INTRODUCTION TO IPM

Contents

What is IPM?

Integrated Pest Management (IPM) can be defined in more ways than one. One definition of IPM is “the use of a combination of different control methods to manage crop pests in a safe, economic and sustainable way”. Some of the management tools that can be used to protect a crop include crop monitoring, pest predation by beneficial insects, mechanical control and a range of different chemicals.

One definition of IPM is “the use of a combination of different control methods to manage crop pests in a safe, economic and sustainable way”.

IPM is a subset of Integrated Crop Management (ICM). ICM is a whole farm management system and incorporates factors such as nutrient monitoring, water use efficiency and soil management, as well as the insect, pest and disease management aspects of IPM (Figure 1.1). Sustainable crop managers will develop their integrated approaches to pest management as part of a larger crop management system.

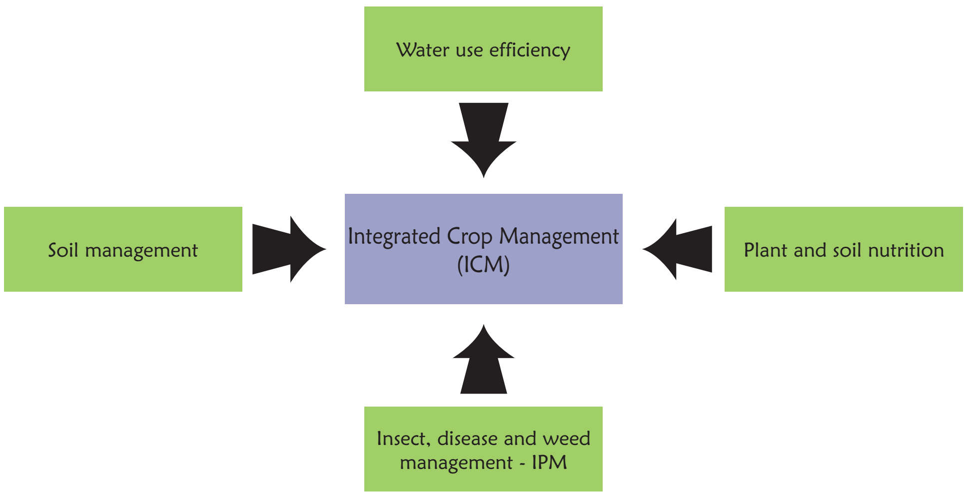


Figure 1.1 Integrated Pest Management (IPM) is a component of Integrated Crop Management (ICM).

The ICM and IPM approaches extend beyond simply controlling or killing the pest. The entire system in which a pest occurs needs to be managed and all the components of the system must be considered as potentially impacting on the pest level.

IPM is a practical and versatile way to manage crop pests and provides a flexible program that can be modified to suit any crop production system. In addition, it will allow you to grow high quality produce while reducing potential hazards associated with some pest management practices.

What makes a pest?

Managing a pest using an IPM program means modifying or manipulating one or more of three conditions so they are less favourable for the pest.

IPM involves managing the entire system and conditions in which a pest occurs. This idea is illustrated by the pest triangle (Figure 1.2). When all three conditions are suitable - that is, the pest is present, the environment is favourable and there is a host crop - the pest will survive and the population will increase. Managing a pest using an IPM program means modifying or manipulating one or more of these three conditions so they are less favourable for the pest.

For example: Environmental conditions can be modified to manage diseases such as Downy mildew. This disease sporulates in the morning and spores require water for germination. Minimising or eliminating irrigation in the morning, and applying it later in the day instead, may reduce disease development.

The impact of a pest can be minimised by planting your crop outside the time window when the pest is likely to cause the most economic damage, or by selecting varieties that may be resistant to certain diseases. The susceptibility of your crop can also be manipulated by maintaining a healthy and vigorous plant. Crops that are water or nutrient stressed tend to be more prone to pest attack.

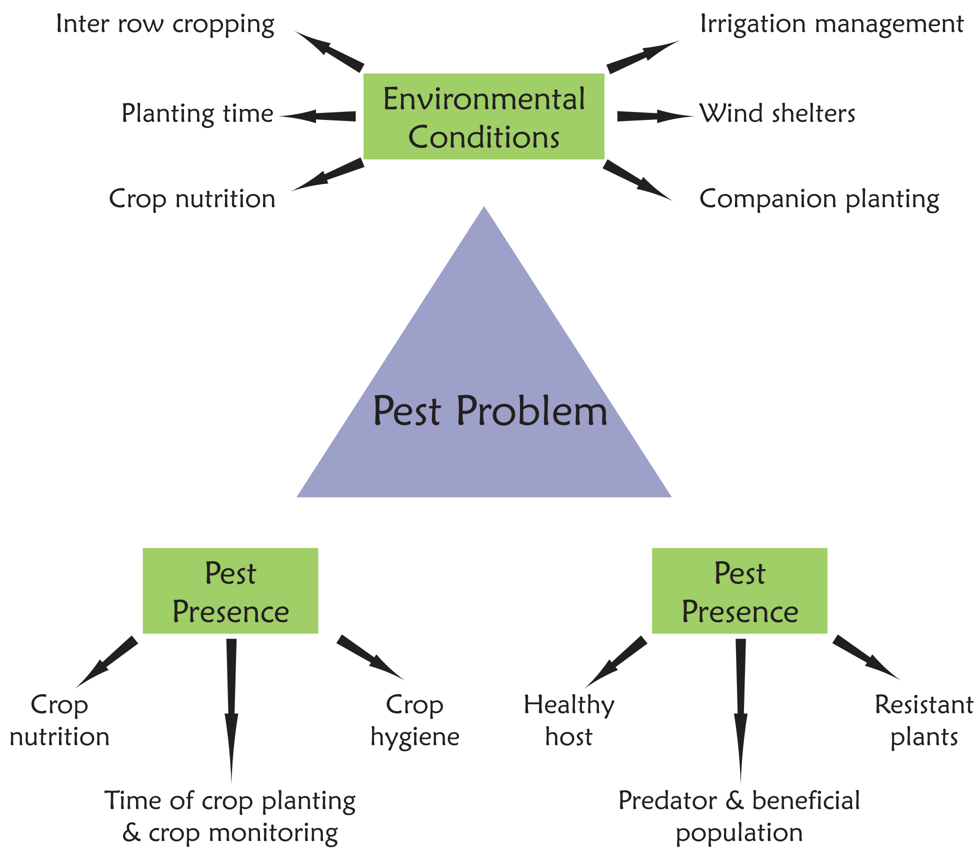


Figure 1.2 The pest triangle and a range of methods that can be used to manipulate the conditions that deter pests from the host crop.

Tools used in an IPM system

Now you know how a pest can establish itself as a pest and the three factors that can be manipulated to reduce the chance of a pest causing economic damage to your crop. From here you can select from a wide range of IPM 'tools' that can be used to deter a pest from establishing, or can better manage it if it becomes established. Many of these you may already be using without realising they can be incorporated into an IPM program. Some of the tools you can select from are shown in Figure 1.3. These can be categorised into one of the four 'tool boxes': mechanical, biological, cultural or chemical management tools.

Mechanical Tools	Brushweeding, inter-row cultivation, flame weeding.
Biological Tools	Introducing and preserving natural enemies and predators, biological sprays (eg Bt's), incorporating nectar producing plants to encourage beneficial predators.
Cultural Tools	Crop hygiene, crop rotation, crop monitoring, ground preparation, cultivar and variety selection, irrigation and nutrient management.
Chemical Tools	Spray thresholds, biological sprays (eg Bt's), crop monitoring to improve timing, using suitable spray nozzles and regular calibration, using a resistance management strategy.

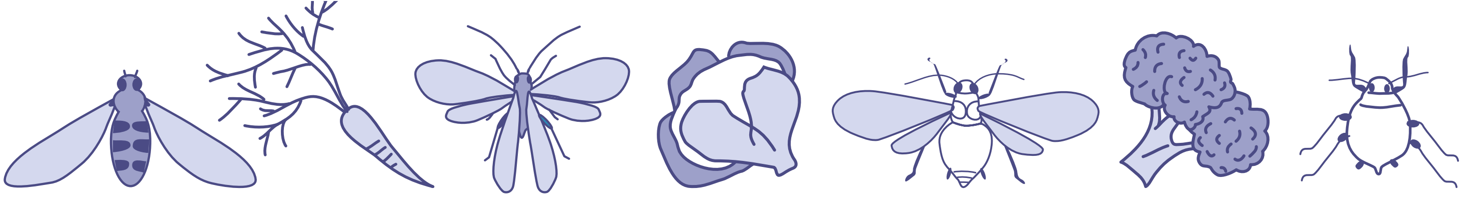
Figure 1.3 The IPM Tool Box - some of the IPM tools that can be used in an IPM Program.

Mechanical Tools

This is the oldest known form of pest control and has primarily been used for weed management. Options such as flame weeding and inter-row cultivation with brush weeders (Figure 1.4), tyned implements and hand weeding are all used. These methods of control can sometimes have negative effects both economically (increase in labour) and environmentally (damage to soil structure), but if used in combination with other IPM tools, can improve weed control. Inter-row cultivation has been a part of weed control in cropping since well before the introduction of herbicides.

Figure 1.4 Mechanical weeding with a brushweeder.

The basics of many of the technologies used in inter-row weed control are very old, but advances in technology (eg. guidance systems) have the potential to greatly improve the cost effectiveness of such techniques. Mechanical tools are also relevant to insect management, for example, through the use of traps to attract and trap insect pests.



Biological tools

Figure 1.5 An adult hoverfly.

Biological control uses natural enemies to reduce the crop pest numbers. Biological control was first observed by farmers in China. They discovered that ants were feeding on certain caterpillars, beetles and bugs and helping control pests in their citrus orchards. As a result, the orchardists grew plants to support the survival of ants around the orchards. This resulted in an increase in ant numbers and a reduction in orchard pests.

Biological control of insects includes the use of predators, parasitic insects and insect pathogens. Predators are insects that feed on many different insect pests. For example, the larvae of the common hoverfly eats the eggs of many different pests (Figure 1.5).

Parasites, also known as parasitoids, are insects that lay their eggs in or on the host insects. The parasite egg hatches inside the host (the pest) and feeds on, and eventually kills, the pest. Many of the parasites in common crops are specific to the host insects they attack. Parasites are usually very small wasp like insects and are therefore quite difficult to identify in the paddock.

Insect pests are also attacked by disease organisms, known as insect pathogens, which may include viruses, bacteria, fungi, nematodes, and other microorganisms that cause insect diseases. Insect pathogens such as strains of *Bacillus thuringiensis*, commonly known as "Bt", are used to control certain insects such as cabbage white butterfly and diamondback moth.

Cultural Tools

Figure 1.6 Using footbaths can reduce the spread of many diseases onto and off the farm.

Cultural control tools are incorporated into an IPM cropping program to minimise the likelihood of pest attack. Cultural tools include crop monitoring, crop health, crop rotation, cultivar selection, planting date and crop hygiene (Figure 1.6). Other elements may be included, such as the use of biodiverse headlands and fencelines that encourage the survival of beneficials and predatory insects of the pest.

Chemical Tools

Chemical control includes the use of natural and synthetic chemicals, commonly referred to as herbicides, insecticides, fungicides and nematicides. Chemical control methods are usually 'fast acting' in killing the targeted pest. When used in an IPM program, selective use and application is essential and therefore chemicals are often applied strategically as a last resort. Care must be taken with chemicals so as to preserve populations of beneficial insects. It is important not to rely on a single chemical, or consistently use products from the same chemical group. Using a range of different chemicals will lessen the risk of chemical resistance developing in the pest population. Resistance management is covered later in this section.

Benefits of IPM

Implementing an IPM system may result in the production of high quality produce at less cost to the grower than the cost of chemical control programs. However, using an IPM system does not necessarily guarantee a "quick fix" result. An IPM system needs constant assessment and evaluation. There may be some initial disadvantages in an IPM system, but in the long term, these are out weighed by the benefits, as shown in the lists below.

Benefits

- Fewer applications of broad spectrum pesticides
- Reduced development of pesticide resistance
- Reduced environmental damage
- Reduced human health risk associated with pest management
- Reduced chemical costs
- Improved crop bio-diversity
- Improved spray application techniques
- Cleaner market produce
- Improved farm management
- Sustainable market access and potential market edge

Disadvantages

- Increased time and resources are needed for an IPM program
- Increased knowledge required about pests and diseases
- Level of damage to the crop may initially increase during transition to an IPM system

There may be some initial disadvantages in an IPM system, but in the long term, these are out weighed by the benefits.

Designing an IPM Program: Monitoring

Figure 1.7 Crop monitoring using a trained crop scout.

Crop monitoring, or scouting, is the most important tool used in any IPM program. It is the tool that provides crop specific information on pest activity in the crop. From this information, the best control option(s) can be selected to target the particular pest at a stage when it is most susceptible. Information from crop monitoring can allow you to:

- Accurately time spray applications to target the pest at the most critical time
- Detect and manage pests before they cause economic damage
- Reduce pesticide use by target spraying
- Become familiar with and understand the cycle of pests in your crop

How to Monitor

Monitoring doesn't mean going to your crop and looking at a few plants at the gate entrance. A trained scout should be used if possible (Figure 1.7). Not only will they do the monitoring, but they will also assist you in setting up an IPM program for your specific crop.

A trained scout would do the following:

- Walk through your crop once or twice a week looking for symptoms or damage from insects or disease.
- Use tools such as pheromone traps or yellow sticky mats to monitor for flying insects.
- Record all monitoring information and interpret the information collected.
- Discuss management options with you.

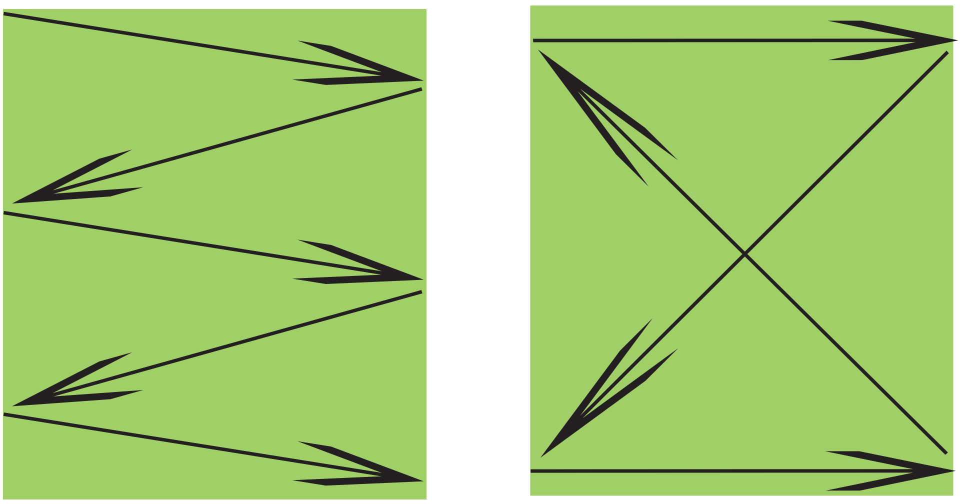
If you are confident at carrying out the tasks of a crop scout, you can save some money by doing it yourself. It is relatively simple once you have trained your eye to accurately identify pests and you know all the management options available.

The basic steps to monitoring are:

- Walk through the crop following a pattern similar to Figure 1.8 or 1.9, selecting random plants along the way.
- Sample 10 - 40 plants throughout the crop once a week, or twice during high-pressure periods. Look for eggs, grubs, feeding damage and disease symptoms. Also make note of the weeds in and around the crop.

- Record the results on a recording sheet. Figure 1.10 is an example of a recording sheet that can easily be adapted to suit your specific crop.
- Analyse and interpret the results and determine what, if any, control actions need to be taken. Ask yourself questions like:
  - Can the beneficial insects control the pest to an economic level?
  - Will the humidity level change to favour disease initiation?
  - Will crop growth smother newly emerging weeds?
  - Are most insect pests present as eggs/larvae/adults?
  - Do I really need to apply a spray?

The growth stage of the plant will determine the part of the plant requiring particular attention. For example, in broccoli, the curd or head is the only marketable part of the plant. Therefore, particular attention is focussed on the leaves that surround the growing point and the head when monitoring.



Figures 1.8 and 1.9 Monitor and sample your crop in either of these patterns.

Crop Monitoring Record Sheet - SAMPLE ONLY

Paddock name: River Hill - East	Monitoring date: 18-01-04
Crop: Broccoli	Growth stage: 8-12 leaf. Not at critical growth stage. High pest threshold.
Planting date: 09-01-04	Scout: S. Smith
Last treatment: Nil	Number of plants checked: 25
Treatment date; Not required yet	Pheromone trap count: Trap 1 - 135 Trap 2 - 101

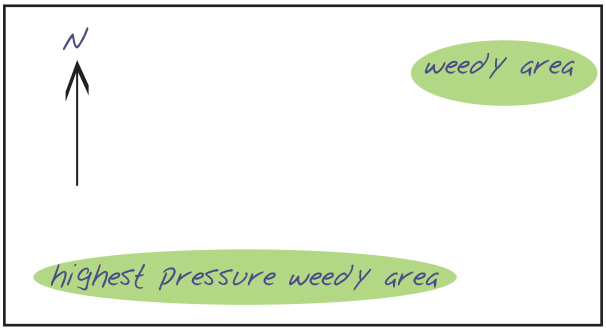
Insect	Eggs	Grubs	Grub size	Damage Level (low, med, high)	Other comments
DBM	Yes	Yes- few	1st instar	Mostly eggs. 100% plant with eggs	Monitored 25 plants
CWB	Yes	No	Young	Very minimal	1/25 plants with grub
Aphids	No	No	-	-	-

Disease	Level of severity (none, low, med, high)	Other comments
No disease present		

Weed	Location (paddock boundaries, neighboring crop)	Other comments
Brassica weeds	Northeast corner and along southern fenceline. Have indicated on map.	Flowering. Many moths flying around weeds.

Comments from monitoring results: Note - if control is required, rainfall, irrigation, humidity, neighboring crops
100% plants with 5 or more eggs, not at critical growth stage, significant beneficial level in field. Will not spray until see grubs feeding on leaves.
Heavy rainfall forecast might wash off young grubs and eggs. Will monitor again after rain. Can hold off from spraying. Will remove brassica weeds.
Most pest pressure southern end of paddock.

Paddock map



Notes

Figure 1.10 Sample crop monitoring sheet.

Equipment needed to monitor your crop

The equipment needed to crop monitor is easy to use and generally not too expensive. A good recording sheet, collecting vials, identification booklets and magnifying lens are some of the essentials. They can be easily carried around the paddock in a small waist bag.

Pheromone traps

Specialised traps containing sex pheromones to attract certain pests. They are used to indicate moth activity and movement within the crop. Traps can be purchased from you local field adviser.

Yellow sticky mats

Attracts small pests such as thrips and also provides a good indication of beneficial insect numbers. They are often used in glasshouses.

Identification 'ute' booklets

Used for identifying specific crop pests. The booklets are an excellent tool for quick pest identification. Most of these booklets can be purchased from any state DPI book stores.

Utensils

Hand lens, vials, collecting bags. A hand lens is ideal for close up inspections of small eggs and grubs plants. Vials with a small air vent are useful for collecting live specimens for identification.

Recording Sheets

Used for recording and archiving monitoring results (see Figure 1.10 for an example).

Using spray thresholds

Just because a pest is present does not necessarily mean it is causing economic damage to the crop. For example, pests can be directly causing damage to the marketable part of the plant or they may be doing indirect damage, such as feeding on the non-marketable part of the plant. Using a control method when pest population is low and damage is minimal or indirect is an unnecessary cost.

Crop monitoring can reduce the risk of applying unnecessary control measures by allowing you to apply a control when the pest pressure reaches a certain level, commonly known as an 'action or spray threshold'.

The action threshold is the level of pest pressure at which you should use a control measure, whether it be a spray or some other means. The action threshold is usually expressed as the number of pests per plant if the pest is an insect, or the number of infected plants if the pest is a disease. If it is a weed, then the threshold would be expressed as the number of weeds per square metre. The action threshold is always set below the Economic Injury Level (EIL). The Economic Injury Level is reached when the cost of damage to the crop, through quality or yield loss, is greater than the cost of controlling the pest. The concept of Action Thresholds and Economic Injury Level are shown in Figure 1.11.

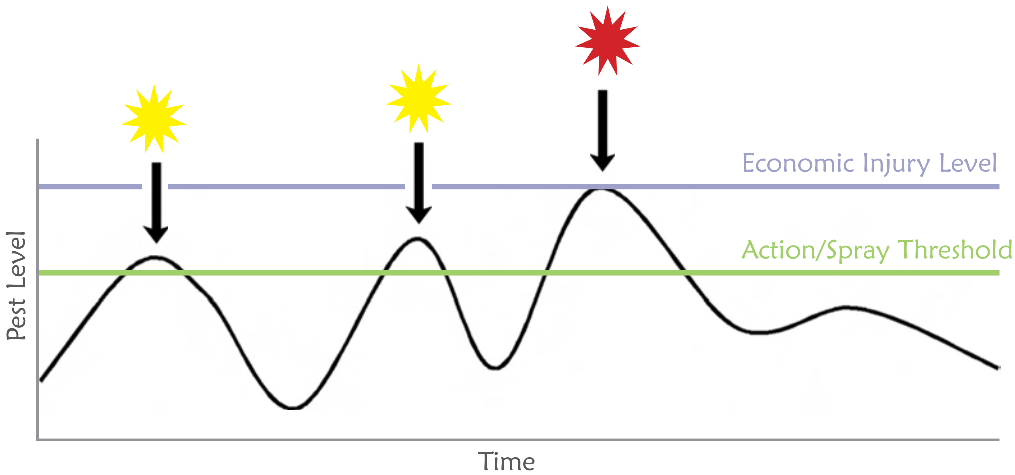


Figure 1.11 The chart indicates the level of pest pressure in a particular crop. Dark arrows indicate when a control tool was needed.

The action threshold (green line) is the point on the chart at which you will need to spray or use another control tool. The threshold level can vary throughout the growth of the crop due to changes in microclimate, value of crop and crop growth stages. The Economic Injury Level (purple line) is the point at which no more damage can be tolerated to the plant, and it costs less to control the pest than the value of the losses incurred through damage to the crop.

Determining the economic and action thresholds requires a significant amount of time and often years of experimentation. Thresholds should be used as a guide to decision making, and in many cases will need to be modified by other factors, such as crop growth stage, value of the crop, beneficials, market demand and the type of pest damage (indirect or direct damage).

It must be remembered that every crop is different - topography, microclimate and crop growth stages all vary and can have a significant impact on the pest level and the threshold. Experience and knowledge are often the key requirements for determining a pest threshold for a particular crop.

Spray application

Monitor your crop 2-3 days after spray application to determine if your spray application was effective in controlling the pest. Factors such as application method, droplet size, nozzle type, operating pressure and correct sprayer calibration can have a significant impact on the effectiveness of pesticide applications.

It must be remembered that every crop is different - topography, microclimate and crop growth stages all vary and can have a significant impact on the pest level and the threshold.

Droplet size

The effectiveness of pesticide application is directly related to droplet size and the number and volume of droplets that come into contact with the target pest. Droplet size is measured by the diameter of the droplet in microns (1 micron = 1 μm = 1/1000 mm).

Larger droplets (350-450 μm) will penetrate into the canopy and the droplets will quickly settle on the plant without drifting. Very fine to medium droplets (150-350 μm) tend to drift around in the plant canopy and will contact both the upper and under side to the foliage. The smaller the droplet, the more prone the spray is to drift.

For example: Herbicides can be applied using a medium to coarse droplet size, as entire plant coverage is not essential to achieve control. However, leaf-feeding insects such as aphids, which feed on both sides of the leaf, need to come in direct contact with the insecticide. Therefore, smaller droplets that drift in and around the plant will be more effective in targeting the pest than heavy droplets.

Nozzle selection

Spray nozzles form and disperse the droplets in a specific way. Selection of the correct nozzle and pressure is important when a desired droplet range is required. For example: conventional flat fan nozzles produce larger droplets making them more suited to herbicide application. Cone nozzles produce a large number of fine droplets making them more suited for applying insecticides and fungicides.

Sprayer calibration

Calibration of spray application equipment is essential to ensure that a known dose of chemical is accurately delivered to the target area. Incorrect calibration can result in not enough, or too much, chemical reaching the target. Calibration should be carried out on a regular basis to ensure output remains constant.

The basic steps to correct calibration are:

Step 1: Determine output in a given time

Step 2: Determine the area covered in that given time

Step 3: Calculate the output per area applied by the equipment

Step One: OUTPUT (A)

The output of the sprayer (in litres/minute) is measured five times and averaged. Output in litres per minute -

1.____________

2.____________

3.____________

4.____________

5.____________

Total per minute _______________ / 5 = Average Output (l/min)

(A) Output = ____________________litres/minute

Step Two: AREA (B)

Determine the distance (in metres) covered in 1 minute at the normal constant operating speed ___________= M1

Measure the width of the swath or sprayer coverage (in metres) ___________= M2

Area sprayed in 1 minute (B) = Distance covered (M1) x swath width (M2)

= (M1)______________x (M2) ______________

(B) = _________________________ (m^2)

Step Three: OUTPUT/ AREA (C)

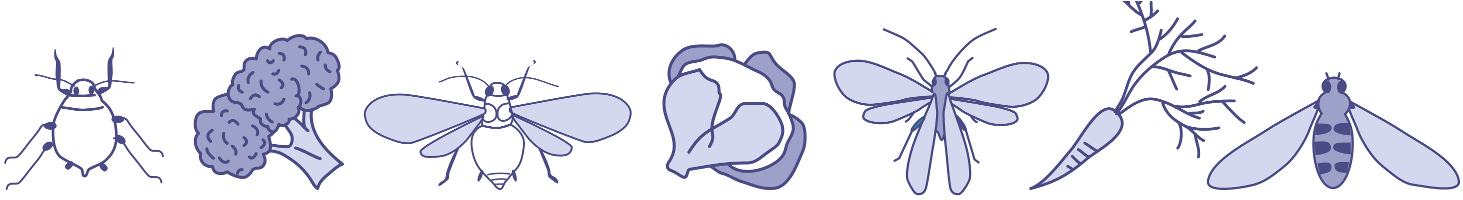
To calculate Output/Area, Divide (A): litres per minute by (B): area in m^2 covered per minute

A / B = (C) (l/m2)

(C)=________________ x 10,000 = ____________________(litres/hectare)

(1 hectare = 10,000 square metres)

(Source: Tasmanian Rural Industries Training Board)



Farm chemical application record

Operator: Joe Farmer			Date: 20-11-04				
Equipment used: boom spray			Equipment condition: good				
Situation (weed control, crop or pasture, animals, insect growth stage etc)							
weed control in potato crop							
Major species present pink weed, radish, fat hen			Growth stage pre-emergence				
Plant density			**Heavy**	Medium		Light	
Paddock identification and area			paddock 4 and 8 hectares				
Growing conditions			v good	**good**	poor	v poor	
Target access			**v good**	good	poor	v poor	
Is the target stressed? (waterlogged, affected by cold, nutrition, health etc) soil a little dry							
Weather conditions			showers	clear sky	overcast	light cloud	
Wind (gusty, calm, etc)	quite calm		wind direction		n-westerly		
Temperature	12°C		frost	no	fog	no	
			rain before	no	rain after	no	
Application data							
Products used Sprayseed			Rate 1.8 L/ha				
Additives/wetters			Yes - Activator @ 50 ml per 100 L				
Total litres farm chemicals used			15 litres				
Dilution rate (if applicable)							
Equipment application setting							
Sprayer pressure	300 kPa		Nozzle used	11003 fan	Water used	100 L/ha	
Tractor speed	6 km/h		Gear	5 H	rpm	1900	
Comments on results of application chemical went on well with good coverage although wind did increase on the last half hectare							
Any problems with equipment during application changed 3rd nozzle on left hand boom at end of application as starting to wear							
Signature Joe Farmer							

Figure 1.12 Spray application record sheet (Source: Tasmanian Rural Industries Training Board)

Pesticide resistance

Pesticide resistance develops when some pests in the population are unaffected by a certain pesticide. Resistance is most commonly found in insects and weeds but has been known to occur in some diseases. The resistant or unaffected pests survive the pesticide application. These resistant pests then breed and the new generation has an increased level of resistance. This eventually leads to an ever increasing level of resistance in the pest population.

Insect pests such as diamondback moth and western flower thrip have developed resistance to various insecticides, such as synthetic pyrethroids (SP's). Rye grass has developed resistance to Group A pre-emergent herbicides.

Resistance development

Insecticide resistance develops in the target pest population when some of the pests survive spray applications. Figure 1.13 illustrates the development of resistance. If the pest population is consistently exposed to the one chemical group, then the proportion of resistant individuals in the pest population will also increase over time.

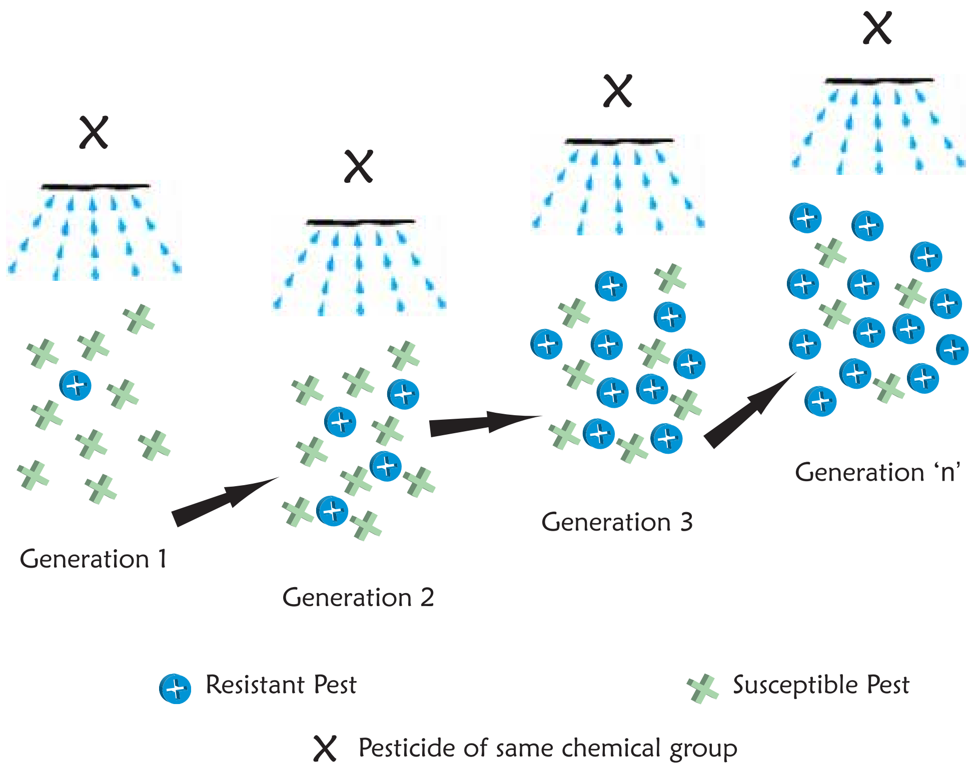


Figure 1.13   Development of pesticide resistance leading to an increase in resistant pests in each new generation (source NSW Agriculture).

Resistance management strategies

A resistance management strategy is required to reduce the selection pressure on target pests. The following ways can be used to reduce the development of resistance:

Crop monitoring

Crop monitoring allows you to accurately time your spray applications so the pest is at its most susceptible stage. Crop monitoring also ensures the absolute minimum number of sprays are applied.

Rotate chemical groups

Chemicals are grouped according to their mode of action. By using different chemicals from different chemical groups you are minimising the risk of resistance development. Refer to Appendix A for chemical groups.

Adequate spray coverage

Adequate spray coverage is essential as it reduces the likelihood of resistant pests surviving.

Follow the pesticide label and permits

This ensures the correct amount is used. Using a high concentration of chemical means that the most resistant pests may survive. Breeding for the next generation will then occur between the most resistant individuals.

Getting started with IPM: The three stages

Adopting IPM can be initiated by breaking the development of an IPM system down into several progressive stages. Remember that IPM may take two to three seasons before a noticeable difference can be seen. Patience and perseverance are the keys!

Stage One	Example
Familiarise yourself with the pests, beneficial insects and damage symptoms most likely to be present in your crop.	Clubroot: plant wilting/clubbed roots. Cutworm: Seedlings such as onions or carrots will be chewed off at the base.
Start crop monitoring by employing a crop scout or do it yourself. Start recording pests present in your crop. Spray according to monitoring results. Use a recording sheet similar to the one shown in Figure 1.10.	Follow monitoring procedures as mentioned earlier in this section of the manual.
Identify cultural practices that could be improved to reduce pest levels.	Foot baths, wash down facilities, weed removal.

Stage Two - as for stage 1, plus...	Example
Monitor your crop and record beneficial and predatory insects / pathogens.	Lacewings, ladybirds, hoverflies, spiders, small beneficial wasps.
Spray according to pest pressure and beneficial numbers. Select sprays that preserve and protect beneficials.	Biological insecticides such as Bacillus Thuringinesis.
Implement cultural practices to reduce pest levels and prevent them from increasing.	Plant spacing variations for better crop ventilation to relieve disease pressure and allow easier inter-row cultivation of weeds.

Stage Three - as for stages 1 & 2, plus...	Example
Start to implement practices that encourage beneficials.	Modify the surrounding environment by planting pollen producing plants.
Avoid practices that can lead to pests developing resistance to chemicals	Use chemicals from different chemical groups when it is necessary to resort to chemical control. Refer to Appendices A, B and C.

Figure 1.14 The three stages of an IPM program.