Lesson 5

OUTDOOR FOOD PRODUCTION

Aim
Understand basic cultural operations and production methods necessary to obtain outdoor food crops.

In this lesson you will consider the following
- Growing outdoor food crops
- Timing crops
- Making gardens more productive
- Sustainable land management
- Composting
- Companion planting
- Vegetable crowing
- Fruit crops
- Pests and diseases of crops
- Windbreaks
- Crop harvesting

GROWING OUTDOOR FOOD CROPS

In this lesson you will learn the production techniques used to grow herbs, vegetables, fruits and nuts, both in the home garden and for commercial production.

Most vegetables have similar requirements, that is, a reasonable amount of sunlight, fertile and well-drained soil, protection from wind, and adequate water during the growing season.

The time of planting is important, because different vegetables have specific tolerances for temperatures. Warm-season vegetables grow best at temperatures over 20˚C, and are generally frost susceptible. Vegetables in this group include tomatoes, capsicums, eggplants (aubergines), potatoes, sweet corn (maize) and vine crops.

Cool-season vegetables grow best at temperatures between 10˚C and 20˚C, and generally tolerate frosts. This group includes broccoli, cauliflowers, onions, spinach, turnips, peas, Brussels sprouts and broad beans.

A third group grows best at temperatures between 15˚C and 25˚C. This group includes lettuce, cabbage, silver beet, carrot, parsnips, celery, radish and leeks.

Techniques for Growing Vegetables and Edible Plants

The following is a brief overview of different ways of growing vegetables and other edible plants outdoors:
Row crops, the traditional method of growing vegetables and other edible plants, both in the backyard and in commercial market gardens. Easy to manage, allowing easy access for planting, fertilising, watering and harvesting.

Companion Planting
Using plants that have beneficial qualities to assist the growth of other plants growing nearby. Companion plants may repel pests, attract pollinators, or improve the soil.

Permaculture Garden
A system of sustainable production, based on ecological principles; incorporates other natural gardening and farming systems such as organic gardening, no-dig gardens, companion planting and biological pest control.

Containers
suitable for a range of smaller-growing vegetables; ideal for gardeners with limited mobility, and gardens with poor soil or restricted space.

No-dig Garden
Building a slow-working compost heap straight onto the surface of the soil as a "raised garden bed", and planting direct into the pile. Ideal for gardens with poor quality soil.

Organic
Using non-chemical methods to grow vegetables; growers use natural products to control insect pests, diseases and weeds, and to enrich the soil. Practices such as mulching, composting, companion planting, green manuring and biological control are widely used by organic growers. An increasingly popular growing system for both commercial and backyard growers.

Hydroponic
No soil gardening, using formulated nutrient solutions to water and feed plants. Roots are supported and protected by a sterile medium in an enclosed environment, such as a pipe or bag.

Starting a Home Vegetable Garden
First step is to assess the site and determine what is to be grown in the plot.

Siting a Vegetable Garden

The vegetable garden should be sited where:
1. It receives maximum sunlight (not shaded by trees and buildings).
2. It has good soil which is well drained.
3. It is relatively free from weeds and other competing plants.
4. There is access to a suitable supply of water.
5. It is sheltered from prevailing winds.

Compromises may be necessary depending on what is available.

Some of the culinary herbs such as parsley, basil and coriander require similar conditions to vegetables and therefore can be included in the vegetable garden. Perennial herbs such as chives, winter savoury, and thyme are useful as borders to edge the vegetable beds. Woody shrub herbs such as rosemary, sage and lavender also make attractive enclosing hedges.

The size of the vegetable plot depends primarily on how much space is available, the size of your family, the vegetables they prefer to eat and the time you have to tend the garden. As a general guide an area of 80-100 sq. metres can provide a family of four with an adequate yearly supply of fresh vegetables if you grow two or more crops in most parts of the plot each year.

What do you want to grow?
What you grow will depend a great deal on your own preferences, as well as environmental factors (e.g. soil, climate), however, when deciding what to grow consider the following:

- Some vegetables produce prolifically in a short time (e.g. radish), while others will be slow to mature (e.g. artichoke). Others can occupy a space for a very long time (e.g. asparagus, up to 20 years).

- Use most of your plot for high yield vegetable varieties if you want to harvest large quantities of produce. Alternatively, you could opt to plant gourmet varieties that are more expensive to buy but give a lower yield.
- Some vegetables and herbs lose flavour and nutritional value if stored for even short periods so are best eaten fresh, for example, tomatoes, lettuce, beans, cauliflowers, basil, coriander and parsley. These vegetables are therefore worth growing yourself.

What quantities of vegetables and herbs can you consume and store?
When deciding what and how much to grow, consider the following points: Do you want to produce all of your own vegetable needs, or will you also buy some? Do you eat a lot of vegetables or not? Do you have sufficient space and suitable conditions (i.e. refrigerators, freezers and preserving facilities) to store your produce? Can you trade or barter your produce with others?

How much time do you have?
Remember that once you have prepared and planted your garden, you need to have the time to do all the necessary tasks at the right time, such as fertilising, weeding, watering, pest and disease control, harvesting, processing and storage. Pests need to be monitored and controlled before they ruin a crop, and quality produce means harvesting at the right time. A small well-managed vegetable plot will often give bigger and better yields then a large, poorly maintained one.

Planning the Cropping Program
Plan for a continuous harvest, as this avoids the feast and famine situation so often experienced by novice gardeners.

1. Stagger the plantings. Most vegetables can be planted over a three to four month period and achieve relatively even yields for each planting. Try planting small quantities of each crop at two-week intervals. This is easiest for varieties grown directly from seed, as the seed can be stored until needed. This way you can also grow two or three seedlings at a time (of cabbage for example). When using seedlings you may need to plant a full punnet (tray) at each planting of 6-8 week intervals. Seedling punnets (trays) do however contain 8-10 plants, and that number of cabbages all maturing at once for example, may be too much for your family.
2. When selecting seeds look for early, mid and late season varieties of each vegetable or fruit. This will stagger harvest times over the entire season.
3. Some vegetables can only be grown at specific times of the year. Others can be grown over extended periods, or even throughout the year - grow these when the other crops are not available.

Getting the Best Out of the Vegetable Plot
Provide Good Drainage
Good drainage is vital for a successful vegetable garden. If you have clay soil or if your site is in a low-lying area then prepare a raised growing bed (30cm above the natural ground level). Use retaining materials such as sleepers, bricks, treated pine and hardwood timber. Provide sufficient drainage holes at the base of the bed so water can readily drain out from behind the retaining material. Slotted drains (agricultural pipes) may be needed if poor drainage prevails.

Prepare the Vegetable Bed
1. Thoroughly cultivate the soil, incorporate compost to a depth of 15cm.
2. Leave for a week then ideally test for pH (simple pH test kits are available from your local nursery). The ideal pH for healthy vegetables is between 6 and 8.
3. Correct the pH if necessary by incorporating lime or dolomite into the soil to raise pH or sulphur to lower it.
4. Continue cultivation with a fork, cultivator or rake to kill all weeds and produce a fine crumbly-textured soil.

Remember:
- Root crops such as carrots and parsnips may need the soil cultivated deeper or a raised bed with additional soil.
- In poor soils it is beneficial to grow a cover/green manure crop to improve the soil fertility and structure. However, do not grow root crops i.e. carrots and parsnips after the addition of manure or a cover crop as it makes them fork. Grow and harvest leafy crops first then sow carrots/parsnips (without any more additives) as the following crop.

Green Manure/Cover Crops help the soil by improving fertility, increasing organic matter, holding more water, and suppressing weeds.

Sow a green manure crop in fallow beds in autumn or winter and dig in before they reach maturity (before flowering) in spring or just leave on top of the soil as mulch.

Soil bacteria have a symbiotic relationship with legumes. The bacteria (*Rhizobium*) infect the root system of legumes and change atmospheric nitrogen into a form that is usable by plants. This nitrogen is contained in root nodules produced by the *Rhizobium*. When the plant is dug in or allowed to decompose on top of the ground the available nitrogen will feed the following crop.

Not all soils contain the necessary *Rhizobium*, so in some cases you may need to buy inoculated seed or inoculants.

What to grow to improve soil fertility:

- Legumes (tic peas, field peas, broad beans, lupins, vetch, alfalfa) add nitrogen and organic matter. Lupins and alfalfa are deep rooted and also help to break up heavy soils allowing deep rooted crops such as tomatoes and corn (maize), to penetrate to lower levels for water and nutrients.
- Clover adds nitrogen and also acts as a weed suppressant when grown as a living mulch under other crops
- Barley increases phosphorous uptake of following crop (excellent crop to precede tomatoes) and also provides excellent mulch.

Destroy All Weeds

Establishing weed control early will mean less work later and a better crop. Dig out and remove the entire root system of perennial weeds, particularly bulbs from weeds such as oxalis, nutgrass and onion weeds. Remove annual weeds as they appear and are just large enough to handle. Don't let them flower as this increases spread.

Practice Crop Rotation

Crop rotation involves growing a series of different crops in a particular organised succession, to improve various aspects of crop and soil health. Crop rotation is more than just a seasonally progressive production system (such as a farm that grows lettuces in summer and cabbages in winter). Crop rotation can be used to:

- Help reduce disease and pest problems.

Each plot should be planted with crops from a different family group each year i.e. potatoes shouldn't follow tomatoes (same family). Cabbages shouldn't follow mustard (also same family). Also try to choose disease resistant varieties or plants that are not prone to the diseases and pests that the previous crop is prone to.

- Minimise weed problems.

Grow crops that suppress weeds i.e. large leaves that exclude light before growing crops that are sensitive to weed competition in the same plot. Grow crops that can cope with weeds at the end of the rotation when weeds may have built up.

- Utilise the fertility you have added to the soil by growing a succession of crops that have different fertility requirements i.e. follow leaf crops with carrots.
- Maintain and improve soil quality by growing plants that have differing root structures and increasing the amount of organic matter returned to the soil.

There are various types of crop rotation systems used. It all depends on your needs and the size of the garden.

The following is an outline of considerations to help prevent build up of pests, diseases and weeds in soils as well as effectively utilising soil fertility.

1. Gross feeder (e.g. tomato), then legume (e.g. beans), then light feeder (e.g. coriander), then green manure, then gross feeder again.
2. Flower crop (e.g. broccoli), followed by fruit crop (e.g. peas), followed by leaf crop (e.g. lettuce), followed by root crop (e.g. carrot).
3. Grow a crop or crops for half of the year, and graze the same area for the other half.
4. Fallow areas between crops (i.e. do not graze or grow a crop).
5. Grow cover crops for green manure at least annually to revitalise the soil.

Rotations should also be designed so that crops from the same family, do not follow one another (in some cases, gaps even of several years may be necessary to get rid of pest or disease problems). In order to develop these kinds of rotations properly, it is necessary to know a little about the scientific names of the plants you are growing.

In organic systems, various crop rotation models are used, which provide a basis for growers to develop individual rotations to suit their needs. These models are organised to ensure that rotation effectively utilises soil fertility and prevents build up of pest disease or weed populations. Rotation models used by organic growers include:

- Gross feeder (e.g. tomato), then legume (e.g. beans), then light feeder (e.g. coriander), then green manure, then gross feeder again.
- Flower crop (e.g. broccoli), followed by fruit crop (e.g. peas), followed by leaf crop (e.g. lettuce), followed by root crop (e.g. carrot).
- Rotations should also be designed so that crops from the same family, do not follow one another (in some cases, gaps even of several years may be necessary to remove pest or disease problems). In order to develop these kinds of rotations properly, it is necessary to know a little about the scientific names of the plants you work with.
- Grow a crop or crops for half of the year, and graze the same area the other half.
- Grow several different crops on the farm, and rotate them so the same crop is not grown in the same field more than once every 2 to 3 years (or preferably longer).
- Fallow areas between crops (i.e. do not graze or grow a crop).
- Grow cover crops for green manure at least annually to revitalise the soil.
- Ley Farming Systems involve alternating cereal grain production with pasture. Annual medics or sub clover are useful in these systems, mixed with grasses, to produce high quality forage.

Use Mulches

Mulching helps control weeds and prevents erosion of the soil from around the vegetable roots, reduces water need and helps provide nutrients. Mulch also increases the soil population of beneficial organisms such as earthworms. Mulch material should not have direct contact with the stems, etc. of the vegetables, as this may result in pest and disease problems e.g. stem or collar rots.

Don't Overcrowd Plants

Don’t plant small seedlings too close together as this will limit growth, even with good soil preparation. Plants starved for space and light will rarely produce a good crop. Spacing is important for sunlight and for root spread. Overcrowding also reduces ventilation around the plants, making them more susceptible to disease problems, such as mildews.

Select and Use Top Quality Seed and Seedlings

Always check expiry dates on seed packets and choose strong, green seedlings. Many seedling producers "starve" their plants purposely to prevent them becoming root bound when contained in punnets. Such plants are often leggy and pale in colour (i.e. nitrogen deficient). Treat starved seedlings by spraying the foliage with a liquid plant food such as a soluble seaweed fertiliser.

Use Disease-resistant Varieties.
Select seeds varieties for disease-resistance characteristics. It is much easier to choose the right variety than try to control a disease which is destroying all your hard work.

Feed the Crop
Annual vegetables grow rapidly and use a lot of plant food. The compost in your seed bed preparation may not be released fast enough to keep up with the plant's growth. Top-dress the soil of your vegetable plot with a suitable organic fertiliser. Plant leaves absorb nutrients very quickly and therefore applying foliar plant food is an ideal way to boost your plants growth, particularly for leafy crops such as lettuce, cabbage, cauliflowers and silver beet.

Control Pests and Diseases Promptly
Regular inspection of your vegetables is a must. The early sighting of pest and disease problems can prompt early action and control with appropriate natural control methods.

Harvest and Process the Produce at the Right Time
One of the real joys of growing your own vegetables is being able to pick, pull or cut vegetables when you need them on a day to day basis. Daily inspections and tasting will determine when they are ready to harvest. Excess harvest means that you can store the "fruits" of your efforts. Select the method (freeze, bottle, dry) and prepare some days in advance to enable you to harvest and process at the optimum time. Some vegetables need to be harvested regularly to maintain the quality of the produce and increase the productive life of the plant. Zucchinis (courgettes), squash, cucumbers and asparagus are all good examples of these kinds of vegetables.

TIMING
The problem with most edible produce is that it grows and matures at certain times of the year. You may have a glut of produce in the summer and autumn only to find that you have little in winter and are virtually starving in early spring. This may not be a problem if you have decided to grow vegetables only at certain times of the year and have no intention of aiming towards self sufficiency. However, if you would like to be self sufficient and grow most of the produce you need throughout the year, then you will need to carefully plan your garden to ensure that this happens.

Whatever you decide you should be aware that different types of plants will yield different results, and you need to carefully select what you will grow and where you will grow it (particularly if you have limited space or limited time in which to care for crops):

- Some plants, once established, require relatively little attention (e.g. nut trees, raspberries), while others need constant attention (e.g. lettuce, tomatoes).
- Some plants produce a lot in a small space (e.g. berry fruit) while others take large spaces to produce even small quantities of produce (e.g. asparagus).
- Some plants take a long time to produce a crop, others bear quickly.
- Some plants require a lot of capital outlay initially (e.g. cost of the plant, cost of fertiliser).
- Some fruit trees bear their fruit biennially (particularly if allowed to produce heavy crops, thinning of crops is essential to prevent biennial cropping) whereas others bear fruit annually.

Another simple approach is to be in rhythm with nature, i.e. eat what is in season but don’t forget that you can extend cropping naturally by choosing and planting, early, mid and late season varieties. Unless it is an area of particular interest to you, trying to grow crops outside of their natural growing season is a waste of time and energy for the home gardener.

MAKING THE GARDEN MORE PRODUCTIVE

If you like colourful flowers, plant them amongst vegetables. If you choose the right species, they can act as 'companion' plants to aid the growth of the vegetables and herbs. Many vegetables and herbs can be grown not only to produce food, but also as attractive garden features. The foliage of many vegetables and herbs is highly ornamental, and many also have flowers that are both visually attractive and pleasingly fragrant.

Include multi-functional plants as much as possible, i.e. plants that produce food and have a number of other uses as well. For example, a tree could provide fruit and shade for people and foraging poultry, pollen for bees, windbreaks, firewood, timber, and leaves for use as mulch or to compost.

Build up the soil and improve its fertility. This is the key to a healthy, thriving garden. Compost all the kitchen scraps and garden clippings and animal manures then dig the compost into the soil. Also add seaweed and any other organic material that will break down in the soil. Earthworms will thrive on the organic matter, further improving the soil structure and fertility. Set up a worm farm and harvest their castings to use as a soil conditioner. If you have chickens give them all the vegetable scraps and fresh grass clippings and excess vegetables from the garden. Use a deep litter system (i.e. straw, old hay or sawdust) and simply toss all your composting material (other then onions, leeks and garlic) onto the litter, the chickens will soon turn it all into lovely compost. Use organic mulches on the soil surface to stop weeds competing with the productive plants, and to reduce the need for watering. Compost produced by chickens is ideal for this as it will also be weed free.

Collect your own rainwater. You could install an underground well that is filled from the underground water table. An alternative is to collect water from guttering by sending it straight into barrels or tanks. Not only will these methods cut down on your water bill, but it ensures that the water you collect does not have any unhealthy additives. Another alternative is to install a grey water filtration system and use this for the ornamental garden saving the fresh storm water for the fruit, vegetables and herbs. Remember that you must check with your local water authority that the collection and use of grey water is allowed.

Minimising Water Use in the Herb, Vegetable and Fruit Gardens

Gardeners often tend to over water. Most plants will adapt to less water by sending their roots down further and wider in search of soil moisture; through this they develop a larger root mass that has the ability to forage a larger area.

Bare soil is the enemy of the garden, as soil moisture soon evaporates even during mild conditions. Once vegetables are harvested more compost should be added and a new crop planted. During winter or other fallow times, plant a cover crop that can be dug in as green manure later. This is another way to conserve water by protecting the soil from moisture evaporation, as well as increasing soil fertility by adding extra valuable organic matter. Alternatively mulch the area thickly with compost and straw and let the earthworms do the job for you.

Even vegetables will grow well without the need for daily watering as long as the soil is well prepared, moist at planting time and mulched immediately the area is planted, or the seedlings are up.

If you do have a problem with a dry garden, even with the use of mulches, other solutions are:

- Using water crystals to improve the bed's water-holding capacity.
- Watering deeper, but less often.
- Using a drip irrigation system. Sprinklers are a wasteful use of water as they tend to water surrounding paths and grassed areas, as well as the vegetable garden. Micro sprayers are prone to water loss due to drift from wind. Even a slight breeze can affect the efficiency.
- Use tanks to collect and store rain water.
- Install a grey water filtration system for reasons already referred to.

Special Gardening Techniques

Gardeners can adopt techniques that will help them to create a healthy high production garden. Some of these techniques are listed below:

Crop Rotation

Crop rotation means that one type of crop creates suitable growing conditions for the following year. For example, the nitrogen added to the soil by peas and beans will create suitable conditions for growing leafy green vegetables. Crop rotation also discourages the build up of pathogens in the soil.

Green Manures

Green manures are crops that are grown specifically to mow or cultivate back into the soil, to improve the structure, the organic matter content, and the fertility of the soil. Green manure crops usually include legumes and crops that provide bulky organic matter. Many genera and species of beans, peas and other legumes are used, along with a wide variety of grasses and broadleaf plants.

Legumes need to 'nodulate' in order to fix nitrogen. Nodulation is the growth of *Rhizobium* bacteria on the roots of legume plants. These bacteria extract nitrogen from the air, and supply this to the plant. In some circumstances, legume seed is 'inoculated' with *Rhizobium* spores to ensure good nodulation.

Legumes should be mown down or cultivated into the soil when the plants begin to flower. It is also important to know that organic matter 'volatilises', or releases, nitrogen and other nutrients into the atmosphere as it dries out. This is one reason why organic growers frequently cultivate green manures into the soil, in preference to simply mowing them down. Leaving mown green manures on the soil surface can prevent erosion.

Sheet Composting

Certified organic growers use a soil development method known as sheet composting. This process involves spreading the compost materials, such as manure and hay, over the production area, then sowing the area to green manure. The green manure utilises the 'raw' nutrients in the manure, and stores it in a biological form. When the green manure is cultivated back into the soil, or mulched back onto the soil surface, the plant materials decompose, holding the nutrients in a stable but plant-available form known as humus. The inclusion of the green manure crop prevents commercial crops from coming into direct contact with the raw manure. Certification standards vary in their requirements, but some standards require two or more green manure crops to be grown following application of raw manure.

SUSTAINABLE LAND MANAGEMENT (for crop production areas)
A well conceived plan for managing crop-growing land is essential to ensure long-term sustainability and minimise the risk of land degradation.

Collecting Information
Before preparing the site for planting, you should collect as much information as you can on factors that will affect future planning and management of the site. Examples of information to be collected and analysed include:

- Land contour maps. Check with your local Agriculture Department or equivalent. In or near populated areas there are often aerial photos available to provide details of roads, hills, buildings, trees, etc. These are particularly useful when in colour.
- Location of permanent streams, dams, established fodder trees, designated green belts, and any other physical elements that are to be retained and managed.
- Environmental waste management procedures. Government authorities can often provide written material available on waste management, as well as provide an advisory service for specific requirements. Wherever there is a suspected contaminated land area (e.g. disused cattle dip), a waste consultant should be engaged to investigate the potential pollution and advise on possible remedies. Consultants are generally listed in the telephone directory.
- Land conservation reports and departments.
- Easements or other restrictions on land use. Check the title deed for easements and other restrictions (e.g. power line access, easement for national horse trail). Check for possible future use of the land (e.g. widening of roadways, power line construction). Check that all fences, including boundary fences, are in the correct position and in good condition.

Examples of decisions which might need to be made for long-term sustainability:

- How to ensure survival of stock though periods of drought or flood?
- How do I ensure the cropping potential (i.e. fertility and soil structure) remains at optimum levels?
- How do I dispose of potentially harmful waste products? The local council or government authority will often advise where and how to dispose of these products. If there is a large quantity a licensed carrier may be required for transport of dangerous goods.
- How do I prevent erosion? Advice is available from government authorities (e.g. soil conservation service). It is particularly important to attempt to slow the speed and volume of water flowing over areas of concern. Grassing and contouring of slopes will usually achieve these objectives.
- How do I manage my farm so that it does not harm native species? The National Parks and Wildlife Service (or equivalent), will advise on this. There are also local wildlife preservation societies which can be helpful. A local veterinarian may be able to advise also.

- How do I prevent contamination of waterways by chemicals and effluent? Contamination can originate on your property or neighbouring properties (e.g. local sewage plant can give elevated levels of copper, selenium and zinc in downstream water. Dumping empty pesticide containers (a strictly illegal practice in most countries), in a gully, creek or stream can also lead to problems down stream).
- How will I divide the property for maximum environmental sustainability and optimum cropping potential (e.g. into paddocks or fields, what different areas will be used for, what areas will be for conservation purposes and what will be farmed, etc)
- How do I manage irrigation to minimise waste water, and leaching excess minerals from soils?
- Check the type of soil, especially sub soil on the property. Check particularly for acid sulphate soil.

Indicators of Land Degradation

a) Deterioration of soil

- Lowering of organic content
- Lowering of E.C. (Electro-conductivity)
- Changes in pH
- Preliminary signs of erosion
- Salinity (White caking on soil surface)
- Reduced plant growth

b) Deterioration in water quality

- Increased E.C. (Electro-conductivity)
- Algal blooms
- Clarity or colour changes

c) Appearance of new weeds or pests (or dramatic changes in their populations).

d) Changes in susceptibility of pests or diseases to treatments (i.e. this can indicate resistance is developing in new generations of the pest).

e) Deterioration in crop quality (or livestock in the case of mixed farms), e.g. increased susceptibility to diseases and pests; discolouration of plant foliage.

f) Deterioration of crop or livestock yields

SUSTAINABLE CULTIVATION METHODS

Soil cultivation is used to:

- Incorporate organic matter or fertility inputs into the topsoil
- Form production beds and prepare seed beds
- Control weeds
- Conserve soil and water

Tillage and cultivation are important issues in organic and sustainable agriculture. Cultivation is a valuable tool for managing the soil, and some forms of cultivation can improve the soil structure when utilised properly. However, cultivation can often be damaging to the soil. This damage results from erosion of cultivated ground, and from destruction of the soil structure by the cultivation process itself.

Organic farming ideally aims for minimum tillage. However, because organic farmers can't use herbicides, tillage is often used as a weed control mechanism. Tillage is also frequently utilised to incorporate crop residues back into the soil, to prepare the soil for planting, and to actually improve soil structure. Various tools and cultivation methods are utilised.

Ripping
Rippers have vertical tines that act to break through the soil layers without turning the soil. The purpose of ripping is to increase the depth to which water, air, and roots can penetrate the soil profile. Deep ripping is frequently done over a number of years, with the rippers being set to rip slightly deeper each year. This allows the soil biology to develop progressively deeper each year.

Ripping along the contour lines can assist in soil conservation since it reduces the down-slope movement of water. 'Keyline' cultivation is a slightly modified form of contour ripping that distributes water away from gullies towards adjacent ridges. Chisel ploughs are a particular sort of ripper.

Harrowing
Harrowing consists of cultivating the surface of the soil with a tool called a harrow, in order to break up clods or cover seed with soil. Frequently, harrows are used after some other sort of plough, to make the surface more even. Harrows utilise various types of tines, including flexible 'spring' tines, rigid tines, and even chains that are designed to drag across the ground.

Disc Ploughing
Disc ploughs consist of a number of rotating discs, which roll along the soil surface burying organic matter. They are frequently used by organic farmers to incorporate green manures or crop residues into the top soil.

Other Methods
Many other methods are utilised for soil cultivation, but these are not always appropriate for organic systems. Tools such as rotary hoes and other implements that invert or turn the soil can be useful, but growers should be aware of the potential for tools such as these to damage the soil structure and inhibit soil biology.

Small-scale Methods
Many organic growers operate on a small scale. Small-scale growers are likely to use a variety of hand tools for soil cultivation. These hand tools may include:

- Chipping hoes, Dutch hoes, stirrup hoes, mattocks and manual wheel hoes for weed control
- Broad forks or digging forks for soil aeration
- Tine cultivators and rakes to prepare seed beds

Planting
Commercial organic market gardeners use a variety of planting techniques such as direct drilling of seeds, greenhouse production and subsequent transplanting of seedlings. Some crops also utilise rhizomes, tubers or other propagules.

Growers can alter the timing and sowing density to manage weeds, pests or diseases. Some growers coat seeds in a clay shell, allowing the seeds to be sown before germination is desired, or providing them with protection until conditions are suitable for their germination. Fungicide or insecticide coated seed is not suitable for use in commercial organic production

Cultivation Techniques
Cultivation involves ripping, digging, scratching or mixing the soil. This may be done for any of a range of reasons, including:

- To mix in compost, fertiliser or a cover crop.
- To kill weeds.
- To break an impermeable layer on the surface to allow water or nutrients to penetrate.
- To improve drainage
- To allow for better plant root penetration.
- To break up an impermeable sub-surface layer.

Cultivation can however also cause problems. Over-cultivation or regular turning can damage soil structure. Cultivation damages some of the small aggregates, allowing the organic matter which binds these aggregates to be consumed by micro-organisms. Cultivation is one of the main culprits in causing erosion, and soil structure decline. It can also change drainage patterns of the soil and can cause the fertile top layer to be diminished by mixing it up with lower soil layers.

Minimal cultivation is normally preferred in sustainable agriculture, but cultivation is a necessary part of any farming operation. Some ways to minimise damage include:

- Tilling only where necessary. For example, leaving strips of land unturned staggered with tilled soil.
- Tilling only when necessary.
- Not tilling when soil is overly wet. A simple test is to take a hand-full of soil and squeeze it in your hand. Moisture levels should be no more than you would get with if you had squeezed a sponge dry.
- It is preferable to use discs or ploughs rather than rotary hoes or tillers which mix the soil more.

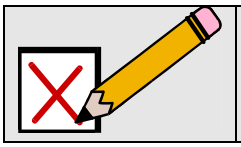
Conservation Tillage

This aims to reduce tillage operations or cultivations to only one or two passes per crop. It has been made possible by the use of herbicides to kill crop residues or pasture prior to planting, and the development of direct drilling seeding machinery capable of seeding through stubble. For some farmers the extensive use of these herbicides does not fit in with their view of what sustainable farming should be, however for many farmers the disadvantages of using such herbicides, are more than offset by the benefits of maintaining or improving soil characteristics, in particular structure. Conservation tillage has been shown to give sustained, improved yields when compared with cultivated paddocks. There are also considerable benefits in reduced labour costs, less wear and tear on equipment, and decreased fuel costs, as a result of the reduced number of passes required.

Stubble retention (from the previous crop) is a major component of conservation tillage. The stubble provides a protective layer on the soil, reducing evaporation losses, and reducing the impact of rain drops. This prevents the formation of surface crusts, and improves aeration and water infiltration. There is also a reduction in diseases of legume crops that are spread by raindrop splash. Soil micro-organisms have also been shown to increase in numbers, further helping to improve soil structure and fertility.

The biggest barrier to the use of conservation tilling has been the cost of buying or modifying tillage and seeding machinery. Conventional seeding machinery has had difficulty coping with the retained stubble. As this method of cultivation has increased in popularity, there has been extensive development of new machinery that can cope with such demands. The gains, however, are seen to more than outweigh the cost outlays, and this method of farming is sure to increase.

(Reference: *There's No Money In Dust: A Guide For Farmers Modifying Their Seeders For Conservation Tillage* by Nicholas Bate.)



SELF ASSESSMENT

Perform the self assessment test titled ‘Self Assessment Test 5.1.’
If you answer incorrectly, review the notes and try the test again.

TRANSPLANTING CROWNS, OFFSETS, TUBERS ETC

Some vegetables, particularly perennial types are often available as crowns, offsets of established plants, tubers etc. Examples include asparagus, globe artichoke, rhubarb and potatoes. These are also discussed individually in the directory of crops section.

Runners
A runner is a special type of stem which grows horizontally along the ground forming new plants at its nodes. Strawberries grow easily from runners, but due to the high incidence of virus diseases in strawberries in many countries, gardeners and growers alike are often advised to not propagate their own plants. Virus free strawberry plants are sometimes propagated in areas isolated from this disease, under government Department of Agriculture supervision. Rooted daughter plants can be dug up and transplanted whenever they have formed sufficient roots.

Offsets
This is a special type of lateral shoot or branch which develops from the base of the main stem of certain plants. Usually this is a shortened thickened stem. Many bulbs reproduce this way producing offset bulblets at their base. The date palm and the pineapple are just two other plants which produce offsets. Lateral shoots from rhizomes (as with banana and orchids) are also called offsets. The offset is removed by cutting close to the main stem with a sharp knife. As many roots as possible should be removed at the same time. It might be necessary to also cut back the top of the plant to balance the amount of top growth with root growth.

Crowns
The crown of a plant is the part of a plant at the surface of the ground from which new growth arises. In some plants the crown is like a large ball or swelling; below it are roots and from it several shoots grow upwards. The crown is cut with a sharp blade so that each section has least one of the shoots or stems plus some of the roots. Many herbaceous perennials as well as some woody shrubs and some indoor/tropical plants can be grown by crown division. Plants also grown this way include Asparagus.

Some Useful Suggestions on Planting
1. Grow perennials together in one section or in separate beds where they won't be disturbed by the necessary preparations for the planting and cultivation of shorter lived crops.
2. Plant tall crops where they won't shade out other crops.
3. Plant crops in long rows rather than in clumps or short rows. This makes cultivation easier, particularly if you are going to use rotary hoes etc.
4. Crops that mature around the same time should be planted together so that an entire section of a bed becomes available for preparation for the next crop rather than patches here and there.
5. Use Inter-cropping methods - the growing of two or more crops in the same bed i.e. a root crop with a leaf crop. It makes the best possible use of available space. Another example is to grow climbing beans up corn stalks.

SOWING AND TRANSPLANTING GUIDE (2.5cm = 1inch)

Crop	*Spacings Average(cm)*	*Depth (cm)*	*Weeks to maturity*	*Remarks*
Broccoli	50 x 70	1.5	10-16	Seed or seedlings. Thin later
Brussels sprouts	50 x 70	1.5	18-25	Seed or seedlings. Thin later
Beetroot	50 x 70	2.0	9-12	Seed
Silverbeet	50 x 70	2.0	8-12	Seed
Cabbage	50 x 70	1.5	8-16	Seed or seedlings
Capsicum	45 x 70	1.0	12-16	Seed or seedlings
Carrots	5 x 60	1.5	10-20	Seed
Cauliflowers	40 x 70	1.5	12-26	Seed or seedlings
Celery	40 x 70	1.5	10-16	Seed or seedlings. Thin later
Chicory	18 x 75	2.0	10-16	Seed or seedlings
Cucumbers	25 x 140	2.0	9 -14	Seed
Egg plants	60 x 80	1.0	14- 18	Seed or seedlings
Kohlrabi	20 x 80	1.0	10-12	Seed thin later
Leek	10 x 40	2.0	20-24	Seed
Lettuce	30 x 90	1.0	9-12	Seed or seedlings
Onions	10 x 40	2.0	24-40	Seed or seedlings
Parsnips	10 x 80	1.5	18-25	Seed
Potatoes	25 x 90	8-12	12-20	Sprouting tubers
Pumpkins	50 x 1.5	3.0	14-22	Seed or seedlings
Radish	2 x 30	1.5	4-5	Seed
Spinach	10 x 40	2.0	7-10	Seed or seedlings
Turnip	10 x 40	1.0	14-16	Seed
Tomatoes	40 x 100	1.5	12-16	Seed or seedlings

USING COMPOST

Any organic material, if left long enough, will eventually rot down due to the action of micro-organisms. Composting is simply a way to harness (or control) this process, to speed up the rate of decomposition, and to minimise nutrient loss due to the process.

Compost incorporated into the soil on the farm, whether broadcasted over the land or actually ploughed in, will improve the physical and chemical features of the soil. This improvement, like most other sustainable practices, will not occur immediately. Time is required.

A farmer may have access to bulk supplies of organic materials. In this situation, it is recommended they accumulate fresh material and stock pile it until a suitable time period has lapsed (about 2-4 months) before it is used on the farm. If material is well aged to begin with, then immediate use may be possible.

The raw material for any compost is organic matter. This may be in the form of unharvested plant material, windbreak prunings, grass slashing of the edges, dead animals and birds, manure, household or farm organic garbage, hay, straw, paper, even sawdust. The smaller and finer the particles are cut up, the quicker the composting process will be.

Diseased plant material should not be used in the compost as it may contaminate new areas when the compost is spread around at the later date. If the farmer has access to dead animal products such as bone, skins, offal or similar, it is important to consider health regulations.

Animal manures are an excellent source of matter for compost. The most commonly used are sheep, cattle, poultry, horse and pig, although others can be quite valuable if you can obtain them in large enough quantities. Animal manures need to be composted for a minimum of six weeks to prevent problems such as burning of leaves and roots from the presence of high levels of ammonium ions in the fresh manure. The ammonium ions are rapidly lost during composting.

Composting of manures is also valuable in reducing potential weed problems that may arise due to the presence of large quantities of seed eaten by grazing animals. The seed passes through the animal and is deposited in the animal droppings where the nutrients present in the manure and the warmth generated as it decomposes create an ideal environment for the seeds germination. Incorporating manure in a compost heap results in much higher temperatures that will kill a large percentage of the weed and grass seeds prior to, or just after germination.

The basic conditions of compost the farmer needs to be aware of are:

- Moisture should be between 40% and 60%. Take a handful of the composting material from at 15 or 20cm deep into the heap/mound of composting material, and squeeze it. It should be about as moist as a moderately squeezed wet sponge. If it is too dry add water to the heap. If it is too wet you may need to cover the heap with plastic, or turn it over regularly to allow for more evaporation to occur.
- Oxygen is incorporated by aerating and turning the heap over occasionally.
- Temperature, which should be between 40 and 60 degrees Celsius. A heap of 1 to 3 cubic metres will provide ideal temperature conditions. Usually the centre of the heap is the warmest and, for this reason, it is advisable to mix up the contents of a heap from time to time.
- pH, which will change during the stages of maturity. Generally you need not do anything to alter pH.
- C/N Ratio or Carbon:Nitrogen (see next below for explanation) ratio should be aimed for around 25-30:1.

If the compost process is permitted to fall outside these guidelines, then the compost will take longer to produce and may lose some nutritional value.

What is the C/N ratio?

For effective composting to occur, the micro-organisms that break down the plant materials require food in the form of nitrogen, phosphorus and potassium. Phosphorous and potassium are generally quite plentiful in composting materials, but there is often a lack of nitrogen. The most important requirement is the ratio of the percent carbon (C) in the materials, to the percent nitrogen (N).

This is called the carbon/nitrogen ratio. Raw garbage, for example, has 25 times as much carbon as it has nitrogen, so its C/N ratio is simply expressed as the number 25. A C/N ratio of around 30 is required for compost activity to take place at an optimum rate. To get a suitable C/N ratio it is necessary to mix materials with a high C/N ratio such as sawdust with materials that have a low C/N ratio such as manures.

How to Build a Compost Heap

The easiest way to build a compost heap is simply to pile up the materials in a heap around 1.5m wide and 1.5m tall. The heap can be left open or surrounded by bricks, timber, wire netting or other similar materials.

Use a variety of organic materials and place them in layers between 5cm and 10cm thick. Moist or juicy material should be in thin layers (no more than 3cm thick) covered by dry organic material such as dry straw or shredded paper.

Between every second or third layer, add a small amount of soil, as this will help introduce the micro-organisms necessary for the decomposition process.

If using a large amount of cooked food, or dry material such as straw, sawdust or paper, add some manure to boost the levels of nitrogen in the composting material.

Every week or so, turn the heap with a garden fork. In rainy weather, cover the heap with plastic, and in hot dry weather spray it lightly with water.

In warm conditions the heap will be ready in around 4 weeks; in colder weather it can take several months.

Compost Bins

There is a range of plastic compost bins available from garden centres, local councils and hardware shops. These are useful for composting small amounts of waste and for making compost in small gardens where you don't want to look out at an open heap of rotting waste.

Fixed bins can be difficult to aerate, and are prone to becoming too dry or too wet. Rotating bins are more expensive but provide quicker, more reliable results.

Compost: The Finished Product

Compost is ready to use when:

- It is crumbly and generally an even texture. (Material such as straw, or flower stems might be still intact.)
- It should drain well, but still have good moisture holding capacity.
- It should be dark in colour.
- It should smell earthy, not rotten or mouldy.
- The high temperatures which occurred in the centre of the heap during decomposition should have dropped.
- There should be few if any disease organisms or weeds left alive in it.

How to Use Compost

- Compost can be used either as a mulch, spread on the surface of the ground, or dug in (mixed with soil), to improve the structure of soil.
- In temperate areas, the best time to add compost is in autumn. Let it lie on the surface over winter then dig it in spring.
- Do not leave compost too long (particularly in warm weather) before using it, as nutrients can be lost over time.
- Don't plant in pure compost alone. Compost is good for most plants, but doesn't have everything a plant needs. Soil is necessary too.
- A potting soil made from loam and compost is still likely to require some fertiliser, particularly phosphorus.

COMPANION PLANTING
Some plants have beneficial effects upon other plants around them, such as helping deter pests or diseases, improving the soil, or even simple things like providing protection from wind or excessive sun. These plants are called “Companion Plants”.

General Principles
In nature, shrubs growing around a tree trunk may protect it from damage by animals. Many animals will at times eat the bark of certain trees.

- Large hardy plants growing beside smaller less hardy ones will provide protection from strong winds, frost and excessive heat. They create a more humid environment beneath the foliage, and can help minimise the effect of dry air in some situations.
- Avoid planting two plants side by side if they are attacked by the same pest or disease. This applies even to the same variety. For example, it is better to alternate cabbage plants with onions in a row, rather than having all the onions together and all the cabbages together.
- Planting decoy plants to attract insects away from the vegetable area.
- Planting a diverse range of plants to ‘confuse’ insects.
- Planting species known to have a beneficial effect on neighbouring plants i.e. chamomile.

Some Companion Planting Associations
Marigolds (*Tagetes* spp.) repel nematodes which attack narcissus (daffodils) and other types of bulbs. Plant a crop in a bed then remove before planting bulbs; or plant alongside bulbs.

Calendula
Calendula spp. attract a range of beneficial predator species including hoverflies, and repel some pest species such as the asparagus beetle and tomato hornworms.

Lavender (Lavandula spp*.)*
The scent and oil helps control a variety of insects but attracts bees.
A poor lime soil results in stronger oil content. A fertile acid soil may grow healthy plants but oil levels and companion plant value is reduced. Wallflowers (*Cheiranthus* spp.) and lavender are mutually beneficial in the production of flowers. Be careful with wallflowers – these are from the Bracicaceae (Cruciferae) family as are many vegetable crops such as cabbage, cauliflower and other Brassicas. The pests and diseases affecting these vegetables will be attracted by wallflowers.

Nasturtiums (Tropaeoloum spp*.)*
These contain oil that insects are attracted to in preference to cabbages and cauliflowers, which have similar oil. Nasturtiums may become infested, but your vegetables growing alongside them can be cleaner than they would otherwise be. Nasturtiums act as a trap crop for aphids.

Pyrethrum
Though this little flowering annual contains a chemical insecticide, as a companion its use is limited. It is effective in controlling pests when planted amongst strawberries. It will also tend to repel flies when planted in large quantities.

Roses
Alliums (Garlic, Chives, etc), planted below roses will help protect against black spot and mildew, and can repel some insects. Parsley helps control aphis on roses.

Sweet Peas
These fix nitrogen in the soil and are therefore beneficial adjacent to most plants but there are a few exceptions: notably Alliums (eg. onions and chives) and other members of the Lily family.

Sunflowers
Squash and cucumber grow well under sunflowers but potatoes do not.
Sunflowers can attract lacewings and wasps which are beneficial insects.
Lacewings help control various pests including thrip, mealy bug, white fly and aphis.

COLD AND THE GARDEN

Understanding Frost

- Frost is most likely to occur or be at its most severe just before dawn.
- Frost moves and settles lower down a slope, so plants higher up the slope are less likely to be affected.
- On a frosty night the air is colder at ground level. Frost can occur on the ground while not occurring on foliage a couple of metres high.
- A wall or fence can provide protection from frost for a distance of up to half the height of the wall.
- Increased ventilation stops frost settling. In some orchards, growers install huge fans to prevent frost damage.

Watch out for flushes of new growth – sometimes an abnormal warm spell is followed by a cold snap – tender new growth is most sensitive to cold.

There are three ways to make the garden warmer:
1. Trap heat by creating suntraps or heat banks
2. Create heat through the use of mulch to keep plants warm
3. Stop cold coming in, by planting windbreaks and building fences and by putting guards around cold-sensitive plants

Protecting Trees and Shrubs

Newly planted evergreen trees and shrubs are most at risk. At the start of winter, place tree guards, made from hessian or plastic, around susceptible plants.

Protecting Fruit

Excessive cold might not cause any obvious damage to fruit trees but if you look carefully, you may see the fruit buds have withered or dropped, and that can significantly affect your crop in the coming season.

Some cold is good though. Many fruit trees need a cold spell to get the fruit buds to form; but the same fruit trees can suffer if a frost occurs late in winter, especially if the buds have started to swell or open.

Protect fruit trees by covering with shade cloth, applying thick layers of mulch, using irrigation at times of frost, or using fans to generate warm air.

COLD WEATHER CHECKLIST

- Watch the weather report daily.
- Move susceptible tub plants under a shade tree or the eaves of the house.
- At the start of winter, put tree guards around newly planted trees and shrubs.
- Ensure good ventilation in the garden to minimise frost.
- Put a thick layer of organic mulch around cold-sensitive plants (as the mulch rots it generates heat so mixing in manure can help generate even more heat). Note that while mulches insulate the soil, they can attract frost as well.
- Cover seedlings with a cloche (a small portable frame, covered with plastic or glass) or bell jar (use an old plastic drink bottle with the neck cut off).

CROP DIRECTORY
The following lists describe the techniques used to grow a range of outdoor crops.

The Brassicas
Broccoli
(*Brassica oleraceae* - Botrytis Group) Brassicaceae
A high-yielding vegetable which crops continuously for several months.

Growing conditions:
Requires high organic matter and a well drained, loose, cultivated soil.
Best planted on mounds or raised beds.
Likes sunny conditions.
Keep weed free.
Do not plant beside tomatoes, beans or strawberries.

Nutrient requirements:
Good levels of nitrogen and phosphorus during development.
Iron and boron are also important.
pH 6.0 to 6.8

Suitable Growing Methods:
Hydroponics: Most systems are suitable. Aggregate systems probably best.
Raised soil beds: Most soils OK if well drained.

Planting:
Seeds can be sown into propagating mix and seedlings transplanted later.
Spacing should be 35 cm x 30 cm.

Special cultural techniques:
Plant support is necessary, even more critical if exposed to any wind.

Problems:
Grubs and can be a serious problem, pest control is essential

Harvest and Post Harvest:
Broccoli heads should be ready for picking 9 to 11 weeks after planting and will bear for a further two to three months.
The heads should be picked well before there is any sign of flowering and should be cut with 5 cm of stalk attached to the head.

Cabbage
(*Brassica oleraceae* - Capitata Group) Brassicaceae
Growing conditions:
Aeration should be very high.
Constant moisture is important
Ideally temperatures above 13 degrees Celsius at all times.

Nutrient requirements:
Nitrogen, phosphorus and iron are particularly important.
Has a higher than average boron requirement.
pH 6.5 to 7.0

Suitable Growing Methods:
Hydroponics: Excellent results from aggregate culture
Plant in raised (mounded) soil beds.

Planting:
Smaller varieties can be sown at a distance of 30 x 30 cm between plants.
Larger varieties will need to be spaced 45 x 45 cm apart.

Special cultural techniques:
Trellising is not required

Problems:
Cabbage White Butterfly grubs must be controlled.
Other pests can include aphis, flea beetles, maggots and cutworm.
Cabbage can be attacked by several fungi including *Fusarium*, downy mildew and *Alternaria* leaf spot.

Harvest and Post Harvest:
Harvested cabbages can be stored for a month or more after harvest at 0 to 3 degrees centigrade and low relative humidity.

Varieties:
There are varieties available to crop at all times of the year.

Legumes
Pea
(*Pisum sativum*) Fabaceae
Growing conditions:
Ideal temperatures are 13 to 18 degrees Celsius.
Requires good drainage.
Responds to slight additions of lime.

Nutrient requirements:
Calcium, iron and phosphorus needed - particularly important.
Adequate manganese is essential to achieve maximum cropping.
pH 6.0 to 7.0
We suggest trying an NPK ratio of 8:1:5

Suitable systems:
Grown on the broad acre or in raised beds (most commonly broadcast and grown as a broad acre crop).
Hydroponics: Aggregate culture should succeed with most media at a 10 cm depth or rockwool.

Planting:
Sow seed direct into permanent position.

Special cultural techniques:
Tall types require trellis/supports.

Problems:
Relatively few apart from some insects.

Lettuce
(*Lactuca sativa*) Asteraceae (Compositae)
Growing conditions:
Growth needs to be fast and at an even rate (will mature in 40-85 days depending on variety).
Shading may be needed in hot conditions.
The root zone should never overheat.
Most varieties prefer temperatures between 12 and 20 degrees Celsius.
Temperatures over 27 degrees Celsius can affect quality and cause flower stalk development.

Nutrient Requirements:
Requires a moderate but steady nutrient supply (too strong or too weak can lead to irregular growth).
NPK early in the season 9:1:16
As growth progresses reduce nitrogen towards harvest.
Tolerates high levels of boron, but only has a moderate requirement.
Molybdenum copper and manganese are more important than most other minor nutrients.
pH 6.0 to 7.0

Suitable Growing Methods:
Hydroponics: NFT has been used in England, Japan and Australia.
Raised soil beds.
Prefers a sandy loam

Planting:
Germinate seeds in sandy propagating mix and plant in rows when they have six to eight leaves.
Plant on a grid approximately 20cm by 20cm.

Special Cultural Techniques:
Remove marked or damaged outer leaves.
Minimise water on leaves on hot days.

Problems:
Irregular bursts of growth can cause decreased quality or quantity of produce.
Rapidly grown lettuces are relatively free of disease.
Excess water or poor aeration commonly causes yellowing or rotting of the lower (outer) leaves.
Some will burn on leaf tips if exposed to too much sunlight.
Pests include aphis, flea beetles, crickets, spring tails, leaf hoppers, caterpillars, whitefly, slugs, snails and whitefly.
Aphis is of particular concern because it transmits viral diseases.
Other disease problems include damping off (*Pythium*), *Sclerotinia*, downy mildew, powdery mildew, Botrytis, *Rhizoctinia* and Anthracnose.

Harvest and Post Harvest:
Are ready to pick after four weeks in summer.
Damaged or marked leaves should be removed on harvest.
Store between 2 and 4 degrees Celsius under high humidity.

Varieties:
Hydroponics is especially suited to the production of the small, fancy leaf type lettuces.
Mignonette can be grown all year (with the aid of a greenhouse in cooler climates).
Some varieties are slower bolting, reacting more slowly to high temperatures. These are most suited for growing in warmer months.

Onion
(*Allium cepa*) Amaryllidaceae
Growing conditions:
Easier to grow from seedlings than from seeds.
Ideal temperatures range is 13 to 25 degrees Celsius.
A relatively dry situation - low humidity, good drainage and aeration and minimum irrigations.
Requires good air movement around foliage to minimize fungal problems.

Nutrient Requirements:
High levels of potassium and nitrogen.
pH 6.0 to 7.0
Prefers inorganic or fast acting fertilisers to slow release organic fertilisers.

Suitable Growing Methods:
Mainly soil grown on formed up mounds.
Hydroponics: Aggregate culture gives excellent results, though not significantly different to soil culture.

Planting:
Seed can be germinated in propagating mix and transplanted or sown direct and thinned.
Most like 15cm spacing: less distance is needed for spring onions.

Special Cultural Techniques:
Cease irrigations on bulb forming onions when bulb has attained full size.
Allow the tops to almost completely die down then lift and store.

Problems:
Too much water causes fungal problems.
Pests include aphis, thrip, maggots and cutworms.
Diseases include downy mildew, *Fusarium*, *Botrytis*, smut and several other virus and fungal problems

Harvest and Post Harvest:
Lift bulb onions after tops die down completely.
Pull spring onions before tops begin to die down.

Potato
(*Solanum tuberosum*) Solanaceae
Growing conditions:
Tubers must not be exposed to light. The green tissue which results is toxic.
Media should not become too warm, though foliage can withstand heat.
Media must be deep (30cm or deeper).
Good drainage and aeration are essential. Grow on hilled mounds.
Some claim potatoes need a shorter growing period in hydroponics compared with soil.

Nutrient Requirements:
Heavy nutrient requirement.
Requires higher levels of phosphorus, otherwise similar nutrition to tomatoes.
pH must be 5.0 to 6.0
NPK 7:1:9 (NB: higher phosphorus than other vegetables)

Suitable Growing Methods:
Normally grown on the broad acre on mounds formed up by tractor drawn implements.

Planting:
Plant sprouting pieces of tuber direct
Disease is reduced if whole tubers (not cut) are planted.
If planting large seed tubers they may be cut, despite the disease risk.

Special Cultural Techniques:
Media may be pushed up to cover any exposed tubers (using a plough).

Problems:
Nitrogen deficiency can become a problem in cold or wet weather, so cool season planting should have particularly good drainage.
Aphis are a major problem as they transmit a virus disease.
Increased zinc reduces aphis problems.

Harvest and Post Harvest:
Harvest when tops begin to die down.
Red skinned varieties have a better keeping quality.

Tomato
(Lycopersicon esculentum) Solanaceae
Growing conditions:
Requires 21 to 24 degrees Celsius for optimum growth.
Growth slows significantly below 18 or above 27 degrees Celsius.
Requires good drainage.
In very hot conditions, some shading is needed.
Avoid very high humidity.
Frost sensitive.
Likes fertile soils, on a slope, in raised beds or sandy soil.
Keep moist will becoming established then reduce watering when fruiting starts.

Nutrient Requirements:
Regular feeding is needed to avoid stunted growth and reduced cropping.
pH 5.5 to 7.0
Likes plenty of fertiliser when growing.

Planting:
Germinate seedlings in propagating mix in greenhouse or sunny window sill.
Plant out seedlings in rows 1 to 1.5m apart with plants 30 to 60cm apart in the rows.
Place a stake (about 2m long) beside each plant on planting and tie to the stake immediately.

Special Cultural Techniques:
Prune out side shoots until flowering commences.
Tie loosely to stake or trellis.
A wind break may be needed in some areas.
Don't plant near apricot trees, potatoes, broccoli, cabbage, cauliflower, Brussels sprouts, turnips or radish.

Problems:
Planting too early can cause crop failure.
Blossom end rot is encouraged by any stress on the plant.
An irregular rate of growth will encourage blossom end rot.
Birds will attack ripe fruits
Pollination can be a problem in a greenhouse (wind and insects normally contribute towards pollination).
Don't smoke near tomatoes. A virus carried in tobacco can infect the plants.
Other pests include aphis, fruit fly, potato beetle, corn earworm, leaf miner, white fly, nematodes and mites.
Other diseases include anthracnose, bacterial canker, bacterial spot, blight, Fusarium wilt, Verticillium wilt and leaf mould.

Harvest and Post Harvest:
Can be harvested green or firm and pink.
Firm ripe tomatoes should be stored at 7 to 10 degrees Celsius and 85 to 90% relative humidity.

Other Crops
Carrot
(*Daucus carota* var. *sativa*) Apiaceae
Carrots are relatively easy to grow.

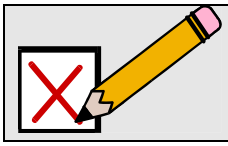
Growing conditions:
Most varieties require sandy, light deep soil that is well drained.
Prefers soils free of strong manures.
Prefers a sunny area but will grow with partial shading.

Nutrient Requirements:
An all purpose fertiliser, plus some lime or dolomite should be added before planting.
Minimize nitrogen, and maintain good levels of phosphorus and potassium.
pH 6.3

Planting:
Depending on variety, seed can be grown in most areas all year round.
Seed is mainly sown in spring and summer.
Seed are mainly small and fine; they can be added to dry sand to increase their bulk and thus are easier to sow. Soak bed well before planting and keep moist until germination.

Problems:
While pest and disease problems are relatively few, aphis and leaf hoppers can occur and several fungal diseases can arise from time to time particularly in excessively wet conditions.

Harvest and Post Harvest:
Carrots can be lifted at any stage of growth.
In a home garden, thinning to allow some carrots to grow bigger will yield smaller carrots to eat.
Varieties:
Short rooted varieties are more successful in heavy or medium soils.
Deep rooted varieties require a deep, loose, preferably sandy soil.



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

COVER CROPS
A cover crop is simply a plant which is grown for the purpose of improving the condition of the soil it is grown in. It is most commonly ploughed in, but can also be cut and left lying on the soil. The latter method is very slow, but can be effective. In theory a cover crop should increase organic content and fertility of the soil, but research has shown that this is not always the case. The real contribution of a cover crop is affected by:

- The amount of growth achieved.
- The plant varieties grown (e.g. legumes add more nitrogen to the soil than they take out during growth).
- Whether any part of the cover crop is harvested and removed from the paddock (perhaps as hay).
- Whether there is a strong leaching effect (e.g. in sandy soils or on steep slopes).
- Temperature and moisture conditions (excessive heat and moisture can result in rapid decay of organic material and in fact little if any increase in soil organic content. Excessive dryness can result in very little decomposition).
- Carbon:Nitrogen ratios of residues. (Residues with high ratios such as 100:1, are slow to decompose, but those with lower ratios may be much better.)
- Soil life (the presence of certain micro- organisms, worms, etc. can have a significant bearing upon decomposition, release of nutrients, and even mixing of residues into the soil mass).

Farmers use cover crops for varying combinations of the following reasons:

- To improve soil fertility, soil structure or tilth
- Control erosion
- Reduce the need for fertiliser and other soil amendments
- To increase nitrogen levels (i.e. legumes as a green manure)
- Improve nutrient availability
- Minimise leaching
- Weed, pest or disease control
- Preparing land for production of other crops (e.g. vegetables or grain)
- As a livestock feed supplement

The cover crops used must be matched with the desired outcome.

Guidelines/principles
The following tips will help in determining selection of a cover crop:

Type of Crop
Perennial crops are generally preferred over annuals. With annuals, large populations of nematodes often move into the soil after maturing, causing problems for the root system of any subsequent plantings.

Effect on Soil pH
Alkaline tolerant plants such as sorghum and barley, can be grown to reclaim alkaline (lime) soils. Growing a single crop of these plants may cause sufficient soil acidification to allow less lime tolerant legumes to be grown, further acidifying the soil and allowing it to be used for livestock or a cash crop.

Timing
The crop should be incorporated (tilled) before maturity (i.e. before flowers and seed forms)

Water Use
While cover crops, like any other crops, do use water, their root growth can lead to better penetration of water into the soil. Additionally, residual organic material left by the plants will lead to increased water conservation.

Legume Cover Crops
Legumes commonly have 15-30% more protein than grasses, giving them better food value for livestock. Another advantage of legumes as a cover crop is the production of the *Rhizobium* bacteria which legumes can be inoculated with, resulting in production of hydronium ions in the soil. These ions in turn lower the soil pH, making the soil increasingly acidic.

The decomposition of organic residue also has an acidifying affect on soil. Increased organic matter does however buffer (i.e. sort of slow down) this acidification. Nevertheless, excessive and continual use of cover crops, especially legumes, without liming or use of a similar treatment can result in soil becoming too acid, and losing productive capacity.

Inoculation of Legumes
You can use pre-inoculated or pelleted seed, or you can inoculate seed yourself.

Inoculating Seed
- Add the inoculant to another medium (eg. peat mixed with water and gum arabic). Use 1 part sticking substance (eg. gum arabic) to 10 parts water. Other sticking materials that can be used include corn syrup, sugar, powdered milk or various commercial stickers.
- It is critical to use only fresh inoculant in the appropriate concentration.
- Use the appropriate *rhizobium* sp. for the legume being grown. Keep in mind that *rhizobia* perform better on some legumes, (eg. alfalfa) when seed is coated with Calcium Carbonate, while others perform better when left uncoated (eg. red clover)
- Check expiry date. Commercially produced, pelleted seed should be sown as soon as possible, at least within 4 weeks of production as it does not store well.
- Always store inoculant in cool, dark place
- In dry conditions, inoculant rate may need to be doubled.
- If legumes exhibit yellowing of foliage, this may indicate nitrogen deficiency resulting from failure of the inoculant.
- Applying some nitrogenous fertiliser when planting a cover crop may actually enhance the nitrogen fixation of the legumes (eg. around 30 kg per hectare of starter nitrogen)
- Generally soil pH needs to be over 5.5 for *rhizobium* to survive.

Shade Tolerant Cover Crops
These include Cowpea (*Vigna unguiculata*), Burr medic (*Medicago polymorpha*), Hyacinth Bean (*Dolichos lablab*)

Salt Tolerant Cover Crops
Strawberry Clover (*Trifolium fragiferum*), White Clover (*Trifolium repens*), Burr Medic (*Medicago polymorpha*), Field Pea (*Pisum sativum*), Barley 'Salina' are all ideal for use in areas of high salination or heavy salt spray.

TRANSPLANTING CROP SEEDLINGS
This involves moving seedlings grown elsewhere to their permanent cropping position. Seedlings are obtained from a variety of sources including those raised in special seedling beds, those grown from seed in containers and those left over from thinning out other sections of the vegetable patch (suitable for some vegetables but not all).

Large quantities of vegetable seedlings are grown commercially in punnets or trays (usually small plastic rectangular containers) to supply commercial and domestic vegetable growers.

Both the seedlings to be moved and the site to which they are being moved should be well watered the day before transplanting is to occur. Container-grown seedlings may need watering up to an hour or two before transplanting commences in order to maintain sufficient moisture in the root zone.

The watering helps reduce the shock to the plant of the transplanting procedure, in particular by helping to keep soil or seedling mix bound together around the roots of the seedling. If the soil etc is dry it generally crumbles away from the root ball readily during transplanting. This exposes the roots to the atmosphere where they are more likely to dry out causing damage to the plant. It is preferable that some soil remains around the plant roots.

Seedlings should be gently lifted out of the bed or container in which they are being grown, taking care to maintain as much soil around the roots as possible. A hole is then made in the bed with a sharp stick or dibber and the seedling planted into the hole, making sure that the seedling is at the same depth as it was in the seed bed or container. Soil is firmed around the plant to hold it in position and the plant is then well watered.

Buying Seedlings
When selecting seedlings for purchase you should always consider the following points:
1. Choose only plants with a healthy appearance. Seedlings should have no obvious discolouring, stunted growth, signs of damage etc.
2. Reject any seedlings with obvious signs of pest or disease damage.
3. Do not choose seedlings that appear crowded in their container, or have extensive root growth protruding from the seedling container. These seedlings will often not transplant as readily as smaller ones that are not pot bound.
4. Be wary of very small seedlings that appear very soft. These may have recently come out of a protected seedling raising area such as a greenhouse and have had insufficient time to 'harden up' before being offered for sale.

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

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), their larvae eat aphids or use a garlic spray. You can also 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 a 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.

Borer
These grubs bore out cavities inside the stems of plants, or the wood of trees. Evidence is often found in the form of entry holes and the castings of dust/wood shavings around these holes. In some cases it may be possible to cut away a section of the plant to verify the presence of borers.

Control
- Natural

Remove the infected parts and burn.
- Chemical

Use a systemic insecticide containing such chemicals as dimethoate or a contact and ingested product containing chemicals such as chlorpyrifos.

Caterpillars
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) or remove by hand.
- Chemical

Spray with products containing chemicals such as nicotine, Pyrethrum (pyrethrins) or other pyrethroid-based insecticides such as cypermethrin and deltamethrin.

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) or remove by hand.
- Chemical

Spray with products containing chemicals such as nicotine, Pyrethrum (pyrethrins) or other pyrethroid-based insecticides such as cypermethrin and deltamethrin

Chafer Grub
A thick white C-shaped grub with a dark-coloured head that burrows in soil and feeds on organic material. It can cause severe root damage and sometimes death of smaller herbaceous plants such as chrysanthemums and grasses. It is also called a cockchafer and it is the grub of a beetle.

Control
- Natural

Grow resistant plants, thorough cultivation and good weed control, heavy rolling on infested lawns or nematode-based products which contain the nematode *Heterorhabditis megidis.*
- Chemical

Use lindane (banned in UK and Europe) or malathion drench (not UK and Europe), or products containing deltamethrin.

Cricket
The common field cricket has a dark brown body about 1 inch (2.5cm) long. It feeds on new tender plant growth.

Control
- Chemical

Malathion (not UK and Europe).

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 and cover plants with fleece or insect-proof mesh (celery, parsley). A biological control is the use of the parasitic wasp *Diglyphus isaea.*
- Chemical

Products containing bifenthrin, rotenone, permethrin, pyrethrins, dimethoate or white oil: only dimethoate is licensed for this purpose in UK.

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 (not UK & Europe) or fatty acids sprayed directly on insects, or products containing deltamethrin (very restricted applications in UK & Europe) or dimethoate.

Mites Including Red Spider Mite

Small red-coloured mites who resemble spiders, almost invisible to the naked eye, that appears as a red haze, usually on the back of leaves. Leaves can turn a bronze colour and die. It is common on peaches, nectarines, strawberries, broad beans, runner beans and many ornamental plants, and often a significant glasshouse problem on tomatoes, cucumbers, capsicums and eggplant (aubergines).

Control

- Natural

Introduce the natural predator *Phytoseiulus persimilis* to the garden, use repellent plants such as onion, garlic and chives or treat with natural plant extracts. In glasshouses keep humidity levels high.

- Chemical

Derris (active ingredient rotenone), malathion, (none of these in UK & Europe) fatty acids, fenbutatin oxide, pirimiphos-methyl.

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 bugs. Colours include red, black, brown, white and pink. They generally attack leaves, soft stems and roots.

Control

- Natural

Products available using the parasitic wasp *Metaphycus helvolus.*

- Chemical

Fatty acids (insecticidal soap) (in UK & Europe) malathion, White Oil (must get direct contact) (not in UK & Europe).

Slater

Also called woodlice, they live in shady places, often moist, under stones or amongst mulch. They eat young tender foliage, preferring plants already damaged by a prior pest.

Control

- Natural

Remove garden rubbish which may harbour slaters.

- Chemical

Some types of snail and slug bait are effective.

Slug

These will attack any relatively tender plant parts. They are more of a problem in moist and poorly drained sites.

Control

- Natural

Product which uses the predatory nematode *Phasmarhabditis hermaphrodita* (eg. “Nemaslug”). For additional controls see section on snails.

Pear and Cherry Slug
A 1cm long black slug-like pest which eats the leaves of pear and cherry trees in spring, summer and autumn: found in the Southern hemisphere.

Control
- Chemical

Malathion, dimethoate, omethoate (none of these chemicals licensed for this use in UK and Europe).

Snail
A major pest of soft tender foliage, particularly young vegetable and flower seedlings; particularly troublesome in moist, shady areas;

Control
- Natural

Use repellent plants such as prostrate rosemary and wormwood or slug barrier products such as wood chips impregnated with myrrh resin (*Commiphora molmol*) sold as “Slugs.biz”. 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.

You can also crush them using your foot or some other solid object or use the predatory nematode (*Phasmarhabditis hermaphrodita*) preparation such as “Nemaslug”.

- Chemical

Snail pellets or powder which contain methiocarb or thiodicarb (not available for use on snails in UK)

Thrip
These tiny insects swarm over leaves and flowers in hot summer. The usual symptom is flecking of leaves or flowers.

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 UK and Europe), chlorpyrifos-methyl, nicotine, (these two are only licensed on some protected crops in UK), dimethoate (in UK 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.

Control
- Natural

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

Malathion, pyrethrum (pyrethrins), nicotine, (not UK & Europe) chlorpyriphos, (UK - outdoor brassicas only), buprofezin.

Vine Weevil
Adult Vine Weevils 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. Target plants in open ground are mainly ornamental with the exception of strawberries. However all plants in containers can be targeted, although the insects prefer ornamental plants. They are a particular problem in azaleas, rhododendrons and camellias.

Control

- Natural

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°C (54°F) to be effective.

- Chemical

Use products containing imidacloprid or fipronil (neither licensed for edible crops in UK or Europe).

Leatherjackets

Leatherjackets are the grey or greyish-brown larvae of the Crane-Fly or “Daddy Long Legs” and can cause serious damage to the roots of Brassica and ornamental plants: high populations in lawns produce yellow patches, which may be further damaged by birds extracting the leatherjackets from the soil.

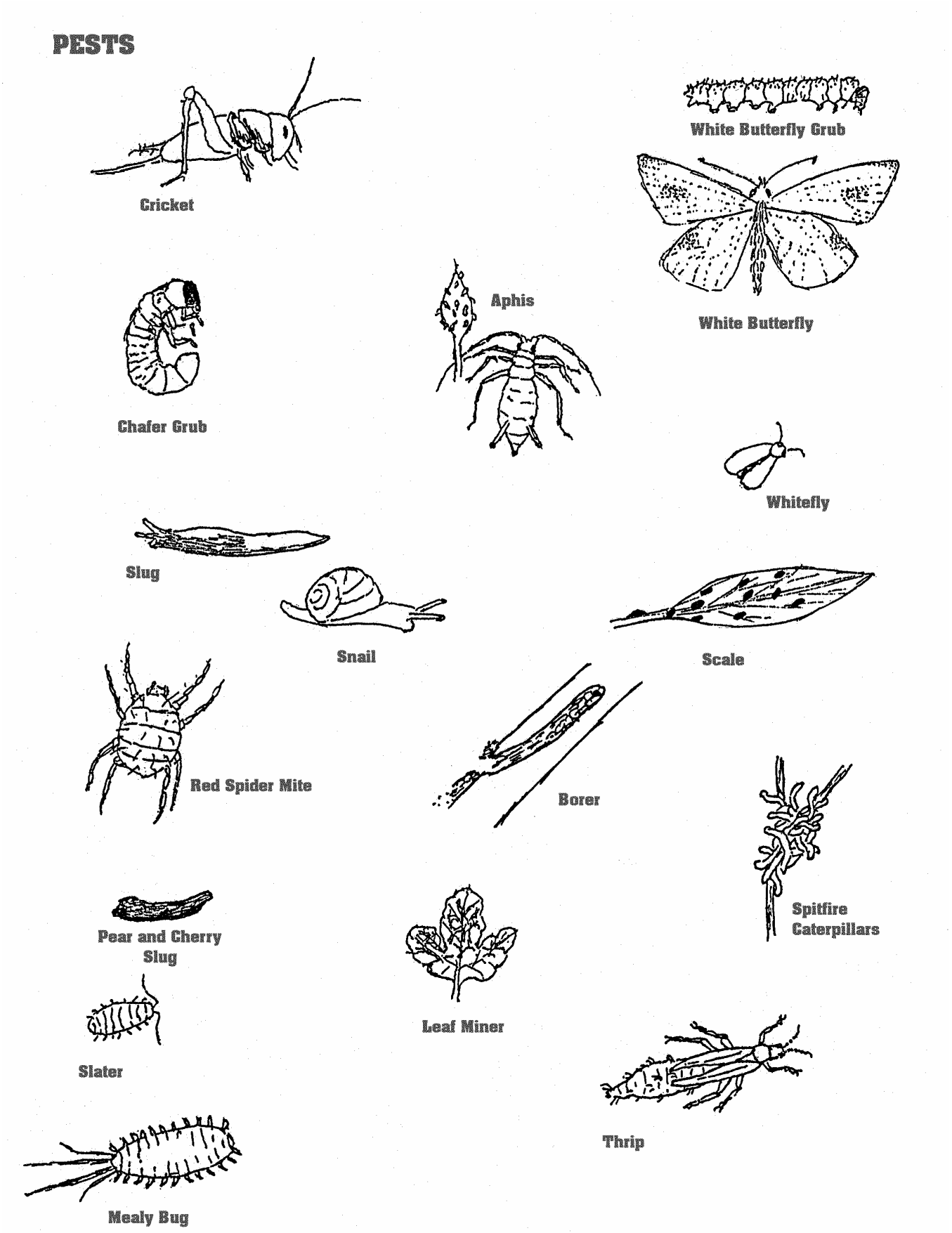
Control

- Natural

Use products containing predatory nematodes (*Steinernema feltiae*), such as “Nemasys Leather Jacket Killer”.

- Chemical

Use products containing chlorpyrifos: slug baits and other products containing methiocarb will help to reduce infestations (only licensed for cereals, potatoes and sugar beet in UK)



COMMON FUNGAL DISEASES OF PLANTS

Anthracnose

Several species of fungus are responsible for Anthracnose in a number of plants. Symptoms are shown in dark brown or black sunken spots on the stems, fruits or seeds. It is a common fungal disease on dwarf and runner beans, where symptoms include reddening on the undersides of leaf veins. Anthracnose is also a significant disease of cucumbers grown under glass, grapes, several species of *Platanus* (planes) and *Salix* (willows).

Control

- Physical/Natural

On large trees, control is almost impossible. You will need to 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 replant 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

- Chemical

Not practicable on larger trees: spray with sulphur suspension and/or Bordeaux mixture depending on plant and time of year: no products licensed for food crops in UK.

Black Leg

This is a rot in potato tubers and in the basal parts of the potato stem, caused by the fungus *Erwinia carotovora* var. *atroseptica*: Symptoms are blackening of stems at or below ground level, stems become slimy, leaves turn yellow and wither. All stems on the same plant may not show the symptoms.

Control

- None

Use only certified disease free seed potato, and only plant whole tubers. Cutting seed potatoes to increase quantity increases disease risk. The bacteria overwinter in the soil and plant debris: practice long crop rotation cycles. “King Edward” variety is thought to be less susceptible.

Blossom End Rot

A fungal disease found on the bottom of a tomato fruit, causing a circle of rot. It is normally due to irregular patterns of watering. A deficiency of calcium may be a contributing factor: very common problem for tomatoes grown in grow-bags.

Control

- Provide good nutrition, especially calcium, deep soil preparation and mulching. Never let soil/compost dry out, particularly during fruit swelling.

Brown Rot

Brown rots are caused by fungi of the *Sclerotinia* spp. and are a very common problem in a wide range of fruits. Soft, brown patches appear on fruit in advanced stages dirty white or yellowish cottony pustules develop on patches, often in concentric rings or stripes. Mummified/infected fruit can fall to the ground and carry the disease through to the next season.

Control

- Natural

Some cultivars are resistant, particularly of apples. Remove infected fruit and mummies and burn and cut out and burn diseased fruiting spurs. Careful hygiene and handling are more effective controls than chemical sprays, in gardens

- Chemical

Bayleton (active ingredient is triadimefon) and zineb, benomyl captan (none licensed in UK and Europe), and fenbuconazole (in UK off-label approval for cherries, plums and mirabelles only), for commercial growers: no products for home gardeners.

Botrytis
Diseases caused by *Botrytis* spp. are probably the most common and widely distributed diseases of vegetables, ornamentals, fruits and even field crops throughout the world: manifesting as grey moulds the disease occurs in humid weather attacking a wide range of plants. The diseases appear primarily as blossom blights and fruit rots. Flowers become spotty at first, and then later they rot and become covered with a greyish-white fluffy or cobwebby mould. Badly diseased buds fail to open. The fungus will spread to the fruits, stems and soft tissues. Botrytis can also infect stems and leaves with mouldy rot and fluffy grey growth, before flowers appear.

Control

- Natural

Botrytis overwinters in the soil on decaying plant debris, so hygiene, via the removal and burning of infected or decaying material is crucial. The fungus requires cool (18-20^{o}C) damp conditions for best growth. Ensure plenty of air circulation; cut out excess/congested soft leafy tissue; do not over-fertilise. Water underneath the plant directly onto the soil: in particular keep flowers dry. If watering in cool conditions this is particularly important. Any diseased flowers or plant parts should be removed and burnt.

- Chemical

Fongarid (active ingredient furulaxyl which is not licensed in UK), Bordeaux mixture (garden applications). commercial applications include either fenhexamid or propamocarb hydrochloride, depending on the plant to be treated.

Damping Off
There are five main fungi species causing damping off diseases (different species of either *Pythium* or *Phytopthora*). This disease occurs on young seedlings and is a serious nursery problem. Symptoms are exceedingly variable but all result in death: common signs are stem lesions at or about soil level, causing the seedling to collapse.

Control

- Natural

Cleanliness, hygiene good air circulation and good drainage will help control this. 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 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.

- Chemical

Benlate or proprietal LeSan DX in Australia; other fungicides such as etridiazole, propamocarb hydrochloride, copper oxychloride may be used, but these 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.*

Die Back
Kills the tips of the plant, and continues killing the stems and leaves as the disease spreads throughout the plant. There are different types of fungal diseases that cause die back and in rare cases viral infections can cause cankers which girdle branches and cause dieback.

The most serious type of dieback from a fungal cause is a secondary symptom of root rot caused by the cinnamon fungus *Phytophthora cinnamomi* which can cause death of fully grown oak, chestnut, avocado, cinnamon trees and azaleas. The term “jarrah dieback” refers to this condition in Australia’s natural forests. *Phytophthora ramorum,* the pathogen causing the disease Sudden Oak Death, has been responsible for mortality of large numbers of oak and other species in North America and is now taking hold in UK and Europe.

Where no immediate evidence of pathogen infestation is evident dieback is probably the result of physiological or is a secondary symptom of a root rot or other soil factor, such as waterlogging or drought. Poor pruning or lopping techniques may also result in stem or branch dieback.

Control

- Natural

Cut off infected parts and burn. In extreme cases, cut back to 30cm beyond the limit of tissue death. Always disinfect tools between cuts, check drainage and ameliorate if ground is waterlogged. Provide feed and water if infection is not severe.

- Chemical

There are chemical controls for some of the pathogens which cause the rot of which dieback is a secondary symptom. It is necessary to first identify the cause of the dieback and select an appropriate chemical. If unsure, in Australia, use a general treatment such as Fongarid (a.i. furulaxyl); in Europe and UK no general purpose product is recommended.

Downy Mildew

Downy Mildews are caused by genera of the *Phycomycetes* fungi. All must parasitize a host plant (described as obligate parasites). Plants and pathogens are usually mutually specific; high humidity 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, zineb (not UK and Europe), mancozeb or sulphur (not licensed for this use in UK), chlorothalonil, propamocarb hydrochloride.

Powdery Mildew

Powdery mildews are caused by many species of fungi of the family Erysiphaceae: 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, mildewy 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

- Chemical

Benomyl, mancozeb, Bayleton (a. i. is triadimefon): none of these is licensed in UK and Europe), or sulphur and dinocap

Grey Mould on Strawberry

Caused by *Botrytis* fungus usually in wet summers; symptoms are fluffy grey mould on the fruit's surface and rotting fruit.

Control

- Chemical

Mancozeb (not licensed for this use in UK), chlorothalonil (outdoor crops), fenhexamid

Peach Leaf Curl

Causes large reddish blisters to appear on peach or nectarine leaves early in spring and throughout the season. The disease reduces tree vigour but does not normally kill. The fungus carries over winter in the bark and bud scales of the tree.

Control

- Copper-based sprays such as Bordeaux mixture or copper ammonium carbonate early in the season and repeat regularly through spring and summer, including once just before leaf fall.

Ring Rot in centre of potato

This disease is caused by the fungus *Corynebacterium sepedonicum*: above ground symptoms may occur so late in the season that they are masked by senescence, however some stems may appear stunted. Interveinal areas of leaflets turn yellowish and the margins roll upward and become necrotic.

If wilting stems are cut a creamy exudates oozes out. The tubers first show a ring of light yellow discoloration and bacterial ooze. Later stages a creamy yellow or light brown, crumbly rot develops, and if squeezed, soft pulpy exudates ooze out.

Control

- Use certified seed potatoes. Make sure all cutting tools are disinfected. The bacterium does not over-winter in the soil, but can over-winter as dried slime on containers, crates tools etc. All of these must be thoroughly disinfested.

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. 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, asparagus, leeks, tebuconazole (off label) legume, beans (*Phaseolus*), broad beans (*Vicia faba*) and oxycarboxin for ornamental specimens or protected ornamentals

Soft Rots

Soft rots are caused by bacteria that affect a wide range of plants, although stored bulbs and vegetables are most at risk. Most attacks can be prevented. The most common bacterium responsible for soft rots is *Erwinia carotovora*: others include *Pseudomonas* spp. and other *Erwinia* spp. Bacterial rots have a significantly more unpleasant smell than fungal rots. Entry to plant tissue is usually via a wound or other damage. Older, less vigorous plants are more susceptible than young plants and in older plants, already beginning to die naturally soft-rot bacteria can attack without the help of wound or damage.

Bulbs, cyclamen corms, iris rhizomes and arum lilies are high risk plants, as are potatoes, tomatoes and cucumbers: other victims include plants such as cabbage, celery, lettuce, *Primula* crowns, *Dieffenbachia* stems. Soft rot is also a problem in stored vegetables.

Planting material, contaminated tools and soil or compost are all methods through which soft-rot bacteria are spread. Moisture is needed to aid bacterial spread and growth. Soils which are over-rich in nitrogen and potash can make the problem worse. Plant tissue tends to be soft and lush when over fertilised.

Control

- Natural/Physical

Dispose of contaminated material by burning, do not compost it. Practice good hygiene and crop rotation, avoid injuries to growing plants or material for storage, control pests and do not over fertilise.

- Chemical

There are no sprays recommended: copper-based fungicides used to control tomato blight, may give a little protection to the fruits.

DISEASES

Die Back

Botrytis

Powdery Mildew

white mould patches

Downy Mildew

yellow patch on top of leaf

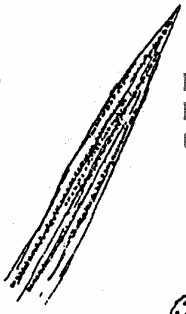
grey mould under leaf

Damping Off

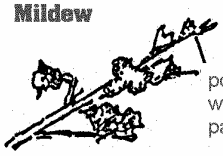
Rust On Back Of Rose Leaf

orange

Rust On Blade Of Grass



Mildew



powdery white patches

black

Black Spot On Rose

Healthy Strawberry

early stage

advanced

Brown Rot On Peach

Blossom End Rot On Tomato

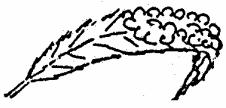
Fruit Rot Or Mould On Strawberry

Strawberry Mildew

Ring Rot In Centre Of Potato

Black Leg Rot In Potato

Anthracnose On Bean



Peach Leaf Curl

Root Rot

Bracket Fungus

DIAGNOSIS OF PLANT DISORDERS

Symptom	Possible Causes	Treatment
Spindly growth	Low light (e.g. shade), excess water, high temperatures, plants too close together.	For protected crops improve light, cut watering reduce night temperature in, greenhouse by cooling or ventilation; for all situations reduce feeding, increase spacing between plants
Growth reduced plants	Insufficient nutrient and/or water.	Feed more often but in low, small concentration. Water more often.
Old or lower leaves yellowing	Nitrogen deficiency	Increase proportion of nitrogen in fertiliser applied. 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 the 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	Phosphorus deficiency	Similar treatment to nitrogen.
Root tips burnt or discoloured	Salts, toxic chemicals in media (sometimes occurs when media is fresh).	Wash away excess nutrient or toxin. Check levels with an EC meter
Woody growth	Plants over hardened (i.e. exposed to too tough conditions), or slow growing.	Increase feeding. If problem is excessive, also prune.
Stems decaying at base of the plant	Damping off disease caused by dirty conditions, high humidity and/or overcrowding	Thin out plants, apply fungicide
Algae, moss or liverwort on surface of the medium.	Excess moisture and nutrient on surface. Does not harm plant initially but can impair flow of water and nutrients through the medium in the long term	Reduce watering, increase ventilation, use better draining medium. Some chemicals e.g. Ferrous sulphate can be used to kill algae and moss.
Poor root growth	Excess nitrogen in the nutrient solution held in the medium, poor aeration or drainage in medium, low temp. in medium, toxic chemical	Determine which of these is the problem, and act accordingly

FRUIT CROPS DIRECTORY

Top Fruit

Apples (*Malus pumila*)

Wide variety of soils and climates, though best in cooler areas. They will grow in wet climates or relatively dry areas (if mulched and irrigated). Cold areas prone to serious frosts and snow can be suitable, as can areas which are almost to the sub tropics provided they have a cold period over winter. Usually space trees to 20ft apart or less if on a trellis (e.g. espalier). They take 4-5 yrs to bear well. Irrigation and fertiliser important, prune annually. Varieties produce fruit on spur systems (spur-bearing) or on tips of lateral branches (tip-bearing): pruning cuts should promote spurs or encourage laterals with fruit buds at their tips. Popular varieties are Granny Smith, Jonathan and Delicious (in Australia), Cox's Orange Pippin, Egremont Russet (in England), Delicious (South Africa). Store in C.A. (i.e. Controlled Atmosphere) or Cool store. Used for juice, canning or fresh. Propagated by budding or grafting onto stocks raised by seed or layering.

Apricots (*Prunus armeniaca*)

Very hardy trees need less feeding than other fruits, otherwise similar to peaches. Spray program is important. In Australia, commence with lime sulphur and carbaryl at bud burst. Follow up sprays of Bordeaux and carbaryl every 6-8 weeks. (Similar spray program is important for most soft fruit.) IN UK and Europe spray with Bordeaux mixture or copper fungicide at leaf fall, at the end of January and in mid-February. Give trees a high nitrogen feed to promote new leaf growth. Prune annually. Fruit occurs mainly on 2nd year old spur wood. Used in canning, jam, dried, juiced and sold fresh. Grown by budding onto peach or myrobalan plum rootstock for medium to large trees: smaller trees can be grown using plum rootstock St. Julien A.

Sweet Cherry (*Prunus avium*)

A temperature of -4°C at full bloom will kill 90% of the flowers, however cold winter temperatures are needed for good fruit bud formation. Sensitive to poor drainage. Ideal site is a slope with good air drainage (i.e. so frosts will move through the orchard to lower in the valley). Soil must be deep – ideally more than 75cm. Regular liming is often practised on heavy soils for preferred pH of 6.5-7.5. Cross pollination is essential. Fertilise early spring annually. Prune in spring as buds burst, not in winter because risk of bacterial canker. not Fruit is processed and used fresh. Harvest mid summer. Propagated by budding or grafting selected varieties onto cherry rootstocks. Vigorous tree and rootstock must be chosen carefully where space is limited.

Acid Cherry (Prunus cerasus)

Flowers appear in early spring, so frost pockets must be avoided. Prefers neutral to alkaline soil, pH7.0. Leave a border of uncultivated soil around the tree: hoe or control weed with herbicide. Fruit is borne on previous summer's growth, so pruning must encourage new shoots to carry the next season's cherries. Cultivation similar to that for sweet cherries.

Kumquat (Fortunella sp.)

Treated similar to lemon. Fruit usually used in marmalade. Propagated by budding onto citrus stock.

Fig (*Ficus carica*)

Ideally warm dry subtropical climate though it will produce well if protected in temperate regions. Well drained loam or sandy loam and lots of sun (but no frost). Ideally pH 7 and 20-24feet (6-7m) spacing between plants. Avoid damaging roots by cultivation, takes 4 years to bear. Root restriction necessary to prevent vigour being invested in tree growth rather than fruit growth. Figs grown in cool temperate regions are parthencocarpic (fruit without fertilisation), and relatively disease free. Main problem is birds (Use netting). Pick and pack in single layer boxes. For dry fruit, usually let dry on the tree and harvest as it falls (in low rainfall areas). Best varieties are White Adriatic and Brown Turkey. Propagate by hardwood cuttings or tip layering. In cool areas heavier crops can be achieved by growing under glass. Red spider mite and mealy bugs may then be a problem.

Grape (*Vitis vinifera*)
Tolerates cold when dormant but not when in leaf; spring frost can be a problem. Ideally sunny, sheltered and well drained position. Grow on trellis. Prune annually **once established** removing a large proportion of the previous season's growth at each prune. Takes 3-4 years to reach full size and begin cropping. Fresh, dried and wine ... also some juice. Wine and dried grapes count for over 80% of the crop. Dried grapes produced in low rainfall areas only. Wine industry is expanding. Propagated by hardwood cuttings.

Grapefruit (*Citrus* x *paradisi*)
Ideally rich, moist, well drained soil. Shelter from frost and wind. More cold resistant than orange. To 10 metres high. Fruit used fresh, for juice or marmalade. Ripens over warmer months. Main varieties are Wheeny and Marsh's seedling. Propagate by budding.

Lemon (*Citrus limon*)
Grown in most areas on most soils provided adequate drainage. Frost hardy. "Meyer" is the best variety in cooler areas. Irrigate and feed well, particularly when young. Takes 3 to 4 years to start bearing. Used as fresh fruit, juice, jam and some manufacturing. "Eureka" produces the largest tree. "Lisbon" is a medium tree. "Meyer" is a small tree. Propagate by budding onto seedling grown citrus rootstock. Popular rootstocks include Citrange, Rough lemon and Sour orange.

Medlar (*Mespilus germanica)*
Tree to 4 metres, grows on most soils if well drained, watering and feeding not vital, deciduous, wind sensitive. Harvest fruit after it begins to fall; it must detach easily from the tree (the fruit is just beginning to decay when truly ripe). Dip the stalks in salt solution when you harvest them. Stratify seed for 12 months then sow: or graft onto quince rootstock.

Nectarine (*Prunus persica)*
Same as for peach.

Olive (*Olea europaea*)
Prefers hot and dry climate (low rainfall) grows elsewhere but needs heat to crop well. Frost and drought resistant. Valuable for oil, fresh fruit or pickled. Propagate by cuttings or suckers.

Orange (*Citrus sinensis*)
Similar to lemon, however prefers a slightly warmer climate. With some protection they will grow and produce cool temperate climates but not areas prone to severe frosts or snow. To 10 metres tall in ideal situations. Fruit is used fresh, juices, candied, as jam and some manufacturing. Propagated by budding onto same rootstocks as lemon.

Pear (*Pyrus communis*)
One of the hardiest and longest living fruit trees, most soils, spray for leaf slug and fruit diseases, fruits on laterals and spurs, prune annually in winter. Propagate by budding and grafting onto quince or pear rootstocks.

Peach (*Prunus persica*)
Temperate and sub tropical plant. Requires cold winters to set fruit buds, very susceptible to waterlogging - drainage is extremely important! Avoid frost when in leaf, ideally fertile, manured sandy loam. Annual pruning and regular spraying important. Fruit borne on 1-year-old laterals. Prune to stimulate formation of new laterals, but leave sufficient laterals for fruit in the following season. Prune in winter. Used for canning, fresh and juice. Main canning variety is 'Elberta'. Propagate by budding onto Elberta peach seedlings or Myurobalan plum stock.

Plum (European) (*Prunus domestica*)
Tolerates cold better than the Japanese plum, withstands wet soils better than many other prunus, prune every winter to regulate fruiting. Popularity decreasing. Propagate by budding and grafting.

Plum (Japanese) (*Prunus salicina*)
Tolerate warmer conditions than European though still a temperate crop, thinning fruit needed occasionally. Prune annually in winter. Fruit is more peach-shaped than the European plum. Unsuited to canning. Increasing popularity. Propagate by budding and grafting.

Pomegranate (*Punica granatum*)
Most soils provided drained, frost sensitive at bud swell, few pest problems, apply 5 kg of general fertiliser per plant per year when mature. Prune to shape remove suckers and encourage spurs. Used for fresh fruit and juice. Holds in cool storage. Fruit bruises easily. Propagate by hardwood cuttings.

Soft Fruit
Strawberries
The commercial strawberry is a hybrid (i.e. a cross between two different species). Some of the popular varieties are summarised as follows: Aromel, Elsanta, Elvira, Cambridge Vigour, Tamella. Strawberries are used fresh, marketed frozen or processed in jam and ice cream. Demand in recent years has been good.

Culture: Best in deep, well drained, acid soil. Heavy feeder (prepare soil with 6.25kg/14lb manure/square metre/square yard). Early crops if on a north slope, late crops on a south slope in the southern hemisphere and the opposite in the northern hemisphere. Grow on beds 1.2m (4ft) wide and 12cmhigh (6 in), 2 rows of plants on the land 30cm (12 inches) apart with approx 35cm (15 inches) between plants in the row. Usually soil is covered with black plastic mulch and plants planted through the plastic. Remove runners to promote cropping. However for the home situation it is wise to remember that black plastic excludes air from the soil and is difficult to irrigate. Airless soils can become sour over time. Straw mulch is an excellent weed suppressing alternative.

Harvest in the cooler part of the day every 2 days. Pick with stem except for jam. A virus disease makes it necessary to treat plantings as a short-term proposition. Plants are usually cropped 2 years and then new plantings are carried out.

Raspberries (*Rubus idaeus*)
Prefer cool protected, moist well drained sites. Plant on raised mounds: wild species grow on cool, moist hillsides. Heavy feeder, so fertilise well. Grow on trellis or stake. Propagate by suckers, root cuttings or tip layers. Fruit is on canes in 2nd year. After canes produce a crop they are removed by cutting to ground level. Retain about 4-8 of the healthiest new canes to produce fruit the next year (NB: This pruning is done annually as soon as fruiting is over). Grow under plastic mulch to control winds. Be careful not to damage roots by cultivation, but keep weed free by shallow hoeing or using herbicides.

Harvest in summer twice weekly. Pick fruits without stalk and store in cool as soon as picked. Fruit sold fresh, frozen or used for jam. One person can handle up to 1 hectare if helped when picking. Approx 12 plants are adequate for a family.

Chinese Gooseberry (*Actinidia chinensis*) Also called kiwi fruit and Yang Tao.
Native to sub tropical China, but adapts to cooler climates, provided protected from frost and wind. Grows well in most well drained soils: prefers neutral pH 7.0, but tolerant of a range of pH. Plant in winter and train on trellis or pergola: 7.5m/25ft between rows and 3m/10ft between plants in rows.

Fertilise at a rate of 675g/1-1 ½ lb of blood and bone plus potash when planted increasing to 4.5-5kg/10-15lb per year on established plants. Plants grown from seed vary in cropping and for this reason grafted plants are used. Mainly used as a dessert fruit but can also be canned or used as a jam. At 9 years old plants produce 15-25 kg. each. Pick when fruit is still slightly firm (late autumn to early winter in cool temperate climates). Pest and disease problems are few and rare. Both male and female (on separate plants) are required to produce fruit -1 male plant to several female plants.

Cape Gooseberry (*Physalis peruviana*)
Needs protection from frost and cold winds. Prefers light well drained soils but grows in most soils. Neutral soil: full sun: heavy feeder: propagate from seed, sown late winter under glass and planted out after the frosts. Related to tomatoes and can be treated similarly. Main commercial use is jam; also eaten fresh and stewed. Ripening takes a long time and is indicated by drying of the husk.

Gooseberry (*Ribes uva-crispa*)
Not related to Cape gooseberry, but the same genus as currants. Relatively cheap and easy cooler climate crop. Ideally cool, well drained situation in full sun or semi shade. Do not plant in a frost pocket and protect from wind: 1.5 metres between plants; soil should not be allowed to become potash deficient: prefers slightly acid soil pH 6.7: don't damage roots by close cultivation; remove old wood from established plants to encourage new growth. Propagate from hardwood cuttings 30cm/12 inches long in late September. Harvest spring to summer depending on variety.

For canning, pick before fruit starts to colour, for eating fresh wait until ripening in progress. Relatively easy to handle because they are firmer than other berries. Prune annually in late June/early July to open the bush against pests/diseases: prune in autumn/winter for fruit structure. Fruit occurs on 2-year-old laterals.

Mulberry (*Morus nigra*)
Native of Asia (probably Persia) but grown in Britain for centuries. Hardy and long lived (well over 100 years) but slow to come into bearing. Best in cool temperate climates: tolerates various soils but prefers in rich, fertile well-drained moisture retentive soil: pH 5.5-7.0. Crops are reliable once they start. Grows to 10 metre x 10 metre spread. Propagate by cuttings from one year old stems.

Blueberry (Vaccinium corymbosum or *V. pennsylvanicum*)
Needs moist cool site (not waterlogged), acid soil (pH 4.5 ideal), rich in humus, tolerates shade but best in sun. Propagate from seed stratified through winter. One of the latest berries to ripen in summer. Cross pollination is necessary for good crops of large fruits. Two different cultivars should be planted together. Fruit is fully ripe when dark blue or blue black colour.

Elderberry (Sambucus nigra)
Well suited to cool areas, semi shade ideal but full sun OK in warmer parts. Tolerant of most soils, grow from cuttings. Not grown commercially except in Europe: only black-fruited elders are grown for fruit. Berries can be used for wine or conserves. Not eaten fresh.

Red Currants (Ribes rubrum)/ White Currants (Ribes sativum) and Black Currants (Ribes nigrum)
Currants are well suited to cold climates. Suited to most soils, provided they are not waterlogged. Frost can be a problem particularly with red currants; ideally provide a cool site out of wind. Grow as bushes; black currants crop well on young (one-year-old) wood, red currants fruit on spurs at base of one-year-old and older stems. Propagate by hardwood (winter) cuttings placed straight in open ground. Do not usually crop until second season: will fruit for 3 to 4 seasons. Most popular varieties of black currant are: ‘Boskoop Giant’ ‘Ben Lomond’ ‘Baldwin’ (most widely grown variety in Europe), ‘Magnus’: red currants ‘Red Lake’ ‘Redstart’ and also white currant ‘Whitebud’, ‘White Versailles’, ‘White Grape’. Have a high chilling requirement i.e. need a lot of cold while dormant over winter.

American Cranberry (*Vaccinium macrocarpum*)
Best in cool areas, avoid extreme frosts on flowers or fruit, however it will withstand extreme cold over winter. Not grown as a regular fruit crop in Britain. A low-growing evergreen vine, produces berries from mid autumn to mid winter. Grow in low sites and bogs, can even tolerate periods of flooding: prefers peaty, acid soils with pH 3.2-4.5. Can grow in trenches 37cm/15 ins. below ground level: mix lots of compost in bottom of trench and place 5-7cm/2-3 inch layer of sand on top of this. Plant into sand at the bottom of the trench and keep moist.

Bramble Fruits (*Rubus species*)
These include loganberry, youngberry, boysenberry, lawtonberry, mammonthberry, phenomenalberry, dewberry, and blackberry hybrids. All have a long trailing habit and are grown on a trellis. Because of their tart flavour, most are used for processing.

Loganberry
Most popular bramble and one of the easiest to grow and handle: parentage Raspberry x Blackberry. Long fruits with sharp taste, for culinary uses, not for eating fresh. In recent times boysenberries and youngberries have replaced some loganberry plantings though.
Wide range of soils; will often grow where other berries won't. Avoid exposure to north winds. Ensure good drainage and good weed control. Plant plants 1.5-2m/5-6ft. apart and rows 2.5m/8ft. apart. Trellis should have two wires at 0.75m/2 ½ ft. and 1.5m/4 ½ ft. above the ground.
Propagate by tip or cane layers or leaf cuttings. Harvest crop in late spring and prune mid summer. Crops in 3rd season and will produce for 10 years or more.

Boysenberry/Youngberry
Just as profitable as loganberries and requiring similar cultivation to the loganberry.
- Youngberry matures mid summer; a hybrid of Dewberry and Phenomenalberry. Excellent for bottling.
- Boysenberry looks identical to loganberry of darker colour, but matures later in summer. Drought-tolerant.

Lawtonberry
Canes which have fruited are removed the following winter: leave 8 or more canes. Similar requirements as for loganberries. Smaller fruit than loganberry but heavier crop. Main commercial value is as preserves but some value exists for fresh fruit sales.

Mammonthberry
A cross between blackberry and dewberry. Fruit is like a large blackberry. Treat like a loganberry.

Dewberry
Native to America. This is a species berry, not a hybrid and considered by some to be one parent of the loganberry. Not grown commercially.

ESTABLISHING AN ORCHARD - WHAT TO CONSIDER
Each plant variety has a preferred set of growing conditions. In order to maximise opportunities in establishing a fruit crop (or any crop) several options should be considered:

a) If you have an existing site you can select plant varieties that suit the growing conditions at that site.

b) If you have selected a crop you wish to grow then you can then select a site that provides the growing conditions suited to that crop.

c) You can modify a site to produce the required growing conditions. This can be very expensive in some cases, and not worth the time, effort and resources required, but in many cases is a viable option. Modifications could include mounding soil to provide better drainage, planting windbreaks, building dams or sinking bores to provide extra water for dry times, providing predator (e.g. rabbit) proof fencing, and digging drainage channels.

d) You can also in many cases modify the crop to suit different growing conditions. This might involve a plant breeding program, or genetic engineering (e.g. producing tomatoes containing genes for cold resistance hence extending the range of areas where tomatoes can be grown, and extending the length of the growing season into cooler periods.

CONSIDERATIONS IN CHOOSING A SITE

The Site

The location, size and internal characteristics of a fruit-growing site must be appropriate for the type of fruit you are growing.

Size

The amount of land required for successful operation can vary from as little as 0.1 hectare (0.25 acre) up to 100 hectares or more. A typical berry farmer might operate on as little as one or two hectares and as much as ten hectares, while some types of berry and pome fruits (e.g. peaches, cherries, apples, pears) generally require much more land to be economically viable. The size of land you might require can depend on the following:

- Cost of land, which you might need to compromise your ideals in line with what you can afford.
- Availability of land, which you might be unable to get the exact size you want (i.e. if you need 1.5 hectares, land might only be selling in 1 hectare or 5 hectare lots in your preferred locality).

Biological

Pest and Diseases

Some sites, particularly those that have been used previously for agriculture, may have large populations of particular pests and diseases present that could be damaging to your plants. Control of these can often be very costly and time consuming. Often a quick inspection on existing vegetation on-site or on crops on adjacent properties will give you an idea of what types of pest and diseases are around.

Existing Vegetation

Existing vegetation can be both advantageous and disadvantageous. Clearing large areas of vegetation so you can establish an orchard can be quite expensive. Large areas of vegetation can pose a fire risk, or they may provide shelter for pests and diseases. Tall trees may create shaded areas, affecting your orchard. Weed infestations may be widespread. Alternatively existing vegetation may act as a windbreak, provide privacy, prevent soil erosion, provide habitat and maintain biodiversity for natural populations of organisms, or provide valuable timber or firewood.

Water

Virtually all orchards will require an additional source of water to supplement natural rainfall. The amount of water required will depend on the amount, reliability, frequency and distribution of rainfall coupled with how many and what type of plants you are growing. Additional water for irrigation is generally obtained from the following sources:

- On-site storage such as dams or tanks where runoff is collected and stored for later use.
- Bore water from underground streams.
- Irrigation channels where water is distributed from storages often large distances away.
- From streams or rivers.
- From mains or town water systems (usually carried by pipes and/or aqueducts or channels).

The site you choose will need to have access to one or more of these water sources, and you will have to have the right or license to draw suitable amounts of water from them.

The quality of the water is also very important. Chemicals in the water may result in toxic symptoms or slow death of plants. Salinity levels should be low otherwise plants could be damaged or the structure of soils or potting media affected. Sediment levels should also be low otherwise blockages of pipes or sprinklers, etc. could occur, and leaf surfaces could be coated with deposited sediment affecting both the plant's ability to photosynthesise and its appearance.

WINDBREAKS

Windbreaks are an important means of increasing crop productivity and can have many long-term benefits for the local environment. As well as protecting crops from cold or hot winds, living windbreaks can reduce erosion and drainage problems and provide a haven for wildlife. Depending on the species used, they might also provide emergency stock fodder, timber, mulch, and perennial crops such as fruit and nuts.

Designing a Windbreak

The wind velocity reduction effect is felt up to 30 times the height of the windbreak, but is most effective between two and 20 times the height of the windbreak, on the downwind side. For example, the most protected area behind a 2m tall windbreak would be from 4m to 40m downwind from the windbreak.

A windbreak consisting of dense-foliaged plants, or a solid timber or brick wall, will deflect wind directly backwards, as well as up and over, creating strong turbulence both in front and behind the windbreak. In comparison, a more permeable windbreak, such as more open-foliaged plants, slatted fences or windbreaks made from shade cloth, filters the wind, allowing the air to flow smoothly through the windbreak with little turbulence.

Plants should not be placed too close together or they will self prune (drop branches) and become too open to be effective. This is particularly important for some conifers, which will self prune their lower branches if planted too closely together, creating a gap below the branches.

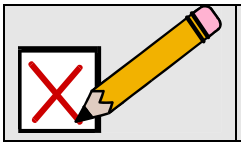
A triple row of plants of different heights is most effective at channelling the wind up and over the windbreak; for example, low-growing plants at the front of the windbreak, slight taller-growing plants behind them, and taller plants at the back.

CROP HARVESTING

Proper harvesting and after care of your crop is essential if you are to reap the benefits of all the hard work you did in preparation.

Harvesting Hints

- For flowering crops (e.g. beans and peas), don't tear off foliage when picking.
- For root crops it is best to lift the vegetable out of the ground with the use of a fork to minimize cutting or tearing of the vegetable.
- For leafy crops (e.g. lettuce, cabbages), a sharp knife is best to cut the plant from its stem.
- For rhubarb or silver beet, it is difficult to cut the leaves without cutting the remaining plant, leaving a piece of leaf attached (which can rot). Pick these by pulling gently from the plant.
- It is important to pick continuous cropping vegetables regularly.
- This ensures that crops continue to develop steadily throughout the season (e.g. marrows, melons, pumpkins, beans, peas, cucumbers, Brussels sprouts).
- Always pick the largest fruits first. These will be the most mature and will begin to deteriorate if left on the plant.
- Pick all vegetables before they become over-ripe and start to deteriorate on the plant.
- If you plan to store them, choose only unblemished fruit which are in peak condition. Tears in the skin of the vegetable may act as an entry point for bacteria and fungi.
- Taste, rather than size, will also influence harvesting time. For example, carrots and turnips are at their most tender when they are 10 to 15 cm long. Peas, beans, soybeans, lima beans, corn and asparagus are all particularly rapid maturing and should be picked whilst they are still tender. Within one or two days of reaching peak maturity, these vegetables will become tough and stringy if left on the plant.
- Similarly, leafy vegetables, squash, rhubarb and most of the root crops should be picked before they become too mature. Exceptions are celery and swedes - the taste of these crops improves the longer they are left to grow.



SELF ASSESSMENT
Perform the self assessment test titled ‘Self Assessment Test 5.3.’
If you answer incorrectly, review the notes and try the test again.

SET TASK
1. Arrange to visit several productive vegetable growing plots or gardens. Discuss the methods used in relation to establishing shelter, soil cultivation, bed systems, crop rotation, methods used to extend the growing season and the available space and how crops develop according to spacing. Take notes.

2. Define in your own words the following terms:
a. Intercropping
b. Crop rotation

Submit your definitions with your assignment.

3. Develop a crop rotation system for a vegetable garden - submit with your assignment.

4. Visit a ‘top fruit’ growing orchard and discuss:
   a. How they choose suitable cultivars and root stocks
   b. Why fertilisation is important in fruit production
   c. The certification schemes available for fruit plants
   d. How pests and diseases are controlled
   e. How they produce their crops, and harvest and store them.

Remember to take notes.

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