OLIVE IPDM

BEST PRACTICE MANUAL

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FOREWORD

This Manual provides a comprehensive summary and explanation of best practice in olive crop plant protection, in the context of an Integrated Pest and Disease Management approach. It is an integral output of the project OL17001 An Integrated Pest and Disease Management Extension program for the Olive Industry. It links with the revised Field Guide to Olive Pests, Diseases and Disorders in Australia, a series of 9 web-based tutorials and 10 flyers on key pests and diseases and IPDM strategies. These documents can also be accessed on OliveBiz (www. https://olivebiz.com.au/).

Similar to the other outputs, this Manual has been developed in light of a 2018 national IPDM survey, grower feedback at 10 field days conducted in 2018-2019 in all olive growing states, and updated information on exotic pests and diseases in light of recent overseas events.

Arthropod pests, diseases and disorders are often key constraints to economic production of olives and olive products through their effects on both yield and quality. This Manual attempts to provide a background the major plant protection problems in Australian olives, and the current best practices to prevent or avoid, reduce or manage these problems.

WHY PESTS AND DISEASES?

The incidence and severity of pests, diseases and disorders occurring in olive groves will depend on a number of factors:

- Your location (region, proximity to other groves or other farming, topography, aspect etc.)
- Your climate (and microclimates within the grove)
- Your soil (including texture, structure, depth, drainage, organic matter content and chemistry)
- Your varieties (i.e., ones most suited to your environment; varieties vary in their vigour and their susceptibility to certain pests, diseases and disorders)
- Your grove design, including planting density and grove orientation
- Your grove management practices, such as:
    - Plant nutrition
    - Irrigation
    - Pruning
- Past history of pests and diseases, even before olives were planted
- Your current monitoring and past plant protection practices

This means that choices made prior to establishing the grove are critical in determining subsequent pest, disease and disorder problems.

It should be remembered that for pests or diseases to cause problems in the grove the following are all required:

1. A susceptible host (including cultivar, in a susceptible condition of health)
2. A suitable environment, including abiotic and biotic conditions in the grove, including the soil
3. The presence of a virulent strain of pest of pathogen at a sufficient population pressure

THE APPROACH: INTEGRATED PEST AND DISEASE MANAGEMENT

The recommended approach to pest and disease management for olive pests and diseases is integrated pest and disease management (IPDM). Based on ecological principles, it encourages reduced reliance on pesticides through the use of a number of control strategies in a harmonious way to keep pests and diseases below the level causing economic injury. It came out of the realisation that too heavy reliance on pesticides (particularly those with broad-spectrum activity) can cause major problems, notably:

- effects on human health and safety
- environmental contamination
- pesticide resistance in target and non-target organisms
- resurgence of secondary pests
- plant damage or yield loss (phytotoxicity)
- residues on fruit and products, with national and international consequences.

There is also general community concern about the use of pesticides, particularly on foods, especially those, such as olive products, reported to provide health benefits.

The major components of IPDM systems are:

- Identification of pests, diseases and natural enemies
- Monitoring of pests, diseases, damage and natural enemies
- Selection of one or more management options on the basis of monitoring results and action thresholds, from a wide range of pesticide and non-pesticide options
- Use of selective pesticides targeted at the pest or disease—for instance, pesticides that will interfere least with natural enemies, targeted only at infested trees or parts of trees.
- Continuous review of management success, and incorporation of new information and techniques

IPDM programs commonly utilise or support biological control provided by natural enemies such as predators, parasites, insect diseases and non-pathogenic antagonistic or competitive microorganisms. These natural enemies may be encouraged or introduced onto groves.

Programs invariably involve cultural control strategies to minimise pest and disease entry and their spread in space and time. Cultural controls include protocols of entry to and movement around farms; sanitation (practices to prevent the spread of pests

and diseases by removing diseased/infested plant material and by decontaminating equipment); manipulation of the field environment to discourage pests and diseases, such as maintaining optimum plant health, opening tree canopies to increase air movement and reduce humidity; eliminating of alternative hosts for pests; or growing nectar- and pollen-producing plants within the grove or surrounding areas to encourage natural enemies. IPDM may also involve the use of tolerant or resistant plant varieties, where available. Chemical pesticides, whether conventional or organically acceptable, are used judiciously and thus play a supportive role.

More detailed information on use of these strategies is presented later in this Manual.

MONITORING: THE FIRST AND MOST IMPORTANT STRATEGY

Monitoring is the most important component of IPDM. This is because the mere presence of a particular pest does not provide enough information for decision-making. The pest or disease may not be sufficiently widespread, or the population levels may not cause enough damage, to warrant undertaking management strategies. Regular monitoring, with effective recording of the results, provides important information that helps in making decisions on whether and when action should be taken, and how effective actions have been. The first step in the development of a pest and disease management program is to concentrate on the most serious pests and diseases, and build up records about the times, locations and conditions where problems are most likely to occur. Because natural enemies play an integral role in the system, they also need to be monitored and recorded.

In commercial situations, monitoring programs need to be quick and efficient while still providing accurate and repeatable results. Monitoring can be undertaken by growers, trained employees or commercial pest scouts. It commonly involves observations of pests, diseases and/or their damage (including plant stress and disorders), usually based on sampling, which may involve actual counts, or recording the abundance and distribution of pests, diseases and their associated damage. Technologies such as satellite imaging, drones and robots with image analysis capacity are increasingly being used to gather plant health data. Other supplementary monitoring methods are coloured sticky traps (yellow is the most common, and attracts small, flying, insects such as thrips, aphids, fruit flies and male scale insects, as well as some beneficial species such as parasitic wasps), and chemical attractant traps that are often species-specific.

Weather/climate data can also commonly be used to predict likely pest and disease outbreaks, usually in conjunction with field monitoring.

The process of monitoring

It is recommended to monitor every grove (or block in large groves) at least monthly during the growing season. Monitor priority blocks (e.g. those with a high fruit load or with a history of pest or disease problems) more frequently (weekly or fortnightly). Divide large blocks into sub-blocks. On each sampling, select at least several rows within each sub-block in a semi-structured way. Sample different rows on each occasion, and combine detailed tree inspection with identification of infestations as soon as possible.

In larger groves, driving slowly down rows makes it possible to detect only high populations of pests and diseases that have already caused a significant level of damage, or in the case of black scale, produced a significant amount of honeydew and sooty mould. (Remember, though, that even when sooty mould is highly visible, it does not necessarily indicate active scale infestations.) Monitoring from a vehicle will also detect only advanced symptoms associated with severe root or limb disease, pesticide injury or nutrient imbalance.

Assessing individual trees is important for early detection of pests and diseases. Within the monitored rows, examine at least several trees in detail. Choose trees in a structured way so that, for example, you check a tree in the first third of the first checked row, then one in the middle third of the second checked row, and one in the last third of the third checked row. The position of the checked trees within the row in each sub-block should change with each visit. For example, the next time, check a tree in the second third of the first checked row, then one in the last third of the second row and so on.

Carefully examine individual trees from all sides and at all heights using a systematic approach. Inspect samples of leaves, twigs, flowers and fruit for the presence of pests (and stage of development), diseases or damage and their stage(s) of development using a 10× hand lens or magnifying glass. Inspect trees for abnormal flower buds, and check for the presence of thrips by beating flower clusters onto a white or dark background, such as cardboard. Inspect fruit for the presence of fruit fly or other damage, as well as for symptoms of disease or deformity. If scale or lace bug is detected, the life stage(s) should be assessed. Examine scale infestations carefully under magnification to determine the stage of scale development and the level of parasitism. Turn over adult scales to check for developing eggs or crawlers (you can also use white or dark material to assist in seeing scale eggs and crawlers). Be aware that magnifying glasses usually have lower magnification than hand lenses and so the quality of the observations are generally inferior. If you are using a hand lens, remember that the working distance, [how far away from an object you should hold] a 10× hand lens is typically 2-2.5 cm.

If a pest or disease is detected, check surrounding trees in the row and in adjacent rows to establish the extent of the infestation. This will assist in determining the extent to which you can apply any selected intervention strategies (whether chemical or otherwise). Using coloured flagging tape to mark infested trees or limbs assists in relocating them. Monitoring marked trees after an intervention (such as pesticide application) will demonstrate its level of success.

Recording monitoring data

Monitoring data should be recorded and kept for review and future planning. Record your monitoring data including date and, in case of detection of pest, disease or damage, note tree(s) ID cultivar and position, extent of damage, pattern of infection, life stage, any parasitism etc.

Make a note of the pattern of infection, which is the association of the disease or pest with:

Terrain (e.g. sheltered or exposed locations, low lying areas)
Weather and aspect (prevailing wind direction, orientation to sun.
Tree characteristics (cultivar, age, part of tree affected)
Cultural practices (irrigation, fertilizers, pesticides, pruning, mulching etc.)

This information also particularly helps in interpreting the monitoring data.

BIOSECURITY: LET'S TRY TO STOP THEM AT THE GATE

Biosecurity is procedures or measures aimed at preventing the introduction and/or spread of harmful organisms and other agents, commonly known as "biosecurity risks". These measures obviously include quarantine; but there are also many other strategies to detect, eradicate or limit the spread of the risks once there has been pest of disease incursion into a country, state, region, district or even a farm.

National biosecurity

While Australia's national quarantine system helps to prevent the introduction of harmful exotic pests, the threat they pose is still very real. It protects your property and the entire industry from the entry, establishment and impact of exotic pests and diseases. As an exotic pest or disease can affect everyone – growers, other associated industries and the community, it is important that everyone plays a part in preparing for and minimising their biosecurity risks. In addition to the possibility of pests entering via natural routes, rapid increases in overseas tourism, imports and exports make it all the more likely that incursions of exotic plant pests and diseases will occur.

Prior to Australian Federation, the individual states were responsible for their own quarantine. The current national Biosecurity Act commenced 2017 and is administered by Biosecurity Australia, an arm of the Australian Government Department of Agriculture, Fisheries and Forestry. While this national quarantine system helps to prevent the introduction of harmful exotic pests and diseases, the threat they pose is still very real.

What is happening at the national biosecurity level for olives?

Plant Health Australia (PHA) is the national coordinator of the government-industry partnership for plant biosecurity. The Australian Olive Association is a member of PHA and signatory to the Emergency Plant Pest Response Deed. As a result, the AOA represents the biosecurity interests of olive producers and the industry.

The national Biosecurity Plan for the Olive Industry (v2.0) (2016) was developed by PHA in collaboration with government and industry resources and expertise. It "outlines key threats to the industry, risk mitigation plans, identification and categorisation of exotic pests and contingency plans." It is available from PHA (02 6215 7700 or email: admin@phau.com.au).

However, growers and other industry persons play an integral part in both the initial detection of any incursions, as well as in implementing the mitigation plans. This requires familiarising yourself and your staff with the Exotic Pests and Diseases identified in the Biosecurity Plan for the Olive Industry (v2.0) (2016) that pose a threat to the Australian olive industry (see later in this Manual). Staff should also be instructed to notify the owner/manager immediately they come across unfamiliar damage, or possible pests or diseases. If a new pest is suspected, call the Exotic Plant Pest Hotline on 1800 084 881.

Biosecurity on your olive grove

Just like charity, biosecurity begins at home. Just as it is important to prevent the entry and spread of overseas pests and diseases into Australia, it is equally important that you prevent the entry and spread of pests and diseases (particularly those not currently present) to your property. Anyone going on to farms has a biosecurity responsibility. Consequently, it is strongly recommended that you develop and actively follow a biosecurity management plan for your property.

While property biosecurity management plans are not mandatory, if one is in operation, it is a legal requirement for all persons to obey relevant signs, procedures and measures outlined in the plan. Note that the offence will not apply if a biosecurity management plan is not in place or is not being implemented.

Two useful NSW DPI Factsheets under Biosecurity Regulation 2017 relating to the olive industry are:
Abandoned and neglected horticultural enterprises
https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0015/724110/Abandoned-and-Neglected-Horticultural-Enterprises.pdf

and Your requirements when visiting a farm
https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/724978/factsheet-your-requirements-when-visiting-a-farm.pdf

It is strongly recommended you implement the following good biosecurity practices:

Come Clean. Go Clean. – Vehicles, farm equipment and even people can carry pests, diseases and weed seeds, especially attached to soil or plant debris. Make sure that visitors clean down on arrival (especially if they have come from other olive groves), including their vehicles, equipment and footwear. Use on-farm vehicles wherever possible.

Provide appropriate parking (preferably off-farm), and **wash down facilities** – especially for contractors and visitors to clean their equipment and tools prior to entry and exit.

Communicate your requirements using clear signage – to ensure only essential vehicles and equipment gain access to any growing area.

Develop a farm biosecurity plan – creating a biosecurity plan provides an opportunity to assess how pests, weeds and diseases could enter your farm, and how to minimise incursions.

Another very useful link:
You can access the document FARM BIOSECURITY ACTION PLAN FOR OLIVE GROWERS, which includes a Grove Biosecurity Checklist from AOA's website https://australianolives.com.au/wp-content/uploads/2018/06/Biosecurity-Olive_Reduced-File.pdf

KEY OLIVE PESTS & DISEASES NOT DETECTED IN AUSTRALIA

There are many pests and diseases both of olives and other crops overseas that are potential threats to the olive industry. The Biosecurity Plan for the Olive Industry (Version 2.0−2016) lists five High Priority pests, based on the criteria of Entry potential, Establishment potential, Spread potential and Economic impact.

These pests are listed as:
·Olive fly (*Bactrocera oleae*)
·Olive moth (*Prays oleae*)
·Leaf scorch (*Xylella fastidiosa* subsp. *multiplex* (with vectors))
·Olive quick decline (*Xylella fastidiosa* subsp. *pauca* (with vectors))
·Verticillium wilt (*Verticillium dahliae* (exotic defoliating strains))

Because of some confused taxonomy. *Xyllella* is treated singly in this section. For further information on these exotic pests and other aspects of biosecurity, see Tutorial 3 (OliveBiz).

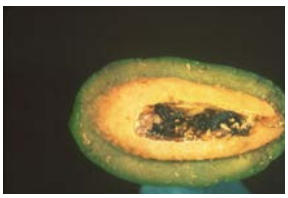
1. Olive fly (*Bactrocera oleae*). Olive fly is the most important pest of olives worldwide. It is widely distributed in the Mediterranean basin, northern and southern Africa, Western Asia, including India and Pakistan, and Northern America (California and Mexico). The female lays eggs in fruit, often when it is green, and developing larvae (maggots) burrow, usually causing fruit drop. Pupation commonly occurs in fruit. Adult flies resemble Queensland Fruit Fly, but have black markings on their wing tips.

2. Olive moth (*Prays oleae*). Olive moth is widespread in Mediterranean countries including northern Africa, and other European locations. The only host is olive and close relatives. Adult moths are silvery grey, and have long antennae. Green or light brown larvae can grow to 8 mm. The pupal stage is protected by loose silk webbing. There are normally 3 generations per season, attacking flower buds and flowers, fruit and leaves, respectively. Damage symptoms include chewing, frass (faecal pellets and webbing), or leaf mining.

Olive fly adult
(A. Loni, Uni Pisa)

Olive fly larva and damage
(A. Loni, Uni Pisa)

Olive moth adult
(INRA, France)



Olive moth larva damage
(INRA, France)

3. Leaf scorch (*Xylella fastidiosa* subsp. *multiplex* (with vectors)) and 4. Olive quick decline (*Xylella fastidiosa* subsp. *pauca* (with vectors)). The bacteria live in the plant xylem (water-conducting) vessels inhibiting the uptake of water and nutrients which leads to disease symptoms that look like water stress – called leaf scorch. A particular strain of *X. fastidiosa* subsp. *pauca* causes trees to dieback - killing them – called Olive Quick Decline Syndrome (OQDS). OQDS was first reported in olives in southern Italy in 2013, but has since been reported more widely, including in Brazil. Most introductions of *X. fastidiosa* occur with the movement of infected plant material. Once present, xylem-feeding insect vectors are the primary pathway by which the disease spreads.

5. Verticillium wilt (*Verticillium dahliae* (exotic defoliating strain)). One strain of this soil-borne fungus has been distinguished as a 'defoliating strain' (DS) on cotton in the USA. It causes wilt and death of olive trees in California and parts of Europe. DS has not been recorded in Australia on olives and is considered a biosecurity threat. Leaves in infected trees can drop when green or turn brown, often with a downward rolling along leaf margins – symptoms appear from autumn to late spring. Only some limbs or branches of a tree may be affected, giving the tree a patchy or one-sided appearance. Trees (particularly younger ones) often die or linger with reduced vigour.

A. Leaf scorch (C. Elliot)

B. Olive decline in groves, Puglia, Italy (A. Bailey)

C. Tree showing symptoms of Verticillium wilt (DS) (L. Burgess)

D. Grove devastated by Verticillium wilt (DS), California (L. Burgess)

A reminder: You should familiarise yourself and your staff with the Exotic Pests and Diseases that pose a threat to the Australian olive industry

CULTURAL STRATEGIES: TRY A LITTLE CLEANLINESS

Sanitation–practices aimed at cleanliness to prevent entry and spread, and recycling of pests and diseases- is an important additional step, and is often undertaken in conjunction with biosecurity measures.

There should be good grove hygiene practices in place with regard to cleaning up pests and diseases, such as mummified fruit for anthracnose, and abscised or infected/infested leaves, twigs or fruit. This may also include pruned material. Overwintering pests or sources of pathogen inoculum can lead to infestations in following seasons.

Consider what is appropriate for your circumstances with regard to removal or destruction of suspect material, including mulching and composting. This also the location (proximity to other productive or abandoned groves), history of pests and diseases etc. Remember that any methods that rapidly dry out material will assist in plant protection. Also, thermal composting is most effective, especially from a pasteurisation process, when the temperature reaches at least 60°C. Nair and Markham (2008) investigating composting methods for bioremediation of olive mill waste successfully incorporated olive prunings as a component to produce high quality, non-phytotoxic compost for re-use in olive groves. Furthermore, addition of organic matter such as compost or green manure adds to soil microbe diversity and abundance, helping to suppress soil-borne or litter-borne pathogens.

Growers with smaller groves can remove and destroy branches infested with black scale or olive lace bug, or even remove trees showing dieback from a known or unknown cause.

Managing alternative hosts of pests and diseases

While a number of olive pests and diseases are host specific and are only associated with olives, others have alternative hosts that may be sources for seasonal carryover and reinfestation. These include insect pests such as black scale, olive lace bug (but only within the family Oleaceae), weevils and indigenous fruit flies, and pathogens such as anthracnose, Phytophthora and Verticillium wilt. Pests and diseases can therefore infest from nearby crop hosts. Remember, alternative hosts may also include weed hosts nearby or in groves, as well as garden plants on farm property. Any such garden and volunteer plants should be part of the farm monitoring and IPDM program, including their removal if they are of concern.

Encouraging plant growth and development

It is axiomatic that a healthy plant is a keystone of IPDM. Likewise, an unthrifty plant is prone to pest and disease problems. As outlined in the Introduction, the innate health of your trees depends on many factors, including the suitability of the location climate, topography, soil physical and chemical attributes, previous land history, the suitability of your varieties for the area, as well as grove design, management practices such as nutrition and irrigation and maintenance of tree vigour through judicious pruning.

Assuming your grove location is fixed, and the varieties are at least fixed for a number of years, management should be focussed on encouraging healthy plant growth. First, understanding and mapping the different microclimates and soils should be undertaken prior to developing and implementing irrigation/drainage and nutritional and alleviating adverse weather programs (such as frosts) or flooding. Soils should be appropriately sampled and analysed, to ensure optimal levels of nutrients and acceptable pH. Soil carbon is an important measure of organic matter status and a good indicator of soil microbiological activity. On-going, regular monitoring of plant nutrient status by leaf analysis is recommended to adjust application of fertilisers and other ameliorants (including organic matter) as appropriate. See Barranco et al. (2010) Olive Growing for more detailed information. Organic matter impacts physical and chemical properties such as improving porosity, decreasing compactability, increasing water infiltration, water holding capacity and soil structural stability and reducing erosion; as well as increasing Cation Exchange Capacity and pH buffering ability. Furthermore, it increases soil biodiversity with respect to arthropods, microorganisms, and other fauna such as reptiles and birds. Soils with high biodiversity suppress soil-borne pests and diseases.

A well-nourished crop plant is generally more tolerant of pests and diseases than one with suboptimum nutrition. However, in highly resistant and highly susceptible cultivars, the nutritional status of the plant has little influence on the severity of pest or disease damage. With regard to plant nutrition the greatest benefits from nutrients are found with moderately susceptible or partially resistant cultivars and nutritional balance is as important as the level of a single nutrient in pest and disease management. Nevertheless, some nutrients (e.g. P and S) appear to affect disease severity simply through greater tolerance and others, including N and K, alter specific host-plant resistance mechanisms. Correction of a micronutrient deficiency generally increases the tolerance/resistance of plants. Cu, B, and Mn influence the synthesis of lignin and simple phenols whereas Si appears to affect physical barriers to invasion.

It is recommended that you conduct at least an initial soil analysis and regular leaf analyses, to monitor the nutrient status of your trees.

Adequate water, applied at correct time

A number of Australian olive groves are unirrigated (rainfed), and others have limited water supplies for irrigation. Water stress not only impacts growth and yield of olives; it can exacerbate certain pest and disease problems, particularly olive lace bug, vascular diseases and apical end rot. Irregular watering can also contribute to occurrence of apical end rot. Overwatering is not only wasteful; it can contribute to root asphyxiation and increase susceptibility to soil-borne root rot fungi such as *Phytophthora* and *Pythium*.

If you irrigate, it is important that soil moisture levels are regularly measured throughout the root profile, to optimize efficiency of water use while preventing water stress, especially at critical periods in the crop's development. See Barranco et al. (2010) Olive Growing for more detailed information.

Pruning for healthy trees (Refs Barranco et al. 2010; Muñoz 1989)

Pruning of olive trees is undertaken for a number of reasons:

- Training pruning during the establishment phase to shaping the young tree
- Optimising leaf/root and leaf/wood leaf/fruit ratio balance to encourage and maintain production
- Keeping the tree in active growth and good health (prevent the tree from losing its vitality and from premature ageing, and promoting vegetative growth as the tree grows older
- Maintaining vegetative balance for light penetration and illumination of foliar surfaces and air movement aeration
- Improving size of fruit

Reducing tree height and width to enable fruit and ability to harvest

Removing or replacing limbs showing signs of ageing/senescence (renewal)

Regenerating decaying or non-productive trees or those affected by natural disaster such as frost.

Apart from maintaining good tree health, judicious pruning also serves other IPDM purposes. Opening up the canopy allows adequate air movement as well as access for sprays. Many fungal pathogens require a period of leaf wetness for spores to germinate. Thus, the more rapidly evaporation of rain or dew on plant surfaces associated with improved aeration and light penetration can reduce fungal infections. Furthermore, immature (crawler) stages of scale insects and olive lace bug have higher survivorship under conditions of cool, moist microclimates. Hot, dry conditions can result in high mortality, so opening up the inner tree canopy through judicious pruning can assist as part of their management program.

Opening up tree canopies also aids penetration of organic sprays (such as copper, pyrethrum, insecticidal soaps) or horticultural oils, as well as conventional sprays. Many permitted pesticides for olives, particularly organically acceptable ones, have contact action (i.e. they are not systemic), so good spray coverage is essential to either contact the pest/pathogen and/or coat as many plant surfaces as possible with the active constituent.

However, also remember that pruning provides wounds that can lead to entry by bacteria such as olive knot (*Pseudomonas savastanoi* pv. *savastanoi*), as well as opportunistic fungal and bacterial pathogens. As a result, a number of growers apply a copper spray or treat large branch wounds with tree wound dressing or non-toxic paint, particularly if wet weather is predicted.

Other cultural methods

Other cultural methods employed in olive groves include early fruit harvesting to minimize problems with anthracnose, and providing habitats etc. for beneficial species (such as intercropping and strip/green manure crops). The latter strategy is discussed further in the Biological Control section below.

BIOLOGICAL CONTROL STRATEGIES: CALLING IN THE REINFORCEMENTS

Biological control is the use of natural enemies of pests and diseases such as predators, parasites, parasitoids (parasites that kill their host), pathogens or competitors. They are part of the range of beneficial species that can be present in olive groves, but this is not always the case. Biological control can be undertaken by:

introducing natural enemies of exotic pests, usually from the pest's region of origin (this is known as classical biological control and is commonly undertaken by government agencies),

releasing/applying mass-produced natural enemies onto properties or sometimes districts (for further information see www.goodbugs.com.au), or

implementing strategies to conserve and support endemic or naturalised beneficial species.

In most cases, biocontrol agents can be further conserved and encouraged by environmental modifications, such as the planting of nectar- and pollen-producing cover crops and the reduction in use of broad-spectrum pesticides.

Olive groves are a stable agroecosystem, and as a result, can have many natural enemies. Generally, presence of high natural enemy populations are indicative of good ecological balance. Some of commonly observed natural enemies, such as spiders, lacewings and larvae (maggots) of hover flies are generalist predators that prey on a range of arthropods. Their role and impact in olive ecosystems is yet to be fully determined. Other more specialised predators, such as ladybirds, target soft-bodied insects such as scales. Some of the ladybird species recorded in olive groves are the native mealybug destroyer *Cryptolaemus montrouzieri*, transverse ladybird *Coccinella transversalis* and orange-spotted ladybird *Orcus australasiae* and introduced white-collared or spotted amber ladybird *Hippodamia variegata*.

Parasites and parasitoids (parasites that kill their host) are generally more host-specific. Many are small (<2 mm) wasps (known as micro-Hymenoptera). that parasitise small arthropods, including scales, aphids and insect eggs.

Biological control of pathogens is a more recent but exciting approach. It is most commonly achieved through the use of antagonistic or competitive microbes, and can be accomplished by:

Modifying cultural practices to favour the proliferation of indigenous antagonists,

Introducing living antagonists into the environment or onto the plant, or

Inoculating the plant with incompatible or hypovirulent organisms.

The mechanisms by which disease is reduced include antibiosis (caused by the release of toxic metabolites), substrate or site competition (particularly for nutrients), parasitism (by a hyperparasite), or inducing cross protection (such as systemic resistance). This is a developing area that could provide alternatives to traditional chemical control for plant diseases in Australian olives. Marketing and use of formulated microbial products with claims for disease control requires their registration as biological pesticides in Australia. To date few products have been through this process and are often marketed as 'growth promoters' or 'soil conditioners'. See section below on legal use of pesticides for further information.

Biological control is much less likely to negatively impact an olive grove ecosystem than many synthetic pesticide options, and may be long-term acting. However, the results may be less efficacious (leading to suppression rather than "control"). Furthermore, biological options may be slower acting.

Information on currently available biological control agents for arthropod pests can be accessed at the Association of Beneficial Arthropod Producers (ABC) Inc. website: https://goodbugs.org.au, and for plant pathogens at the APVMA website: https://apvma.gov.au/. More information and images of common beneficial species found in olive groves are available in the Field Guide to Olive Pests, Diseases and Disorders (available on OliveBiz).

Other non-chemical strategies

There are a number of physical and mechanical strategies that can be employed as part of IPDM programs. These include mechanical devices and barriers (e.g. for birds, rabbits, kangaroos, weevils, ants) and traps such as coloured sticky traps for monitoring or mass trapping (although not commonly used in olives in Australia). Examples in olive production discussed in this manual include weevil trunk bands, and tree guards (the latter in the Weeds section in this Manual).

SELECTED PESTICIDE STRATEGIES: TAKE CARE WHEN PLAYING WITH FIRE

The strategic use of pesticides can play an important role in many IPDM strategies. They should never be relied on as the only or first option, especially when other IPDM strategies (as previously described in this Manual) are being employed. Nor should they be considered the final option (i.e., when all else fails). However, their judicious use by intervening at critical strategic times (such as around flowering for anthracnose management, or crawler emergence for scales and olive lace bug, or prior to the onset of prolonged wet weather) may reduce the need for more substantial pesticide use later on.

Prior to purchasing any pesticide for a specific use, check to confirm that it is registered/permitted for use against the pest or disease in the crop. Preferentially select pesticides that are IPDM friendly. Natural or organic pesticides are not always the least environmentally disruptive choice (for example, many are broad-spectrum). Narrow spectrum (selective) pesticides target a limited range of pests or diseases. However, these are more prone to resistance build-up in the target species. Some other safe and effective options are pesticides which disrupt pest development or behaviour, such as pheromones (communication chemicals), insect growth regulators and oil sprays (in addition to suffocation, oil sprays reduce feeding, settling of crawlers and oviposition).

Remember, the disruption to agro-ecosystems by pesticides is a consequence of:

- their spectrum of activity of the pesticide (broad-spectrum pesticides are often more disruptive)
- their residual activity (residual pesticides are generally more disruptive)
- how frequently they are applied
- whether the whole grove is treated, or only sections (such as spot-spraying infested trees, “hot spots” or blocks)

Always consider what is required under the circumstances. Regular monitoring for pest and disease incidence and beneficial species will give you greater confidence in your choice, and will allow time for considered decision making.

Legal use of pesticides

The Australian Pesticides and Veterinary Medicines Authority (APVMA) regulates use of pesticides in Australia. It evaluates the safety and performance of agvet chemicals intended for sale to ensure the health and safety of people, animals, crops, trade and the environment are protected. Before chemical products can be legally sold, supplied, marketed or bought in Australia, they must be registered by the APVMA. As part of the registration process, the APVMA approves product labels which include

information that identifies the product and explains how the product is to be used, stored, disposed of and managed in the event of poisoning.

As olives are a minor crop, a number of legally acceptable pesticides are the subject of Permits. The APVMA administers a permits scheme that allows for the legal use of chemicals in certain ways that are contrary to the label instructions or, in certain circumstances allows for the limited use of an unregistered chemical product. Note that permits have expiry dates, and pesticides cannot be legally used if the permit has been surrendered or has expired.

To find APVMA registered chemicals, search the APVMA Public Chemicals Registration Information System (PubCRIS) database to find agvet chemical products, active constituents and labels approved and registered for use in Australia at: https://apvma.gov.au/pubcris. You can also search the APVMA database to find minor use and emergency use permits: https://apvma.gov.au/permits

All agricultural chemical applications must accord with the currently registered label for that particular agricultural chemical, crop, pest and region. Note that state regulations detail additional requirements associated with the use of agricultural chemicals including record keeping, and training and licensing requirements for applications. Always read and follow the label when handling and applying chemicals. Label conditions may specify spray quality, spray conditions including mandatory wind speed range, and no spray zones/buffers. Furthermore, the approved list of target pests and diseases and the crop as well as the Withholding Period is also provided, together with recommendations of timing and frequency of application and resistance management strategies. Be aware of federal and state regulations for chemical application. Staff responsible for handling and applying pesticides must be qualified according to relevant state and federal requirements. There may also be workplace health and safety requirements related to storage and use of hazardous chemicals, which require a hazard analysis to be completed, in addition to maintaining an inventory of the hazardous chemicals you use and store and current copies of the Safety Data Sheets for each of those chemicals. Users are not absolved from compliance with the directions on the label or the conditions of the permit by reason of any statement made or not made in this publication.

Qualifications required for pesticide use

In many states, it is mandatory for commercial pesticide users to hold a current licence, such as those achieved by undertaking a Growers are recommended to undertake the SMARTtrain course, Chemical Application, or the standard ChemCert

course, which cover the higher AQF3 competencies. Please check the requirements in your state to comply with these regulations. It is strongly recommended that all growers/managers also undertake these courses, even if they are not applying pesticides themselves. In the latter situation, they are likely to be supervising someone who does, and also probably responsible for selection of pesticides and associated safety equipment.

Best practice for spray application

While there are many different types of applicators for sprays, the 2018 Olive IPDM survey indicated that the most widely used was air blast sprayers, but other common were boom sprayers (including oscillating boom) and hand application (including wands from tractor-drawn or on-vehicle sprayers). Maintenance of spray application equipment, including thorough cleaning after use, is an important part of ensuring efficient and efficacious pesticide applications. Equipment should also be calibrated for uniformity of output in multi-nozzle applicators, and actual output of the spray rig. Modern computerised pesticide sprayers can provide accurate spray output data, but it is useful to have the equipment regularly calibrated and to have nozzles checked to ensure uniform application.

When using pesticides, best practice means not only doing the best job you possibly can, but also being able to demonstrate what you have done and how it has impacted others. Movement of spray beyond the target area is undesirable as it represents wastage of product and exposure of non-target sensitive areas to potentially damaging materials. Label conditions may specify spray quantity, spray conditions including mandatory wind speed range, and no spray zones/buffers. Be aware of all federal and state regulations for chemical applications.

Prior to spray application and product selection, check the proximity of susceptible crops and sensitive areas such as houses, schools, waterways and riverbanks. It is good practice to notify neighbours and staff of your spray intentions, regardless of label requirements. By doing this, sensitive crops or areas that you may not have been aware of can be accounted for.

Weather conditions need to be checked regularly during spray applications (this means continual visual observations and actual measurement at least every load) and recorded as per label requirements. These sites evaluate a range of factors to produce tables indicating times that may be suitable for spraying. You can access the websites at either Spraywisedecisions.com.au or Syngenta.com.au for more information. Labels may contain a requirement to measure weather parameters at the site of

application. This can be done with handheld equipment (e.g. Kestrel 3000, 3500, 4000 or equivalent) or portable weather stations. On-board weather stations that provide live weather information while the sprayer is operating are also available. Higher ambient air temperatures and lower relative humidity conditions increase evaporation rates. Higher evaporation rates decrease droplet size and increase the risk of drift for water-based sprays. On the other hand, cooler and higher humidity reduce evaporation, which may be detrimental with certain pesticides (including spray oils and copper fungicides), potentially leading to phytotoxicity.

It is a legal requirement to maintain records of pesticide applications, including chemical and rate, operator, weather conditions, and other information.

IDENTIFYING PESTS, DISEASES, DAMAGE AND BENEFICIAL SPECIES

In two industry IPDM surveys, growers have indicated they are most confident in identifying common olive insect pests, followed by diseases, and least confident in identifying beneficial species. However, identification of the cause from damage symptoms can be difficult, and often requires specialist expertise. This is because similar symptoms may have a myriad of causes, either individually or in combination. For example, conditions that result in unhealthy trees may predispose them to attack by pests and diseases. This section provides brief descriptions of key olive pests and diseases in Australia. Information on the broad range of pests and diseases is provided in The Field Guide to Olive Pests, Diseases and Disorders; and more detailed information on black scale, olive lace bug, weevils, anthracnose, Cercospora leaf mould, and peacock spot is available in a series of web-based tutorials; accessible on OliveBiz.

Tables 1–3 below should assist in determining the possible causes of symptoms on your trees and the likely pest, disease or disorder. Table 4 a list of current registered or permitted pesticides, together with conditions of their use, as at August 2020, based on information from APVMA website. While these tables may be useful, it is wise to consult an expert for diagnosis if you have not seen the symptoms before, or if the cause is not obvious. To identify or confirm diagnosis of pests or diseases, the recommended option is to contact the Plant Health Diagnostic laboratory of your State Department of Agriculture (or its equivalent).

For information on how to send specimens and associated charges, please see the following links.

NSW: https://www.dpi.nsw.gov.au/about-us/services/laboratory-services/plant-health

Qld: https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/agribusiness/grow-help-australia

SA: https://pir.sa.gov.au/research/services/crop_diagnostics/horticulture -pathology

WA: https://www.agric.wa.gov.au/bacteria/ddls-plant-pathology-services

Vic: http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/diagnostic-services#crop-health-services

Tas: https://dpipwe.tas.gov.au/biosecurity-tasmania/plant-biosecurity/plant-diagnostic-services

Possible symptoms and causes of pest and disease problems in Australian olive groves

Table 1 presents the possible causes for symptoms you may encounter in your olive grove. Use the table below to determine the possible causes of symptoms on your tree(s). It is a guide the common pests, diseases and disorders associated with symptoms on trees or olive products. It should enable you to access further information on the possible causal organisms, including from output material from this IPDM project, including the revised Field Guide, or tutorials on the key pests and diseases (accessible at OliveBiz). Note, however, that a particular symptom may have a number of possible causes; conversely, a particular pest or disease may display multiple symptoms.

Only the key Australian pests and diseases, as identified by industry surveys, field days and sampling are included in this Manual. Most common arthropod pests are presented in Table 2 and most common diseases and disorders are presented in Table 3. This does not necessarily imply that these pests or diseases will occur in your grove, nor that other pests and diseases may not cause problems. All currently known important pests, diseases and disorders are described in the Field Guide to Olive Pests, Diseases and Disorders in Australia (available on OliveBiz). And, as previously stated, if you are still unsure, please contact your state pest and disease diagnostic laboratories.

Table 1. POSSIBLE SYMPTOMS AND THEIR CAUSES IN OLIVES

	Common name of:		
Symptom	**Pest**	**Disease**	**Disorder**
Leaf yellowing & branch dieback	African black beetle Armoured scales Black scale	Charcoal rot Leaf mould Peacock spot Phytophthora Rhizoctonia Verticillium Wound canker	Tip death
Leaf spots, leaf discoloration & damage	Grasshoppers Lace bug Lt-brown apple moth Rutherglen bug Weevils	Leaf mould Peacock spot	Sooty mould
Leaf fall	Lace bug	Leaf mould Peacock spot	Problems with water and plant nutrition
Flower damage	Thrips	Anthracnose	
Fruit damage and rot	Armoured scale Green vegetable bug Fruit fly	Anthracnose Peacock spot	Apical end rot
Stem damage, galls and bumps	Cicadas	Crown gall Olive knot	Sphaeroblasts & oedema
Stem cankers & death		Phytophthora Verticillium Wound canker	
Root rotting and damage	African black beetle (larvae) Weevils (larvae)	Charcoal rot Nematodes Phytophthora Rhizoctonia	Clay panning or root plaiting
Tree blackening	Ants Black scale		Sooty mould

Table 2. MOST COMMON ARTHROPOD PESTS
Based on industry surveys and field observations (Major pests are in bold)

COMMON NAME	SCIENTIFIC NAME	STATUS	DISTRIBUTION
Ants	**Formicidae**	**Important with black scale**	**All states**
Black scale	***Saisettia oleae***	**Most reported, but rarely serious**	All states
Fruit flies	*Bactrocera tryoni*	Occasionally important	Qld, NSW, northern Vic
Grasshoppers/locusts	*Acrididae*	When swarming	All states
Green vegetable bug	*Nezara viridula*	Rarely important	Eastern states
Olive bud mite	*Oxycenus maxwelli*	Minor	Mainly WA
Olive lace bug	***Froggattia olivinia***	**Major**	**All states, esp. NSW, Qld, WA**
Rutherglen bug	*Nysius vinitor*	Some years can be pest	All states
Weevil, curculio beetle	*Otiorhynchus cribricollis*	**Important in WA**	**WA, also Vic, SA**

KEY MAJOR INSECT AND PEST DESCRIPTIONS (in order of importance)

Black scale, *Saissetia oleae* (and associated Ants, many spp. [Formicidae])

This worldwide species is widely distributed in Australian olive production areas, and can cause severe problems in some groves resulting in leaf drop, reduced tree vigour and twig dieback in heavy infestations. The presence of ants and black sooty mould associated with the honeydew produced by the scale can also compound problems of tree health and management. Scales attack leaves and twigs, resulting in leaf drop, reduced tree vigour and twig dieback in heavy infestations. Ants and sooty mould are commonly associated with the production of honeydew by adults and nymphs of black scale. The movement of ants up a trunk is indicative of active black scale in the

tree, even if the scales are not immediately obvious. Management of black scale will reduce ant problems, and vice-versa.

There are 2 to 3 scale generations per year, with the first generation nymphs hatching in late spring or early summer. Hot, dry weather reduces the survival of crawlers. Opening up tree canopies exposes crawlers to greater likelihood of dehydration, and also to access by sprays targeted against them.

Natural enemies of black scale include the small parasitoid wasps *Metaphycus* spp., the egg predator *Scutellista caerulea,* ladybird beetles and the scale-eating caterpillar and the scale-eating caterpillar *Mataeomera dubia*.

Black scale infestation with ants attending and sooty mould

Minimal use of “soft” insecticides, such as oil sprays or insect growth regulators will maximize biological control of black scale in groves. However, correct timing of applications of these products to coincide with scale crawler emergence and ensuring adequate tree coverage are critical factors in their success. See Table 4 and APVMA website for legal chemical options, and their use.

For further information see tutorial and flyer on Black Scale (on OliveBiz).

Olive lace bug*, Froggattia olivinia*

Olive lace bug is a native species first described feeding on the native olive *Notelaea longifolia* in New South Wales has now spread to all olive-growing states, probably with movement of infested plant material.

Adult lace bugs are mottled brown and 3 mm in length. Overwintering occurs as eggs and occasional adults. Eggs are laid on the underside of leaves and are commonly

covered with tar-like excrement. Highly spined nymphs emerge in spring, and are present in clusters, piercing the leaf surfaces and feeding on cell contents, similar to adults. This results in yellow spotting and sticky dark spots on leaves, which become totally yellow and fall in heavy infestations. Twig dieback may also occur in severe infestations, and flowering and fruiting can be delayed for a year or more. There is evidence that some varieties (e.g., Barnea, Corregiola, Frantoio) are more tolerant. Stressed trees are also more susceptible and more vulnerable to attack.

There are 5 nymphal stages (instars) which can complete their life cycle in as little as 5-6 weeks, depending on climatic conditions. There can be up to 3 generations per season (maybe 2 in southern states). This may lead to overlapping generations later in the season. Newly emerged nymphs of the first generation should be targeted for control, prior to them attaining adulthood. Similar to scale, hot, dry weather reduces the survival of crawlers. Opening up tree canopies exposes crawlers to greater likelihood of dehydration, and also to access by sprays targeted against them

Non-chemical management practices include restricting new infestations from nearby forests or groves, including on equipment, and trying to avoid stressing trees. Few natural enemies have been recorded; green lacewings have been observed predating on lace bug nymphs, and spiders and birds may also be predators. Green lacewings are commercially available and may be of some use in suppressing populations.

For further information see tutorial and flyer on Olive Lace Bug (OliveBiz).

A. Lace bug damage **B**. Adults on leaves **C**. mixed stage nymphs on underside of leaf

Apple weevil (Curculio beetle) *Otiorhynchus cribricollis*

Apple weevil, has been implicated in damaging olive trees, especially during the early stages of establishing a grove. It is primarily a problem in WA and Vic, occasionally SA. Adults are nocturnal and flightless, emerge from the ground in summer and climb trees to chew leaf margins, creating a typical scalloped appearance. Severe infestations can damage growing tips, and reduce yield, especially in young trees. The soil-dwelling larvae (legless grubs with white bodies and brown heads) may feed on plant roots, but there are no reports of serious damage to olives.

The effectiveness of insecticides in reducing the abundance of apple weevil, applied normally as butt sprays has been demonstrated. However, there are currently few chemical options available. An effective non-chemical alternative is either a sticky or a fibrous barrier applied to the tree trunk. In the latter case, apple weevils in particular become enmeshed in the fibres. Poultry, including guinea fowl, have also been reported to contribute to garden weevil control in orchards and vineyards.

Check new plantings for leaf and stem feeding. Confirm whether these weevils are the cause by observations at night or digging around the base of trees during the day.

Apple weevil adult (L) and damage (R)

For further information see tutorial and flyer on Apple Weevil (on OliveBiz).

Queensland fruit fly, *Bactrocera tryoni*

The Queensland fruit fly (Qfly or QFF), has been reported occasionally damaging olive fruit. Qfly is endemic to Qld and the coastal parts of NSW, but has recently spread to southern inland NSW and northern Vic. Female flies lay eggs in ripening fruit, causing small piercing marks. Larvae may develop in fruit. Damaged fruits may prematurely

ripen or fall, and are predisposed to fungal fruit rots. This damage also predisposes fruit to fungal rots.

There are commercially available baits (Cue-lure, methyl eugenol) used to trap males, mainly for monitoring, and baits for female flies but these are likely to have limited effect, especially in seasons of high fly populations. Protein baiting using yeast autolysate with a toxicant has been successfully used to target female fruit flies in other crops. Area-wide management is encouraged against QFF in south-western NSW, and Victoria, including use of sterile insect technique (SIT). Outbreaks within the Greater Sunraysia Pest Free Area (GSPFA) are managed by a combined State Government, Industry and Community collaboration.

These fruit flies should not be confused flies with the closely related exotic olive fly.

Queensland fruit flies

Rutherglen bug, *Nysius vinitor*

This small (5 mm) native bug commonly breeds on weeds, especially developing seeds, occasionally reaching plague numbers in spring and summer and may swarm onto trees. Heavy feeding can cause severe damage with scorched appearance of leaves and death of twigs. While generally of minor importance, it may be prevalent in favourable seasons.

Rutherglen bug adult (L) nymph (R)

Green vegetable bug, *Nezara viridula*

This large green stink bug (adult 15 mm) commonly migrates into olive groves from nearby crops (so tends to be more common in grove borders) and directly damages fruit by piercing with its mouth parts as well as predisposing fruit to rots. Immature nymphs (5 stages) are commonly gregarious (found in groups), and are dark-coloured with lighter white, yellow and orange spots. An egg-parasite wasp, *Trissolcus basalis*, has been introduced and is well established in many districts.

Green vegetable bug adult and nymphs (L) and damage (R**)**

Table 3. MOST COMMON DISEASES AND DISORDERS
Based on industry surveys and field observations (Major diseases are in bold)

COMMON NAME	SCIENTIFIC NAME	STATUS	DISTRIBUTION
Anthracnose	***Colletotrichum* spp.**	**Major, particularly in wet summers /autumns**	**All states exc. Tas**
Leaf mould/ cercosporiose	***Pseudocercospora cladosporiodes***	**Increasing incidence in some locations**	Reasonably widespread
Olive knot	*Pseudomonas savastanoi* pv. *savastanoi*	Increasing in some groves	Sporadic
Peacock spot	***Venturia oleaginea***	**Can be a major problem**	NSW, SA, Tas, Vic
Phytophthora root rot	*Phytophthora* spp.	Minor, mainly associated with young plantings and poor drainage	NSW, VIC, SA, WA
Rhizoctonia root rot	*Rhizoctonia* spp.	Minor	Sporadic
Verticillium wilt	*Verticillium dahliae*	Important in some locations with previous crops	NSW, VIC, SA, WA
Wound cankers/dieback	Various, inc. *Botryosphaeria* sp., *Pseudomonas* sp., *Ralstonia solanacearum*	Minor, but widespread and increasing	All states, esp. NSW, Qld, WA
Apical end rot/ soft nose	Disorder	Occurs in some areas, associated with nutrition/watering	Various locations
Sphaeroblasts/ oedema	Disorder	Minor	All states

MAJOR DISEASE AND DISORDER DESCRIPTIONS

Anthracnose, *Colletotrichum* spp.

Anthracnose causes soft circular rots on fruit usually on the shoulder, and at high humidity produces an orange slimy mass of spores on the fruit surface (soapy fruit). It is commonly seen close to harvest when fruit softens. Young shoots and leaves can also be infected causing dieback. It is particularly prevalent in districts with summer-autumn rainfall, where it can be very severe in seasons suitable for its development. The pathogen can initially infect flowers and young fruit under warm, wet conditions, and secondary infections later in the season may rapidly spread as the fruit ripens and orange-pink fungal spores are produced and spread by wind and rain. Fruit infection results in reduced oil quality. Anthracnose and other fruit rots may be associated with damage by insects such as fruit flies and green vegetable bug, and environmental damage such as that caused by hail. Some varieties such as Barnea, Jumbo Kalamata and Manzanillo and are more susceptible. The pathogen survives on infected mummified fruit and infected twigs. Early season infections occur through flowers. Spores are spread by rain splash and wind. Infection can remain latent until fruit matures. Spores can infect ripe fruit and form new spores within 4 days. Inoculum is carried over winter in infected mummified fruit, and twigs.

Spray programs need to commence in winter. Non-chemical management practices include removal of mummified fruit, early harvesting especially of susceptible varieties, and pruning trees for more open canopy for air movement and sunlight access.

For further information see tutorial and flyer on Anthracnose (OliveBiz).

Anthracnose on fruit (L) and flowers (R)

Peacock spot, *Venturia oleaginea* (formerly *Spilocaea oleaginea*)

Peacock spot is widespread throughout eastern and central Australia, and can cause severe problems, particularly when conditions are most favourable (i.e. warm and humid, especially in spring). Most new infections occur on young spring growth during wet weather, which is followed by a latent period of about 30 days. Round spots from 2–10 mm diameter on the upper surface of the leaf and occasionally on stems, peduncles and fruit, first appear as small pale blotches, later becoming muddy green to black, often with a yellow halo. Under higher temperatures older lesions develop into whitish scabs, where the cuticle separates from the epidermis. Severe infection may cause defoliation, which can kill new wood and reduce production in the following year. Young leaves may remain symptomless. It overwinters in old, infected leaves. Spores germinate in free water and are blown or splashed onto the leaves. Spores attached to leaf trichomes can also be dispersed by wind. The disease is generally inactive in summer. Some cultivars appear to be more tolerant to this disease. Non-chemical management practices include removal of fallen infected leaves and pruning trees to open up the canopy for air movement and sunlight access.

Management of this disease has traditionally relied on cultural practices such as mulching or removal of fallen leaves over winter, together with pruning to open up the canopy, and fungicide applications.

Peacock spot on leaves (L) and fruit (R)

Cercospora leaf mould, Cercospora leaf spot, Cercosporiose, *Pseudocercospora cladosporioides*

This is a disease that is being increasingly recognized in Australian olive groves. Grey mouldy blotches develop on the underside of the leaves. The tops of the leaves turn yellow then brown, and finally drop. Defoliation mainly occurs on the inner parts of the tree canopy. Significant leaf drop weakens trees to further pest and disease attack. This disease may occur together with peacock spot, causing significant

defoliation and damage to new growth and reduced crop production. Fruit are rarely infected, but, if so, they show round, reddish-brown spots. Fruit from affected trees may also abort or drop prematurely.

The fungus overwinters in old infected leaves. It usually infects in autumn, targeting the young spring growth. It is favoured by high humidity and rain, and mild temperatures (12-28°C), with the optimum temperature for spore germination 21-22°C. Winter rain and winds allow spores to disperse. There is a long latent period (up to 11 months) between infection and symptom development. Olive varieties can vary in susceptibility. Fungal spores on fallen leaves are a potential source of new infections so mulching with organic matter may reduce carry-over of the pathogen between seasons.

For further information see tutorial and flyer on Cercospora leaf mould (OliveBiz).

Cercospora leaf mould on leaves

Root and vascular diseases

Numerous cases of olive tree decline and death have been reported. Leaves wilt, yellow and may drop. Trees may die suddenly, or slowly decline over several years. Sudden death is common when stress is placed on the tree, such as during flowering, fruit development or hot weather. Pathogenic fungi isolated from trees showing symptoms include *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp. and occasionally *Verticillium dahliae.*

These diseases are commonly associated with poor soil drainage, but can be transmitted by movement of soil and infected plants. *Verticillium dahliae* is most common on land which has previously grown susceptible crops such as tomatoes, potatoes or cotton. Non-chemical management practices include quarantine/biosecurity, improved soil drainage, addition of well-composted organic

matter; biocontrol fungi (e.g. *Trichoderma* spp.) have been used in other crops to suppress some of these soil-borne diseases.



Crown canker and root rotting from *Phytophthora* Tree with wilted branch from *Verticillium*

Opportunistic tissue-invading microorganisms

Many examples of localised trunk and stem dieback are not associated with known olive pathogens. It is suspected that tissue death is a result of entry of opportunistic fungi and bacteria through wounds such as pruning cuts and other mechanical injury.

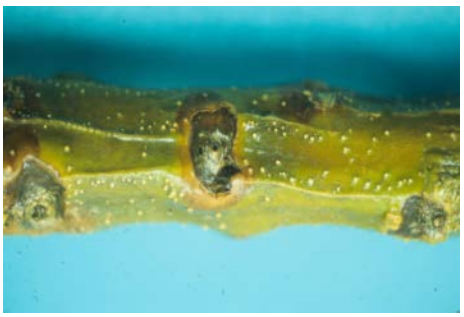
Occasional trunk and stem galls are also associated with opportunistic bacteria. Olive knot, *Pseudomonas savastanoi* pv. *savastanoi,* has been recorded in a number of groves in Australia, particularly associated with the variety Barnea. The bacterium is very difficult to control, as it is spread by splash from infected trees, and also by pruning.

Olive knot galling around wound site

Wound cankers

Opportunistic wound invaders include fungi such as *Botryosphaeria* sp., *Pycnoporus coccineus* (white wood rot) and bacteria such as *Pseudomonas syringae*, *Ralstonia solanacearum* and *Xanthomonas campestris*. Symptoms vary from slow decline of trees and tree death to localised cankers around wound sites with occasional branch death above the infection. There can also be brown staining of the vascular system. These pathogens can be borne by wind, water and soil, and are favoured by wounds,

wetness and high humidity causing moisture films around wound sites. Wounds, whether invaded or not, can be associated with cold temperatures, sun scald and herbicide, as well as pruning, but in many cases the cause cannot be determined. Wounds can be protected by treating with copper fungicides, or painting with a wound sealant or acrylic paint.



Pseudomonas syringae causing localised wounds at leaf scars

Sphaeroblasts and oedema

Sphaeroblasts are knob-like growths up to 10 mm wide which protrude from stems. When they are cut open, a spherical lump of wood can be removed from the surrounding tissue. Their cause is unknown, and they commonly occur on the cultivar 'Barnea'. They do not appear to cause any deleterious effects on tree growth or yield.

Symptoms of oedema are small, brown, corky growths up to 5 mm wide that form on the surface of stems or roots from enlarged lenticels (breathing holes in bark). They occur when high soil moisture causes excessive water uptake, which engorges the cells near the lenticels. These cells can rupture from the high water pressure, and the plant forms callus tissue in an effort to heal. When roots experience periods of high soil moisture, some tissues may also asphyxiate (because of reduced oxygen levels). Consequently, these roots are predisposed to infection by a range of minor pathogens or opportunistic invaders such as *Fusarium*, *Pythium* and various bacteria.

Sphaeroblasts

Oedema

WEEDS

While this manual is focused on arthropod pests and diseases, weed management also plays an important role in IPDM. There are numerous weeds, depending on location and season, which can occur in olive groves. Many inter-row weeds can be adequately managed via a regular slashing/mowing program. However, particularly for weed management within rows and around irrigation lines there are a very large number of herbicides registered for use in olives, details of which can be accessed from the APVMA website.

Note that a number of herbicides, including glyphosate, can damage olive trees, particularly when they are young. Systemic herbicides can be taken up and translocated via green trunks, as well as by leaves (especially from trees with low foliar skirts).

Tree guards on newly planted trees are useful in deterring damage from herbicide use, rabbits and hares, and sunburn. There are many types of guards, including plastic sleeves, PVC, corflute, and carton cardboard. For those wanting to “tread softly on the earth”, there are biodegradable options, as well as recycled or recyclable plastic. Most tree guards are reusable.

HOW FAR ALONG ARE YOU AT ADOPTING IPDM?

Now you have read the previous sections of the Manual (unless you have inadvertently turned to this page), it is time to assess how far you have developed your own IPDM program for the farm.
In practice, there are different stages to which growers adopt IPDM. This is dependent on a number of factors, including:

- your location and previous history
- your philosophical world-view, including interest in organic production,
- whether it is a full-time or part-time business or hobby
- the size of the property
- whether you live on or off the property
- whether you have a manager, consultant, or workers
- what farm equipment (including pesticide application equipment) you have access to, and
- confidence in your ability to recognise pests and diseases and to select an integrated series of strategies in a calm and methodical way.

The first stage of adopting IPDM practices involves:

Improved cultural and hygiene practices (including biosecurity), and
Monitoring of pests/diseases to better time pesticide applications

The next stage involves (as well as the above):

Monitoring of beneficial species
Predicting pest and disease populations
Selection of “softer” pesticides where possible
Spot and target applications of pesticides, where appropriate

A further stage involves:

Employing environmental modifications to encourage beneficial species, and to discourage pests (including inter-row plantings)
Release of mass-reared beneficial species/ entomopathogens/ antagonists

Probably the ultimate stage of IPDM is to design the entire production system to minimise pest problems before embarking on the enterprise.

So where do you think you fit on this IPDM scale? And do you think you can (or want to) go further in adopting IPDM in your grove?

There is also a seasonal IPDM check list following for you to review (following page).

IPDM SEASONAL CHECKLIST/PLAN

Develop your IPDM strategy

Review last seasons' IPDM approach and its success, modify accordingly. Good record keeping supports assessment of your IPDM strategy.

Communicate your IPDM goals and management plan for the coming season to your workers.

Know your enemy and options for management

Get the latest information and IPDM related information, including from OliveBiz.

Participate in IPDM training, field days, workshops, or on-line information

Take a long-term approach

Consider well beyond the coming season

Think beyond the crop

Participate in Area Wide Management of pests and diseases. Some, such as those for Queensland Fruit Fly, are well-established.

Consider native vegetation as part of pest management. Maximise its value by improving its health, linking patches of vegetation, and keeping it diverse for a range of species (including birds and bats).

Have good on-farm hygiene

Have and implement your Farm Biosecurity Plan

Practice "Come Clean-Go Clean"

Consider options to escape, avoid or reduce pests

Manage areas of vegetation on and off-farm to encourage beneficials

Consider insecticide choice or releasing beneficials to build beneficial numbers

Monitor crop development to maintain a healthy crop

Maintain high beneficial numbers

Monitor crops effectively and regularly

Remain up-to-date with regular monitoring of key pests and diseases, beneficials, and plant damage

Track pest and disease trends

Grow a healthy crop

Manage nutrition and irrigation to maintain a healthy crop
Undertake soil and leaf tests to determine plant nutrition requirements

Choose pesticides and apply them wisely

Consider alternative strategies to use of pesticides

Consider insecticide selectivity and their impact on beneficials and bees

Review your legal pesticide options by accessing the APVMA website

Avoid overuse of broad-spectrum and prophylactic sprays

Base selection and timing of application on monitoring of results

Consider spot spraying, to minimize both cost and negative impacts

Monitor effectiveness of pesticides following application

Apply good resistance management principles, including minimizing pesticide applications and rotating pesticide groups

Table 4. CHEMICALS REGISTERED OR LEGALLY PERMITTED FOR USE AGAINST KEY OLIVE PESTS AND DISEASES (August 2020)

TARGET PEST OR DISEASE	ACTIVE CONSTITUENT	MoA GROUP (I)nsecticide (F)ungicide	PRODUCT(S)	REGISTERED OR PERMIT	CONDITIONS OF USE
Black scale	Emulsifiable Botanical Oil	9B (I)	ECO-OIL® MITICIDE/INSECTICIDE BOTANICAL OIL CONCENTRATE, POOP®	Registered	No WHP.
	Paraffinic oil, Petroleum spray oil	9B (I)	isoCLEAR HPO, TRUMP®, SACOA BIOPEST®	Registered	WHP 1 day.
	Pyriproxyfen	7C (I)	ADMIRAL®, various others	Registered	Max 2 applications/season. WHP 7 days.
Ants	Pyriproxyfen	7C (I)	DISTANCE PLUS ANT BAIT®	Registered	Max 3 applications/season, min 3 months apart between each one. No WHP.
	Chlorpyrifos	1B (I)	various	PER14575 Until Mar 2022	Apply no more than 2 times /season. No WHP, but no grazing (Ground, butt treatments only).
Olive lace bug	Clothianidin	4A (I)	SAMURAI®	PER14897 Until Mar 2023	1 application/season. Add MAXX Organosilicone surfactant. WHP 56 days.

	Potassium soap		NATRASOAP®	PER14414 Until Sep 2023	Apply 2 treatments 7–10 days apart. Organically acceptable. No WHP.
	Dimethoate	1B (I)	ROGOR®, various others	PER13999 Until Mar 2021	Max 4 applications/season. 2 sprays, 7–14 days apart. Not to be used for table olives. WHP 6 weeks.
	Esfenvalerate	3A (I)	SUMI-ALPHA FLEX®, various others	PER86677 Until Dec 2023	Max 4 applications/season to fruiting trees, ≥ 14 days apart. WHP 14 days.
	Pyrethrins	3A (I)	PYGANIC, and others	PER81870 Until Oct 2024	Max 6 applications/season, ≥ 14 day re-treatment interval. Use different MoA product after 2 applications. WHP 1 day.
Green vegetable bug, Rutherglen bug	Dimethoate	1B (I)	ROGOR®, various others	PER13999 Until Mar 2021	Max 4 applications/season. 2 sprays 7–14 days apart. Not to be used for table olives. WHP 6 weeks.
Weevils	Alpha-cypermethrin	3A (I)		PER14791 Until Nov 2021	Max 2 applications/season to trees of fruit bearing age. No WHP, but no grazing (Ground, butt treatments only).

Anthracnose	Azoxystrobin	11 (F)	Various	Registered	Max 2 applications/season >21 days apart. WHP 21 days.
	Metiram & Pyraclostrobin	M3+11 (F)	AERO®	PER14908 Until Jul 2024	Max 2 applications/season >21 days apart. WHP 21 days.
	Mancozeb	M3 (F)	Various	PER88358 Until Jul 2023	Max 4 applications/season >14 days apart WHP 14 days
	Copper (cupric hydroxide, cuprous oxide, tribasic copper sulphate)	M1 (F)	Various	PER11360 Until Nov 2021	WHP 1 day Also for other fruit rots Generally organically acceptable
	Copper oxychloride	M1 (F)	Various	Registered	WHP 1 day Also for other fruit rots May not be organically acceptable
	Copper oxychloride + copper hydroxide	M1	AIRONE WG FUNGICIDE	Registered	WHP 1 day Also for other fruit rots May not be organically acceptable
Olive knot	Copper oxychloride + copper hydroxide	M1	AIRONE WG FUNGICIDE	Registered	WHP 1 day Also for other fruit rots May not be organically acceptable

Peacock spot, Grey mould, Leaf spots	Copper (cupric hydroxide, cuprous oxide, tribasic copper sulphate)	M1 (F)	Various	PER11360 Until Mar 2017	WHP 1 day Generally organically acceptable
	Copper oxychloride	M1 (F)	Various	Registered	WHP 1 day May not be organically acceptable
	Copper oxychloride + copper hydroxide	M1	AIRONE WG FUNGICIDE	Registered	WHP 1 day Also for other fruit rots May not be organically acceptable
Phytophthora, Verticillium Wilt	Metham	8 (F)	Ken-Pam 423 fumigant	Registered	Pre-plant soil treatment. 14-30 day minimum interval between treatment and planting

FURTHER INFORMATION AND LINKS

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