NATIONAL PARKS
LET'S MAKE SINGAPORE OUR CITY IN NATURE

Community in Bloom

HORTICULTURAL BEST PRACTICES FOR EDIBLE GARDENING

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This guide is intended to assist community gardeners on good horticultural practices that will enable them to grow healthy, edible plants in a sustainable way. It covers horticultural techniques including plant propagation, integrated pest management, companion planting, as well as good practices for harvesting your edibles and ensuring that your harvest is safe for consumption.

1 OVERVIEW

Community gardeners harvesting their tomatoes at Jurong Spring Zone A RC community garden.

As Singapore transforms into a City in Nature, NParks is launching several initiatives to bring nature closer to all Singaporeans. One such initiative is 'Gardening with Edibles', which has enabled more members of the community to grow their own edibles and experience the benefits to health and well-being that come from gardening. To support this growing interest in edible gardening, by 2030, NParks aims to increase the number of community gardens island-wide to 3,000 and the number of allotment plots in parks to 3,000 under its flagship gardening programme, Community in Bloom.

Growing edibles is becoming more popular among community gardeners and members of the public. It is a favourite pastime of our seniors and an upcoming trend for the younger generation. Learning about growing edibles can be fun and rewarding for both the gardeners and their friends and family.

Whether you are a beginner or a seasoned gardener with years of experience, this guide aims to be a useful resource on promoting good horticultural practices that are sustainable. These can be applied in your garden to ensure that the fruits of your labour are safe for consumption.

To make it easy for the public to grow edibles, NParks has also created a vast range of online resources on gardening. Visit our website for resources such as brochures and videos.

2 SOIL

UNDERSTANDING YOUR SOIL

Soil is a key component of the garden that supplies essential nutrients, water, oxygen and root support for all edible plants to grow and flourish. It is important that the plants are given a good start by providing them with healthy and biologically active soil that is free of contaminants. Soil from unknown sources may contain toxic chemicals, heavy metals or harmful microorganisms which may cause edibles to become unsafe for consumption.

Soil and Plant Health

Growing healthy and nutrient-rich plants begins by using healthy soil. Healthy soil for edibles is rich in organic matter and biologically active, supporting a diverse community of soil organisms which include beneficial bacteria, fungi, algae, protozoa and nematodes amongst many other microorganisms. These organisms are all part of the soil ecosystem and play an important role in promoting plant health and ensuring an adequate supply of nutrients for the plants.

Plants and soil organisms depend on interactions with each other to grow, reproduce and survive. Soil microorganisms like bacteria and fungi consume by-products released from plant roots as well as organic matter such as plant residue. In turn, they support plant health by decomposing organic matter and converting it into nutrients for plants. Other vital functions of soil microorganisms include improving the soil structure which promotes root growth, as well as suppressing soil pathogens.

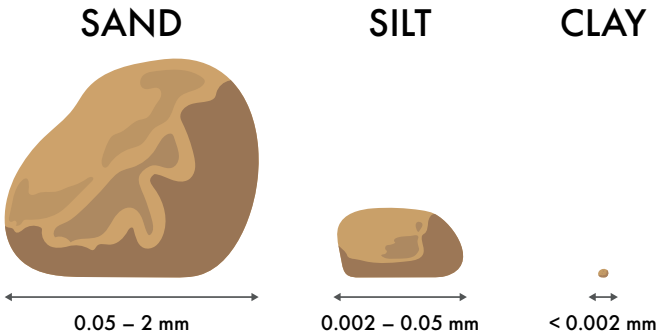
Soil Composition

Soil is made up of mineral particles, organic matter, water and air. The three main types of mineral particles are sand, silt and clay.

Sand
Sand particles are the largest particles at around 0.05 – 2 mm in diameter. The large particles allow water and important nutrients to move through easily. Hence sandy soil dries out fast and needs to be watered more frequently.

Silt
Silt particles are between clay and sand in terms of size. They are finer than sand and tightly packed together, which inhibits drainage and air circulation.

Clay
Clay particles are the smallest particles, usually less than 0.002 mm in diameter. Clayey soil retains water and nutrients well due to its tiny, dense particles. However, clayey soil also drains slowly and can become hard and compacted when dry.



2. SOIL

Soil Texture

The proportion of sand, silt and clay particles will determine the soil texture and type. The proportion will also determine the physical properties such as bulk density, drainage rate and capacity to hold nutrients. Below are some soil types which can be found in community gardens in Singapore.

Loamy soils are a good mixture of clay, sand and silt. They are the ideal soil type for most plants as they contain high organic content, also known as humus. This fertile soil will support just about any type of plant.

Clayey soils are dense and heavy soils which do not drain well or provide space for plant roots to flourish. On hot days, they become hard and dry, and become sticky when wet. They have greater capacity to hold nutrients.

Sandy soils are low in nutrients and water holding capacity. They have a gritty feel or rough texture, and lose water very quickly.

Organic Matter

Organic matter is material produced by living organisms and broken down through decomposition by microorganisms. One such example is humus. It is the dark brown organic material in soil made up of decomposed organic matter, such as dead leaves and other plant material.

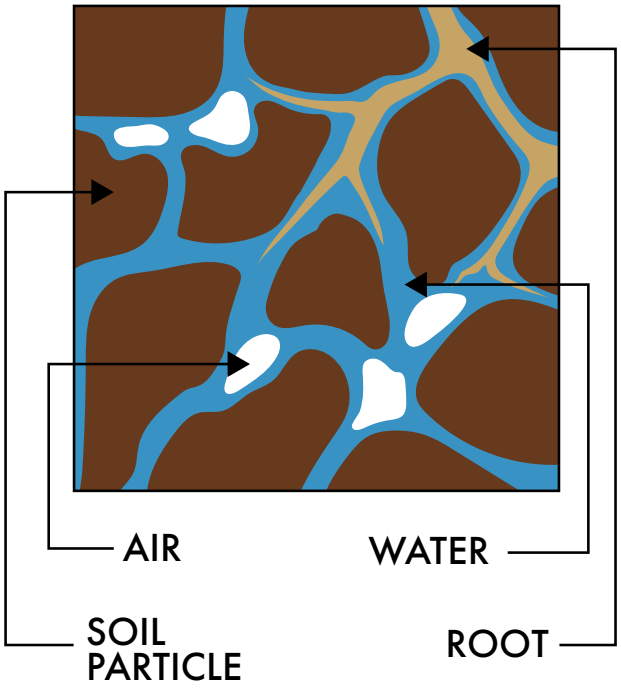
Horticultural Grit

Grit refers to inorganic materials like coarse sand, pumice and LECA (Lightweight Expanded Clay Aggregate) that can be added to soil to improve drainage. The recommended particle size is 1 – 4 mm in diameter.

Aeration, Water Holding Capacity and Drainage

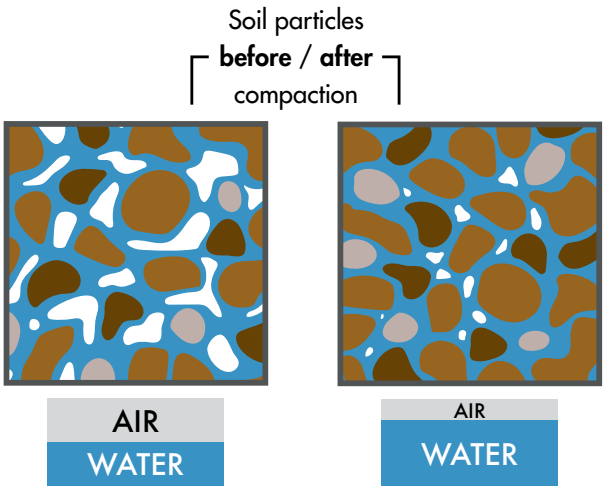
Air and water are vital for root and plant growth. They are found in the pores of the soil. Air in the soil also contains atmospheric nitrogen which some plants can convert to a form that they can use. Soil oxygen is also crucial to the survival of soil organisms that benefit plants.

Adding organic matter such as compost will help to improve the air supply and soil texture through the formation of aggregates. Additionally, organic matter helps to hold more water in the soil.



2. SOIL

Bulk Density



Bulk density is an indicator of soil compaction. Soil compaction occurs when soil particles are compressed together, reducing the pore space between them. Heavily compressed soils have a higher bulk density.

Compacted soil has a lower rate of both water infiltration and drainage. This happens because large pores help water to move more effectively through the soil than smaller pores. The exchange of gases is slower in compacted soils, causing aeration-related problems. Compacted soils are also more difficult for roots to penetrate.

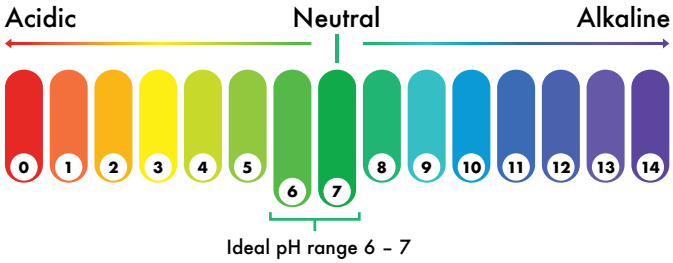
To minimise compaction, you should loosen the soil and add organic matter such as compost to improve the soil texture.

Soil pH

Soil pH is defined as the relative acidity or alkalinity of the soil. Soil can be acidic (low pH) or alkaline (high pH) depending on which minerals are present.

Soil fertility is directly influenced by pH. The ideal pH range is 6 – 7 because this is the level where nutrients are stable and readily available for plant uptake. Most leafy and fruiting edibles grow well in this range.

If the pH is too high or too low, it can slow down the growth of plants by starving them of nutrients, mainly micro-nutrients. Regular application of fertilisers does not mean that the nutrients will be available to your plants if there is an issue with the soil pH. Very high or low pH can also damage plant roots, and is not conducive for beneficial microbial growth.



2. SOIL

Understanding Existing Soil Properties

Understanding the existing soil properties in the garden is a critical step to help you choose the right soil amendments before planting. You can conduct simple tests to help you identify the type of soil and pH level.

The Mason Jar Soil Test

This test is a quick and easy way to determine the soil texture.

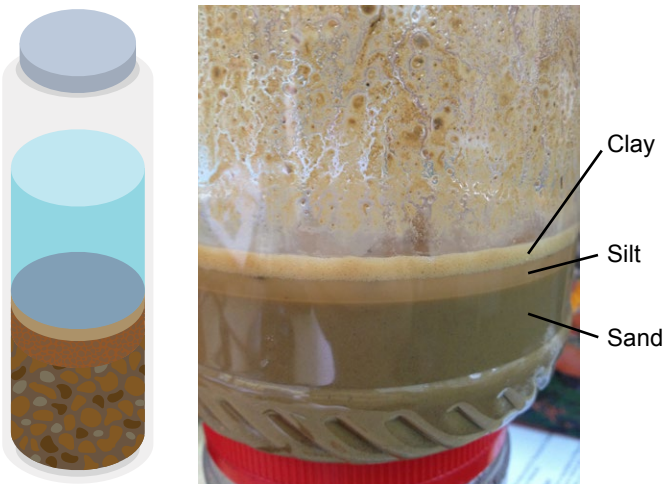
Approximate time to complete: Up to 1 day

Materials: Jar (with lid), soil sample from the garden, water, liquid dish soap, ruler, sieve or colander (optional)

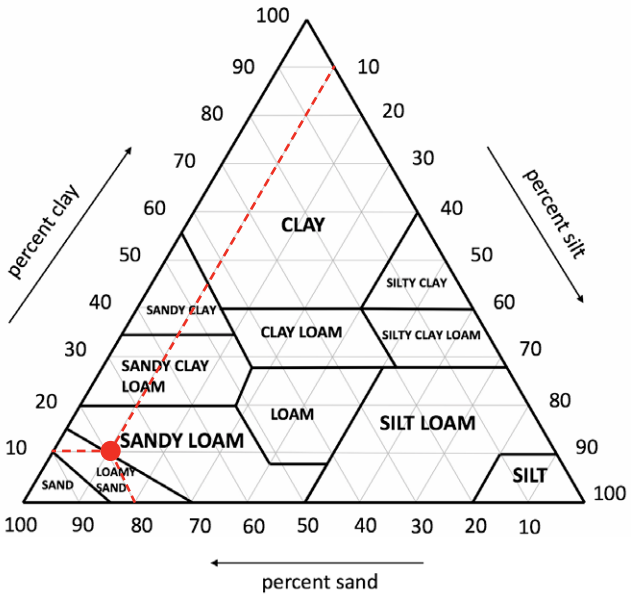
Steps:

1. Collect enough soil to fill one-third of the jar.
2. Remove any pebbles, debris, rocks and large organic matter (such as leaves, sticks or roots) from the soil. If possible, sift the soil using a sieve or old colander.
3. Crush any lumps of soil.
4. Place the soil in the jar and fill the remaining two-thirds with tap water.
5. Add about 1 teaspoon of liquid dish soap.
6. Secure the lid and shake the jar for 3 to 5 minutes.
7. Set the jar in a place where it can sit undisturbed for 24 hours.
8. After 24 hours, the contents would have settled into distinct layers. The heaviest material is sand which will sink to the bottom. This will be followed by silt and lastly clay at the very top.
9. Using a ruler, measure the height of each layer and the total height of all 3 layers to calculate the percentage of clay, silt and sand.
10. Use the soil texture triangle to estimate the soil type. Track the lines with the percentages measured to obtain the spot on the triangle where all 3 lines intersect. The region at the intersection indicates the soil type present.

Example:



Layer	Height Measured	Percentage
Clay	0.5 cm	10%
Silt	0.5 cm	10%
Sand	4 cm	80%
Total Height	**5 cm**	



Result: Sandy Loam (red dot on the triangle)

2. SOIL

Soil Ribbon Test

This is a quick and simple test to determine the soil type.

Steps:

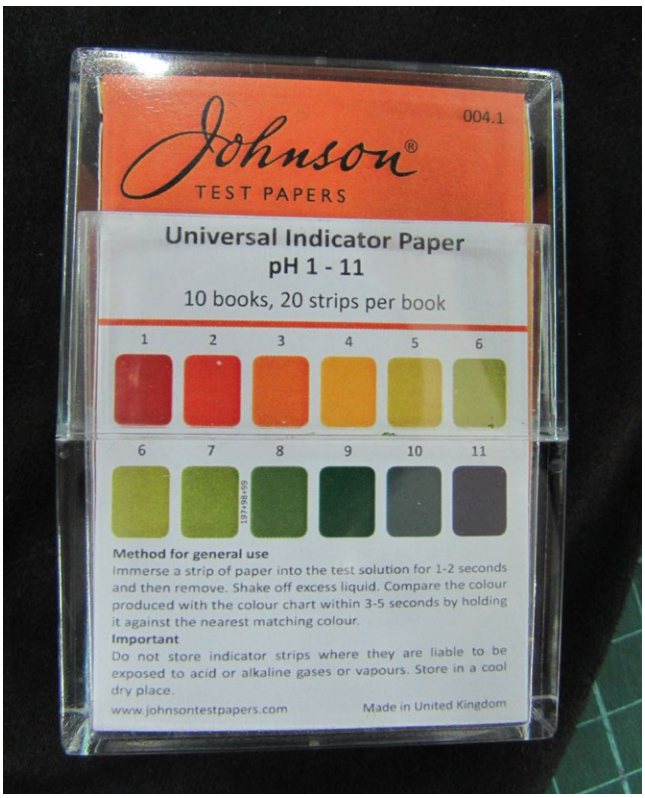
1. Moisten a handful of soil and roll it into a ball in your hand.
2. Place the ball of soil between your thumb and forefinger. Gently squeeze and push the soil forward with your thumb to form a ribbon.
3. Keep the ribbon thickness and width uniform while lengthening the ribbon. Push until the ribbon breaks under its own weight.
4. Measure the ribbon length and compare it to the results below to find out your soil type.

Ribbon length:

- Less than 2.5 cm = loam
- 2.5 cm to 5 cm = clay loam
- More than 5 cm = clay

Soil samples with high sand content are unable to form a ribbon. A long ribbon usually indicates a higher clay content.

Measuring Soil pH



Soil pH can be tested using a soil pH meter, a pH probe or a pH test kit. These are often available at local nurseries or online retailers. Testing your soil pH will help you to understand the soil condition and amend it if necessary.

If your soil is too acidic (low pH), apply lime (calcium carbonate, calcium oxide and dolomite). If the soil is too alkaline (high pH), apply granular sulphur or organic matter such as compost. Correction of soil pH requires some time for the chemicals to be broken down to improve the soil pH. It is not a quick-fix solution that will yield results in a few days.

2. SOIL

SOIL PREPARATION FOR GROWING EDIBLES

It is essential to prepare your soil before planting. Well-maintained soil is part of a healthy foundation for an abundant and productive garden, where plants are also better prepared to withstand pests.

Soil Mix for Growing Edibles

In general, soil for growing edibles should be loamy and well-draining. It should also be regularly enriched with organic material such as compost to add nutrients, support beneficial microorganisms, and improve the soil texture and water retention.

Soil mix suitable for growing edibles is commercially available in plant nurseries. You may choose to buy from plant nurseries or make your own soil mix to experiment with different materials.

Growing mix for outdoor edibles:

- 1 part loamy soil
- 1 part organic material*
- Organic fertiliser as directed by manufacturer

Growing mix for indoor edibles:

- 1 part loamy soil
- 1 part grit*
- Organic fertiliser as directed by manufacturer

**Experiment with the ratio of organic material or grit to achieve the most suitable soil mix for your plants.*

Clayey soils are unsuitable for growing most edible plants as they tend to get easily waterlogged and are too dense for good root formation. You can improve clayey soil by adding organic matter to improve its texture, aeration and drainage. Organic matter also helps to boost plant growth.

Grit can also be added to improve drainage. After adding the components, break up the soil and mix well.

If you have clayey soil that needs improvement, here is a suitable ratio for growing edible plants:

- 1 part clayey soil
- 1 part organic material
- 1 part grit
- Organic fertiliser as directed by manufacturer

Watch the video guide on mixing soil for growing edibles at ***go.gov.sg/soil-2***

Organic fertilisers are derived from either animal excretions, such as processed chicken manure, or vegetable matter like compost, as well as properly decomposed crop residues. Avoid applying raw manure or fresh plant matter onto your plants as these may attract pests before they are adequately decomposed to release the nutrients. The smell may also be a public nuisance. It may harbour microorganisms that are harmful to human health as well. More information on fertilisers can be found in Chapter 4: Caring For Edible Plants.

2. SOIL

PLANTER BEDS

If the current soil conditions are not suitable for growing edible plants, you can consider using planter beds. A simple planter bed can be created by adding ideal soil mix to the planting location to create a raised mound, and keeping it in place by using edging material like bricks. Other options for planter beds include planter containers.

Types of Planter Beds

Raised planter beds can be filled with the ideal soil mix to enable edible gardening in an area that would otherwise not support it.

There are a variety of planter beds and containers available on the market. Gardeners can purchase these off the shelf or build their own planter beds using materials such as drainage cells and bricks.

Raised earth mounds

Planter beds made with bricks

Concrete block planter beds

DIY planter beds using drainage cell material

Tray containers

Plastic planter containers

2. SOIL

About Raised Planter Beds

Raised planter beds are becoming popular as they are inclusive and can cater to seniors, as well as those who may be physically challenged.

They can be made of concrete, bricks or other sturdy building materials. To ensure easy access within the planter bed, it should be at least 25 cm in height and less than 120 cm in width. Provision of weep holes at the base of the planter beds can help to drain excess water.

For more information on building raised planter beds, refer to "A Guide to Designing and Implementing Allotment Gardens".
go.gov.sg/AGguide

Benefits of Raised Planter Beds

1. Increased Accessibility

Raised planter beds make it easier to garden in a smaller space. Raised beds can also be designed to be at a proper height that improves access for wheelchair users or for gardening to be carried out comfortably without bending over or kneeling down.

2. Control Over Soil Quality

One of the greatest benefits of raised planter beds is the opportunity to control the soil quality of the planting area. You can create the optimal growing medium from scratch by filling the planter bed with the ideal soil mix for edible plants.

3. Better Drainage

Raised planter beds enable gardeners to care for plants from the side instead of stepping over the soil. This prevents soil compaction and damage to the plants. The higher elevation of the planter beds relative to the ground level also allows for improved drainage.

4. Creation of Usable Space

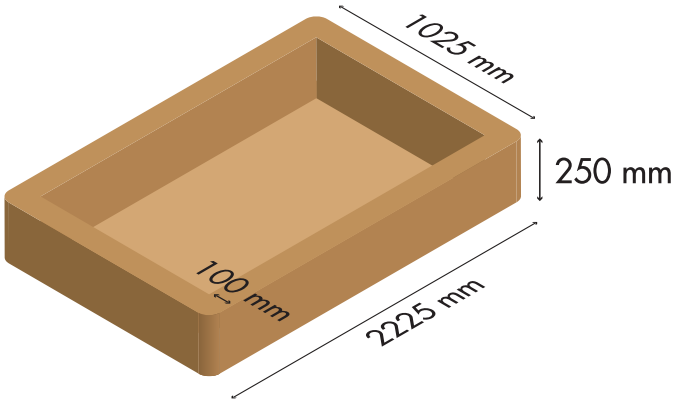
Raised planter beds can be placed over a concrete surface or compacted urban soil which is not ideal for growing edible plants.

2. SOIL

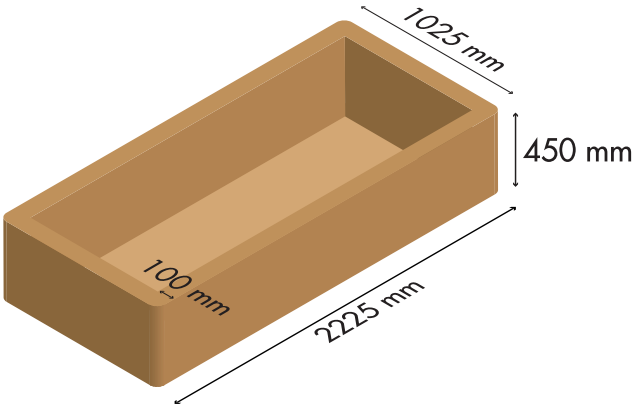
CONCRETE PLANTER BEDS

Constructed planter beds can be customised to meet the height requirements of the users.

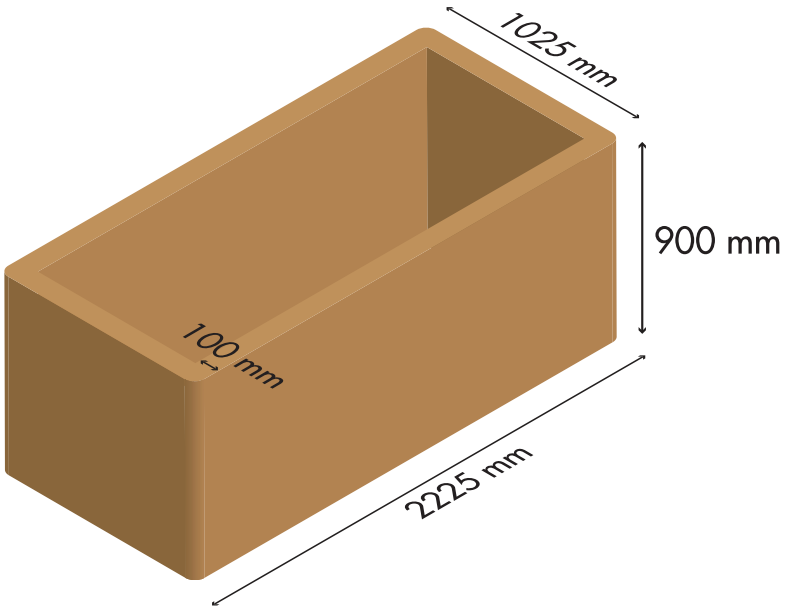
Ankle-height raised beds (0.25 m tall)



Knee-height raised beds (0.45 m tall)



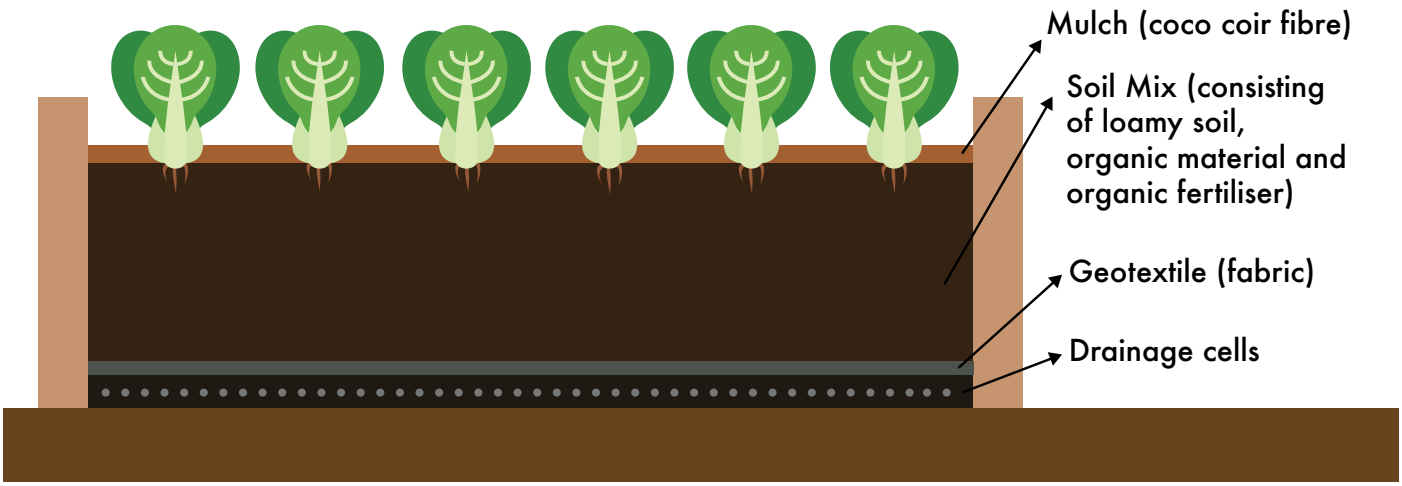
Waist-height raised beds (0.9 m tall)



2. SOIL

How to Fill A Raised Planter Bed

Here is a guide on filling raised planter beds.



Steps:

1. Place a layer of drainage cells at the bottom of the raised bed and cover with a layer of landscape fabric (geotextile). This will help to prevent excessive amounts of water from ponding within the raised bed.

2. Add soil mix for growing edibles. You may purchase existing commercial soil mix or make your own as given below:

    - 1 part loamy soil or top soil
    - 1 part organic material (e.g., matured compost)
    - Organic fertiliser (as directed by manufacturer)

    Adding compost will help to improve the condition and structure of the soil, enhance moisture retention and encourage the growth of beneficial microbes, fungi and insects which will help to further loosen and enrich the soil.

    Organic fertilisers such as worm castings, kelp meal, bone meal and processed chicken manure can also be added to help boost the growth of edible plants. Mix them into the soil as directed by the manufacturer.

3. After planting your raised bed with edible plants, place a final layer of mulch across the top, which will help to keep the soil moist and suppress the growth of weeds. Coco coir fibre makes a great material for mulching. More information on mulching can be found on page 13.

Tips on Growing Edibles Safely

- Use soil from reliable sources. Soil from unknown sources may contain harmful microorganisms or chemicals which can be absorbed by plants. If consumed, they can have negative health effects
- Keep pets out of the garden to prevent the accidental inclusion of raw animal manure
- Remove any diseased plant debris and always prepare the soil prior to every round of planting
- Clear away any leftover plant debris, trim back the perennials and ensure a clean start for the next planting cycle

COMPOSTING AND MULCHING

Adding compost and/or mulch are effective ways to improve the quality of your soil for growing edibles.

Traditional Composting

Compost is organic matter made up of mostly plant material which has been broken down by the action of bacteria and other organisms. It helps to release nutrients back into the soil and improve the soil condition.

Community gardens can invest in a composting bin or designate a composting area. This will help to reduce horticultural waste and provide free compost for the garden.

For traditional composting, you will need both carbon-based 'brown' materials and nitrogen-based 'green' materials. Examples of these materials are given below.

Carbon-based 'browns'	Nitrogen-based 'greens'
• Dry leaves	• Grass clippings
• Shrub cuttings	• Tea leaves
• Used egg cartons	• Coffee grounds
• Woody plant parts	• Egg shells
	• Raw vegetable and fruit scraps

Steps:

1. Choose a location for the compost bin or heap in a sheltered area of the garden
2. Cut the 'browns' and 'greens' into smaller shreds for faster composting. Spread them in layers on top of each other, and add some healthy soil or old compost between the layers. The soil and old compost will introduce beneficial soil bacteria and fungi to kick-start the composting process.
3. Add enough water to ensure that the compost pile is moist. Do not overwater.
4. Turn the bin or mix the materials every week to aerate the heap. This will introduce air and speed up the decomposition process. Heat will be generated during this process.
5. Continue to add the 'browns' and 'greens' to the mix. Add water if necessary, to keep the pile moist.
6. After two to four months, the compost should be black and have an earthy smell.

Watch our video guide on composting at ***go.gov.sg/diycomposting***

2. SOIL

Here are some common issues that community gardeners have with composting, along with some solutions for addressing them.

Common Issues	Possible Reasons	Solutions
Compost turns smelly	• Too much water content and lack of air flow	• Open the lid of the compost bin and allow the compost to dry • Add more 'browns' • Turn the materials more frequently • Place the compost bin under shelter from rain
Materials take a long time to become compost	• Materials are too coarse	• Cut the materials into smaller pieces before adding into the compost bin for faster decomposition
	• Compost pile is too dry	• Add water to keep the compost heap moist • Add more 'greens'

Tips on Growing Edibles Safely

- Avoid using raw animal waste as compost material as it may harbour harmful microorganisms
- Do not add pest-infected plant material as it may contaminate the compost and make it unusable in the garden
- Infected plant material should be disposed of properly in a separate bag away from the garden and not used for compost material

Mulching

Organic mulch is any organic material that is spread over the soil surface. It can be applied on soils used to grow fruiting edibles, including fruit trees. Examples are coco fiber, matured compost and wood chips.

Benefits of mulching:

- Reduces the growth of weeds
- Enriches the soil and improves soil fertility by releasing nutrients as it breaks down
- Reduces evaporation and soil erosion
- Regulates soil temperature and keeps the roots cool

How to apply the mulch:

1. Spread an even layer (2 – 5 cm thick) of mulch on the soil, around the stems of edible plants
2. Make sure that the mulch is not in contact with the collar of the stems, as this can cause rotting

3 GROWING EDIBLE PLANTS

SELECTING SUITABLE PLANTS

Growing your own edible plants can be very rewarding. Whether you are growing them in your own plot or together with others in a community garden, understanding your soil and environmental conditions first will help you to select the most suitable plants. Ensuring that the environmental conditions match the optimal conditions for your edible plants will increase your chances of success.

Considerations When Growing Plants

Amount of light
Edible plants generally need to receive at least 4 – 6 hours of direct sunlight daily, hence the location of the garden or planting beds needs to be sunny.

Soil conditions
Fertile and well-draining soil is important as this will allow edible plants to take up nutrients rapidly and prevent root rot.

Water
It is important to have a clean source of water and understand the water requirements of the plants. Frequency of watering will depend on the prevailing environmental conditions and plants.

Air circulation
Good airflow can help to reduce pests in your garden. Poor airflow creates a damp and humid environment where pests such as garden snails will thrive.

Available space
Proper planning and efficient use of space in your community garden or planter beds will maximise the yield of your garden.

Amount of time
The amount of time required to maintain your garden, including watering, fertilising and weeding, will depend on which plants you are growing and how large the planting area is.

In the next few pages, you will be introduced to common edible plants which are suitable to grow in our local climate.

Legend


Prefers full sun

> 6 hours of sunlight


Requires a lot of water


Prefers semi-shade

4 – 6 hours of sunlight


Requires a moderate amount of water

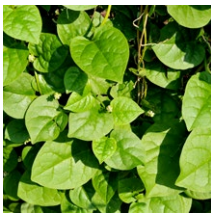
3. GROWING EDIBLE PLANTS

Leafy Edibles

These edibles are generally the leaves of food crops. There are numerous varieties of leafy edibles that can be grown in Singapore and they are widely grown in community gardens and allotment gardens. Here are some commonly cultivated leafy edibles.

Cai Xin
Brassica rapa cv. (Parachinensis Group)
Well-draining Soil

Kale
Brassica oleracea (Acephala Group)
Well-draining Soil



Ceylon Spinach
Basella alba
Well-draining Soil

Kangkong
Ipomoea aquatica
Well-draining Soil

Chinese Mustard
Brassica juncea
Well-draining Soil

Lettuce
Lactuca sativa
Well-draining Soil

Bayam
Amaranthus tricolor
Well-draining Soil

Sweet Potato
Ipomoea batatas
Well-draining Soil

Kailan
Brassica oleracea (Alboglabra Group)
Well-draining Soil

Xiao Bai Cai
Brassica rapa (Chinensis Group)
Well-draining Soil

3. GROWING EDIBLE PLANTS

Fruiting Edibles

These edibles are generally the fruits of food crops. Here are some commonly cultivated fruiting edibles which can be grown in Singapore.

Bitter Gourd
Momordica charantia
Well-draining Soil

Lady's-Finger
Abelmoschus esculentus
Well-draining Soil

Brinjal
Solanum melongena
Well-draining Soil

Long Bean
Vigna unguiculata
Well-draining Soil

Chilli
Capsicum annuum
Well-draining Soil

Pumpkin
Cucurbita moschata
Well-draining Soil

Corn
Zea mays
Well-draining Soil

Tomato
Solanum lycopersicum
Sandy Clay Loam Soil

Cucumber
Cucumis sativus
Well-draining Soil

Winter Melon
Benincasa hispida
Well-draining Soil

3. GROWING EDIBLE PLANTS

Root Edibles

Root edibles are food crops with edible underground storage organs such as swollen tap roots, corms, rhizomes and tubers. As the edible portion is underground, gardeners have to occasionally dig into the soil around the roots to check if the edibles are ready to harvest.

Arrowroot
Maranta arundinacea
Well-draining Soil

Radish
Raphanus sativus
Loose and Well-draining Soil

Bangkuang
Pachyrhizus erosus
Moist and Well-draining Soil

Sweet Potato
Ipomoea batatas
Well-draining Soil

Elephant Foot Yam
Amorphophallus paeoniifolius
Moist and Well-draining Soil

Tapioca
Manihot esculenta
Well-draining Soil

Fingerroot
Boesenbergia rotunda
Moist and Well-draining Soil

Taro
Colocasia esculenta
Loose, Fertile Soil

Peanut
Arachis hypogaea
Well-draining Soil

Water Chestnut
Eleocharis dulcis
Waterlogged Soil

3. GROWING EDIBLE PLANTS

Herbs & Spices

These edible plants are usually aromatic and are commonly used to flavour our local dishes or make drinks. Here are some herbs and spices that are commonly grown in community gardens.

Garlic Chives
Allium tuberosum
Well-draining Soil

Lemongrass
Cymbopogon citratus
Moist and Well-draining Soil

Curry Leaf Tree
Murraya koenigii
Well-draining Soil

Pandan
Pandanus amaryllifolius
Moist Soil

Spearmint
Mentha spicata
Moist Soil

Sawtooth Coriander
Eryngium foetidum
Sandy, Well-draining Soil

Indian Borage
Coleus amboinicus
Sandy Soil

Thai Basil
Ocimum basilicum
Well-draining Soil

Laksa
Persicaria odorata
Well-draining Soil

Turmeric
Curcuma longa
Well-draining Soil

More information on these edibles can be found at ***go.gov.sg/whattogrow***

3. GROWING EDIBLE PLANTS

Harvest Cycles

Different plants mature at different rates. Understanding their harvest cycles will help you to manage your garden. Use the tables below to decide which plants to grow and when to grow them.

Leafy Edibles Harvest Cycles

Common Name	Scientific Name	Germination	Sowing to Harvest
Chinese Spinach	*Amaranthus tricolor*	3 – 5 days	~ 21 days
Kangkong	*Ipomoea aquatica*	~ 3 days	~ 21 days
Kailan	*Brassica oleracea* (Alboglabra Group)	3 – 5 days	21 – 55 days
Cai Xin	*Brassica rapa* (Parachinensis Group)	3 – 5 days	30 – 40 days
Kale	*Brassica oleracea* (Acephala Group)	3 – 5 days	~ 35 days
Chinese Mustard	*Brassica juncea*	3 – 5 days	~ 40 days
Xiao Bai Cai	*Brassica rapa* (Chinensis Group)	~ 3 days	40 – 45 days
Ceylon Spinach	*Basella alba*	~ 7 days	42 – 56 days
Lettuce	*Lactuca sativa*	~ 4 days	~ 56 days

Fruiting Edibles Harvest Cycles

Common Name	Scientific Name	Germination	Sowing to Harvest
Lady's-Finger	*Abelmoschus esculentus*	6 – 7 days	47 – 97 days
Long Bean	*Vigna unguiculata*	3 – 5 days	49 days
Bitter Gourd	*Momordica charantia*	5 – 7 days	59 – 69 days
Corn	*Zea mays*	4 – 6 days	70 – 200 days
Tomato	*Solanum lycopersicum*	~6 days	77 – 105 days
Winter Melon	*Benincasa hispida*	7 – 14 days	80 – 140 days
Chilli	*Capsicum annuum*	6 – 21 days	88 – 125 days
Pumpkin	*Cucurbita moschata*	~7 days	90 – 120 days
Cucumber	*Cucumis sativus*	~3 days	100 – 140 days
Brinjal	*Solanum melongena*	~14 days	105 – 133 days

Root Edibles Harvest Cycles

Common Name	Scientific Name	Propagation Method*	Planting/Sowing to Harvest
Radish	*Raphanus sativus*	Seed	30 – 50 days
Peanut	*Arachis hypogaea*	Seed	110 – 130 days
Sweet Potato	*Ipomoea batatas*	Stem Cutting	120 days
Fingerroot	*Boesenbergia rotunda*	Division by Rhizomes	120 – 155 days
Taro	*Colocasia esculenta*	Division by Corms	120 – 305 days
Bangkuang	*Pachyrhizus erosus*	Seed	150 days
Water Chestnut	*Eleocharis dulcis*	Division by Corms	210 – 275 days
Arrowroot	*Maranta arundinacea*	Division	240 – 365 days
Tapioca	*Manihot esculenta*	Stem Cutting	270 – 365 days
Elephant Foot Yam	*Amorphophallus paeoniifolius*	Division by Corms	365 days

*Corms, rhizomes or tubers from some of the edibles featured above can be bought in local wet markets and supermarkets.

3. GROWING EDIBLE PLANTS

PROPAGATING YOUR PLANTS

There are several methods to propagate edibles for your garden. Here are some examples.

Seed Propagation

Seeds can be obtained from:

- Local nurseries or supermarkets
- Existing mature plants

You can check the seed pack for useful information on growing the plant, including:

- Expiry date
- Sowing depth, maturity time, planting distance and other growing requirements

Tips:

- In general, the seed germination rate will decrease over time. Use the seeds as early as possible.
- Store unused seeds in air-tight containers, in a cool and dry place such as a refrigerator to extend the shelf life.

Sowing Your Seeds

Seeds can be sown directly into planter beds. Alternatively, they can be grown in seed trays first, which allows for greater control over environmental conditions and pests, and enables the gardener to protect them until they are established.

Sowing Directly into Planter Beds

1. Prepare the soil for sowing or use potting mix.
2. Make shallow grooves according to the planting distance and depth recommended on the seed packet.
3. Sprinkle two to three seeds evenly into the grooves.
4. Cover the seeds with a thin layer of soil.
5. Water the soil thoroughly with a fine spray.

After sowing, install netting over the bed to protect the plants from rain and pests.

Sowing into a Seed Tray

1. Fill a seed tray with potting mix. Egg cartons also work well as seed trays.
2. Sow the seeds into the potting mix.
3. Cover the seeds with a thin layer of potting mix.
4. Water the soil thoroughly with a fine spray.
5. When the seedlings are about 5 – 10 cm tall, transplant them into the planter beds.

After sowing, water at least once or twice per day.

Watch the video guide on sowing your seeds at ***go.gov.sg/seedlings***

3. GROWING EDIBLE PLANTS

Transplanting

Transplanting Seedlings

If you start your seeds in a seed tray, you will want to transplant them into the planter bed when they develop their second or third set of leaves. This will ensure that they have more space to grow and soil depth for root development.

Steps:

1. Select healthy seedlings for transplanting. They should be growing upright with two or three pairs of leaves.
2. Make planting holes in the soil bed. Follow the recommended planting depth and distance between plants on the seed pack. Planting close together will cause the seedlings to compete for nutrients and may result in smaller plants.
3. Remove the seedlings from the seed tray. Avoid disturbing their root ball.
4. Transplant them into the planter bed and cover the root ball.
5. Press the seedlings down to stabilise their position and keep them upright.
6. Water the soil gently to avoid injuring the seedlings.

Watch our video guide on sowing and transplanting at ***go.gov.sg/gwe-yt***

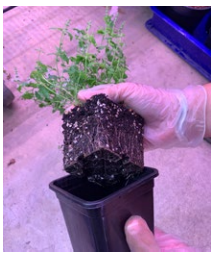
Transplanting Potted Plants

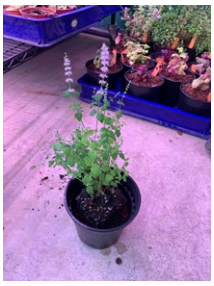
Edibles grown as potted plants should be transplanted once they have outgrown their pot or their growth has slowed down. At this point, they should be transplanted into a planter bed or a larger pot to provide them with more space and soil depth to grow.

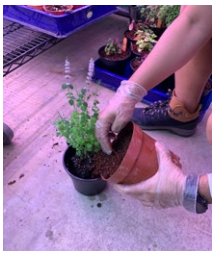
Transplanting into a Larger Pot

Steps:

1. Pick a suitably sized pot. It should be about twice the size of the previous pot.
2. Place a plastic netting (or dry leaves) across the holes at the bottom of the pot to prevent soil erosion. Add a layer of sand or gravel at the bottom to increase the drainage. Top up with potting mix or suitable soil mix to half of the pot's depth.
3. Make a hole in the soil about 1.5 times the width of the root ball of the plant. The depth of the hole should be the same as the root ball.
4. Cut off all dead plant parts and roots before transplanting. Avoid using infected plants.
5. Press the sides of the pot to loosen the root ball and gently remove the plant from the pot. Do not pull the plant out by the stem. If the roots are tightly bound, loosen them gently. Place the plant in the hole.
6. Check if the depth of the hole is correct. The new soil level and the original soil level of the root ball should be at the same level.
7. Include a stake to support the plant if it is likely to topple over.
8. Fill the remaining spaces with compost and soil and gently pat down the stem collar to stabilise the plant.
9. Water the plant and spread a layer of mulch around it.







Transplanting into a Planter Bed

Steps:

1. Remove any weeds and loosen the soil in the planting area. Add organic fertiliser or compost if required to enhance the soil condition.
2. Dig a hole about twice the width of the root ball of the plant. The depth of the hole should be the same as the root ball.
3. Follow steps 4 – 9 from the previous section (Transplanting into a Larger Pot).

3. GROWING EDIBLE PLANTS

Vegetative Propagation

Besides sowing seeds, many edibles can be propagated vegetatively. This involves removing parts of a parent plant to create new plants. Vegetative propagation is advantageous because it takes a shorter time for plants to reach maturity, and the new plants retain the characteristics of the parent plant.

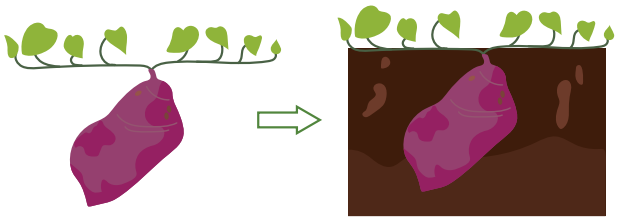
There are many different methods to use, depending on what type of plant you are trying to propagate.

Propagation by Division of Suckers and Offshoots

For clumping plants such as Lemongrass, Pandan, Banana and Pineapple, you can divide the clumps into individual clusters or separate offshoots from the parent plant.

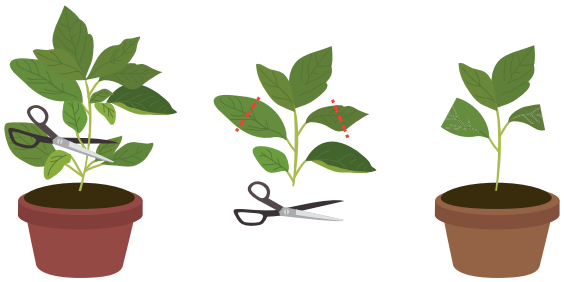
Watch the video guide on division at ***go.gov.sg/herbs-division***

Propagation by Corms, Bulbs and Tubers



Corm-, bulb- or tuber-producing plants such as Spring Onion, Leek and Water Chestnut can be propagated by burying these plant parts into well-draining soil.

Propagation by Stem Cutting



Plants such as Basil, Mint and Indian Borage can be propagated by stem cuttings. Select a branch with three to four nodes (growing points) and cut it with a clean pair of secateurs. Keep the top two or so pairs of leaves and remove the rest. Insert the cut branch into a mixture of sand and peat.

Watch the video guide on making stem cuttings at ***go.gov.sg/propagate-herbs***

Saving Your Seeds

If you have a particular plant in your garden which displays excellent health, appearance, vigour or taste, you may want to harvest the seeds and store them for your next planting. Fruiting edibles such as Brinjal, Lady's-Finger and Winter Melon are examples of plants that are easy to propagate via harvested seeds.

Steps:

1) Collect a mature fruit from the plant.
2) Remove the seeds, clean them and allow them to dry completely.
3) Place the seeds in an air-tight container.
4) Label the container with the name of the seeds, favourable characteristics and the date that they were harvested.
5) Store the seeds in a cool and dry environment, such as a refrigerator.

Tips:

1. Seeds from hybrids will not have the same characteristics as the parent plant.
2. Seeds from open pollinated or heirloom varieties will have more similar characteristics as the parent plant.
3. Plants grown from seed will naturally have slight variations even if they are from the same fruit. To reduce variation, grow plants of the same variety closely together to prevent cross-pollination between different varieties.

4 CARING FOR EDIBLE PLANTS

WATERING

Different plants have different water requirements. It is important to know your plants' watering needs as both overwatering and underwatering can be detrimental to edibles.

A community gardener watering edible plants at a community garden.

Overwatered plants show signs of wilting because of root rot. Their leaves will also drop off.

Underwatered plants show signs of wilting because there is not enough internal water pressure to keep the stems and/or leaves firm. They may also appear stunted and weak, and their lower leaves will turn yellow and drop off.

Tips:

- Scrape off the top layer of the soil (~ 1 cm) in one small area. Observe the soil colour and use your finger to feel the moisture of the soil. Soil is usually darker when moist
- Alternatively, use a probe to detect the soil moisture
- Water plants thoroughly
- Water plants regularly, according to their water requirements and environmental conditions
- Avoid strong jets of water as they will damage plants and wash away the soil
- Check for any waterlogging
- Minimise water usage by mulching, which will reduce evaporation from the soil. Auto-irrigation systems can also help reduce water usage because they can be controlled

Tips on Growing Edibles Safely

- Use clean water to water your plants as using contaminated water can come with health risks.

FERTILISING

Nutrients in the soil are depleted over time when growing plants. Fertlisers can be added to replenish the nutrients and increase soil fertility, hence producing healthy plants.

Nutrients required by plants fall into two groups, essential nutrients and micronutrients.

- **Essential nutrients (macronutrients):**
  - **Nitrogen (N):** Leafy edibles need fertilisers high in nitrogen to grow lush green foliage.
  - **Phosphorus (P):** Fruiting edibles require phosphorus to promote flowering and early seed formation. Phosphorus also helps to increase the strength of stems and promotes root growth.
  - **Potassium (K):** Fruiting edibles need fertilisers high in potassium to promote fruiting and help fruits grow faster and bigger. Potassium also increases their resistance to disease.
  - Besides the essential nutrients mentioned above, other macronutrients like calcium, magnesium and sulphur are important for plant growth and reproduction.
- **Micronutrients**
  - Edible plants also require micronutrients such as boron, chloride, iron, copper, zinc, manganese and molybdenum for healthy growth.

Types of Fertilisers

Organic fertilisers are derived from decaying plant and animal matter. They add carbon to the soil and promote the growth of populations of beneficial microorganisms.

Examples:
- Fish emulsion
- Seaweed
- Animal manure

Characteristics
- Usually slow-release unless in liquid formulation
- Less likely to cause fertiliser burn (which can manifest as yellow or brown discolouration of leaves)
- Usually lower nutrient ratio

Inorganic fertilisers are derived from minerals in the soil or made via chemical processes.

Examples:
- NPK mix compound (15:15:15)
- Ammonium sulphate
- Ammonium nitrate
- Ammonium phosphate
- Potassium nitrate
- Super-phosphate

Characteristics
- Usually fast-release, especially in liquid form
- Can cause fertiliser burn if used excessively due to salt build-up
- Leaches out of the soil

4. CARING FOR EDIBLE PLANTS

When and How to Apply Fertiliser

- In general, leafy edibles require fertilisers higher in nitrogen content. It is usually added once every 10 – 14 days. For fruiting edibles, herbs and spices, fertilise once a month. However, please note that the application frequency can vary depending on the type of fertiliser and plant.
- Water the plant after fertilising to wash away excess fertiliser and help the plant absorb it better.
- Fertiliser should also be applied before the plant starts flowering or after hard pruning.
- Follow the manufacturer's instructions on the frequency and amount of fertiliser to use. This depends on the formulation of the fertiliser.
- The main principle is to apply small but frequent amounts of fertiliser. Use less or more diluted fertiliser to avoid fertiliser burn if you are unsure of the amount to apply. The alternative is to use slow-release fertiliser.

Tips on Growing Edibles Safely

- Avoid using raw animal waste as fertiliser as it may harbour harmful microorganisms or pathogens.
- Follow the manufacturer's label instructions on the amount and frequency of the product application for different plant types.
- Fertilisers may leach into the ground and contaminate water sources if used excessively. Apply only in small quantities and as needed.
- Ensure that the fertilisers do not come into contact with leaves or stems as they will 'burn' the plant.
- Use the right type and amount of fertilisers for optimal plant growth.
- Fertiliser contaminated with harmful microorganisms may pose food safety issues to consumers.
- Use well-composted fertiliser from a reliable source.
- Fertilisers should be stored in a proper storage area.

4. CARING FOR EDIBLE PLANTS

PRUNING

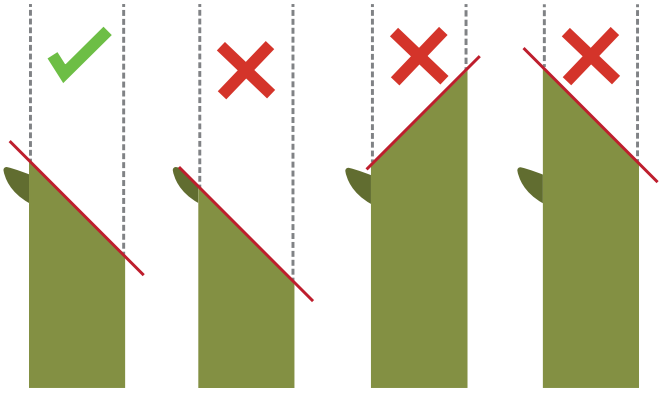
Pruning is an important part of plant care, for both herbaceous and woody edible plants.

Benefits of pruning:

- Improves plant health
- Removes diseased or weak plant parts
- Thins out densely growing plants, improving air circulation, allowing light penetration and preventing the growth of algae and fungi
- Controls the shape and growth form of plants
- Controls the growth of fast-growing plants
- Encourages stems to branch
- Promotes the production of flowers, buds and fruits

Tips:

- Keep pruning equipment sharp and clean. Disinfect after use on diseased plants
- When pruning, try not to remove more than one-third of the plant's leaves and branches
- Prune during the wet season or after rain to reduce stress on the plant
- Use a pair of sharp secateurs/pruners to make clean, straight cuts. Jagged cuts and torn branches make the plant more prone to disease



Correct pruning | Cut too near the node | Cut sloping toward the node | Cut too high

Steps:

1. Start by cutting off dead, diseased and weak parts
2. Prune from the bottom of the plants upwards
3. Prune from inside out, starting near the trunk or main stem. Selectively remove stems to thin the plant out
4. Cut the stem at an angle of approximately 45 degrees, near a node, with the angle of the cut sloping away from the node.
5. After pruning, apply fertiliser to promote the recovery of wounds and growth of new shoots

WEEDING

Weeding is another important part of plant maintenance.

Weeds will compete with your plants for nutrients, water, space and light. They can also harbour pests and make your garden unsightly.

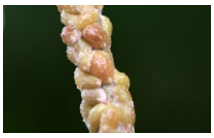
Tips:

- Avoid using herbicides to remove weeds.
- Wear gloves when removing weeds manually
- Remove weeds as soon as they appear
- Mulch around your plants to inhibit germination and growth of weeds in your garden

5 PESTS OF EDIBLE PLANTS

SIGNS OF PLANT PESTS

According to the *International Standards for Phytosanitary Measures (2007)*, a plant pest is "any species, strain or biotype of plant, animal or pathogenic agent that causes harm to plants or plant products". This includes weeds (undesirable plants), vertebrates (such as rodents), insects, mites, nematodes, molluscs (like snails and slugs) and disease-causing agents such as bacteria, fungi, viruses and phytoplasmas.

Sign	Description	Pests Involved
	Curled leaves, distorted shoots and leaves, silver coating on leaves	Sucking pests like aphids, spider mites, whiteflies, mealy bugs, scraping insects like thrips
	Web-like threads, white spots on leaves, yellowing of leaves, drying of leaf edges, stunting of plants	Sucking pests like spider mites, whiteflies, leaf hoppers
	Fluffy white cottony or pill-like insects along stems and leaf veins	Mealy bugs
	Brown or white, round or oval scales covering stems or veins of leaves	Scale insects
	Chew marks on leaves, partially-eaten seedlings	Chewing insects like caterpillars, beetles, grasshoppers; also snails, slugs
	Holes in stems, branches or trunks, with insect frass, sawdust coming out, holes in fruits, dieback of affected branches and stems	Stem borers, fruit borers
	Irregular tunnels or patches that are pale or brown between the upper and lower surfaces of leaves	Leaf miners
	Galls on leaves	Gall wasps, gall midges, gall mites, cecid flies, psyllids

5. PESTS OF EDIBLE PLANTS

COMMON PLANT PESTS

There are many different types of plant pests. They can be categorised according to their mode of infestation or how they affect a plant. Here are some of the common plant pests that you may encounter in the garden.

Sucking Insects

Sucking insects have piercing mouthparts and feed on plant sap. Most are very small and not visible to the naked eye. Feeding damage by sucking insects causes deformities in plant tissue and reduction in plant vigour. Some sucking insects (such as aphids, whiteflies and leaf hoppers) can spread harmful plant viruses.

General treatment: Wipe leaves with wet cloth if the population is small. For severe infestation, prune off infested plant parts or the whole plant.

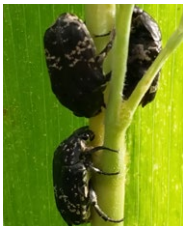
Pest	Characteristics	Treatment
Aphids 	• Vary in colour (including green, yellow, black or blue) • Associated with ants which eat the sweet fluids they secrete • Can spread plant viruses • Commonly infect edibles such as beans, Brinjal, Chilli, Lady's-Finger and Tomato	• Use of onion, garlic and chilli spray (see page 42)
Spider Mites 	• Microscopic, smaller than aphids • Cause leaf curling and bronzing • Found among new shoots, buds and the underside of the curled leaves • Webs usually spotted underneath the leaves • Commonly infect edibles such as Bayam, Brinjal, Kangkong, Chilli, Cucumber, Lady's-Finger, melons, Radish, Sweet Potato and Tomato	• Prune off infested parts • Wipe off with wet cloth
Whiteflies 	• Tiny flies which fly up from the leaves when disturbed • Nymphs and eggs found on underside of leaves • Can spread plant viruses • Commonly infect edibles such as Bayam, Brinjal, Chilli, Lady's-Finger, Long Bean and Tomato	• Use of citrus spray (see to page 42)
Mealy Bugs 	• Have a cottony covering which protects them from insecticides • Associated with sooty mould (which grows on leaves) and ants • Can be present in soil, attacking roots	• Prune off infested parts • Scrape off the insects from infected parts
Scale Insects 	• Scales or shell-like bumps on stems or leaves • Associated with sooty mould (which grows on leaves) and ants • Commonly infect a wide range of leafy edibles, fruiting edibles and other plants	• Prune off infested parts • Scrape off scale insects from infected parts
Thrips 	• Minute, slender insects that feed on plant sap • Cause leaf curl, brown-coloured flower buds, silver spots on leaves, thickening and distortion of leaves and leaflets, heavy leaf fall	• Apply netting over plants or plant beds • Use of blue sticky traps

5. PESTS OF EDIBLE PLANTS

Chewing Pests

Chewing insects eat voraciously, making holes in leaves or stripping plants of their leaves completely. This leads to a reduction in the quality of vegetable crops.

General treatment: Remove by hand as soon as they are spotted. If possible, install netting over plants or planter beds as a means of prevention.

Pest	Characteristics	Treatment
Caterpillars 	• Larvae of moths and butterflies that feed heavily on leaves either in groups or individually • Can be hidden in rolled leaves or among foliage; some have colours that help them to blend in with the plant • Commonly infect leafy edibles from the genus *Brassica*, such as Bai Cai, Caixin, Kailan	• Use of onion, garlic and chilli spray (see page 42)
Beetles 	• Insects with hard exoskeletons and strong mandibles to feed on plants. • Adults often fly to the plant at night to feed and fly off by morning, so they are rarely seen • Some larvae are borers in tree trunks, branches and twigs • Edibles which are vulnerable include most leafy edibles from the genus *Brassica*	• Use of onion, garlic and chilli spray (see page 42)
Grasshoppers and Locusts 	• Insects with strong hindlegs that allow them to hop or jump from plant to plant • Large swarms can devastate whole crops of plants	• Use of onion, garlic and chilli spray (see page 42)

Borers and Miners

Borers and miners are the larval stage of moths, butterflies, fruit flies, weevils and beetles. The adults lay their eggs in tree trunks, fruits, flower stems and buds, and the larvae feed on this plant material when they hatch, harming plants and crops.

General treatment: Pick off and destroy infected plant parts.

Pest	Characteristics	Treatment
Borers 	• Larvae tunnel through fruits, causing holes to form • Fungi and bacteria enter as a secondary infection and cause the fruits to rot away • Destroy of fruit crops like Mango, Papaya, Chiku and Star Fruit	• Wrap fruits with paper or netting to prevent insects from laying their eggs in the fruit • Install fruit fly traps
Miners 	• Larvae feed through leaf tissue using their strong mandibles • Create lines or patches on leaves • Severely-mined leaves may shrivel and die or defoliate	• Use of yellow sticky tape to trap the adult flies

5. PESTS OF EDIBLE PLANTS

Other Invertebrates

Invertebrates like millipedes, snails and slugs can become garden pests when they become too numerous.

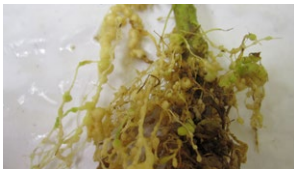
General treatment: Remove by hand.

Pest	Characteristics	Treatment
Millipedes 	• Feed only on dead organic material	• Install physical barriers such as smooth garden edging • Use pitfall traps with a light source
Snails and Slugs  	• Nocturnal pests that feed on plants by chewing • Leave silvery slime trails • Common snails that infest edibles are the African Land Snail (*Achatina fulica*) and Awl Snails (*Allopea* spp.)	• Remove by hand • Use of yeast traps to attract and drown them • Use of solarisation (see page 37) • Avoid using salt as it can result in high soil salinity, which affects the uptake of nutrients by plants

Parasitic Nematodes of Plants

Plant parasitic nematodes are thread-like roundworms that feed on plant parts.

General treatment: Rotate crops or employ companion planting. Be sure to use new soil when replanting.

Symptom	Characteristics
Root Knot Nematodes 	• Cause severe galling in roots, hindering water and nutrient uptake • Cause wilting in leaves and decay in roots, eventually killing the plant • Infect plants such as Brinjal, Cucumber, Lady's-Finger, Long Bean, Melon, Pea, Pepper, Squash and Tomato
Root Lesion Nematodes 	• Cause browning and lesioning of roots • Cause root system to become shallow and weak • Infect plants such as Long Bean and Mustard
Burrowing Nematodes 	• Cause slow decline of plant, toppling disease • Tips of roots turn black • Infect many varieties of leafy edibles

5. PESTS OF EDIBLE PLANTS

PLANT PATHOGENS

Most diseases of edible plants are caused by fungi and viruses. Some are caused by bacteria. These pathogens exist in nature waiting for suitable environmental conditions to attack and weaken plants. Some insects can also spread these pathogens by feeding on diseased plants. Healthy plants can resist these attacks but if their growing environment has been compromised due to high moisture, mechanical injury, or presence of other plant pests, they are more likely to be affected.

Bacteria

Bacteria are single-celled microscopic organisms which are not visible to the naked eye. They spread by water, splashing rain and insects, and move across the plant surface and tissue via existing wounds.

General treatment: Remove infected plants and dispose of them properly. Do not propagate from infected plants. Avoid overhead watering.

Symptom	Characteristics
Water-soaked lesions 	• Wet, dark and translucent appearance on leaves
Bacterial Wilt 	• Caused by a soil bacterium that spreads through root wounds • Leaves start wilting, followed by the rest of the plant • Affected stems and roots may show bacterial ooze when ends are put in water
Canker 	• Brown spots on leaves and fruits, often with an oily or water-soaked appearance

Viruses

Viruses are submicroscopic infectious particles which cannot be seen with the naked eye. They are capable of infecting the host cells and affect plant growth and development. They usually spread by insects or infected cutting tools.

General treatment: Remove infected plants and dispose of them properly. Do not propagate from infected plants.

Symptom	Characteristics
Mosaic on leaves 	• Mottling and distortion of leaves, flowers and fruits • Severe stunting of plant; curling and crinkling of leaves • Can be easily transmitted to plants by contaminated gardening tools, pots and adjacent infected plants • CMV (Cucumber Mosaic Virus) is a common virus that can infect more than 1,200 species of plants, including Chilli, Pumpkin, Spinach, Squash and Tomato • CMV can be transmitted through insect vectors such as aphids and leaf hoppers

5. PESTS OF EDIBLE PLANTS

Fungi

Fungi are multicellular, microscopic organisms that reproduce by spores and spread via wind, water, soil, insects, animals and people. They constitute the largest number of plant pathogens responsible for a range of serious plant diseases.

General treatment: Remove infected plants and disinfect cutting tools. Use a sterile potting mix to reduce occurrence. Proper care of your plants is the best preventive measure of fungal diseases.

Symptom	Characteristics
Damping off 	• Caused by a soil-borne fungal disease • Usually refers to the rotting of stem and root tissues at and below the soil surface • Causes seeds and new seedlings to rot and die
Plant rot 	• Stems, trunk or roots rot and become soft • Leaves fall off and the plant dies • Brown to black rot of stem near soil surface • May show small mustard seed-like bodies called sclerotia (caused by *Sclerotinia rolfsii*, a fungal pathogen) or web blight caused by *Rhizoctonia* fungus
Black or white powder on leaves 	• Black, white or grey powdery growths on leaves or fruits caused by fungi that cover the plant leaves or fruits with a layer of spores under humid conditions • Severe infestation can reduce photosynthesis and cause the plant to decline • Black growth from sooty mould is secondary to infestation by insects that secrete honeydew, such as aphids and mealy bugs
Yellowing 	• Caused by bacteria or fungi • Yellowing may start as yellow spots or leaves turning yellow on one side of the plant; this may be followed by leaves and stems wilting and roots turning from dark brown to black • Caused by soil borne fungi that can persist for years in soil without plant hosts • Note that yellowing of leaves is a very general plant symptom; besides fungal infection it may be caused by insects, environmental factors or nutrient deficiencies
Leaf spots 	• Most commonly caused by *Septoria* fungi but can also be caused by other pathogens such as species of *Alternaria*, *Pseudomonas* and *Xanthomonas* • Appear as pale brown spots with dark borders on the leaves • Affects edibles such as Cucumber, Pumpkin, Melon and Tomato
Anthracnose 	• Caused by fungi in the genus *Colletotrichum* • Causes dark lesions or sunken spots of various colours on leaves, stems, fruits and flowers, and may cause cankers to form on leaves • Symptoms vary depending on plant host

6 INTEGRATED PEST MANAGEMENT (IPM)

THE IPM APPROACH

Although pests are harmful to plants, they are still a part of nature and play important roles in the ecosystem. Embracing this idea, Integrated Pest Management (IPM) does not aim to completely eradicate plant pests but rather to keep their population levels low. This is done with an environmentally sensitive approach to pest management that relies on a combination of common-sense practices.

The IPM Approach

1. Identify pests and understand their life cycles
Correct identification of plant pests is key for IPM. Identification is followed by establishing an action threshold – a point at which the pest population or environmental conditions indicate that pest control action must be taken. Spotting a single pest does not always mean control is needed.

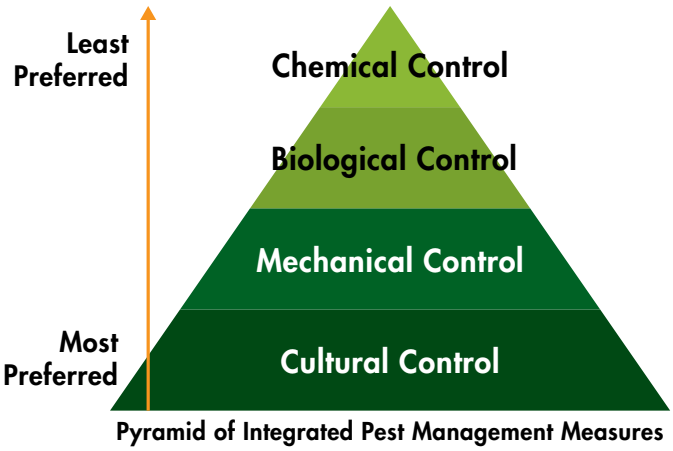
2. Monitor for pests
Check your plots or garden regularly for plant pests. Keep a magnifying glass or hand lens handy for easier identification. You can monitor plant pests with regular checks or use traps to monitor pest levels so that appropriate actions can be made once they reach the action threshold.

3. Tolerance
Strive for ecological balance in your garden and don't expect your plants to look picture-perfect. Remember that some pests are more damaging than others, and you can still have a good harvest even if pests are present. Establish your tolerance level for pests and pest damage.

4. Prevention
The first line of pest control is to prevent pests from becoming a threat. This may mean using cultural methods such as rotating between different crops and starting with healthy seeds or rootstock.

5. Control
Once preventive methods are no longer effective or available, the situation may require some control measures. Select the most effective and environmentally-friendly method with a combination of cultural control, mechanical control and biological control measures. Chemical control should always be the last resort when growing edibles, as improper use of commercial pesticides may cause damage to our health and environment.

See below for a diagram of preferred pest controls when growing edibles.



Pyramid of Integrated Pest Management Measures

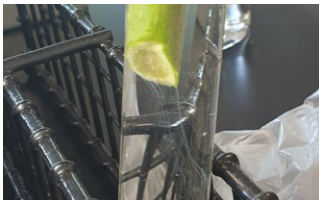
6. INTEGRATED PEST MANAGEMENT

BEST PRACTICES FOR IPM

Best practices for IPM include monitoring and trapping pests to identify them and understand how they are affecting your plants, prevention through the use of good horticultural practices, and when necessary, appropriate pest control measures in the garden.

Monitoring and Trapping

Learn how to identify beneficial insects and plant pests. Look out for their telltale signs, and also learn to diagnose the symptoms that they cause in plants.

Technique	Description
Visual Observation 	Look for physical signs and symptoms of pest infestation such as the presence of actual pests, leaf curling and yellowing.
Bush or Branch Shaking 	Hold a piece of white paper below the plant branches. Moderately tap the branches and look for any pests that drop onto the paper. This method is good for detecting small pests.
Net Sweeping 	Sweep insect net above canopy of plants and look for any pests collected.
Bacteria Ooze Test 	Cut off infected branches or stems and dip them into a cup of water. Look for any murky liquid oozing out, which may indicate bacterial infection.

6. INTEGRATED PEST MANAGEMENT

Trapping Methods

Types of Trap	Description
Sticky Traps 	Sticky traps are coloured papers coated with an adhesive to capture insects. Yellow sticky traps are good for capturing a broad array of pests while blue traps are good for capturing thrips.
Light Traps 	Insects are generally attracted to light. Light traps are good for capturing nocturnal insect pests.
Lure Traps 	Lure traps use chemicals such as pheromones and food odour to attract and trap insects. An example is a fruit-baited trap.

Weekly Monitoring Checklist

Checkbox	Description
☐	Monitor pest populations on a regular basis to detect and identify pests and potential problems as early as possible
☐	Inspect plants regularly for early symptoms
☐	Identify problems early and analyse if they are the result of pests, environmental conditions or nutrient deficiency
☐	Use traps as a means to catch and monitor pests in the garden, and to determine when their populations reach thresholds which require action for control

6. INTEGRATED PEST MANAGEMENT

Cultural Control

Cultural control starts with the decisions you make when choosing and caring for your plants. Prevention is always the first line of defence. Healthy plants resist pests better than weak, unhealthy ones. Here are some recommendations for cultural control measures.

Choose Plants Suited to Your Garden

- Plants will have more problems and fail to thrive in inappropriate conditions. Sun-loving plants may be more prone to pests and other problems when planted in shady areas and vice versa

Select Pest-resistant Plant Varieties

- Some varieties are more resistant to pests than others

Practice Good Sanitation

- Remove infected plant parts and use fresh soil for new batches of plants to prevent further spread of pests
- Conduct frequent removal of weeds as they can harbour many pests which can spread to your garden plants
- Clean your gardening tools and pots frequently to stop pests from spreading to uninfected plants

Rotate Planting of Different Crops

- Grow different kinds of plants on a rotational basis, which will help to break the pest life cycle and reduce pest populations

Ensure Optimal Growing Conditions

- Water the base of plants preferably in the morning to allow excess water to evaporate in the afternoon, which can reduce the potential of some pest and disease outbreaks
- Provide sufficient space for your plants to reach their mature size, which will help to minimise the spread of infection between plants
- Improve soil structure to allow water to drain easily, which reduces disease and plant stress
- Check your soil pH to ensure it is suitable for your plants

Practice Push-Pull Pest Management or Companion Planting

- Grow 'push' plants to repel pests from the garden, and 'pull' plants to attract and draw them away from susceptible edibles
- Growing different plant species within the same planter bed helps to reduce the visual and chemical cues many pests rely on to infest a particular plant. Companion planting with certain plants such as Lemongrass can help to repel insects while Marigolds can help to repel whiteflies and kill soil nematodes

To find out more about the types of companion plants, you can visit ***go.gov.sg/whattogrow***

6. INTEGRATED PEST MANAGEMENT

Mechanical Control

Mechanical or physical control involves the use of traps, screens, barriers, fences and nets to prevent pest activity or to remove pests from an area. Here are some methods that are appropriate for both small and large gardens.

Method of Control	Description
Pruning and Proper Disposal of Plant Parts 	• Remove infected plant parts promptly, place them in bags and dispose of them away from the garden
Netting 	• Place netting over planter beds or plants to act as barriers to prevent pests from entering the planter beds
Mass Trapping 	• Set up multiple light traps to trap nocturnal insects • Set up multiple sticky traps to trap flying insects; yellow sticky traps are useful for leaf miners and whiteflies, while blue sticky traps are useful for thrips
Lure Trap 	• Set up lure or pheromone traps to capture male insects
Solarisation 	• Cover the ground with a black porous netting for a week until the soil cracks • Solarisation of soil helps to eradicate chewing pests such as snails and slugs

6. INTEGRATED PEST MANAGEMENT

Biological Control

All pests have natural enemies to control their populations in nature. Biological control is the use of natural enemies to to keep pests in check. It involves the introduction of Biological Control Agents (BCAs) that can typically can be found in the natural environment. There are generally two types of BCAs, insect predators and pathogens.

Benefits of biological control:

- Causes little or no damage to plants
- Does not leave residues
- Can reduce or eliminate the need for pesticides if used appropriately

Notes:

- Biological controls are not instant fixes as they need time to multiply before they can control the pest populations
- It is necessary to introduce them before plants become heavily infested
- Should not be introduced before the pest becomes active or reaches the action threshold, as they can only breed when their prey or host is present

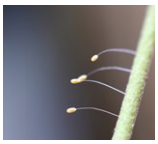
Insect Predators

Characteristics:

- Insects that feed on other insects
- Capture and consume pests such as aphids, scales and spider mites
- Generally larger in size and stronger than their prey
- Can consume more than one type of prey
- They attack different life stages of pests, especially the larvae that feed on plants
- They do not harm or damage plants
- Safe for users

6. INTEGRATED PEST MANAGEMENT

These are beneficial insects which are usually present in your garden due to existing pests. The use of chemical pesticides will deter these insect predators.

Insect Predators	Characteristics
Ladybirds 	• Can consume up to 60 aphids per day • Usually lay their eggs near prey
Praying Mantises 	• Aggressive predators that eat any and all types of insects and spiders • Camouflaged predators that sit motionless waiting for prey to come within reach
Lacewings  	• Small and pale green with delicately veined wings • Larvae, also known as aphid lions, look like miniature alligators that use their hooked jaws to drain fluids out of prey like caterpillars, beetles and aphids • Larvae can eat hundreds of prey in their 7 to 10 day life cycle
Dragonflies 	• Feed on mosquitoes, gnats, flies, swarming ants and swarming termites
Hover Flies 	• Adults are pollinators, and feed on nectar and pollen • Larvae are dull green worm-like predators, and feed on a variety of garden pests like aphids, thrips, scales, caterpillars and mealy bugs

6. INTEGRATED PEST MANAGEMENT

Pathogens: Bacteria and Fungi

These are biological pathogens that occur in nature. They attack insect pests and may be referred to as microbial pesticides.

Characteristics:

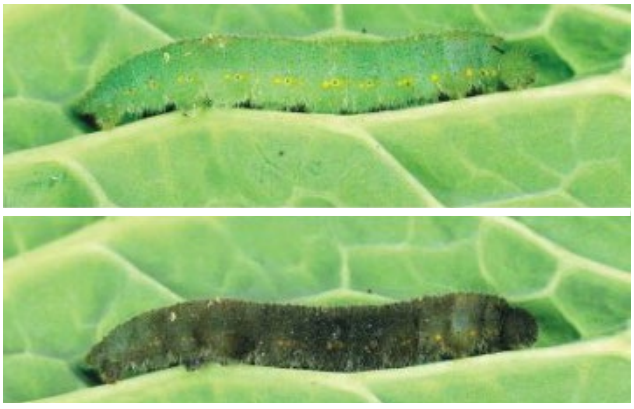
- Can be bacteria or fungi
- Also known as microbial pesticides
- Kill or debilitate their host and are relatively host-specific
- Naturally occur in the soil
- Only attack their host and cause no harm to other beneficial insects
- Provide natural long-term immunity to crops and soil
- Safe for users

***Bacillus thuringiensis* (Bt)**

Description: *Bacillus thuringiensis*, also known as Bt, is a soil borne bacterium that fights mosquitoes and insects in their larval stage. It is an effective biological pesticide for very specific pests and is available in various commercial forms. These include Bti – *Bacillus thuringiensis israelensis* for control of mosquitoes, and Btk – *Bacillus thuringiensis kurstaki* used to control lepidopteran insect pests.

Insect Pests Attacked: Caterpillars, mosquito larvae, and the larvae and adults of certain beetles.

Mode of action: Once eaten by insects, formulated Bt is broken down into particles that damage their gut and cause them to die within a day or so.



(Top image) A healthy Cabbage White butterfly, and (bottom image) the same caterpillar a few days later following infection by Bt

***Trichoderma* fungi**

Description: *Trichoderma* fungi are powerful natural enemies of other plant pathogenic fungi and are able to parasitise and inhibit their growth and development. These beneficial fungi can colonise soil and artificial growing media, establishing around plant roots to compete with pathogenic fungi for space and nutrients. Products containing *Trichoderma* are commercially available.

Pathogenic Fungi Attacked: Soil-borne pathogens such as *Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia solani* and *Sclerotium rolfsii*.

Mode of action: *Trichoderma* fungi form an association with plant roots where they compete with other soil microorganisms for nutrients and space. They also protect against invading plant diseases. They target fungi and absorb their nutrients for their own growth and development.

Microbial pesticide *Trichoderma harzianum*

6. INTEGRATED PEST MANAGEMENT

Chemical Control (Natural Pesticides)

Pests are a recurring problem when growing edibles, and as such, gardeners may turn to chemical control measures to protect their crops. Any chemical substance that is meant to kill or repel plant pests is a pesticide, and can be made synthetically or from a more natural source, such as directly from other plants.

When used in excess, pesticides can have harmful effects on garden biodiversity and the environment, particularly if they are made from strong synthetic chemicals. Pesticides also take time to wash away or wear off, and can be harmful if eaten by people if they are applied to crops too close to harvest. Some natural pesticides are commercially available and registered locally as pesticides. Therefore, the differentiation from a synthetic chemical pesticide may not be that clear. Thus, discretion is advised when deciding to use chemical control.

Benefits of Natural Pesticides:

- Derived from natural sources to repel and eliminate harmful pests
- Only target a certain species or a few different species
- Can be made at home

Notes:

- Some are effective for only a short time after application
- Always handle with care and apply according to instructions on the label
- Commercially available sources may not always be chemical-free
- Not effective for severe infestations
- Should only be used when the pest has been correctly identified
- Should only be used when no other cultural or mechanical control measures are available or effective
- Should only be used when enough buffer time (at least a week or more) is available between the time of application and harvest
- Should not be used when the target pests are near or in an ecologically sensitive area (such as a waterbody or biodiversity garden)

Tips:

- Wear protective clothing such as gloves and long sleeves while applying
- Apply the natural pesticide thoroughly, both on top and underneath the leaves
- Spray during the cooler part of the day and avoid applying during hot sunny weather, to reduce the risk of plants burning
- Spray during the later part of the day when pollinators are less active
- When trying a new natural pesticide on a plant, always test it on a couple of leaves (observe for a few days) to check for phytotoxicity or any damage to the foliage
- After testing, bump the use up to five days, but watch the plant carefully to make sure it can handle it without being damaged
- Do not apply natural pesticides before rain, as the rain will wash off the applied pesticides and expose the plants to pests again
- Natural pesticides are not instant fixes to pest problems and may damage plants if not properly used
- If you are buying products off the shelf, take time to read the label and avoid buying products with little or no information about the ingredients
- Always wash your edibles thoroughly after harvesting and before consumption
- If natural remedies have no effect, you may consider starting over in the garden, by destroying infested edibles and grow new plants

6. INTEGRATED PEST MANAGEMENT

Here are some examples of natural homemade remedies that you can make at home using food ingredients. However, note that natural remedies are not always effective, especially for treating severe infestations. Do test them out on a couple of leaves and watch for damage for a few days before applying to other areas.

1. Onion, Garlic and Chilli Spray

For treatment of thrips, aphids, caterpillars and leaf-eating insects; works as a repellent

Ingredients:	Steps:
• 2 bird's eye chillies, chopped • 2 large onions, chopped • 2 bulbs garlic, chopped • 1 L water	1. Combine all ingredients 2. Mix with water and allow to steep for 24 hours 3. Sieve out the residue and pour liquid in spray bottle 4. Spray on the top and underside of the leaves 5. Solution can be stored for two weeks in a dark place

2. Citrus Spray

For treatment of whiteflies

Ingredients:	Steps:
• Orange or lemon peels • 1 L water	1. Boil water 2. Remove from heat and add peels 3. Cover and steep until cool 4. Sieve out the residue and pour liquid into spray bottle 5. Spray directly on the pests

3. Milk Solution Spray

For treatment of powdery mildew

Ingredients:	Steps:
• 1 part milk • 10 parts water	1. Mix the milk with water 2. Pour in spray bottle 3. Spray directly on the affected areas

6. INTEGRATED PEST MANAGEMENT

4. Baking Soda and Water Solution Spray

For treatment of red spider mites and some fungal diseases

Ingredients:	Steps:
• 1 tablespoon baking soda • 1 L water	1. Mix all ingredients together 2. Pour into spray bottle 3. Spray on the affected areas

5. Eco-Enzyme Spray

For treatment of a broad range of insects; works as a repellent

Ingredients:	Steps:
• 300 g vegetables or fruit waste • 100 g brown sugar • 1 L water	1. Add brown sugar into the container 2. Add 1 L of water 3. Stir well until fully dissolved 4. Add vegetable or fruit waste and mix well 5. Seal the container and label with the date 6. During the first month of fermentation, stir the mixture twice a week to release gas created during fermentation 7. Allow fermentation to continue for another two months, stirring the mixture weekly to fortnightly 8. After three months, the mixture will be ready for use. Sieve out the residue and pour liquid into another container 9. Dilute the liquid with water before use. Start with a more diluted solution. Recommended ratio is 1 part liquid per 100 parts water. *Watch the video guide on* ***go.gov.sg/diy-ecoenzyme***

6. Chrysanthemum Spray

For treatment of a broad range of insects; works as a repellent

Ingredients:	Steps:
• 300 g fresh chrysanthemum flowers or; • 100 g dried chrysanthemum flowers • 4 L hot water	1. Add the chrysanthemum flowers to water and boil for 20 mins 2. Soak for 24 hours 3. Sieve out the residue and pour liquid into the spray bottle 4. Spray on the affected areas

7 GOOD PRACTICES FOR MOSQUITO-FREE GARDENS

GROWING AQUATICS AND PLANTS THAT COLLECT WATER

This section features good gardening practices to prevent mosquito breeding while gardening at home or in community gardens. Keeping your fellow gardeners healthy is as important as keeping your plants healthy. Incorporating the practices mentioned here in your gardening routine will go a long way in making you, your neighbours, and your loved ones safer.

Aquatic and Semi-aquatic Plants

Aquatic and semi-aquatic plants such as lotuses can beautify a garden. These need to be grown fully or partially submerged in water. Here are some environmentally-friendly tips to enjoy them while preventing mosquitoes from breeding in your garden.

Tip #1: Introduce small fish to large water-containing pots or tanks, and ponds

Platies and guppies eat mosquito larvae and they help to add a point of interest to the garden.

Bti granules may be in loose pellets or in a 'dunk' form.

Tip #2: Apply mosquito larvicide to the water

Bacillus thuringiensis israelensis (Bti) granules are a natural larvicide. They are environmentally friendly and safe for plants and aquatic animals.

Plants that Collect Water

Some plants such as bromeliads may accumulate water in their leaf sheaths. Here are some tips to prevent this.

Tip #1: Flush water 'pockets' in plants thoroughly and frequently

Using fresh water from a hose or watering can, flush out water-collecting 'pockets' frequently (daily or every other day) to displace accumulated water and remove any mosquito eggs and larvae.

Tip #2: Apply mosquito larvicide to plant parts that collect water

Add Bti to plant parts that collect water. When using Bti, follow the manufacturer's recommendations. Do note that Bti is environmentally friendly and safe for plants and animals, such as mammals, birds and fish.

7. GOOD PRACTICES FOR MOSQUITO-FREE GARDENS

GENERAL HOUSEKEEPING

A key factor to a successful and beautiful garden is good housekeeping an maintenance. Here are some tips for keeping a well-maintained garden that is not only aesthetically pleasing but safe for all to enjoy.

Tip #1: Check for stagnant water frequently

Stagnant water may accumulate in various spots in the garden, such as pots, dishes, pails, drains and even in plants. Check areas in the garden that may collect stagnant water to prevent mosquito breeding.

Tip #2: Pour away stagnant water in pots and dishes, and scrub the inner surfaces

Remove stagnant water that accumulates in pots, dishes and containers regularly. Scrub the inner surfaces of these items to remove any mosquito eggs that may stick to them.

Tip #3: Have a proper storage area for items that collect water, such as pots, dishes and pails

Keep unused pots, dishes, pails and containers in a dry, sheltered area to prevent water from accumulating in them.

Tip #4: Loosen clayey soil to allow water seepage

The surface of clayey soil can become dry and compacted over time, so water may collect on the surface. This is not good for plants because the water does not reach the roots, and it can also create conditions for mosquitoes to breed. Use a fork or trowel to loosen the soil regularly.

Tip #5: Clear fallen leaves from the ground and drains

Clear fallen leaves regularly as they can collect water and clog up drains. You can break the fallen leaves into smaller pieces to use as mulch for plants, or dispose of them in bags. Check and clear the drains regularly to prevent debris and water from accumulating.

8 ENSURING YOUR EDIBLES ARE SAFE FOR CONSUMPTION

GOOD PRACTICES WHEN GROWING EDIBLES

Growing edible plants is satisfying and enjoyable, but care should be taken to ensure that the fruits and vegetables grown are safe for consumption and meet Singapore Food Agency's food safety guidelines. The tips provided here aim to reduce contamination and help you to grow safer edibles.

Soil Preparation

- Use soil from reliable sources to ensure that they do not contain harmful microorganisms or chemicals which can be absorbed by plants and have negative health effects if consumed
- Keep pets out of the garden to prevent the accidental inclusion of raw animal manure
- Remove any diseased plant debris and always prepare the soil prior to every round of planting
- Clear away any leftover plant debris, trim back the perennials and ensure a clean start for the next planting cycle

Water Source

- Use clean water to water your plants as using contaminated water can cause health risks

Fertilising

- Avoid using raw animal waste as fertiliser as it may harbour harmful microorganisms or pathogens
- Follow the manufacturer's label instructions on the amount and frequency of the product application for different plant types
- Fertilisers may leach into the ground and contaminate water sources if used excessively. Apply only in small quantities and as needed
- Ensure that fertilisers do not come into contact with leaves or stems as they will 'burn' the plant
- Use the right type and amount of fertilisers for optimal plant growth
- Fertlisers contaminated with harmful microorganisms may pose food safety issues to consumers
- Use well-composted fertiliser from a reliable source
- Fertilisers should be stored in a proper storage area

Keeping Plants Upright

- Trellising or staking is a great way to keep plants from touching the soil and free of plant pests
- Provide ample spacing between plants

Composting

- Avoid using raw animal waste as compost material as it may harbour harmful microorganisms
- Do not add diseased plant material as it may contaminate the compost and make it unusable in the garden
- Infected plant material should be disposed of properly in a separate bag away from the garden and not used for compost material

Pest Control

- Protect fruits with suitable wrapping material where possible to prevent attacks by pests
- Install netting to deter entry by pests and use rain shelters to prevent disease due to rain damage and overly wet soil conditions
- Avoid using pesticides. Incorrect use of pesticides may pose a risk to human health and damage the environment. Use Integrated Pest Management (IPM) methods which are safe and environmental-friendly
- Do not use any dubious products with claims to be capable of killing plant pests. Always use properly labelled products with clear product information and direction of use. Follow the dosage and correct application method and frequency
- Observe a waiting period between application and harvest

Practice Good Personal Hygiene and Housekeeping

- Use gloves when handling soil
- Wash hands with soap after gardening
- Clean and dry tools regularly to prevent the spread of pests to other healthy plants
- Keep all tools and materials in a proper storage area after use to prevent young children from accessing them
- Keep the garden clean and tidy to prevent other urban pests like rats and cockroaches from entering

8. ENSURING YOUR EDIBLES ARE SAFE FOR CONSUMPTION

GOOD PRACTICES WHEN HARVESTING AND STORING EDIBLES

Other than following good practices when growing edibles, you should also follow through with good harvesting practices to keep your garden free of pests and ensure that your harvest is safe to eat.

- Harvest as soon as the fruit is ripe to prevent the spread of plant pests
- Pests are attracted to rotten edibles which are more susceptible to diseases. These pests may spread to other plants

Before Harvesting:

- Sanitise tools before harvesting
- Do not let harvesting tools come into contact with soil
- Avoid watering the edibles before harvesting

During Harvesting:

- Use clean gloves, harvest containers, trays, baskets and work surfaces
- Ensure tools are kept clean to prevent contamination
- Harvesting should be fast and minimise damage and contamination to the edible plants
- Remove leaves that have turned yellow
- Do not let harvested edibles come into contact with garden soil
- Keep harvested fruits and vegetables from direct sun as soon as possible

After Harvesting:

- Wash harvested fruits and vegetables thoroughly with clean water before consuming
- Dry harvested fruits and vegetables with a clean cloth or paper towel before storing them in the refrigerator
- Place the edibles in containers before storing them in the refrigerator
- Sanitise tools after harvesting

To find out more on Good Food Safety Practices, you may visit SFA's website at ***www.sfa.gov.sg/food-information/food-safety-education/good-food-safety-practices***

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ABOUT COMMUNITY IN BLOOM

Community in Bloom (CIB) is a programme that was launched by the National Parks Board (NParks) in 2005. It aims to nurture a gardening culture among Singaporeans by encouraging and facilitating community gardening efforts. Through gardening, individuals can come together to build community bonds and strengthen social resilience in our City in Nature.

For more information on the CIB programme, visit our website at **www.nparks.gov.sg/cib** or email us at **CommunityInBloom@nparks.gov.sg**.

Visit NParks Flora & Fauna Web at **www.nparks.gov.sg/florafaunaweb** for more information on plants in Singapore.

For more gardening resources and tips, visit **go.gov.sg/gardening-resources**.

To learn more about our City in Nature, visit **www.nparks.gov.sg/CityInNature**

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