apple aphid shoot infestation, Stanthorpe, 17DAA8, 9 Feb 2009
30
20
10
0
Untreated control
Samurai @ 20 g ai/100 L + Maxx
Calypso @ 18 G ai/100 L
Delegate @ 2.5 g ai/100 L


%Lateral apple branches with WAA infection, 25DAA9, Stanthorpe 2000.
12
10
8
6
4
2
0
Untreated Control
Calypso
Gusathion

Delegate on WAA parasitic wasp

Many growers have a concern about using Delegate due to its effects on the parasitic wasp, *A. mali*. New Zealand apple growers had a problem with woolly apple aphid in 2007-08 season and have attributed this to the use of Delegate. The Nelson Mail newspaper of 12 Aug. 2008 reported

Pipfruit growers raise concerns about woolly aphid outbreaks

"Growers at the Pipfruit NZ conference expressed concern that the push for low residue fruit markets in Europe was jeopardising other markets. For example, Hawkes Bay growers changed a spray for codling moth to satisfy the Taiwan market and the woolly apple aphid population 'exploded'. Subsequently four exporters have been suspended from supplying China after the discovery of woolly aphids in consignments of Hawkes Bay apples."

The link between the use of Delegate and the WAA problems was not entirely clear. Work on the toxicity (in vitro) of Delegate in comparison to other commonly used insecticides was commissioned and surveys of grower practices were done. Delegate was shown to have some detrimental effects, as do most orchard insecticides. A contributing factor was that the season in question was hotter than usual and particular dry. Consequently insects were more active and there was not the rain to wash the wool off the colonies so the wasp may not have had the same access to the WAA.

To investigate the issue under Queensland conditions an isolated Granny Smith apple orchard, on seedling rootstocks, with a high infestation of woolly apple aphid (on roots and shoots) was chosen to apply Delegate to in the 2008-09 season. Delegate was applied by the grower with his conventional airblast sprayer eleven (11) times during the season. The only other insecticides applied during the growing season were two applications of Success2 during bloom for western flower thrips.

Woolly apple aphids infested the trees and the parasitic wasp *A. mali* established at the site and increased in activity during the latter half of the season. The wasp eventually controlled the WAA infestation. This was consistent with WAA and *A. mali* population dynamics in an apple orchard where the parasite was not disrupted by toxic insecticide sprays.

Percentage of woolly aphids parasitised by *Aphelinus mali*

	% Parasitised	% Parasitised and emerged	Total % parasitised	% Unparasitised
19/02/09	15.0	3.7	18.7	81.3
18/03/09	20.1	5.0	25.1	74.9
08/04/09	39.6	22.6	62.2	37.9

The conclusion from the Queensland trial was ; "Eleven applications of Delegate did not prevent the parasitoid *Aphelinus mali* establishing in a commercial Granny Smith orchard and increasing in numbers and eventually controlling a woolly apple aphid infestation.

Experiments in some other locations have shown Delegate to be harsher on the parasitic wasp than the Qld experience. It could be that different populations have different sensitivities and local information should be sought from experienced agronomists.

Apple dimpling bug (ADB)

Campylomma liebknechti

ADB characteristics

Apple dimpling bug (ADB) gets its name from the dimple like indent that develops on apples that have been damaged by their feeding during flowering. It is a native to Australia and has a lot of natural hosts, including wattle. It is considered a pest in cotton as it feeds on small cotton squares but also a beneficial insect as it feeds on heliothis eggs and mites in cotton.

The ADB is olive green or greenish-brown in colour and about 3mm long. There is usually some variation in size and colour of individuals. They are very mobile and fly away when disturbed. They can move large distances, particularly when wind assisted. In the Stanthorpe district an incursion into apple orchards is often associated with warm westerly or northerly winds. It is assumed that the bugs are moving from weeds and native plants on the inner Darling Downs. Likewise, when the apple blossom has fallen any resident bugs (that have not been sprayed) usually move out of the orchard to other hosts.

ADB fruit damage

The ADB pierces the developing apple ovary, (which is just 1 to 2 mm in diameter at this stage) with its mouthparts to get to the sap. The scarred tissue doesn't develop as well as the rest of the apple and the sunken area resembles a dimple. However the dimple damage is not the first manifestation of damage – there is usually a small raised scar on the side of the ovary or apple stalk. As the apple grows it quickly envelops this scar. If the mature apple is sliced through the base of the dimple a 'trace' of darker scar tissue from the skin to the apple core can often be seen. Sometimes at the base of the dimple there is a small dark spot of damage to the skin but often there is no external mark on the skin, just the dimple depression.

ADB often also 'sting' the stalk of the developing apple. The damage to the stalk often caused it to be shed from the tree preferentially during the natural shedding of fruitlets just after bloom and again when apples are marble to golf-ball size. Because of this the level of ADB damage observed in a crop can reduce over time, but also if infestations are high during flowering the overall crop yield can be reduced.

Monitoring of ADB

Because dimpling bugs are so mobile, it is important to monitor for them every day during the blossoming period. Not every block every day, but a number of representative blocks every day. Particular notice should be taken of the pests in outside rows and in any orchards adjoining bush areas.

Blossoms are 'tapped' into a container and the contents examined for dimple bugs and thrips. A common technique is to use a white plastic container (ice cream bucket or Tupperware dish) with deep sides. This will slow the dimple bugs exit once they re-orientate themselves after being 'blossom-tapped'.

Every season is different and once there is an incursion every orchardist's treatment and level of control will be a bit different, so district wide monitoring is not as useful after an incursion. Individual orchards need to be monitored to determine if control has been effective and to be alert for any fresh incursions.

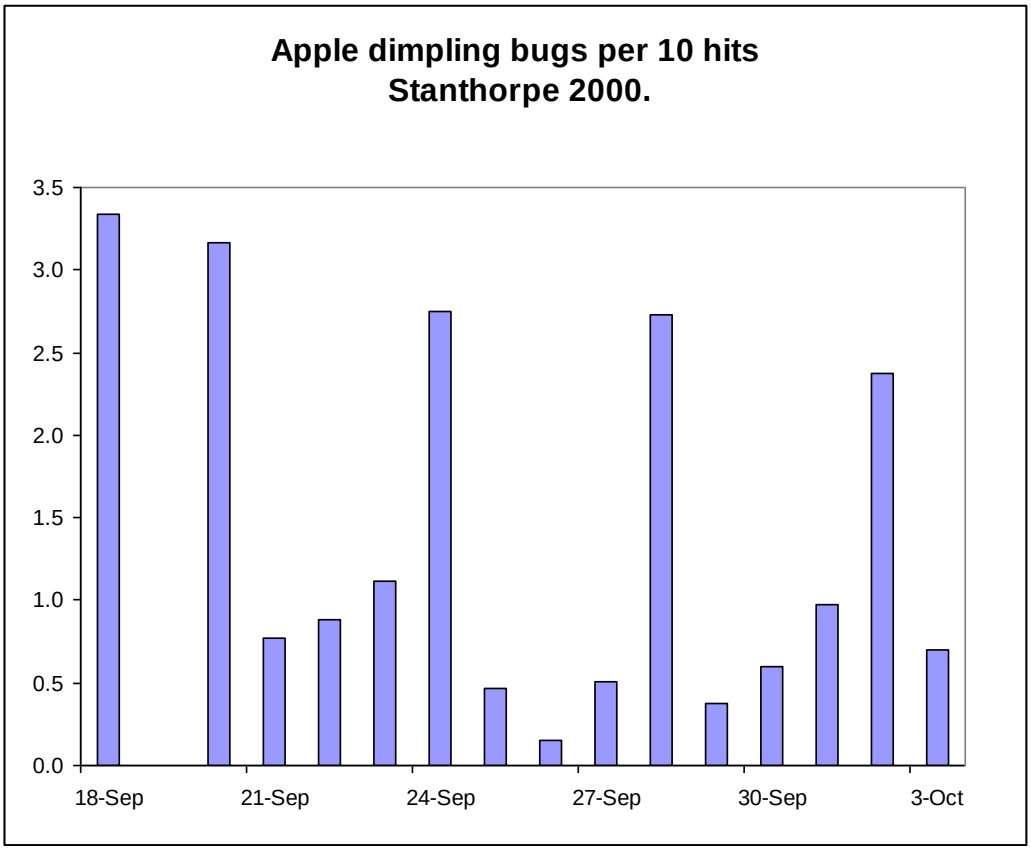
There is a local Qld threshold of 1 to 2 dimple bugs per 10 blossom-taps or 'hits'. On the next page are graphs of the district wide monitoring in 2000 and 2007. These were very different years. In 2000 there were a lot of ADB in the district before flowering commenced and there were several re-incursions with favourable winds. However in 2007 the threshold wasn't reached until late in the blossom and some varieties were past petal fall by then. Many days monitoring revealed nil ADB's. Spraying by the calendar or by crop stage is not recommended with this pest.

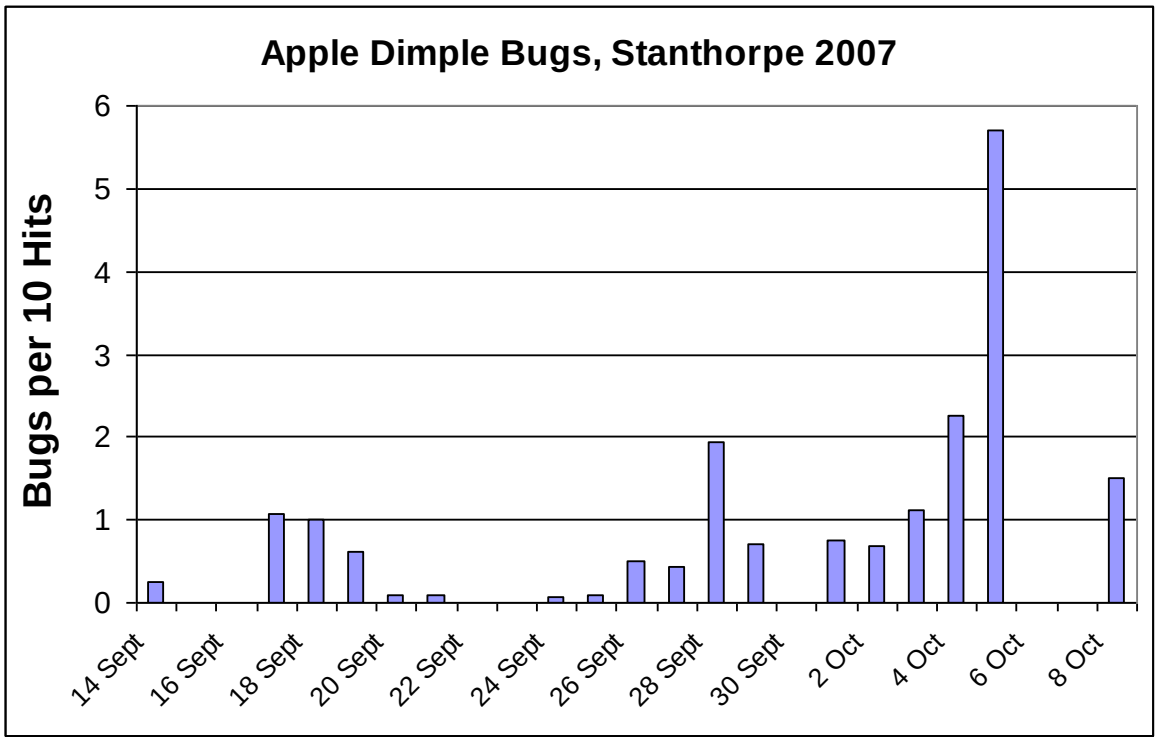
The mobile nature of dimple bugs make it difficult to conduct trials because they may fly in to a block, bite then die, but the bite still shows up as damage. Leaving unsprayed trees mean they jump around the trial

block and ‘smooth’ out the data! The other problem (well a problem for researchers) is that there is not enough dimple bug every year to reach economic threshold. It took three trials and about six years to get decent data to register Calypso for ADB.

Apple dimpling bug will sometimes infest stonefruit blossoms and as stonefruits flower before apples it can be an early indication of their presence in the district. ADB don’t appear to damage stonefruit or perhaps injured fruit all shed from trees. Fruit sucking bugs (myriads) are sometimes a pest of stonefruit but seem to be mostly well controlled by Mavrik sprays applied for plague thrips.

Dimple bugs sprayed with Calypso stop feeding but remain alive and in the blossoms for several days before they die. Be aware of this when scouting after spraying. Experienced scouts can tell if an apple dimpling bug has been sprayed and looks a bit dozy! Because of the high growth dilution over flowering we are not seeing Calypso last more than 5 – 7 days (which may be long enough).





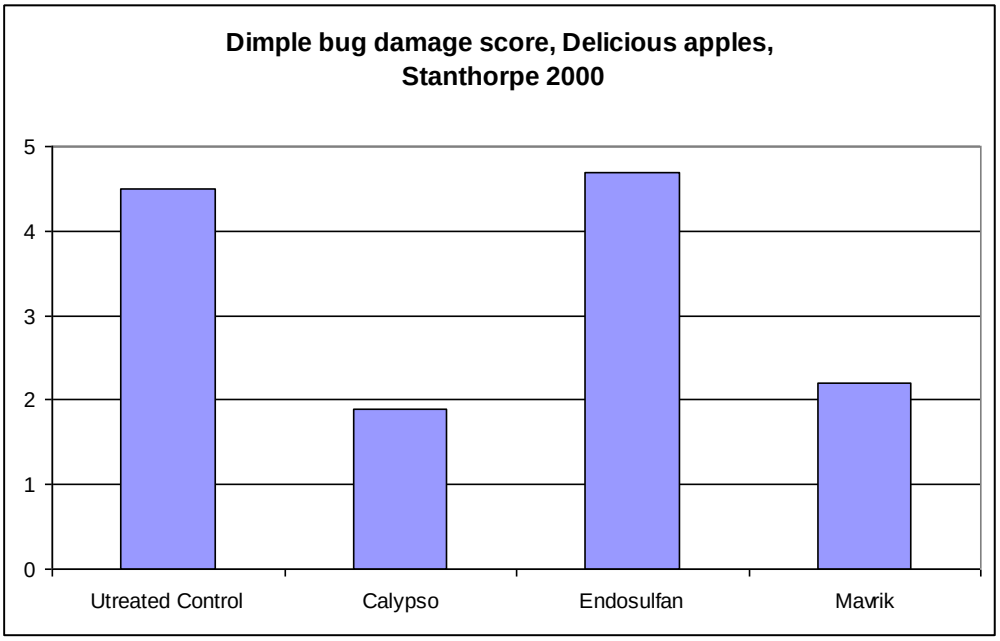
How to control ADB

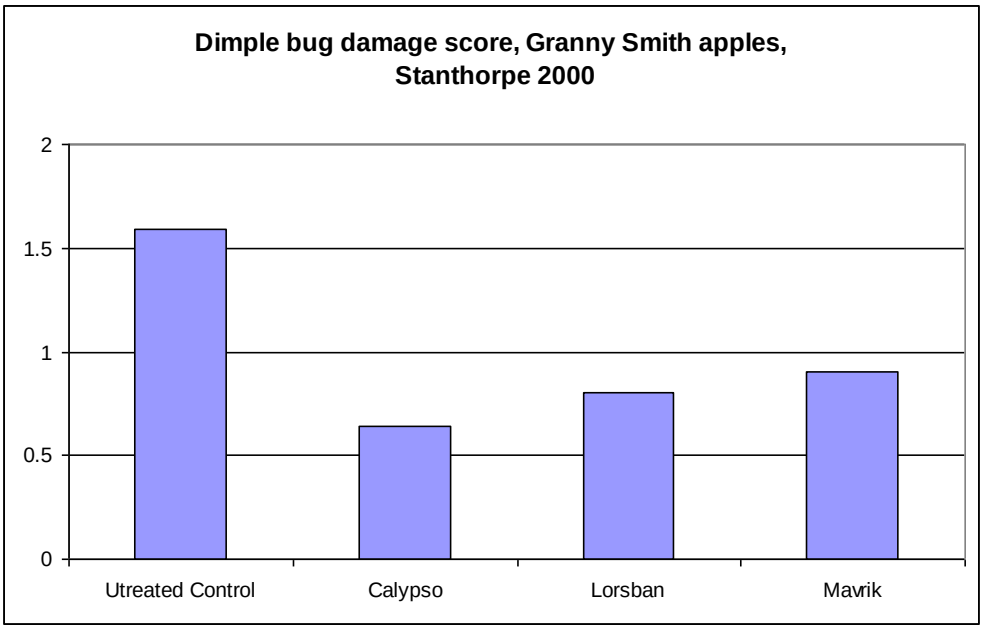
1. Monitor and act on threshold
2. Use Lorsban WG as a prophylactic treatment at pink tip stage
3. Use Calypso as a knockdown insecticide
4. Do not use Mavrik (tau-fluvalinate) as it will wipe out predatory mites for 12+months

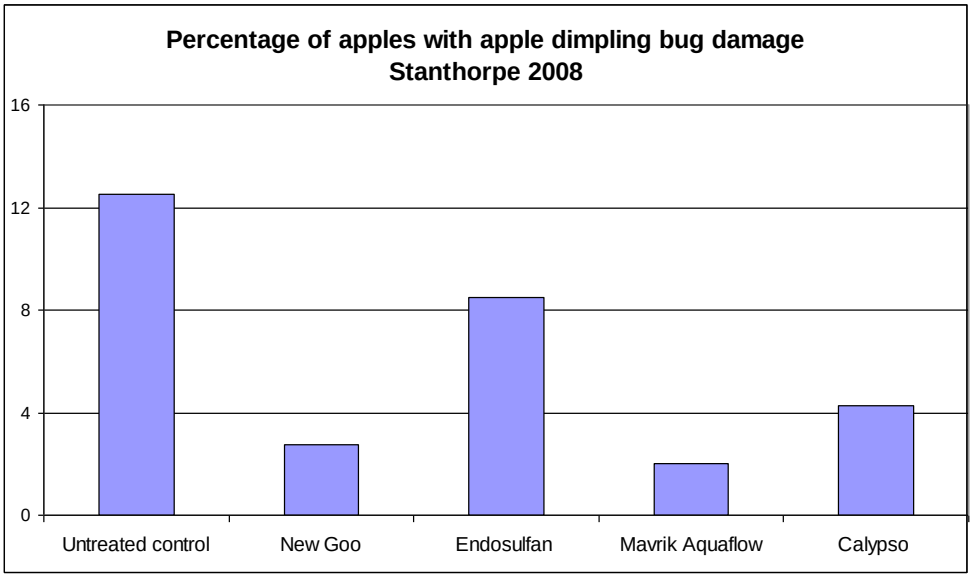
Insecticides for ADB control

Product	Form-ulation	Label Comment
Lorsban	750 WG	Apply up to late pink (balloon stage). Re-apply at the end of flowering if necessary. Do not apply for a maximum of 3 days before bees are actively foraging
Calypso	480 SC	Correctly timed applications of Calypso will significantly reduce fruit damage caused by apple dimpling bug, however a substantial reduction in pest numbers may not always be evident. Apply an initial spray from pink stage to petal fall when pest numbers reach accepted threshold levels as indicated by monitoring. Spray thoroughly to ensure complete coverage of flower parts and developing fruitlets, using dilute spraying equipment (concentrate spraying is not appropriate for this use). A second spray and/or other control measures may be necessary under high pressure.

	Lorsban	Calypso	Delegate
Dimpling Bug	**Yes**	**Yes**	
WFT			**Yes**
Plague Thrips	**Yes**		**Partial**
Group	1B	4A	5
Woolly Aphid	Yes	Suppression	
Codling Moth		Yes	Yes
LBAM	Yes		Yes
Mealy Bug	Yes		
Heliothis			Yes


Dimple bug damage score, Delicious apples,
Stanthorpe 2000
5
4
3
2
1
0
Utreated Control
Calypso
Endosulfan
Mavrik

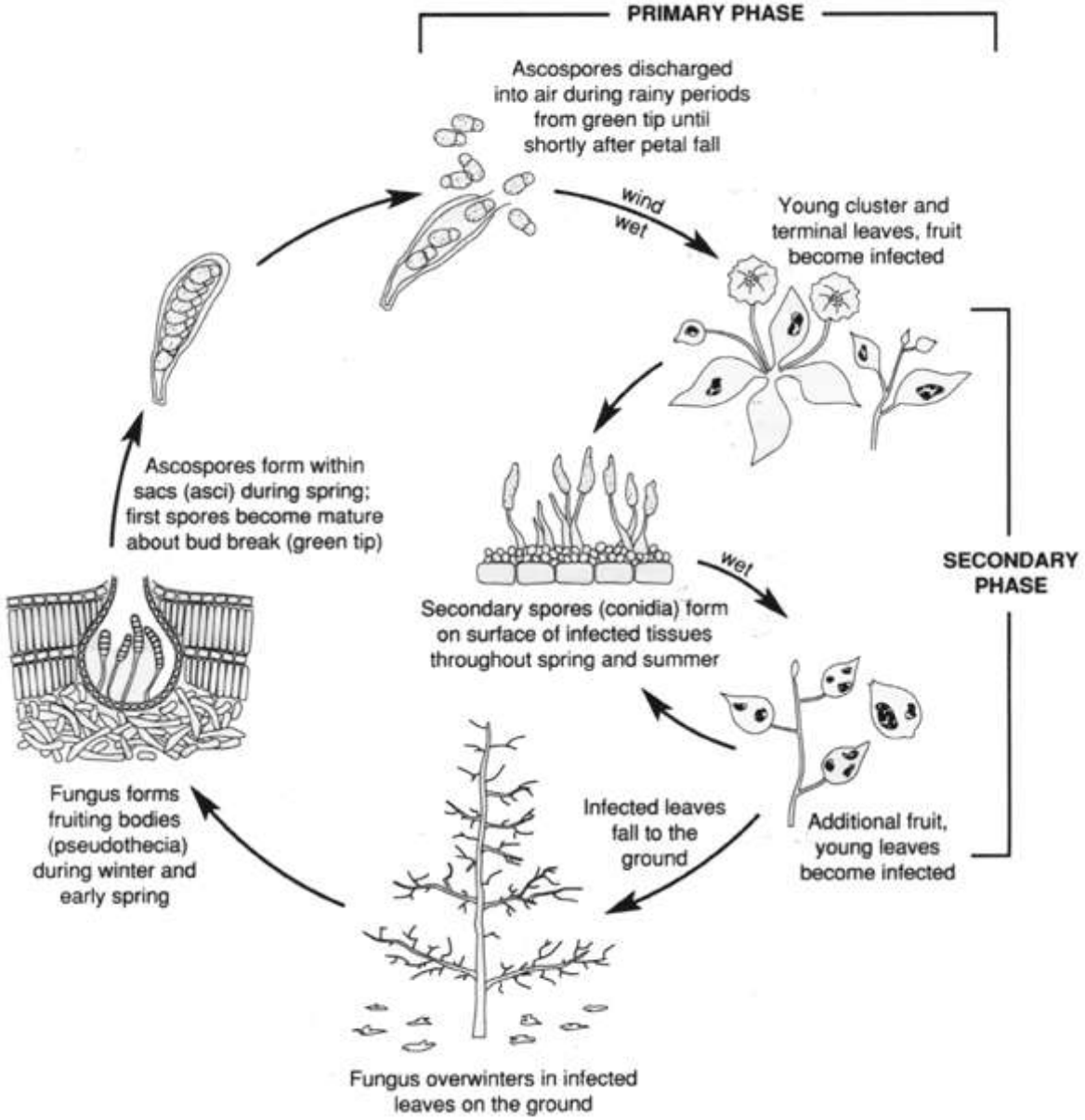

Dimple bug damage score, Granny Smith apples,
Stanthorpe 2000
2
1.5
1
0.5
0
Utreated Control
Calypso
Lorsban
Mavrik


Percentage of apples with apple dimpling bug damage
Stanthorpe 2008
16
12
8
4
0
Untreated control
New Goo
Endosulfan
Mavrik Aquaflow
Calypso

Black Spot

Venturia inaequalis (apple black spot or scab), *Venturia pirina* (pear black spot or scab)

The black spot disease cycle



Its important to understand that black spot in the spring and summer only originated from black spot last season and the winter is a time to control the disease with hygiene measures.

Black spot is the ' key disease' of apples and pears. Left untreated it can cause almost total crop loss. It is usually well controlled because growers having a good understanding of the disease, the availability of good fungicides and until recently some dry seasons. Before the last two wet seasons powdery mildew was more of a problem than black spot. However, black spot is now back in most districts and here are ten possible reasons why;

1. Farm sizes are increasing and there are not as many spray machines per hectare on farms. After infections there isn't enough time to over the whole orchard with a curative fungicide, and likewise there may not be enough time to get a protectant fungicide on the whole farm before rain.

2. Mixing rates need revisiting. Most orchardists have reduced spray application water volumes to get better droplet size and do less fill-ups. But, if water volumes are reduced then chemical mixing rates must be increased proportionately or you are under-dosing. The amount of fungicide to apply on a hectare of trees should always equal what you would have applied if you were mixing at dilute rates and spraying to 'the point of run-off'. Under-dosing may work in low pressure situations, but leads to a false sense of security. There are no environmental or economic reasons to register a fungicide at a higher the rate than it works at. I have done registration trials with almost all the fungicides presently used and know that the label rate works and it's not far from the rate that doesn't work. Registered rates from the 1970's were a long way up the response curve, but todays registered rates are a lot close to the 'shoulder'.

3. Speeds are increasing. Because farms are larger there is a need to drive spray machines faster to get the job finished. But if you travel *too* fast your coverage will suffer. Groundspeed, airflow and canopy depth all need to match or you won't get even coverage. Water carries the fungicide but it is air flow that carries the droplets to the tree. If you drive too fast you could still be putting the right quantity of fungicide per hectare on the trees, just not spreading it evenly. The appropriate speed is directly related to the airflow your sprayer generates and the target leaf canopy. Air volume and air speed are different things, and some sprayers deliver the air at different points up the canopy. The important thing is that air (which is carrying the spray droplets) moves completely sideways through and vertically up a canopy.

4. Decision making. Has rain weathered my protectant spray? Was there an infection period during yesterday's rain? How many days after an infection can I expect a curative spray to work? What is the best protectant? Should I mix a curative and a protectant fungicide? With less Department advisors and extension officers, orchardists have to build up their knowledge and networks of advisers to help with decision making on their specific orchards.

5. It's a numbers game. Spores are looking to infect and more spores in the orchard means more chance they will. If you had black spot on leaves or fruit last season you will have spores carried-over this winter ready to release in spring. If you have carry-over spores there is no room for risk taking and all management options should be tweaked for the worst case scenario. If you didn't have black spot last season you have options to reduce your inputs.

6. Trees are more prone to disease. We have changed the type of tree we grow. Most orchards are now irrigated, fertigated, have grassed inter-rows and many are hail netted. This produces 'softer trees' that have young leaves on them for longer. Young leaves that are still expanding are more susceptible to black spot than older leaves. Newer varieties are naturally vigorous and although we like to see trees settled and with no fresh growth in mid-summer there are always some blocks or some individual trees that have too much growth. Why are older leaves less prone to black spot? There are physical and

biochemical reasons and collectively these mechanisms are called ontogenic resistance. Be aware of ontogenic resistance when assessing the risk of each infection period, but don't assume your orchard is uniform and that every leaf and every tree is at this stage. Lowering risk is about looking at the weakest links.

7. A better environment for black spot. When we install hail netting we increase humidity, lower windspeeds and block some sunlight so leaves stay wetter for longer and increases the chance of infection. Not cultivating the orchard soil allows more infected over-wintering leaves to survive till spring. This sort of hygiene was a cornerstone of pest and disease controls before modern pesticides. Sweep leaves from under trees and mulch them. Intact leaves protect black spot lesions and broken leaves rot and the overwintering black spot will be destroyed. Encourage the bugs responsible for leaf rotting by spraying urea and organic brews onto fallen leaves.

8. Fungicide shortages. World agriculture is growing and pesticide supply is sometimes not keeping up. Resellers won't keep large stocks or order early. The only way to safeguard yourself against shortages is to always have enough fungicide in the shed for at least two month's spraying and keeping your supply topped up.

9. Orchards have got busier. Orchards are very busy places during spring - there are less trained staff and more jobs to do. Getting ahead with your jobs list during late winter is critical. Black spot shouldn't establish because 'we were too busy doing other jobs to put on enough fungicide'.

10. Confusion over fungicides. To some extent there are too many fungicides available! There are 11 protectants (Captan, Chorus, Delan, Dithane, Flint, Polyram, Pristine Stroby, Syllit, Thiram and Ziram), 7 curatives (Bogard, Rubigan, Saprol, Systhane, Syllit, Topas and Viva) and 3 dual purpose fungicides (Fontelis, Syllit and Vision). Fontelis is a very welcome new curative as some tolerance to the DMI curatives has been reported recently. There is no 'best fungicide' and each of the listed fungicides has a best fit based on their strengths and weaknesses. Most fungicides are multi-purpose so when choosing a black spot fungicide consider the other apple diseases; powdery mildew, Glomerella, Alternaria, sooty blotch/fly speck.

Basics of black spot control;

- The disease overwinters in old dead leaves on the orchard floor.
- Winter spores (ascospores) are released, when mature, in spring with rainfall that occurs in daylight. There is a Day-Degree model that predicts the maturity of ascospores and hence when the largest releases will be.
- Spores sit in a water film on new leaves and fruit and infection is only successful if the leaf and fruit are wet for long enough at threshold temperatures. These are called Mills periods and black spot warnings are based on measuring leaf wetness, temperature and humidity.
- Warnings usually finish in December as the supply of overwintering spores runs out, leaves develop some natural resistance and there are less new soft leaves as fruit growth takes over.
- New black spots are the summer spore (conidiospores) lesions.
- Summer spores can infect leaves and fruit up until leaf fall. The aim is to not get summer infection by stopping winter spores !
- Summer spores don't need daylight to release, they wash onto leaves/fruit and infect after Mills periods.
- There are two types of fungicides; protectant and eradicant/curative.
- DMI curatives do not provide much forward protection so always mix a protectant with a curative. This is also important for resistance management.
- There are normal protectants and 'super protectants'.
- Eradicants have different number of days 'kickback'. Presently we have three groups; the DMIs (group 3), Syllit (group U12) and Fontelis (group 7). Rotate these to protect them.

Black spot warning services

- measures weather (temp. rainfall, leaf wetness)
- uses computer to keep records
- compares records to " Mills tables"
- interpreted by Dept of Ag, Co-op or reseller agronomists.
- industry advised by email and fax

Why does the black spot warnings finish around December?

- the over wintering dead leaves run out of spores
- the existing green leaves on the trees get tougher
- there is less new growth with soft leaves as fruit grows

There is a Day Degree model to predict the maturity of overwintering spores and what proportion will be 'ripe' and ready to be released at each rainfall event. Sometimes this information is incorporated into the warnings.

Black spot warnings helps you answers two basic questions;

1. do I need to spray ?
2. what will I use ?

Weathering of fungicides.

There is experimental data with Captan to show that 12mm of rain is enough to reduce spray deposits on apple leaves to 60% of the applied dose and to 20-30% after 25mm. In the absence of rain the spray residue on mature leaves was reduced by 59 - 78 % after 7 days. Also that immature leaves had only 75 % of the deposits that mature leaves had after 7 days due to growth dilution. Hence an immature leaf sprayed before 25 mm+ rain may have only had 10% of the original spray cover left after a week. [natural pesticide loss over 6 days (50 %), the reduction by 25 mm rain (75 %) and losses from leaf expansion (25 %)]. Gentle rain weathers less than heavy rain.

However the greatest reduction in spray deposits is caused by growth dilution, especially in spring when buds are opening, shoots regularly producing new leaves and fruits and leaves are enlarging in size each day.

Older protectants (with the exception of Delan) have a high concentration of active ingredient (998 ppm) compared to the newer protectants (113 ppm) and the eradicants (average 162 ppm). This is one reason why the eradicants do not have very good protectant activity.

The super protectants are described as having the ability to bind to, penetrate into and re-distribute around plant tissue (not systemic but 'mesostemic').

Of interest, I have an old Cyanamid leaflet that says "at the same concentration Delan is 20 times more effective than mancozeb". If only modern marketing could be so aggressive!

I have some BASF information (2002) that describes and experiment where 15 mm rainfall was applied every 24 hours for 5 days. Polyram's protection was gone in 1 day, Delan's protection lasted 2 days and Stroby's protection for just over 3 days.

Five steps for successful black spot control

1. Hygiene – help overwintering leaves breakdown with urea and mulching.
2. Anticipate rain and apply protectants before the rain.
3. Act on warnings – apply eradicants after infection periods if no protectant cover existed.
4. Think of the main risk factors: variety susceptibility / overwintering spore load / intensity of infection period / expected weathering of last applied fungicide / your attitude to risk.
5. After each rainfall event in spring ask yourself two questions; do I need to spray? If I do then what will I use?

Powdery Mildew

Podosphaera leucotricha

The powdery mildew disease

Grows on the twig, leaf, flower and/or fruit surface. Puts 'roots' into tissue for nutrients.
New leaves are susceptible for only a short period after they emerge from the bud.

High humidity needed for infection but no water needed for spore germination – in fact moisture usually inhibits new infections.

Optimum temperature is 19 – 25^{o} C.

- Hence risk of infection decreases as summer temperatures rise.
- But good conditions return in autumn usually.

Infection of new lateral and fruit buds occurs within a month after they have formed. Fungus lays dormant inside these buds until budbreak next spring.

Terminal buds and flower bud most likely to be overwintering source. Mycelia survive *inside* the buds so are protected from winter applied fungicides.

Infection at flowering and soon after when fruitlets are small can cause webbed russet on apples, which lead to rejections. The ongoing infection of leaves causes reduced photosynthesis and hence smaller and paler apples.

If there are significant overwintering infections then control should start at green tip or at flowering at the latest.

Most growers control the disease well enough to keep the disease off the fruit, but it too often becomes a significant leaf disease.

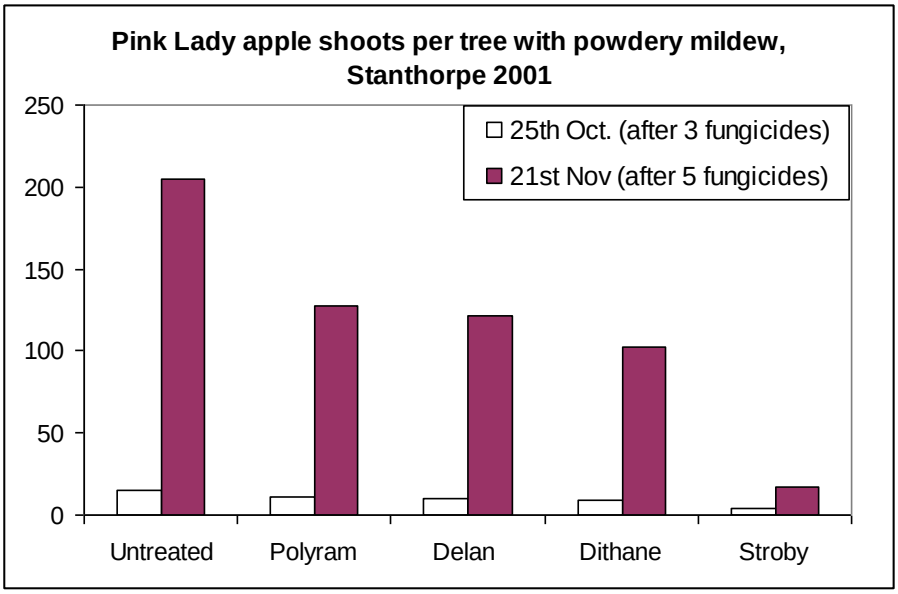
The increasing importance of powdery mildew

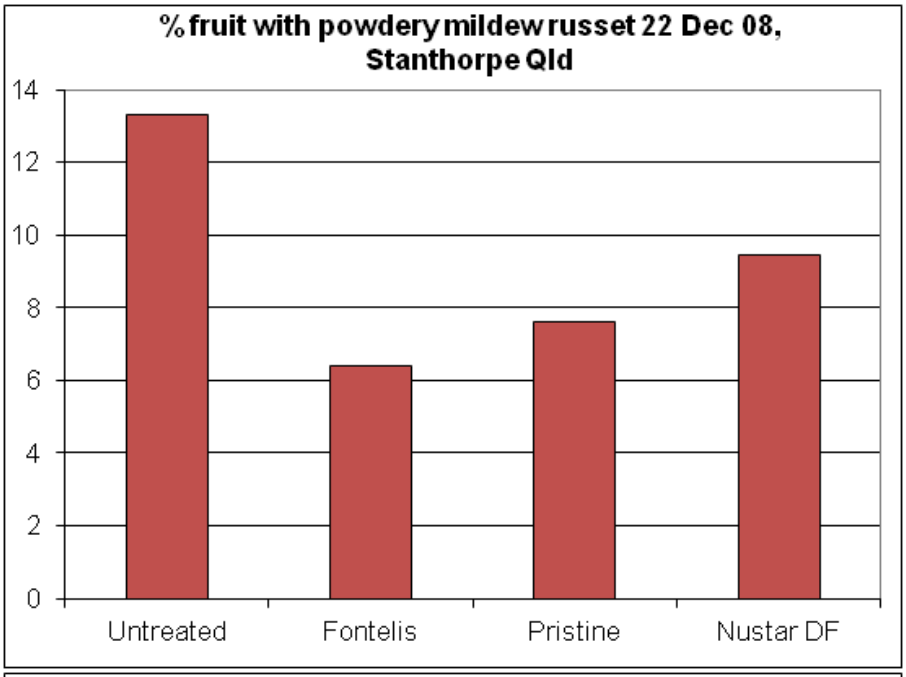
The disease was traditionally very important to control in Jonathan and sometimes Granny Smith apples, as these were the most susceptible varieties. However the new varieties Royal Gala and Pink lady are very susceptible to powdery mildew and these make up half the plantings of most orchards.

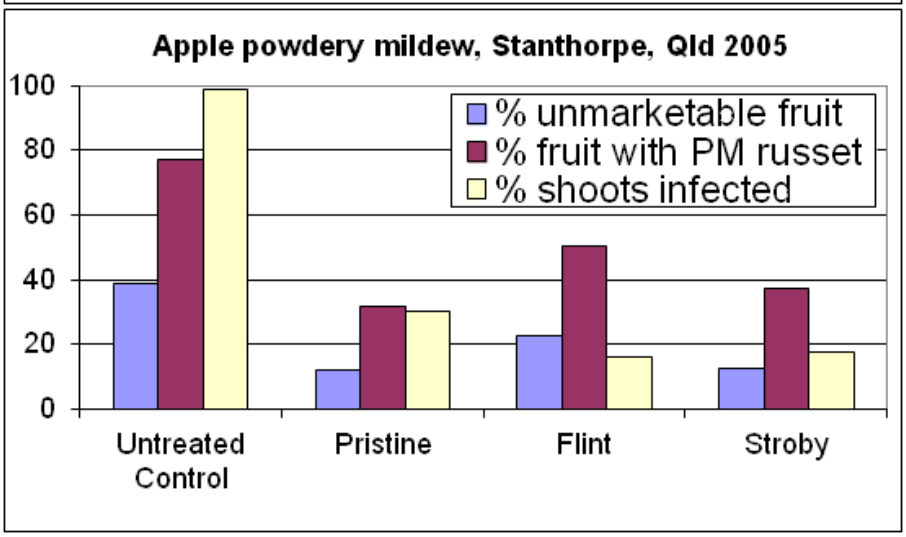
Traditional pruning methods removed most of the buds infected with powdery mildew in winter, but modern, longer pruning methods allow infected buds to remain in the tree as a source of inoculum in spring.

Hail netting, thicker tree canopies and grassed swards all increase orchard humidity which also favours the disease. Improved agronomy (irrigation and nutrition) has increased the length of time that new terminal leaf growth is available in the orchard for infection.

As a result of these agronomic changes powdery mildew is now often a more widespread problem than black spot.


Pink Lady apple shoots per tree with powdery mildew, Stanthorpe 2001
250
200
150
100
50
0
25th Oct. (after 3 fungicides)
21st Nov (after 5 fungicides)
Untreated
Polyram
Delan
Dithane
Stroby


% fruit with powdery mildew russet 22 Dec 08, Stanthorpe Qld
14
12
10
8
6
4
2
0
Untreated
Fontelis
Pristine
Nustar DF


Apple powdery mildew, Stanthorpe, Qld 2005
100
80
60
40
20
0
% unmarketable fruit
% fruit with PM russet
% shoots infected
Untreated Control
Pristine
Flint
Stroby

Alternaria - Alternaia leaf blotch, Alternaria fruit spot

The Alternaria disease

We are still learning about the lifecycle and causal weather conditions of this disease. There is a group of species involved, which differ around the world and Australia. They interact with different varieties differently. A very good APAL – HAL funded project at present being conducted by Dalphy Harteveld, a PhD student at University of Queensland – see separate handout.

Definitely a wet weather disease, but only if warm temperatures prevail. Alternaria is a common wound fungus in apple orchards and is not always associated with the development of the disease. Leaf damage from mites may be associated with infections. Carryover is mostly on overwintering leaves but also on bark and twigs.

Can cause extensive defoliation which affects fruit size and colour. When leaf infection is high fruit can also be infected.

Trial work shows that mid-season (November) sprays are very important. Treating after symptoms appear is of little use.

Delicious is mildly susceptible and Alternaria was sometimes seen on Delicious in the 1980's when broad spectrum fungicides were reduced in favour of DMI fungicides. Alternaria has increased in importance in the past 10-15 years. Possible reasons include;

- In the 1990's plantings of the susceptible varieties Gala, Fuji and Pink Lady increased, which increased the sources of the disease and the number of orchard blocks per farm where it resided and could spread from.
- With the advent of some new narrower spectrum fungicides (Chorus, Flint, Stroby) in the mid-late 1990's there was reduction in the use of broad spectrum fungicides that were suppressing this disease.
- Over the past 25 years improved agronomy and closer planting have made tree canopies denser. Hailnetting has increased the humidity and shade levels. Perhaps trees are wetter for longer after rain and dew and infection is enhanced. Orchard soils ceased being disced each year in favour or inter-row grass swards, which also has allowed over-wintering inoculum to survive.

Alternaria control

Protectant fungicides have performed better than curatives in Queensland. There were permits for Polyram and Delan and they have both performed well in local trials. Pristine has performed very well in trials and has been registered for Alternaria. Stroby and Vision have provided some control in limited trials.

Differences in the suite of fungicides that control it between states (NSW/Qld) and countries (USA, Australia, Italy).

The disease can 'explode' very quickly if there are several days of warm, wet weather in mid summer. Its possible that a few 'pioneer' lesions establish in trees in spring and early summer and provide large amounts of inoculum for fresh outbreaks if the weather is right.

The disease may infect leaves in the month after bloom and lay dormant as a latent disease to express in the right weather conditions. So early fungicides also important.

Too many apple fungicides ?

Apple and pear growers presently have over 19 fungicides from 8 groups to choose from!

This is an excellent situation for avoiding fungicide resistance however the choice of which fungicide to use when has become a little confusing.

Two types of fungicides. There are 2 broad classes of fungicides; protectants to use pre-infection and eradicants to use post-infection.

Protectant fungicides prevent successful fungal infection and should be applied before any infection periods (usually before rain). Eradicant fungicides have the ability to eradicate a fungal infection after it has started and can be applied after rainfall and infection has initiated. The exceptions are Dodine and Fontelis which are both dual purpose protectant/curative fungicides and Vision which is a pre-mixture of both a protectant and a black spot eradicant.

It is known that some protectants do have some short 'kick back' activity but it is often only a number of hours and too short to be useful eg several hours for Captan and up to a day for Delan.

However the eradicant activities of the newer protectant fungicides Chorus, Stoby, Flint, Fontelis and Pristine are a little longer that those of the older chemicals, but still not long enough to obtain registration for practical purposes. But the curative activity adds to their effectiveness. Because of this and the distribution and adherence properties of Chorus, Stroby, Flint and Pristine within plant tissue they have been tagged as 'super-protectants'.

How to choose a fungicide?

No fungicide is perfect and there are positives and negatives for each product.

1. Consider the main disease problem at the time or in a specific orchard eg black spot at flowering or Glomerella in November.

2. Always consider the millions of predatory mites that are working on your behalf to control mites. If you do chose to use Dithane then limit the use to 2 -3 sprays mid-season.

3. Consider potential leaf or fruit damage implications, eg is Captan or Delan being used before or after oil, is the fungicide an EC formulation or is Syllit being used in cold weather?

4. Resistance management. Always tank mix protectants with any eradicants applied to avoiding resistance to eradicant fungicides. Curatives are poor protectants so mixing them covers both bases.

5. Don't use price as a reason not to use an appropriate fungicide. Be aware that pest and disease control chemicals are a small portion of the over costs of production.

Prices differ for every fungicide used and usually there is a reason for this. The more expensive products do more or the cheaper products have some drawbacks. This list changes a little when I update it every few years. At present there is a plentiful supply of Dithane in Australia as much was ordered for chick peas and didn't get used, hence its price has fallen. There is a world wide shortage of Polyram so its price has drifted up over the past two seasons.

The important thing to take from the table below is that the super-protectants cost more than the ordinary protectants but you can expect more from them. Notice that Chorus is the cheapest super-protectant because it doesn't offer much control for funguses other than black spot.

Fontelis is priced like two fungicides because it is a good protectant and a curative. Vision is also in this class, but the curative component is of an older group.

Fungicide	Rate per 100 litres	Cost per Ha ($) *
Dithane R'shield	175	26.93
Captan	110	31.09
Ziram	150	32.13
Delan	18	32.72
Syllit	80	38.16
Polyram	175	47.67
Chorus	40	58.46
Flint	10	61.56
Stroby	10	67.50
Fontelis	75	71.82
Pristine	40	110.59
Systhane	12	52.20
Bogard	25	49.50
Syllit	120	57.24
Topas	25	59.04
Vision	75	64.53
Bogard (powdery rate)	50	99.00
Fontelis	112.5	107.73

* Application rate of 1,800 L/ha

Group	Fungicide	Black Spot		Powdery mildew	Alternaria	WHP (days)
		Action	'Kick Back'			
9	Chorus	Super-protectant	Nil	Not registered		NR
11	Stroby	Super-protectant	Very short	Excellent protectant		42
11	Flint	Super-protectant		Excellent protectant		35
11 & 7	Pristine	Super-protectant		Excellent protectant	Registered	14
M4	Captan	Protectant	Almost nil	Not registered, but weak background protection		7
M9	Delan	Protectant			Good Qld activity Previously a permit	21
M3	Dithane	Protectant				14
M3	Polyram	Protectant			Good Qld activity Previously a permit	14
M3	Thiragranz	Protectant				7
M3	Zineb	Protectant				14
M3	Ziram	Protectant				7
3	Saprol	Eradicant	3 days	Mainly curative		1
3	Topas	Eradicant	4 days	Excellent curative		14
3	Viva	Eradicant	4 days	Mainly curative		7 apples 14 pears
3	Rubigan	Eradicant	4 - 5 days	Mainly curative		14
3	Bogard	Eradicant	5 days	Mainly curative (Recently registered)		28
3	Systhane	Eradicant	5 days	Mainly curative		21
3 & 9	Vision	Protectant & Eradicant	5 days	Protectant and curative		NR
7	Fontelis	Protectant & Eradicant	3 days	Good protection		28
U12	Syllit	Protectant & Eradicant	1½ days	Not registered		5
H	Nimrod	Not registered		Protectant and curative		7

NR = not required if used as per label timing

Fungicide	Positives	Negatives	Preferred Use Period
Chorus	Super protectant/ soft on predatory mites	Narrow spectrum	Green tip to petal fall
Stroby	Super protectant/ soft on predatory mites Better on powdery mildew than Flint in some trials	Long WHP Can only use 3 per season	Before December for powdery control
Flint	Super protectant/ soft on predatory mites	Long WHP Can only use 3 per season	Before December for powdery control
Pristine	Super protectant/ soft on predatory mites Two modes of action	Long WHP Can only use 3 per season	Early, mid or late depending on disease
Captan	Soft on predatory mites Short WHP	Can't apply after or before oil sprays	Mid to late season
Delan	Activity on Glomerella and Alternaria 'Sticks' well	Can't apply after or before oil sprays Ordinary stored fruit restriction	After bloom onwards
Dithane	Used for Glomerella control 'Sticks well'	Harmful to predatory mites	Twice in November
Polyram	Activity on Glomerella and Alternaria	Moderate harm to predatory mites	All season
Thiragranz		Allergies	All season
Zineb		Not strong on any particular disease	All season
Ziram		Not strong on any particular disease	All season
Saprol		An EC formulation	Not while apples small/tender
Topas	Preferred powdery mildew curative	An EC formulation	Not while apples small/tender
Rubigan			All season
Viva			All season
Bogard	Long 'kick back' period		All season
Systhane	Long 'kick back' period		All season
Vision	Long 'kick back' period and good powdery activity Protectant & Curative		Not later than 4 weeks after petal fall
Fontelis	Good powdery activity Protectant & Curative		Before December for powdery control
Syllit	Useful on established black spot infection Soft on predatory mites	Can russet fruit in some conditions Not a good mixer	Green tip to full bloom or post infection

Nimrod	Systemic powdery mildew spray	Not a good mixer	When powdery evident