Nursery Pesticide Application

Best Practice Manual

September 2013

Nursery & Garden Industry Australia

HAL
Horticulture Australia

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- Rankins Nursery Pty Ltd, Officer VIC 3809
- Combined Nursery Sales, Baxter VIC 3911
- Chavallum Wholesale Nursery, Palmwoods QLD 4555

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INTRODUCTION

The nursery industry in Australia is very diverse, with enterprises ranging from small, owner-operator ventures to large, multi-million-dollar corporate businesses. A wide range of plant types is grown, from immature seedlings through to fully mature trees. Some production occurs in glasshouses and shade houses, while in other cases, stock is grown in open plan production areas. It is in this range of environments that pesticides need to be efficiently and safely applied for the management of pests (insects, pathogens and weeds).

The management of pests is an important part of nursery operations. A wide range of pest management measures is available, including chemical, biological, varietal and mechanical measures. All available control methods should be considered before a chemical option is employed within an Integrated Pest Management (IPM) program. The purpose of this manual is to provide information on the effective and safe application of pesticides as part of an IPM strategy for plant nurseries.

The right spray equipment, when correctly used within a well-considered pest management program, is a critical factor in ensuring the success of that program. However, consideration must be given to the type of pest, the pesticide's mode of action and the environment in which the pesticide needs to be applied. In nurseries, special consideration should be given to the production environment, the influence of shade structures and irrigation systems and the proximity of neighbours and the workforce.

A note on legal usage of chemicals

> ***This manual does not consider or discuss the registration status or legal usage of specific chemicals, or their active constituents, as it is the legal obligation of the nursery operator to abide by the national and local approved registrations.***

Currently in Australia (excluding Victoria) if the specific crop and cropping system (e.g. nursery stock, non-food) is not registered on the label it is illegal to use that product unless a 'Minor Use' or 'Emergency' permit has been issued by Australian Pesticides and Veterinary Medicines Authority (APVMA). It is illegal to use a pesticide, with the same active constituent as a product that is registered, if that pesticide does not have a label registration or an APVMA permit.

Minor Use Permits allow industries that apply small volumes of pesticide to legally access the product when the manufacturer or importer decides not to register the pesticide for that specific crop or cropping system. The nursery industry is currently leading a Minor Use Pesticide program for pesticides, funded via the Nursery Products Levy, to secure access to priority pesticides[1].

[1] *McDonald, J. (2012). Nursery Production Minor Use Permit Pesticide Program. Nursery Technical Papers Issue no. 11*

Best management practice for pesticide application in the nursery industry

What is best practice?

Best practice in any industry is usually described as a process of continual improvement in how operations are carried out. In the area of pesticide application this means that individuals and organisations need to assess how appropriate their current operations are and put into place plans and programs that continuously improve those operations.

What is this manual designed to do?

This manual is designed to assist nursery operators in identifying and understanding the range of pesticide application equipment available and the key issues related to the use of pesticides in the nursery environment.

To assist the nursery industry in improving the safe and effective application of pesticides, this manual includes information on:

- developing spray management plans
- the types of pesticides available and their storage, handling and disposal

- the risks various pesticides may present and the selection and use of personal protective equipment to manage these risks
- suitable operating conditions for pesticide application and managing spray drift
- the advantages and disadvantages of various types of pesticide application equipment
- the calibration of pesticide application equipment
- case studies detailing examples of industry practice and critical comments
- useful contacts and references.

How to use this manual

Each section of the manual provides information on the range of products and techniques available to nursery operators for the application of pesticides.

Best management practice is a process of continual improvement. This manual enables users to examine their practices with a view to improving the safe and effective use of pesticides in their situation.

Due to the diverse nature of the nursery industry, frequent changes in legislation and the development of new application equipment, it is impossible to provide examples of best practice for all the types of spraying operations that are likely to occur. This manual contains background information that individual nurseries should consider so that they can develop and improve their current practice.

Throughout the various sections of the manual, the advantages and disadvantages of a range of products and techniques are discussed. It is the responsibility of the user to determine which of these products and techniques may lead to improvement in the safe use of pesticides.

The following key is used within this manual to indicate sprayer type, droplet size, pesticide type, nursery design, expected coverage and nursery size that may be suitable for each type of application equipment discussed.

Key to symbols used in this manual

Sprayer type

Ultra low volume | Low volume | High volume

Nursery design

Open plan | Shade house | Glasshouse

Droplet size

Fine and very fine | Medium | Coarse

Coverage

Spot spray | Blanket spray

Pesticides

Fungicides | Herbicides | Insecticides

Nursery size

Small | Medium | Large

Requirements for best management practice in pesticide application

Best practice in the selection and use of pesticides begins with the correct identification of the TARGET and then the development of a pest management program, which may include the use of pesticides. If a pesticide is to be used, it must be applied to the right PLACE at the right TIME with minimal impact on people, beneficial organisms, property and the environment.

Nursery operators should ask themselves a series of questions before commencing any pest management program. These include:

1) Has the target been identified correctly?

Before proceeding with the use of any pesticide it is essential to determine the biological target. For example, different application techniques may be required to manage insect pests, weeds or plant pathogens.

2) Has the most appropriate method or methods of pest management been chosen?

As part of an Integrated Pest Management (IPM) regime a number of methods are available to the nursery operator. Issues such as cost, safety, effectiveness and chemical resistance of insects should be considered before chemical control is employed. Other methods include:

- mechanical—pruning, hand weeding, hoeing
- cultural—hygiene strategies, controlled environments, insect meshes
- biological—beneficial insects, predator releases, companion planting
- genetic—pest and disease resistant cultivars
- quarantine—use of exclusion areas, plant movement restrictions
- chemical—herbicide, fungicide, insecticides

There may be a number of pesticides registered for the management of a single pest in various industries or locations. Only products that are registered for the particular situation should be used.

When selecting a pesticide operators must consider:

- the susceptibility of the target pest
- the susceptibility of non-target organisms
- the stability of the product (e.g. whether the chemical is quickly broken down or has an ongoing or residual activity)
- the cost of the pesticide and the cost of application
- the type of formulation and safety issues
- the logistics (ease of transport, handling and storage)
- the availability of the product of choice
- the shelf life of the product.

3) Is the right amount being applied?

The correct dose of pesticide should, in most situations, be uniformly distributed across the area to be treated. This can be achieved by using an appropriate application technique with accurately calibrated equipment. Pesticides should always be applied at the rate specified on the product label. The label is a legal document, and the label information on usage conditions and other directions must be followed.

4) Is the product being applied to the right place?

It is common for pesticides to be applied to only a portion of a nursery rather than the entire area. It is important that these areas are readily identifiable so that the pesticide is applied at the correct location and accurate records of use can be kept.

5) What is the best time to apply the product?

If the product is not applied at the right time the treatment may be ineffective. Factors that influence the timing of application include:

- the lifecycle of the pest*
- the meteorological conditions
- other activities that are occurring in the area
- staff and bystander locations and re-entry periods.

*Many products are most effective at certain stages of the pest lifecycle or stage of plant growth. For example, many insect pests are only susceptible to certain products during their immature (larval or nymphal) stages. Similarly many weed species will only be affected by some herbicides while they are small, actively growing and not experiencing stress.

6) Is the appropriate personal protective equipment (PPE) being used?

Operators should consult the product label and the Safety Data Sheet (SDS), previously referred to as MSDS or Material Safety Data Sheet, before proceeding with any operation, to determine what PPE is required when mixing and applying the chosen product.

An understanding of the principles of safe mixing, loading and use of pesticides is required. Carrying out a risk assessment will assist in the identification of hazards and the management of risks.

7) Was the desired outcome achieved?

After every application, after the re-entry period has expired, assess how well the product performed. Record this information and keep it for future reference, along with the data gathered that led to the decision to use the pesticide treatment.

8) Were there any unexpected outcomes?

Were there any detrimental effects on workers or adjacent areas? If so, were these recorded and how may they be minimised in the future?

Using this information to implement best management practice in pesticide application

All of the previous questions should be asked prior to, during and after each pesticide application. By asking these questions, recording the results and using the information contained in this manual, the practices and procedures that can assist in moving towards best management practice in pesticide application can be implemented.

CHAPTER 1.

SPRAY MANAGEMENT PLANS

All nursery operations should have a spray management plan, including a risk assessment. Chemical users should be aware (or be made aware) of the risks associated with chemical application. A generally accepted risk assessment process has been established for effectively managing risks.

The process is:

1. Identify the hazard.
2. Assess the level of risk.
3. Control the risk.
4. Review.

Generic risk assessment templates and policies are available online or through your state workplace health and safety department (refer to the contact details on page 84). These should form part of a 'Spray Management Plan' covering areas such as spray operator training, managing other nursery staff so that they do not come into contact with contaminated stock or spray drift, timing of applications, record keeping and emergency procedures.

1.1 Training

All spray operators involved in the application of nursery chemicals should be qualified according to relevant state training and accreditation requirements. For example, all spray operators should have completed a farm chemical users course (e.g. ChemCert) or other equivalent recognised chemical application course (refer to the contact details on page 84). Employers have legal responsibilities to ensure that their employees are correctly trained in the use of chemicals and related equipment and ensure they are aware of, and adhere to, the record keeping requirements.

1.2 Time of application

Pesticides are most effective when they are applied at the right time. Pests are most effectively managed with pesticides when they are small or just starting to develop rather than when they are more mature. Plants should be monitored or checked regularly for pests (insects, plant pathogens and weeds) so that pest management activities can be performed at the right time.

Another factor to consider when deciding when to spray is the presence of other nursery staff, clients or members of the public. In general, it is best to arrange spraying operations so they are undertaken at times when no one else is around, such as after closing time or on the weekends.

Weather conditions before, during and after application can all influence the timing of the spray application. Chapter 3 discusses in detail the influence of weather conditions on the likelihood of spray drift and these factors should be considered while deciding when to spray.

In general, pesticides should not be applied to plants that are stressed due to weather conditions. For example, avoid the application of pesticides during the hottest part of a summer day or if a frost is present.

1.3 Record keeping

Spray operators need to keep accurate records of all spraying activities. This should be part of any quality control strategy and is required under state and federal legislation. It is also mandatory for compliance with codes of practice covering workplace health and safety.

The spray operator should maintain up-to-date records of pesticide usage and spray operations. The operator should complete a spray report after every spray operation. The report should include the date, time, area sprayed, amount and type of pesticides applied, recorded application rates, crop details, pests present, operator(s) involved, equipment used, nozzle type, settings (e.g. spray pressure) and meteorological conditions (wind speed and direction, temperature and humidity).

Maintaining accurate records of all pesticides used at the nursery site will assist the manager in making informed management decisions.

The information recorded must include:

- calibration data, including specific nozzle information (type, pressure of operation/rotation speed etc)
- registered pesticide used, and the amount used
- personal protective equipment used and maintenance details of PPE
- environmental conditions
- area sprayed (location and size)
- pest/crop description.

Table 1 is a sample checklist for spraying operations. Another example of a recording system is the Nursery & Garden Industry Australia (NGIA) Pesticide Usage Form (figure 1). This is an electronic form that allows the creation of a coding system for your nursery spray operations. For example, a shade house might be referred to as Area 1 and a glasshouse as Area 2. You can produce a code for particular operations, e.g. spraying could be S1 and mixing M1.

Nursery & Garden Industry Queensland

Spray Diary Recording Sheet

Nursery & Garden Industry Australia

Business Name: _____ Sheet No: _____

Business Address: _____ Have you read the label? Yes No

Name of Operator: _____

Date & Start Time/ Finish Time	Area Sprayed (code*)	Crop Treated (code*)	Target Pest (code*)	Pesticide Trade Name		Pesticide Label Rate	App. Rate (L/ha)	PPE Worn (code**)	Wind Speed (km/hr), Direction & Temperature (ºC)	Application Equipment Used (code**) & Calibration Date	Spray Result	Operator Signature
				Trade Name	Active Ingredient							

*** You can develop a unique code for these data fields to identify an area, crop or target pest. Alternatively, enter the full details.**

**** You can use a code from those provided on the right hand side of this recording sheet.**

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Figure 1. Nursery & Garden Industry Australia (NGIA) Spray Diary Recording Sheet

Table 1. Sample operational plan – overview checklist

Task	Tick	Notes
PLANNING – PRE SPRAY		
Chemical user		Joe Bloggs
Field owner		Fred Bloggs
Location	√	6 km SE of Country Town
Area to be sprayed, area (hectares) and type	√	Bedding plants
Nature of pest problem		
Are there any alternative methods to spraying?	√	No
Consult an up-to-date Awareness Zone Chart	√	Yes
Sensitive areas within Awareness Zone	√	Vineyard 1 km
Communicate to neighbours	√	Yes, by phone 5/7/13
Check user training credentials	√	ChemCert® 15/12/12
APPLICATION		
Equipment in proper working order and calibrated	√	Leak repaired
Spray equipment	√	Hand gun
Nozzle type		Dg 110-03
Nozzle number		1
Droplet size		BCPC medium
Settings		
Spray pressure (bar)	√	2 bar
Product label and SDS read and understood	√	Yes
Check wind direction is away from susceptible areas	√	Yes
Wind direction in °	√	From NE 040°
Windspeed in k/hr	√	10 k/hr
Temperature in °C	√	27 °C
Relative humidity %	√	50%
Cloud cover in eighths		2/8
Approximate stability class (unstable, neutral or stable)		Neutral
Is a ground surface temperature inversion present?		No
Are weather parameters within acceptable limits?	√	Yes
Are you wearing correct PPE for the job?	√	Yes
Date		13/4/2013
Time start of spraying		10.00 hr
Time end of spraying		16.00 hr
Chemical type(s)		
Product application rate (L/ha)		2.5 L/ha
Bulk volume rate (L/ha)	√	50 L/ha
Amount of product used		35 L
Treated area (ha)		0.2 ha
Is crop/other buffer used?	√	30 m boundary
POST SPRAY EVALUATION		
Were results satisfactory? (note numbers controlled/escaped)	√	Yes
Could there be any improvements?	√	No
All spray records correct, up-to-date and stored safely?	√	Yes
Full name of chemical user	Signature	Date

1.4 Emergency procedures

There are a number of hazards that exist when using registered pesticides. These can include fires, spills and poisoning. It is important that the nursery has emergency procedures in place to respond to any incident. It is also important to evaluate current practice to avoid an emergency situation. The following section discusses the areas that should be covered in planning and dealing with emergencies.

A plan for handling emergencies such as spills, accidental contamination of people and the environment should be developed as part of a risk assessment related to the use of pesticides in the nursery. Completion of a 'Managing farm safety' course will assist in understanding and carrying out a risk assessment. This knowledge can then be used to manage hazards.

Both the EcoHort Nursery Industry Environmental Management System and the current AgSafe® Accreditation Training Manual (2002) contain detailed information on emergency procedures related to pesticide storage and handling.

Fires

Prevention of fires must be a primary consideration when organising the storage of products on the nursery site. Incompatible products such as flammable chemicals, oxidants and corrosive products should not be stored next to each other.

A fire management plan may include the following points:

1. Raise the alarm and evacuate the premises.
2. Notify the fire brigade and police.
3. If it is safe to do so, start fire-fighting operations with on-site equipment suitable for the purpose (e.g. hand-held fire extinguishers). Wear protective clothing.
4. Check that the fire-water and spilt product is being contained.
5. If run-off occurs or there is a danger of exploding containers, consider withdrawing and allowing the fire to burn out.
6. Any person experiencing side effects from fire (e.g. dizziness) should be placed under medical care.
7. Remove contaminated clothing. On completion of activities, equipment and all clothing should be cleaned and a shower taken by all personnel involved.

Spills

The guiding principles in clean-up operations following an accidental spill are:

1. Isolate the affected area.
2. Wear appropriate personal protective equipment (PPE) as recommended on the label.
3. Contain the spilled chemical and prevent further contamination.
4. Decontaminate the affected area with a suitable absorbing medium or other appropriate means (refer to the SDS).
5. Dispose of the spill by safely packing the absorbing medium into proper containers.

In the event of a major spill incident call '000'.

At each chemical storage area, a 'spill response equipment kit' suitable for the purpose should be maintained. A basic kit to deal with spillage should be kept at the mixing and measuring site. A spillage kit should consist of[1]:

- sand or soil, kitty litter or vermiculite
- hydrated lime (several bags)
- square-mouthed shovel(s)
- open drums (20 L and 200 L) to collect materials
- bleach (hypochlorite) (20 L drum)
- funnels, a broom, banister brush and pan
- PPE suitable for handling concentrates, including eye protection, gloves, respirator and disposable foot protection.

Emergency numbers must be clearly displayed at the sites of storage, handling and mixing. If a person has been injured or requires medical attention as a result of the spill some states require the incident to be reported.

[1] *ChemCert Australia, Chemical Users Handbook, 2013.*

Poisoning

Rapid response is essential in all cases of poisoning. The speedy removal of the source of contamination and rapid first aid implementation and transport to hospital or a doctor may save a life. For information on first aid, read the appropriate label and SDS (see figures 3 and 4 for examples).

> ***Do not substitute first aid for professional treatment. First aid is only to relieve the patient before medical help is reached. Check for danger to yourself before first aid is attempted.***

If a person who has been in direct contact with a pesticide shows signs of poisoning, take the following steps:

1. Stop any further exposure to the poison by moving the patient away from the contaminated area and from the vicinity of agricultural and veterinary chemicals. Quickly remove any contaminated clothing and wash skin.
2. Begin first aid immediately. See product label for instructions.
3. Call a doctor as quickly as possible but do not abandon the first aid treatment.
4. Keep the patient as quiet as possible and complete the first aid treatment.
5. Keep patient warm and comfortable.

> ***The national Poisons Information Hotline is 13 11 26.***

CHAPTER 2.

CHEMICAL SELECTION, STORAGE, HANDLING AND DISPOSAL

The selection of chemicals and their proper storage, handling and disposal is critical to operator safety and protection of other people and the environment.

2.1 Labels

The pesticide label is a legally-binding document that has been approved by the Australian Pesticides and Veterinary Medicines Authority (APVMA), formerly known as the National Registration Authority (NRA). It provides sufficient information to allow the safe and efficient use of the pesticide, provided the directions are followed carefully (figures 2 and 3).

The label lay-out is largely dictated by regulation and will depend on the size of the pack and the amount of information required to be provided. A minimal design would be a main panel plus an ancillary panel, but there may be two ancillary panels. If this format provides inadequate space, some information can be printed on a leaflet attached to the container, in which case the leaflet is part of the label.

First and foremost the spray operator must read, understand and adhere to the pesticide product label prior to any spraying operation.

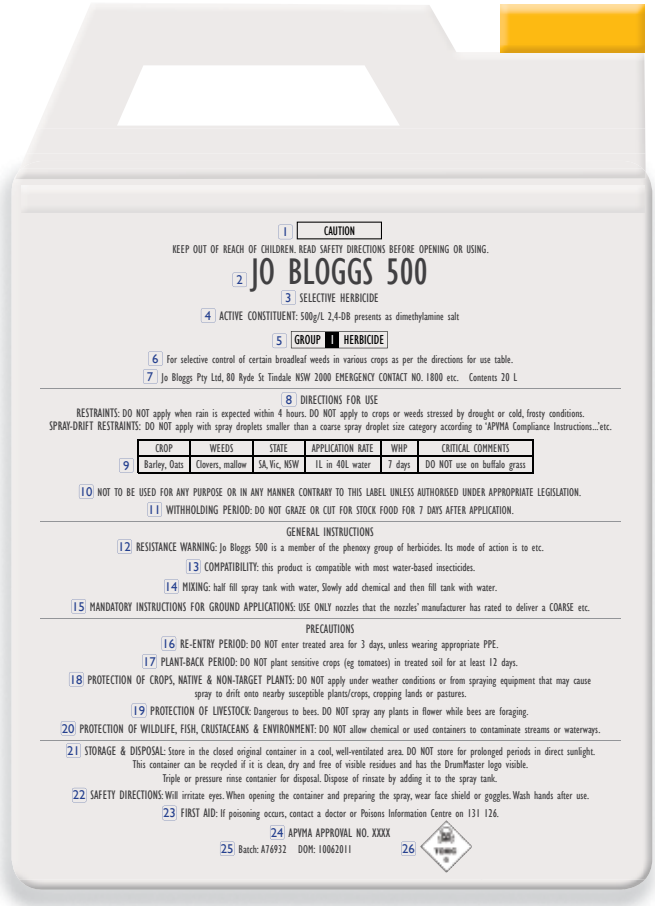

Figure 2. Typical format of a pesticide label (Source: *http://www.apvma.gov.au/use_safely/docs/understanding_labels_booklet.pdf*)

Section A

1 The signal heading

2 Brand name (or trade name)

3 Type of chemical

4 Active constituent

5 Resistance group

6 What the chemical does

7 Name, address and phone number of the business that made the chemical

Section B—Directions of use

8 Restraints

9 Directions for use table

10 NOT TO BE USED FOR. . . statement

11 Withholding period (WHP)

Section C—General instructions

12 Resistance warning

13 Compatibility

14 Mixing instructions

15 APVMA compliance instructions for mandatory droplet size categories

Section D—Precautions

16 Re-entry period

17 Plant-back period

18 Protection of crops, native and other non-target plants

19 Protection of livestock

20 Protection of wildlife, fish, crustaceans and the environment

Section E

21 Storage and disposal

22 Safety directions

23 First aid

24 APVMA approval number

25 Batch number, date of manufacture (DOM) and expiry date

26 Dangerous goods/hazardous chemical information

Confidor 200 SC

CAUTION
KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Confidor® 200 SC

INSECTICIDE

Active Constituent: 200 g/L IMIDACLOPRID

GROUP 4A INSECTICIDE

For the control of various insect pests of cotton, fruit, vegetables and ornamentals as specified in the DIRECTIONS FOR USE table

GENERAL INSTRUCTIONS

Insecticide Resistance Warning

For insecticide resistance management, Confidor is a Group 4A insecticide. Some naturally occurring insect biotypes resistant to Confidor and other Group 4A insecticides may exist through normal genetic variability in any insect population. The resistant individuals can eventually dominate the insect population if Confidor and other Group 4A insecticides are used repeatedly. The effectiveness of Confidor on resistant individuals could be significantly reduced. Since occurrence of resistant individuals is difficult to detect prior to use, Bayer CropScience accepts no liability for any losses that may result from the failure of Confidor to control resistant insects. Confidor may be subject to specific resistance management strategies. For further information contact your local supplier, Bayer CropScience representative or local agricultural department agronomist.

Resistance Management Strategies

Cotton aphid in cotton

Observe the cotton industry Insecticide Resistance Management Strategy (IRMS).

Aphids, whitefly and melon thrips in various crops (foliar sprays)

Do not apply Confidor (or other group 4A insecticides) in consecutive sprays within and between seasons. Rotate with registered insecticides from other mode of action groups.

Confined environments such as glasshouses:

Annuals - Do not apply more than one spray of Confidor (or other group 4A insecticides) to any one crop.

Perennials - Rotate with registered insecticides from other groups. Use a maximum of three Confidor (or other group 4A insecticides) sprays in any 12 month period.

Brassica and lettuce (seedling drench applications)

DO NOT apply Confidor 200 SC or any other Group 4A Insecticide following a seedling drench application of Confidor 200 SC or any Group 4A Insecticide in that crop.

Mixing

Prior to pouring, shake container vigorously, then add the required quantity of Confidor 200 SC to water in the spray vat while stirring or with agitators in motion.

Application

Foliar Spray Application

Where rates are expressed in mL/100 L mix specified rates of product per 100 L water and spray plants to "point of run-off" stage, thoroughly covering all plant surfaces.

Where rates are expressed in mL/ha apply specified rates per hectare using appropriate spray equipment and sufficient water to provide adequate penetration and coverage. Aim to apply even small droplet coverage over all plant surfaces. Equipment settings and water volume may need to vary, depending on the growth stage of the crop.

Special Instructions for Cotton

Thorough coverage of cotton plants is essential to achieve maximum performance from Confidor plus Pulse. Equipment should be calibrated to achieve a **minimum of 60 droplets/cm² on the target foliage**. A droplet **Volume Median Diameter (VMD)** for optimum performance from Confidor plus Pulse is dependent on equipment and is defined below. Do not apply when unfavourable environmental conditions may reduce the quality of spray coverage.

Ground Application (Cotton)

Application using ground equipment should be made using **hollow cone nozzles** with a **minimum spray volume of 100 L/ha**. Hollow cone nozzles are recommended but if flat fan nozzles are used, higher water volumes will be required and nozzles should be configured to ensure thorough coverage. A droplet **VMD of 150 - 180 microns** must be used. Where multiple nozzles per row are used, they should be of the same specification to ensure that each nozzle contributes an equal proportion of the required dose. Where multiple nozzles per row are used (particularly for banded applications) ensure the correct nozzle overlap pattern is achieved on the target foliage. **Banded applications less than 100% are not recommended beyond the 15 node crop stage.**

Bayer CropScience

Figure 3. Sample pesticide label (courtesy of Bayer CropScience Pty Ltd)

Confidor 200 SC

Aerial Application (Cotton)
Apply in a **minimum spray volume of 25 L/ha**. A droplet **VMD of 120 - 150 microns** must be used. Do not exaggerate swath width or exceed a swath width of 20 to 22 m. Do not apply Confidor plus Pulse using Ultra Low Volume (ULV) methods. The use of large droplet placement equipment is not recommended.

Special Instructions for Stone Fruit
Dilute Spraying
- Use a sprayer designed to apply high volumes of water up to the point of run-off and matched to the crop being sprayed.
- Set up and operate the sprayer to achieve even coverage throughout the crop canopy. Apply sufficient water to cover the crop to the point of run-off. Avoid excessive run-off.
- The required water volume may be determined by applying different test volumes, using different settings on the sprayer, from industry guidelines or expert advice.
- Add the amount of product specified in the Directions for Use table for each 100 L of water. Spray to the point of run-off.
- The required dilute spray volume will change and the sprayer set up and operation may also need to be changed, as the crop grows.

Concentrate Spraying
- Use a sprayer designed and set up for concentrate spraying (that is a sprayer which applies water volumes less than those required to reach the point of run-off) and matched to the crop being sprayed.
- Set up and operate the sprayer to achieve even coverage throughout the crop canopy using your chosen water volume.
- Determine an appropriate dilute spray volume (See Dilute Spraying above) for the crop canopy. This is needed to calculate the concentrate mixing rate.
- The mixing rate for concentrate spraying can then be calculated in the following way:
  EXAMPLE ONLY
  1. Dilute spray volume as determined above: For example 1500 L/ha
  2. Your chosen concentrate spray volume: For example 500 L/ha
  3. The concentration factor in this example is: 3 X (ie 1500 L ÷ 500 L = 3)
  4. As the dilute label rate is 25 mL/100 L for stone fruit, then the concentrate rate becomes 3 x 25, that is 75 mL/100 L of concentrate spray.
- The chosen spray volume, amount of product per 100 L of water, and the sprayer set up and operation may need to be changed as the crop grows.
- Do not use a concentrate rate higher than that specified in the Critical Comments.
- For further information on concentrate spraying, users are advised to consult relevant industry guidelines, undertake appropriate competency training and follow industry Best Practices.

Seedling drench application (brassicas and lettuce)
Ensure even application
Deliver the target rate of Confidor to seedling trays, ensuring uniform distribution of Confidor to each transplant cell. This may be achieved by a single (full rate) or consecutive, multiple (part rate) passes of the application mechanism. Confidor should be applied through dedicated nursery equipment e.g. a hydraulic boom or other suitable equipment which has been carefully set up and calibrated to ensure uniform distribution. **DO NOT use watering cans, hand wands, impact sprinklers and other imprecise means of application.**

Avoid run-through from cells
Applied spray volume must be related to the cell media moisture content and cell capacity, to ensure that there is virtually no loss of applied spray as run-through from cell trays during or following the Confidor application.

Prevent spray drift from treatment area
Spray application should be in an enclosed area, or for example, with an adequately shrouded spray boom, to ensure there is no opportunity for spray drift from the treatment site.

Minimise and capture excess spray
The quantity of excess spray, i.e. applied spray mixture which is not confined in the cell medium, must be minimised by appropriate application equipment set-up. Excess spray includes applied spray which misses the target, runs-off or inadvertently runs-through the cells. Any such excess must be captured and should be filtered and returned to the spray tank or stored for collection by a licensed waste treatment service provider.

Avoid losses from watering after treatment
Avoid watering seedlings after application. If watering is necessary it must be done sparingly. **DO NOT allow run-through from the cells.**

Schedule treatment to minimise time interval to planting
Seedling damage may result from Confidor seedling drench treatment, particularly if transplanting does not occur soon after treatment. It is recommended that transplanting occur within 24 hours of treatment, therefore application should be scheduled accordingly, close to the time of seedling dispatch.

Bayer CropScience

Confidor 200 SC

Compatibility
Confidor 200 SC is compatible with Antracol®, Baycor®, Nitofol®. Do not mix concentrates together but add each to the spray tank separately. As formulations of other manufacturers' products are beyond the control of Bayer CropScience, all mixtures should be tested prior to mixing commercial quantities. As changes in climatic conditions can alter the sensitivity of plants to mixtures of sprays, Bayer CropScience cannot be responsible for the behaviour of such mixtures.

Export of Treated Produce
Growers should note that MRLs or import tolerances do not exist in all markets for edible produce treated with Confidor. If you are growing edible produce for export, please check with Bayer CropScience for the latest information on MRLs and import tolerances before using Confidor.

Note on Ornamentals
Confidor 200 SC Insecticide has been used on a wide range of ornamental plant species without damage. However, some species and varieties are particularly sensitive to chemical sprays and as this is often related to local conditions it is advisable to treat only a small number of plants first, in order to ascertain their reaction before treating the whole crop.

PRECAUTIONS
Seedling drench application:
At the nursery - gloves should be worn when handling treated seedling trays or seedlings. Cotton overalls buttoned to the neck and wrist (or equivalent clothing) should also be worn, particularly if seedlings and/or trays are still wet following treatment.
On farm including during planting - gloves should be worn when handling treated seedling trays or seedlings.

PROTECTION OF LIVESTOCK
Dangerous to bees. DO NOT spray any plants in flower if bees may forage on treated flowers.
DO NOT graze any treated area, or cut for stock food.
DO NOT feed produce harvested from treated area to animals, including poultry.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT
DO NOT contaminate streams, rivers or waterways with the chemical or used containers. Imidacloprid is toxic to certain aquatic species.
Aerial application: A spraydrift minimisation strategy should be employed at all times when aerially applying sprays. The strategy envisaged is exemplified by the cotton industry's Best Management Practices Manual.
Seedling drench application: DO NOT allow run-off from treatment areas to enter drains and waterways.

STORAGE AND DISPOSAL
Store in the closed, original container in a cool, well ventilated area. Do not store for prolonged periods in direct sunlight.
1 litre pack
Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. DO NOT dispose of undiluted chemicals on-site. Dispose of container at an approved waste management facility. If an approved facility is not available bury the empty packaging 500 mm below the surface in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable vegetation and tree roots, in compliance with relevant Local, State or Territory government regulations. Empty containers and product must not be burnt. Do not re-use empty container for any other purpose.
10 litre pack
Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. DO NOT dispose of undiluted chemicals on site. If recycling, replace cap and return clean containers to recycler or designated collection point. If not recycling, triple rinse, break, crush or puncture and deliver empty packaging for appropriate disposal at an approved waste management facility. If an approved waste management facility is not available bury the empty packaging 500 mm below the surface in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable vegetation and tree roots, in compliance with relevant Local, State or Territory government regulations. Empty containers and product must not be burnt. Do not re-use empty container for any other purpose.

SAFETY DIRECTIONS
Harmful if swallowed. May irritate the eyes and skin. Repeated exposure may cause allergic disorders. Avoid contact with eyes and skin. When preparing product for use, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), a washable hat, elbow-length chemical resistant gloves and goggles. Wash hands after use. After each day's use, wash gloves, goggles and contaminated clothing.

FIRST AID
If poisoning occurs contact a doctor or Poisons Information Centre (telephone 13 11 26).

MATERIAL SAFETY DATA SHEET
Additional information is listed in the Material Safety Data Sheet, which can be obtained from www.bayercropscience.com.au.

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Confidor 200 SC

EXCLUSION OF LIABILITY
This product must be used strictly as directed, and in accordance with all instructions appearing on the label and in other reference material. So far as it is lawfully able to do so, Bayer CropScience Pty Ltd accepts no liability or responsibility for loss or damage arising from failure to follow such directions and instructions.

APVMA Approval No.: 50548/50935

Confidor®, Antracol®, Baycor® and Nitofol® are Registered Trademarks of Bayer

FOR 24 HOUR SPECIALIST ADVICE
IN EMERGENCY ONLY
PHONE 1800 033 111

DIRECTIONS FOR USE

FOLIAR SPRAY APPLICATIONS

CROP	PEST	RATE	WHP	CRITICAL COMMENTS
Cotton	Aphids	250 mL/ha + Pulse Penetrant at 0.2% v/v (2 mL/L water) or equivalent organosilicone surfactant* (eg Freeway Gold) * Check with Bayer CropScience for recommended organosilicone surfactants	13 weeks	The addition of Pulse Penetrant or equivalent is critical for the performance of Confidor. Apply early in the establishment of an aphid infestation when numbers are low (ie no more than 1 or 2 leaves per plant with honeydew present). Applications made later than this **may** result in reduced control. Shorter residual control may be evident and a repeat application of a registered aphicide (follow the Cotton Insecticide Resistance Management Strategy for cotton aphid) may be required to achieve complete control: • if applications of Confidor plus Pulse or equivalent are timed too late (see above); or • if existing high density aphid colonies (hotspots) are present; or • if aphids have established throughout the plant canopy (especially lower in the canopy); or • if there is high reinfestation pressure; or • if there is rapid crop growth; or • if Confidor plus Pulse or equivalent is used following a spray-failure (eg resistance to organophosphate or carbamate insecticides). Note: Where resistance to carbamates or organophosphates is suspected, Confidor plus Pulse or equivalent should be used first so as not to delay control of the aphids present. Aphids treated with Confidor plus Pulse or equivalent may still be present on the plant but will not be feeding. Control of aphids should initially be assessed by a reduction in fresh honeydew and not on the presence of aphids on the plant. After ingesting Confidor, aphids may take up to 5 days to die.
	Mirids, brown flea beetle			Apply when pest numbers reach treatment threshold levels as determined by field checks.
Stone fruit	Green peach aphid, black peach aphid	**Dilute spraying** 25 mL/100 L **Concentrate spraying** Refer to the Application section	21 days	Apply at first sign of aphid infestation. Apply as a full cover spray, ensuring thorough coverage. Apply by dilute or concentrate spraying equipment. Apply the same total amount of product to the target crop whether applying this product by dilute or concentrate spraying methods. Do not use in equipment that requires rates greater than 125 mL/100 L of water (i.e. greater than 5 X concentrate).
Cucurbits	Green peach aphid	25 mL/100 L or 300 mL/ha	1 day	Apply at first sign of aphid infestation.
Capsicum, eggplant potato			7 days	
Tomato			3 days	
Brassicas	Grey cabbage aphid, turnip aphid		7 days	Apply at first sign of aphid infestation. Add a wetting agent.
Sweet potato	Silverleaf whitefly, including type B	25 mL/100 L or 250 mL/ha	7 days	Apply at first sign of whitefly or melon thrips infestation. Apply dilute sprays (25 mL/100 L) to run off. Ensure thorough coverage of underside of leaves. Use of droppers will improve coverage of underside of leaves.
Cucumber			1 day	
Eggplant	Melon thrips		7 days	

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Confidor 200 SC

FOLIAR SPRAY APPLICATIONS (continued)

CROP	PEST	RATE	WHP	CRITICAL COMMENTS
Roses	Aphids	25 mL/100 L	_	Apply as a thorough cover spray at first sign of insect infestation.
Ornamental plants	Aphids, azalea lace bug, bronze orange bug, citrus mealybug, Fullers rose weevil, greenhouse thrips, harlequin bug, silverleaf whitefly (suppression)			
	Hibiscus flower beetle	50 mL/100 L		Spray buds and flowers as needed.
	Longtailed mealybug	50 mL/100 L + surfactant		Apply 3 sprays 2 weeks apart. Use a non-ionic surfactant at label rate.
	Psyllids	25 mL/100 L		Spray at first sign and then a week later.
	Soft scales	25 mL/100 L		Spray in late spring or when small scales are first seen. Apply 3 sprays 2 weeks apart. Add a wetting agent.
Duboisia	Green peach aphid	25 mL/100 L		Apply when aphid numbers reach spray threshold levels as determined by regular monitoring. Ensure thorough coverage of all leaves.
Pandanus trees	Flatid (*Jamella australiae*)	**Spot spray** 875 mL/100 L of water **Stem injection** 1.75 L/1 L of water		**Spot spray:** Spray 100 mL of mixture directly into the leafy throat of each head. **Stem injection:** Drill holes 0.5 to 1 cm in diameter and 10 cm deep at an angle of 30° 1 to 1.5 m above ground level. Drill one hole per limb (or trunk in single trunked trees). Apply 5 mL of mixture in each hole and seal the hole. Do not reapply in the same holes. Uptake of Confidor, and therefore control of the pest in heavily infested heads already showing severe damage, will be slow and may be incomplete.

SOIL APPLICATIONS

CROP	PEST	RATE	WHP	CRITICAL COMMENTS
Apples	Woolly aphid	**Chemical control** 6 mL/1 L of water/tree **Beneficial insect plus chemical control** (eg *Aphelinus mali* plus Confidor) 3 mL/1 L of water/tree	-	For trees up to 7 years of age. During late summer or autumn, apple trees with woolly aphid colonies or damage should be identified and marked for treatment the following season. At green tip to petal fall, apply 1 litre of the prepared Confidor mixture to moist soil immediately around the base of the tree trunk. Ensure the mixture infiltrates the soil around the trunk and does not run off the soil. Control weeds before application. Do not disturb or remove the soil around the trunk during the season. If aerial colonies are present at application, maximum effectiveness may not be achieved until the following season. **Do not treat more than once in any 2 year period.**
Azaleas in pots	Azalea lace bug	3.5 mL/250 mL water/pot	-	Use as a soil drench for pots up to 20 L capacity. Prior to application remove mulch and dead vegetation, and moisten the soil surface. Apply the Confidor mixture, and then water it in well immediately after application.
Elm	Elm leaf beetle	7 mL/25 mm of tree diameter at breast height	-	Mix the required dose in sufficient water to adequately treat each tree. Use at least 50 L of mix per tree up to a tree diameter of 400-500 mm and then 100 L per tree for larger trees. Inject mix to a depth of 20-30 cm in a minimum of 4 injection sites per tree, 0.75 to 1.5 m apart, arranged in an evenly spaced grid to just beyond the drip line. Ensure root zone is adequately moist with active root growth. Keep treated area moist for 7-10 days after treatment. Treat at least 6-10 weeks prior to pest attack in late winter or early spring when roots are active. DO NOT treat if soil is waterlogged.
Ornamentals in pots	Scarab beetle larvae	3.5 mL/5 L water	-	Use as a soil drench. 5 L of mixture will treat twenty 6 L pots. Prior to application remove mulch and dead vegetation, and moisten the soil surface. Apply the Confidor mixture, and then water it in well immediately after application.
Roses	Aphids	3.5 mL/2 L water/plant	-	Use as a soil drench by pouring mixture evenly around drip zone. Use this rate for plants up to 1 m high. For each additional metre of plant height, add 2 mL extra of Confidor to the 2 L of water. Prior to application remove mulch and dead vegetation, and moisten the soil surface. Apply the Confidor mixture, and then water it in well immediately after application.

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Figure 3. Sample pesticide label (courtesy of Bayer CropScience Pty Ltd) (*continued*)

SEEDLING DRENCH APPLICATIONS
Restraint:
DO NOT transplant seedlings treated by seedling drench into hydroponic production systems.

CROP	PEST	RATE	WHP	CRITICAL COMMENTS
Brassicas (broccoli, Brussels sprouts, cabbage, cauliflower, kohlrabi)	Silverleaf whitefly, including type B	**Seedling drench** 40 mL/1000 seedlings	-	**BRASSICAS ONLY** **Green peach aphid, onion thrips:** When Confidor is used for the control of silverleaf whitefly, including type B, control of green peach aphid and onion thrips will also be achieved. **Seedling drench (prior to transplanting)** Apply to the transplant cell, once only, prior to transplanting. For applications specifically against green peach aphid and onion thrips, select the rate taking into account the likely crop type, crop growing period, the anticipated degree of pest infestation and previous field experience (e.g. consideration of crop variety, time of year, predator activity, soil type). Refer to **Additional Critical Comments – all crops** below for further advice. **LETTUCE, CHICORY, ENDIVE, RADICCHIO ONLY** **Seedling drench (prior to transplanting)** Apply to the transplant cell, once only, prior to transplanting. The **maximum** recommended application rate per 1000 seedlings will depend on the proposed field planting density, as shown in the **RATE** column. **Planting densities up to 70,000 plants per hectare** In the **RATE** column, identify the desired planting density and the corresponding recommended rate range. Select the rate taking into account the likely crop growing period, the anticipated degree of pest infestation and previous field experience (e.g. consideration of lettuce type, variety, time of year, predator activity, soil type). The lower rate will usually be adequate for crops with a short growing period (e.g. less than 6-7 weeks), while the higher rate will be necessary for most situations where conditions are highly favourable for aphid infestation and for longer crop growing periods (e.g. greater than 6-7 weeks). The lower rate may also be appropriate where control from the Confidor application is not required for the entire crop growing period and where insecticides with alternative modes of action will be used as part of a broader lettuce aphid management strategy during latter stages of crop development. Refer to **Additional Critical Comments – all crops** below for further advice. **Planting densities from 70,000 to 110,000 and 110,000 to 150,000 plants per hectare** In the **RATE** column, identify the desired planting density and the corresponding recommended rate range. Select the rate taking into account the likely crop growing period, the anticipated degree of pest infestation and previous field experience (e.g. consideration of lettuce type, variety, time of year, predator activity, soil type). The lower rate will be suitable where a short duration of control is required, while a higher rate will generally provide an increased length of control. *Critical Comments continued next page*
	Green peach aphid, onion thrips	**Seedling drench** 20-40 mL/1000 seedlings		
Lettuce (head lettuce)	Currant-lettuce aphid	**Planting densities up to 70,000 plants/ha** 35-55 mL/1000 seedlings applied as a seedling drench	6 weeks	
Lettuce (excluding head lettuce), chicory, endive, radicchio		**Planting densities from 70,000 to 110,000 plants/ha** 12.5-35 mL/1000 seedlings applied as a seedling drench	4 weeks	
		Planting densities from 110,000 to 150,000 plants/ha 12.5-25 mL/1000 seedlings applied as a seedling drench		
		Planting densities from 150,000 to 300,000 plants/ha 12.5 mL/1000 seedlings applied as a seedling drench		

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CROP	PEST	RATE	WHP	CRITICAL COMMENTS
Continued from previous page				*Continued*
				However these rates may not provide control of currant lettuce aphid for the entire crop growing period. Monitor crops and if required use insecticides with alternative modes of action as part of a broader lettuce aphid management strategy during latter stages of crop development. Refer to **Additional Critical Comments – all crops** below for further advice. **Planting densities from 150,000 up to 300,000 plants per hectare** In the **RATE** column, identify the desired planting density and the corresponding recommended rate. This rate may not provide control of currant lettuce aphid for the entire crop growing period. Monitor crops and if required use insecticides with alternative modes of action as part of a broader lettuce aphid management strategy during latter stages of crop development. Refer to **Additional Critical Comments – all crops** below for further advice. **Additional Critical Comments – all crops** Confidor provides effective management of pest populations. However, Confidor may not provide complete control of pests for the entire growing period in all situations. Crops should be monitored for pests following transplanting and throughout the life of the crop. If pests are observed in the crop additional chemical control may be required, in which case an insecticide with a different mode of action should be used. Refer to **GENERAL INSTRUCTIONS** for **Resistance Management Strategy** information. Refer to **GENERAL INSTRUCTIONS** for **Seedling Drench Application** directions and **PRECAUTIONS** when handling treated seedlings. Seedling damage may result from Confidor seedling drench treatment particularly if transplanting does not occur soon after treatment. It is recommended that transplanting occur within 24 hours of treatment and that planted seedlings receive sufficient irrigation (preferably using overhead sprinklers) as soon as possible after transplanting to further minimise the risk of seedling damage. This may be particularly relevant under conditions of rapid drying of the transplant cell medium. If watering is required between applications and planting, it should be done sparingly, only as required. **DO NOT allow run-through from the cells**. When transplanting treated seedlings ensure that the growing medium is fully transferred to the field with each seedling. Seedling production nurseries supplying Confidor treated seedlings must ensure that; a) Supplied batches of seedlings are clearly identified as having been treated with Confidor 200 SC Insecticide. b) Paperwork accompanying the seedlings and provided to the recipient indicates the rate of Confidor applied per 1000 seedlings, and the time and date of treatment. c) Growers accepting delivery of treated seedlings have obtained a copy of *Confidor 200 SC seedling drench – instructions for growers*, available from Bayer CropScience (1800 804 479 or www.bayercropscience.com.au)

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION

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WITHHOLDING PERIODS
Foliar spray applications
Harvest:
Cucurbits: DO NOT HARVEST FOR 1 DAY AFTER APPLICATION
Tomatoes: DO NOT HARVEST FOR 3 DAYS AFTER APPLICATION
Brassicas, capsicum, eggplant, potatoes, sweet potatoes: DO NOT HARVEST FOR 7 DAYS AFTER APPLICATION
Stone fruit: DO NOT HARVEST FOR 21 DAYS AFTER APPLICATION
Cotton: DO NOT HARVEST FOR 13 WEEKS AFTER APPLICATION

Soil or seedling drench applications
Harvest:
Apples: NOT REQUIRED WHEN USED AS DIRECTED
Brassicas: NOT REQUIRED WHEN USED AS DIRECTED
Chicory, endive, lettuce (excluding head lettuce) and radicchio: DO NOT HARVEST FOR 4 WEEKS AFTER APPLICATION
Head lettuce: DO NOT HARVEST FOR 6 WEEKS AFTER APPLICATION

All applications
Grazing:
DO NOT GRAZE ANY TREATED AREA, OR CUT FOR STOCK FOOD.
DO NOT FEED PRODUCE HARVESTED FROM TREATED AREA TO ANIMALS, INCLUDING POULTRY.

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Figure 3. Sample pesticide label (courtesy of Bayer CropScience Pty Ltd) (*continued*)

Safety data sheet (SDS)

Previously referred to as an MSDS or Material Safety Data Sheet, a Safety Data Sheet (SDS) contains more detailed information about the nature of the product and how to respond if there is an emergency. An example of an SDS is provided in figure 4.

Information in the SDS includes:

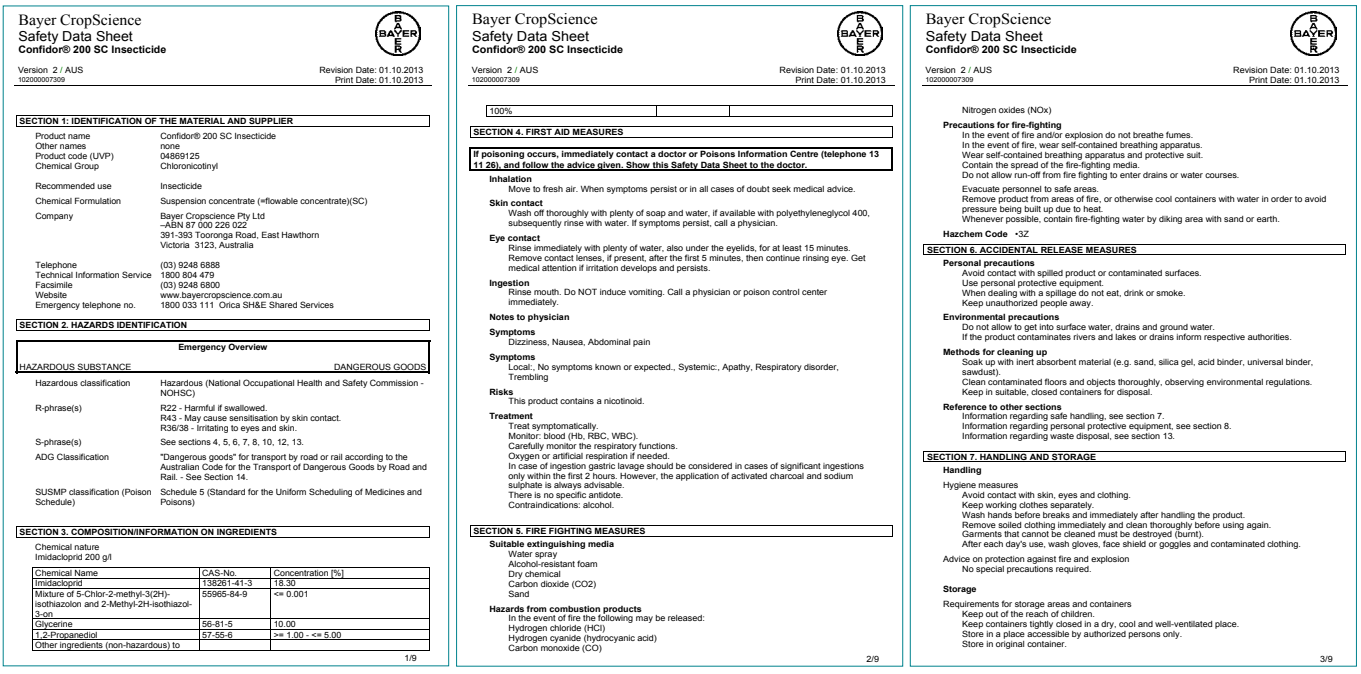
- identification details (e.g. product name and physical description/properties)
- health hazards (e.g. health effects and first aid)
- precautions for use (e.g. personal protection and flammability)
- safe handling information (e.g. storage and transport)
- information on toxicity
- information on ecological effects.

A product's SDS is available on request at the point of sale and is also downloadable from the manufacturer's website. A current SDS for each product should be made available for users. The SDS is reviewed by Safe Work Australia as part of the chemical registration process and provides useful additional information if an emergency occurs.

For an SDS to be useful three things need to happen:

1. The SDS should be read and understood before an emergency.
2. The SDS must refer to the actual pesticide formulation being used.
3. The SDS must be current and easily available to the applicator.

An SDS for each product being stored or used should be available for staff to read and copies kept in or adjacent to the pesticide storage area.



Bayer CropScience
Safety Data Sheet
Confidor® 200 SC Insecticide

Version 2 / AUS
102000007309
Revision Date: 01.10.2013
Print Date: 01.10.2013

SECTION 1: IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Product name	Confidor® 200 SC Insecticide
Other names	none
Product code (UVP)	04869125
Chemical Group	Chloronicotinyl
Recommended use	Insecticide
Chemical Formulation	Suspension concentrate (=flowable concentrate)(SC)
Company	Bayer Cropscience Pty Ltd -ABN 87 000 226 022 391-393 Tooronga Road, East Hawthorn Victoria 3123, Australia
Telephone	(03) 9248 6888
Technical Information Service	1800 804 479
Facsimile	(03) 9248 6800
Website	www.bayercropscience.com.au
Emergency telephone no.	1800 033 111 Orica SH&E Shared Services

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

HAZARDOUS SUBSTANCE DANGEROUS GOODS

Hazardous classification	Hazardous (National Occupational Health and Safety Commission - NOHSC)
R-phrase(s)	R22 - Harmful if swallowed. R43 - May cause sensitisation by skin contact. R36/38 - Irritating to eyes and skin.
S-phrase(s)	See sections 4, 5, 6, 7, 8, 10, 12, 13.
ADG Classification	"Dangerous goods" for transport by road or rail according to the Australian Code for the Transport of Dangerous Goods by Road and Rail. - See Section 14.
SUSMP classification (Poison Schedule)	Schedule 5 (Standard for the Uniform Scheduling of Medicines and Poisons)

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical nature
Imidacloprid 200 g/l

Chemical Name	CAS-No.	Concentration [%]
Imidacloprid	138261-41-3	18.30
Mixture of 5-Chlor-2-methyl-3(2H)-isothiazolon and 2-Methyl-2H-isothiazol-3-on	55965-84-9	<= 0.001
Glycerine	56-81-5	10.00
1,2-Propanediol	57-55-6	>= 1.00 - <= 5.00
Other ingredients (non-hazardous) to		100%

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Safety Data Sheet
Confidor® 200 SC Insecticide

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SECTION 4. FIRST AID MEASURES

If poisoning occurs, immediately contact a doctor or Poisons Information Centre (telephone 13 11 26), and follow the advice given. Show this Safety Data Sheet to the doctor.

Inhalation
Move to fresh air. When symptoms persist or in all cases of doubt seek medical advice.

Skin contact
Wash off thoroughly with plenty of soap and water, if available with polyethyleneglycol 400, subsequently rinse with water. If symptoms persist, call a physician.

Eye contact
Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Get medical attention if irritation develops and persists.

Ingestion
Rinse mouth. Do NOT induce vomiting. Call a physician or poison control center immediately.

Notes to physician

Symptoms
Dizziness, Nausea, Abdominal pain

Symptoms
Local:, No symptoms known or expected., Systemic:, Apathy, Respiratory disorder, Trembling

Risks
This product contains a nicotinoid.

Treatment
Treat symptomatically.
Monitor: blood (Hb, RBC, WBC).
Carefully monitor the respiratory functions.
Oxygen or artificial respiration if needed.
In case of ingestion gastric lavage should be considered in cases of significant ingestions only within the first 2 hours. However, the application of activated charcoal and sodium sulphate is always advisable.
There is no specific antidote.
Contraindications: alcohol.

SECTION 5. FIRE FIGHTING MEASURES

Suitable extinguishing media
Water spray
Alcohol-resistant foam
Dry chemical
Carbon dioxide (CO2)
Sand

Hazards from combustion products
In the event of fire the following may be released:
Hydrogen chloride (HCl)
Hydrogen cyanide (hydrocyanic acid)
Carbon monoxide (CO)

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Nitrogen oxides (NOx)

Precautions for fire-fighting
In the event of fire and/or explosion do not breathe fumes.
In the event of fire, wear self-contained breathing apparatus.
Wear self-contained breathing apparatus and protective suit.
Contain the spread of the fire-fighting media.
Do not allow run-off from fire fighting to enter drains or water courses.

Evacuate personnel to safe areas.
Remove product from areas of fire, or otherwise cool containers with water in order to avoid pressure being built up due to heat.
Whenever possible, contain fire-fighting water by diking area with sand or earth.

Hazchem Code •3Z

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Avoid contact with spilled product or contaminated surfaces.
Use personal protective equipment.
When dealing with a spillage do not eat, drink or smoke.
Keep unauthorized people away.

Environmental precautions
Do not allow to get into surface water, drains and ground water.
If the product contaminates rivers and lakes or drains inform respective authorities.

Methods for cleaning up
Soak up with inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust).
Clean contaminated floors and objects thoroughly, observing environmental regulations.
Keep in suitable, closed containers for disposal.

Reference to other sections
Information regarding safe handling, see section 7.
Information regarding personal protective equipment, see section 8.
Information regarding waste disposal, see section 13.

SECTION 7. HANDLING AND STORAGE

Handling

Hygiene measures
Avoid contact with skin, eyes and clothing.
Keep working clothes separately.
Wash hands before breaks and immediately after handling the product.
Remove soiled clothing immediately and clean thoroughly before using again.
Garments that cannot be cleaned must be destroyed (burnt).
After each day's use, wash gloves, face shield or goggles and contaminated clothing.

Advice on protection against fire and explosion
No special precautions required.

Storage

Requirements for storage areas and containers
Keep out of the reach of children.
Keep containers tightly closed in a dry, cool and well-ventilated place.
Store in a place accessible by authorized persons only.
Store in original container.

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Figure 4. Example Safety Data Sheet (SDS) for Confidor® (courtesy of Bayer CropScience Pty Ltd)

Advice on common storage
Keep away from food, drink and animal feedingstuffs.

SECTION 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Control parameters	Update	Basis
Glycerine (Mist.)	56-81-5	10 mg/m3 (TWA)	08 2005	AU OEL
Glycerine (Inspirable dust.)	56-81-5	10 mg/m3 (TWA)	08 2005	AU OEL
1,2-Propanediol (Particulate.)	57-55-6	10 mg/m3 (TWA)	08 2005	AU OEL
1,2-Propanediol (Total vapour and particulates.)	57-55-6	474 mg/m3 / 150 ppm (TWA)	08 2005	AU OEL

For further details on the Occupational Exposure Standards, see Section 16.

Biological limit values
none

Personal protective equipment - End user

Respiratory protection: Respiratory protection is not required under anticipated circumstances of exposure.

Hand protection: Elbow-length PVC or nitrile gloves

Eye protection: Goggles

Skin and body protection: Cotton overall buttoned to the neck and wrist
Washable hat

Engineering Controls

Advice on safe handling
Use only in area provided with appropriate exhaust ventilation.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form: suspension
Colour: white to light beige
Odour: weak, characteristic

Safety data

pH: 7.0 - 8.5 at 100 % (23 °C)

Flash point: No flash point - Determination conducted up to the boiling point.

Ignition temperature: no data available

Autoignition temperature: 405 °C

Upper explosion limit: no data available

Lower explosion limit: no data available

Vapour pressure: no data available

Relative vapour density: no data available

Density: ca. 1.10 g/cm³ at 20 °C

Water solubility: miscible

Partition coefficient: n-octanol/water: no data available

Viscosity, dynamic: 400 - 800 mPa.s at 23 °C
Velocity gradient 7.5 /s

Surface tension: 48.9 mN/m

Explosivity: Not explosive
92/69/EEC, A.14 / OECD 113

Other information: Further safety related physical-chemical data are not known.

SECTION 10. STABILITY AND REACTIVITY

Conditions to avoid: Heat, flames and sparks.

Materials to avoid: Acids
Bases
Strong oxidizing agents

Hazardous Decomposition Products: Thermal decomposition can lead to release of:
Hydrogen chloride (HCl)
Hydrogen cyanide (hydrocyanic acid)
Carbon monoxide
Nitrogen oxides (NOx)

Thermal decomposition: 210 °C
Exothermic decomposition.

Thermal decomposition: The value mentioned relates to the active ingredient.

Hazardous reactions: No hazardous reactions when stored and handled according to prescribed instructions.

SECTION 11. TOXICOLOGICAL INFORMATION

Potential Health Effects

Inhalation: May be harmful if inhaled.

Skin: Irritating to skin. Repeated or prolonged skin contact may cause allergic reactions with susceptible persons.

Eye: Causes eye irritation.

Ingestion: Harmful if swallowed.

Acute oral toxicity: LD50 (rat) > 1,218 mg/kg

Acute inhalation toxicity: LC50 (rat) > 2.238 mg/l
Exposure time: 4 h
Determined in the form of a respirable aerosol.
Highest attainable concentration.

Acute dermal toxicity: LD50 (rat) > 4,000 mg/kg

Skin irritation: No skin irritation (rabbit)

Eye irritation: No eye irritation (rabbit)

Sensitisation: Non-sensitizing. (guinea pig)
OECD Test Guideline 406, Buehler test

Chronic toxicity: Imidacloprid did not cause specific target organ toxicity in experimental animal studies.

Assessment Mutagenicity
Imidacloprid was not mutagenic or genotoxic based on the overall weight of evidence in a battery of in vitro and in vivo tests.

Assessment Carcinogenicity
Imidacloprid was not carcinogenic in lifetime feeding studies in rats and mice.

Assessment toxicity to reproduction
Imidacloprid caused reproduction toxicity in a two-generation study in rats only at dose levels also toxic to the parent animals. The reproduction toxicity seen with Imidacloprid is related to parental toxicity.

Assessment developmental toxicity
Imidacloprid caused developmental toxicity only at dose levels toxic to the dams. The developmental effects seen with Imidacloprid are related to maternal toxicity.

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity effects

Toxicity to fish: LC50 (Rainbow trout (Oncorhynchus mykiss)) > 535 mg/l
Exposure time: 96 h

Toxicity to fish: LC50 (Leuciscus idus (Golden orfe)) 237 mg/l
Exposure time: 96 h
The value mentioned relates to the active ingredient imidacloprid.

Toxicity to fish: LC50 (Rainbow trout (Oncorhynchus mykiss)) 211 mg/l
Exposure time: 96 h
The value mentioned relates to the active ingredient imidacloprid.

Toxicity to fish: LC50 (Cyprinus carpio (Carp)) 280 mg/l
Exposure time: 96 h
The value mentioned relates to the active ingredient imidacloprid.

Toxicity to aquatic invertebrates: EC50 (Water flea (Daphnia magna)) > 535 mg/l
Exposure time: 24 h

Toxicity to aquatic invertebrates: EC50 (Chironomus riparius (non-biting midge)) 0.0552 mg/l
Exposure time: 24 h
The value mentioned relates to the active ingredient imidacloprid.

Toxicity to aquatic invertebrates: EC50 (Hyalella azteca) 0.055 mg/l
Exposure time: 48 h
The value mentioned relates to the active ingredient imidacloprid.

Toxicity to aquatic invertebrates: EC50 (Water flea (Daphnia magna)) 85 mg/l
Exposure time: 48 h
The value mentioned relates to the active ingredient imidacloprid.

Toxicity to aquatic plants: IC50 (Desmodesmus subspicatus) > 1,000 mg/l
Growth rate
Exposure time: 72 h

Toxicity to aquatic plants: EC50 (Pseudokirchneriella subcapitata) > 100 mg/l
Exposure time: 72 h
The value mentioned relates to the active ingredient imidacloprid.

Toxicity to bacteria: EC50 (Activated sludge) > 10,000 mg/l

The value mentioned relates to the active ingredient imidacloprid.

Toxicity to other organisms: LD50 (Coturnix japonica (Japanese quail)) 31 mg/kg
The value mentioned relates to the active ingredient imidacloprid.

Toxicity to other organisms: LD50 (Colinus virginianus (Bobwhite quail)) 152 mg/kg
The value mentioned relates to the active ingredient imidacloprid.

Toxicity to other organisms: (Apis mellifera (bees))
The value mentioned relates to the active ingredient imidacloprid.
Toxic to bees.

Additional ecological information
No other effects to be mentioned.

Additional Environmental Information: no data available

SECTION 13. DISPOSAL CONSIDERATIONS

Metal drums and plastic containers:
Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. Do not dispose of undiluted chemicals on site. If recycling, replace cap and return clean containers to recycler or designated collection point. If not recycling, break, crush or puncture and bury empty containers in a local authority landfill. If no landfill is available, bury the containers below 500 mm in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable

vegetation and tree roots. Empty containers and product should not be burnt.

SECTION 14. TRANSPORT INFORMATION

ADG

UN number	**3082**
Class	9
Subsidiary Risk	None
Packaging group	III
Description of the goods	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (IMIDACLOPRID SOLUTION)
Hazchem Code	•3Z

According to AU01, Environmentally Hazardous Substances in packagings, IBC or any other receptacle not exceeding 500 kg or 500 L are not subject to the ADG Code.

IMDG

UN number	**3082**
Class	9
Subsidiary Risk	None
Packaging group	III
EmS	F-A , S-F
Marine pollutant	YES
Description of the goods	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (IMIDACLOPRID SOLUTION)

IATA

UN number	**3082**
Class	9
Subsidiary Risk	None
Packaging group	III
Environm. Hazardous Mark	YES
Description of the goods	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (IMIDACLOPRID SOLUTION)

SECTION 15. REGULATORY INFORMATION

Registered according to the Agricultural and Veterinary Chemicals Code Act 1994

Australian Pesticides and Veterinary Medicines Authority approval number: 50548

See also Section 2.

SECTION 16. OTHER INFORMATION

Trademark information: Confidor® is a registered trademark of the Bayer Group.

This SDS summarises our best knowledge of the health and safety hazard information of the product and how to safely handle and use the product in the workplace. Each user should read this SDS and consider the information in the context of how the product will be handled and used in the workplace including in conjunction with other products.

If clarification or further information is needed to ensure that an appropriate risk assessment can be made, the user should contact this company.

Our responsibility for products sold is subject to our standard terms and conditions, a copy of which is sent to our customers and is also available on request.

Further details on the Occupational Exposure Standards mentioned in Section 8:
CEILING: Ceiling Limit Value
OES BCS: Internal Bayer CropScience "Occupational Exposure Standard"
Australia OELs (Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment)
PEAK: Exposure Standard - Peak means a maximum or peak airborne concentration of a particular substance determined over the shortest analytically practicable period of time which does not exceed 15 minutes.
STEL: Exposure standard - short term exposure limit (STEL): A 15 minute TWA exposure which should not be exceeded at any time during a working day even if the eight-hour TWA average is within the TWA exposure standard. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes between successive exposures at the STEL.
SKIN_DES: Skin notation: Absorption through the skin may be a significant source of exposure.
TWA: Exposure standard - time-weighted average (TWA): The average airborne concentration of a particular substance when calculated over a normal eight-hour working day, for a five-day working week.

Changes since the last version are highlighted in the margin. This version replaces all previous versions.

END OF SDS

Figure 4. Example Safety Data Sheet (SDS) for Confidor® (courtesy of Bayer CropScience Pty Ltd) (*continued*)

2.2 Formulations and mixing

When a pesticide is purchased, the product consists of a mixture of components designed to keep it stable until required for use. They may also assist in its ease of handling and final effectiveness. The part that affects target pests is called the 'active constituent' and the other additives are called 'inert constituents'. These may be liquid or dry but together the total mixture is a 'chemical formulation'. Exact details of formulations are commercially sensitive because they directly influence the cost of manufacture. Formulations vary significantly but, in Australia, they are expected to have a stable shelf life of at least two years.

Types of formulation

Pesticides registered for use in plant nurseries are formulated in a wide variety of ways. It is not unusual to find the same active constituent available in several different formulations, each suited to a particular use and target pest situation. Formulations will vary in the hazards associated with their use, risks to the environment, efficacy in pest management and cost. Where a choice exists, it is best to select the formulation that presents the least risk to the spray operator. The level of risk is noted as the 'signal heading' on the label's central panel (see figure 2). The properties of the active constituent will usually dictate the choice of formulation that can be used to produce a stable, consistent and marketable product.

The simplest way to classify pesticide formulations is whether they are sold as a liquid or a solid. Within each of these two main categories there are a number of different formulation types.

Liquid formulations

Liquid formulations (e.g. Supracide 400) are typically diluted in water to produce the final spray mix, although for some ultra low volume (ULV) applications they may be applied 'directly from the container'. The amount of formulation added to the sprayer is typically measured using a graduated cylinder or jug. The following are the general types of liquid formulations.

Solutions

These are true liquids, which contain the active constituent dissolved in either water (water-based aqueous concentrates) or a solvent that mixes (is miscible to form a liquid concentrate) with any water that may be added to make up a spray solution. The advantages and disadvantages of the 'carrier' solutions will depend on the solvents used, the concentration of the active constituent and the type of application equipment used.

Advantages of solutions	Disadvantages of solutions
• relatively easy to measure, handle, transport and store • need little agitation once mixed for application • being liquids, they cause minimal abrasive wear on spray equipment, especially on nozzle orifices	• the solvent system used may pose phytotoxic risks under high temperature conditions • the solvent may increase the risk of skin irritation and absorption if accidental operator exposure occurs • the solvents may cause equipment deterioration, particularly of washers and seals, which may need frequent replacement to avoid equipment leaks • some solvents employed are highly flammable and result in the product being classified as a 'dangerous good', with consequent restrictions on how it may be transported and stored

Emulsifiable concentrates (ECs)

As the name indicates, ECs contain an emulsifier in the formulation (e.g. Supracide 400®), which enables the active constituent to be dissolved in an organic solvent and then spread evenly through the carrier water when a spray solution is made up. The final spray solution is an emulsion and is usually milky white in colour.

Advantages of emulsifiable concentrates	Disadvantages of emulsifiable concentrates
• relatively easy to measure, handle, transport and store • need little agitation once mixed for application • being liquids, they cause minimal abrasive wear on spray equipment, especially on nozzle orifices	• the solvent system used may pose phytotoxic risks under high temperature conditions • the solvent may increase the risk of skin irritation and absorption if accidental exposure occurs • the solvents may cause equipment deterioration, particularly with washers and seals, which may need frequent replacement to avoid equipment leaks • some solvents employed are highly flammable and result in the product being classified as a 'dangerous good', with consequent restrictions on how it may be transported and stored

Suspension concentrates (SCs) or flowable concentrates

This type of formulation (e.g. Confidor 200 SC®) was introduced to try and overcome some of the handling problems associated with wettable powders (WPs) or solid formulations. In SCs, the active constituent is milled to a finer size than with WPs and then packed off as a suspension of fine particles within a liquid, which is then further diluted, usually with water as the carrier liquid to make up a spray mixture.

Advantages of suspension concentrates	Disadvantages of suspension concentrates
• because of the finer particle size, there is much less chance of nozzle or filter blockages than with WPs • there is no dust problem when measuring out	• the suspension may settle out in storage so packs of SCs must always be shaken vigorously before measuring out the dose required • there is a limit of about 50% in the concentration of active constituent that can be incorporated without causing stability problems in the formulation

Solid formulations

Solid formulations may range from fine powders to large granules. They typically require a balance to weigh out the correct amount to add to the spray tank. Some products may come in small pre-weighed packets that can be used as is or have special pre-calibrated mixing cylinders specifically for that formulation.

Soluble powders

As the name indicates, this type of formulation dissolves in water to form a true solution (e.g. ProGibb®).

Advantages of soluble powders	Disadvantages of soluble powders
• easy to store and transport • have lower phytotoxicity risks than ECs • can be packed in disposable packages	• must avoid breathing in the powder when measuring out doses • measuring can be difficult unless pre-packs are used

Wettable powders

WPs are designed to be dispersed in water to form a suspension, which is then applied as a spray (e.g. Dithane M-45®). Wettable powders are a convenient way of packing high concentrations of the active constituent (up to 80% of the product) in a stable condition that has commercial appeal. This advantage (to the manufacturer) is outweighed by a number of disadvantages as listed below, which have led to a decline in the popularity of WPs.

Advantages of wettable powders	Disadvantages of wettable powders
• a convenient way of packing high concentrations of the active constituent	• constant agitation in the spray vat is needed to avoid uneven dosing caused by particle settlement in the spray vat • the suspended particles are abrasive and can cause accelerated wear in nozzles and pumps • the suspended solids can block nozzles and filters, particularly if agitation in the spray tank is inadequate • many WPs require careful pre-mixing with a little water to ensure even dispersion and this process can be difficult with some alkaline bore waters • measuring out by weight can be hazardous unless pre-packs are used and then the pre-packs have to coincide with the dose required per tank of spray

Water dispersible granules

This type of formulation is a popular one as newer formulation technologies have produced micro-granules that can carry high concentrations of active constituent (acceptable with low toxicity products, e.g. Simagranz®). The actual concentration put into a particular product will depend on the toxic hazards associated with the active constituent, but concentrations of up to 900 g/kg have been achieved.

Advantages of water dispersible granules	Disadvantages of water dispersible granules
• can carry high concentrations of active constituent • avoids the problems of dust generation • has pour characteristics like a liquid to make measuring easy • fine milling of the base ingredients of the formulation prior to actual granule formation ensures no problems with blockages after dispersal takes place in the spray vat • the high concentration means that these formulations are more efficient to transport and store	• a specific order of mixing may be required when more than one product is to be included in a spray solution • specific weighing or measuring jugs may be required for each product

Other formulations

Granules

Free-flowing granular formulations have been used for many years as a means of applying pesticides to manage soil-borne pests or to apply a pesticide in remote areas that depend on rainfall for later activation. Some granules are formulated using a polymer matrix that degrades at a predictable rate, releasing small doses of active constituent over an extended period. These are known as slow or controlled release granules and they were introduced as a means of extending the period of activity for pesticides with shorter active lives. They are a replacement for the long-lasting organochlorines such as DDT and BHC, which were removed from the marketplace in 1987. Granules provide a relatively safe means of handling very toxic pesticides as the formulation involves scattering a small amount of active constituent through a much larger bulk of inert material, usually clay (e.g. SuSCon Green®).

Advantages of granules	Disadvantages of granules
• ready to use without mixing and are easy to apply • application does not involve carrying water, thus reducing soil compression and easier application in hard-to-access areas • usually have little or no dust associated with them and therefore present a low drift hazard • the application equipment needed to disperse them is relatively cheap compared with hydraulic sprayers • granules can penetrate foliage to reach the soil surface more easily than spray droplets, which can sometimes be an advantage	• more expensive than most other formulations because the amount of active constituent incorporated is at a lower concentration • may require soil incorporation or follow-up rain before becoming usefully active • may present a hazard to non-target species, especially birds • not adhering to foliage may be a disadvantage

Aerosol dispensers

These are convenient but are usually expensive. It is difficult to control placement of spray fall-out and this can pose a high risk of inhalation. The formulations often contain a flammable propellant under pressure, which represents a potential hazard if the container is punctured or incinerated (e.g. white oil).

Fumigants

These can be hazardous formulations and many have been phased out of the marketplace. They are toxic to a wide range of organisms and often do not discriminate between pests and beneficial species. They can penetrate target areas very efficiently and usually only involve a single application. Fumigants are extremely hazardous to use and most require special training in safe handling, particularly in regard to the use of appropriate protective equipment. Confining fumigating gases to the desired area of action can sometimes cause problems (e.g. methyl bromide or chloropicrin).

Water soluble crystals

This formulation type is being used for 2, 4-D based products packed in water soluble plastic packaging. These are simply dropped into the spray vat to dissolve in the carrier and form the spray solution. The user is not exposed to the pesticide at any time, increasing the safety of the operation.

Microcapsules

An alternative version of the *Bacillus thuringiensis* var. kurstaki toxin Cry1A produced in the cells of genetically modified *Pseudomonas fluorescens*, which die in such a way that they constitute a rigid capsule for the enclosed insecticidal protein. This is claimed to improve protection from UV radiation.

Water quality

The pH of the water used as a carrier for a pesticide is often overlooked when considering the factors that affect the performance of a pesticide. Some pesticides are susceptible to decomposition (or hydrolysis) in acidic or alkaline water. This can have a noticeable effect on the degree of pest control obtained because a certain amount of pesticide will have decomposed before it is actually used. The longer a spray mix is allowed to stand before use, the greater the decomposition of the active constituent. The carrier water pH has the ability to reduce the effectiveness of some pesticides in less time than it takes to spray out the tank mix!

Generally, pesticides are most stable within a pH range of 4.5–7.0, the optimum being pH 5.0–6.0. Some pesticides are not affected by pH and are stable over a pH wide range. Usually, decomposition is more rapid with increasing alkalinity. Insecticides, especially organophosphates, carbamates and synthetic

pyrethroids, are generally more severely affected by alkaline water than fungicides or herbicides. Some pesticides are incompatible with alkaline materials such as lime, sulphur, calcium chloride and bordeaux mixtures, to name a few. If there is any doubt about the compatibility of certain pesticides, consult the product label.

In some cases, a minor change in the pH can significantly affect the performance of a pesticide. Carbaryl, for example, is a common insecticide used in the nursery industry and it is stable in water at pH 5.0. But in water with pH 7.0, carbaryl decomposes by 50 per cent (also known as a half-life) in 30 days, and at pH 9.0, decomposes 50 per cent in only 24 hours, cutting its effectiveness greatly. To increase pesticide effectiveness, users can follow the following recommendations:

- Do not store and reuse mixed pesticides. Mix and use for each individual job.
- Always read the pesticide label to determine if there are any recommendations for addressing carrier water pH.
- Source information from technical bulletins on products or toll-free numbers that are listed on the product labels.
- Companies that supply buffering agents are also very good sources of information on pesticide stability and products that should be used in specific situations.

Adjuvants

Adjuvants are substances added to a formulation or spray mix for the purpose of improving its performance or stability.

There are many different types of adjuvants, including drift retardants, sequestering agents, synergists, buffers and surfactants. 'Surfactant' is a general term used to describe surface active agents, which includes adjuvants such as wetting agents, stickers and anti-foaming agents. Some drift retardants may also be considered surfactants.

Wetting agents

These are sometimes called spreaders or wetters and are sometimes included in a formulation, but in many cases there is a label direction to add a certain quantity of a wetting agent to the spray solution, dependent on the volume being applied. Wetting agents are designed to lower the surface tension of the liquid being applied so that instead of resting as a number of individual droplets on the surfaces targeted, it spreads as an even film with a much larger area of contact. When adding a wetting agent to a pesticide, it is important to always select a non-ionic wetter unless other types of wetters (cationic or anionic) are recommended on the pesticide label. Certain spray oils are registered for use in spray mixes. Care should be taken to follow label directions and to avoid problems with phytotoxicity by not applying pesticides in the heat of the day or in full sun.

> ***Always consult the registered label for advice and recommendations about the use of spray additives.***

Synergists

These are chemicals added to a formulation to enhance the performance of the active constituent although alone they have little or no activity. Examples include piperonyl butoxide added to some pyrethroid insecticides to improve knock-down of flying insects and ammonium thiocyanate added to amitrol-based herbicides to improve uptake and weed kill.

Buffers

These are chemicals that can alter and maintain the pH of carrier water at a different level to its normal pH. Some chemicals perform more consistently under slightly acidic conditions and in many places the local water supply is a little alkaline. Acidifying buffers have the ability to lower the pH, which would be an advantage with certain organophosphates, and assist in reducing antagonism when making up mixtures with glyphosate (e.g. Roundup®).

Sequestering agents

These are used in some formulations to overcome the problems caused by hard water containing excessive amounts of calcium and magnesium salts. In a number of phenoxy herbicide formulations, ethylenediaminetetraacetic acid (EDTA) is added as it combines preferentially with the calcium and magnesium present in hard water to form soluble salts. This prevents any 2,4-D acid reactions, which would produce insoluble (solid) salts that would fall out of solution.

Stickers

These help increase the rain-fastness of a spray application, reducing the need for a repeat spray, and are often used as additives to protectant fungicide sprays specifically applied before rainfall events.

Anti-foaming agents

These can save time when recharging spray vats with high pressure water. Excess foam production can occur due to traces of wetting agent left from the previous vat load.

2.3 Transport

Some nursery chemicals are classified as dangerous goods (DG), which means they are subject to the Australian Dangerous Goods Code (available at *www.ntc.gov.au/filemedia/Publications/ADG7October2011.pdf-* Cited September 2013). With most DG products compliance with the Code does not become a legal obligation until the loads exceed 1 t, but with some products the amount can be as low as 250 kg or L. Compliance involves appropriate documentation, defined responsibilities and vehicle placarding.

If a vehicle is used regularly to transport pesticides it should contain an emergency kit of appropriate PPE, a dry powder fire extinguisher, a shovel, a broom and a bag of neutralising agent, such as hydrated lime.

Loading

- Nursery chemicals should never be transported in the same cabin space as people, pets and food. "Ute it. Don't boot it."
- Always check the chemical containers for corrosion and leaks.
- Check containers have complete labels.
- Distribute the load evenly and secure it to prevent movement.
- Do not leave vehicles carrying chemicals unattended.

Unloading

- Check the load is complete.
- Immediately clean up any spillage that may have occurred in-transit.

2.4 Storage of nursery chemicals

Chemicals should normally be obtained shortly before expected use. This will keep the stocks held at a nursery to a minimum and make secure, safe storage a straightforward task.

Storage and handling of containers of pesticide requires particular care and attention. This is an essential part of a safety audit.

Characteristics of a storage facility[2]

The storage area should be:

- located a minimum of 10 m from any dwelling and 15 m from the property boundary
- free of any flood threat or water damage
- clear of vegetation for 3 m around the facility
- constructed of fire-resistant materials
- have a sealed floor that is bunded to contain any spillage
- well ventilated and cool
- kept locked and secure
- placarded to make known its contents.

A storage area should have:

- a reliable water reservoir of clean water for washing and decontamination
- an available emergency shower, preferably fed from a separate storage tank
- the necessary equipment on hand in case of a fire, spill or accidental poisoning
- stock kept off the floor
- the stock grouped by chemical, type or dangerous good (ADG) classifications
- the stock rotated so that unused material is not accumulated
- space available to store empty containers, prior to disposal.

[2] *ChemCert Australia, Chemical Users Handbook, 2013.*

A storage and handling facility that has been well designed has four components:

1. A storage cabinet or room

The storage cabinet or room should be located in an area that isolates chemical fumes and dust (i.e. from any personnel), with good ventilation. Many storage lockers are available with good ventilation. Pesticides should be stored at temperatures of 5–35°C.

> ***Custom-built storage sheds with excellent ventilation, built in showers etc. are available from several manufacturers.***

2. A mixing area

The mixing area should contain a work surface and appropriate measuring equipment. A water supply and sink are needed for chemical preparations and clean up. A fume hood may be installed over the mixing table to remove fumes away from workers.

3. A place to store equipment and records

A separate area or room is recommended for storing protective clothing, equipment, records and SDS sheets.

4. An area for loading and rinsing spray equipment

The loading area can be part of the mixing area or it can be separate. It should be large enough to hold the largest sprayer. The purpose of this area is to collect spills while loading and emptying and to provide an area for washing down the sprayers after use. A drench shower and eye wash should be located nearby (Bartok, 1996).

All rinsate and pesticide residues from wash facilities (e.g. basins and shower) must be prevented from contaminating storm water drains, creeks and streams, the ground etc. Collect all rinsate and wash-down water and dispose of appropriately (refer to Section 2.6 on disposal).

2.5 Personal protective equipment (PPE)

Pesticides are often toxic to mammals and each product has been evaluated in terms of the risk posed to humans. This information is found on the SDS for each product and the recommendations for handling it appear by law on the label of each registered pesticide. Read both of these documents before choosing suitable personal protective equipment for the mixing and application of pesticides. Employers are responsible for the protection of their employees. The employer has a legal duty of care to ensure that workers know how to use personal protective equipment properly. It is important to identify the potential hazards and protect against them.

Modes of pesticide contamination

Pesticides present different risks of poisoning depending on the active chemistry and the carrier. There are several pathways by which pesticides may come in contact with humans—respiratory (by breathing in), dermal (through the skin), ingestion (via the mouth) and insinuative (through puncture or injection).

Each product poses different levels of risk for each pathway and so planning protection will require consideration of the risk posed by every pesticide that will be used. Each product's SDS contains information on the risk posed by each mode of contamination. Different risks may also be posed by various methods of application and these should be identified by carrying out a risk assessment.

Respiratory exposure and protection[3]

Contaminants can be breathed in through mouth or nose and are absorbed into tissues via the lungs. Respiratory hazards take the form of:

Particulates

- dusts—solid particles moved by air
- mists—liquid droplets suspended in air
- fumes—thermally generated particles.

Gases and vapours

- gases—chemicals that mix with air at room temperature
- vapours—substances that evaporate from liquids and solids at room temperature.

Respiratory protection is provided through properly fitted face masks that remove contaminants by filtering them from the airstream breathed by the user. The Australian/New Zealand Standard AS/NZS 1715–2009 'Selection, use and maintenance of respiratory protective devices' provides comprehensive guidance on how to select the correct type of respiratory protective device (RPD).

Protection from particles

Particulate filters remove material between 0.6 and 2.0 microns in size from the airstream. They filter the air through fibres, which are often electrostatically charged, to attract contaminants as well as mechanically block their movement. Filters clog over time and should be replaced when breathing through them becomes difficult.

Filters are categorised to match specific groups of contaminants.

Filter type	Contaminant
P1	mechanically generated dusts and mists
P2	mechanically and thermally generated dusts, mists or fumes
P3	highly toxic dusts, mists and fumes

[3] *3M Occupational Health and Environmental Safety Division (2011). 3M™ Administrative Respiratory Protection Program St Paul, MN, USA. (Cited September 2013).*

Protection from gases and vapours

Gas and vapour filters contain activated charcoal to absorb organic contaminants and remove them from the airstream. The charcoal, usually found in plastic cartridges, is chemically treated to attract and bind particular chemical groups and so must be matched to the contaminants expected in the environment where they are used.

Filter type	Contaminant
A	organic vapours (solvents)
B+E	acid gases
Form	formaldehyde
G	low vapour sprays (most agricultural pesticides)
K	ammonia

Filter classes

Filters of all kinds come in four classes that describe their capacity, i.e. the amount of contaminant they can remove from air.

Filter class	Capacity to remove contaminants
Class Aus	low concentration of contaminant for short durations
Class 1	higher concentrations or longer duration of use
Class 2	higher concentrations or longer duration of use
Class 3	highest concentration of contaminant or longest duration of use

Respirator cartridges

The cartridges fitted to respirators usually consist of both a particulate and a gas/vapour filter. Cartridges containing activated charcoal should be taken off the equipment between uses and stored in a clean, airtight container (such as a re-sealable plastic bag) to avoid deterioration through exposure to water and other vapours. They must be replaced when they are no longer absorbing the gas or vapour, usually apparent when the operator can detect odours while wearing the equipment. Effectiveness of the equipment can be crudely tested by applying a drop of strong smelling perfume or nail polish thinner (acetone) to the air intake of the cartridge before use. If this can be detected by the wearer then the cartridge/s must be replaced.

Powered full helmets

Powered helmets have the advantage of providing filtered air under positive pressure, which increases safety and removes the work of the lungs having to draw in air against filter resistance as in cartridge respirators. A full helmet is necessary for high-risk situations and for spray applicators with beards. All powered air purifying respirators should comply with AS/NZS 1716:2012[4] and should be fitted with filters appropriate to the particular task.

[4]AS/NZS 1716:2012 Respiratory Protective Devices Search on Sai Global (Cited September 2013).

Dermal exposure and protection

Material can be absorbed through the skin, particularly if there is moisture on the skin, such as sweat. Overalls, gloves, boots, aprons, goggles and face shields are used to mechanically prevent pesticides from reaching the skin. Gloves and boots should be non-absorbent and without lining so that pesticides do not permanently contaminate equipment. Overalls need to be washed between uses and should be removed and replaced if they become visibly wet with spray. Fresh water, soap and showering facilities need to be available where pesticides are mixed and used so that skin can be cleaned immediately in the event of contamination.

Areas of high blood flow such as eyes, ears, face, head and groin have increased absorption rates and particular care should be taken in protecting them. These areas are often scratched or rubbed by operators even when wearing protective gloves, which can lead to contamination of otherwise protected areas.

Ingestion

Pesticide material can splash into the mouth, be accidentally eaten, fall onto food or droplets may fall without notice into the mouth and be swallowed. Take care to use a face shield when mixing pesticide concentrates as splashing can occur.

Insinuative exposure

puncture wounds, such as a high pressure spray that breaks the skin or injects material under it, can lead to pesticide exposure. This is more common in glasshouse management than in most other plant industries due to the use of mechanical foggers.

Hearing protection

Exposure to the noise of mechanical equipment, especially that of small engines such as those found in foggers, misters and the like can damage hearing. Ensure that operators and other staff have suitable ear protection, such as expanding foam earplugs or earmuffs. Consult resellers/manufacturers to determine what equipment is appropriate for the particular task.

Table 2. Personal protective equipment required for handling pesticides

Protected Area	Equipment Item	Comments
Body	Overalls 	Buttoned at the wrist and neck. These must be clean at the start of each day, splash proof and worn outside the boots.
	Apron 	A full-length plastic apron gives added frontal protection when mixing concentrates.
Eyes	Goggles 	To give complete eye protection.
Face	Face shield 	To give protection against face splash.
Feet	Footwear 	Never use absorbent materials such as leather. Use rubber or PVC, preferably with steel toe cap.
Hands	Gloves 	Chemical-resistant, preferably unlined and elbow length (e.g. nitrile PVC gloves).
Head	Washable cotton hat, overall hood 	Head covering to prevent scalp/hair exposure.
Respiratory system	Respirator 	Half or full-face respirator incorporating a cartridge filter system. Refer to the Australian Standard AS/NZS 1716:2012 Respiratory Protective Devices to select the correct respirator and cartridge.[5]

[5] *AS/NZS 1716:2012 Respiratory Protective Devices Search on Sai Global (Cited September 2013).*

Table 3 illustrates the relative risks associated with various types of pesticides, method of application and choice of application equipment. Some operations present a much higher risk to people and property than others.

For each of the various levels of risk a range of personal protective equipment has been suggested. In all instances chemical labels should be read fully and adhered to and the SDS consulted for further information.

Table 3. Personal protective equipment during spraying operations

		Choice in products				
Risk	Situations	Herbicide	Insecticide/ Fungicide	Method of spray	Choice of equipment	PPE for spraying
Low to moderate	Open area	e.g. glyphosate[1] (e.g. Roundup®)	e.g. NPVs, Bt (e.g. Gemstar®, Dipel®)	High volume (>200 L/ha)	Shielded sprayer, hydraulic boom, knapsack.	Overalls, boots, goggles
Moderate to high	Shadehouse	e.g. fluazifop-p-butyl[2] (e.g. Fusillade®)	e.g. carbaryl[1], mancozeb[1] (e.g. Dithane/ M45®)	Low volume (10–200 L/ha)	Hydraulic boom, spinning disc (herbi), airshear	Overalls, gloves, boots, washable hat, appropriate respirator (where indicated on label), face shield, goggles
High to very high	Enclosed area (glasshouse)	e.g. paraquat[3] (e.g. Gramoxone®)	e.g. methidathion[3] (e.g. Supracide 400®)	Ultra low volume (<10 L/ha)	Electrostatics, spinning disc (ulva), foggers (ULV/CDA)	Overalls, gloves, boots, full-face respirator (or goggles and ½ face respirator), face shield, washable hat, goggles
	Mixing	Most pesticides				Overalls, gloves, boots, full-face respirator (or goggles and ½ face respirator), face shield, washable hat and apron

[1] *Caution (low potential for harm, domestic poisons)*
[2] *Poison (moderate potential for harm, industrial and agricultural poisons)*
[3] *Dangerous poisons (high potential for harm, special poisons)*

Maintenance of personal protective equipment

- All PPE should be cleaned as soon as possible after each use. It must not be contaminated with residues from a previous occasion.
- Soaking overalls in a slightly alkaline bleach solution (such as ammonium or sodium hydroxide) will prevent residues becoming 'fixed' in the fabric and break down any organophosphate or carbamate pesticide residues that may be present.
- A similar solution may be used to wipe over other items of PPE prior to storage.
- It is wise to check all items prior to storage for signs of wear and tear so that replacements can be obtained before the next occasion the equipment is needed.
- Respirator cartridges should always be removed and stored in a clean air-tight container (such as a resealable zip-lock plastic bag) to prevent a reduction in useful life (see page 23).
- The usage period of respirator cartridges containing activated charcoal should be recorded and they should be tested for efficiency regularly (see page 23).
- Care should be taken to service the inhalation and exhalation valves in the body of cartridge respirators.

The spray operator must wear protective clothing as recommended on the label when mixing and applying pesticides.

Protective clothing and equipment should be checked before use, cleaned and checked after every day's use and then stored in a clean dry area away from pesiticides.

Mixing the concentrate when preparing to spray can be the most hazardous time for the operator.

2.6 Disposal

It is the responsibility of the user to see that wastes such as unused chemicals and empty containers are disposed of properly. Empty containers can be a hazard to curious children and animals. Improperly disposed of chemicals can result in water contamination and crop damage. The current AgSafe® *Accreditation Training Manual* (2002) has further information on this topic.

There are services available that can be used to dispose of chemical waste and containers. Such services include drumMUSTER and ChemClear[6].

The following steps are guidelines for disposing waste properly:

- Purchase only the required amount of pesticide needed for one season to avoid disposal problems associated with excess product.
- Always read the label for disposal instructions.
- Wear the appropriate protective clothing during the disposal of any unwanted pesticide or pesticide mixture.
- Treat contaminated clothing and protective equipment, contaminated soil or materials used to clean up spills in the same manner as nursery chemical waste. The current AgSafe® *Accreditation Training Manual* (2002) has further information on this topic.
- Use accredited disposal schemes, such as drumMUSTER and ChemClear, where available[6].

The label must remain on the container at all times.

drumMUSTER

drumMUSTER is the national program for the collection and recycling of empty, cleaned, non-returnable crop production and on-farm animal health pesticide containers. Containers will be inspected for visible signs of pesticide residue or any liquid before being accepted for re-use or recycling. For the drumMUSTER website refer to the contact details on page 84.

Disposing of unused mixed product

Small amounts of excess pesticide mixture are frequently left at the end of an application and are also created when rinsing spray tanks or empty pesticide containers. This material must be disposed of properly. Check the pesticide SDS for specific risks of contamination.

> ***This material must never be allowed to enter streams or drainage from the property.***

Excess spray can be disposed of by spraying over the crop, although care should be taken that authorised rates of application are not exceeded by the addition of this application to the treatment previously applied. Alternatively, a mulched area might be used, with the same provision concerning registered rates of application per area.

Areas where mixing and cleaning of equipment are performed create risks of pesticide spillage. They should be bunded to prevent run-off or drainage to watercourses and suitable materials kept nearby for the neutralisation of spilled material. Wash water collected from this area must be retained to allow pesticide breakdown.

[6] www.chemclear.com.au; www.drummuster.com.au

Cleaning spray equipment

Rinsing

Spraying equipment should be cleaned in the same manner as pesticide containers to remove spray residues that may clog equipment or present a safety hazard. This should be performed directly after use to prevent drying or caking, which may be difficult to remove later. The inside of the spray tank must be rinsed out and the rinsate run out through the nozzles or other applicator until the tank is empty. This should be repeated at least twice and the outside of the equipment inspected for visible residues.

Neutralising

Plastic and fibreglass spray tanks and the plastic spray lines absorb trace quantities of pesticides during use. This can later create hazardous vapours or contaminate spray mixes of other materials. This can create risks for operators and target plants, depending on the pesticides used. Ideally, use separate spray tanks for different groups of pesticides used, i.e. herbicides, insecticides and fungicides, or members within these categories used for different management activities. Consulting the records of pesticides previously applied with equipment can avoid expensive mistakes, damaging sensitive crops or endangering staff.

While separate equipment may be an option for large plant nurseries, most operators will want to neutralise the residues in equipment from time to time so that they can safely use it for a variety of purposes.

Table 4. Recommendations for use of cleaning agents[7]

Chemical used	Cleaning agent per 100 L water	Instructions
All herbicides	Commercial cleaning agent	Follow directions of cleaning agent label.
Phenoxy herbicides (2,4-D, Dicamba, MCPA etc)—salt and amine formulations Small traces of 2,4-D can damage sensitive plants. Preferably do not use the same sprayer to apply other chemicals to sensitive plants. Hoses may need to be replaced.	1–2 L household ammonia per 100 L water or	Thoroughly agitate, flush small amount through system and let remainder stand in sprayer overnight. Flush and rinse with clean water several times before use.
	500 g washing soda or	Same as above but let stand for at least 2 hours.
	1 kg trisodium phosphate per 100 L water or	Same as above but let stand for at least 2 hours.
	250 g fine activated charcoal and half a cup of detergent (liquid or powder) per 100 L water	Make a sudsy solution. Agitate, operate sprayer for 2 minutes, let remainder stand for 10 minutes, then flush through sprayer. Rinse.
Phenoxy herbicides—ester formulations	500 g washing soda + 4 L kerosene + 125 g powder detergent	Rinse inside of tank and flush small amount through system. Let stand for at least 2 hours. Flush and rinse.
Sulfonylurea herbicides	500 ml sodium hypochlorite (chlorine) bleach (6% solution)	Flush through the boom for at least 10 minutes including spraying out the jets. Make sure all spray lines, filters etc are well cleaned. Rinse out. Repeat the operation for at least another 10 minutes. Allow the sprayer to stand for at least 12 hours.
Other herbicides	125 g powder or liquid detergent to make a sudsy solution	Rinse with clean water afterwards.
Insecticides and fungicides	125 g powder or liquid detergent to make a sudsy solution	Rinse with clean water afterwards. Organophosphate and carbamate insecticide may be detoxified by adding household ammonia to the cleaning solution at 1 L per 100 L water.

[7] *Source: Chandlers IAMA, Hardi International, format based on Chemcert, Spray Application and Risk Management in Vineyards, 2003.*

Rinsing containers

Rinsing and cleaning containers are the first steps in proper disposal. State laws require users to follow label instructions that specify that containers must be rinsed. Local shire and municipal councils will only accept properly rinsed and cleaned containers at their approved refuse landfills, after inspection of the containers. Under current regulations in most states, containers that have not been properly rinsed can be classified as hazardous wastes[8].

Containers should be rinsed directly after emptying their contents as residues are more difficult to remove when dry. Proper rinsing of nearly all types of pesticide containers will remove more than 99% of any pesticide residue remaining in the container. Rinsing into the spray tank also conserves valuable pesticide.

Two commonly used procedures are effective for proper rinsing of pesticide containers: 1. pressure rinsing and 2. triple-rinsing. Clean water must always be used to rinse containers.

Pressure rinsing

Some spray equipment manufacturers supply a special rinsing attachment that enables drums and bags to be rinsed using a pressure nozzle. This method is generally faster and easier to carry out than triple-rinsing (AgSafe® *Accreditation Training Manual*, 2002). There are two basic forms: 1. the 'piercing nozzle' and 2. 'sucker-flusher' probes. The piercing nozzle makes its own hole and is inserted into the bottom or side of the container. In this case the rinsate flows out through the regular opening. Sucker-flusher probes enter through the normal aperture and suck fluid from the bottom of the container while spraying pressurised water from nozzles on the side of the probe back from the head.

The steps to follow when pressure rinsing are:[8]

1. Remove the cap from the container. Empty contents into the tank and allow to drain for an extra 30 seconds after the flow reduces to drops.
2. For piercing nozzles, insert the pressure nozzle by puncturing through the lower side of the container. Do not, however, puncture plastic containers (such as 20 L drums) if they are part of a manufacturer's re-use program; these should be triple-rinsed. For sucker-flusher probes, insert through the regular opening and do not invert the container (i.e. ignore step 3).
3. Hold the container upside down over the sprayer tank so the rinsate will run into the sprayer tank.
4. Turn the water on and rinse for the length of time recommended by the manufacturer (normally at least 30 seconds) or until the rinsate coming from the container is clear. Move the nozzle or probe about so that the stream of water reaches all parts of the container to rinse all inside surfaces.
5. Rinse the container cap when there is a clear stream of water coming out of the container, or alternatively, rinse separately in a bucket of water and pour this into the spray tank.
6. Check the container thread and the outside surfaces of the container and, if contaminated, rinse with a hose into the spray tank.
7. Look inside the container to ensure that thorough cleaning has occurred.
8. Let the container dry completely (this may take several days), then replace the cap.
9. Store containers where they can remain clean and dry until they can be taken to a collection or disposal site.

[8]*Refer to the drumMuster fact sheet 'Effective rinsing of farm chemical containers' (Cited September 2012)*

Triple-rinsing

Triple-rinsing is a three-stage manual rinsing process, involving the following steps:

1. Remove the cap from the container.
2. Empty the contents into the spray tank and allow the container to drain for an extra 30 seconds after the flow reduces to drops.
3. Fill the container with water to between 20% and 25% of its capacity.
4. Replace the cap securely.
5. Shake, rotate, roll or invert the container vigorously for at least 30 seconds, so that the rinse reaches all inside surfaces. For 200 L drums, rolling between two people is advised.
6. Remove the cap. Add the rinsate from the container into the sprayer tank. Let it drain for an extra 30 seconds after the flow reduces to drops.
7. Repeat steps 3–6, two more times.
8. Check the container thread and the outside surfaces of the container and, if contaminated, rinse with a hose into the spray tank.
9. Look inside the container to ensure it is thoroughly clean.
10. Wash the cap.
11. Let the container dry completely (this may take several days), then replace the cap.
12. Store containers where they can remain clean and dry until they can be taken to a collection or disposal site.

2.7 Environmental protection

Any pesticide material that does not reach or remain on the target may pollute the atmosphere, water and soil. These are important natural resources and operators have a legal responsibility to avoid contaminating them. Potential sources of pesticide pollution include:

- drift of droplets in air away from the target area
- pesticide transported by water from the target area:
  - » leaf run-off due to excess spray volume or overly large droplets
  - » irrigation or rainfall on recently sprayed areas
- droplets falling on soil where there is incomplete canopy cover by target foliage
- rinsate from equipment washing and spray mixing
- leaching from pesticide treated potting mixture.

Atmospheric contamination

Pesticide droplets that are carried in the air away from the target can cause significant damage to other, non-target plants and unprotected people, soil and water. This is commonly referred to as 'spray drift' and is the main theme of chapter 3 of this manual.

Soil contamination

Pesticides contacting the soil may be adsorbed on soil minerals and organic matter or remain in a soluble form that can be moved by water. Contaminants may leach into the water directly or may be carried on soil particles, particularly during storms and irrigation. Contaminated soil also creates hazards through direct skin exposure to the soil, inhalation of pesticide in dust or vapours moving into the air. Persistent pesticide contamination in soil can move into the surrounding environment over time, thus creating an ongoing source of pollution.

Water contamination

Water rapidly spreads pollution through the environment. Pesticides can remain active even at very low concentrations, creating adverse impacts on environmental and community health. Many pesticides are toxic to mammals and pose a direct health hazard. Water in populated areas is tested regularly for contamination and the likelihood of poor management being identified and prosecuted is high. Further, many birds and aquatic life forms (e.g. fish and crustaceans) are extraordinarily sensitive to insecticides and herbicides. Pesticide pollution exposes operators to prosecution under state laws governing environmental protection.

Pesticide residues can also be carried by water to the watertable. These contaminants are no longer exposed to the normal biological and physical factors such as micro-organisms, heat, light and air that degrade pesticides. Thus, groundwater contamination can be very persistent.

Pesticide degradation

While pesticides may have a shelf-life of two or more years in storage as concentrated form, dilute sprays in the natural environment are expected to degrade more swiftly. This is a major consideration in the creation of product advisory information during registration.

Factors that increase the breakdown of pesticide molecules include:

- exposure to direct sunlight (UV)
- soil and plant micro-organisms
- high temperature
- filtering, through sand, vegetation or organic matter
- aeration (if in water)
- plant metabolism.

Table 5 contains data on the breakdown and persistence of some pesticides in the environment. While this illustrates the general differences between types of chemical, actual performance will depend strongly on soil type, water quality and other environmental factors.

Managing pesticide contaminants in soil and water

Assess the pathway of drainage water from areas of pesticide application. What sensitive areas are in the downstream environment? Consult each SDS to determine the specific risks each pesticide poses, including all soil and potting-mix treatments. What flows of water are expected under normal operation and during floods?

Due to their intense management of production areas, nurseries are more able to manage water than most other plant industries. When designing drainage for a production area consider ways to maximise the factors that increase pesticide degradation. For example, if soil is well drained, seal the floor of the production area with a plastic sheet under the gravel to prevent water travelling down into the soil profile. Expose water leaving the target area to unpasteurised soil and sunlight and ideally filter it slowly through a sand bed. If water can be collected, do so in shallow, aerated ponds, with reeds or other water plants. If water is otherwise of suitable quality, it may be economical to treat it and recycle it for re-use as irrigation water, which further decreases risks posed to the surrounding community.

The quality of water leaving commercial properties is likely to come under increasing scrutiny in the near future, and careful planning of growing areas now may help to avoid costly liability later.

To reduce the risk of polluting soil and water with pesticide:

- Plan to leave most spray on the target:
  - » avoid run-off, don't over-spray or use the largest droplet sizes, which can roll off leaves
  - » avoid drift from the target area.
- Ensure the correct rate per area or concentration is being applied at the correct frequency and use properly calibrated equipment.

Table 5. Physical properties and predicted mobility of selected pesticides

					Predicted mobility	
Trade name	Common name	Soil sorption index (K_{oc})	Water solubility (ppm)	Soil half-life (days)	Surface runoff	Leaching
Herbicides						
Aatrex	atrazine	100	33	60	medium	small
Banvel	dicamba	2	500,000	14	small	large
Basagran	bentazon	35	2,300,000	20	medium	large
Bladex	cyanazine	190	170	14	medium	medium
Buctril	bromoxynil	190	<1	5	medium	small
Curtail	clopyralid	1	300,000	30	small	large
Dacthal	DCPA	5000	<1	100	large	small
Dual	metolachlor	200	530	20	medium	medium
Eptam	EPTC	280	375	30	medium	medium
Eradicane	EPTC	280	375	30	medium	medium
Far-Go	triallate	2400	4	82	large	small
Goal	oxyfluorfen	100,000	<1	35	large	small
Gramoxone	paraquat	100,000	1,000,000	500	large	small
Lasso	alachlor	170	240	15	medium	medium
Prowl	pendimethalin	24,300	<1	90	large	small
Roundup	glyphosate	24,000	900,000	47	large	small
Sencor	metribuzin	41	1220	30	medium	large
Stinger	clopyralid	1	300,000	30	small	large
Sutan	butylate	126	46	12	medium	medium
2,4-D Amine	2,4-D amine	20	796,000	10	small	medium
Tordon	picloram	16	200,000	90	small	large
Treflan	trifluralin	7000	<1	60	large	small
Velpar	hexazinone	54	33,000	90	medium	large
Insecticides						
Ambush	permethrin	86,600	<1	32	large	small
Asana XL	esfenvalerate	5300	<1	35	large	small
Counter	terbufos	3000	5	5	medium	small
Cygon	dimethoate	8	25,000	7	small	medium
Diazinon	diazinon	500	40	40	medium	medium
DiSyston	disulfoton	1600	25	5	medium	small
Dyfonate	fonofos	532	13	45	large	medium
Furadan	carbofuran	22	351	50	small	large
Kelthane	dicofol	8,000,000	1	60	large	small
Malathion	malathion	1800	145	1	small	small
Orthene	acephate	2	818,000	3	small	small
Parathion	parathion	5000	24	14	large	small
Penncap-M	methyl parathion	5100	60	5	medium	small
Pounce	permethrin	86,000	<1	32	large	small
Pydrin	fenvalerate	5300	<1	35	large	small
Sevin	carbaryl	200	114	10	medium	small
Temik	aldicarb	30	6000	30	small	large
Thimet	phorate	2000	22	90	large	small
Fungicides						
Bayleton	triadimefon	273	260	21	medium	medium
Benlate	benomyl	190	2	240	large	large
Bravo	chlorothalonil	1380	<1	30	large	small
Captan	captan	100	4	3	small	small
Dithane	mancozeb	2000	<1	70	large	small
Maneb	maneb	1000	<1	60	large	small
Manzate	mancozeb	2000	<1	70	large	small
Ridomil	metalaxyl	16	7100	21	small	large
Telone II	dichloropropene	32	2250	10	small	medium
Tilt	propiconazole	100	110	20	medium	medium
Vitavax	carboxin	264	170	7	medium	small

Source: Colorado State University, Best management practices for agricultural pesticide use

- If the soil is naturally well drained, use an impermeable layer under the production area to avoid groundwater contamination and consider recycling run-off to filters, ponds etc.
- Prevent erosion of soil that may receive spray.
- Pesticide-treated potting soil is contaminated. Do not allow water to run through it and then to waste. Reuse or allow it to break down where it cannot drain into an uncontrolled waterway. Drainage systems should be designed to collect and hold run-off water on site.

2.8 The law and nursery chemicals

Laws exist at both the federal and state level to regulate the use of pesticides. These are aimed at ensuring the safety of operators, the environment and the community. In general, responsibility for pesticides prior to the point of sale is regulated by federal legislation and the responsibility for transport, storage and application after sale is regulated by separate legislation in each state and territory.

Disclaimer

> ***This manual attempts only to outline the areas of legislation concerned with pesticide management and does not seek to provide information on the specific laws or their application in the states and territories of Australia.***

Laws and practices vary between states, as do the application of some federal standards. They are subject to constant revision and up-to-date information should be sought for each inquiry. To ensure you are aware of the Acts and Regulations that may affect the way you operate, contact your state Nursery Industry Development Officer for more details.

Other reliable sources of information include:

- commonwealth, state and territory departments of agriculture, primary industries, lands or environment
- certified agricultural safety trainers e.g. ChemCert.

See contact details on pages 84–85 for ways to obtain further information on agricultural pesticide use legislation for each state in Australia.

Duty of care

People handling pesticides, and their employers, have a duty of care to comply with all safety requirements of storage, handling and use. Duty of care legislation in contract or common law covers acts or omissions that cause harm. It is the responsibility of workplace managers to ensure safe practice and they are directly responsible for the compliance of employees in the workplace. They are also responsible for the safety of all equipment used, employee protection from exposure to risk and protection of the environment.

Federal law

Australian Pesticides and Veterinary Medicines Authority

For a pesticide to be sold or legally used in a nursery in Australia it must be registered by APVMA. APVMA examines each product in the areas of:

- human toxicology
- environmental impact
- occupational health
- efficacy.

APVMA invites public comment before granting clearance or otherwise. It may also administer 'minor use', 'permit' and 'off-label' schemes, usually in conjunction with relevant state departments, to supervise small market uses not large enough to support the cost of generating normal data submission packages and label extensions.

National Standards (AS)

Australian Standards exist for storing and handling pesticides. Each state has legislation that covers these areas and recognition and application of the national standards varies widely between states. The current relevant Australian Standards are:

- AS 1940 (2004) *The storage and handling of flammable and combustible liquids*
- AS 2507 (1998) *The storage and handling of agricultural and veterinary chemicals*
- AS/NZS 4452 (1997) *The storage and handling of toxic substances*
- AS/NZS 3833 (2007) *The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk containers*

State and territory law

Once clearance has been given for sales to proceed, a pesticide is subject to the legislation of each state. This involves a number of different legal Acts with their accompanying Regulations. In some cases the formal legislation is supported by 'codes of practice' or 'compliance guidelines', which are documents designed to assist in understanding what the law requires.

It is important that nursery operators are aware of the regulations that may affect or limit the types of operations they may wish to carry out in each state or territory. The current AgSafe® *Accreditation Training Manual* (2002) provides an excellent summary of this area on a state-by-state basis.

Examples of SOME areas where legislation exists relating to the nursery industry include:

- the use of particular pesticides and how they may be applied
- the operation of particular pieces of equipment, and where they may be operated
- workplace health and safety Regulations and who may apply pesticides
- health Acts and Regulations that determine how and where pesticides may be stored, used and disposed of
- environmental protection Acts that encompass water, air and noise management
- noise pollution Regulations for powered equipment
- numerous others, depending on the location of the nursery.

In some states within specific regions special, more restrictive regulations apply to the use of agricultural chemicals. For example in Victoria, Agricultural Chemical Control Areas (ACCAs) exist where the use of some chemicals is prohibited unless authorisation and a permit has been received that includes notifying the local authority of the time, date and exact location of the proposed chemical application.

Occupational health and safety legislation

There is also considerable legislation that regulates pesticide use, even though not directly addressing it. Of particular interest for managers and operators are laws concerning occupational health and safety. These laws generally cover:

- identification of hazards
- risk management
- risk reporting
- activities in the workplace
- emergency response (safety, first aid, spill management)
- facilities
- personal protective equipment
- hazardous substances
- training monitoring and records.

Workplace managers are directly responsible for employee compliance to these laws.

A process of legislative harmonisation is currently underway nationally to bring states under the standardised *Work Health and Safety Act 2011*. The main objective of this process is to provide for a balanced and nationally-consistent framework to secure the health and safety of workers and workplaces. The national legislation has already been adopted by some states and territories while others are operating under temporary transitional arrangements and others are unwilling to sign up to the proposed Act. It is recommended that advice be sought from the relevant state or territory government to determine the progress of the harmonisation process at the time of reading. Links to all agencies are available from http://www.safeworkaustralia.gov.au or by calling 1300 551 832.

Table 6. Occupational health and safety legislation in Australian states

State/territory	Acts and Regulations
Australian Capital Territory	*Work Health and Safety Act 2011*
New South Wales	*Work Health and Safety Act 2011*
Northern Territory	*Work Health and Safety (National Uniform Legislation) Act 2011*
Queensland	*Work Health and Safety Act 2011*
South Australia	*Work Health and Safety Act 2012*
Tasmania	*Work Health and Safety Act 2012*
Victoria	*Occupational Health and Safety Act 2004*
Western Australia	*Occupational Safety and Health Act 1984*

CHAPTER 3.

SUITABLE CONDITIONS FOR PESTICIDE APPLICATION AND MANAGING SPRAY DRIFT

Spray drift is a major consideration in relation to the safe use of pesticides.

Spray drift is the movement of a pesticide (as droplets in the air) outside the intended target area. This off-target movement of pesticide has the potential for injury or damage to humans, plants, animals, the environment or property.

Spray drift does not include off-target movement of a chemical due to post-spray volatilisation or movement in water, soil or organisms, although this chemical movement can also be very damaging (see sections 2.5 to 2.7).

It is recognised that nearly all spray application of pesticide results in some spray drift. However, if uncontrolled and excessive, spray drift can cause:

- damage to crops in neighbouring areas
- contamination of neighbouring crops resulting in illegal residues on produce
- loss of expensive chemical and reduced efficacy on target pests
- death of beneficial organisms such as bees, and predators and parasites of pest organisms
- environmental contamination
- adverse publicity and community concern.

Spray drift is usually the result of:

- spraying in unsuitable weather conditions
- using spray equipment inappropriately (i.e. use inconsistent with manufacturer's instructions or training guidelines)
- using an unsuitable (e.g. unregistered or unapproved) pesticide formulation for a particular use or in a particular area
- failing to identify and allowing spray to drift onto susceptible non target areas
- using a droplet size that is too small.

In plant nursery operations drift can occur internally to other parts of the nursery (e.g. neighbouring plants or areas where other staff are working) or externally to the nursery (e.g. neighbouring houses or fields). It is important to consider the potential for both internal and external drift before undertaking the application of pesticides.

3.1 Managing spray drift

There are four main methods that can be used to reduce spray drift in the nursery. These are:

1. Control droplet size when applying sprays or use solid formulations such as granules.
2. Use appropriate application techniques.
3. Select the correct meteorological conditions.
4. Use buffer zones (including vegetative and artificial structures).

Droplet size

Droplet size is probably the single most important factor in managing potential pesticide spray drift. Because large droplets fall towards the ground significantly faster than small droplets, the airborne transport of droplets is significantly reduced if small droplet production is kept low.

However, all droplets used for spraying pesticides are small! Droplets are measured in micrometres (µm). It is easy to refer to droplets of 10, 100 or 500 µm, forgetting that 10 µm and even 100 µm droplets may not be visible to the naked eye.

As an example, the full stop at the end of this sentence is approximately 300 µm in diameter. A micrometre is 1/1000 of a millimetre (mm) and thus a 500 µm droplet is half a millimetre in diameter. A 500 µm diameter droplet is considered a large droplet in spray application technology.

Droplet behaviour under optimum spraying conditions

In general terms we can say that droplets in the following size ranges will behave as described below:

Approximate droplet size	Expected behaviour under suitable spraying conditions
Less than 50 µm	If water based, will evaporate quickly and will typically be lost before reaching the target.
Droplets 50–150 µm	Will move with air movement (wind), and may move off-target. However, if managed well under good spraying conditions, they can improve target penetration and coverage.
Droplets < 200 µm	Considered 'driftable' because they may reduce in size due to evaporation (if water based), and hence move with the wind.
Droplets > 350 µm	May bounce or run off without the addition of adjuvants, hence may not be useful for spraying foliage.

Droplets between 100 and 350 microns are considered the MOST USEABLE fraction of the spray cloud when spraying foliage (e.g. useful for many insecticide sprays).

Estimators of droplet size in the droplet cloud

Unfortunately, no practical spray nozzles are currently available to produce droplets that are all the same size. All commercial nozzles generate a range of droplet sizes. It is therefore difficult to exactly describe the output from a spray nozzle in terms of droplet size produced. Some pesticide labels describe the droplet size to be used by an applicator in terms of the volume median diameter (VMD).

The VMD divides the droplet spectrum into two equal parts. One half of the total spray volume is made up of droplets larger than the VMD and the other half made up of droplets smaller than the VMD. A diagrammatic representation of VMD is shown in figure 5. If droplets from a spray nozzle could be lined up in order of size, the VMD indicates the droplet size that would divide the sample in half by volume.

Two different nozzles may produce the same VMD but may actually produce quite a different droplet cloud. One nozzle may produce droplets that all fall in a very narrow band around the VMD while the other nozzle may produce a broad spectrum of droplet sizes.

Most hydraulic nozzle manufacturers' catalogues now indicate droplet size produced using the spray quality categories of very fine (the smallest), fine, medium, coarse and very coarse (the largest). Refer to table 7 for the designation of droplet size ranges in microns. An example from the Spraying Systems Co. catalogue is shown in figure 6[9]. This scheme of describing droplet size was originally devised by the British Crop Protection Council (BCPC) during the mid 1980s as a means of standardising the relationship between a variety of measurement systems and describing the entire droplet spectrum generated by a spray nozzle. Currently, air induction nozzles are not included in the classification scheme. To reduce drift, select nozzles and pressure settings that produce a coarse or very coarse spray.

[9] *Spraying Systems Co. catalogue*

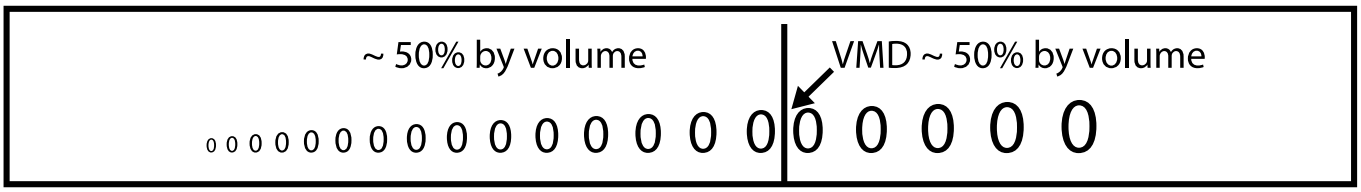


Figure 5. Illustration of the volume median diameter (VMD)

3.2 Understanding spray quality classifications

A number of nozzle manufacturers provide information on the spray quality from their hydraulic nozzles (for ground application) at various pressures according to the British Crop Protection Council (BCPC) and American Society of Agricultural & Biological Engineers (ASABE) standards.

Table 7. ASABE droplet categories, average sizing and potential uses (ASAE S572.1)

ASAE category	Colour code	VMD of droplet cloud	Potential uses
Extremely fine (XF)	purple	< 60 µm (microns)	insecticide
Very fine (VF)	red	61–144 µm	insecticide
Fine (F)	orange	145–235 µm	fungicide
Medium (M)	yellow	236–340 µm	herbicide/insecticide
Coarse (C)	blue	341–403 µm	herbicide
Very coarse (VC)	green	404–502 µm	herbicide
Extremely coarse (XC)	white	503–665 µm	herbicide
Ultra coarse (UC)	black	> 500 µm	herbicide

Examples of spray quality charts for various nozzle types

PRE-ORIFICE	HARDI ISO LD	bar					
		1.5	2.0	2.5	3.0	4.0	5.0
	LD-110-01	M	M	M	M	M	F
	LD-110-015	M	M	M	M	M	M
	LD-110-02	M	M	M	M	M	M
	LD-110-025	C	C	M	M	M	M
	LD-110-03	C	C	C	C	M	M
	LD-110-04	C	C	C	C	C	M

LOW PRESSURE AIR INDUCTION	HARDI ISO MINIDRIFT	bar					
		1.5	2.0	2.5	3.0	4.0	5.0
	MINIDRIFT-015	C	C	C	C	M	M
	MINIDRIFT-02	VC	C	C	C	C	M
	MINIDRIFT-025	VC	VC	C	C	C	M
	MINIDRIFT-03	VC	VC	VC	C	C	C
	MINIDRIFT-04	VC	VC	VC	VC	C	C

HIGH PRESSURE AIR INDUCTION	HARDI ISO INJET	bar					
		3.0	4.0	5.0	6.0	7.0	8.0
	INJET - 01	VC	VC	VC	C	C	C
	INJET - 015	VC	VC	VC	VC	VC	C
	INJET - 02	VC	VC	VC	VC	VC	VC
	INJET - 025	VC	VC	VC	VC	VC	VC
	INJET - 03	VC	VC	VC	VC	VC	VC
	INJET - 04	VC	VC	VC	VC	VC	VC

HYBRID PRE-ORIFICE	Turbo TeeJet®	bar									
		1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0
	TT110-01VP	C	M	M	M	F	F	F	F	F	F
	TT110-015VP	C	C	M	M	M	M	M	F	F	F
	TT110-02VP	C	C	C	M	M	M	M	M	M	F
	TT110-025VP	VC	C	C	M	M	M	M	M	M	M
	TT110-03VP	VC	C	C	C	C	M	M	M	M	M
	TT110-04VP	XC	VC	C	C	C	C	C	C	M	M

AIR INDUCTED TWIN JET	Air Induction Turbo TwinJet®	bar								
		2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	AITTJ110-02VP	VC	VC	VC	C	C	C	C	C	C
	AITTJ110-025VP	VC	VC	VC	C	C	C	C	C	C
	AITTJ110-03VP	XC	XC	VC	VC	VC	C	C	C	C
	AITTJ110-04VP	XC	XC	VC	VC	VC	C	C	C	C

HYBRID AIR INDUCTION	Turbo TeeJet® Induction	bar									
		2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0
	TTI110-015VP	UC	UC	UC	UC	XC	XC	XC	XC	XC	XC
	TTI110-02VP	UC	UC	UC	UC	UC	UC	XC	XC	XC	XC
	TTI110-025VP	UC	UC	UC	UC	UC	UC	XC	XC	XC	XC
	TTI110-03VP	UC	UC	UC	UC	UC	UC	XC	XC	XC	XC
	TTI110-04VP	UC	UC	UC	UC	UC	UC	XC	XC	XC	XC

UC	XC	VC	C	M	F	VF
Ultra Coarse	Extra Coarse	Very Coarse	Coarse	Medium	Fine	Very Fine

Figure 6. BCPC classification scheme used to define spray quality by spraying systems (F=fine, M=medium, C=coarse, VC=very coarse)[9]

An example of the use of these classifications is provided below, which is an excerpt from the Spraying Systems TeeJet® catalogue[9].

Spray Quality and Nozzle Outputs									
Typical of 110° conventional flat fan nozzles (not reduced drift fan nozzles). Note: Check with your nozzle supplier for the actual spray quality for their nozzles.									
Nozzle code		11001	110015	11002	11003	11004	11005	11006	11008
ISO colour		Orange	Green	Yellow	Blue	Red	Brown	Grey	White
Pressue (bar)	1.5	0.29	0.42	0.56	0.85	1.13	1.41	1.70	2.26
	2.0	0.33	0.49	0.65	0.98	1.31	1.63	1.96	2.61
	2.5	0.37	0.55	0.73	1.10	1.46	1.82	2.19	2.92
	3.0	0.40	0.60	0.80	1.20	1.60	2.00	2.40	3.20
	3.5	0.43	0.65	0.86	1.30	1.73	2.16	2.59	3.45
	4.0	0.46	0.69	0.92	1.39	1.85	2.31	2.77	3.69
		Nozzle output = litres/minute							
Spray Quality		Fine		Fine/Medium		Medium		Medium/Coarse	Coarse

Figure 7. Spray qualities at various pressures for XR nozzles (V=very fine, F=fine, M=medium, C=coarse)

With hydraulic nozzles it is possible for one type of nozzle to produce a range of spray qualities depending on the pressure of operation. The higher the pressure, the smaller the droplets produced will be, hence the finer the spray quality it is assigned.

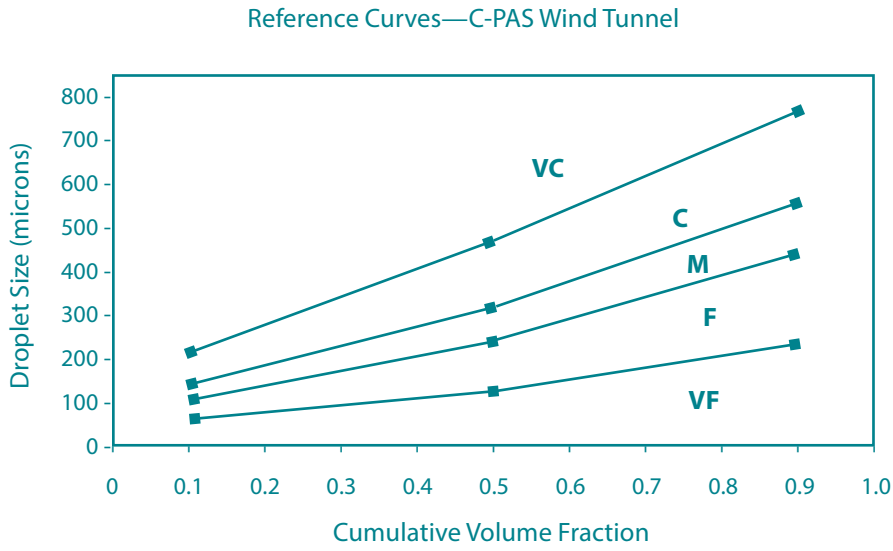
What are the BCPC and ASAE S572.1 classifications?

The BCPC and ASAE S572.1 classifications describe spray quality (the range of droplet sizes produced by a nozzle). This spray quality is determined by comparing a nozzle's output of different sized droplets (droplet spectrum) at a given pressure against the outputs of a set of standard reference nozzles. This is done using a laser-based instrument and, due to the comparative nature of the standard, nozzles will achieve the same classification regardless of testing technique.

There are three key measurements used in determining the spray quality classification. These describe the proportion of volume through the nozzle resulting in different size categories.

Key measurements	Proportion of volume in different size categories
D[v,0.1]	10% of the spray volume produced by the nozzle results in droplets smaller than this size (diameter in microns).
D[v,0.5]	Also known as the volume mean diameter (VMD). 50% of the spray volume produced by the nozzle is in droplets smaller than this size (diameter in microns). 50% of the spray volume is in droplets larger than this size.
D[v,0.9]	90% of the spray volume produced by the nozzle is in droplets smaller than this size (by diameter in microns).

These three measurements are plotted on a graph to produce boundaries for each spray quality classification. A reference curve from a Malvern laser instrument, as shown in figure 8, is used for this purpose.



Droplets smaller than a particular size (microns). For example 0.1 is the D[v,0.1], 0.5 is the D[v,0.5] also known as the VMD and 0.9 is the D[v,0.9].

Figure 8. Example of BCPC reference curves used to determine spray quality

Using reference curves to understand nozzle outputs

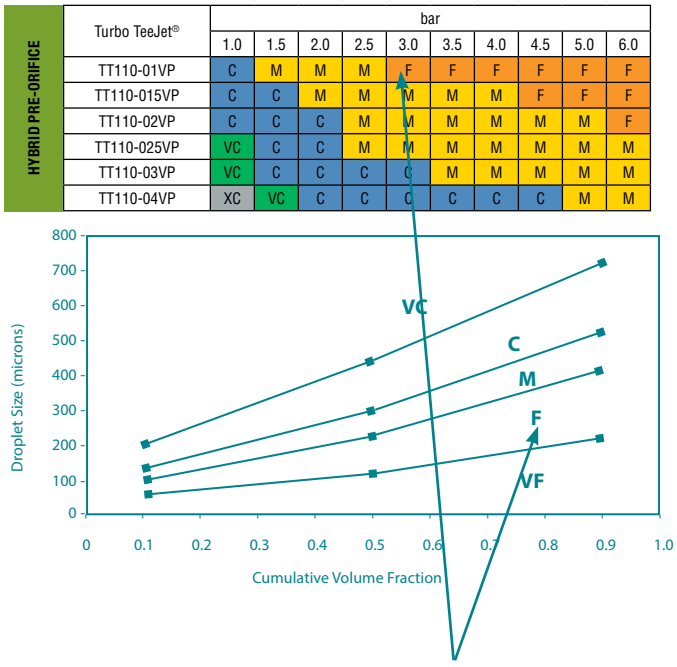
By using the reference curves in conjunction with the spray quality classifications, nozzle outputs can be better understood. For example, a nozzle that has been assigned a FINE spray quality will produce droplet sizes within a particular range.

Figure 9 shows that a fine nozzle will have a D[v,0.1] of 60–100 µm. This means that 10% of the spray volume is in smaller droplets than these sizes. A fine nozzle will also have a D[v,0.5] or VMD of 131–239 µm.

Where a particular nozzle can produce a FINE spray quality at a range of spray pressures, the droplet sizes produced will be largest when operated at the lowest pressure required to stay within the FINE classification (towards 239 µm).

If the nozzle is operated at the highest possible pressure to stay within a FINE spray quality the droplet sizes produced will be smaller. It is possible that the VMD could be as small as 131 µm.

By understanding how droplets of various sizes behave in differing conditions, the reference charts can be used to estimate the spread of droplet sizes produced when operating nozzles to deliver spray. Pesticide applications can be better planned using this information.



A nozzle that has been assigned a FINE spray quality will produce droplet sizes within a particular range.

Figure 9. Using the reference curves and spray quality charts

Using BCPC spray quality classifications to select nozzles

When selecting a nozzle for a particular purpose, an understanding of what the classifications mean in terms of the types of droplets each classification includes is required. The behaviour of various droplet sizes can then be used to select the appropriate nozzle for particular situations. For example, in a situation where drift would be of particular concern, it is important that after determining the desired droplet size for the target (which should be close to the VMD) a nozzle is selected with the largest possible size of 'fine' droplets D [v,0.1].

Droplet sizes for different targets

Regardless of the target, the objective should be to obtain the best coverage possible while minimising the off target losses, such as drift or run-off, as much as practicably possible. The understanding of the droplet sizes required for different targets is gradually improving. Recommendations for the application of different pesticides onto different targets are continually being developed so it is important to keep up-to-date with developments.

Label instructions need to be followed for the correct application of particular product types. Where this information is not provided the general principles provided in table 8 can be applied.

Table 8. General guide to application of different product type

Product types	Spray classification	Comment
Insecticides		
Contact	Fine–Medium	If using the finer end of the droplet spectrum.
Systemic	Fine–Medium	If using medium, stay at the finer end.
Fungicides		
Protectant	Very fine–Fine	Be aware of droplet spectrum and evaporation.
Curative/eradicant	Fine–Medium	If using medium, stay at the finer end.
Herbicides		
Soil applied	Coarse	Use appropriate water volumes to ensure coverage.
Contact	Medium	Medium preferred where conditions allow.
Systemic	Medium–Coarse	Use at the coarse end and monitor conditions.

Nozzle types

Nozzle selection is an important factor when considering spray drift. It is well known that spray drift can be minimised—and spray efficiency maximised—by selecting an appropriate nozzle for a spray job. Most pesticide labels do not provide recommendations for a specific nozzle for a particular job. However the ASAE categories (extremely fine, very fine, fine, medium, coarse, very coarse, extremely coarse and ultra coarse) enable the spray performance of most common hydraulic systems to be characterised. The system allows operators more choice in selecting a nozzle type, size and pressure for a particular task, provided the selected combination produces the droplet size that falls within the specified category. Notice that in the example shown in figure 6 the droplet size generated by a Spraying Systems Turbo TeeJet® increases as orifice size is increased and spray pressure is reduced.

Spray pressure

Spray pressure should be as low as possible, consistent with nozzle specifications and coverage requirements. Check the manufacturer's nozzle catalogues for recommended pressure of operation.

When the pressure at the nozzle is increased, most hydraulic nozzles generate a finer droplet spectrum. To reduce drift potential, use low pressures.

Many nozzle manufacturers now provide low pressure nozzles that can be operated as low as 100 kPa (where 100 kPa = 1 bar = 15 psi). This will be marked on the nozzle with the other specifications as 'LP'.

It is important to note that:

- spray volume should be controlled by changing nozzles not by changing pressure, i.e. selecting nozzles with a greater throughput to increase volume
- all sprayers should be fitted with an accurate, easy to read pressure gauge.

Nozzle spray angle

A flat fan nozzle that has a wider spray angle will normally produce a thinner sheet of spray solution, which results in smaller droplets than will be produced by a narrower angle nozzle operating at the same pressure. For example a 110° flat fan can normally be expected to generate a finer droplet spectrum than an 80° flat fan operated at the same pressure with the same orifice size (and flow rate). In terms of drift control, the benefits of a lower nozzle height provided by a wide-angle nozzle, can outweigh the disadvantages associated with smaller droplet spectrum produced due to the wider angle nozzle.

Spray volume

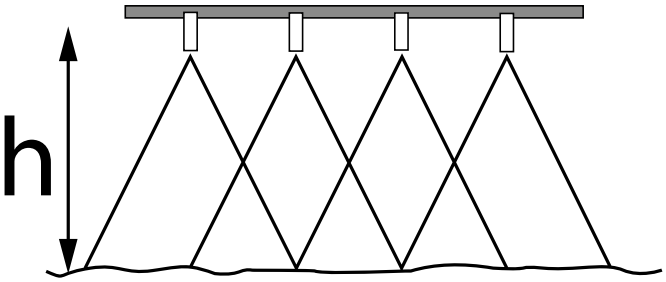
A larger nozzle orifice increases the droplet size when operated at the same pressure as a smaller nozzle orifice. It will also increase the rate of flow and thus the amount of spray used per unit of time. This results in the use of more carrier fluid per area at the same speed of application, and the concentration of pesticide should be lowered accordingly.

Application techniques

Release height

Release height of the spray is an important factor that influences the potential for spray drift. The higher droplets are released, the greater the potential for drift. Release height of sprays should be as low as possible, consistent with nozzle specifications and target coverage requirements (see diagram below).

When boom sprayers are fitted with flat fan nozzles, boom height should not exceed the optimum height as specified by the nozzle manufacturer. The height (h) required to sufficiently overlap spray patterns varies depending on the angle of spray emission (e.g. 80°, 110°) from the nozzles. With most 110° flat fan nozzles, a minimum height of 35 cm, and a maximum of 50 cm, above the target is usually recommended.



Boom stability

On boom sprayers, adequate boom stabilisation is essential to prevent sway and dipping, which alter the height and evenness of spray. This is especially important for operation on uneven ground. Boom height may be lowered to produce less spray drift, although modification to nozzle number, type and orientation is usually required to maintain an even spray pattern across the boom. The use of wide-angle flat fan nozzles (e.g. 110°) usually permits lower boom heights to be used effectively.

3.3 Meteorology

The weather plays an important role in controlling the fate of pesticides applied as sprays. It is essential that operators engaged in spraying are aware of the immediate environmental parameters. Low cost, hand-held anemometers and psychrometers are available to monitor wind velocity and humidity respectively. The purchase of meteorological station data loggers is recommended for larger enterprises that regularly apply pesticides.

The spray operator must observe wind direction, wind speed, temperature and humidity, and check that they

are within acceptable limits before spraying takes place. The operator should record wind direction, wind speed, temperature and humidity prior to and during every spray operation.

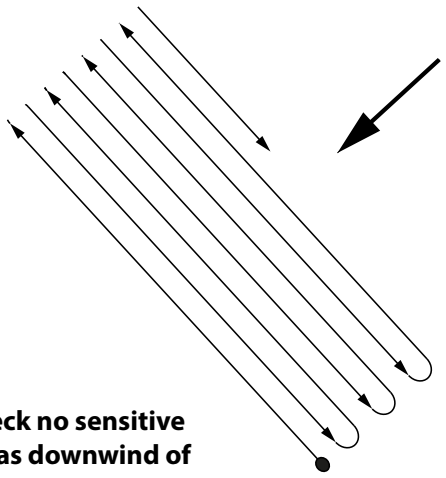
Rainfall and irrigation

It is important to time spray applications to avoid periods of rain or irrigation. Spraying onto leaves or other surfaces that are already wet dilutes most pesticide formulations and may lead to an increase in run-off, wasting the product and causing pollution. Wetting the sprayed surface after application can cause similar results depending on the 'rain-fastness' of the pesticide. Read product labels to determine appropriate practices. As a general rule, protectant pesticides (e.g. bordeaux mixture), which sit on target surfaces and contact pests directly remain vulnerable to washing off. Additives can be mixed with some formulations of pesticide to improve their durability on the target surface. Systemic pesticides are absorbed by plants if sufficient time for absorption is allowed prior to wetting and can remain active after wetting.

Wind

Direction

Droplets, particularly small ones, move with the air. Therefore, measuring the wind direction prior to and during application is essential. Importantly, the wind can be used to direct sprays away from identified susceptible areas. Do not spray when the wind is blowing towards susceptible areas.



Spraying should, where possible, be carried out with a crosswind, working into wind towards the unsprayed area (see adjacent diagram). All spray operators should be alert to changes in wind direction during spraying and modify or cancel a spray program as necessary.

Wind speed

Wind speed should be about 3–15 km/hr for most spraying operations. Droplets, particularly medium and large droplets, move greater distances in stronger wind conditions so some forms of pesticide drift can be reduced if application is undertaken during low wind speed conditions. However, spraying should not normally take place if the wind is light and variable in strength or direction.

Temperature

Whenever possible, spraying should be avoided in high ambient air temperatures. Water-based sprays are prone to evaporation, which decreases droplet size. Small droplets fall more slowly and may even remain suspended in the air, increasing the likelihood of drift and decreasing the amount delivered to the target. This is particularly true when air temperatures are high and the relative humidity is low. Initial droplet size may be increased to compensate for this, or an adjuvant can sometimes be added to the formulation to decrease evaporation. In open areas, high temperatures also mean the onset of unstable atmospheric conditions, which make it difficult to control the movement of droplets.

Humidity

Spraying of water-based sprays should not take place under conditions of high temperature and low humidity, i.e. when the wet bulb depression (a measure of evaporation potential) is greater than about 10°C. Thermometer-based whirling psychrometers or electronic hand-held instruments are available that can quickly assess relative humidity and temperature, both under shade structures and in the open.

Atmospheric stability

Stability is a term used to describe the vertical movement and mixing of air in the atmosphere (see figure 10). If the atmospheric conditions are unstable, such as occurs on a summer afternoon, the dispersion rate of pesticide sprays may be high. Spray droplets or vapours can be lifted up rather than settling, resulting in increased off-target drift.

In conditions of moderate stability where there is air movement, turbulence is created when air moves over the ground or plant canopy. This mixes air into the leaves of the plants and can assist in even delivery of pesticide droplets to targets within a leaf canopy.

Air moving slowly (less than 5–10 km/h) toward the target, without updraughts, represents ideal spraying conditions for many hydraulic spray operations.

Under very stable conditions with little air movement, such as very early mornings, large droplets fall more vertically and an increased proportion of pesticide is deposited on upper leaf surfaces. Without air movement to swirl them into the canopy, very fine droplets may even fall so slowly as to evaporate before impact and remain suspended in the air, leading to increased risk of drift during later air movement.

Temperature inversions

If the sky is clear at night, the ground can lose heat rapidly. The ground then cools the air layers adjacent to the soil surface, particularly if humidity (and thus heat capacity of the air) is low. Under these conditions, air close to the ground becomes cooler than air above. Since this phenomenon is opposite to the normal condition of the atmosphere (temperature decreasing with height), the condition is called 'surface temperature inversion'.

Temperature inversions tend to suppress the vertical movement of air and therefore, in effect, present a

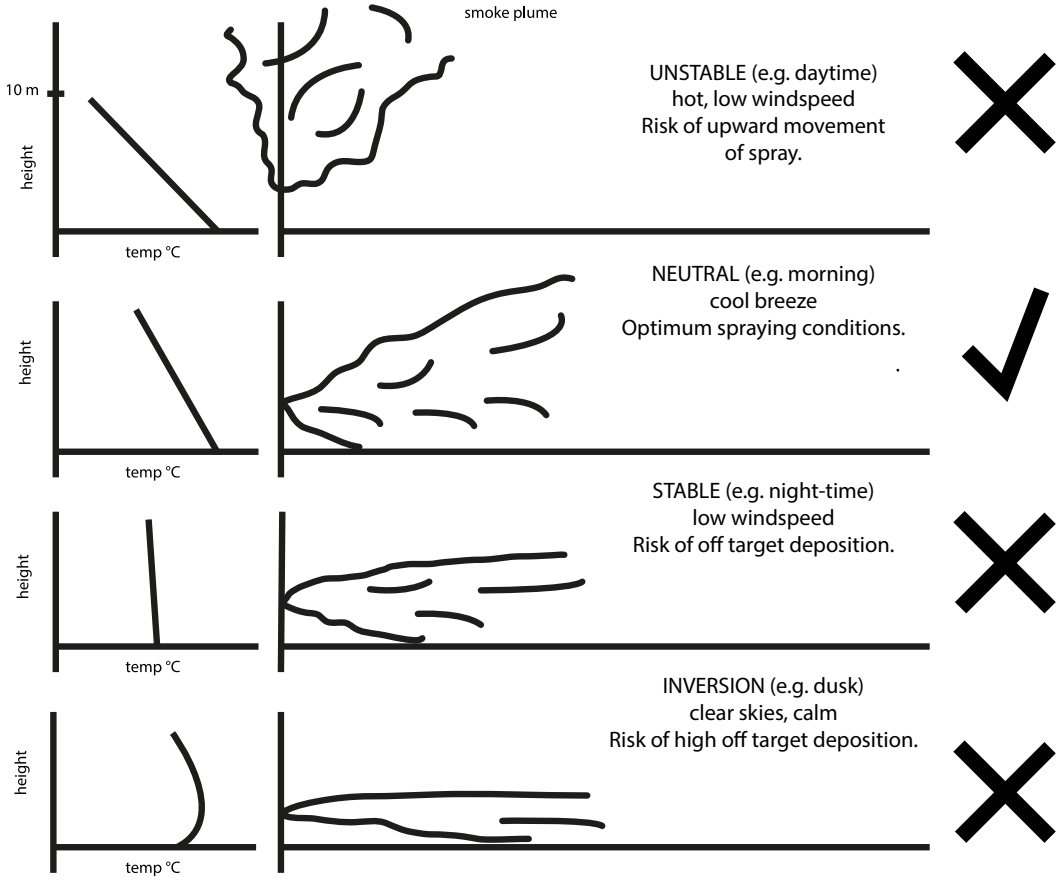


Figure 10. Basic guide to air stability showing the behaviour of smoke or dust under various stability conditions

barrier to the transport of small droplets to the crop canopy. Inversions usually form under very low wind speed conditions.

Spraying should be avoided under such circumstances, since small droplets are capable of remaining airborne for long periods after drifting above an inversion layer. This has been known to cause severe damage several kilometres away from where spraying took place.

Assessing conditions

Spraying should therefore ideally take place in neutral atmospheric conditions with slight air movement. The stability of the atmosphere can be assessed using smoke, or driving a vehicle along a dusty track. Movement of material up into the air indicates instability and concentration of smoke or dust within a thin layer indicates the presence of a surface temperature inversion.

3.4 Vegetative buffers

Trees and shrubs planted downwind of an agricultural area or nursery boundary can be used to capture droplets moving out of the sprayed area and thereby reduce spray drift. Their use has been trialled by several commercial nurseries.

Principles of buffers

If a dense barrier is presented to airflow, air tends to flow up and over the barrier. This is illustrated in figure 11a, where the airflow deviation over a solid board (0% porosity) placed in a wind tunnel is shown. The region directly behind the barrier is characterised by low pressure and turbulent eddies. Dense, low porosity structures are less effective in trapping the droplets moving with the air except in the immediate region behind the barrier because small droplets (under 100 µm) move readily in the airstream and are carried above and around the barrier.

A porous barrier, however, allows some air to pass though its structure while still deflecting some airflow over the top. This is illustrated in figure 11b where a nylon mesh with 50% porosity (50% solid and 50% open) was placed in a wind tunnel. The figure shows that there was less deviation of air over the top of the barrier compared to the solid barrier. The airflow behind the barrier was also straighter and less turbulent than behind the solid barrier. With a porous barrier, droplets can be carried through a buffer and this increases the chance of capture within the buffer

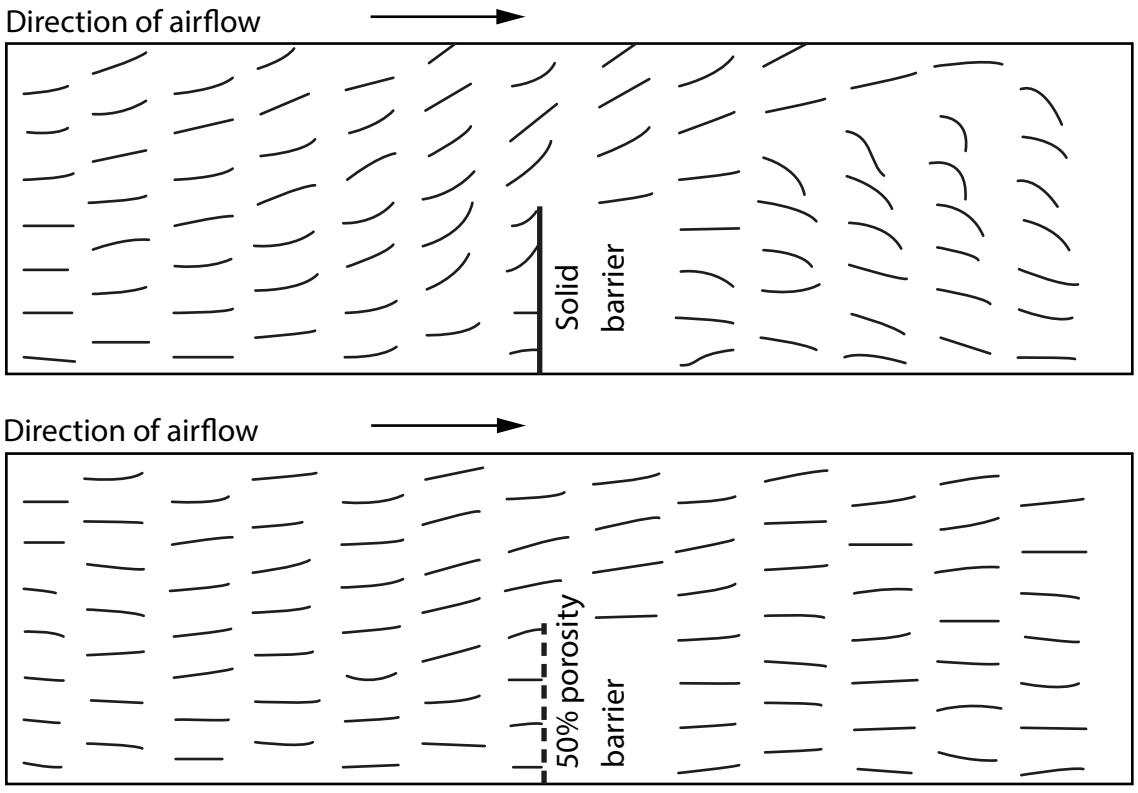


Figure 11a and 11b. Effect of barrier porosity on airflow characteristics

structure. A porous barrier can effect a greater removal of spray droplets than a solid barrier.

Using vegetation as a buffer

In designing vegetative buffers, the primary aim is to maximise the catching surface for the spray droplets while also minimising the amount of airflow passing around the buffer. This is not designed to be a complete windbreak, but more of a strainer or filter. The aim of a vegetative buffer is to use the natural surfaces (leaves, stems, flowers and seeds) of the trees or shrubs to catch pesticide droplets as they move in the air through the vegetation. Vegetative elements that present a small frontal area to the moving droplets are the most successful at catching droplets. Trees such as the river she-oak (*Casuarina* spp.) that have thin, needle-like foliage and numerous small branches are particularly suitable. Large leaves that are covered in small hairs can also be very efficient at removing droplets. Most natural surfaces are not smooth. Plants may have a complex rough surface comprising small protruding spikes or hairs and leaf veins. All these factors help to increase the catch efficiency of the plant. Movement of the leaves caused by the flow of air around shrubs and trees also increases the efficiency of small droplet capture.

Constructed buffers

Due to the intense land use of nurseries, it can be more convenient to erect artificial buffers using shade cloth and timber posts. These require no growing time and have the added benefit of retaining humidity and reducing the vulnerability of stock to wind damage. Contact your state Nursery Development Officer for information on construction details, or read the Nursery Paper *Windbreaks, an investment in quality and profitability.*[10]

Height of buffers

Because turbulence causes dispersion of a spray cloud, and it 'spreads' vertically as well as horizontally, a vegetative barrier must be higher than the release height of the spray. The greater the density of the buffer (the lower the porosity), the higher a barrier needs to be in relation to the spray release height. Wind tunnel tests have shown that the minimum height of the barrier should be at least one and a half (1.5) times the release height of the spray for a barrier with 50% porosity. If the porosity is reduced to 40%, the minimum height of the barrier increases to double (2 times) the release height.

For a solid barrier the required height approaches infinity, so solid barriers are not suitable unless they entirely enclose the sprayed area (as per a poly or glasshouse). As a general guide, the minimum height of the buffer should be double the release height (see figure 12). For example, if spraying is conducted by hand at a release height of one metre, then the buffer height should be at least two metres.

Width of buffers

The wider the buffer, the greater their ability to reduce spray drift. With a wide buffer it is possible to increase the number of surfaces available for droplet collection without significantly reducing the airflow through the buffer. A wide buffer is impractical in many rural–urban interfaces, so a compromise may sometimes be needed.

Distance of buffers from spraying

The closer the vegetative buffer is to the release point, the greater the proportion of spray that will be intercepted. Figure 13 shows that a vegetative buffer at position A would tend to intercept a greater proportion of a spray cloud than a buffer located at position B. However, the

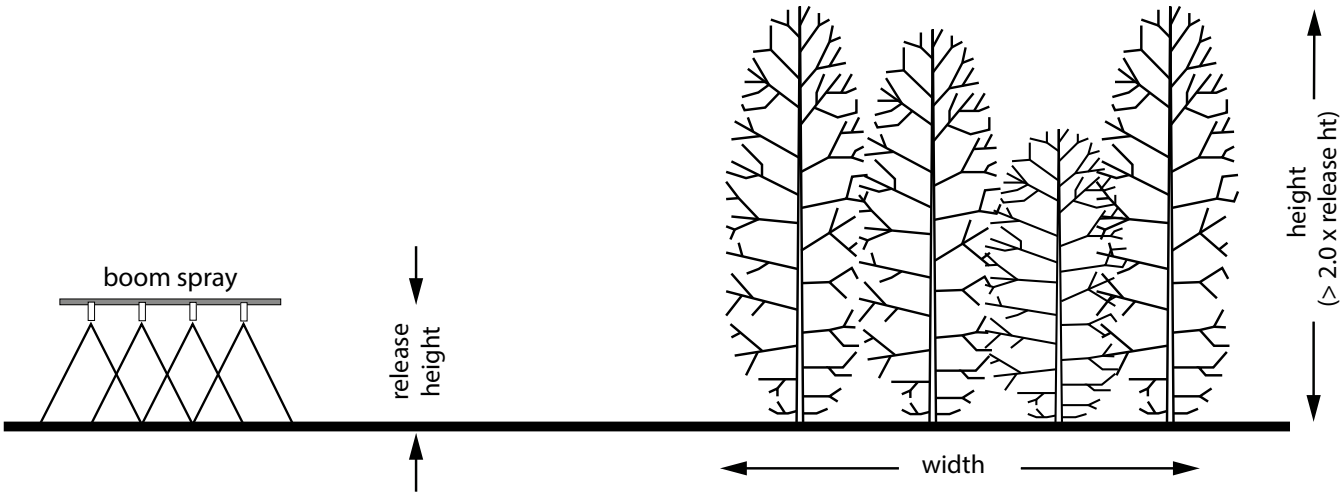


Figure 12. Optimum vegetative buffer dimensions

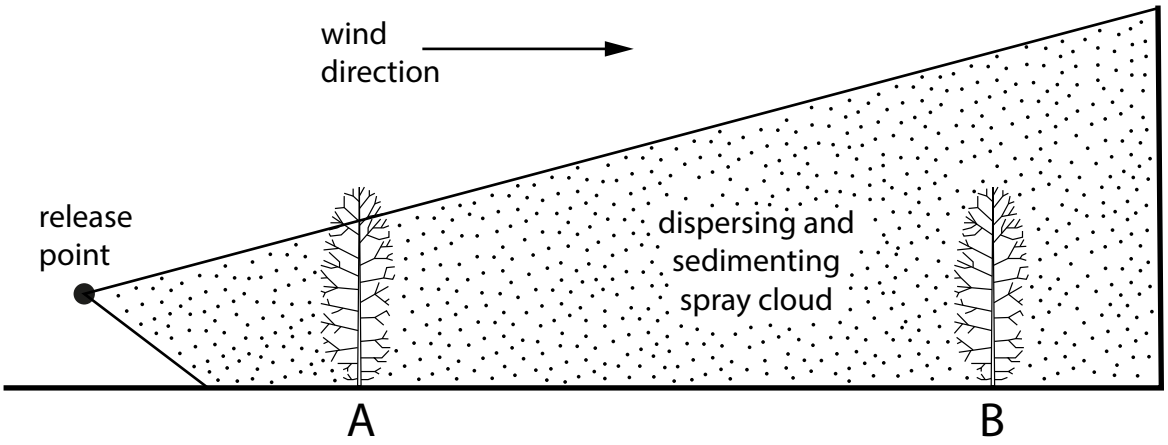


Figure 13. Effect of distance from release point

concentration through the spray cloud is not constant and usually tends to be greatest near ground level. A buffer at position B could still be expected to intercept a reasonable proportion of the airborne droplets.

[10] *Windbreaks, an investment in quality and profitability*

Planning guidelines in queensland

In 1997 the Department of Natural Resources in Queensland introduced the *Planning Guidelines: Separating Agricultural and Residential Land Uses*[11]. The guidelines have the following objectives:

1. To protect the use of reasonable and practicable farming measures that are practiced in accordance with the *Environmental Code of Practice for Agriculture* and associated industry-specific guidelines.
2. To minimise scope for conflict by developing where possible, a well-defined boundary between agricultural and residential areas and not interspersing agricultural and residential areas.
3. To minimise the impacts of residential development on agricultural production activities and land resources.
4. To minimise the potential for complaints about agricultural activities from residential areas.
5. To provide residents with acceptable environmental conditions in residential areas that are located adjacent to agricultural production areas.

The Queensland guidelines specify a minimum spray drift buffer width of 20 metres planted with trees and at least 10 metres clear of vegetation to either side of the vegetated area to give a total buffer width of 40 metres[11]. A schematic cross-section of this arrangement is shown in figure 14. A 20-metre clear area, (10 metres either side of the buffer) is included in the design to provide a fire break, allow access to the buffer for maintenance and limit solid structures immediately next to the buffer elements. Provided the requirements of the guidelines can be met by other means, the guidelines do allow buffer layouts to be altered. The Queensland guidelines provide a sound minimum basis for the construction of buffer areas between conflicting land uses.

[11] *Planning guidelines, separating agricultural and residential land uses*

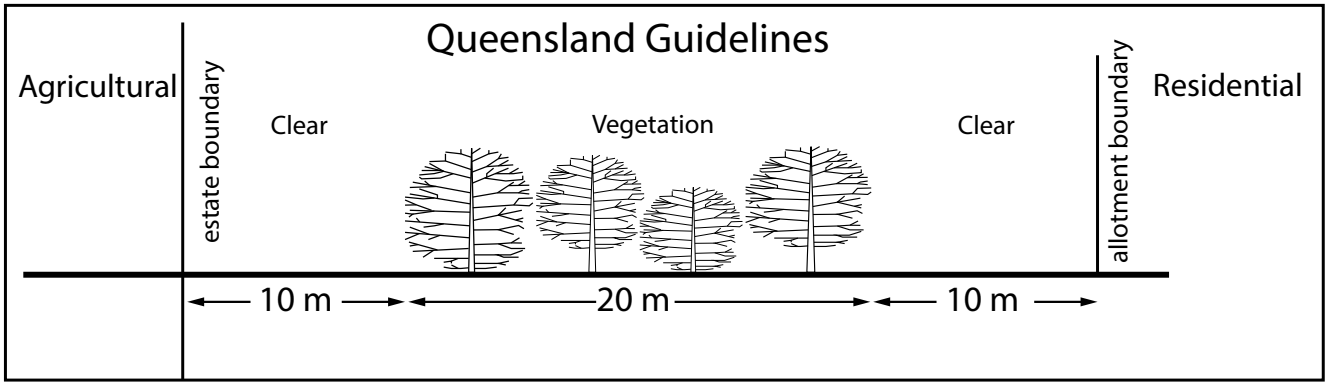


Figure 14. Schematic illustration of vegetative buffer required for spray drift mitigation as defined by *Planning guidelines: Separating agricultural and residential land uses*[11] (DNR 1997)

3.5 Spray drift strategy summary

In summary, operators can manage off-target movement of sprays in the nursery if they:

- *Identify all areas around an area to be sprayed that could be susceptible to spray drift damage.*
- *Communicate on a regular basis with neighbours regarding proposed spray schedules and activities.*
- *Maintain a copy of relevant safety data sheets (SDS) for all pesticides stored and used.*
- *Read, understand and follow the pesticide product label prior to mixing and spraying.*
- *Observe and record wind direction, wind speed, temperature and humidity prior to and during application.*
- *Avoid spraying when air is moving toward susceptible areas.*
- *Avoid spraying if the wind is light and variable in strength or direction.*
- *Spray water-based sprays when temperatures are the lowest (in a 24 hr cycle).*
- *Avoid spraying water-based pesticides under conditions of high temperature and low humidity.*
- *Spray when atmospheric conditions are neutral.*
- *Avoid spraying during highly stable conditions or when surface temperature inversion exists.*
- *Spray with a crosswind and progress upwind.*
- *Ensure spray equipment is correctly calibrated and appropriate nozzle systems are selected.*

CHAPTER 4.

PESTICIDE APPLICATION EQUIPMENT AND TECHNIQUES

A wide variety of pesticide application equipment is available. Assess the suitability of the equipment for the specific task and choose appropriate application techniques.

4.1 Sprayer types

Sprayers used in plant nurseries are commonly classified according to the volume of spray they apply per sprayed area. Application type and delivery volumes are determined by the choice of nozzle. It is the nozzle that delivers the spray solution as spray droplets are distributed over the treatment area.

Nozzle selection is one of the most important considerations when selecting a sprayer. In this manual, nozzle types have been separated into three categories according to the way they are used when fitted to pesticide application equipment used in nurseries: 1. high volume, 2. low volume and 3. ultra low volume.

High volume

High volume sprayers are the most common types of sprayer used in nursery operations. Application rates range from about 200 L/ha to over 2000 L/ha. High volume sprayers are typically used where the label refers to spraying to run-off. Hydraulic nozzles such as flat fan and hollow cones or adjustable hand guns are typically used on high volume sprayers. These sprayers may range from small units such as the Silvan Selecta® range, up to large, purpose-built units such as the QuikSpray 9TBE®.

Low volume

Low volume sprayers are used as an alternative to high volume hydraulic sprayers for pesticide application in plant nurseries, particularly where label rates are expressed as a volume of chemical per unit volume of spray solution (e.g. 300 mL per 100 L of water). Although they may be more expensive, they may also provide better target coverage. Some low volume sprayers may also reduce the time required for spraying and, therefore, cost of labour. Low volume equipment typically uses

air-shear or spinning discs (commonly referred to as CDA or 'controlled droplet applicator' nozzles) to generate droplets. Examples of air shear include the Silvan Turbomiser® and the Hardi® backpack mister. The ULVA+® and Herbi4® sprayers are examples of CDA technology.

Ultra low volume

Ultra low volume sprayers used in nursery applications are commonly called foggers and they apply very low volumes (less than 10 L/ha) of chemical mix. In some cases, the pesticide is applied neat or directly from the container without any mixing with water. The use of ultra low volume systems is only possible if the spray is delivered as very small droplets. Examples include the Curtis Dyna-Fog® and the pulsFog®.

4.2 Sprayer components

Sprayers come in a large range of types and sizes, from small, hand-held sprayers to large, self-propelled machines. While there is such a large variety, there are some basic components that are found on nearly all types of sprayers (see figure 15). The basic components used in liquid application systems include:

- nozzles to generate droplets
- a method of holding the nozzle so that the spray is directed towards the target (e.g. boom)
- a frame or chassis and drive
- a tank to hold the chemical
- a method to make liquid flow (e.g. pump)
- an agitation system to keep the spray solution well mixed
- pressure regulators and control valves
- a filtration system (suction and pressure in-line filters)
- auxiliary equipment, such as a clean water tank, diaphragm check valves and spray management valves.

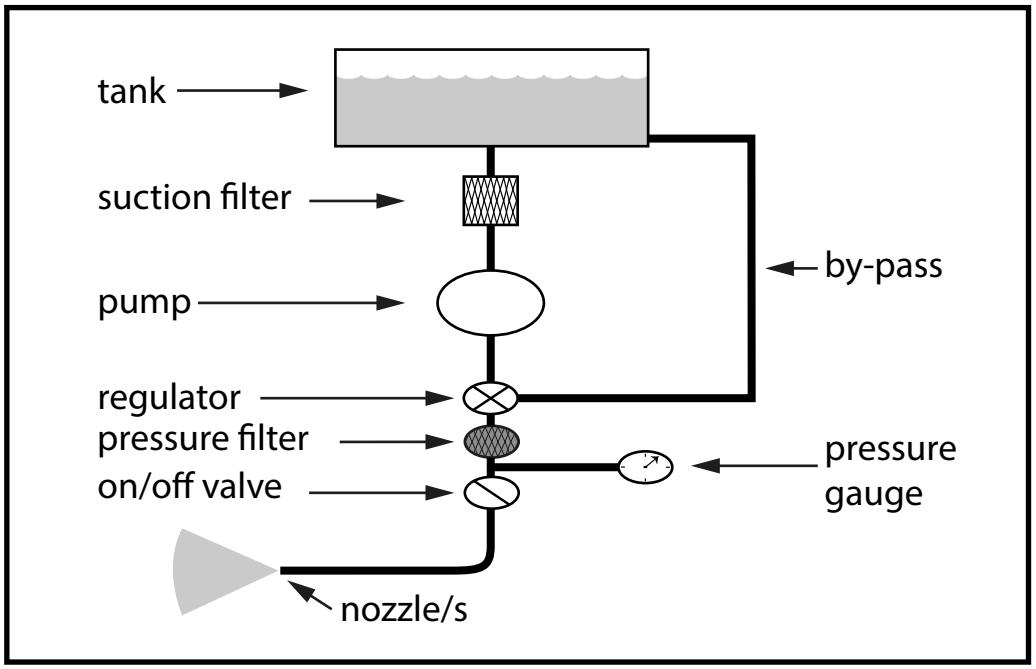


Figure 15. A typical layout of application equipment (high and low volume) used in the nursery industry

Tank

The spray tank should be of an appropriate size for the type of sprayer used and the volume of pesticide mixture required for the area to be sprayed. The shape of the tank should allow for easy access for filling and ease of drainage and cleaning. A small sump in the tank is generally recommended so that a minimum amount of liquid remains within the tank after the majority of the spray solution has been used.

Materials used in tank construction need to be resistant to chemicals, non-corrosive, not easily damaged, resistant to sunlight and easy to repair. A gauge showing volumes at various percentages of fill is important.

Pump (liquid flow)

The spray liquid is usually forced through the nozzle using a pump to generate pressure. Some hand-held systems such as the ULVA® and HERBI® use gravity for the liquid to flow (tank positioned higher than nozzle). A wide variety of pumps are available for application systems. Examples include diaphragm, centrifugal, piston, roller, and gear pumps. Pumps used in nursery situations are commonly powered by a 12 V battery, a separate petrol motor on the sprayer or a tractor driven power take-off (PTO).

When selecting a pump, the following factors should be considered:

- the operating pressure required
- the output (L/min) of liquid required
- power requirement to drive the pump
- type of chemicals to be used
- durability of the pump
- costs.

Agitation system

Many chemical formulations consist of fine powders or particles that need to be held in suspension in the chemical mix. If the mix is left to stand, these particles may settle on the bottom of the tank. A system to agitate or mix the chemical is therefore required. This is usually achieved by recirculating some of the spray mix back to the spray tank. The pump output should be greater than that required to operate the nozzle to allow recirculation back into the tank during spraying. Once flow to the nozzles is stopped, the total flow from the pump is redirected back into the spray tank. Sometimes special fittings are used on the bypass system to increase the agitation in the tank.

Other methods of agitation include mechanical systems, such as a rotating paddle, or manual agitation, by physically shaking the tank of small hand-held equipment. Pesticide labels should always be consulted to determine any specific requirements for agitation.

Pressure regulators and control valves

Liquid flow rate and pressure to nozzles must be controlled to ensure that sprayer output is consistent. This is generally achieved by use of pressure regulators and/or control valves. These may be operated manually or electronically, particularly for the larger sprayers. All systems MUST be fitted with a pressure gauge. The gauge should be positioned as close as practicable to the nozzles and be clearly visible to the operator. On tractor mounted equipment, two separate pressure gauges may be necessary, one visible to the operator and the other nearer to the nozzles used for calibration and set-up of equipment.

Filtration system

Filters are required to prevent nozzle blockage. Blockage results in wasted time, increased risk of chemical exposure if nozzles or filters require cleaning in the field and poor coverage in the field if individual nozzle blockages are not detected. Factors such as the water source, pesticide formulation and pump agitation capability influence the type of filtration system required for the sprayer.

There are typically several stages of filtration in liquid application equipment. These stages and typical mesh sizes are listed below. Mesh size is defined as the number of openings along a linear inch. Thus 100 mesh has 100 openings along a linear inch, or 10 000 openings per square inch.

Filter stage	Typical mesh size
Tank inlet filter	50 mesh
Suction filter	40–80 mesh
Pressure line filter	40–80 mesh
Nozzle filter	50–100 mesh

For hydraulic nozzle operation, the manufacturer's recommendations should be followed. The fitting of pressure in-line filters with easy access and colour-coded filters is recommended. For positioning of the pressure in-line filter, refer to figure 15.

Auxiliary equipment

Auxiliary equipment such as a fresh water tank and chemical handling equipment can be added to a sprayer system for increased safety and easier preparation of chemicals. Smaller chemical tanks such as chemical induction hoppers can be added to the side of the larger tanks at an accessible height to allow safe pouring of chemicals. Clean water tanks are important for hand washing and use in emergencies when clean water may be unavailable in the field.

4.3 Spraying equipment

Symbols describing spraying equipment

To assist in ease of use and economy of space within the manual, symbols have been used to indicate certain aspects of spray application. These symbols are listed and described below and on page 2. The symbols have been included with the general descriptions and advantages and disadvantages of each piece of pesticide application equipment described in this chapter.

Where one or more symbols have been included with the description of the equipment, this indicates that this piece of equipment is suitable for the use or uses that each of those symbols indicates.

For instance, some sprayer types are suitable for use at a range of volumes and may have all three sprayer type symbols included with their descriptions, whereas others may only be suitable for use at one volume, such as many of the ultra low volume sprayers. Some sprayers may produce a wide range of droplet sizes, while others may produce a narrow range of droplet sizes.

Some sprayers will be useful in a range of nursery operations, whereas others may be limited to glasshouse, polyhouse or outdoor use.

The symbols are used to indicate what sprayer type, droplet size, pesticide type, nursery design, expected coverage and nursery size may be suitable for each type of application equipment discussed.

If in doubt about any of the symbols used in this chapter, please refer back to this key.

> ***Always refer to the manufacturer's catalogue when selecting or fitting appropriate accessories such as nozzles, handpieces, etc for pesticide application.***
>
> ***Be sure to check the output and nozzle specifications to ensure that they are appropriate for the task intended.***

Key to symbols used in this manual

Sprayer type


Ultra low volume


Low volume


High volume

Nursery design


Open plan


Shade house


Glasshouse

Droplet size

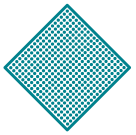

Fine and very fine


Medium


Coarse

Coverage


Spot spray


Blanket spray

Pesticides


Fungicides


Herbicides


Insecticides

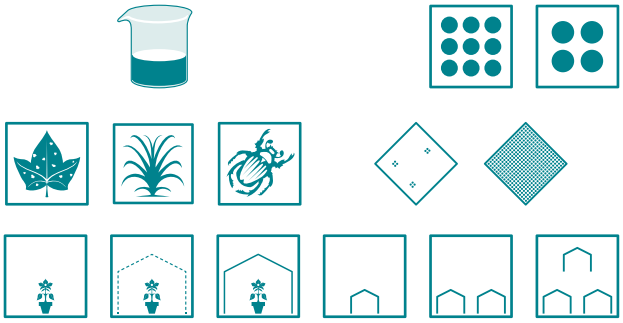
Nursery size


Small


Medium


Large

Hydraulic nozzles



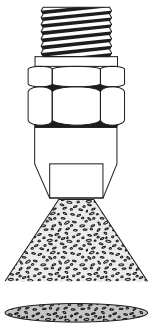
Hydraulic nozzles come in a wide variety of designs. Droplets are formed by forcing the spray liquid under pressure through specially designed holes, or 'orifices', in the body of the nozzle. The most common types of hydraulic nozzles are the flat fan and hollow cone nozzles. The spray patterns produced by these two nozzle types are shown in the diagrams below. In general, flat fan nozzles produce a slightly larger droplet size than the hollow cone nozzle and can be operated at lower pressures than hollow cone nozzles.

The droplet size produced by hydraulic nozzles increases as the orifice size is increased (allowing higher flow rates) or as the operating pressure is decreased. Decreasing pressure also decreases the angle of the spray pattern.

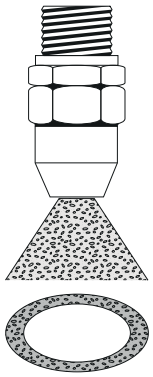
Most manufacturers of hydraulic nozzles now produce low drift nozzles that are designed to produce larger droplet sizes under typical operating conditions. The larger droplet sizes can assist in reducing drift, but may also reduce coverage on plant surfaces due to the lower number of droplets that are generated per volume of spray liquid. Drift reduction nozzles produce larger droplets through minor charges to the nozzle design. Typically, these changes are in the form of a pre-orifice or by air inclusion in the liquid.

Hydraulic nozzles are usually mounted at or near the end of a hand lance or hand gun, or along a boom.

Flat fan nozzle



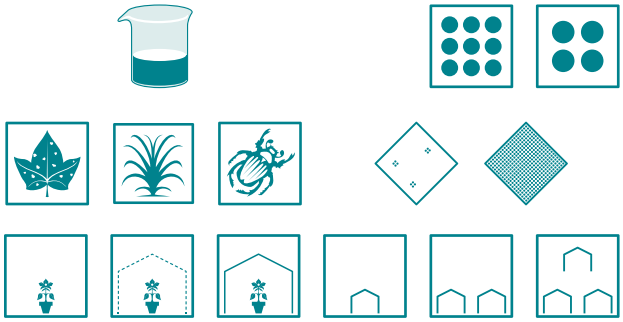
Hollow cone nozzle



Advantages	Disadvantages
• versatile • low cost • nozzles are easy to use—no moving parts • nozzles can be used for a wide range of situations • nozzle components are easily changed • parts are of a simple design • the wide droplet spectrum allows for some operator error	• difficult to get uniform coverage • nozzles are prone to wear • nozzles require regular calibration • pressure and distance to target must be known • air assistance is sometimes required for efficient small droplet capture on targets • nozzles generate a wide droplet spectrum that can lead to wastage and/or pesticide drift

NOZZLES: HIGH VOLUME

Hand guns



The hand gun is the most commonly used spray nozzle in nursery situations. They are usually operated at a high pressure of 10–30 bar (150–450 psi), although lower pressure versions are available. Due to this high pressure, hand guns are able to throw the spray liquid long distances, which enables the operator to stand in walkways and direct the spray to the far side of racks or bays. However, this increased throwing distance encourages the production of large droplet sizes. These large droplets may lead to poor coverage, particularly on lower leaf surfaces, excessive use of pesticide mixture, run-off and contamination of the environment. The use of too high a pressure can also result in very fine droplets being produced (misting). These fine droplets are prone to drift away from the application area and may also contaminate the operator. The high pressure may also result in damage to foliage nearest to the release point from the hand gun.

Spray guns may have either a fixed swirl chamber or an adjustable swirl chamber that allows a change of spray angle and thus the spread of the spray. Adjustable nozzles can provide spraying flexibility, however a greater degree of operator knowledge is required to correctly use these nozzles. Changes to flow rate, operating pressure, width of the spray, throwing distance and droplet sizes will all influence the effectiveness of pest management. For details of these influences refer to chapter 3 of this manual.

The trigger on adjustable nozzle guns allows the operator to change the flow rate and nozzle performance. While this has practical advantages, it makes these systems difficult to calibrate when using products that need to be applied on a volume per unit area basis (e.g. L/ha) rather than a volume per volume or concentration basis (e.g. 300 mL per 100 L of spray solution).

Sprayer units fitted with a high-pressure hand gun can be mounted on tractors, trailers or hand-pushed carts, which increases manoeuvrability. One significant disadvantage of the hand gun is that the coverage is dependent upon the individual spray operator. Some product labels recommend that the volume of spray has to be applied until run-off occurs on the plant. This definition of 'run-off' is an ambiguous term and the amount applied by different operators can vary considerably across a target area. Run-off also results in loss of spray into the environment.

Advantages	Disadvantages
• versatile—can be used for all spraying operations • nozzles may be adjusted to suit operating conditions • relatively inexpensive • can be used in various sizes of nursery	• difficult to calibrate • highly subject to operator error • difficult to achieve uniform coverage • high risk of run-off and environmental contamination

Air shear sprayers

Air shear nozzles use high-speed air (up to 300 km/hr) to convert the spray solution into droplets. The spray liquid is fed at low pressure to the nozzle through a suitable restrictor and the jet of liquid emerging at the nozzle orifice is then sheared by the high speed air into droplets that are carried to the target in the air stream produced by the sprayer.

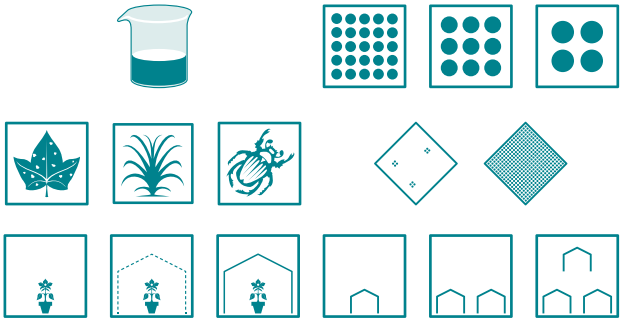
Droplet sizes generated from air shear nozzles are usually fine to very fine. The most important variable determining droplet size is the air:liquid ratio. Larger droplets are obtained with increased liquid flow and/or through a reduction in air velocity. The spray liquid should be spread into a sheet to maximise the effect of airflow and obtain efficient break-up into droplets. Variation in droplet size depends to some extent on the design and position of the spray liquid orifice in relation to the airstream.

Air shear systems may have a high power requirement because of the need to produce high-speed air for the efficient formation of small droplets. Such systems range from backpack misters to large tractor powered units such as the Turbomiser®. Hearing protection is generally required when operating these systems due to the noise generated by the motor and fan. Newer models of backpack misters tend to be quieter and may be preferable to older models.

The air used in the production of the droplets can also be used to constrain droplets within the airstream and to direct the droplets towards the target. This can increase the droplet capture and coverage on the target. Various deflectors and diffusers can be used to manage and direct the droplet-laden air to the targets.

Advantages	Disadvantages
• small droplets can result in good coverage under suitable conditions • air movement can aid penetration into canopy and droplet capture on targets • spray covers a large area quickly • changing air/liquid flow can alter droplet size • low quantities of carrier fluid required	• cost of equipment • high level of operator knowledge required • small droplets are prone to drift • high power requirement • not suitable for spot spraying • can be noisy

Controlled droplet applicators (CDA)



Controlled droplet application (CDA) is a method of producing droplets using spinning discs or cages. CDA sprayers produce a narrower range of droplet sizes compared to hydraulic nozzles. The droplet sizes produced by CDA sprayers can be increased or decreased by changing the rotational speed of the disc or the flow rate of the liquid, or a combination of both. The selection of the disc or cage type is also important for managing droplet size.

Rotational speed for battery operated equipment, such as the Herbi 4® or ULVA® CDA sprayers can be affected by the number of batteries or the charge of the batteries. Flow rate can also be affected by the viscosity of the liquid. In some models the flow rate can be changed by changing the metering orifice.

- To produce smaller droplets—increase rotational speed, or decrease flow rate, or a combination of both.
- To produce larger droplets—decrease rotational speed, or increase flow rate, or a combination of both.

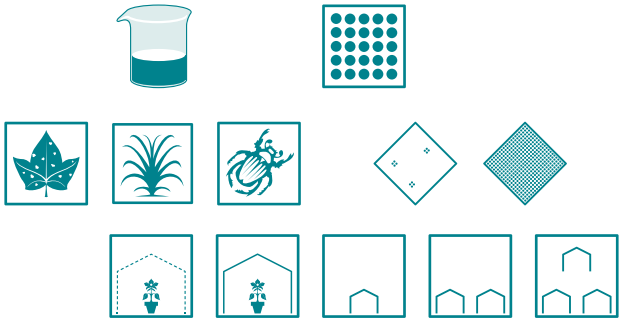
For optimum outcomes and management of the droplet sizes, refer to the manufacturer's handbook. The selection of disc or cage types is important in managing the droplet spectrum produced by the sprayer.

Small discs spinning at high speeds can produce fine droplets that considerably increase the target coverage when applying insecticides and fungicides. Many of these systems, such as the ULVA +®, use a fan with the spinning disc to direct droplets towards the desired target. This can further increase coverage by improving penetration and target capture of the spray droplets. ULVAs have smaller discs that spin at higher speeds and are better suited to insecticide and fungicide operations in controlled environments such as glass or polyhouses. Herbis, on the other hand, have larger discs that normally spin at lower speeds and produce larger droplets. They are typically used for herbicide application.

Advantages	Disadvantages

• a narrow range of droplets can be produced
• uniform droplet size
  » Herbi® units minimise small droplets (minimising drift)
  » ULVA+® units minimise large droplets (minimising waste and carrier volumes)
• air assistance can be used to increase coverage/ penetration
• nozzle systems can be tailored for the production of certain droplet sizes (e.g. high speed small discs produce fine droplets, low speed large discs generate larger droplets)
• generally light weight and low energy use
	• most nozzle systems require relatively complex motorised components
	• for effective use, specialist knowledge and a high level of understanding is required
	• accurate droplet formation requires the correct disc or cage, rotational speed and liquid flow rate
	• may be difficult to calibrate, as swath width may vary depending on wind conditions and operating height
	• battery driven models may need regular recharging or battery replacement

Electrostatics



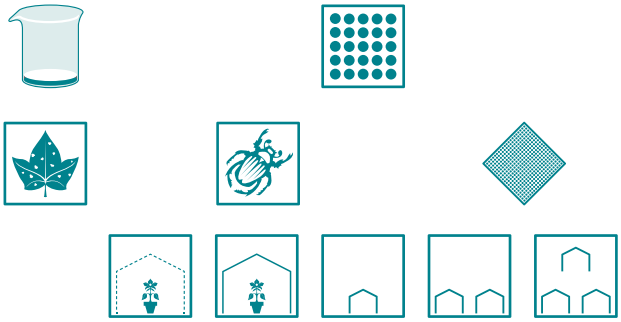
In electrostatic sprayers the spray material is given a static electric charge as it travels through the nozzle. In theory this can help to create droplets that are more uniform in size, which disperse more evenly because they repel each other, since all droplets carry a like charge.

Several styles of electrostatic sprayers are available. They require an independent power supply to charge the tank. Other units are cart-mounted with an integral compressor powered by a petrol engine or electric motor. Electrostatic sprayers work best if the sprayer-to-target distance is less than 4–5 m.

Penetration of spray into a dense canopy and coverage onto the under leaf surfaces can be poor because the droplets are attracted to the nearest surface, which may well be the outer foliage of the plant. Electrostatic charging is only effective for small droplets. The charging may also not be sufficient to overcome other effects such as wind, so they are best used in controlled environments such as glasshouses or polyhouses.

Advantages	Disadvantages
• small droplets potentially give a more uniform coverage on both upper and lower leaf surfaces	• high operator hazard as spray can be attracted to operator and equipment • very high level of knowledge required for successful use • high level of maintenance

Cold foggers



Cold foggers, also known as mechanical foggers, use high-pressure pumps and atomising nozzles to produce very small fog-sized particles of less than 15 µm. Distribution of the spray material is through a hand-held gun or external fan unit. With the fan unit, the distance and the area that can be treated depend on the capacity of the fan. Multiple units or multiple settings may be needed to cover large areas.

Often it is difficult for fine droplets to penetrate dense canopies, however, many studies have shown good pest management has been achieved using foggers.

Safety is important when using a mechanical fogger employing a high-pressure pump. Hands and arms must be kept away from the outlet because at 2000–3000 psi spray particles can penetrate the skin very easily. Information should also be gathered on the length of time that fog stays suspended in a still or controlled environment to determine the period for safe re-entry to the area.

Advantages	Disadvantages
• blanket spray • suitable for glasshouse/polyhouse application if appropriate products are used • very small droplets can result in good coverage	• drift • operator hazard • can't spot spray • small droplets may not penetrate dense plant canopies

Thermal foggers

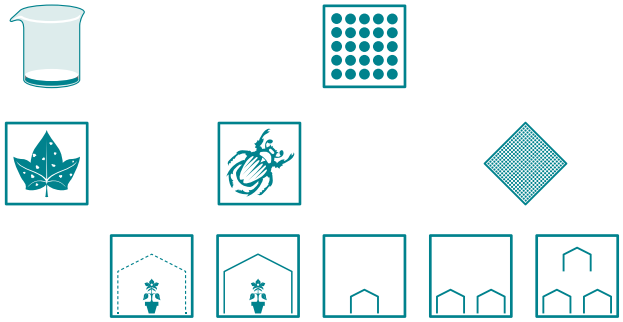


Photo: pulsFOG Germany

Thermal foggers require a specially formulated carrier that is mixed with the pesticide to improve uniformity of droplet size and distribution of the spray material. The carrier also decreases molecular weight, allowing the particles to float in the air for up to six hours without settling or evaporating. This means the spray is able to penetrate far into the structure rather than settling near the spray unit. This can be a disadvantage when access to the treated area is required. Venting of the treated area before access must be considered.

A thermal fogger uses a system similar to that used in jet engines. The pesticide is injected into the extremely hot, fast moving air stream, where it is vaporised into fog-sized particles. Moving from one end to the other, a hectare can be covered in as little as 30 minutes.

Air circulation systems in a building will improve the uniformity of coverage and foliage penetration.

The temperature and humidity in the greenhouse can also affect the spray droplets. Under high temperatures and low humidity, the spray droplets will tend to fall out of the air quicker and increase the level of deposits on the upper leaf surfaces.

Due to the level of noise generated by thermal foggers, hearing protection should be worn when using this equipment.

Advantages	Disadvantages
• blanket spray • suitable for glasshouse or polyhouse use • very small droplets can result in good coverage, particularly when combined with air movement • saves time in spraying	• drift • operator hazard from small droplets and noise • spot spraying is impossible • small droplets may not penetrate dense plant canopies without air movement

NOZZLES: OTHER

Wick wipers

Rope wick applicators are a convenient way of applying herbicides to manage weeds in plant nurseries. They produce no drift and therefore can be used close to other plants. They are ideal for weed management on paths, particularly in retail situations where the opportunities for spot spraying may be limited.

Rope wick applicators are used for wiping translocated herbicides (e.g. glyphosate) onto the foliage of susceptible weeds. They consist of a container from which the pre-mixed spray solution is able to soak an absorbent surface without dripping excess liquid.

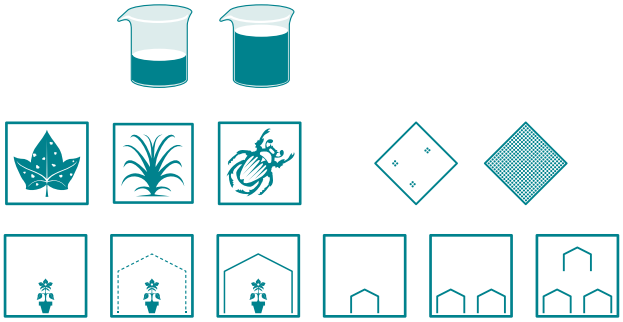
The main problems with wick wipers are the difficulties in avoiding dripping, or conversely, having too dry a wick, and accumulation of dirt on the surface of the applicator. The hand-carried rope wick applicator is mainly used for spot treatment of weeds on paths and between beds where the likelihood of the wick contacting nursery plants is minimal.

Advantages	Disadvantages
• no drift • low cost • easy to use	• translocated herbicides only • products recommended for use in wick wipers are usually non-selective

NOZZLE HOLDERS : HYDRAULIC SPRAYERS

On many nursery sprayers the nozzle-holding device is hand-held by the spray operator. Nozzle-holders can incorporate structures such as shields to minimise drift or otherwise modify the spray pattern and management (e.g. diaphragm check valves).

Hand-held nozzles



For most sprayers used in nursery situations the nozzle is held by hand and manually directed towards the target. The nozzle may either be a hydraulic hand gun or hydraulic nozzle at the end of a lance. More than one hydraulic nozzle may be used on a small boom arrangement. They usually have a trigger or tap to enable the operator to quickly and easily start and stop liquid flow to the nozzle.

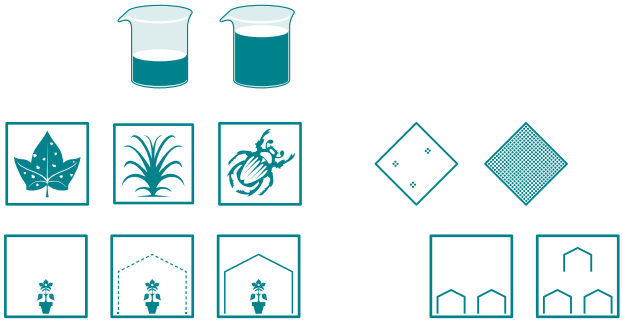
The nozzles can be at the end of a long flexible hose connected to the remainder of the sprayer components, which can then be parked at a convenient location. This approach allows greater freedom for the operator to move around the nursery. The hose is usually manually rolled and unrolled but some units (e.g. QuickSpray®) have a radio controlled unit to remotely coil and uncoil the hose.

When applying the pesticide mixture to the target, the operator needs to carefully move the nozzle in such a way that uniform coverage of the target is achieved over the entire treatment area.

Advantages	Disadvantages
• flexible operation—able to manoeuvre around nursery structures such as irrigation risers and building supports	• difficult to calibrate • operator exposure due to direct handling of nozzle and hoses • uniform deposits difficult to achieve

NOZZLE HOLDERS (VEHICLE-MOUNTED)

Boom sprayers



Vehicle-mounted boom sprayers can be used to treat larger areas within the nursery more uniformly than is possible with hand-held equipment.

A boom is a structure on which more than one nozzle is mounted. The boom is usually attached to the other components and driven along roadways with the boom directed over the target area (plant bed). Most booms are mounted at the rear of the spray tank, although some are in front so that the operator can see the position of the nozzles in relation to the rows. The front mounted boom position can result in increased risk of operator exposure to the pesticides.

For nursery sprayers a single-, or occasionally, a double-wing boom is used. During spraying, the outer sections are often mounted so that they can be moved out of the way of any obstructions. Manufacturers have used various methods to pivot and fix the boom sections for easy handling. Normally, the booms are unfolded by hand, but on some sprayers, positioning of the boom can be managed hydraulically without the operator leaving the tractor or vehicle.

A wide range of hydraulic nozzles can be fitted to the boom. The nozzle body may be screwed into openings along the boom, but often the boom incorporates special nozzle bodies clamped to the horizontal feed pipe. A diaphragm check valve should be used with each nozzle to prevent dripping of liquid when pressure to the boom is low (i.e. the vehicle is stationary). Nozzles are evenly spaced along the boom and the height of the boom should be adjusted according to the type of nozzle being used and the manufacturer's recommendations.

The pattern from each nozzle has to be overlapped to achieve as uniform a distribution of spray as possible across the whole boom. Some operators use a double overlap. If the boom is set too high drift potential is increased and excessive overlap can occur, resulting in very uneven distribution. The subsequent 'peaks' and 'troughs' occur with both fan and hollow cone nozzles, but are generally more pronounced with hollow cone nozzles. Uneven distribution also results if the boom is set too low.

Advantages	Disadvantages
• quick to cover the target area • greater uniformity in deposition than hand guns • nozzles can be changed to suit situation	• booms can be difficult to manoeuvre around the nursery (e.g. irrigation risers, building structures) • nozzles wear and should be replaced regularly

NOZZLE HOLDERS (VEHICLE-MOUNTED)

Vertical booms

A vehicle mounted boom fitted with controlled droplet applicator (CDA) heads has various names including 'vertical boom' and 'vertical mister'. Each head consists of four spinning discs and a fan. These are driven by hydraulic pressure generated by a pump under the tank that attaches to the tractor's power take-off (PTO). The heads are normally operated at around 2000 rpm to generate droplets that are then moved toward the target in the air-stream created by the fans.

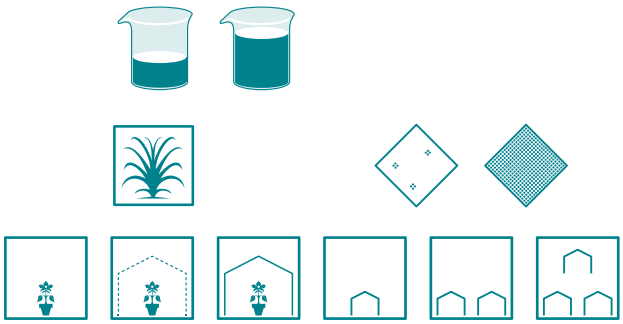
Heads can be fitted facing forward or backward to suit the orientation of the target. The entire unit, including tank, is usually mounted on the three point-linkage of a small tractor.

When using vertical booms care must be taken to determine that the fans create sufficient air movement so that spray droplets penetrate into the plant canopy. This is an important part of calibration with this equipment.

Advantages	Disadvantages
• quick to cover the target area • greater uniformity in deposition than hand-held CDA equipment • attitude and airflow can be adjusted to suit target	• tractor mounted equipment can be difficult to manoeuvre around the nursery • risk of drift if airflow not entirely intercepted by target • greater requirement for operator knowledge • difficult to spot spray small areas

NOZZLE HOLDERS

Shielded sprayers



Shields are sometimes placed around the spray nozzle to prevent droplets (usually of herbicide) travelling away from the target area. With sprayers generating air movement they may also be used to direct droplets in the air stream toward the target. This technique is particularly suited for weed management around the nursery such as weeds growing in walkways and near buildings.

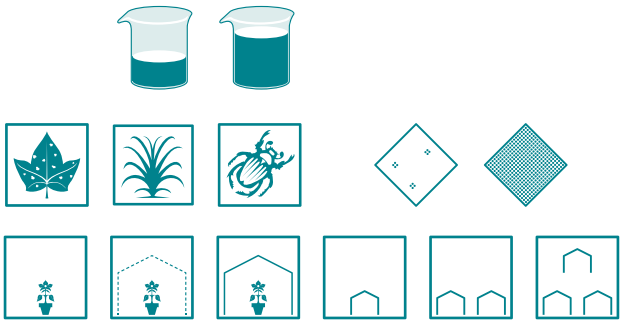
Shielded sprayers can be suitable for applying non-selective chemicals because they can minimise the off-target losses. When shields are fitted to knapsack sprayers a flat fan nozzle should be used, with a spray angle that is appropriate for the shield design. Even when using a shielded sprayer the correct hydraulic nozzle should be selected for the target, only spray during suitable conditions and operate at a pressure that minimises the formation of small droplets.

Advantages	Disadvantages
• low drift • suitable for herbicide application • can decrease chemical use by spot spraying	• generally not used for insecticide/fungicide application to plant nurseries • large units can be relatively expensive • the weight of the shield on hand-held units

FRAME/CHASSIS AND DRIVE

The sprayer requires some form of frame or chassis to hold all the sprayer components together. This needs to be of sufficient strength to carry the load (including a full spray tank). A method of driving the sprayer over the treatment area is also required. This can be achieved by foot, tractor, 4WD motorbike or self-contained drives.

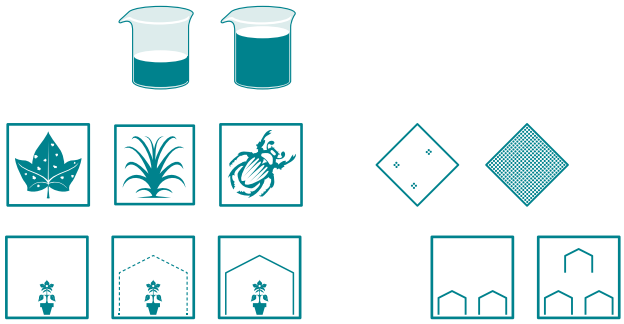
Trailers



Trailer sprayers come in a large variety of sizes and shapes. The size of the trailer typically relates to the area requiring treatment. The larger the area, the larger the spray components and hence, the larger the trailer. Trailer sprayers are often fitted with one or more hydraulic hand guns or a wand on a short boom fitted with nozzles.

Advantages	Disadvantages
• versatile • flexible	• difficult to turn in small areas • bulky

Tractor three-point linkage mounts

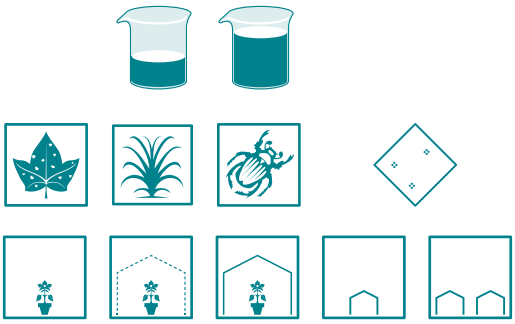


The entire sprayer unit may be mounted on the three-point linkage of a tractor. This method is more common in large nurseries. The Silvan Turbomiser® is a commonly used example of a tractor-mounted droplet delivery system. The same principles apply as with smaller scale equipment. In this case, as an air shear sprayer, it is not suitable for herbicide application because of the large number of small droplets produced that create a high potential for drift.

Tractors can be fitted with cabins and suitable air filters to decrease operator exposure to pesticides during application.

Advantages	Disadvantages
• quicker to cover large target areas • small droplets in a moving airstream can improve target capture	• only suitable for larger operations • may require more horsepower to operate than available on many small tractors • drift needs to be considered

Backpack/knapsack or hand-held hydraulic sprayers



Knapsack sprayers are carried by the operator, usually on the back. The pump is usually a piston or diaphragm driven by a lever that the operator moves up and down during use. Small petrol motor-driven pumps or electric pumps operating on a rechargeable 12V battery may be used on some units. Most lever-operated knapsack sprayers are fitted with a simple lance with usually one or two nozzles at the end. Hydraulic nozzles are typically used.

When using lever-operated knapsacks, the operator works the pump several times with the tap closed so that pressure is built up in the pressure chamber. The tap is opened and the operator continues to pump steadily with one hand while spraying with the other. Ideally a pressure control valve is also fitted adjacent to the tap. Spray management valves (SMVs) can be fitted to ensure that the pressure at the nozzle remains constant. Most older-style knapsacks deliver low pressures of 1–5 bar, but some newer models are capable of 8–9 bar.

Compression sprayers

Some units have a small tank that can be carried by hand or slung over the shoulder by a strap. These are referred to as compression sprayers. A hand pump, usually built into the tank, is used to pressurise the tank to a level suitable for correct operation of the nozzle. An SMV should be fitted to ensure constant pressure during spray operations. A pressure relief valve should also be fitted into these sprayers to release pressure for refilling.

All systems that rely on manual pumping suffer from fluctuating pressure levels. The operator may over-pump the sprayer and create excessive pressure or may under-pump, which results in insufficient pressure being produced. These changes in operating pressure alter the flow through the nozzle and therefore the droplet size generated. A constant pressure SMV positioned just before the nozzle can overcome these variations in pressure.

Advantages	Disadvantages
• suitable for spot spraying • for small operations • a range of nozzles can be used for target and pesticide combinations	• operator hazard—may leak, weight on back • variable pressure (unless SMV used), variable flow rate • must be calibrated for each operation

CHAPTER 5.

CALIBRATION

The objective when applying pesticides is to deliver the required amount of active constituent of the chemical to the desired target area. Regular calibration allows the operator to check that each of the components of the sprayer is operating within acceptable limits. It will also prevent over-dosing or under-dosing the target areas and reduce unnecessary contamination of the environment.

Over-dosing occurs when more than the recommended amount of a pesticide or mixture of pesticides is applied to the target area. This can result from hydraulic nozzle wear and other faults, such as increased pressure and varying travel speed, resulting in increased flow rates.

Over-dosing results in:

- wasting pesticides or products, time and money
- possible damage to crops (phytotoxicity)
- the possibility of exceeding the product's maximum residue limit (MRL)
- extra wear and tear on equipment
- possibly reducing the effectiveness of the product
- increased risk to non-target area
- increased risk of developing pest resistance to pesticides.

Under-dosing occurs when less than the recommended amount of active constituent is delivered to the target. This can be caused by blocked nozzles or filters and varying travel speed. This problem is difficult to detect with the eye and often goes unnoticed until a major blockage occurs.

Under-dosing results in:

- wasting chemicals, time and money
- reduced effectiveness of the product or pesticide
- increased risk of development of resistance to insecticides and fungicides
- possible production losses due to pest damage or competition.

Regular calibration of equipment will help to identify and reduce these problems.

> ***Do not rely on experience to know how far a tank will spray.***
>
> ***Equipment calibration is the only way to check the sprayer's application rate per area and identify problems in the uniformity of output.***

5.1 Calibration technique

Calibrating a piece of equipment for the application of pesticides as droplets involves four steps. These four steps are used in calibrating all types of sprayers, including hand-held equipment, boom sprayers, air-assisted hydraulic and air shear sprayers, misters and even agricultural aircraft. The form used by Nursery & Garden Industry Queensland is provided on page 68 to assist with the relevant calculations. The basic principles of calibration are discussed for collecting information. In the final section, these principles are applied to the major types of equipment.

> ***It is important that accurate records are kept of the calibration process.***

Before commencing calibration

It is important to ensure that the sprayer is operating correctly before taking any measurements of the sprayer's performance. The equipment must be checked and adjusted if necessary before calibration. The operator or supervisor should check the:

- the sprayer is clean
- the pesticide label recommendations in relation to rates and safety requirements

- the pressure gauge is operational (if fitted)
- pressure regulator setting (if one is fitted)
- spray lines and filters for leaks, blockages
- nozzle and sprayer description
- environmental conditions
- equipment is the most suitable for the job.

Steps for generalised sprayer calibration

A. Measure sprayer output (L/min)

The sprayer output is calculated by collecting and measuring the output of the nozzle(s) at the operating pressure required, into a container for one minute. The output from all nozzles should be measured. To reduce any errors, this procedure should be performed at least three times, then an average reading calculated.

The measured output of a nozzle is only acceptable if it varies by less than 10% from the manufacturer's new nozzle specifications. If the measured output of a nozzle varies by more than 10% from the manufacturer's new nozzle specifications, that nozzle should be replaced.

Enter the result at A on the calibration sheet (page 68).

B. Calculate the area sprayed in square metres per minute (m^2/min)

Calculating the area sprayed during the calibration requires two activities:

1. The first information required is the sprayer/nozzle's swath width in metres. Swath width is the width of spray coverage that is effectively delivered by the nozzle(s) to the target area, i.e. how wide the sprayer can effectively spray. For many plant nursery situations, the swath width can be taken as the width of the beds being sprayed.
2. The second measurement is the distance travelled (in metres) by the sprayer during one minute (see diagram below). This is measured while actually spraying with water.

The area sprayed in metres squared per minute (m^2/min) is calculated from the swath width and distance travelled using the formula on the calibration sheet.

Enter the result at B on the calibration sheet (page 68).

C. Calculate the sprayer's application rate in litres per hectare (L / ha)

This step determines the sprayer's output over a given area. For liquids this is known as the application rate in litres per hectare (L/ha). Registered pesticides must be applied at the application rate specified on the label. The sprayer application rate is calculated by using the data collected in steps A and B.

Enter the result at C on the calibration sheet (page 68).

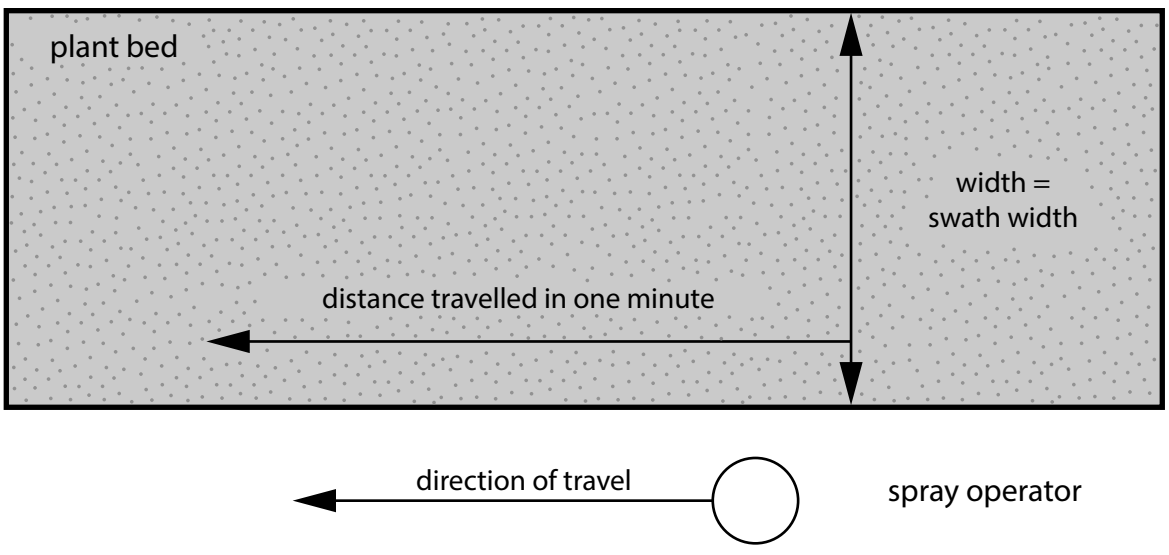
D. Calculate the amount of chemical required per spray tank volume

This is a critical step in the calibration procedure, as it ensures that the recommended label rates of pesticides are applied to target areas by determining the amount of chemical to be added to the spray tank to make up the volume that is to be used.

To calculate the amount of pesticide to add to the required tank volume the following information is needed:

- Sprayer application rate (L/ha) (calculated in step C)
- Registered product label rate (L/ha or g/ha or kg/ha or L/100 L or g/100 L or kg/100 L as stated on the label)
- Tank volume (L) for the amount of spray being prepared.

Enter the result at B on the calibration sheet (page 68).



Date: …….. Name:……..

Nursery & Garden Industry Queensland

CALIBRATION SHEET

APPLICATION RATE

Accredited NIASA Nursery – Setting the Standards

A = LIQUID FLOW (NOZZLE OUTPUT) FOR 1 MINUTE

NOZZLE OUTPUT/FLOWRATE = [……...] L/Min (A)

B = AREA (WIDTH X DISTANCE)

WIDTH (SWATH WIDTH) = [ ] (W)

DISTANCE TRAVELLED = [ ] (D)

W X D

[……] X [. ……..] = [……...] m² (B)

APPLICATION RATE

A ÷ B x 10 000 (C)

[ ] ÷ [ ] x 10 000 = [ ] L/ha

AMOUNT OF CHEMICAL TO ADD TO THE TANK.

SPRAY TANK SIZE = [ ] Litres

APPLICATION RATE = [ ] L/ha (Above Answer)

CHEMICAL RATE = [ ] L/ha (Label Rate)

TANK SIZE ÷ APPLICATION RATE x CHEMICAL RATE (D)

[ ] ÷ [ ] x [ ] = [ ] L

5.2 Hand-held sprayer calibration

Calibration checklist for hand-held equipment

- Ensure the sprayer is clean and filled with the required volume of water for the exercise.
- Check and record the operating parameters (e.g. nozzle type, travel speed and height, product rate and water rate).
- Adjust the pressure setting to the required operating pressure or fit a spray management valve (SMV). Record the pressure.
- Check the equipment for possible leaks and blockages.
- Use a measuring cylinder or jug and collect the output from the nozzle(s) when the sprayer is operating at the required pressure for one minute. For high pressure nozzles, it may be easier to place a small length of hose (e.g. 1 m) over the nozzle.
- Record the volume collected for each nozzle.
- Measure the nozzle output(s) for one minute and record the result two more times.
- Work out the average output per minute for each nozzle from the three trials.
- Check that all nozzles are not more than 10% above the manufacturer's new nozzle specifications. If they are more than 10% above, replace them. If they are below, this indicates there is probably a blockage in the nozzle or the filters.
- Record the total output from the nozzle(s) measured and record the result at A on the calibration sheet.
- Record the swath width of the sprayer. When spraying beds with a hand-held nozzle the swath width may be taken as the bed width.
- Measure the distance travelled in one minute. This distance should be measured while moving the nozzle in the desired fashion to achieve uniform coverage of the bed.
- Calculate the area and record the result at B on the calibration sheet.
- Calculate and record the sprayer's application rate at C on the calibration sheet.
- Record the label application rate.
- Record the spray tank volume.
- Calculate and record the amount of chemical required per spray tank volume. Record the result at D on the calibration sheet.

5.3 Boom sprayer calibration

Check list for boom sprayer calibration

- Ensure the sprayer is clean and filled with the required volume of water for the exercise.
- Adjust the PTO revs and pressure setting to the required operating pressure.
- Check and record the operating parameters such as nozzle type, operating speed (gear, engine revs and PTO revs), boom height, product rate and water rate).
- Check the equipment for possible leaks and blockages.
- Use a measuring cylinder or jug and collect the output from each of the nozzles when the sprayer is operating at the required pressure for one minute.
- Record the volume collected for each nozzle.
- Measure the nozzle outputs for one minute and record the result two more times.
- Work out the average output per minute for each nozzle from the three trials.
- Check that all nozzles are not more than 10% above the manufacturer's new nozzle specifications. If they are more than 10% above, replace them. If they are below, this indicates there is probably a blockage in the nozzle or the filters.
- Record the total output from all of the nozzles measured and record the result at A on the calibration sheet.
- Record the swath width of the sprayer. When spraying beds with a hand-held nozzle the swath width may be taken as the bed width.
- Measure the distance travelled in one minute. This distance should be measured while moving the nozzle in the desired fashion to achieve uniform coverage of the bed.
- Calculate the area and record the result at B on the calibration sheet.
- Calculate and record the sprayer's application rate at C on the calibration sheet.
- Record the label application rate.
- Record the spray tank volume.
- Calculate and record the amount of chemical required per spray tank volume. Record the result at D on the calibration sheet.

5.4 Calibration of misters (+ CDA)

Check list for mister calibration (+ CDA equipment)

- Ensure the sprayer is clean and the tank is filled with the required volume of water for the exercise.
- Check and record the operating parameters e.g. engine (head rotation speed), travel speed and height, product rate and water rate.
- Adjust the engine speed (or the head rotation) setting to that required for operating.
- Check the equipment for possible leaks and blockages.
- Detach the spray liquid feed from the reservoir at a point before it enters the nozzle (CDA head). Use a measuring cylinder or jug to collect the output from the pipe when the sprayer is operating at the required speed for one minute.
- Record the volume collected for each feed pipe (on large misters and CDA machinery there may be several).
- Measure the feed pipe output(s) for one minute and record the result two more times.
- Work out the average output per minute for each nozzle from the three trials. Then work out a total output for the equipment when all are functioning together. Enter this as A on the calibration sheet.
- Record the swath width of the sprayer. In this case, swath width is the maximum horizontal distance spray travels while still achieving effective coverage of the target. This can be determined accurately with the use of water sensitive paper placed on the target during a water test spray to check the number and size of droplets travelling to the target. Water sensitive paper and information on using it should be available from major pesticide suppliers.
- Measure the distance travelled in one minute by the equipment. This distance should be measured while moving the nozzle in the desired fashion to achieve uniform coverage of the bed.
- Enter the swath width and distance travelled then calculate the area and record at B on the calibration sheet.
- Calculate and record the sprayers application rate at C on the calibration sheet.
- Record the label application rate.
- Record the spray tank volume.
- Calculate and record the amount of chemical required per spray tank volume at D on the calibration sheet.

CHAPTER 6.

CASE STUDIES

The following section contains short case studies. These provide real examples of the current practices from the nursery industry in relation to purchase, storage and handling of agricultural pesticides. For each of the areas in which information was gathered, a rating has been used to indicate the level of performance relative to best practice for the nursery industry. Critical comments have also been provided for each case study to assist in understanding the development of best practice.

Key to the ratings used in the industry case studies contained in this section

RATINGS	
Must be improved	☆
Could be improved	☆ ☆
Reasonable practice	☆ ☆ ☆
Towards best practice	☆ ☆ ☆ ☆

Case Study 1	**Production description:** Main products include ornamentals (gingers and heliconias, natives, gardenias, murrayas, durantas, allamandas, cordylines, crotons). Produced in shade houses, igloo and open areas. **Operation type:** Production nursery only.	*OVERALL RATING* ☆½
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** Hand pump sprayers for spot application. **Calibration:** Information not supplied.	☆☆☆
2. Chemical handling, storage & disposal	**Transport:** Ute.	☆☆
	Storage: Locked refrigerator cabinet.	☆☆
	Personal protective equipment: For insecticides and all mixing operations a washable hat, overalls, boots, gloves and respirator are used. For herbicides and fungicides a washable hat, overalls and boots are used.	☆☆☆
	Disposal: Use remaining product on other produce (not usually an issue).	☆☆
3. Spray drift	**General operating parameters:** Information not supplied.	☆
	Typical spraying conditions: Wind speed: nil–5 km/hr. Temperature: less than 32°C. Humidity: Information not supplied.	☆☆
	Spray drift management strategies: No strategies in place.	☆
4. Overall management of spraying operations	**Training:** Information not supplied.	☆
	Record keeping: Information not supplied.	☆
	Emergency procedures: Information not supplied.	☆

CRITICAL COMMENTS (by management area)
1. Calibration of equipment essential and records of calibration and usage must be kept. 2. Chemical handling i) Use of an old refrigerator cabinet is not recommended and it has no ventilation. ii) Eye protection, goggles or faceshield should be worn particularly when measuring or mixing concentrates. 3. Records must be kept of all pesticide use and application methods and conditions. 4. Training of staff is required, as are records, and emergency procedures for managing spills must be in place.

Case Study 2	**Production description:** Main produce includes gardenias, lavenders and herbs. Open areas used for production only. Glasshouse used for propagation. **Operation type:** Production nursery only.	***OVERALL RATING*** ☆☆
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** High volume PTO sprayer with hand gun, Silvan 400 L. **Calibration:** Variable cone nozzle on hydraulic hand gun.	☆☆
2. Chemical handling, storage & disposal	**Transport:** Van.	☆
	Storage: In chemical store (no details given).	☆☆
	Personal protective equipment: Washable hat, overalls, boots, gloves, goggles/face shield and respirator are used for insecticides (Bugmaster®, Malathion, Rogor), herbicides (Roundup®, Gesatop®, Tryquat®), fungicides (Kocide®, Bravo®, Octave®) and mixing operations.	☆☆
	Disposal: Only mix enough product for job requirements.	☆☆☆
3. Spray drift	**General operating parameters:** Information not supplied.	☆
	Typical spraying conditions: Wind speed: Not measured. Temperature: less than 28°C. Humidity: Not measured.	☆☆☆
	Spray drift management strategies: Drift is not an issue, therefore no strategies in place.	☆
4. Overall management of spraying operations	**Training:** All operators trained with farm chemical user course and apprenticeships.	☆☆☆½
	Record keeping: Handwritten onto a spread sheet.	☆☆☆
	Emergency procedures: Dial 000, SDS on hand, atropine on site and Ipecac syrup.	☆☆☆

CRITICAL COMMENTS (by management area)
1. Hydraulic pressure variable nozzle hand guns are difficult to calibrate and this usually results in uneven dosing of the target with pesticide and run-off to waste. 2. Products need to be separated from driver/passengers during transport and the chemical store locked and clearly placarded. 3. Operating parameters need to be measured and recorded. Spray drift is always an issue and must be carefully considered. 4. Having atropine and Ipecac syrup on site is not recommended as it should only be administered under medical supervision.

Case Study 3	**Production description:** Main product lines include annual flowers, vegetables, seedlings and herbs. Produces in shade house, glasshouse and open areas. **Operation Type:** Production nursery only.	***OVERALL RATING*** ☆☆☆
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** QuickSpray (2 x retractable reels (600L tank) and 2 x 1600 cc Kubotas (200 L tanks). **Make and model:** Quickspray® 9TBE600, Kubota B5100E® and B6100E. **Calibration:** Regular calibration and equipment maintenance.	☆☆½ ☆☆☆☆
2. Chemical handling, storage & disposal	**Transport:** Tray truck.	☆☆☆
	Storage: Chemical storage shed.	☆☆☆
	Personal protective equipment: Tyvek suits, boots, gloves (nitrile), goggles/face shield and respirator are used for all insecticide, herbicide, fungicide and all mixing operations.	☆☆☆☆
	Disposal: Use excess on other crops. Operators don't mix large quantities, but prefer to go back and re-fill if more is required.	☆☆☆½
3. Spray drift	**General operating parameters:** Information not supplied.	☆
	Typical spraying conditions: Wind speed: less than 10 km/hr. Temperature: less than 26°C. Humidity: Not applicable.	 ☆☆☆ ☆☆☆☆ ☆
	Spray drift management strategies: Not necessary due to our location. We never spray when windy and most crops are under cover.	☆☆
4. Overall management of spraying operations	**Training:** All operators are trained in the farm chemical users course.	☆☆☆☆
	Record keeping: Spray request form—date, operator/s, purpose of spray, crops to spray, litres required, locations, chemical, rate, amount, wetter, unit speed, unit (equipment), weather, hours. All details recorded.	☆☆☆☆
	Emergency procedures: Emergency showers, sand bags, safety protocols and first-aid officer on site during all spray operations.	☆☆☆½

CRITICAL COMMENTS (by management area)
1. High volume hydraulic spraying can result in waste of pesticide and run-off to the environment. 2. The pesticide storage area needs to be locked, well ventilated and placarded. 3. Spray drift is always an issue requiring consideration and careful planning, even high volume hydraulic sprayers produce some fines (small droplets prone to drift). 4. Emergency contact numbers and product SDS sheets need to be available.

Case Study 4	**Production description:** Main product lines include house plants, exotic shrubs (gardenias and natives). Produces in shade house, glasshouse and open areas. **Operation type:** Production nursery only.	***OVERALL RATING*** ☆☆☆
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** Annovi Reverbi AR 30 pressure sprayer with 300 L tank, 2 hoses and reels with 2 turbo gun 400s. Granule applicator (supplied with product) and knapsack sprayer used for some herbicide operations. **Calibration:** Information not supplied.	☆☆☆
2. Chemical handling, storage & disposal	**Transport:** By suppliers vehicle – flat bed truck with secure chemical box bolted to tray.	☆☆☆☆
	Storage: Secure locked room, shelved, ventilated and signed.	☆☆☆☆
	Personal protective equipment: PPE used for spraying insecticides (Orthene Xtra®, Vertimec®, Pirimor Wg®, Confidor® 200 SC, Kelthane®, Talstar® 80 SC) and fungicides (Rovral® Aquaflo, Fosject®, Wettabel Sulphur, Bravo® 720) (including their related mixing operations) includes overalls with hood, boots, gloves and power helmet. Overalls with hood, boots, gloves and respirator are used for herbicide (Ronstar, Rout, Weedmaster) operations. The same equipment is used for mixing herbicides plus goggles/face shield.	☆☆☆
	Disposal: Extra pesticide is sprayed on other crops.	☆☆☆½
3. Spray drift	**General operating parameters:** 2.75 L/min @ 10 bar	
	Typical spraying conditions: Do not have facilities to measure conditions. Spraying ceases when considered to be ineffective or to produce too much drift.	☆
	Spray drift management strategies: Do not spray when wind is too strong or blowing from particular direction.	☆☆
4. Overall management of spraying operations	**Training:** All spray operators are ChemCert accredited.	☆☆☆☆
	Record keeping: Will use computer records in future. Presently use record sheets (weather conditions, PPE, name of mix, trade name, quantity, vat volume, area to be sprayed, plants to be sprayed, plant code, size, signature).	☆☆☆
	Emergency procedures: Office is always open when any spray application occurs. Spill kits are supplied to contain any spills, safety showers on site.	☆☆☆

CRITICAL COMMENTS (by management area)
1. Calibration information for all sprayers is required and calibration needs to be repeated regularly. 2. Records of respirator cartridge usage need to be kept. Respirators and all other PPE should be carefully stored away from pesticides. 3. Environmental conditions before and during spraying should be measured. A pressure of 10 bar will produce a lot of small droplets, which may drift out of the target area. 4. Emergency numbers and SDS information for products should be available.

Case Study 5	**Production description:** Indoor plants. Produces in shadehouses. **Operation type:** Production nursery only.	***OVERALL RATING*** ☆☆½
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** Optima Croplands **Make and model**: Silvan 300 L tank. Pump and motor (HR30TG) 5½ Honda motor. **Calibration:** Output of machinery 6 L every 46 seconds.	☆☆
2. Chemical handling, storage & disposal	**Transport:** Delivery truck.	☆☆☆
	Storage: In a chemical shed.	☆☆½
	Personal protective equipment: For insecticide (Vertimec®) and fungicide (copper, Dithane®, sulfur) operations a washable hat, overalls, boots, gloves, sunglasses and respirator are used. For herbicide operations (Roundup®) overalls, boots, gloves and respirator are used. Overalls, boots, gloves, face shield, respirator and apron are used for mixing operations.	☆☆☆½
	Disposal: Respray over the crop or target area.	☆☆☆
3. Spray drift	**General operating parameters:** Information not supplied.	
	Typical spraying conditions: Wind speed: less than 30 km/h. Temperature: less than 32°C. Humidity: 65% or higher.	☆ ☆☆☆ ☆☆☆
	Spray drift management strategies: Fibre glass walls and trees.	☆☆½
4. Overall management of spraying operations	**Training:** All operators have been trained through ChemCert.	☆☆☆☆
	Record keeping: Record keeping sheets (date, crop type, pest or problem, area treated, amount of mix used, notes, results, name of operator, signature).	☆☆☆☆
	Emergency procedures: Bucket, shovel, plastic bags and broom are all kept for spills. Shower is close by.	☆☆☆

CRITICAL COMMENTS (by management area)
1. Spraying equipment needs to be calibrated and records kept. 2. The pesticide storage area needs to be well ventilated, locked and well placarded. 3. Operating conditions, including equipment settings need to be recorded for all operations.

Case Study 6	**Production description:** Outdoor trees, shrubs and groundcovers. Produces in shadehouse and open areas. **Operation type:** Production nursery only.	*OVERALL RATING* ☆☆
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** Hydraulic spray pump, PTO-driven, Hardi mistblower®. **Calibration:** Information not supplied.	☆☆☆
2. Chemical handling, storage & disposal	**Transport:** Delivered by supplier.	☆☆☆☆
	Storage: Chemical shed.	☆☆
	Personal protective equipment: Overalls, boots, gloves, goggles/face shield and respirator used for all insecticide, herbicide and fungicide applications.	☆☆☆
	Disposal: Extra product used on stock gardens.	☆☆½
3. Spray drift	**General operating parameters:** Information not supplied.	
	Typical spraying conditions: Wind speed: When leaves are blowing across ground. And when spray may drift towards sensitive areas. Temperature: Done early morning. Humidity: N/A	☆ ☆
	Spray drift management strategies: Shadehouses near perimeter of nursery.	☆☆
4. Overall management of spraying operations	**Training:** All operators have been ChemCert accredited.	☆☆☆☆
	Record keeping: New industry spray diary.	☆☆☆
	Emergency procedures: SDS sheets available, emergency shower.	☆☆½

CRITICAL COMMENTS (by management area)
1. The term 'mistblower' is confusing, it might refer to an air shear sprayer or an air assisted hydraulic sprayer (most likely the second). 2. The storage area for pesticides needs to be locked and well ventilated. 3. Records must be kept of operating conditions and the calibration of equipment. 4. A spill kit is also required along with emergency contact numbers.

Case Study 7	**Production description:** Main product lines include plant seedlings (vegetables, potted colour, specialised flowers, pot plants), herbs, tropical foliage plants, trees and shrubs. 70 acre orchard. Produces in shadehouse, glasshouse and open areas. **Operation type:** Production nursery only and retail.	***OVERALL RATING*** ☆☆☆½
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** Small pneumatic sprayers, knapsack for small use areas, 450 L spray carts from tractor, PTO-driven. **Make and model:** Mostly all Hardi equipment. **Calibration:** Information not supplied.	☆☆ N/A
2. Chemical handling, storage & disposal	**Transport:** Supplier's vehicle (truck or heavy ute).	☆☆☆☆
	Storage: Locked, brick shed, plus separate locked compartment for some chemicals. The shed is specially constructed for spillage and has concrete bunding.	☆☆☆☆
	Personal protective equipment: For insecticide (Orthene, Pounce®), herbicide (Rout®, Gramoxone®), fungicide (Zineb®, Saprol®, Kocide®) and mixing (not insecticides) operations the PPE used includes washable hat, disposable overalls, boots, gloves, goggles and respirator. The same is used for Roundup® and mixing insecticides minus the washable hat, and potentially no goggles for the Roundup®.	☆☆☆½
	Disposal: Excess spray is sometimes dispersed over grassed wasteland away from drains, creeks etc. or collected in a sump from rinsing operations.	☆☆☆
3. Spray drift	**General operating parameters:** Ceramic nozzles, at 100 psi (5 L/min).	☆☆
	Typical spraying conditions: Wind speed: By observation. Weather station phoned daily. Temperature: less than 27°C if possible. Humidity: Difficult in houses, but good drying day essential. When chemical can't dry, we won't spray. We phone for dew point if in doubt.	☆☆☆½
	Spray drift management strategies: Shadehouses have sidewalls mostly. Vegetation screens are planted for open areas.	☆☆☆
4. Overall management of spraying operations	**Training:** All spray operators are ChemCert accredited.	☆☆☆☆
	Record keeping: Record sheet (date, crops, chemical, rate/litre, reason, start & finish time, operators signature).	☆☆☆☆
	Emergency procedures: Showers, eye wash and workplace health and safety officer on site. Spillage bucket, SDS and emergency contact numbers available. **Extra notes:** All personnel using pesticides have blood samples taken at the firm's expense annually by a visiting doctor. The list of chemicals used is forwarded to the doctor. No person to date has been found to be in any danger.	☆☆☆☆ ☆☆☆☆

CRITICAL COMMENTS (by management area)
1. Calibration of all equipment is essential and records should be kept. 2. The same PPE for all products is recommended as good practice to avoid confusion. 3. A full record of operating conditions is necessary for all applications of pesticide. 4. The overall management is very good.

Case Study 8	**Production description:** Main product lines include roses and topiary. Produces in shadehouse and open areas. **Operation type:** Production nursery only.	***OVERALL RATING*** ☆☆½
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** Quickspray unit. **Calibration:** Information not supplied.	☆☆
2. Chemical handling, storage & disposal	**Transport:** Delivered by company of purchase.	☆☆☆☆
	Storage: In a steel locked shed.	☆☆½
	Personal protective equipment: Overalls, boots, gloves, goggles/ face shield and respirators are used for insecticides (Confidor®, Lorsban® Talstar®), herbicides (Basta®, Rout®, Afalon®), fungicides (Dithane®, Ridomil®) for mixing and spraying operations.	☆☆☆
	Disposal: We don't have any, all our chemicals are always bought on demand.	Not assessable
3. Spray drift	**General operating parameters:** No information given.	
	Typical spraying conditions: Wind speed: We have to judge wind speed. Temperature: Generally we do not spray above 30°C. Humidity: Not Applicable.	☆
	Spray drift management strategies: No strategies as we do not spray when weather conditions are unsuitable.	☆½
4. Overall management of spraying operations	**Training:** All are either qualified or trained in the farm chemical users course.	☆☆☆
	Record keeping: All records are kept in a book, for every spray application.	☆☆☆
	Emergency procedures: We have a shower, fire extinguisher and emergency phone number.	☆☆½

CRITICAL COMMENTS (by management area)
1. Calibration of equipment must be carried out frequently and records kept. 2. The pesticide storage area needs to be well ventilated, appropriately signed and locked. 3. Records of operating conditions need to be kept and the management of spray drift carefully considered. 4. A spill management kit should be available at the mixing and loading site/s.

Case Study 9	**Production description:** Main products include fuscias, hibiscus, hydrangeas, bougainvillea, Australian natives and outdoor shrubs. Produce in shadehouse, glasshouse (propagation only), open areas and igloo. Total area 2.3ha. **Operation type:** Production nursery only.	*OVERALL RATING* ☆☆½
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** High volume sprayer, AR 30 SP (Annovi Reverberi) pressure pump – powered by Kubota. **Calibration:** Information not supplied.	☆☆
2. Chemical handling, storage & disposal	**Transport:** Truck.	☆☆
	Storage: Locked shed.	☆☆☆
	Personal protective equipment: Disposable overalls, rubber boots, disposable gloves and respirator used for insecticide (Maverick®, Confidor®), herbicide (Glyphosate®, Spray Seed®, Ronstar®) and fungicide (Baycor 300®, Alliette®, Ridomil Gold®) operations.	☆☆☆½
	Disposal: Only mix required amount of chemical. Any excess is sprayed onto stock plants as a preventative.	☆☆☆½
3. Spray drift	**General operating parameters:** Information not supplied.	
	Typical spraying conditions: Wind speed: Information not supplied. Temperature: Summer months early morning or evening. Humidity: Information not supplied.	☆
	Spray drift management strategies: Information not supplied.	☆
4. Overall management of spraying operations	**Training:** All spray operators participate in the industry training refresher every 2–3 years.	☆☆☆
	Record keeping: Chemical record book (date, chemical used, rate & quantity mixed, plants sprayed, operator).	☆☆☆
	Emergency procedures: No procedures.	☆

CRITICAL COMMENTS (by management area)
1. Calibration of spraying equipment and the keeping of records are both essential. 2. A well-ventilated and signed pesticide storage area required. Transport truck needs to be adequately managed. 3. Measurement of operating conditions when spraying and keeping records is important. 4. Emergency procedures including contact numbers and an emergency spill kit need to be available.

Case Study 10	**Production Description:** Product lines include semi-advanced and advanced plants, produced in open areas only. **Operation Type:** Production nursery only.	***OVERALL RATING*** ☆☆
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer types:** Contract sprayers using hand lances and boom sprayer. Also 4WD bike with CDA equipment. **Make and model:** Quickspray (400 Lt) 3-pt. linkage Silvan boom and 1200 Undavina CDA. **Calibration:** Information not supplied.	☆☆☆½ ☆
2. Chemical handling, storage & disposal	**Transport:** Chemical company delivers via trucks.	☆☆☆☆
	Storage: Lockable cabinet in locked shed.	☆☆☆½
	Personal protective equipment: For all insecticide (Folimat 800, Mavrik®), herbicide (Roundup®, Gesatop 560®, Ronstar®) and fungicide (Bravo 720®, Baycor 300® and Copper Oxy) mixing operations overalls, boots, gloves, goggles/face shield and respirator or power helmet are used.	☆☆☆
	Disposal: Very rare to have remaining product. If necessary it is emptied onto grassy area near washdown site if not used up on another suspect crop, or (if herbicide) stored in drums in spray shed.	☆☆☆
3. Spray drift	**General operating parameters:** Information not supplied.	
	Typical spraying conditions: Wind speed: Information not supplied. Temperature: less than 30°C. Humidity: 50% or higher.	☆☆½
	Spray drift management strategies: Boundary plantings and windbreaks.	☆☆☆
4. Overall management of spraying operations	**Training:** Some operators have been trained in the Farm chemical users course.	☆☆
	Record keeping: Spray record sheet (date, area ref., crop, weed/pest/disease targeted, chemicals & additives used, recommended rate, litres of spray applied, temperature, signature).	☆☆☆½
	Emergency procedures: SDS sheets easily accessible, colour tags to be worn when spraying eg. if S6 – yellow tag. Up to date first aid cabinet – IPECAC and atropine tablets, long life milk. Trained first aiders on site.	☆☆☆☆

CRITICAL COMMENTS (by management area)
1. Calibration of spraying equipment needs to be carried out regularly and records kept. Contractors should be asked to supply records of their activities. 2. The pesticide storage cabinet should be well ventilated and signed. 3. Operating conditions during spraying should be measured and recorded. 4. All operators should be ChemCert accredited. Ipecac syrup and atropine should not be available as they can only be used under direct medical supervision.

Case Study 11	**Production description:** Main product lines include annuals and vegetables. Specialises in one species of flowering plant. Produces in shadehouse, glasshouse and open areas. **Operation Type:** Production nursery only.	*OVERALL RATING* ☆☆
MANAGEMENT AREA	CURRENT OPERATION	RATING
1. Application equipment & techniques	**Sprayer Types:** 200 L spray machine Hardi pump. Also 8/t Hozelock handspray used at times (for glasshouse and open areas only). **Calibration:** Information not supplied.	☆☆½ ☆
2. Chemical handling, storage & disposal	**Transport:** Ute.	☆☆
	Storage: In certified storage which complies with American and Australian Standards.	☆☆☆
	Personal protective equipment: Overalls, boots, gloves and respirators are used for insecticide (Ambush®, Mavrik®, Pirimor®), herbicide (Roundup®, Gesatop®) and fungicide (Dithane®) operations. Mixing information not included.	☆☆½
	Disposal: Excess is shared between growers or disposed of in a separate chemical drainage system.	☆
3. Spray drift	**General operating parameters:** Information not supplied.	
	Typical spraying conditions: Wind speed: Moderate. Temperature: less than 30°C. Humidity: Humidity in Melbourne not an issue.	☆½
	Spray drift management strategies: All staff are notified of spraying to vacate area. No Entry signage erected.	☆☆
4. Overall management of spraying operations	**Training:** All operators are trained in the farm chemical users course or in the house training manual.	☆☆☆
	Record keeping: Record sheets include spray list, chemicals used, chemical manifest, water treatment, drenching sheet.	☆☆☆
	Emergency procedures: No information supplied.	☆

CRITICAL COMMENTS (by management area)
1. Calibration of all pesticide application equipment is essential and records must be kept. 2. Disposal: It is not advisable to store pesticide mixtures; mixing can be the most hazardous time when using pesticides and mixing and use protocols need to be in place. 3. Environmental conditions at the time of pesticide application must be measured and recorded. 4. Emergency numbers and a spill kit need to be available.

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APPENDIX 1. CONTACT DETAILS

DISPOSAL OF USED PESTICIDE CONTAINERS AND CHEMICALS

drum MUSTER

Phone: 1800 008 707

Website: www.drummuster.com.au

ChemClear

Phone: 1800 008 707

Website: www.chemclear.com.au

LEGISLATION

Australasian Legal Information Institute

Website: www.austlii.edu.au

ComLaw

www.comlaw.gov.au

New South Wales

Nursery & Garden Industry, NSW and ACT (NGINA)

344–348 Annangrove Road

Rouse Hill, NSW 2155

Phone: 02 9679 1472 Fax: 02 9679 1655

Email: info@ngina.com.au

Website: www.ngina.com.au

Environmental Protection Agency (EPA)

Website: http://www.epa.nsw.gov.au/pesticides/index.htm

New South Wales legislation

Website: www.legislation.nsw.gov.au

Northern Territory

Nursery & Garden Industry, Northern Territory (NGINT)

PO Box 348

Palmerston, NT 0831

Phone: 08 8983 3233 Fax: 08 8983 3244

Email: ngint@ntha.com.au

Department of Primary Industries and Fisheries

Phone: 08 8999 5511

(Ask for Chemical Services)

www.nt.gov.au/

Northern Territory legislation

Website: www.dcm.nt.gov.au

Queensland

Nursery & Garden Industry, Queensland (NGIQ)

Cnr Orange Grove & Riawena Roads

PO Box 345, Salisbury, QLD 4107

Phone: 07 3277 7900 Fax: 07 3277 7109

Email: info@ngiq.asn.au

Website: www.ngiq.asn.au

Department of Agriculture, Fisheries and Forestry Call Centre

Phone: 13 25 23 (ask to speak to the appropriate policy officer within the DAFF Animal and Plant Health Service)

Website: www.daff.qld.gov.au

Queensland legislation

Website: https://www.legislation.qld.gov.au/OQPChome.htm

South Australia

Nursery & Garden Industry, South Australia (NGISA)

505 Fullarton Road

Netherby, SA 5062

Ph: +61 8 8372 6822 Phone: 08 8271 1012

Fax: 08 8372 6833

Email: gfuller@ngisa.com.au

Website: www.ngisa.com.au

Bioscecurity South Australia

Website: www.pir.sa.gov.au/biosecuritysa/ruralchem

South Australia legislation

Website: www.legislation.sa.gov.au

Tasmania

Department of Primary Industries, Parks, Water and Environment

Phone: 1300 368 550

Spray drift complaints: 1800 005 244

Website: www.dpiw.tas.gov.au/inter.nsf/ThemeNodes/EGIL-52N435?open

Nursery & Garden Industry, Tasmania

9 Takari Place

Mornington TAS 7018

PO Box 3009

Rosny Park TAS 7018

Phone: 03 6244 7977 Fax: 03 6244 7977

Email: ngit@bigpond.com

Tasmanian legislation

Website: www.thelaw.tas.gov.au

Victoria

Nursery Industry Association of Victoria (NGIV)

3/307 Wattletree Road
Malvern East VIC 3145

PO Box 2280, Wattletree Road LPO,
East Malvern VIC 3145

Phone: 03 9576 0599 Fax: 03 9576 0431

Email: ngiv@ngiv.com.au

Website: www.ngiv.com.au

Department of Environment and Primary Industries

Phone: 136 186

www.dpi.vic.gov.au/agriculture/farming-management/chemical-use

Victorian legislation

Website: www.legislation.vic.gov.au

Western Australia

Nursery & Garden Industry, Western Australia (NGIWA)

PO Box 135

Mount Helena WA 6082

Phone: 0419 930 008

Email: reception@ngiwa.com.au

Department of Agriculture and Food

Phone: 08 9368 3333

Website: www.agric.wa.gov.au/PC_92826.html

Western Australian legislation

www.slp.wa.gov.au/legislation/statutes.nsf/default.html

PRODUCTS AND SERVICES

Nursery & Garden Industry Australia (NGIA)

Unit 58 Quantum Corporate Park

5 Gladstone Road

Castle Hill, NSW 2154

PO Box 7129

Baulkham Hills BC, NSW 2153

Phone: 02 8861 5100 Fax: 02 9659 3446

Email: info@ngia.com.au

Website: www.ngia.com.au For information on FMS, EcoHort, NIASA and BioSecure HACCP.

Agsafe Limited

Level 2, AMP Tower, 1 Hobart Place, Canberra City, ACT 2601

GPO Box 816, Canberra City, ACT 2601

Phone: 02 6230 4799 Fax: 02 6230 6710

Email: info@agsafe.com.au

Website: www.agsafe.com.au

ChemCert Australia Inc.

For all enrolment and courses inquiries:

Freecall: 1800 444 228

Website: www.chemcert.com.au

Cornell University Pesticide Active Ingredient information

Website: pmep.cce.cornell.edu/profiles/index.html

Extonet Pesticide Information Profiles

Website: extoxnet.orst.edu/pips/ghindex.html

Standards Australia

Level 10, The Exchange Centre

20 Bridge Street, Sydney

GPO Box 476

Sydney, NSW 2001

Freecall within Australia: 1800 035 822

Fax: 02 9237 6010

Website: www.standards.org.au

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Call within Australia: 131 242

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Email: sales@sai-global.com

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Poisons information hotline

Phone: 13 11 26

Australian Pesticides and Veterinary Medicines Authority (APVMA)

The APVMA is the regulator of pesticides and veterinary medicines up until the point of retail sale. For regulation policy issues, chemical use issues or for the regulation of other chemical products, please view information from the responsible organisations.

18 Wormald Street, Symonston, ACT, 2609, Australia

PO Box 6182, Kingston, ACT, 2604, Australia

Phone: +61 2 6210 4701

Email: contact@apvma.gov.au

Website: www.apvma.gov.au

Adverse experiences

To report an unintended effect from the use of registered agricultural or veterinary chemicals.

FreeCall: 1800 700 583 (within Australia). Charges apply for calls made from mobile phones

Fax: +61 2 6210 4776

Email: aerp@apvma.gov.au

Agricultural chemical products, active constituents and permits

Phone: +61 2 6210 4748 Fax: +61 2 6210 4776

Email: pesticides@apvma.gov.au

Fees, Levies and Invoice queries

Phone: +61 2 6210 4852 Fax: +61 2 6210 4874

Email: finance@apvma.gov.au

Feedback and complaints

Phone: +61 2 6210 4746 Fax: +61 2 6210 4776

Email: feedback@apvma.gov.au

APPENDIX 2. GLOSSARY OF PESTICIDE TERMS

COMMON ABBREVIATIONS

APVMA	Australian Pesticides and Veterinary Medicines Authority
EC	Emulsifiable concentrate—a liquid pesticide formulation
IPM	Integrated pest management
MRL	Maximum residue level
MSDS	Material safety data sheet (now known as SDS, see below)
OC	Organochlorine pesticide
OP	Organophosphate pesticide
SC	Suspended concentrate—a liquid pesticide formulation
SDS	Safety data sheet
SP	Soluble powder pesticide formulation
SP	Synthetic pyrethroid pesticide
ULV	Ultra low volume sprays, usually oil based

DEFINED TERMS

Acetone	A volatile solvent, such as that used in many nail polish removers.
Acidic	A low pH (< 7) e.g. vinegar is mildly acidic, sulphuric acid is very acidic.
Active constituent	That part of a farm chemical formulation that is biologically active on the pest target.
Adjuvant	A secondary 'helper' chemical added to improve the effectiveness of a pesticide spray.
Aerosol	Fine droplets, small enough to stay suspended in air.
Alkaline	A high pH (> 7) e.g. bore water is mildly alkaline, sodium hydroxide is very alkaline.
Anionic	Negatively charged (ions).
Anti-foaming agent	A substance added to a formulation to prevent excessive foam forming during the mixing of ingredients.
Buffering agent	A chemical which, when added to a solution, has the ability to resist changes to pH or hydrogen ion concentrations. Acidifying buffers are used to counter alkaline bore water supplies that can improve spray solution stability and performance.
Cationic	Positively charged (ions).
Diffusion	The spreading and penetration of particles by natural movement into space that may be enclosed, as in the case of respirator filter elements.
Dispersal	The process of spreading a population, usually by seeds or spores.
Efficacy	A measure of how well a product does the job it was designed to do.

Emulsifiable concentrate	A chemical formulation consisting of an active constituent dissolved in an organic solvent together with an emulsifier to facilitate the formation of an even, milky emulsion when mixed with water.
Flowable concentrate	Sometimes called suspension concentrates. These are suspensions of finely milled solid active particles mixed with and suspended, usually, in water that can be measured out by liquid volume.
Formulation	The make-up of the farm chemical as purchased. It consists of the active constituent(s) together with a number of other components that are added to assist handling, efficacy, safety and stability.
Hydrolysis	The breakdown of the active ingredient over time, when mixed in poor quality water.
Integrated pest management	The coordinated use of all available pest management methods to keep pest populations below economic injury levels.
Larva	An immature or young insect that has a pupal or resting stage.
Lifecycle	The successive life stages of a plant or animal as they progress from birth to death.
Maximum residue limit	The maximum legal amount of chemical residue expressed in parts per million that is permitted to be present in marketed produce. No chemical is given clearance for use on a crop or animal unless an MRL has previously been established.
Mode of action	How the agrochemical actually works, e.g. nerve poison.
Non-ionic	A molecule that does not ionise when placed in water. Nearly all wetting agents used in agriculture are non-ionic.
Nymph	An immature insect that does not have a pupal or resting stage, e.g. green vegetable bug.
pH	A measure of acidity. Low pH is acidic (< 7), high pH is alkaline (> 7).
Phytotoxic	A damage response to applying agrochemical, such as a chemical burn.
Resistance	The appearance of a high level of tolerance to a pesticide in a pest species. This is likely to occur when the pest population has been subject to high selection pressure by repeated exposure to pesticides with a similar mode of action.
Selective chemicals	Pesticides that have the ability to selectively target a pest without affecting the crop in which the pest is present.
Sequestering agent	In formulations, adjuvants designed to differentially combine with certain metallic elements, isolate them in soluble compounds and prevent the precipitation of solid particles that could block filters and nozzles.
Soluble powder	A chemical formulation that is packaged as a powder and dissolves completely in water to form a spray solution.
Stable/stability	Meteorological conditions when little or no wind occurs. Not suitable for spraying.
Stickers	An adjuvant added to a product to reduce run-off.
Solution	A liquid containing one or more compounds in a completely homogenous state. Usually refers to chemicals dissolved in and mixed with water (i.e. an aqueous solution).

Surfactant	Short for 'surface active agent'. This term is used to describe wetting agents, stickers and spreaders. Usually non-ionic when used with farm chemicals.
Suspension concentrate	See 'flowable concentrate'.
Synergist	A chemical that increases the biological effect of another when the two are mixed.
Synthetic pyrethroids, organophosphates and carbamates	Insecticides that act as a nerve poison. They work the same way on humans as they do on insects.
Target	The place where the spray should be directed, which depends on how the product actually works (i.e. its mode of action).
Translocated herbicides	Once applied, these products will move within the plant to the site of action.
Water miscible	Another liquid that is able to mix completely with water to form a homogenous mixture.
Wettable powder	A chemical formulation designed to form a suspension when mixed with water to make up a pesticide spray solution.
Wetter	See 'surfactant'.

APPENDIX 3. PESTICIDE ACTIVITY GROUPS AND STRATEGIES TO AVOID PESTICIDE RESISTANCE

The following pages are a list of the major groups of pesticide chemicals published by APVMA. These are grouped by target into insecticides, fungicides and herbicides, and each is described in terms of its activity on the target organism, usually the disruption of a metabolic pathway. Also included is a description of management strategies to avoid pests developing resistance to pesticides and practical examples from the nursery industry.

For more detailed information about activity groups and labelling view *http://www.apvma.gov.au/morag_ag/vol_5/labelling_code.php*

CropLife Australia provides information about management strategies to minimise the risk of pesticide resistance developing. *http://www.croplifeaustralia.org.au/default.asp?V_DOC_ID=1952*

Resistance management groups: Insecticides

Table 8. Avcare Insecticide Resistance Action Committee (AIRAC) Mode of Action Classification for Insecticides)

Group	Primary Target Site	Chemical Subgroups
1A	Acetyl choline esterase inhibitors * all members of this class may not be cross resistant	carbamates*
1B		organophosphates*
2A	GABA-gated chloride channel antagonists	cyclodienes
2B		polychlorocycloalthanes
2C		fiproles
3A	Sodium channel modulators	pyrethroids and pyrethrins
4A	Acetyl choline receptor agonists/antagonists	chloronicotinyls
4B		nicotine
4C		cartap, bensultap
5A	Acetyl choline receptor modulators	spinosyns
6A	Chloride channel activators	avermectin, emamectin benzoate
6B		milbemycin
7A	Juvenile hormone mimics	methoprene, hydroprene
7B		fenoxycarb
7C		pyriproxifen
8A	Compounds of unknown or non specific mode of action (fumigants)	methyl bromide
8B		phosphine generating compounds
9A	Compounds of unknown or non specific mode of action (selective feeding blockers)	pymetrozine
9B		cryolite
10A	Compounds of unknown or non specific mode of action (mite growth inhibitors)	clofentezine, hexythiazox
11A	Microbial disrupters of insect midgut membranes (includes Transgenic B.t. crops) * all members of this class may not be cross resistant	B.t. tenebrionis
11B		B.t. israelensis
11C		B.t. kurstaki, B.t aizawai *
11D		B.t. sphaericus
11E		B.t. tolworthi
12A	Inhibition of oxidative phosphorylation, disrupters of ATP formation	organotin miticides
12B		diafenthiuron
13A	Uncoupler of oxidative phosphorylation via disruption of H proton gradient	chlorfenapyr
14A	Inhibition of magnesium stimulated ATPase	propargite
15A	Chitin biosynthesis inhibitors	acyl ureas
16A	Ecdysone agonists	tebufenozide and related
17A	Homopteran chitin biosynthesis inhibitors	buprofezin
18A	Unknown dipteran specific mode of action	cyromazine
19A	Octopaminergic agonist	amitraz
20A	Site II electron transport inhibitors	hydramethylnon
21A	Site I electron transport inhibitors	rotenone, METI acaricides

Source: *http://www.apvma.gov.au/morag_ag/vol_5/labelling_code.php*

Resistance management groups: Fungicides

Table 9. Fungicides listed by activity group.

Group	Mode of action group	Chemical group	Active constituent
A	Benzimidazole	Benzimidazole	benomyl carbendazim thiabendazole thiophanate-methyl
B	Dicarboximide	Dicarboximide	iprodione procymidone vinclozolin
C	DMI	Imidazole Piperazine Pyridine Pyrimidine Triazole	imazalil prochloraz triforine pyrifenox fenarimol bitertanol cyproconazole diclobutrazole difenoconazole flusilazole flutriafol hexaconazole myclobutanil paclobutrazol penconazole propiconazole tebuconazole triadimefon triadimenol triticonazole
D	Phenylamide	Acylamine Oxazolidinone	benalaxyl furalaxyl metalaxyl metalaxyl-m oxadixyl
E	Morpholine	Morpholine	tridemorph
F	Phosphoro-thiolate	Organo-phosphorous	pyrazophos
G	Oxathiin	Anilide	carboxin oxycarboxin
H	Hydroxy-pyrimidine	Pyrimidinol	bupirimate dimethirimol
I	Anilinopyrimidine	Anilinopyrimidine	cyprodinil pyrimethanil
J	Hydroxyanilide	Hydroxtanilide	fenhexamid
K	Strobilurin	Strobilurin	azoxystrobin kresoxim-methyl trifloxystrobin
L	Phenylpyrroles	Phenylpyrroles	fludioxinil

Y	Multi-site activity	Carbamate Phosphonate Inorganic Dithiocarbamate Phthalimide Chlorophenyl Quinone Hydroxyquinoline Pyradinamine Cyclic imide	iodocarb propamocarb fosetyl-Al phosphorous acid copper (cuprous oxide) copper (hydroxide) copper (oxychloride) iodine mercury sodium metabisulphite sulphur mancozeb metiram thiram propineb zineb ziram chlorothalonil quintozene dithianon 8-hydroxy quinoline sulphate fluazinam captan
X	(Unspecified)	Cinnamic acid derivative Sulfamide Dinitrophenyl Organophosphate Guanidine Thiadiazole Quinoxaline	dimethormorph dichlofluanid tolyfluanid dinocap tolclofos-methyl dodine guazatine etridiazole oxythioquinox pencycuron

Source: http://www.apvma.gov.au/morag_ag/vol_5/labelling_code.php

Resistance management groups: Herbicides

Table 10. Herbicides listed by activity group

	Group	Mode of action group	Chemical group	Active constituent
HIGH RISK	A	Inhibitors of acetyl coA carboxylase (Inhibitors of fat synthesis/ACC'ase inhibitors)	Aryloxyphenoxy-propionates ('Fops') Cyclohexanediones ('Dims')	diclofop-methyl fluazifop-butyl haloxyfop-ethoxy-ethyl quizalofop-p-ethyl fenoxaprop-ethyl propaquizafop sethoxydim tralkoxydim cycloxydim clethodim
	B	Inhibitors of acetolactate synthase (ALS inhibitors)	Sulfonylureas Imidazolinones Sulfonamides	chlorsulfuron halosulfuron-methyl metsulfuron-methyl rimsulfuron sulfosulfuron triasulfuron bensulfuron-methyl thifensulfuron-methyl sulfometuron-methyl imazethapyr imazamox
MODERATE RISK	C	Inhibitors of photo-synthesis at photosystem II	Triazines Triazinones Ureas Nitriles Benzothiadiazoles Acetamides Uracils Pyridazinone Phenyl-pyridazine	ametryn atrazine simazine cyanazine terbutryn prometryn propazine metribuzin hexazinone diuron linuron metoxuron siduron ethidimuron methabenzthiazuron fluometuron tebuthiuron methazole bromoxynil ioxynil bentazone propanil bromacil terbacil chloridazon pyridate
	D	Inhibitors of tubulin formation	Dinitroanilines Benzoic acid Pyridines	trifluralin oryzalin pendimethalin benfluralin chlorthal thiazopyr

MODERATE RISK	E	Inhibitors of mitosis	Carbamate Thiocarbamates Organophosphorus	propham chlorpropham tri-allate EPTC vernolate molinate pebulate bensulide
	F	Inhibitors of carotenoid biosynthesis	Nicotinanilides Triazole Pyridazinone Pyrazoles Aryl triazolinones Isoxazolidinones Isoxazoles	diflufenican amitrole norflurazon benzofenap clomazone isoxaflutole
	G	Inhibitors of protoporphyrinogen oxidase	Diphenyl ethers Oxadiazole	acifluorfen carfentrazone-ethyl oxyfluorfen oxadiazonoxadiargyl
	H	Inhibitors of protein synthesis	Thiocarbamate	thiobencarb
LOW RISK	I	Disruptors of plant cell growth	Phenoxys Benzoic acid Pyridines	2,4-D 2,4-DB MCPA MCPB dichlorprop mecoprop dicamba picloram clopyralid fluoxypyr triclopyr
	J	Inhibitors of fat synthesis	Alkanoic acids	2,2-DPA flupropanate TCA
	K	Herbicides with diverse sites of action	Amides Organoarsenic Carbamates Amino propionates Benzofurans Phthalamate Nitriles	diphenamid metolachlor propachlor propyzamide MSMA asulam phenmedipham flamprop-methyl ethofumesate naptalam dichlobenil
	L	Inhibitors of photo-synthesis at photosystem I	Bipyridyls	paraquat diquat
	M	Inhibitors of EPSP synthase	Glycines	glyphosate glyphosate-trimesium
	N	Inhibitors of glutamine synthase	Glycines	glufosinate-ammonium

Source: http://www.apvma.gov.au/morag_ag/vol_5/labelling_code.php

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