INTEGRATED PEST&DISEASE MANAGEMENT for Raspberries and Blackberries

raba Raspberries & Blackberries Australia

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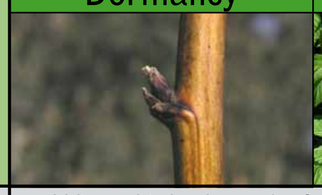
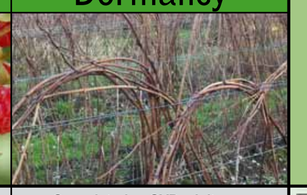
IPM is simply integrating all your management activities with the aid of an action plan developed for specific crop stages. Effective management of any pest or disease is rarely achieved with a single management measure.

Dormancy	Leaf Growth	Flowering	Harvest	Dormancy
				

The Pest Management module of the *Rubus Integrated Fruit Production Manual* provides background information on IPM. Contact the RABA office to source the *Rubus IFP Manual.*

Nezara viridula — Green Vegetable Bug, GVB

BUGS	**Adults overwinter in maize crops (non-feeding), under tree bark or in farm sheds In warmer coastal areas green vegetable bug (GVB) will feed and breed all year round** — **GVB invade crops at flowering. Eggs are laid underneath leaves in rafts. Nymphs and adults feed by piercing flower buds and fruitlets. Damage is visible as distorted growth, usually *after* infestation has occurred** — **Overwintering GVB adults are purple-brown**
Monitoring	Monitor weeds and trap borders to manage GVB populations during non-bearing periods — Check 5 bushes per block each week for adults, nymphs and egg rafts by tapping flowers and laterals over white sampling tray. Use threshold of 5 bugs per 5 bushes
Cultural Activities	GVB move from crop to crop as their numbers increase through the season. Use trap crops to reduce movement into the berry crops at flowering. Sow triticale, sorghum, millet, buckwheat, and sunflower, and use tall, open seed-headed varieties. Trap crops are most preferred by GVB when seeds are forming up to soft-dough. Sow trap species to overlap and extend flowering and seed maturation around berry flowering. Use GVB monitoring records to know the high risk periods for different berry varieties
Biological Activities	*Spined predatory shield bug, GVB parasitic fly* (Trichopoda giacomellii) *and GVB egg parasite* (Trissolcus basalis) *will naturally seek out GVB in trap crops* — *There are no commercially available predators or parasitoids for management of green vegetable bug*
Chemical Controls	*There is no chemistry approved for use on green vegetable bugs in raspberries or blackberries. Sprays targeting aphids are likely to have some effect but control is not guaranteed. Check* www.arga.com.au *for products currently approved for use in berries*

Photos *(Left Top)* Newly hatched GVB nymphs are red but change colour when they moult, through brown to black & yellow, to adult green. *(Left Bottom)* 4th instar nymphs are still oval-shaped *(Right)* Adult GVBs are shield-shaped, bright green and well camouflaged in foliage. They are good fliers and best monitored in early - midmorning in the top third of the canopy.

Carpophilus spp — Dried Fruit Beetle

CARPOPHILUS	**Larvae, pupae and adults overwinter in fruit dumps and mummified fruit** — **Larvae pupate underground. Adults become active and mate in-situ** — **Populations peak late spring to mid summer. Adults lay eggs in maturing and rotten fruit. Larvae move underground to pupate. Carpophilus beetles will carry disease spores to clean fruit and cause infections where their eggs are laid inside fruit** — **Beetles continue breeding over winter in rotten fruit**
Monitoring	Crop Hygiene is Key — Maintaining block hygiene by removing rotten fruit is the best control for beetles because they can speedily re-infest a block after an insecticide treatment — Begin weekly monitoring of carpophilus pheromone traps in the earliest varieties once dusk temperatures reach 22ºC. Hang traps 1.5m high. Use trap threshold of 2 beetles — Check 10 fruit trusses on 5 bushes per block (50 trusses). Use threshold of 5 beetles per block — Monitor fallen fruit and fruit dumps where serious fruit losses occurred in the season
Cultural Activities		Remove rotten and fallen fruit regularly. Adults are excellent flyers and will move in from other blocks and farms. Beetles can emerge from buried fruit - composting or shallow burial of waste fruit does not reduce infestations. Buried fruit must be below 40cm underground — Slash or remove rotten fruit in blocks. Burn or bury waste fruit under 40cm soil
Biological Activities		*There are no commercially available predators or parasitoids of carpophilus*
Chemical Controls		Use Attract and Kill Bait Traps to reduce carpophilus numbers. An area-wide treatment is ***essential*** and should begin well before harvest

Photos *(Left)* Carpophilus beetles are 1 to 2mm long, oval shaped and dark brown to black. *(Right)* Adult carpophilus beetles will fly over 1km in warm weather and are attracted to the scent of maturing and rotten fruit. Attract-and-Kill Traps contain 2 specific attractants plus an insecticide strip. Put traps out before fruit begins to ripen.

Bactrocera tryoni — Queensland Fruit Fly, QFF

Q FLY	**Adults survive mild winters in protected places** — **Adults emerge in spring and seek out maturing fruit to lay eggs under skin** — **Larvae feed inside the fruit, creating internal rots and fruit-fall. Pupation occurs underground. Females only mate once in their life & require protein before egglay begins. Fly activity increases when temperatures cool off & rainfall occurs**
Monitoring		Put out male fruit fly traps at 400m intervals and check weekly throughout season — Monitor temperature and rainfall throughout season Use threshold of 20 flies per trap to begin bait spraying — Check 25 trusses of fruit per block. Use threshold of 5 trusses per block with maggots to begin cover sprays
Cultural Activities	Remove neglected host trees close to blocks	High fruit fly numbers require a continuous source of ripening fruits through the season. Manage fruit fly in alternative hosts near the berry crop at the same time as the crop. For very large areas use mass-baiting of males at 10-20 traps/ha — Minimise unharvested fruit left after picking Slash / mulch or remove all fallen fruit from the block
Biological Activities		*There are no commercially available predators or parasitoids for management of Queensland fruit fly*
Chemical Controls		Use baiting program when trap thresholds indicate fruit fly activity has started. **Regular baiting is essential** to reduce immature females before egg-laying. Decrease intervals between bait application when rain occurs. Use bait thickeners during periods of high pressure. Avoid using broad spectrum insecticides for cover sprays

Photos *(Left)* Raspberry fruit with recent internal larval damage *(Right)* A female fruit fly lays 6 to 8 eggs at a time. Females mate once only and require a protein feed before laying, to mature their eggs. Bait sprays attract these females before their eggs are ready. Female adults can live for up to 2 months, laying continuously.

Helicoverpa spp — TSM

HELIOTHIS	**Larvae pupate through winter in cool regions but are active all year in northern regions** — **First flight occurs in spring-early summer. Eggs are laid in top third of canopy. Larvae damage soft tip growth and when fully grown drop to the ground to pupate below soil surface** — **Second or third cycles are common in warmer regions** — **Pupation can extend to 300 days in unfavourable conditions**
Monitoring		Check weekly for grubs and damage in 50 growing tips per block. Use threshold of 5 grubs in 50 tips. Look for single round eggs with vertical ribs. Flag leaves with attached eggs and monitor daily for hatching. Thresholds for unparasitised eggs are regional-specific. In high pressure areas use pheromone traps to record moth flights and estimate level of egg-lay
Cultural Activities	Disrupt pupal cavities down to 10cm below soil surface	Grow a range of grasses and broad-leaf plants between rows to ensure flowers are present all season. Plants producing many small flowers are safer for minute insects than large single flowers. Where migrating heliothis cause problems in most years consider growing trap crops which can be turned under — Disrupt pupal cavities to 10cm below soil surface to reduce high populations in spring
Biological Activities	*Pollen and nectar sources allow parasitoid adults to live longer, and to lay more eggs*	Earwigs, spiders, predatory bugs, parasitoids and predatory fly larvae reduce grub numbers. Ladybeetles, lacewing larvae and parasitoids reduce egg numbers. Release *Trichogramma* for high numbers of eggs found. Apply *Bt* to grubs less than 12mm when thresholds are exceeded — Encourage diverse soil biology to reduce numbers of moths surviving pupation
Chemical Controls		Apply IPM-compatible insecticides when grub thresholds are exceeded or when pheromone traps indicate hatching of extensive egg-lay is imminent. Check *www.arga.com.au* for products approved for use in berries

Photos *(Left)* *Helicoverpa armigera.* Heliothis are generally tip feeders and are rarely as big as loopers when fully-grown. *(Right)* Heliothis moths lay eggs in singles. A *Trichogramma* wasp lays her egg in a heliothis egg (note the striations). *(Inset)* Healthy pale egg and dark parasitised egg.

Epiphyas postvittana — Light Brown Apple Moth

LBAM	**Light brown apple moth larvae overwinter in ground cover** — **Larvae pupate in ground cover** — **Adult moths emerge and first flight occurs. Females lay eggs on foliage in rafts of pale, flat overlapping eggs. Grubs emerge, roll leaves and damage fruit. Up to three flights can occur in one season. Eggs, grubs and pupae can all be present when generations overlap** — **Grubs migrate to ground cover for winter**
Monitoring		Put out pheromone traps at 2/ha — Check pheromone traps weekly for moth flights. When a flight occurs calculate degree days (DD) to gauge timing of grub hatch. Use threshold of 5 moths/ha (refer to DD calculation at bottom of poster). Check 50 growing tips weekly for rolled leaves. Use threshold of 5 grubs in 50 shoots
Cultural Controls	Control capeweed & clover to reduce overwintering larval numbers	Use LBAM pheromone ties in large blocks — Plant diversity is essential to maintain pollen and nectar sources for beneficials. Grow a range of grasses and broad-leaf plants between rows to ensure flowers are present all season. LBAM will stay out of crop canopy where inter-rows provide preferable food and shelter — 'Messy' borders and inter-rows over winter assist in maintaining beneficial populations
Biological Controls	*Earwigs, lacewings, spiders and parasitoids reduce numbers of LBAM grubs and eggs*	Release 2-3 batches of Trichogramma wasps 10 to 14 days apart at 120DD from first flight or spray *Bt* at 130DD - late afternoon to avoid deactivation by the sun, before grubs are big enough to roll leaves for protection — Consider running poultry in late autumn / winter to reduce grub numbers
Chemical Controls		Apply IPM-compatible insecticides for LBAM grubs when DDs are reached. Smallest grubs are the most susceptible to grub sprays Maintain cover if trap thresholds are exceeded over several consecutive weeks. Check *www.arga.com.au* for products approved for use in berries

Photos *Left:* A green LBAM grub with characteristic leaves bunched together with webbing. When disturbed grubs play dead, wriggle vigorously or escape on a silk thread. *(Top right)* Grubs pupate within webbing inside rolled leaves. This pupa has a parasite beside it. *(Bottom right)* The tell-tale white cocoon of a parasitoid that ate the grub and pupated in its place.

Chloroclystis spp & Ectropis spp — Dry Berry

LOOPERS	**Loopers overwinter as pupae under weed leaves or in plant debris** — **Looper moths fly from October onwards Eggs are laid close to flowers & new foliage** — **Eggs hatch 3-5 days after laying. Larvae feed on leaves and flowers and pupate within plant debris** — **Summer and autumn flights occur with various species Newly hatched grubs move into ripening fruit** — **Larvae can be found in foliage up to June. Loopers overwinter as pupae**
Monitoring		Use pheromone traps for *C.argentifera* and check weekly. Thresholds are region-specific — Look for single round eggs and monitor daily for hatching. Check weekly for 'looping' grubs and leaf feeding in 50 growing tips per block. Use threshold of 5 grubs in 50 tips
Cultural Activities	Use mulch to increase ground-dwelling predators that eat overwintering pupae	Grow a range of grasses and broad-leaf plants between rows to ensure flowers are present all season. Plants producing many small flowers are safer for minute insects than large single flowers — 'Messy' borders and inter-rows over winter assist in maintaining beneficial populations
Biological Activities		Earwigs, spiders, predatory bugs, parasitoids and predatory fly larvae reduce grub numbers. Ladybeetles, lacewing larvae and parasitoids reduce egg numbers — Consider running poultry in late autumn/ winter to reduce numbers in spring
Chemical Controls		Apply IPM-compatible insecticide when threshold has been reached. Use *Bt* for grubs less than 12mm — In areas where loopers are problematic maintain cover with *Bt* for harvest period

Photos *Left:* A newly-hatched looper is harder to spot in raspberry foliage but far more vulnerable to *Bt* sprays than later stages. Loopers are mainly leaf eaters but small grubs can be found in packaged ripe fruit. *(Right)* Loopers move with a distinct looping action and can grow to 35mm in length

Thrips imaginis, Thrips tabaci — Plague thrips & Onion thrips

THRIPS	**Thrips overwinter as adults in weeds and grasses, leaf litter and other protected places** — **Adults move from ground cover to berry flowers. Silvering in ripe fruit is mostly done at flowering, by nymphs and adults piercing developing drupelets close to the calyx. Pupation occurs in the soil** — **Adults migrate back to flowering grasses and weeds before winter**
Monitoring		Monitor flowers in inter-row for presence of pest thrips before crop flowers — Shake 25 trusses per block upside down onto white container each week. Use threshold of 75 thrips in 25 samples — Monitor maturing fruit for thrips damage
Cultural Activities	Plant diversity is essential to maintain pollen and nectar sources for beneficials but can also provide great habitat for pest thrips. Ensure trap-crops and inter-row plants do not dry off before crop has finished flowering — Encourage carabid beetles and other ground-dwelling predators to reduce pupating thrips and emerging adults	
Biological Activities	*Pirate bugs, lacewing larvae, ladybeetles, and predatory mites* montdorensis *and* cucumeris *will reduce thrips numbers*	In tunnel blocks inundate with *montdorensis* and *cucumeris* predatory mites and soil-dwelling predatory mite *Hypoaspis* In field crops inundate with pirate bugs *Orius armatus*
Chemical Controls		Apply IPM-compatible insecticide when bees are inactive (early morning or late evening) —

Photos *Left:* Plague thrips and *(Centre)* onion thrips appear similar in size and colour. Western Flower Thrips are darker and slightly larger than plague and onion thrips. *(Right)* *Montdorensis* predatory mite attacking a thrip larva. Female *montdorensis* lay only 3 to 4 eggs per day, but can consume up to 14 thrips per day.

Tetranychus urticae — TSM

TWO-SPOTTED MITE	**In cold winters females go into diapause on old prunings or ground-cover - no feeding occurs** — **Females emerge from diapause from September onwards. Colonies occur on the underside of leaves. Severe infestations have webbing and leaves turn yellow and fall off. Egg-to-egg cycle can be as short as 7 days at 30ºC and populations build very quickly in hot dry weather** — **In warmer regions diapause may not occur and all life stages feed through the winter**
Monitoring	Overwintering colonies are orange. Predatory mites will overwinter close to TSM colonies — Check weekly for all mite stages on undersides of leaves. Target older leaves with bronzing appearance. Look for predatory mites in TSM colonies. Sample 10 older leaves from 5 bushes per block (50 leaves) and record numbers of predators and TSM. Use threshold of 80% leaves have TSM present OR TSM increasing faster than predators for 3 consecutive weeks
Cultural Activities	*TSM predators include green lacewings, stethorus beetles and predatory mites* Typhlodromus occidentalis *and* Phytoseiulus persimilis	Avoid synthetic pyrethroid insecticides for 8 weeks before introduction of predatory mites. Avoid releasing predators in heavy rain or during overhead irrigation. Encourage plant diversity in inter-rows to provide alternative food sources for predatory mites and other beneficials
Biological Activities		In protected crops introduce *persimilis* early and regularly. Introduce predatory mites to field crops at first sighting of TSM. *Stethorus* beetles are voracious consumers of TSM
Chemical Controls	In tunnels apply white oil as plants emerge from dormancy to reduce mite pressure	Apply IPM-compatible miticides when threshold is reached and TSM are increasing faster than predatory mites. Overlapping generations of TSM may require a general miticide 10 days following first application. Avoid broad spectrum insecticides as they encourage pest mite flares.

Photos: *(Left)* TSM adult attacked by two *Typhlodromus occidentalis* predatory mites, with pearly predator eggs nearby. Typhlodromus is suited to warm dry conditions. *(Bottom Right)* Orange predatory mite *persimilis* with TSM adult, amongst TSM and predator eggs. *Persimilis* is suited to shady humid conditions - look inside the canopy. *(Top Right)* Leaf damage appears on lower foliage first.

Botrytis cinerea — Grey Mould

BOTRYTIS	***Botrytis* overwinters on diseased canes and mummified fruit. Spores spread by rain and wind** — **Spores germinate and penetrate plant tissue using natural openings or micro wounds** — **92% of fruit infections begin during flowering & remain latent until fruit matures or warm moist conditions occur** — **Latent infections develop as fruit ripens. New infections start in drupelets near collar and spread across the fruit** — **Botrytis overwinters on diseased canes, dead leaves and other decaying material**
Monitoring	*Botrytis spores are always present - complete eradication from the crop is not possible*	Monitor plants for physical damage - frost, hail, wind, insects, wires, other diseases — Monitor weather for cool moist conditions (temperatures 18 to 21ºC favour *Botrytis* germination) — Check 10 fruit trusses on 5 bushes per block each week to determine severity — Review monitoring records to assess botrytis severity for next season
Cultural Activities	Remove, mulch or compost prunings to reduce *Botrytis* spores. Prune and train canes for airflow	Encourage free air movement around flowers to speed up drying after rain. Separate primocanes from fruiting canes and keep row bases clean and narrow. Minimise dead material inside the canopy — Maintain airflow and use drip irrigation to keep canopy dry. Remove and destroy affected fruit. Minimise mummified fruit — Where high losses occur annually, consider raincovers or biennial cropping
Chemical Controls	Calibrate your sprayer	Apply protective fungicide if physical damage occurs *(eg hail)* — Apply preventative fungicides - reduce *Botrytis* infections at flowering to reduce disease pressure at harvest — Maintain protectant coverage on developing fruit during wet conditions

Photos *(Far Left) Botrytis* spores on ripe fruit. *(Centre) Botrytis* infection of green berries. *(Right) Botrytis* infection on boysenberry. At flowering include dead sucker material when applying protectant fungicides to foliage and flowers to reduce spore load.

Peronospora sparsa — Dry Berry

DOWNY MILDEW	**Downy mildew overwinters in roots, crowns, canes, and floricane buds** — **Fungal growth occurs on new leaf growth. Infected leaves have light yellow-green areas which become angular & purple. Whole leaves may brown and fall off. Spores are released after 30 minutes of leaf-wetness at 20-25ºC** — **Spore release causes secondary infection of fruit & leaves. Infected berries shrivel and die, often splitting in half** — **Fungal mycelium overwinters in protected plant parts of roots, crowns and buds**
Monitoring	*This disease is more common in blackberries and boysenberries.*	Monitor weather for high-risk periods: temperatures over 20ºC coinciding with leaf-wetness for over 30 minutes, on 10 days or more in the month. When humidity is high, look for symptoms on primocanes and leaves close to the ground and towards the centre of the canopy
Cultural Activities	Use downy-tolerant varieties and avoid areas with downy history. Remove alternative hosts	Maintain an open canopy to increase airflow, reduce humidity and duration of leaf-wetness, and maximise spray penetration. Use drip irrigation. Use row or crop covers to keep leaves dry. Utilise pruning, trimming and nutrition to avoid dense canopies — Remove and destroy old fruiting canes after harvest
Chemical Controls	*Alternative hosts include wild blackberries and roses*	Apply IPM-compatible fungicides during high-risk periods

Photos *Far Left:* Downy mildew can cause blackberry fruit to split in two. *(Centre)* Blackberry leaves show angular dead spots close to leaf veins. *(Far Right)* Downy mildew symptoms are not 'downy' in appearance.

Podosphaera aphanis — Yellow Rust of Raspberry

POWDERY MILDEW	**Powdery mildew overwinters in infected cane tips and dormant buds** — **Infections start on dry leaves in high humidity over 15ºC. Visible signs appear 4 weeks after infection** — **Optimum conditions are 18-25ºC and over 97% humidity. Pale patches develop on leaves with powdery white growth underneath. Fruit develops a mealy grey mat of fungus. Severe infections stunt canes and kill berries** — **Severe infections reduce winter hardiness**
Monitoring	*This disease is more common in raspberries*	Monitor weather for temperatures over 15ºC and high humidity — Monitor weather conditions for temperature and humidity. Check 5 canes per block weekly for symptoms — Check fruit weekly for white powdery symptoms. Check 5 bushes per block — Review monitoring records to develop management plan for next season
Cultural Activities	Plant resistant cultivars Remove wild blackberry hosts	Ensure good airflow through the canopy to maximise spray penetration. Prune, train & thin out primocanes early to reduce humidity in canopy. Manage nutrition and irrigation to avoid a highly vigorous canopy — Remove late-forming infected primocanes — Use tip pruning to remove some infection sources before next season
Chemical Controls	Apply lime sulphur as a dormant spray	Apply protective fungicides when conditions suit infection (before symptoms are visible) — Apply IPM-compatible curative fungicides if symptoms appear

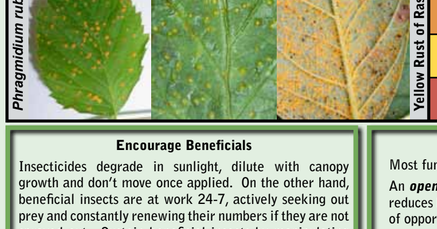
Photos *Far Left:* Powdery symptoms and leaf mottling on raspberry leaves. *(Centre)* Powdery mildew infected flower buds and curled stunted leaves in raspberry. *(Far Right)* Powdery symptoms on green fruit. Powdery mildew is much less of a problem in wet seasons.

Phytophthora var. rubi — Yellow Rust of Raspberry

PHYTOPHTHORA	**Fungal mycelium survives inside infected root pieces within the soil** — **Spores germinate in wet soils over 10ºC. New roots & crowns are infected in spring** — **Primocanes of infected plants wilt and die. Floricane laterals are stunted with small, chlorotic leaves with scorched edges. Infected plants have few fibrous roots. Main roots have brick-red staining underneath the outer root layer** — ***Phytophthora* spores can remain viable in the soil for many years**
Monitoring		Check wet areas for plants showing symptoms, infections often occur in patches. Dig up the crown and roots of any plants with symptoms and check for red staining and lack of fibrous roots
Cultural Activities	Plant on raised beds with good drainage. Use disease-free stock that is tolerant or resistant. Water-logged roots are under stress and more susceptible to infection	AVOID over-irrigation. Destroy infected plants and prevent movement of soil or water from infected areas to clean areas. Prevent soil compaction which occurs with traffic in wet conditions. *Phytophthora* is suppressed in conditions of low soil compaction, high levels of organic matter and good biological activity — Plant into clean ground. Increase soil calcium levels
Chemical Controls		Apply IPM-compatible fungicides to reduce phytophthora symptoms in spring — Apply IPM-compatible fungicides to reduce phytophthora symptoms in autumn

Photos *Far Left:* Whole primocanes wither and die amongst healthy growth. *(Centre)* Floricane laterals are droopy, chlorotic and have scorched leaves. *(Far Right)* Infected roots are brick-red when the top layer of root bark is peeled away.

Phragmidium rubi-idaei — Yellow Rust of Raspberry



RUSTS	**Yellow rust overwinters as black teliospores on leaves and in cracks on bark** — **Raised yellowish spots appear on top side of leaves, releasing spores from orange rings around the spots** — **Yellow rust spots appear on the lower leaf surface. The secondary infection cycle continues through summer** — **As temperatures cool in autumn, black overwintering spores appear in the centre of the yellow rust spots**
Monitoring	*Leaf wetness, high humidity and mild temperatures (11ºC to 25ºC) favour infection*	Check weekly from early spring for pinhead-size yellow raised spots on tops of leaves in known hot spots Look on the underside of leaves for yellow rust spots, particularly where there is old leaf debris
Cultural Activities	Use pruning / training for optimum cane density for lower humidity, better airflow and spray penetration	Manage primocane density to maintain an open canopy to increase airflow, reduce humidity and maximise spray penetration. Keep ground cover low to reduce humidity around canes — Remove, mulch or compost prunings and leaf litter to reduce spore load next spring Where losses are consistently high, consider biennial cropping
Chemical Controls	Late dormant application of protective fungicide may be beneficial	Apply fungicide at first sign of rust on upper sides of leaves. Maintain protective cover for 4 to 5 weeks

Photos *Far Left:* Raised rust spots on the upper leaf surface. *(Centre)* Close-up of rust pustules. *(Right)* Underneath the leaf rust-coloured spores are released. The black spots are teliospores - hardened spore vessels designed to withstand harsh winter conditions.

Encourage Beneficials

Insecticides degrade in sunlight, dilute with canopy growth and don't move once applied. On the other hand, beneficial insects are at work 24-7, actively seeking out prey and constantly renewing their numbers if they are not sprayed out. Sustain beneficial insects by manipulating their micro-environment to be more suitable for them.

- Maintain nectar and pollen-producing plants as alternative sources of food and shelter
- Reduce the use of chemicals which kill these insects
- Reduce or change cultural activities that destroy their habitat

Canopy Management for Disease Control

Most fungi require a film of water to germinate their spores.

An ***open canopy*** provides sunlight and air movement that reduces humidity. Wet berries dry more quickly and the window of opportunity for fungi to grow and sporulate is shorter.

- Reduce excessive vigour by reviewing variety, trellis type, lateral growth, fertiliser and water inputs
- Increase canopy airflow by trimming foliage and keeping in-row weeds short, to reduce risk of botrytis and rusts
- Keep records that help to show which production practises have increased or decreased disease from season to season

Spore Load = Spores per square metre

The number of fungal spores present can change how effective your fungicide **appears** to be in controlling specific diseases.

When a very high spore load is present, a spray that is 99%-effective will ***appear* not to work**. Even though only 1% of spores remain viable, they are high enough in number to infect a **visible proportion of your crop**.

High spore loads cannot be controlled in wet conditions.

Managing your disease severity in high-disease seasons is critical for keeping spore numbers low for moderate and low disease seasons.

Toxicity of Chemical Sprays

All sprays that you apply will change the balance of beneficial arthropods and fungi in your berry patch.

Never spray for insect pests "just in case". Know your pest and beneficial levels by regular monitoring and record keeping.

Check the toxicity of sprays before applying them, at

- www.cottoncrc.org.au (Pest Management Guide PDF)
- www.side-effects.koppert.nl
- www.biobest.be (Side Effects)

When inundating your crop with beneficial wasps, mites or bugs, plan ahead to avoid residue toxicity from previous sprays.

Calculating Degree Days for Targeted LBAM Control

90% of LBAM eggs hatch within 130 degree days (DD or ºD) of the first major moth flight (more than 5 in a trap or per ha).

- Record maximum and minimum daily temperatures starting at the first flight caught in your pheromone traps
- Find the average temperature each day, by adding max and min, and dividing the answer by 2
- Subtract 7 from the average temperature to get the day degrees for one day (replacing negative numbers with zero)
- Add each day's DDs together up to a total of 130DD. Time your grub spray to go on at 130DD after the first moth flight

Timing and Coverage

When caterpillars hatch the first thing they eat is their egg capsule. Good spray coverage ensures pest grubs contact and consume the spray in their first meal. Coverage depends on having the right sprayer for the canopy type, and also having it calibrated to deliver the right amount of chemical to the right place in the canopy. *Get your sprayer calibrated every year.* Consider contractors as an expert alternative if your spray gear is not up to the job.

Timing a spray to the most vulnerable insect stage is done with regular and consistent monitoring and recording. Monitoring answers the questions "*Do I need to spray?*" and if Yes, "*When do I spray?*" Monitoring also gives excellent feedback each week on how effective your IPM activities are for the season. If monitoring is not for you, consider a crop scout for the essential months of the year.


Trichogramma wasp on LBAM egg raft


Netelia caterpillar parasite


Parasitoid eggs laid onto a caterpillar


Assassin bug sucking contents out of caterpillar


Ladybird larva eating aphids


Syrphid fly larvae attacking aphids


Green lacewing larva with camouflage


Hatching lacewing eggs

Photo Acknowledgements Clockwise from immediate left **Lacewings**-Bugs for Bugs; **Lacewing**-DCrawford; **Syrphids**-HortResearch, NZ; **Ladybeetle** -ASteinhauser (FGT); **Assassin Bug** - CO'Hora; **Caterpillar** - JDay; **Netelia**-EDaley; **Trichogramma**-DCrawford (Bugs for Bugs); **Rusts** JStark (WSU PPDEN); PBristow (QSU); MBolda (UCANR); **Phytophthora**(2) Washington State University (Whatcom); **Powdery Mildew**(2) Cornell University; **Downy Mildew** J Pscheidt; SKoike (UCCE); PBachi (UKREC); **Botrytis** Washington State University (Whatcom); SChapman (Chapples); Washington State University (Whatcom);**TSM** -HortResearch; PFisher (OMAFRA); The Good Bug Book; **Thrips** (3) MSteiner (NSW DPI);**Looper** MBolda (UCANR); MCrossley; **LBAM** ; MBolda (UCANR); PDomeney (TIA); PRapley (DPIPWE); **Heliothis** DPapacek (Bugs For Bugs); ; TNAU; JWessels (Qld DPI); **Q-Fly** (2) QDPI; **Carpophilus** (2) MHossain; **Bugs** (3) Anon

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