LESSON 5

PLANT CULTURE

LESSON AIM

Understand the horticultural techniques used to maximise cropping in hydroponics, including treatment of plant disorders and the implementation of production schedules.

FLOW CHARTING THE CROP

Throughout the life of any crop, you will need to do a range of different tasks. It is often helpful to break down the growing period into weeks, designating the tasks which are to be undertaken each week (obviously the actual time of carrying out any task will vary a little according to changes in the weather and different varieties of plant etc.)

Example of a Simple Flow Chart for Growing Lettuce

WEEK	TASK
1	Sow seed in 75% sand and 25% peat and place in greenhouse.
2	Check for germination. Keep well watered.
3	Check for damping off, thin out if necessary. Spray fungicide if necessary
4	Plant seedlings into NFT channels
	Spray with insecticide (Malathion) for caterpillars etc.
	Feed with high Nitrogen fertiliser.
5	Check for insect and fungal problems. Remove affected leaves, plants, or spray.
6	Treat with fungicide.
7	Check for disease, insect damage and nutrient deficiencies.
9	Harvest.

Obviously some crops involve more work - pruning, changing nutrient solutions, shading, temperature control, staking etc. Any such tasks should be included in a flow chart. Analysis of the crop's life in this way will help you plan your production

CONTROLLERS

Salinity Controllers

As described in Lesson 4, total salts concentration is determined by measuring electrical conductivity of the nutrient solution. This needs to be monitored closely as the nutrient concentration will be continually dropping due to nutrients being taken out and used by the plants growing in the system.

An EC meter (Electrical Conductivity meter) is a device which measures the flow of electricity between to electrodes. If the concentration of salts in the solution is stronger, there will be a stronger flow of electrons.

A salinity controller - monitors and shows the EC level in the solution at all times, and operates injection pumps which add concentrated nutrient solution to the solution in the system when the level falls.

EC will increase if temperature increases. Because of this, it is necessary to provide temperature compensation in the salinity control system. This is usually calculated on the basis of 2% per degree centigrade.

A salinity controller automatically compensates for EC drop bringing it back to a predetermined level, thus maintaining optimum nutrient levels at all times.

Over a period of time, there can be a buildup of unused salts (ie: parts of the nutrient solution chemicals which are not used). This can create an inappropriate EC reading which will make adjustments to the setting on your salinity controller necessary. Alternatively the solution needs to be replaced with a fresh solution.

Although salinity controllers can maintain nutrient solutions for periods at optimum levels, it is advisable chemical analysis of the nutrient solution (for nitrogen, potassium, calcium, magnesium, phosphorus and iron) also be carried out from time to time. In large commercial operations, such a chemical analysis should be undertaken every two weeks.

Portable meters like this can be dipped in nutrient solution and used to readily measure pH or conductivity.

pH Controllers

pH (the level of acidity or alkalinity) is critical to the growth of many plants. Different plants prefer to grow within different limits of pH. Most plants prefer to grow in a pH range of 5.5 to 6.5

A pH controller is a device linked to an electrode in the catchment tank. The electrode measures the pH of the nutrient solution and relays the reading to the controller. The controller can be programmed to inject predetermined amounts of acidic or alkaline solution into the catchment tank if the pH reaches an upper or lower limit. This way, the pH of the solution can be brought back to a level which is suitable for the plants being grown.

If the nitrogen supply in the solution is predominantly potassium or calcium nitrate, the pH will rise during cropping and acid needs to be added periodically to bring the level back to a reasonable level.

If the pH drops below 5.0, there can be problems with corrosion of parts in the pump.

Usually nitric or phosphoric acid are used to correct high pH in nutrient solutions. They are pre mixed in 1:10 or 1:20 with water and injected into the catchment tank as required, allowing maximum mixing to occur before the adjusted solution is delivered to the plants.

When mixing concentrated acids: always add the acid to the water. It can be very dangerous adding the water to the acid.

POST HARVEST STORAGE

The period of time you can store a fruit or vegetable can often be extended by using one of the following processes:

Cooling

Fruits differ in the lowest temperature which they can tolerate. Many tropical fruits suffer damage at temperatures below 10 centigrade; some below 15 centigrade. Apples and pears will tolerate 0 centigrade or lower. Generally, for every 10 degree drop in storage temperature, the fruit's respiration rate (ie. sort of the rate of breathing) halves. With a lower respiration rate, the fruit is much slower to die.

Best results are always achieved by cooling immediately after harvest. The most common method of cooling is refrigeration (whether in a large warehouse or in a small home refrigerator). Some fruits keep better at high humidity; others at low humidity. Some fruits do not store well if their skins are wet (eg. strawberries). These fruits are often stored in well ventilated trays with forced (moving) cold air.

Drying
Organisms that cause decay cannot grow at moisture levels below 10-15%. Crops preserved by sun drying include: apples, apricots, currents, grapes, peaches, bananas, figs, dates, pears and plums.

Forced hot air drying is sometimes used commercially; though many fruit growers still practice natural sun drying. If you plan on growing fruits for drying, it is normally advisable to grow in areas which have low rainfall at the time of harvest.

Canning/Bottling
Fruit is placed into a container which is able to be sealed airtight very quickly. The container and fruit are sterilized either separately or together using boiling water/steam. The fruit is sealed immediately the sterilization is completed; thus locking out all chance of decomposition.

Controlled Atmosphere Storage
Fruits are placed in either a sealed container or sealed room. The carbon dioxide level in the sealed atmosphere is increased (sometimes as high as 20% or more). This reduces the rate of transpiration and extends the storage life of the fruit considerably.

Relative Humidity Storage
Most fleshy fruits store best at high relative humidity (90-95%). These fruits include apples, pears, avocadoes, berries, pawpaw, pineapple, figs and pears.

Vacuum Storage
After fruits are placed in storage, the temperature is lowered to an appropriate level; air is pumped out, and a vacuum is maintained.

Freeze Drying
This involves removing water by sublimation of ice at temperatures below freezing. This is an expensive technique, but has promise for future commercial application.

Freezing
The quicker the reduction in temperature: the more satisfactory the finished product. The lower the storage temperature, the longer the food will be preserved for.

Temperature (degrees Fahrenheit)	*Length of Storage*	
	Strawberries	Peaches
0	1 year	1year
10	6 weeks	8 weeks
20	1 week	10 days

Most home freezers store at between -10 and 0 degrees Fahrenheit.

PEST AND DISEASES IN CONTROLLED ENVIRONMENTS

Pests and diseases can be more of a problem in a greenhouse than outside. On the one hand, the greenhouse is contained, which means it can be protected from infection (providing you practice cleanliness). Unfortunately, once you do get a pest or disease into a greenhouse, it tends to spread throughout the whole house very quickly (partly because the plants are growing so close together, partly because the warmth and humidity of the greenhouse tends to provide ideal conditions for pest and disease problems). Fungal problems are in particular of great concern in the greenhouse.

Fungi
General characteristics common to all fungi:
-Lack of chlorophyll i.e. lack the ability to produce or secure energy. They therefore must live off other organisms - in some cases dead, in some cases alive).
-Structurally they are thread-like filaments (mycelium) which grow inside the tissue they colonize. Fruiting bodies usually emerge from these threads on the surface of the tissue they colonize.
-Fruiting bodies produce thousands of spores at a time each one having the ability to grow into a new mass of mycelium, infecting new tissue.

Different species of fungi vary from one to another in the following ways:
*The rate at which they affect the organism they attack.
*The severity with which it causes damage.
*The ease with which the spores take hold.
*The part(s) of the 'plant' it affects.
*The length of time spores will remain viable before causing infection.

Common Fungal Problems
Damping Off
Several general of fungi are included in this group. Symptoms and control of all are the same.
Symptom affecting young seedlings- damping off attacks the roots and bases of the stems. A rot occurs where the roots join the stems and the top falls over. The plant then dies. These diseases particularly affect plants which are too close together. Once infection begins it spreads very fast (i.e. it can spread through a tray of seedlings in less than a day).
Control: Hygiene...never use infected soil (preferably use sterilized soil).
Avoid hot, humid and poorly drained situations.
Use Spray Le San DX or Fongarid.

Powdery Mildew
Symptoms...attacks a wide range of plants (fruit, vegetables, ornamental plants etc), normally affecting the leaves or fruits... most prevalent in warm or humid conditions, particularly if soil is dry. Shows as white or grey white fur or patches and spreads quickly causing death to parts or the whole plants.
Control... *Remove and burn infected parts. *Spray with lime sulphur, Karothane or Fungarid.

Botrytis (Grey Mould)
Symptoms...Grey fur mould on stems, fruit or other parts, and thrives in humid conditions. Common on cucumbers and other cucurbits such as pumpkin etc, tomatoes, petunia, fruits or berries etc.
Control...*Remove and burn infected parts. *Reduce watering keeping the plant drier. *Spray with Fongarid.

Pest, Disease and Disorder Control *(Chemical and Cultural)*
Insects cause a major problem for greenhouse crops. An Integrated Pest Management program should be mandatory in all commercial greenhouses. The major insects in greenhouse include aphids, fungus gnats, leaf minors, mealy-bugs, mites, scale insects, slugs, snails, thrips and whiteflies.
The most common methods of application of pesticides are:
Aqueous spray application – where solutions of chemicals diluted in water are sprayed onto the plants or effected area, manually, either from a backpack sprayer or a boom sprayer.

Mist application – is similar to aqueous but uses preparations 10-20 times more concentrated but applied in much less volumes.
Dust application – powdered solutions are occasionally used due to health regulations this application is process is now less popular
Aerosol, Smoke and Fog application – dispense the pesticides throughout the greenhouse in inaccessible locations including crevices and under benches. This method of application has little or no residual effect.
Systemic application – liquid solutions are applied to the soil medium usually through the irrigation system. They are taken up by the plants and result in death to insects feeding on the plant. The advantage of this application method is the long residual effect that can eliminate the need for other methods of control.
Combinations of chemicals can have lethal effects on plants and others may become ineffective. Check with the manufacturer before combining.

Cultural Controls
Include the cleanliness and hygiene of both the greenhouse and staff in and around the area is of utmost importance to reduce the likelihood of an outbreak.
Other controls include: using a soil medium that has been pasteurised, and kept in hygienic storage conditions, away from contamination until required for use,
Sterilise pots and containers – this includes all tools, wire or plastic supports and watering system parts.
Sterilise potting benches – often materials accumulate around benches and dirt tends to be left. Keep benches clean and tidy. Sweep them off after use with a broom kept for that purpose only. Disinfect weekly
Be aware of foreign soil being imported onto the site. Keep a tray of disinfectant in front of the entry door, so on each entry, they must step into the solution to wash off foreign soil.
Clean up debris constantly – never discard plants or parts onto the floor – always straight into a bucket. When working, wear a removable cloth around your waist so plants are not constantly in contact with your clothing. Similarly, jewellery, clothing and hair should not come into contact with plants. Remove the remainder of the crop immediately after harvest. All organic residues should be composted in heaps far enough away so that soil borne organisms, windblown spores and insects cannot make their way back to the greenhouse.
Weed control – weeds can serve as hosts to pathogens that can infect crops so remove them regularly.

Current Legislation
Greenhouse operators are legally required to follow the approved uses and application rates as described on the labels of all chemical containers. They must keep the Material Safety Data Sheets for each chemical used onsite in an accessible location and ensure all operators are licensed and trained in the application of each chemical.
Regulations are frequently changed and updated and it becomes the responsibility of the operators to keep themselves informed of any changes by regularly contacting the government department responsible.
There are also growers associations and publications that should keep you up to date with relevant information. Legislation is updated not only on chemicals but also on environmental standards.
All countries and states will have an Environmental Protection Authority that will supply you with the legislative updates. Local municipal council environmental departments may impose local by-laws which you need to be aware of.

Biological and Integrated Pest Management
IPM is a pest control system in which preventative, surveillance and corrective measures are integrated into a holistic program. It is not meant to kill every pest in the greenhouse, but to attain an acceptable level of pest control while reducing the use of harmful chemicals and pesticides and thereby reducing the impact of the operation on the environment. It is the combination of many strategies that would include:
Weed control, Cleanliness of structure and surrounding areas, Inspection and quarantining of new plants, screening of entrances to the greenhouse, frequent inspection of crop and surveillance for pests including identification and quantification and accurate recording of that information, adjustment of environmental conditions to make it uncomfortable for the pests but not the plants and finally, pest eradication methods by biological control.

Many growers introduce predator insects or pathogenic micro-organisms into the crop when pests are first noticed and these quickly dominate and destroy the pest.

Beneficial Agents

One specific agent may be introduced for a particular benefit. This may be for pest control such as ladybirds to control aphids, or

To reduce the potential of a fungal outbreak by planting garlic – companion planting with roses, the sulphur from garlic reduces the spread of fungal diseases or

Planting of legumes to provide a nitrogen source for a particular crop – corn benefits greatly from having a crop of beans planted amongst it.

The introduction of beneficial agents differs from the more holistic approach of IPM, by being a very specific and managed strategy.

Economic Thresholds

Profit depends on the management of the expenses and the production of revenue. The economic threshold is when the profit is greater than the expenses. The market price of produce varies with the supply and demand. Producing out of season crops or producing higher quality crops and maximising growing space will increase revenue. Revenue is directly tied to the choice of market outlet. Prices can vary among different outlets. Speed of payment is important – a quick payment cash flow permits the grower to minimise the interest of loan repayments. Increasing prices to increase profit usually does not work for the primary producer. Slow payment and unrecoverable debt can send a grower bankrupt.

Improving profits is dependant on managing and reducing expenses. Growers react to sudden changes but often overlook subtle changes. These may include fuel prices, marketing and transporting expenses and consumable supplies.

The economic threshold and therefore profitability of the business is dependant not only on growing and production decisions, but also equally on intelligent business decisions.

Methods of Introduction

It is all too easy for pests and diseases to enter the greenhouses: the producer must remain vigilant and not drop his guard for any exception. It takes only a small amount of a fungi, bacteria or pest to enter the production facility and rapidly increase the population to inflict considerable damage before being noticed and brought under control.

The most common sources of introduction include:

- Materials imported from offsite for use – soil is the most common carrier of infection, new plant stock –all new stock should be quarantined for 2 weeks to ensure they are free of harbouring disease
- Visitors to the site – especially those visiting from within the industry.
- Staff wearing inappropriate clothing or shoes.
- Not enforcing hygiene regulations – not ensuring each entrant has the soles of their shoes dipped into disinfectant at the entrance to each shed.
- Incorrect disposal of onsite waste – all green waste must be composted a minimum of 100 metres from the sheds to avoid contamination.

Major Pests, Diseases and Disorders of Crops Identified

Infectious diseases in greenhouse crops often cannot be eradicated. At best they can be contained. Some cannot be contained, with the only control being to remove and destroy the infected portion of the crop. Generally, fungicides are not as effective as insecticides.

Prevention through hygiene and care are the most effective strategies in reducing outbreaks. However, some diseases are inevitable in monocultures, forced growing conditions. Some disease organisms are transmitted in the soil or through the irrigation water or may be imported on the bottom of a shoe. Some fungi are windblown.

Prudent scrutiny of plants on a daily basis in association with checking for pests and water requirements is the best form of detection.

There are many pathogenic diseases of greenhouse crops and are categorised into 4 groups.

1. *Viruses* – are microscopic infections. Plants do not produce antibodies, so they never completely recover or become immune. Once a plant is infected, it will remain infected for life, even though the symptoms become masked or the plants may grow out of it. The most common symptom is stunting or dwarfing. Leaves display colour change and show spots, streaks, blotches and rings of yellow, brown or black.

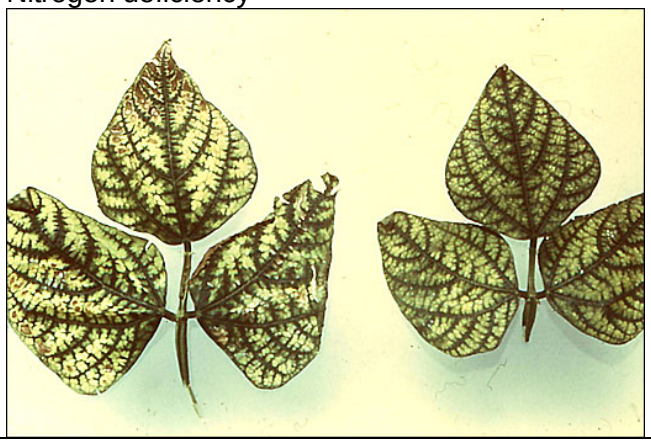
Leaves may also change in shape and size, usually developing rolled margins.
Generally viruses are not spread from seed they can spread unaided from cell to cell in one plant. They require assistance to spread from one plant to another and a wound in which to enter the plant. Most frequently, viruses are spread from insects feeding on a healthy plant after feeding on an infected plant, by grafting with a scion from an infected plant or by using infected stock plants as a source of cuttings. Insect control is therefore critical to virus control in greenhouses.

2. *Bacteria* – are single cell micro-organisms that are extremely difficult to control. Control is primarily through prevention and elimination of infected plants. There are bactericides to aid control but these have limited success.

3. *Fungi* – are multi-cellular organisms, are the most numerous and fortunately are able to be controlled. The most common fungi include Powdery Mildew, Botrytis Blight, Pythium Root Rot, Rhizoctonia Root Rot, Dampening-Off Disease and Verticillium Disease. There are fungicides available to treat these diseases.

4. *Nematode Diseases* – are very small, round worms sometimes referred to as eelworms. Not seen with the naked eye they exist in all soils, but most nematodes are beneficial while some are destructive. It is not until large numbers build up that they can do injury to plants. Inoculation with a microbial mixture containing beneficial nematodes will keep the harmful varieties from population explosions. Symptoms cause plants to appear stunted and wilt quicker on warmer days. When the root systems are inspected, galls are apparent. The presence of root–knot nematodes increases the amount of plant injury from bacterial and fungal diseases or breaks the resistance of plants to these diseases. Other than root feeding nematodes there are foliar nematodes that cause deformity of young growth, leaf spots and sometimes defoliation.

DIAGNOSIS OF CROP DISORDERS

SYMPTOM	*POSSIBLE CAUSES*	*TREATMENT*
Spindly growth	Low light (eg. shade), excess in temperatures, too close together.	Improve light, cut watering, reduce night temperature in plants greenhouse by cooling or ventilation, reduce feeding, increase spaces between plants
Growth reduced small plants	Insufficient nutrient lack of water	Feed more often but in lower concentration. Water more often.
Old or lower Leaves Yellowing	Nitrogen deficiency 	Increase proportion of nitrogen in your solution. Change the form of nitrogen being used to a form which is easier to be taken in by the plant. Check solubility of nitrogen in your formula, check pH (this can affect nutrient availability) and adjust if needed.

Young leaves yellowing between veins	Iron deficiency 	Similar treatment as for nitrogen above.
Purple leaves Root tips burnt or discoloured	Phosphorus deficiency, Excess fertiliser or salts, toxic chemicals in media (sometimes this occurs when media is fresh.	Leach media thoroughly to wash away excess nutrient or toxin. Check levels with an EC meter.
Woody growth	Plants over hardened or slow growing	ie. exposure to tough conditions is excessive. Increase feeding, if slow growing and also prune
Stems very wet and decaying at base of the plant	Damping off disease caused by dirty conditions, high humidity or over crowding	Thin out plants, Apply fungicide
Algae, moss or liverwort on surface of the medium	Excess moisture and nutrient on surface. Doesn't harm plant initially but can impair flow of nutrient solution in the long term	Reduce watering, increase ventilation, use better draining medium. Some chemicals may need to be used to kill algae and moss.
Poor root Growth	Aeration or drainage, low temperature in medium, toxic chemical in medium.	Determine which of these is the problem and act accordingly

PESTS

A wide variety of animals can be pests to plants.
Here are some examples.

Aphids

- Insects which feed on plants or which transmit other problems such as fungal and virus diseases from plant to plant.
- Animals which cause physical damage by digging around plants, knocking plants or eating plants (e.g. goats, birds, dogs, etc).
- Animals causing burn to plant tissue by urinating on them (e.g. dogs).
- Man causing physical harm to plants by compacting soil through over use, knocking and damaging plant tissue, transmitting pests and diseases to the vicinity of "clean" plants, by deliberate vandalism, and through other forms of mismanagement.
- Snails, slugs, nematodes, yabbies, wood lice, mites and other small animals feeding on plants, transmitting diseases, etc.

DISEASES

Plant pathology is difficult to define comprehensively, though the following definitions give some insight into the subject:

"Plant pathology is the section of botanical science which deals with diseases and troubles in plants".

"Disease in a plant consists of a series of harmful physiological processes caused through irritation of the plant by a primary agent"

"Cellular irritability is the basis of plant pathology"

Black spot on roses

Plant pathology is generally distinguished from insect and other pest problems. Plant pests actually eat the plant, or break the plant by standing on it (as does the human pest). Plant disease is different: plant disease is far more subtle, disturbing the microscopic physiological processes which go on within the plant.
When a plant is diseased, it may be affected by one, two, or more different problems.
It is often difficult to identify what is wrong with a plant clearly, because the problem is in fact a combination of problems. A possible scenario might be as in the example below:

- The plant is weakened by poor nutrition.
- Excessively humid conditions create an environment conducive to the growth of an infectious fungus.
- The plant which is weakened by poor nutrition is infected by the fungal disease which develops in humid conditions.
- The roots begin to rot through fungal attack.
- Because the roots are damaged, the plant does not take in water and nutrients as well as it would normally.
- The leaves of the plant are infected by a second disease because the plant is weakened and more susceptible to infection.

DIAGNOSIS OF PROBLEMS

Problems can be looked at as being in one of three possible categories:

1. Nutritional - The plant has either too little or too much of one or several particular nutrients available to it.
2. Environmental - The environmental conditions are not suitable e.g. Air too dry or too humid, interruption in nutrient flow.
3. Pathological - One or several organisms are interfering with the health of the plant (such organisms are called "pathogens").

Chemical spray damage

It requires a great deal of knowledge and expertise to be able to diagnose plant troubles. Do not expect to develop such ability quickly. The first and perhaps most important skill to develop is an ability to inspect a plant and look for the tell tale symptoms which can provide an indication of what might be wrong.

FINDING OUT WHAT THE PROBLEM IS

Before we can help a plant we need to know what is causing the problem/s. It requires a great deal of knowledge and expertise to be able to diagnose plant troubles. Do not expect to develop such ability quickly.

Inspecting a plant to find the tell-tale symptoms which will provide an indication of what is wrong is the first and perhaps most important skill to develop.

CONDUCTING AN INSPECTION

A sick plant may have one or several causes at the same time.
There are thousands of possible causes which can contribute to a plant's problems.

More often than not, there are several factors involved. Minor diseases or environmental problems may weaken the plant, making it susceptible to some more major (obvious) disorder.

When you inspect a plant for problems, systematically consider all of the things which might possibly be going wrong.

TELL TALE SYMPTOMS

Wilting

- Insufficient water in the soil.
- Leaves drying out faster than the water can be taken up (too hot).
- Something stopping water going up the stem (eg. borer, disease, etc. in lower part of plant)

Take a close look!

Yellow Leaves

If older leaves

- Lack of Nitrogen (feed with a nitrogen fertiliser).
- Lack of Nitrogen caused by wet soil -wet soil stops nitrogen being taken into the plant (improve drainage or cut watering).
- Chemical damage
- Soil very dry

If younger leaves

- Iron deficiency
- Other nutrient deficiency
- Chemical damage

Zinc and iron deficiency

Look to see if damage is distributed evenly over the plant

- On one side only.
- On the top only.
- On the most exposed parts. Is there a pattern?

Look to see if damage has only just happened....or is past?

- The appearance of the growing tips tells you the current condition.
- Young shoots indicate a healthy plant overcoming past problems.
- Excessive side shoots lower down indicates disruption of hormone flow in the plant, or some other problem in the upper parts of the plant.

IS THERE MORE THAN ONE PROBLEM?

The following information relates to plant production both in the greenhouse and in a field setting
Often your plants can suffer from more than one problem. Frequently these different problems are interrelated, with one causing others to develop. For example, poor drainage may result in damage to a plant's roots. This in turn can result in reduced vigour, opening the plant up to attack from various pests and diseases. These pests and diseases may be obvious, but the damaged roots may not. The most important problem is called the "primary problem" and other problems which can occur as the plant weakens, are called "secondary" problems.

Green vegetable bug

When you look for a problem, always remember; you might be looking for several answers (not just one).

What If you are unsure?
For anything you are uncertain of, devise a treatment which could be used for what you think is the most likely problem, and apply that treatment. You will be able to determine whether that was the problem or whether it was something else by watching how the plant responds.

The table below provides a systematic approach to inspecting plants which you suspect, (or know) might be unhealthy.
You should look at each of the "items" one at a time, following the guide given by the "method of inspection" column.

ITEM	METHOD OF INSPECTION	WHAT TO LOOK FOR
LEAVES	View old and young leaves- both above and underneath	Burning, discolouration, holes Leaf drop, Insects -live or dead
STEMS	View top to bottom, push foliage out of the way.	Stem rot, spots or other markings. Suckering, Side shoots, thin or thick stems.
GROWTH HABIT	Stand back and view, look at where strong growth is and direction of buds.	Is it balanced appropriate for type of plant (bushy for shrub...strong terminal growth for tree etc.) Growth rate
SOIL	Feel surface of soil, push finger 2-4cm below surface. Remove plant from pot	Moisture/dryness Hardness, root density, burrows, wet/dry spots
ROOTS	View holes at bottom of pot, Remove plant from container, View surface of soil.	Root tip burn, Rotting, Distribution of roots -even? Discolouration. Growing tips

DIFFICULT TO DIAGNOSE PROBLEMS

If you can't determine a problem easily with the information on the previous pages; you then have only two options:

1st option: TRY A GENERAL PESTICIDE (one that works on many different problems)
You don't really need to know what it is, as long as you can cure it.
a/ Try some common treatments:
If it's a pest or disease, but you don't know which pest; remove and burn the diseased plant, then replace with a new plant.
Or spray with a broad spectrum pesticide (eg. sulphur or benomyl for diseases), Malathion or Rogor for pests.
b/ If the plant is generally unhealthy; attend to feeding, watering, weed control, drainage, mulching and pruning out any weak, diseased or dead wood. This could rejuvenate it and help it overcome most types of problems, as long as they are not too severe.

2nd option: SEEK MORE EXPERTISE.
If you can't identify, the problem using the information you have learnt do far or your own general knowledge, the following may provide more expertise:

a/ Literature
You may discover what the problem is by reading or studying more. Visit the library; buy more books, magazines etc. write away for literature from chemical companies or take a further course.

b/ Advice from experts is sometimes available free of charge through government departments and other places such as:

- Various government departments (eg. agriculture, botanic gardens)
- Nurseries -often give free advice as an enticement for you to buy from them; level of expertise varies.
- Schools and tertiary institutions.
- Chemical companies
- Magazines -some offer a write in service, either for a fee or at a nominal charge

c/ Diagnosis Services/Consultants
These are services you pay for, run by government departments, schools, universities, private businesses, etc. Their methods of identification are usually too complex for the average home gardener but their information is up to date and in line with council/state/federal law regulations.

Some of these advanced techniques may involve dissecting plant tissue, culturing pathogens in a laboratory, or doing soil nutrition level tests.
These services can be costly, sometimes running into hundreds of dollars, but they are the most accurate, and in the case of particularly serious problems; they can stop problems persisting or developing which might be much more costly.

IPM (Integrated Pest Management)
The six main ways used to control pests and diseases are as follows:

1. Sanitation - maintaining good hygiene
2. Physical control methods e.g. mowing, slashing, burning, flooding, hand removal, physical barriers (i.e. netting, fences), etc.
3 Using plant varieties that are resistant to pests and diseases
4. Biological controls
5. Chemical controls (artificial and naturally derived).
6. Soil drenches/dips

If you look carefully at the above six ways of managing pest and diseases you will see that the list starts with the control method that will have the least impact on the environment. Today most countries, adhering to 'World's Best Practice' guidelines will encourage the use of the IPM system. Integrated Pest Management is a means of controlling pests without relying totally on chemical insecticides.
In the past farmers and horticulturists main approach to pest and disease control was to either wait until there was evidence of a problem and then eradicate the pest or disease with the application of chemicals, or implement a pest control program with regular and routine chemical treatments before there was any sign of damage.

The approach that IPM takes is to look carefully for pests throughout the season and make decisions on what to do based on the results of the monitoring process
Through the implementation of an IPM system pests are more likely to be found when they are still only in low numbers due to the fact that the plants are being checked regularly for signs of infestation or disease. The problem will be dealt with early before the outbreak becomes too big.

There will always be some pests present in a crop or on plants. This does not necessarily mean that a control method needs to be implemented that quickly kills the pest, in IPM the best control method will also take into account control measures already in place i.e. biological control and not jeopardise their effectiveness. It must be ascertained just how many pests can be tolerated without damage to the plants or crop In and this is dependant on the location, variety and other crops growing nearby.

Using an IPM strategy horticulturists need to be able to identify the many different insects including pests and those that are not pests as well as diseases found on their crops or plants, they should know when action is needed by ascertaining whether an infestation is at a level so as to be of concern, and to ascertain the number of beneficial insects present.
They also need to know how many pests can be tolerated before they need to take action; resistance to insecticides is an outcome as a result of chemical overuse in the past. Monitoring crops on a weekly basis will enable you to determine what the pests and beneficial insects are doing and whether the beneficial insects are controlling the pests, intervention should only occur when biological and cultural controls are not sufficient.

Insecticide use in IPM
If the cultural and biological controls are not performing the job of preventing unacceptable levels of damage, insecticides may be appropriate, but ideally it would be best to use chemicals that kill the pest and do not kill beneficial insects. With the broader application of IPM more selective products are coming onto the market and this is a continuing trend. For example, virus to control heliothis caterpillars is being sold as GemStar, bacteria to control many caterpillar species is sold under many names, including Dipel and XenTari.

Chemicals that kill aphids but not most beneficial species include Pirimor and Chess. If pests are seen in numbers that can cause damage, or introduce disease, should insecticides be used? It must be understood that use of insecticides can make some pest problems far worse, although they can solve other pest problems.
Extreme care must be made in the selection, timing and application of any insecticide. The treated crop should be monitored to make sure that the insecticide did what was asked. In addition, the potential losses hopefully saved by insecticide application should be weighed up against other insect or disease problems that can be created by the treatment.

What Does IPM Involve?
Knowledge of the organism's life cycle, its habits, environmental requirements and natural predators forms the basis of all IPM programs. IPM treatments use a combination of strategies including biological, mechanical, physical and chemical tools as well as other common-sense cultural and managerial practices. Education is central to the overall success of an IPM program

In an IPM program, chemical controls are generally considered a last resort, unless there is a genuine emergency requiring a rapid response. When a chemical control is needed, the hazard associated with that chemical, which includes its toxicity and the potential for human and environmental exposure, must be assessed and the least hazardous chemical control chosen. A range of preventative measures should be used in an integrated system.

Non-Chemical Pest Control Methods
Cultural and managerial: Change habitat to eliminate food, water and shelter. This may include changes to the design of structures such as greenhouses and glasshouses to incorporate pest-resistant materials also to ensure adequate hygiene and sanitation procedures are in place. This is particularly important in relation to rats and mice.

Biological and microbial: The pest's natural predators are used to control the pest, this may include ways conserve natural predator numbers, laying attractant baits for the target pest, building up predator numbers by feeding or purchasing commercially available ones (e.g. lady beetles used to control aphids); and, the use of microbes such as bacteria, fungi and viruses to minimise the numbers of pests, e.g. the microbial insecticide Bacillus thuringiensis or 'BT' which kills caterpillars. Although it must be stated that care needs to be taken in introducing "control" species into the environment as the full effect of this practice is not fully understood.

Pheromones and attractants
Pheromones are chemical signals emitted by animals, e.g. sex pheromones and alarm signals. Pheromone traps work by using a pheromone attractant to lure the insect into a trap

Insect growth regulator
The application of juvenile growth hormones can prevent juveniles from metamorphosing into adults thereby inhibiting sexual reproduction and pest numbers. Other insect growth regulators inhibit the production of chiton in insects, which is the waxy outer cuticle.

Repellent
Botanical materials such as natural oils like citronella and eucalyptus can repel insects.

Desiccating dusts
Dusts made from natural materials such as diatomaceous earth and silica aerogel kill insects by abrading the outer waxy coating that keeps water inside their bodies thereby dehydrating them.

Pesticidal soaps and oil
Pesticidal soaps are often made from coconut oil which contains fatty acids that are toxic to insects. Soaps are considered to have low toxicity to mammals but high toxicity to aquatic life. Oils are usually highly refined and light so they can be applied to plants.

Botanical pesticides
Botanical pesticides derived from plants can be easily degraded in the environment, but they tend to be broad spectrum and kill more than the target pest, e.g. pyrethrum*, neem, rotenone. It is important to realise that botanical pesticides can also be toxic and must be used with caution and according to label directions. Also check in your country to ensure that these products are still scheduled for use.

Changes occur constantly as products are tested or more information becomes known.

*Pyrethrum is a botanical insecticide extracted from the daisy flower Chrysanthemum cinerariaefolium and may also be referred to as 'pyrethrins'. Pyrethrum or pyrethrins should not be confused with 'pyrethroids' which are synthetically produced pesticides based on pyrethrum.

Labels

The label offer a wealth of information concerning safety precautions, application rate and modes, directions, storage conditions, first aid and safety instructions, batch numbers and container disposal instructions.

Registration safeguards of chemicals assess:

* Residues in foods
* The safety of persons using the chemicals
* Environmental safety
* Safety to the plants or animals being treated
* Trade issues.

After reading the labels always adhere to:

* do not exceed label dose/application rates
* do not apply chemicals more frequently than label instructions
* do not use chemicals contrary to a specific label prohibition
* observe withholding periods stated on the label.

NB. Permits may be granted by some states in some countries to use chemicals outside these restrictions.

COMMON PEST PROBLEMS ON PLANTS

WARNING:

Some chemicals listed may be restricted or banned in some countries.

Chemicals are constantly under review and various countries or states have differing laws governing use. It is imperative that you research chemicals before using them. Remember that a product may have restricted use i.e. it may only be used to control a particular pest on a particular plant: it may not be used to control the same pest on a different plant

e.g. a product with the active ingredient chlorpyrifos may be used to control aphids on Brassicas in general production, but not on Brassicas grown as fodder crops: dimethoate may be used to control thrips on peas, but not on other plants

You should be aware of the regulations in your country as well as those for your state /region

Material Safety Data Sheets (MSDS) or Pesticide Information Sheets are available for all manufactured chemicals. You should ensure that you have a copy of each sheet for every chemical that you have in use or storage.

Please note:

1. Some control recommendations i.e. burning plant material may not be legal in your country.

2. There may not be current scientific evidence to back-up purported benefits of companion planting in every instance.

3. Some **'natural'** methods of pest and disease control may not be legal in your country i.e. kerosene – banned in some countries.

*Check with relevant government authorities before using suggested control methods.

DISEASES

ANTHRACNOSE

A group of diseases affecting foliage, stems or fruit, which appear as

EITHER:

a/ small or large dark-coloured dead spots

OR

b/ sunken spots with a slightly raised rim

Anthracnose diseases are common on dwarf and runner beans, vine crops, species of *Platanus* (planes) and *Salix* (willows).

Symptoms:
Dark brown, purplish, red or black sunken spots on stems, fruits or seeds: may cause fruit drop and fruit rot: in addition twig or branch die-back may occur: symptoms may include reddening on the undersides of leaf veins, particularly in bean crops.

Control
Physical/Natural –

- On large trees, control is almost impossible: remove or collect fallen, diseased parts and burn: if practicable prune off affected twigs.
- Use clean seed: infected seed is recognisable by dark spots on light-coloured seed or indefinite pale marks on dark seed.
- Do not re-plant susceptible crops in areas where conidia (fungal spores) may be lingering in the soil
- In glasshouses routinely disinfect the fabric of the house, avoid wide fluctuations in temperature and ventilate well: sulphur suspension.

Chemical – not practicable on larger trees: spray with sulphur suspension and/or Bordeaux mixture depending on plant and time of year: In some countries, Zineb and Maneb may be recommended more often than copper sprays: these chemicals are not licensed for this use in EC countries and U.K.

BLIGHT
A disease characterised by general and rapid death of plant parts: parts of a plant (e.g. leaves) stop growing and die without rotting: rotting may occur later, particularly in damp or humid conditions.
Blight is generally sudden, and commonly involves death of parts of a plant, and sometimes dropping of leaves or fruit. Blight is caused by several different pathogens for example *Alternaria solani* causes Early Blight in potato and tomato, *Phythophthora infestans* causes potato and tomato blight, *Pseudomonas phaseolicola* causes Halo blight in dwarf, French and runner beans.

Types of Blights
Blights are often named according to the part of the plant they infect and the plant variety they occur on: e.g. AZALEA PETAL BLIGHT is blight caused by the fungus *Ovulinia azaleae*: small spots develop on affected petals - white on coloured flowers, pale brown on white flowers: as the spots increase in size they develop a water-soaked appearance and eventually the flowers become wet, slimy masses. Only 3 days may elapse between onset and complete collapse of the flowers.

Control:

- Hygiene is most important for all blights. Remove and burn all infected tissue as soon as detected.
- Copper sprays will help control most blights, though some require other specific chemical sprays e.g. mancozeb (a dithiocarbamate fungicide) is used to control potato blight.

Alternaria spp.
There are many different Alternaria diseases, and these are the most common diseases of many plants throughout the world. Alternaria diseases cause both blights and leaf spots. Sometimes the leaf spot and blight effects appear together.

Plants affected include:
Cucurbits, Carnations, Carrots, Potato, Tomato, Violet, *Zinnia*, *Schefflera* spp. (Umbrella tree), *Hedera* spp. (Ivy), *Aralia*.

Control:

- Use copper based preparations and zineb in Australia: azoxystrobin (carrots), iprodione (seed treatment) for bedding plants and ornamentals in U.K.

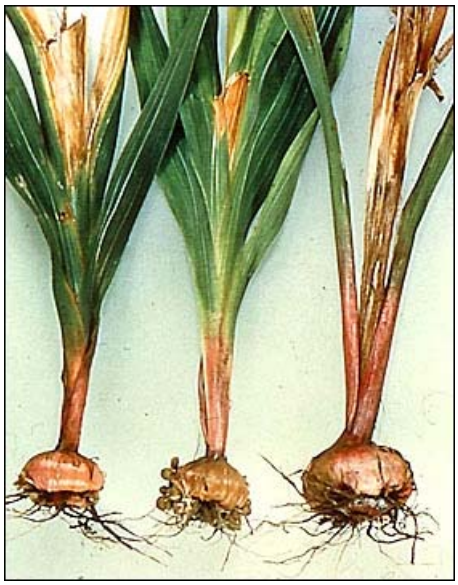
Leaf Blight
This is a generic name for diseases caused by several pathogens e.g. *Alternaria dauci* causes carrot leaf blight: *Marssonina* spp. cause Poplar leaf blight: *Diplocarpon maculatum* causes Quince leaf blight. Leaves develop spots or patches of dead tissue: the leaves may drop, or may be held on the plant. In woody species, dieback may be associated with leaf blight. The infection in dead areas will spread to other parts of the plant, often after increasing in size.
A number of different fungi can cause leaf blight and a large number of different plants can be affected.

Control:
- Spray with Zineb (not U.K. and Europe) or copper-based preparations, when leaf buds are half open and again when leaves are half grown to full size.

BOTRYTIS

Grey moulds, are serious, widespread diseases worldwide on flowers, vegetables, ornamentals, fruits and some field crops. They are the most common diseases of greenhouse crops.

Symptoms:



Mainly occurs as blossom blights or fruit rots but can also appear as damping off of seedlings, stem cankers, spots on leaves or rots of below ground parts such as tubers or bulbs. Blossom blights often precede and lead to rots on other parts of the plant. The fungus usually establishes in flower, as they age: flowers turn brown and rot: the infection then spreads to the other plant parts. In humid conditions a noticeable fluffy, cobwebby, whitish-grey or light brown growth is produced that is characteristic of Botrytis disease.

Control:
Natural
- In greenhouses humidity should be reduced by improved ventilation and increased heating,
- Prompt removal of infested debris,
- Harvested plant storage organs such as onion bulbs can be stored at 32-50 degrees C for 2-4 days to remove excess moisture then stored at low temperatures in as dry conditions as possible.

Chemical
In Australia, products such as Fongarid (soil drenches), Zineb, Difolitan, Maneb are all been used to control Botrytis disease, as are sprays containing dicloran, thiram and iprodione: in U.K. dicloran, thiram and iprodione are licensed for control of Botrytis diseases in specific crops. Strains of *Botrytis* resistant to some of these chemicals have been found.

CANKER
A canker is a localized spot of dead tissue i.e. dead tissue in one place only. Cankers generally begin at a wound or at a dead stub: from this point they expand in all directions, perhaps even girdling a stem. Expansion and development will be much faster along the main axis of the stem, branch or twig. When a canker extends until the entire branch is girdled, the shoots beyond that point die: this is one form of dieback. If there is dieback from the tips of a plant, the cause may be blight, or a canker which is "choking" the plant somewhere below the tip.

True cankers appear on woody plants and are caused by both bacteria and fungi: they may also be caused by factors other than pathogens.

Symptoms
Fungal canker shows as sunken and discoloured patches on the bark: these become elliptical as they expand, with the bark shrinking in concentric rings around the canker. The branch usually becomes swollen: girdling of the shoot may occur, causing dieback. Bacterial canker is characterised by flatter lesions which exude gum: the lesions may also appear as splits, necrotic areas within the woody tissue or scabby excrescences on the surface.

Control
Physical
- Cut out severely cankered branches and spurs:

Chemical
- Usually only of value in cankers of tree fruit crops such as apple and pear or bacterial canker of cherry and plum: use Bordeaux mixture, carbendazim (apples) and copper oxychloride: chemical sprays are not practicable on larger trees.

DAMPING OFF

Damping off disease in seedlings

Characterised by young plants rotting off at soil level and collapsing.
There are several fungi species causing damping off. These include *Pithium, Rhizoctonia, Phytophthora, Sclerotium* and *Fusarium*. This type of disease is common in seedlings and is a serious nursery problem. Older plants are rarely killed by this group of diseases; however their growth may be considerably retarded by root damage.

Symptoms:
Symptoms are exceedingly variable but all result in death: seeds can rot before germination; shoots from freshly germinated seeds can rot before they emerge from the growing media, or young seedlings rot at the base after they have emerged and collapse. On older trees, root and stem lesions and root rots may occur.

Control:
Natural/Physical
- Cleanliness, hygiene, good drainage: provide good ventilation.
- Do not plant too close together: apparently healthy seedlings from a container of diseased ones should not be used: seed trays/punnets/boxes should be disinfected before use.
- Use sterilised compost.
- If possible use sterilised seed raising and potting mixes when growing your own plants (if the compost provenance is uncertain small quantities of compost for domestic use can be cooked in an oven for 2 hours at 120^{o}C, as a sterilising process).

- Potting mixes using composted tree barks e.g. pine bark instead of soil, significantly reduce the incidence of damping off.

  Chemical
- Dust your seeds with zineb (Australia) or thiram.
- Benlate or proprietal LeSan DX in Australia: other fungicides such as etridiazole, propamocarb hydrochloride, copper oxychloride may be used, but these are all crop, growth-stage and pathogen specific e.g. copper oxychloride – for tomato seedlings: or thiram as a seed treatment for lettuce: Previcur (active ingredient propamocarb) kills *Pythium* but not *Phytopthora.*

GALLS

Abnormal lumps and swellings: on plant tissue.

Galls are abnormal swellings, lumps or growths which can occur on virtually any type of plant tissue. Galls can be caused by certain fungi, bacteria, insects or nematodes: the causal insects live and feed in the gall.

Although galls give their host plant a bizarre appearance, in most cases no real harm is caused to the plant.

LEAF SPOT

Brown or black spots on leaves: which are dead tissue.

Leaf spot diseases occur on a huge range of plant varieties: they are characterised by spots of dead and discoloured tissue on a leaf, usually brown or black. Leaf spot diseases are some of the most common diseases of virtually any plant.

Most leaf spots flourish during or after wet weather. They rarely require attention, unless an outbreak is severe: nevertheless, affected leaves should always be removed and burned:

Many different fungi cause different leaf spots on different types of plants: some are unique in the disease they cause and may or may not be plant specific, e.g. *Pseudopeziza ribis* affects currant and gooseberry: *Heterosporium varibile* affects spinach: *Coniothyrium hellebore* affects hellebores: *Glomerella cingulata* affects rhododendrons and azaleas: *Phyllosticta* sp. affect anemone: other leaf spot diseases are caused by pathogens which also cause other diseases, such as *Alternaria* or *Septoria*

Control:

Natural/Physical
- Where plants are growing very close together, increase ventilation/air circulation by removing alternate plants.
- Use treated seed, where available treated.
- Practice crop rotation.

Chemical
- Where available, treatments tend to be plant and/or disease specific e.g. mancozeb can be used on gooseberries.

MILDEW

Causes young leaves and tip growth to become distorted and appear grey. Commonly occurs on azaleas, apples and a wide range of other plants.

- Black Mildew

Appearance is similar to powdery mildew, only a dark colour: cobweb-like to powdery black patches appear on the upper surfaces of mature leaves. As the infection develops, the upper leaf surface becomes densely coated with a black powdery growth of fungal hyphae. Sometimes confused with "sooty mould", black mildew does not develop on the sticky exudates known as honey dew, which are secreted by insects, as does the sooty mould. Sooty mould also differs from black mildew because it is saprophytic (feeds by absorbing dead organic matter) and superficial. Several fungi cause black mildew in a number of plants such as *Epipolaeum abietis* in *Abies* spp.: *Meliola* sp. in *Magnolia grandiflora* and *Apiosporina collinsii* in *Amelanchier* spp. Bamboo species are also affected by Black Mildew.

No chemical controls are recommended. In *Amelanchier* spp. where black mildew is a symptom of “witches broom” formations, the brooms may be cut out.

- Downy Mildew

The fungi which cause downy mildews are obligate parasites – that is the must parasitize a host plant to survive. High humidity, damp conditions and a film of water on plant tissues increases susceptibility of host and development of mildew. The upper leaf surface develops yellow spots, while a grey mould begins to develop on the underside, directly below the spots: later the lesions turn brown and the under surface turns dark grey: distortion of the leaves and stems may occur.

Control:

Chemical – Bordeaux mixture, chlorothalonil, propamocarb hydrochloride, zineb (not U.K. and Europe), mancozeb or sulphur (not licensed for this use in U.K.).

- Powdery Mildew

they are probably the most common, conspicuous and widespread diseases: easily recognisable, they affect all kinds of plants from grasses to forest trees. Infections are characterised by spots or patches of white to greyish, powdery, cobwebby growth on young tissues or entire plants. Causes young leaves and tip growth to become distorted and appear grey. Commonly occurs on azaleas, apples, roses, peach, strawberry, grape and a wide range of other plants.

Control:

Natural /Physical

- Don't overcrowd plants.
- Water from underneath in hot, humid or moist conditions.

Chemical

- Sulphur, dinocap, benomyl, mancozeb, myclobutanil, flutriafol, Bayleton (a. i. is triadimefon which is not licensed in U.K. and Europe).

ROTS

A rot is a disease which causes decay or disintegration of plant tissue

The decay may be either dry (where the tissue remains hard) or wet (where the tissue becomes soft and squashy).

It may affect only one part of the plant e.g. fruit or roots, or the whole plant.

Rots can be caused by either fungi or bacteria.

Control:

Chemical sprays can be used to prevent rots on fruits and vegetables.

BLACK LEG

Blackleg is caused by the bacterium *Erwinia carotovora* var. *atroseptica*, is a soft rot of potato stems. Very common: often one of the earliest potato diseases to occur, particularly in wet seasons.

Symptoms:

Upper leaflets curl inwards, and turn yellow and the plant collapses due to blackening and rotting of the stem at or below ground level: the plant may die before any tubers have formed, but any which have developed show brown or grey slimy rot inside. In store tubers will rot completely and spread the bacteria to neighbouring healthy ones.

The variety “Sebago” is very susceptible to this disease: “King Edward” variety is thought to be less susceptible.

Control:

- Maintain good drainage and do not over irrigate.
- Plant complete tubers and minimise damage or wounding to tubers.
- Use only certified disease free seed potato.
- Bacteria over-winter in the soil and plant debris: practice long crop rotation cycles.

BLOSSOM END ROT

Physiological disease caused by irregular watering and calcium deficiency.

Symptoms:
A more-or-less circular brown or green-black patch, often sunken, at the end of the fruit farthest from the stalk: the skin in the discoloured area shrinks and toughens, becoming leathery.
Normally caused by irregular patterns of watering such as excess rainfall followed by a period of drought: in most cases the disease is due to a shortage of water at a critical stage of fruit development: calcium deficiency causes blossom end rot – this is rarely because the soil is deficient (except where tomatoes are raised in growing bags): the fruits are deficient in calcium which regulates passage of salts through cell membranes.

Control:

- Add calcium oxide to the growing media or spray the plant with a 1% calcium chloride solution – soil pH should be about 6.5.
- Do not allow the growing medium to dry out.
- Good deep soil preparation, good nutrition and mulching to conserve moisture are all beneficial.

COLLAR ROT
On Seedlings and Vegetables: similar to damping off disease: tomato seedlings and young plants fall over, turn brown and die. Pea, bean, marrow, lettuce, cucumber, beetroot, cabbage, seedlings etc. - seeds rot or seedlings collapse: main stem rotten and shrivelled at soil level. Cuttings rot and collapse.

Control:
Soil drench with Quintozene (Australia): or treat with iprodione (onions/leek/garlic): etridiazole: captan.

On Citrus:
Gum oozing from bark, wet patches of bark, bark becoming dry and flaking off - occurs close to soil level on the trunk.
Collar rot usually occurs on the trunk close to ground/soil level causing bark to flake and wood to rot.

At first, gum oozes from the bark: this is followed by development of patches of damp, soft bark.

Later the bark in this area may become dry and flake off. Badly affected trees will fail to produce new growth and will eventually die.

Lemons are the most susceptible, but all citrus trees can be affected. Many citrus trees are grafted on disease-resistant rootstocks; when planting make sure the graft union is well clear of the ground and organic material is clear of the trunk.

Control:
Cut away infected parts with a sharp knife and paint with a copper paste such as Bordeaux mixture or copper hydroxide (sold as Kocide in Australia).

CROWN ROT
Crown rot caused by the fungus *Sclerotium rolfsii* is one of many diseases described by the name Crown rot: several different *Sclerotium* species cause rot diseases and several different species of fungi cause diseases, which are also known by the name Crown Rot. The disease affects almost all plants, except some field grain crops: seedlings and vegetables are particularly affected.
Crown rot caused by *S. rolfsii* is also known as Southern Blight in America.
First visible signs are yellowing and wilting of lower leaves or leaf dieback from tip downwards: at the same time the stem is covered with a white, cottony growth, appear on the stem: the upward spread of infection depends on the amount of moisture present, spreading rapidly in wet weather: the fungus moves even more rapidly into the roots, finally destroying the root system and can spread over the soil.
This fungal growth produces droplets of oxalic acid which kills tissue which comes in contact with it. Reduced nitrogen may affect susceptibility of plants to *S. rolfsii* infection: it is possibly the form of nitrogen (ammonium or nitrate) available to the host or pathogen that affects the disease: trials have demonstrated that each form has exactly the opposite effect to the other and these results depend on host species being considered.

Control:
Difficult:

- Use crop rotation and cultural practices such as deep digging to bury surface debris, liming to bring pH to about 7.0.
- Remove diseased plants.
- In some cases treating the soil with Terraclor (active ingredient quintozene, which is not licensed in U.K.), Fongarid (active ingredient furulaxyl which is not licensed in U.K.), mancozeb, metalaxyl-M (both off-label licences in U.K.) or captan can be effective.
- Current research into a mycoparasite, *Trichoderma harzianum*, (present in most soils), as a biological control agent is proving promising.

RUST

Rusts are caused by Basidiomycetes fungi and have a world-wide distribution of about 4,500 species: they affect a wide range of vegetables, fruit, trees and ornamentals, including corn (cereals) and beans. Many rusts alternate between different host plants, during different stages of their growth; the two hosts may often be unrelated botanically and control can be achieved by eradicating one host to benefit the other. Rust fungi tend to attack only certain host genera. General symptoms are characterised by brown to orange spots, pustules or stripes, normally on leaves. The parasitic rust causes a general debilitation to the host plant, draining nutrient from it without actually killing it.

Control: Chemical: rusts are a significant issue in commercial crop production, particularly cereals: as a result there are many products for rust control, but most of these are highly plant or pathogen specific.
For general use products such as mancozeb, maneb and those containing copper and/or sulphur are suitable. More specific applications include:

- Chlorothalonil+tetraconazole for rust in autumn sown barley.
- Fuberidazole+triadimenol seed treatment against rust in cereals.
- Azoxystrobin for crown rust in oats.
- Azoxystrobin (off label) for rust in herbs, lettuce.
- Tebuconazole (off label) legume - beans (*Phaseolus*).
- Oxycarboxin for ornamental specimens, protected ornamentals.

SMUT
Diseases caused by Basidiomycetes fungi of the order Ustilaginales occur all over the world: related to rusts, most produce a black sooty or powdery mass of spores: the spore colour sometimes varies:
Most common on grasses and cereals, affecting seed e.g. corn kernels (maize), also leaves, stems, flowers on other plants including anemones, *Calendula* spp., dahlia, gladioli, onion, leeks, salsify, scorzonera, spinach, *Viola* spp.
The most serious are caused by members of the genus *Ustilago*, with those of the genus *Entyloma* causing fewer serious problems: e.g.
Ustilago maydis on sweetcorn (maize – Zea mays): smut balls up to 5cm diam. Form on the kernels: each ball contains black, powdery or greasy spores, particularly during long, hot summers: cut off and burn infected kernels before bursting: practice long crop rotation.
Urocystis anemones on anemones and *Troilus* sp.: *U. eranthidis* on *Eranthis* sp. (winter aconite): *U. violae* on violas.
Entyloma dahliae on dahlias: Bordeaux mix/copper.

Control:
Difficult: most spores persist in the soil for several years, so cultural practices such as rotation are important: destruction of infected plants by burning:
Primary chemical control by dusting seeds with fungicides or growing resistant varieties: e.g. carboxin + thiram as a seed treatment in oats, reduces susceptibility.
<u>NB: Only sow treated corn seed.</u>
Bordeaux mixture can be effective in some cases such as *Entyloma dahliae.*

SOOTY MOULD
A black coating on the surface of plant tissue made up of dark coloured threads of fungi. These fungi are not parasitic but grow on the "honey dew", the sugary deposit exuded by insects such as aphis or scale: the fungi do not directly affect the plant, but as a dense layer of mycelium forms on the leaves, the plant's ability to photosynthesize is inhibited:

- Sooty mould indicates the presence of pest insects.
- Sooty mould stops photosynthesis occurring in plant tissue, by stopping light reaching the green tissue underneath.

Control:

- Spray to control the problem insects, thus stop the production of honeydew.
- Some fungicides may kill the mould, but if the honeydew remains, the fungus will re-grow.

WILT
Wilt s are characterised by drooping foliage.
Plants lose their freshness and foliage droops because of a lack of water. Wilt diseases involve bacteria or fungi interfering with the supply of water to the plant. Because the symptoms do not occur necessarily where the infection is, it is a lot more difficult to treat a wilt disease than many other diseases. Vascular wilts are widespread, very destructive, spectacular and frightening!
Often infection occurs through wounds or root hairs below the soil, so spraying the foliage will not help at all.
Plants Affected: A wide range of plants including deciduous trees, vegetables, flowers and other plants.

The two most common wilt diseases are caused by different species of *Fusarium* and *Verticillium* fungi and are usually soil-borne (occasionally seed-borne) organisms: species of a third genus *Ceratocystus* generally cause wilts in trees e.g. Dutch elm disease, *C. ulmi* and oak wilt, C*. fagaceae*: *C. ulmi* is the exception where the pathogen vector is a beetle.

Fusarium Wilt
Soil-borne fungus: red-brown longitudinal streaks will be seen in the internal tissues of affected stems are cut open near ground level.
On Tomatoes: a prevalent and damaging disease where tomatoes are grown intensively: most common on glasshouse tomatoes in Europe and northern states of U.S.: in warm temperate climates, and on warm sandy soils it is destructive on outdoor crops: rapid wilting on hot days, lower leaves yellow and wilt first, spreading upwards: infected stems have longitudinal, brown streaks through the tissue when cut open: the disease needs warm weather (25 to 30 º C) to develop.
On *Dianthus* spp. especially pinks: occasional branches turn yellow, and wilt: eventually the whole plant is affected: brown longitudinal streaks develop in the inner tissues.
On Melons: growth rate is slow, occasional leaves wilt, spreads to whole plant.
On China aster (*Callistephus chinensis*): stems blacken just above the ground level or halfway up and develop pink fungal growth.
(NB: *Fusarium* spp. can cause other disease problems such as diseased gladioli corms, bulb rots etc).

Control:
Vascular wilts are among the most difficult to control: a single fungal spore is sufficient to decimate the plant – one infected therefore control with fungicide is virtually impossible: combined with this, the fungi's ability to persist in the soil, almost forever, presents additional problems.
Crop Rotation is important, but not always practicable or effective: hot water treatment of seed should be practiced: soil sterilisation for glasshouse crops should be practiced:
For field grown tomatoes, use of resistant varieties is the only practical measure:
Infected plants must be removed and burnt: when removing plants, it is important to take with them, as much of the surrounding soil as possible and then replace this with clean soil.
Drenching the soil with suitable fungicide is a relatively difficult option, since the chemicals known to attack the pathogens, are now subject to restrictions or bans in many countries.

Verticillium Wilt
Verticillium wilts are worldwide in distribution but most important in areas of temperate zones: more than 200 plant species are susceptible: including tomato, eggplant (aubergine), pepper, cantaloupe and watermelon, chrysanthemum, aster, dahlia, pome fruit trees, roses, cotton, potato, alfalfa and trees such as maple (*Acer* spp.)

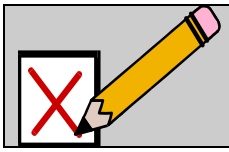
Symptoms are virtually identical to those of Fusarial wilts and the two pathogens usually require laboratory examination to distinguish them. *Verticllium* will introduce wilts at lower temperatures than *Fusarium*.

On Tomatoes: Lower leaves yellow, wilt and become dry. This progresses up the plant. Infected stems have longitudinal, brown streaks through the tissue when cut open.
On Chrysanthemums: Lower parts become yellow, purple or pink-green colour and wilt from base upwards, and die: Infected stems show brown streaks though tissue if cut open longitudinally.

(NB: This is a soil borne disease, will remain in the soil, and can affect other plants years later).

Control:
Control of *Verticllium* wilts is dependent on:
- Use of disease-free plants.
- Disease-free soil: soil fumigation is only feasible for small areas of high-value crops.
- Use of resistant varieties .
- By not planting susceptible crops where solanaceous plants have been grown repeatedly.
- Crop rotation.
- Improve drainage.

- Lightly affected woody plants may recover: assist them by application of nitrogenous fertilisers (but not nitrates) to boost the growth of new wood, which may remain disease free.
- Some research is currently underway in to the use of biological controls.



SELF ASSESSMENT
Perform the self assessment test titled ' Test 5.1
If you answer incorrectly, review the notes and try the test again.

PLANT VIRUSES - THEIR DETECTION AND DIAGNOSIS

Viruses are small microscopic organisms which live inside the bodies of other organisms. They are parasites and can have a wide variety of different effects on the organism they infect. One of the most common symptoms in plants is a change of colour in leaves/and or flowers. Infected leaves frequently show light green or yellow patches (i.e. a variegated effect) due to interruption of chlorophyll production: hence photosynthesis is reduced. This type of infection can cause reduction of crop yield or quality, or a general stunting of the plant.

One of the most severe effects of virus would be death, although this is not common (virus can only live in a host organism while the host is alive; if the host dies, the virus dies and hence eliminates itself). Growth patterns can be disturbed and changed by virus. In some cases stunting (mild or severe) will be the only obvious effect. In other cases, virus can cause distortion in the growth such as twisting, blistering or other distorted formations in leaves, stems, roots or flowers. In extreme cases, leaves can be reduced to a central midrib i.e. with no leaf blade at all.

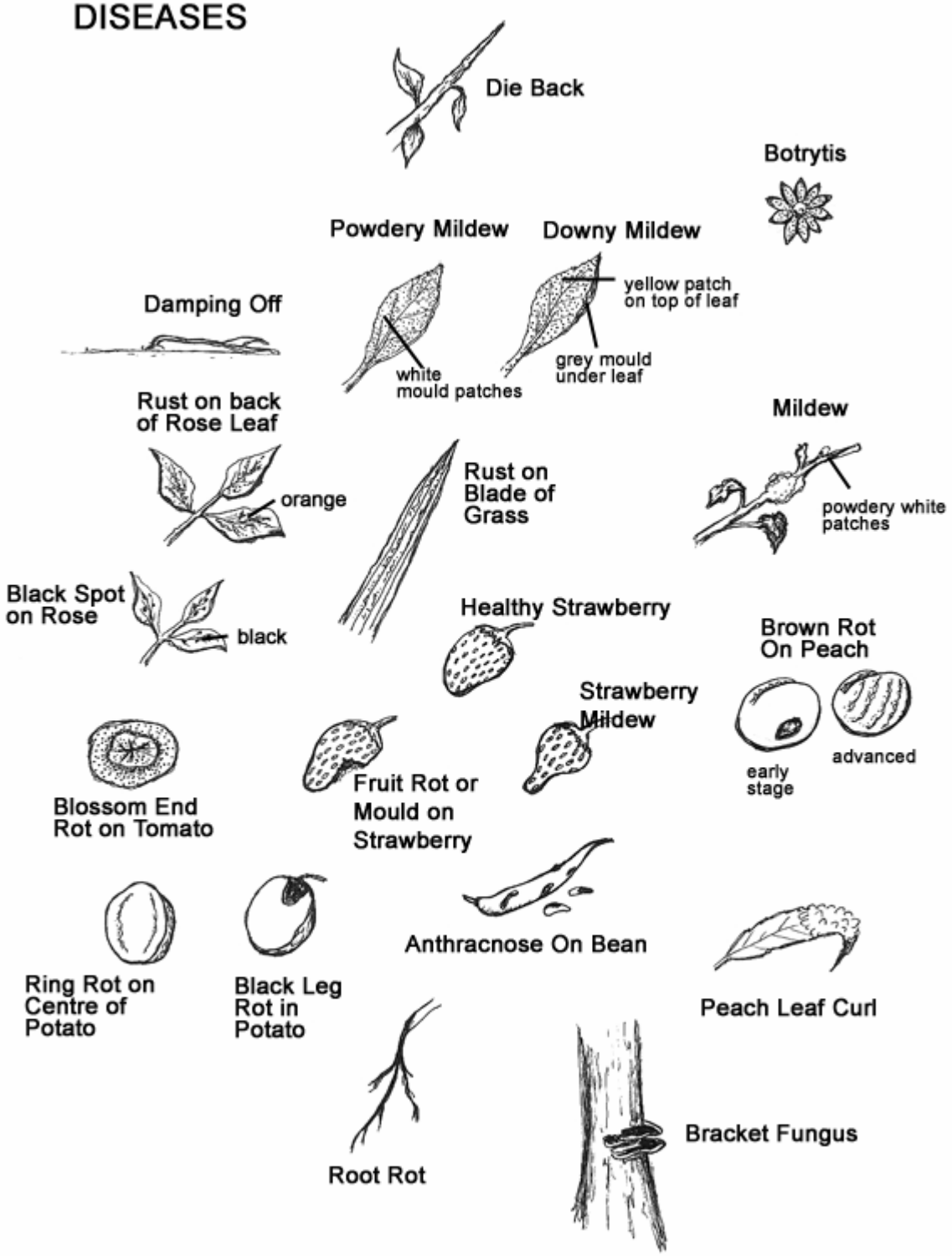
Flowering and seed production can be stopped completely by a virus. Virus can also induce leaf rolling, leaf yellowing, plant wilting and changes to the physiological processes in the plant so that some functions of a cell's metabolism cease completely.

One or several of these symptoms might occur. Plants which are very commonly affected by serious virus problems include: tomatoes, gladioli, carnations, chrysanthemums, strawberry, passion-fruit, *Daphne* spp. and tulip. There are others, but you should watch these in particular.

VIRUS CONTROL
Viruses are not as easy to control as most other diseases. Once a plant cell is infected with a virus, the only way to eradicate the virus is by killing that plant cell. In the case of virus, generally speaking, prevention is the only cure.

- If a plant is infected with virus...remove and burn the plant.
- Make sure (when dealing with plants which are very susceptible to virus) that you always start out with "clean stock".
- Control insects (aphis in particular): insects are the most important vectors (carriers) of virus from one plant to another: fungi and nematodes also spread virus.
- Use plant varieties which are more tolerant to virus, when the choice is available.

DISEASES


Die Back
Botrytis
Powdery Mildew
Downy Mildew
yellow patch on top of leaf
Damping Off
white mould patches
grey mould under leaf
Rust on back of Rose Leaf
Mildew
orange
Rust on Blade of Grass
powdery white patches
Black Spot on Rose
black
Healthy Strawberry
Brown Rot On Peach
Strawberry Mildew
advanced
early stage
Blossom End Rot on Tomato
Fruit Rot or Mould on Strawberry
Anthracnose On Bean
Ring Rot on Centre of Potato
Black Leg Rot in Potato
Peach Leaf Curl
Root Rot
Bracket Fungus

PESTS

APHIS spp. (Aphids)
Many different types, 1-4mm long, in various colours, most commonly green. They sit on soft plant tissue with a syringe like mouthpiece injected into the plant tissue sucking nutrients out of the plant. They can transfer virus or other diseases from plant to plant. They are normally found in colonies comprising dozens to thousands of individuals. Aphids are most likely to attack the more tender tissue on shoot tips, leaves or stems. They can also attack bulbs and roots.

Control
Natural – outside:

- use predatory insects such as Ladybirds - adults and larvae eat aphids: or Lacewings (*Chrysoperla* or *Chrysopa* species) - larvae eat aphids:
- use a garlic spray
- use companion planting:
    - Dill and Fennel- amongst vegetables - attracts hoverflies, which then eat aphids.
    - Garlic and Chives- under roses - keeps away aphids.
    - *Tagetes* (African and French Marigolds) - amongst tomatoes and vegetables - deters aphids through scent and by attracting hoverflies.
    - Nasturtium (*Tropaeolum*) - amongst vegetables - attracts aphids away from the vegetables.

Natural – inside:

- Use parasite such as *Aphidius colemani* – a parasitic wasp which lays its egg inside the aphid which is subsequently eaten by the wasp larva.
- Use a pathogen such as *Erynia neoaphidis* – the most common fungus that infects aphids.

Chemical – spray with products which have active ingredient chemicals of Pyrethrum (pyrethrins), nicotine, pirimicarb or malathion.

Woolly Aphid-*(Eriosoma lanigerum)*
Distinguished from other aphis by fluffy cotton wool like appearance: it may be mistaken for a mould but if the colony is rubbed with the finger, it becomes wet with crushed aphids: infested plants may develop irregular swellings on the twigs and stems.

BEETLES

Beetles and weevils are in the largest order - Coleoptera - within the class Insecta.
Beetles have two distinct stages in their life - a larval stage where the beetle has the appearance of a legless caterpillar, and the familiar adult stage. Both the adult and larval stages of beetles have chewing mouthparts and can damage a wide range of plants. Damage is variable - some adults and larvae chew leaves and shoots; larvae may chew roots or tunnel through wood; and large infestations may simply break smaller branches and interfere with pollination and fruit development.

Weevils
Weevils are a type of beetle with a characteristic long "snout". There are many different types, which attack a wide range of different plants.

Vegetable Weevil (Listroderes difficilis)
Originally from South America, the vegetable weevil has spread around the world including Australia (Queensland, New South Wales and Tasmania), South Africa and the United States including Hawaii.

- adults are dull, grey-brown, with an inconspicuous, pale grey V-shaped mark near the end of each wing cover.
- about 1 cm long,
- larvae are cream coloured when they first hatch becoming pale green in colour: slender, legless and about 10-12 mm long when fully grown
- adults feign death when disturbed

Both adults and larvae do damage. They feed, mostly at night, on the buds, foliage, stems and roots of many vegetables. They attack a wide range of vegetables and ornamental annuals: fleshy rooted vegetables (carrots, beetroot etc) are especially susceptible. The stems of some plants may be cut off at the soil line, the damage resembling that of cutworms. Larval damage to fleshy root crops is characterized by stunted growth, roughened irregular shaped grooves on the outer walls and by tunnels being eaten into the roots of turnip, carrot, radish, etc.

Only female vegetable weevils exist: reproduction is parthenogenic (without fertilization)

Control
Natural

- Research work in the USA with parasitic wasps and a parasitic fly has produced promising results, but so far, natural predator releases have been unsuccessful in Australia.
- Crop rotation helps to keep populations down in localities where the vegetable weevil is a serious pest: the preferred host crops should not be planted in the same field or adjacent fields in successive years: field borders should be kept clean and free of wild hosts such as chickweed

Chemical

- Control of adults and larvae can be achieved using residual insecticide sprays or granular insecticides when the pest and damage are found: product labels should be checked closely to ensure that selected insecticides are legal on the crop to be treated

Vine Weevil (*Otiorhynchus sulcatus)*
Adult Vine Weevil take unsightly bites out of the edges of plant leaves: their wrinkled, creamy white grubs (larvae) inhabit containers or the soil, and attack the roots of herbaceous plants, young trees and shrubs. They are a particular problem in azaleas, rhododendrons and camellias. The adult beetles feed on the foliage of many herbaceous plants and shrubs, especially *Rhododendron*, evergreen *Euonymus*, *Hydrangea*, *Epimedium*, *Bergenia*, *Primula* and strawberry.
Adults:

- Adults are dull black beetles with a pear-shaped body when viewed from above
- 9mm long.
- Adult weevils are active on the foliage at night; during the day they hide in dark places.
- Slow moving insects: cannot fly but are very persistent crawlers and climbers.

Larvae:

- Larvae (grubs) live in soil:
- Plump, white, legless grubs with pale brown heads.
- Up to 10mm long.

Control
Natural

- After dark, inspect plants and walls by torchlight and pick off the adult weevils: in glasshouses, look under pots or on the underside of staging where the beetles hide during the day.
- Trap adults with sticky barriers, such as Agralan Insect Barrier Glue, around pots or glasshouse staging.
- Encourage natural enemies such as birds, frogs, toads, shrews, hedgehogs and predatory ground beetles.
- Use a product based on predatory nematodes *Steinernema kraussei* such as “Nemasys Vine Weevil Killer” which can work at temperatures to 5ºC (40ºF) or predatory nematodes *Heterorhabditis megidis* which require temperatures of 12^{o}C (54^{o}F) to be effective.

Chemical

- use products containing imidacloprid or fipronil and soil drench containing thiacloprid

BUGS
Occur most commonly on plants, though there are members which occur in virtually all types of situations.

Plant bugs, cicadas, leaf hoppers, tree hoppers, physllids, whiteflies, aphids, greenflies, scale, mealy bugs, shield bugs, water-boatmen all belong to the order Hemiptera.
A large and variable order, mouthparts are modified for sucking and piercing they normally have 4 wings (a few species have only 2 or no wings): the fore wings are normally thicker.

"True" bugs belong to the sub order Heteroptera and include a diverse array of insects that have become adapted to a broad range of habitats --terrestrial, aquatic and semi-aquatic. This sub-order includes – plants bugs, seed bugs, stink bugs, lace bugs, squash bugs and leaf-footed bugs, broad-headed bugs, assassin bugs, water boatmen, water scorpions etc.

Many bugs have a similar appearance to beetles. The major differences are that bugs feed by piercing and sucking the plant juices, and they do not have a separate larval stage.

Green vegetable bug *(Nezara viridula)*
Green vegetable bugs are common in Australia and New Zealand: they are thought to have originated in southern Europe, but are now found in most warm-temperate to tropical parts of the world. They feed on almost any plant from which they are able to suck the sap. Solanaceous plants such as tomatoes, potatoes, tamarillos, and black nightshade are all attacked, and so are beans, corn, and passionfruit: also pecans.

In August 2004 green vegetable bug was discovered in the U.K. by Max Barclay, curator of beetles at the Natural History Museum. These bugs attack a wide range of crops, from soft fruits to potatoes and beans, damaging fruit, transmitting disease and leaving plants open to attack by other pests. The green vegetable bug is similar to the U.K. native green shield bug (*Palomena prasina*) but is a paler green colour, narrower and longer, growing up 15mm (1/2in). Unlike the native green shield bug, adult green vegetable bugs have no brown markings and are uniformly green. Young, green vegetable bugs have distinctive white-spotted backs, with red edging.

- Adults are green, shield-shaped with three small spots in a line between wing insertions: younger bugs show a triangular arrangement of black spots with smaller yellow spots underneath, on the back
- Approximately 15mm long by 8mm wide
- Feed by inserting their sharp, tubular mouthparts into soft plant tissues and sucking the sap
- Prefer sunny positions: they will hide with small disturbances, but if the disturbance persists they will drop to the ground or fly away.
- When provoked they can exude a brownish, foul-smelling fluid which stains fingers or clothes and leaves a persistent odour: this defence mechanism makes them unattractive as food to most predators
- Plants react in different ways to attack by the bug: generally causes blotching and distorting of fruit and vegetables: beans shrivel and become deformed: on tomatoes hard, corky growths appear where the fruit has been pierced.

Control:
Natural
- A parasitic fly *Trichopoda giacomellii*, a native of South America, has been used in parts of Australia in pecan orchards: a three to five fold reduction in green vegetable bug numbers is usually observed.

Chemical
- Deltamethrin (a synthetic pyrethroid) is now the preferred treatment for green vegetable bug and other pod-sucking bugs. Dimethoate is not recommended on adult bugs or larger nymphs. Activity of this chemical is restricted to the very young immature stages of the insect (nymphs).

Harlequin Bug *(Murgantia histrionica)*
The harlequin bug is an important insect pest and has the ability to destroy an entire crop where it is not controlled. It injures the host plants by sucking the sap of the plants, causing them to wilt, turn brown and die. Favourite hosts attacked include crucifers such as horseradish, cabbage, cauliflower, collards, mustard, Brussels sprouts, turnip, kohlrabi and radish and many species belonging to the hibiscus plant family (Malvaceae), including ornamental hibiscus species and cotton: other plants attacked include tomato, potato, eggplant, okra, bean, asparagus, beet, weeds, fruit trees and field crops.
The harlequin bug is a serious pest in the southern USA southern insect ranging from the Atlantic to the Pacific and in Australia.

- Adults are gaudy black and red/orange coloured adults: at rest, the front pair of wings overlap and the insect's back appears to be marked with a distinct "X".
- Flat and shield-shaped.
- 9-12 mm length.
- Causes wilting, browning, and eventual death.
- Can cause blotching on fruit.

Control:
Natural
- Companion planting of rue is said to deter bugs from raspberries.
- Hand-pick adults and crush egg masses (effective if done often): eliminate weedy areas around garden in early spring: conduct thorough post-harvest clean up; being careful to remove all plant debris.

Chemical
- Insecticides should be applied when bugs first appear and applications repeated as necessary.
- Dust with pyrethrum or other botanical insecticide
- Spray dimethoate or maldison.

CATERPILLARS


Loop caterpillar

There are many different types of caterpillars which normally eat the tender parts of a plant (leaves and young shoots). Some, like the spitfires cluster together in colonies as one ball of crawling grubs. Most caterpillars however are solitary, each one crawling around independent of the others.

Control
Natural –
- Spray with Dipel DF (a commercially available bacterial preparation containing a bacterium called *Bacillus thuringiensis* which infects and kills only caterpillars pillars).
- Remove by hand.

Chemical –
Spray with products containing chemicals such as nicotine, Pyrethrum (pyrethrins) or cypermethrin, deltamethrin, deltamethrin+pirimicarb.

Cabbage White Butterfly
These lay lemon/yellow bullet-shaped eggs on virtually all plants in the cabbage family (e.g. cabbage, cauliflower, broccoli, sprouts, turnip, radish, kale and weeds like wild radish mustard and winter cress). The caterpillars of this butterfly eat leaves, cauliflower heads, etc.

Control
Natural –
- Companion plants such as onion, garlic, sage or African and French marigold (*Tagetes*) will help repel this pest.
- Spray with Dipel DF (a commercially available bacterial preparation containing a bacterium called *Bacillus thuringiensis* which infects and kills only caterpillars).
- Remove by hand.

Chemical - Spray with products containing chemicals such as nicotine, Pyrethrum (pyrethrins) or cypermethrin, deltamethrin, deltamethrin+pirimicarb.

LEAFHOPPERS
A number of species of insects are called Leafhoppers: affect a large range of ornamental and crop plants. Symptoms are characterised by small, pale green or white dots on upper surfaces of leaves: these gradually join up into one big area and much of leaf green colour is lost. Leafhoppers transmit virus diseases.

- Small, pale yellow insects.
- About 2-3mm long.
- Jump when disturbed.
- Suck sap from undersides of leaves: cause shiny sticky sap on branches.
- They can infest a very large range of plants in large numbers.

Control:
- pyrethrum (pyrethrins) for mild infestations
- Lebaycid (fenthion) or Rogor (dimethoate) for heavy infestations (Australia): or bifenthrin in U.K.
- apply when leaf spotting is first seen

LEAF MINER

A small insect that eats long winding tunnels between the surfaces of leaves. Normally tunnels are white first, but turn brown later. This group of pests can attack a very wide variety of plants.

Control
Natural –
- Remove infected parts and burn: control weeds which support them:
- Cover plants with fleece or insect-proof mesh (celery, parsley).
- Glasshouse – biological control using parasitic wasp *Diglyphus isaea.*

Chemical –

- Products containing bifenthrin, rotenone, permethrin, pyrethrins, dimethoate or white oil.

MEALY BUG

The adults resemble a slater (wood louse) covered with white waxy powder and waxy cotton-like threads. They are generally 5-20mm long, can live on roots, under bark, and move about on a plant according to seasonal conditions. This pest is a significant problem on grape vines, apples, pears and many ornamental plants. Mealy bugs are related to scale insects.

Control

Natural –

- Spray with a strong stream of water to dislodge the insects from the plant, or touch insects with a swab of cotton wool dipped in alcohol.
- Use predatory beetles *Cryptolaemus montrouzieri* or a combination of beetles and lacewings for heavy infestations.

Chemical –

- White oil or fatty acids sprayed directly on insects, or products containing deltamethrin or dimethoate.

MILLIPEDES

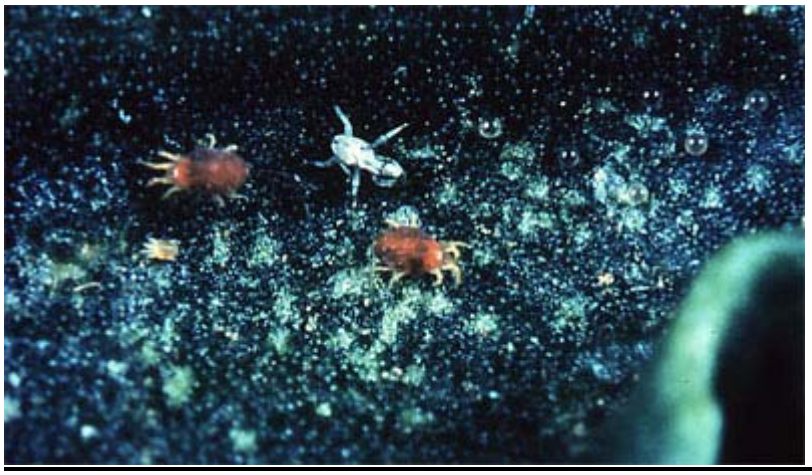
Millipedes are small worm-like animals, with up to 50 articulated segments and two pairs of legs per segment: (centipedes have one pair of legs per segment and are mainly carnivorous). They are usually hard, with a shell like skin: the most common are black in colour, but there are species that are spotted and others, (particularly greenhouse species), in various shades from white to brown:

- They thrive in moist soils with a high organic content.
- Generally eat rotting, dead vegetation but will damage seedlings by biting through stems or defoliating before seedling has established.
- Extend wounds on bulbs, corms and tubers that have been caused by other pests such as slugs or by pathogens.
- Can become a garden pest after prolonged rain, especially in greenhouses and when present in large numbers.

Control:

- Good hygiene.
- Avoid planting/keeping seedlings in infested areas.
- Dust or spray Carbaryl (not U.K.): there are no chemical treatments licensed in U.K. for millipede control.
- Some types of slug/snail baits will have an effect (but not all).
- Diatomaceous Earth dusted over the garden may also have some effect to discourage millipedes: (diatomaceous Earth is a naturally occurring insecticide formed from the fossil remains of diatoms, a kind of algae. Its sharp dagger like edges cut through the cuticle (outer shell) and absorb the fluids released therefore dehydrating the animal, causing it to die.

MITES INCLUDING RED SPIDER MITE



Spotted Mites

Small red-coloured mites who resemble spiders, almost invisible to the naked eye, that appear as a red haze, usually on the back of leaves. Leaves can turn a bronze colour and die. Mites attack and feed on a variety of plants and animal materials. They are common on azaleas, camellias, and many other ornamental plants, and often a significant glasshouse problem.

- Many types damage plants by the sucking sap and, in the case of some, distorting plant growth.
- Some mites are used to attack and control harmful species.
- Plants which are watered regularly are less susceptible to the mites.

Control
Natural –
- Introduce the natural predator *Phytoseiulus persimilis* to the garden.
- Use repellent plants such as onion, garlic and chives.
- In glasshouses keep humidity levels high.
- Treat with natural plant extracts.

Chemical – derris (active ingredient rotenone), malathion, fatty acids, fenbutatin oxide, pirimiphos-methyl

NEMATODES
Nematodes, also known as eelworms, are microscopic worms (1-2mm long, 0.1mm wide), which attack and can burrow into plant tissue; commonly roots or leaves.
- They can cause distortion in growth (such as swellings), yellowing or dead patches.
- They are responsible for introducing virus and other diseases into plant tissues.
- Several species are used as biological controls on, for example, slugs, vine weevil.

Control:
Natural:
- Companion planting: e.g. plant French or African marigolds (*Tagetes* spp.) in the soil: a chemical given off by the marigold roots deters soil nematodes: NB. There may not be current scientific evidence to back-up purported benefits of companion planting in every instance.
- Crop rotation.
- Resistant varieties within an integrated pest management system.
- Current research into nematophagous fungi.

Chemical:
- Apply chemicals such as Nemacur (fenamiphos) (not U.K. and Europe) or aldicarb and carbosulfan: the latter two products have very limited and specific applications, with many restrictions to their use.
- ***Note***: the active ingredients of most nematicides are organo-phosphates and are prohibited or being withdrawn in most countries of the world because they are among the most toxic chemicals known to man.

SCALE INSECTS
These are small, shield-like insects which fix themselves to a part of a plant and insert their mouthpiece into the plant. They remain in the one spot and do not move. They are related to mealy bug. Colours include red, black, brown, white and pink. They generally attack leaves, soft stems and roots. They feed by sucking the sap from the plant and can cause serious weakening of the plant. There are a number of different types of scales, varying in colour and the appearance of the covering shield.
Scale insects are usually associated with a black sooty fungus which grows on the sugary secretions produced by the feeding insects. The fungus is generally harmless, although over a period of time it may also affect the vigour of the plant.

Control
Natural – products are available using the parasitic wasp *Metaphycus helvolus.*
Chemical – fatty acids (insecticidal soap), malathion, White Oil (must get direct contact).

SLUGS and SNAILS

Slugs will attack any relatively tender plant parts. They are more of a problem in moist and poorly drained sites. Snails are a major pest of soft tender foliage, particularly young vegetable and flower seedlings: particularly troublesome in moist, shady areas.

Leopard slug

Control
Natural –

- Use repellent plants such as prostrate rosemary and wormwood.
- Use slug barrier products such as wood chips impregnated with myrrh resin (*Commiphora molmol*) sold as “slugs.biz”: fresh sawdust will have the same effect for a while, but may lead to problems with nutrient absorption in the soil.
- Place out a saucer of stale beer (they drink it and will drown in the saucer) or use a purpose made slug/snail trap filled with beer:
- Crush them using your foot or some other solid object.
- Use predatory nematode (*Phasmarhabditis hermaphrodita*) preparation such as “Nemaslug”.
- Improving drainage and drip irrigating (instead of sprinkler irrigation will help).
- Dusting with diatomaceous earth.

Chemical - Snail pellets or powder which contain methiocarb or thiodicarb

THRIP
These tiny (1-2mm long) insects swarm over leaves and flowers in hot summer. The most common symptom is flecking of leaves or flowers. Thrips vary in colour – black, brown or cream coloured.

Control
Natural –

- A small board, painted white and covered with a sticky substance such as honey will attract and hold thrips.
- Use products containing predatory mites *Amblyseius cucumeris.*

Chemical - malathion or derris (rotenone) (neither of these licensed for this use in U.K. and Europe), chlorpyrifos, nicotine, dimethoate (in U.K. and Europe peas only), natural plant extracts.

WHITEFLY

There are many different types of whitefly. The young six-legged insects are minute in size, they feed on leaves and produce scales from which small winged flies emerge. They can occur in large numbers on many types of ornamental and crop plants including eucalypts, potatoes, tomatoes, beans, etc. They commonly occur on the underside of leaves and fly in large numbers when disturbed.

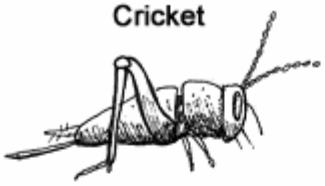
Control

Natural –

- Use companion plants such as nasturtium and marigold.
- Whiteflies (*Trialeurodes vaporariorum*) are parasitised by a small wasp, *Encarsia formosa.*
- Use products contining the fungal parasite *Verticillium lecanii.*

Chemical - malathion, pyrethrum (pyrethrins), chlorpyriphos, nicotine, buprofezin.

PESTS


Cricket


White Butterfly Grub


White Butterfly


Aphis

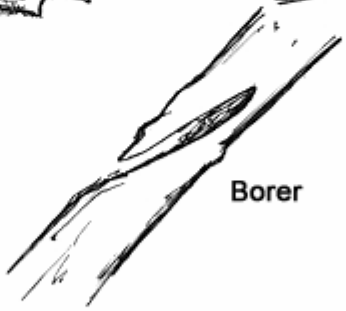

Whitefly


Slug


Snail


Scale


Red Spider Mite

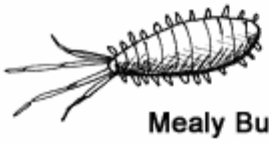

Borer

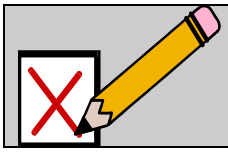

Spitfire Caterpillars


Pear and Cherry Slug


Slater


Thrip


Mealy Bug



SELF ASSESSMENT
Perform the self assessment test titled ' Test 5.2
If you answer incorrectly, review the notes and try the test again.

SET TASK

Search the internet, or write to or telephone, three different agricultural chemical companies (or their distributors - people such as stock agents/farm supplies etc), and obtain technical literature on insecticides and fungicides available for control of disease and pest problems which you have read about in your text material. If you already have a good collection of reference material in this area, you need not do this.

NOTE: Companies are interested in disseminating information to the serious growers, but may consider "students" to be unlikely buyers, and thus not worth spending time with. If you represent yourself as someone involved in or planning to start growing commercially, you will probably receive more help.

Alternatively visit a trade show, or agricultural/horticultural field day. Agricultural chemical suppliers are usually well represented at these, and are likely to have a wide selection of brochures available.

ASSIGNMENT
Download and do the assignment called ‘Lesson 5 Assignment’.