



**DEPARTMENT OF AGRICULTURE**

**UNDER SSEPERS - ATMA -2021-2022**

# **ROOFTOP AND KITCHEN GARDENING**

**TRAINING MANUAL**



**DIRECTOR**  
**SAMETI, Kudumiyamalai.**

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**STATE AGRICULTURAL MANAGEMENT AND EXTENSION TRAINING INSTITUTE (SAMETI)**  
**KUDUMIYANMALAI.**



**DEPARTMENT OF AGRICULTURE AND FARMERS' WELFARE**

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## DEPARTMENT OF AGRICULTURE

**P.SANKARALINGAM, M.Sc., (Agri)**

**Director  
SAMETI**

### Foreword

For a balanced diet, an adult should have an intake of 85 g of fruits and 300 g of vegetables per day as per the dietary recommendation of nutritional specialists. Several factors like escalation in the price of agricultural inputs like fertilizers and pesticides and middle men's profit during the change over from wholesale to retail market have pushed up the cost of vegetables and fruits so high that a middle class family find it extremely difficult to purchase the day to day requirement of vegetables. In this context producing their own vegetable in our backyards using the available fresh water as well as kitchen water has become the need of the hour. Roof top garden and kitchen garden will become the integral part of the family life benefitted by the supply of toxic free fresh fruits and vegetables. In urban areas, due to escalating population, most of the available land is being concretized for construction purpose. Therefore the need for other alternative, for increasing the vegetable production in the cities is to be thought of. Considering the importance of the facts mentioned above and to enable the city dwellers to grow vegetables in the available space in the open terraces in residential flats and Individual houses gardening in the roof is the only available solution. The art of creating the greenery on the roof top is known as "Roof Gardening". The existing roof top can be effectively utilized for growing fruit plants, vegetables, homestead medicinal plants, flower plants and ornamental plants. Other than the decorative benefits, roof plantings may also provide food. I appreciate the contribution of the TNAU scientists and staff of SAMETI in bringing out this publication in a fitting manner.

with best wishes

*Vamidandi*

Date:- 17-09-2021

Place:- Kudumiyamalai

**Director,  
SAMETI Kudumiyamalai**



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## INTRODUCTION TO ROOF TOP VEGETABLE CULTIVATION

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In the quest for attaining self-sufficiency, till the last decade utmost priority has been given to the food grain productivity, while pushing at the same time the priority of the horticultural segment which includes fruits and vegetables to the backset. This calls for a new strategy to balance between the two segments which together gives a wholesome progress both in terms of food productivity and food security in the real sense. The need for diversification to horticulture sector was acknowledged by the Government of India in the mid-1980s by focusing its attention on investment in this sector. The total production and economic value of horticultural produce, such as fruits, vegetables and nuts has doubled in India over the last 15-year period from 2002 to 2017. The percentage share of horticulture output in agriculture is more than 30%. The horticulture has thus moved from rural confines to becoming a commercial venture.

### **Importance of fruits and vegetables in nutritional security**

Vegetables constitute an important component of a balanced diet for human. They supply important vitamins and minerals that the human body needs for a healthy and active life. Vegetables like carrot, pumpkin, peas, turnip, beetroot, sweet potato, onion, cabbage, greens like amaranthus, moringa, agathi, chekkurmanis and spinach are important sources of vitamin A. Ascorbic acid or vitamin C is present in appreciable quantities in broccoli, brussels sprouts, kale, Cauliflower, tomato and peas. Vitamin D is available in greens which are good source of Vitamin E also. Green leafy vegetables are good source of the other essential vitamins *viz.*, niacin and vitamin K.

Most important minerals required for our regular activity are calcium and iron. Okra, garlic, cabbage, turnip, kale and artichoke are the rich sources for calcium. Iron is supplied to the body by vegetables like Spinach, Beetroot, Sweet Potatoes, Turnip, Kale and Artichoke. Iodine which is essential for the human body is provided by onion, okra and summer squash. Many of the vegetables are the source of roughage aiding in digestion. Most of the vegetables (with the exception of tomato) are alkaline in reaction which is very beneficial to neutralize the acid reaction of non-vegetarian foods.

Vegetables like potato, sweet potato, cassava, yam *etc.*, are good sources of carbohydrates and therefore are important subsidiary foods, while others like peas and beans provide protein. Besides the above merits, many of the vegetables such as onion and chilli add palatability to our food. The added advantage of these spicy vegetables is their protective nature against diseases. The per capita requirement of fruits and vegetables for an adult is 92g and 300g per day as recommended by Indian Council of



Medical Research, New Delhi and National Institute of Nutrition, Hyderabad. But Indian data shows availability of an average of 46g and 130g, respectively. This is considerably much lower in rural India. The dieticians advocate intake of 125g leafy vegetables, 75g other vegetables and 100g root and tuber vegetables everyday to make our diet balanced. Though the food grain production has reached about 230 million tonnes, the malnutrition among the rural poor is a worrying factor. The production pattern itself may be the curse, because the green revolution largely remained a cereal revolution. Coarse grains and pulses which supply the poor man's staple and protein requirements have not been given adequate attention.

Besides this, different factors like escalation in the price of agricultural inputs such as fertilizers and pesticides, transporting charges from the place of production to the market, middle men's profit during the change over from wholesale to retail market have pushed up the cost of vegetables so that a middle class family finds it extremely difficult to purchase the day to day requirement of vegetables.

Vegetable crops have high export potential and vegetables worth more than 250 crores are being exported annually both in fresh form or processed form. Traditional vegetables like onion, potato, bhendi, bitter gourd, chillies and non-traditional vegetables like asparagus, celery, sweet corn, baby corn, beans, peas and cherry tomato have been short listed by APEEDA for export. Among the different vegetables, onion occupies first place in export of fresh vegetables, thus earning valuable foreign exchange to the country. Onion and traditional vegetables are being imported by Gulf countries, Singapore, Malaysia, Sri Lanka, Bangladesh and Nepal. Non-traditional vegetables are being imported by Australia, European countries, South East Asia and Gulf countries.

**Table 1 Nutritive value of vegetable crops**

Vegetable	Moisture (g)	Protein (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)
Tomato	94.0	1.20	48.0	26.0	0.40
Chilli	85.0	2.90	30.0	80.0	1.20
Brinjal	90.0	1.00	9.0	10.0	0.25
Bhendi	90.0	1.90	81.0	63.0	0.80
Onion	86.8	1.20	180.0	50.0	0.70
Ash gourd	96.0	.	30.0	20.0	1.00
Bitter gourd	92.0	2.00	20.0	70.0	1.00
Bottle gourd	96.0	.	20.0	10.0	0.70
Muskmelon	95.2	0.30	32.0	14.0	1.40

Watermelon	95.8	0.20	11.0	12.0	7.90
Cabbage	92.0	1.40	46.0	38.0	0.80
Cauliflower	91.7	2.40	30.0	76.0	170
Potato	74.0	1.60	10.0	35.0	0.70
Pea	72.0	7.20	20.0	139.0	1.50
French bean	91.0	1.70	50.0	28.0	1.70
Carrot	82.2	0.90	48.0	30.0	0.60
Palak	91.5	0.89	30.0	15.0	813.0

Finally, vegetables are a vital source of nutraceuticals that promote health by their protective role in the body. Vitamin C is part of the family of terpene compounds that protect cells from free radicals and ionizing radiation. Some terpenes are very protective of vaginal, uterine, and cervical tissues. Glucosinolates found in cruciferous vegetables and allylsulfides from onions and garlic have important functions in building and regulating the immune system. These compounds, along with isoflavones, flavonoids, indoles, and other nutraceuticals improve and protect the circulatory system, enhance detoxification activity in the liver and prevent or suppress various kinds of cancer.

Vegetables are a valuable component of any diet, contributing minerals, vitamins and other nutrients which may otherwise be lacking. These compounds can enhance human growth and development, improve general health and strengthen immune responses to combat disease. In situations where dietary choices are limited, or when immune systems are compromised, vegetable consumption can make the difference between normal health and life-threatening disease.

## **Urbanization**

Urbanization in India began to accelerate after independence, due to the country's adoption of a mixed economy, which gave rise to the development of the private sector. According to 1901 census, population residing in urban areas in India was 11.4%. This was increased to 28.53% during 2001 census, and crossed 30% as per 2011 census and now stands at 31.16%. As per World Bank, India, along with China, Indonesia, Nigeria, and the United States, will lead the world's urban population surge by 2050.

In the past 15 years, nearly 22 per cent of the cultivable land area already converted into constructions includes commercial complexes and houses. In this continuation, there is a rise in global temperature by evolving greenhouse gases. Concern to food production, there is big reduction in cultivable area and production which leads to reduction in per capita food materials. Availability of the vegetable produce for the urban

areas is only through transportation from the villages and distance marketing. It is often neither fresh nor good. Pesticides and preservatives may also diminish the health value of produce. These arise the need to produce more vegetables in a limited area is the trend towards sustainability. Vegetables / fruits production in the roof top is one of the newer system of crop cultivation to produce quality produce on daily requirement basis by utilizing the available space in the houses of urban areas.

### **What is roof garden / terrace garden?**

"Roof garden / terrace garden is the cultivation of produce for food on the roof / terrace of a building". In many ways, rooftop farming is a specialized application of what is often referred to as a 'roof garden'. In addition to the aesthetic, recreational, ecological, and architectural benefits provided by roof gardens, rooftop farming's focus on vegetable production supplies, it maintains the community with fresh produce and promotes small-scale vegetable production as well as a tangible connection to nutritional security. Rooftop garden / terrace garden is most common in urban areas, where ground-level for vegetable production opportunities are scarce. It works wonders for urban planning, as well rooftop farms absorb solar radiation reducing the 'urban heat island effect', insulates and cools the host building (and thereby reduces electricity use), and manages storm water by delaying and reducing the hazards of rainfall runoff.

Small roof garden (4 x 4 m<sup>2</sup>) vegetable cultivation can be sufficient for a small family (3- 4 nos.) if maintained properly. Nowadays "Clean city and Green city" is the concept ruling in all the newly developed urban cities. Cultivation of vegetables in roofs and balconies of the homes will give aesthetic appearance to the buildings and homes.

The yield of vegetables is very high. Most of the vegetables if properly grown in terrace garden can give a good quality produce compare to the field produce. The organically grown vegetable without any pesticide residues is achieved, when it is grown in terrace garden. Also the produce from terrace garden are more fresh and good quality compare to the markets. Terrace garden grown vegetables can be raised throughout the year. Many of the vegetables like palak, brinjal, bhendi, tomato, amaranthus etc., can be grown easily in home top/ terrace / roof gardens. Some green vegetables are ready for harvest within 45-60 days. Thus several vegetable crops can be grown one after the other, throughout the year in roof gardens. Nowadays, many early varieties of vegetables are available which can grow earlier and yield good returns to the roof top growers.

As the demand increases in cities, cost of the vegetables become very high. As such there is urgent use to utilise every bit of space available, for vegetable cultivation. A kitchen garden for a house hold, a school garden for a school or a

college's not only produce the valuable vegetables, but also lend an aesthetic appearance and beautify the drab surroundings.

### **Advantages of a roof/terrace garden grown vegetables**

- ❖ To supply fresh fruits and vegetables with high nutritive value
- ❖ To supply fruits and vegetables free from toxic chemical residues
- ❖ Help to save expenditure on purchase of vegetables
- ❖ Induces children on awareness of dignity of labour
- ❖ Organic vegetables can be produced
- ❖ Urban roof garden has long been promoted as an easy and effective strategy for beautifying the built environment and increasing investment opportunity.
- ❖ The plants on green roofs can capture airborne pollutants and atmospheric deposition. They can also filter noxious gases. The temperature moderating effects of green roofs can reduce demand on power plants, and potentially decrease the amount of CO<sub>2</sub> and other pollutants being released into the air.

### **Crops suitable for roof/terrace garden**

#### **Annual crops**

Tomato, brinjal, chilli, onion, bhendi, gourds, pumpkin, cucumber, vegetable cowpea, lablab, cabbage, cauliflower, beetroot, raddish, knolkhol, amaranthus, palak, fenugreek, coriander; mint etc.

#### **Perennialcrops**

Moringa, chekkurmanis, curly leaf, papaya, lime, pomegranate and custard apple.

#### **Crops not suitable for roof garden**

Cassava, tree crops like mango, guava, sapota, jack etc.

## **BASIC REQUIREMENTS FOR SUCCESSFUL ROOF TOP VEGETABLE PRODUCTION**

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In order to establish a roof/terrace garden certain basic requirements like selection of site, containers, media and selection of crop are very important for successful cultivation

### **Selection of site**

The first and foremost principle for establishment of roof garden lies in effective site selection that could support the weight of the roof and building infrastructure. The identified site should possess the penetration of quality light, optimum temperature and suitable wind breaks which will otherwise reduce the overall temperature and decrease the rate of transpiration. Wind conditions on a roof can be dramatically different from those on ground level. Generally, higher the elevation stronger the wind. Combined with the increased sun and heat exposure on a rooftop, plants could have a hard time for surviving unless some precautions are taken. In windward direction, plants having sturdy stem are grown such as brinjal, chilli, bhendi etc., or alternating with plants having short stem such as palak which will not be affected by wind damage. When selecting plants as windbreak, plants with thick leaves with hairy or waxy surfaces are selected. Their evaporation rate is lower than thin, smooth leaves. In addition proper access should be possible to carry out necessary operation.

Plants can be placed in north or east direction to obtain the required quantum of light. Seeds differ in their responsiveness to light. Hence the site selected should be able to supplement the required light for germination of seeds. In some cases, light is essential for germination- absence of light promotes germination- regardless of the light regime. A general rule is that the smaller the seed, the more likely light is necessary for germination. If light is necessary, seeds must be fully imbibed for the optimum response. The type and amount of light also affects the uniformity of germination.

Appropriate space has to be allocated between each plant. Taller plants can be placed in the north direction which avoids shading the nearby shorter plants. The floor should be of waterproof. One coating of water proof painting should be done before establishment of roof garden in the open terrace. If the temperature goes beyond 40°C during summer, survival of crops is very difficult. In such conditions, erection of shade net (35% shade) is essential.

## Selection of crops

The ultimate aim of roof/terrace garden is to incur the basic vegetables which are normally rich in vital minerals, nutrients, free from pest and diseases. Basic vegetables includes tomato, brinjal, bhendi, chilli, lab-lab, cluster beans, snake gourd, bitter gourd, ridge gourd, coccinia. Leafy vegetables which include amaranthus, coriander, palak, annual moringa, curry leaf etc. While arranging the plants long season crops can be grouped together which will facilitate easy operation and thus short season crops can be grown with crop rotation. Space can be saved by planting quick growing vegetables along with slow growing when after harvest of quick growing vegetables which provide space for slow growing ones. In small space area growing vine crops saves more area.

Selection of crops can be season specific or even depending upon the prevailing price in the market. If a particular vegetable costs more during a particular season that can be grown in larger scale. Thus effective selection of crops promotes continuous supply of vegetables.

**Table 2. Duration of vegetable crops**

Sl.No	Name of the vegetable	Duration (days)
1	Tomato	150
2	Chilli	160-210
3	Brinjal	150
4	Bhendi	105
5	Onion	70-90
6	Ash gourd	120
7.	Bitter gourd	135
8	Bottle gourd	135
9	Muskmelon	120
10	Watermelon	120
11	Cabbage	90-120
12	Cauliflower	90
13	Potato	135
14	Pea	120
15	French bean	120
16	Carrot	90
17	Beetroot	60
18	Raddish	45
19	Palak	30
20	Greens	25

## Selection of varieties

Varieties are selected based on the traits such as early maturing, high yield and pest and disease resistance. Seed source should be collected from institutes that rely on quality seed production. They practice techniques such as seed priming and seed pelleting. Seed priming is practiced to enhance the vigour, germination and viability. Seed pelleting also provides uniform sized seeds. Hybrids may be avoided while selecting varieties for roof garden since it requires high tech cultivation and the cost of seed also high when compared to local varieties.

**Table 3. Crop selection and raising the vegetables in roof top garden**

Sl. No.	Vegetables	Sowing / planting		Days to first harvest after sowing/planting
1.	Amaranthus	Sowing	February- March July- August	25-30
2.	Beet root	Sowing	October-December	90-100
3.	Bittergourd	Sowing	February-March	55-60
4.	Brinjal	Transplanting	January- February July -August	45-60
5.	Broad bean	Sowing	September-October	70-75
6.	Chilli	Transplanting	January - February July- August	50-60
7.	Cluster bean	Sowing	July- August	30-35
8.	Cowpea	Sowing	January - February	60-65
9.	Cucumber	Sowing	February- March	45-50
10.	Methi / Fenugreek	Sowing	September-December	45-50
11.	Mint	Transplanting	March- July	45-50
12.	Okra/Bhendi	Sowing	June- July	30-35
13	Onion	Transplanting	June-July October - November	75-80
14	Radish	Sowing	Round the year	25-30
15	Spinach	Sowing	September - October	50-55
16	Tomato	Transplanting	December - January June- July	60-65

## Cropping pattern

Generally almost all vegetable and spice crops are raised in three seasons Vaikaasi pattam, Adi pattam and Thai pattam. For small scale purpose *i.e.*, cultivation in home stead gardens, we need not depend on any season; but raising of vegetables can be avoided during summer seasons.

**Table 4. Cropping pattern**

May-June to September-October	September-October to December-January	December-Janua to May-June
<b>Annualcrops</b>		
(a) Bitter gourd	Lab lab	Snake gourd
(b) Brinjal and chilli	Amaranthus	Okra
(c) Ash gourd	Pumpkin	Amaranthus
(d) Bushy/semi-trailing cowpea	Tomato	Cucumber
(e) Okra	Ashgourd	Chilli, brinjal
(f) Pumpkin	Okra	Onion
<b>Perennialcrops</b>		
(a) Vegetables	Drumstick, curty leaf, culinary banana, Chekkurmanis, Agathi	
(b) Fruits	Banana, acid lime, papaya, West Indian cherry, guava, rose apple etc.	
(c) Spices	Ginger, turmeric, mango ginger	

### 1. Fruit crops suited for roof garde

- a. Banana, Guava, Acid lime and Papaya

### 2. Vegetable crops suited for roof garden

- i. Transplanted vegetables: Tomato, Brinjal, Chilli
- ii. Direct sown vegetables: Bhendi, Amaranthus, Cucurbita - ceous vegetables like Bitter gourd, Snake gourd, Ridge gourd, Bottle gourd, Radish and Beet root

### 3. Spice crops suited for roof garden

Turmeric, Coriander and Fenugreek

### 4. Medicinalcrops suited for roof garden:

Agathi, Adathoda, *Aloe vera*, Oomathai, Lemon grass, Oomavalli, Karisalanganni, Perandai, Keelanelli, Thuthuvelai, Ponnanganni and Manathakali



## **Selection of containers**

Container and growing media are important components in roof gardening as they form the framework for establishment of plants. Selection of appropriate media and containers should be done for growth promotion. The range of containers commonly helps in ease of establishment include earthen pots, plastic pots, polyethylene bags, grow bags and plastic drums. Apart from the range of containers, container size and depth is an important factor to be considered. For a successful roof/terrace garden drainage holes in the containers are an essential factor. Proper drainage system should be ensured for draining surplus water after rainfall. Containers should be selected based on the geometry or spread and root spread of the selected crops.

### **Clay and Plastic pots**

The essential difference between these two types of container is one of porosity. Plastic pots are non-porous, whereas clay pots can have varying degrees of porosity, depending upon the manner in which they are made. Porous clay pots differ from plastic pots in three main ways:

- (a) Water is lost by evaporation from the clay wall, hence the medium in the pot may get dried frequently.
- (b) The latent heat of evaporation from the clay wall results in a reduction in the temperature of the medium filled in the pot.
- (c) The flow of water from the medium into the clay wall results in the loss of some nutrients to the plants

Clay pots are not recommended in buildings which cannot withstand the high pressure. Hence plastic pots and plastic drums are utilized to grow perennial crops.

### **Polyethylene bags**

Shallow rooted plants are suitable for growing in polyethylene bags. Greens are highly suitable and can perform well in bags. Annual and biennial season vegetables are preferred to be grown in bags.

### **Plastic Drums**

Crops like annual moringa, curry leaf, brinjal, chilli, papaya grow well in plastic drum as they have deep layer of soil that fix in good establishment.

### **Grow bags**

Grow bags forms an effective structure but the media get dried up frequently hence regular watering has to be done and require special frames to support climbing plants. HDPE grow bags are available in different colours *viz.*, outer green and inner orange, blue and orange / blue. It is also available in various sizes (as listed in the table 3) and quality based on the thickness (120 gsm, 160 gsm, 200 gsm, 340 gsm).

**Table 5. Sizes of grow bags**

Roundtype		Rectangular type	
S.No.	(in inches)	S.No.	(in inches)
1	09x09	1	12x12x06
2	09 X 12	2	12x12x09
3	12x12	3	12x12x12
4	12x15	4	18x12x06
5	15x12	5	18x12x09
6	15 X 15	6	18 X 12 X 12
7	12x15	7	18x18x06
8	18x12	8	18x18x09
9	18 X 18	9	18x 18x 12
10	12x24	10	24x 12x06
11	24x 12	11	24x12x09
12	24x24	12	24x 12 x 12
13	12x06	13	24x24x06
14	12x09	14	24x24x09
15	15x 06	15	24 X 24 X 12

**Water source**

Water quality is defined as its optimum range in pH and EC value. Saline water cause physiological drought in plants. Water should be free from contamination. Drainage water is not suitable for vegetable cultivation as it contains heavy metal residues that are phytotoxic to plants. Watering with drainage water should be strictly avoided.

**Drip system**

Due to the nature of roofs, a roof garden is built on cement or other rigid basis, which offers an extremely narrow root zone or substrate layer. In some cases the substrate layer is no more than 20 cm high, limiting the availability of resources, such as nutrients, while complicating the plant growing process. These unique growing conditions require a solution that is extremely precise and resource efficient. In addition to this most people who own urban rooftop garden have at some point experienced issues with plant death due to lack of water. Many homeowners believe that upon setting up a new rooftop garden, they will consistently water their new plants and flowers. The reality is most people don't have the time to water their plants regularly and underestimate the commitment needed to watering. Hence, properly installed rooftop drip irrigation system will eliminate these problems. Moderate to high water pressure is preferable. If the water pressure is low, there may not be enough force to have a long drip system or soaker hose. In this case, several shorter hoses on separate zones would get water to all the plants.

## **Media**

Growing media should possess good water holding capacity and pore size distribution for water retention. It should also possess aeration for better root development. Cation Exchange Capacity of growing media measures the media's ability to prevent nutrients from leaching, thus retains them for plant use. Commonly used media in roof top gardening include coco peat and pot mixture. Pot mixture contains the proportion of soil: FYM: sand. They have heavy weight when completely irrigated hence not much preferred for roof gardening.

### **Coco peat**

Composted coirpith is the commonly used media which is mixed along with vermicompost. They are completely sterilized and are available in affordable rates. Cocopeat is a multipurpose growing medium made out of coconut husk. The fibrous coconut husk is pre washed, machine dried, sieved and made free from sand and other contaminations such as animal and plant residue. Cocopeat is a very good alternative to traditional peat moss and Rock wool. Its air filled porosity and high water holding capacity makes it, an ideal growing medium for the plant crops. It is 100% organic and eco friendly, free from soil borne pathogen and weed. It has a pH of 5.7-6.5 and EC level <1 dsm·' which makes it ideal for plant growth. They possess high moisture retention properties and are weight less forming an added advantage.

Other polymers like hydro gels are used in pots which can hold upto 4 times the water irrigated nowadays hydrating clay are used which also helps in more water retention.

## CROP MANAGEMENT TECHNIQUES FOR ROOF/TERRACE TOP VEGETABLE CULTIVATION

Successful production of vegetables in the roof garden involves sowing/transplanting in the right season, application of optimum quantity of inputs/ fertilizers, providing optimum water to the plants and pest and disease management at right time.

### Season

Most of the vegetables can be cultivated throughout the year in Tamil Nadu since the prevailing climatic conditions are suitable for growing almost throughout the year except winter vegetables which requires cooler climate. The month of sowing of the important vegetables are furnished in the following table.

**Table 6. Season of vegetable raising in roof top garden**

Crops	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tomato	✓	✓			✓	✓	✓	✓			✓	✓
Brinjal	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Chilli	✓	✓			✓	✓	✓	✓			✓	✓
Bhendi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Onion	✓	✓	✓				✓	✓			✓	✓
Lablab	✓					✓	✓	✓	✓	✓	✓	✓
Cabbage								✓	✓	✓	✓	✓
Cauliflower						✓	✓	✓	✓	✓	✓	✓
Beetroot	✓					✓	✓	✓	✓	✓	✓	✓
Raddish	✓					✓	✓	✓	✓	✓	✓	✓
Palak	✓	✓	✓			✓	✓	✓			✓	✓
Amaranthus	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
Gourds	✓	✓					✓	✓	✓			✓
Pumpkin	✓	✓					✓	✓	✓			✓
Ash Gourds	✓	✓					✓	✓	✓			✓
Watermelon	✓	✓					✓	✓	✓			✓

## **Propagation methods**

The vegetable crops are propagated either through seeds or vegetative plant parts. In case of seed propagation seeds are sown either directly or transplanted in the containers by raising the seedlings in the nursery beds or grow bags. For raising crops like tomato, brinjal, chilli, carrot, cabbage, cauliflower seeds procured from the institutes have to be sown in protrays using digested coir pith as media. Protray nursery are commonly used to raise hybrid seedling, since the hybrid seeds are more costly. It is very adoptive and easy technology of growing vegetable seedlings in roof/terrace garden compared to raised bed nursery. For raising raised bed nursery, land is essential but for protray nursery it is not mandatory. This technique ensures that a large number of seedlings can be raised in minimum space at reasonable cost to get quality seedlings. The grow bags are filled with natural potting media *viz.*, coir compost, vermicompost, organic manure, farm yard manure and red earth soil.

### **Steps involved in raising protray or flat tray seedlings**

- ❖ Use pro-tray having 98 cells (tomato, brinjal, chilli, cauliflower, cabbage) or 50 cells (for gourds) for raising the seedlings.
- ❖ Fill the seedling tray with coco peat ( digested coirpith)
- ❖ For optimum germination, sow seeds in well-drained sterile medium and water twice daily.
- ❖ Sow one seed per cell and cover 1 cm deep. Germination can vary depending on variety, seed quality and soil mixture.
- ❖ Cover the tray with a plastic sheet or leave as such until germination (3- 4 days).
- ❖ Water the tray thoroughly every day, or as needed (not too wet or too dry), using a fine sprinkler.
- ❖ Depending up on the crop and infestation follow plant protection schedules.
- ❖ The seedlings are ready for transplanting in 25 -35 days

### **Raised bed nursery**

Nursery beds are also used for raising seedlings especially in vegetable crops propagated through seeds. Treat the seeds with *Pseudomonas fluorescens* 10g/Kg, *Trichoderma viride* @ 4g/kg of seeds to check the infection of soil borne diseases. In the well prepared nursery bed, make a line at a spacing of 5 cm then sow the treated seeds at 1 cm depth. The general rule for sowing depth is 2-3 times of the thickness of seed. Sow the seeds in the lines and cover it with soil or farmyard manure. Water it twice a day till germination and then once in a day. Avoid broadcasting seeds in the grow bags. Thick sowing or sowing with broad casting also leads to increase in an incidence of damping off disease. If seeds are sown too deep, nutrient reserves will

be exhausted before the plant emerges or emerging plants will be weak or liable to die. If sown too shallow, then it is likely to be eaten by birds or washed away by the splash of rains or irrigation water.

After 4-6 weeks (depends on the crops) of sowing, the plants become 10-15 cm tall and are ready for transplanting. Select healthy plants for transplanting and always transplant in the early morning or late evening.

Some of the crops like onion, mint, potato, tuber crops like cassava, sweet potato and yams are vegetatively propagated.

**Table 7. Vegetative propagating materials used for raising vegetables**

Sl. No	Crop	Propagating
1	Onion	Bulbs
2	Potato	Tubers
3	Sweet potato	Vine cuttings
4	Cassava	Setts
5	Elephant foot	Corm
6	Colocasia	Cormels
7	Dioscorea	Tubers

These specialized plant parts can be used as propagating materials and this can be sown directly in the container.

### **Watering**

Plants in pots and containers need a lot of care and attention. It is essential to water the plants judiciously depending upon the season, kind of crop, size of the plant and size of the container. Plants need extra water during summer season and hence the plants should preferably be irrigated twice a day. Too much watering will also lead to problems; hence we should strike a intelligent balance. The thumb rule for irrigation is that the top soil should be scratch about one inch and seen, if the lower soil is damp, there is no need of immediate. irrigation. Due to evaporation, the top soil generally dries even though the soil may have enough moisture to sustain the plant. In general, watering can be done as and when required.

### **Staking**

Depending on the growth stage of plants, they need staking (i.e) support. Plants like lab lab, ribbed gourd, bottle gourd and snake gourd needs staking or it has to be trained in panda! system for proper support. In addition to the above, plants like tomato, brinjal and chilli also need staking on 60th day of planting.

## **Fertilizer application**

For maximum growth and yield of crops can be achieved not only through organic manures and can be improved better by the application of inorganic fertilizers. Top dressing with nitrogenous fertilizers improves plant growth and yield of vegetables. This can be done by applying urea or DAP or ammonium sulphate in small quantities. In general, 5-10 g of urea may be applied in moist soil once in a week or 10 days starting from 3 weeks after sowing or 2 weeks after transplanting. In general, 5 to 10 g of complex fertilizers (17:17:17/20:20:20) containing NPK mixture is applied in three stages as follows:

- ❖ 30 days after planting (*i.e*) on set of vegetative phase= 5 to 10g/plant
- ❖ 60 days after planting (*i.e*) on set of flowering phase = 15 to 20 g/plant
- ❖ 90 days after planting (*i.e*) on set of fruiting phase= 15 to 20 g/plant

In addition to the above, vermicompost 100 gram/ plant should be applied at monthly intervals. Care must be taken that vermicompost should not mix with any inorganic fertilizers. Hence, the application of vermicompost and inorganic fertilizers should not be practiced simultaneously. Heavy doses of fertilizer are very harmful. Immediately after fertilizer application, the plant should be watered.

## **Weed Control**

Hand hoeing and weeding helps in aeration in the root zone and help the plant grow healthy. Weeds should be removed gently in leafy vegetable crops like amaranthus, fenugreek, spinach, coriander etc.

## **Pest and disease management**

- ❖ Pick and destroy the larvae found on fruits and vegetables and then spray Neem oil @ 4 ml + sticking agent 2 ml/Lit of water or kadi soap
- ❖ Neem Seed Kernel Extract @ 3 % + sticking agent 2 ml/Lit of water or kadi soap
- ❖ Avoid spraying of toxic chemicals.

Based on the growth pattern and climatic factors vegetables are attacked by various pests and diseases. Aphids and jassids are small sucking insects, injuring the plants especially in early stages of their growth. Spraying of Dimethoate @ 2ml/lit of water+ Neem oil @ 4 ml + sticking agent 2 ml/lit of water or kadi soap controls these insects. Fruit fly and fruit borer are serious pests of some vegetable crops. They damage young fruits and make them unfit for consumption.

The affected fruits should be plucked and destroyed. The plants should be sprayed once or twice with recommended insecticides. After spraying, fruits should not be harvested for 7-10 days for consumption. Fungal diseases (damping off and wilt) and viral diseases affect the plants particularly during the rainy season. Fungal diseases can be controlled by drenching the soil with 'Captaf' solution @ 2g/lit of water. Virus affected plants should be removed and destroyed.

## **Harvesting**

Vegetables harvested at the peak of maturity and used promptly, are always superior in nutritional content, freshness, flavour and appearance. Leafy vegetables should be picked up frequently when tender. Root vegetables should be pulled out while tender otherwise they become pithy. Tomato is picked at ripe stage, brinjal and okra are picked after they attain full size but still tender.

Rare vegetables *viz.*, leek, fennel, and soya are not available in market always. Thus these can be advantageously raised in containers. Curry leaf, Checkurmanis and gooseberry can also be grown in medium to big sized containers in a roof garden.

## **Post harvest operations**

### **Digging of soil**

As soon as the season is over *i.e.*, after the final harvesting of vegetables, remove the plant from the pot or polythene cover and dump the soil in open place and break the clods.

### **Application of organic manures**

After 15 days, add organic manures and mix the soil thoroughly and refill the pots or polythene covers.

### **Choose alternate crops**

In order to maintain proper recycling of nutrients, crop rotation can be adopted. Hence choose alternate crops for the next season.

## **Plant nutrition**

A suitable medium is necessary for plant growth and soil is such a medium. The importance of good soil is to supply nutrients to the growing plant, retain moisture and hold the plant firmly on the ground. Good textured and enriched soils contain most of the nutrients required for plant growth. However, the quantity and type of nutrients required by plants differ from plant to plant. Accordingly, some plants require small quantity of manuring while others require large quantity for their good growth. Plants require 16 mineral nutrients that include carbon, hydrogen and oxygen (CHO) as building block nutrients and that are available in nature and can be taken from air and water. Other nutrients essential for healthy plant growth are nitrogen, phosphorus and potassium (NPK), which are primary nutrients, required in large quantities; Calcium, magnesium and sulphur (Ca, Mg, S), are secondary nutrients and are required in small quantities; and molybdenum, zinc, boron, manganese, ferrous, chlorine and copper (Mo, Zn, Bo, Man, Fe, Cl, Cu), which are the micronutrients required in very small quantities.



Organic manures are made through decomposition of plant and animal debris and inorganic manures called chemical fertilizers which are manufactured in factories. Organic manures are sufficient and highly recommended for growing vegetables based on home and kitchen gardens. Wherever there is a shortage of organic manures, they are mixed with small quantities around 5 percent of chemical fertilizers to meet the requirement of various fruit and vegetable plants grown in terrace gardens. Manures and fertilizers should be applied at the time of sowing seeds, seedling planting, flowering and fruiting stages to get more yield of good quality.

The materials that contain a low percentage of nutrients and need to be applied in larger quantities are called manures and the industrially manufactured materials that contain a high percentage of nutrients are called fertilizers. Manures are bulky while fertilizers are concentrated in nature.

### **Advantages of organic manures**

- ❖ Organic manure provides all the nutrients that are required by plants but in limited quantities.
- ❖ It helps in maintaining C:N ratio in the soil and also increases the fertility and productivity of the media.
- ❖ It improves the physical, chemical and biological properties of the media.
- ❖ It improves both the structure and texture of the media.
- ❖ It increases the water holding capacity of the media.
- ❖ Due to increase in the biological activity, the nutrients that are in the lower depths are made available to the plants.
- ❖ It acts as mulch, thereby minimizing the evaporation losses of moisture from the media.

### **Major organic sources**

Carbon present in soil is in the form of organic matter. The organic materials most commonly used to improve soil conditions and fertility include farm yard manure (FYM), animal wastes, crop residues, urban organic wastes (either as such or composted), green manures, bio-gas spent slurry, microbial preparations, vermicompost and biodynamic preparations. For all organic matter, atmospheric carbon dioxide serves as the main source of carbon.

### **Farm Yard Manure (FYM)**

FYM is the cheapest and most readily available organic source of manure. Cow dung, leftover fodder and bedding material soaked with cattle urine from the cattle sheds are collected and heaped on the ground or filled in big pits or trenches and kept for 2-3 months for decomposition.

## Compost

Composting is a natural way of recycling biodegradable organic waste like leftover food, fruit and vegetable waste, grasses, paper, wood, feathers and crop residues, etc. Composting can be carried out under control under aerobic conditions in which microorganisms break and decompose solid organic waste into a simple organic humus rich substance called compost.

### Home based composting

Small-scale composting for home gardens or kitchen gardens or terrace gardens in city areas can be worked out and this composting can be done in bins, wooden boxes, plastic crates, small pits or trenches near our homes. Trench composting is relatively simple. The household organic material like leftover food, fruits and vegetable wastes and non plastic litter are collected, mixed and filled up in a 3 to 5 m long, 1 m wide and 0.3 m deep trench, layer by layer, followed by spraying of sufficient water to moisten the dry material to speed up the process of decomposition. Fill the material up to 6 inches above ground and plaster the dome of trench with the help of soil mud or cow dung slurry to prevent nutrient losses through evapo-transpiration.

The manures and fertilizers should be applied when the plant needs them most. The plant needs more nutrition at the time of emergence of new flushes and differentiation of flower buds before flowering. Plants also utilize nutrients very fast during flowering and fruit development. However, as a thumb rule, manuring should be done once at the time of sowing or planting of fruits and vegetable crops having a harvesting period of less than 3 months, and twice, thrice and four times when the harvesting period is less than 6, 9 and 12 months, respectively.

**Table 8. Quantity of inorganic manures required for the vegetable crops**

Sl.No.	Crop	N	P	K
1	Tomato	6.00	7.00	7.00
2	Brinjal	8.00	6.00	4.00
3	Chilli	4.00	2.50	2.50
4	Bhendi	3.00	2.50	2.50
5	Cluster bean	2.00	1.50	15.0
6	Gourds (Bitter gourd, ridge gourd, snake gourd, bottle gourd, ash gourd, pumpkin, cucumber)	15.0	12.0	12.0
7	Cowpea	2.00	1.50	1.50
8	Lablab	2.00	1.50	1.50
9	Annual Moringa	50.00	15.0	30.0
10	Radish	2.00	1.00	1.00
11	Amaranthus	2.00	-	1.00

## **Watering**

Pot culture require a less volume of soil and hence a few but frequent watering applications. Beds in soil have more depth and the volume of soil medium requires more water with less frequency of watering. In the cultivation of fruits and vegetables, using pot culture, care should be taken to water the newly potted plants less but frequently for their survival and firm establishment. Water requirements of plants depend on the season and atmospheric temperature. Under normal conditions, pots should be watered when the soil in the pot becomes moderately dry. However, as a rule of thumb, pots should be watered once a day in summer, twice a week in winter and according to requirements during the rainy season. For watering beds in soil, there are a number of irrigation methods like surface irrigation, sprinkler irrigation and drip irrigation. The sprinkler and drip irrigation methods are more efficient and productive than the surface irrigation method but they incur a high cost of establishment and are normally not recommended for small home based kitchen gardens. The most common method of watering beds in soil is using surface irrigation in which water is provided through surface flow or through watering cans when the area to be irrigated is small. Hard water / salt water should be avoided.

## **Harvesting of vegetables**

Maturity of vegetable means the stage at which they should be harvested for consumption. It is a stage of attainment of physiological full growth of the part of the plant to be harvested for consumption. Maturity stage would depend on the purpose of harvesting. If we want to consume the plant part as vegetable, it should be harvested at full maturity but still succulent and tender without the development of fibers. If we want to extract seed from the plant then maturity has a different meaning and the plant part is harvested at its full life maturity. Knowledge of maturity indicators is very important to save produce from yield losses by early harvesting or over maturity conditions by late harvesting.

If vegetables are harvested at an immature stage then they become susceptible to shrinking and the quality of the produce become inferior. On the other hand, over ripe harvest tend to become soft. Both early and late harvesting of vegetables results in extremely poor quality and life span. Therefore, it is extremely necessary to harvest vegetables at the right stage of maturity which cannot be decided by a rule of thumb.

**Table 9. Maturity indices for vegetable crops**

Tomato	Full grown fruits turn light yellow to reddish tint. First harvest will take place 70-75 days after transplanting. Total duration is about 120-135 days.
Chilli	Green fully mature before they change green to red. First harvest is at 65-70 days after transplanting. Total duration is 210 days.
Brinjal	The fruits become ready for first picking is about 70 days after transplanting depending on the variety. The harvesting of the fruits should be done as soon as it attains a good size and colour before the seeds get hardened.
Bhendi	The fruits are ready for harvest in about 45-55 days after seed sowing depending upon variety and season. Fruits should be harvested before attaining fibreness.
Amaranthus	Four to five weeks after sowing, when leaves are dark green, tender and full grown it is ready to harvest leaves or the whole plant.
Onion	Leaves turn yellow and dry and the top shoot falls down. Duration 70-90 days from sowing of bulbs.
Radish	Depending on the variety, the radish root becomes ready for harvesting 45 to 60 days. If late harvested the root turns spongy and becomes fibrous and not fit for salad.
Carrot	Carrot becomes ready for harvest when leaves turn yellowish and roots grow fully but still juicy and tender.

There are different methods of harvesting of vegetables. However, hand picking is the most popular method of harvesting owing to the small size of the plot and the produce. Fruity vegetables like tomato, chilli, brinjal and gourds can be easily harvested by handpicking. Leafy vegetables like coriander, fenugreek, spinach, amaranthus and root vegetables like carrot, radish and beet root can be harvested by pulling them out manually. Sweet potato can be harvested by digging with hand tools like shovel or trowel to avoid injury to underground tubers.

## **CULTIVATION OF LEAFY AND LEGUMINOUS VEGETABLES IN ROOF TOP/TERRACE GARDEN**

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### **1. Cultivation of leafy vegetables in terrace garden(Amaranthus, Coriander, Fenugreek, Moringa for leaf)**

#### **Crop Selection**

Almost all leafy vegetables that are grown in a typical terrace garden will also do well as a container-grown plant. Vegetables that are ideally suited for growing in containers include amaranthus, coriander, fenugreek, tomato, brinjal, chilli, bhendi, lablab-bush type cabbage, cauliflower, knol-khol, cowpea, french beans and moringa which are commonly suited for terrace garden cultivation. The process of selection of varieties is extremely important for the terrace garden.

#### **Growing media for leafy vegetables**

Any growing media with high water holding capacity, provides nutrients and a physical support in order to grow healthy plants is ideal for cultivation. A good growing media must also drain well. Synthetic or soilless mixes are well suited for vegetable container for gardening / terrace gardening and may be composed of sawdust, wood chips, peat moss, perlite, or vermiculite. They should be free from disease causing pathogens and weed seeds, should hold moisture and nutrients but drain well and lightweight. Soilless mixture/media can also be prepared by mixing horticultural grade vermiculite, peat moss, limestone, superphosphate and garden fertilizer. To one part of vermiculite and peat moss, 10 tablespoons of limestone, 5 tablespoons of 0-20-0 (superphosphate) and 1 cup of garden fertilizer such as 6-12-12 or 5-10-10 should be added. The material may be mixed thoroughly while adding a little water to reduce dust formation. The mixtures are to be thoroughly moistened before seeding or transplanting. Soil mixtures are made of equal parts of sphagnum peat moss or compost, pasteurised soil and vermiculite or perlite. Composted cow manure is then added to improve the physical properties of the soil and as a nutrient source. Soil mixtures have higher water holding capacity than soilless mixes.

#### **Sowing of leafy vegetable seeds**

Most of the leafy vegetables are direct sown crops. Leafy vegetables *viz.*, amaranthus, coriander and fenugreek are broadcasted on the hills or lines which are formed above the growing media and covered with light media to ensure easy germination. Those seeds are very fast in germination and they germinate 4-6 days after sowing. After that light irrigation is needed for better growth and 15 days after germination, poly feed of 19:19:19 NPK formulation can be sprayed as foliar nutrient to ensure leaf yield and better growth @ 2g/l.

## **Fertilizer application**

Commercial fertilizers are either time-release or water soluble. Time-release fertilizer is mixed with the potting media at the time of planting. The NPK combination of 20-20-20 or 19-19-19 are the two grades commonly sold in the market.

The easiest way to add fertilizer to the plants grown in containers is to prepare a nutrient solution and pour it over the soil mixture/media. There are many good commercial fertilizers which are available to make nutrient solutions. While applying one should always follow the application directions on the label. Nutrient solutions can be prepared by dissolving 40-60 gm of a complete fertilizer such as 10-20-10, 12-24-12, or 8-16-8 in 15 litre of warm tap water. This mixture is highly concentrated and must be diluted before it can be used to fertilize the plants. Apply only tap water to keep the soil mix moist enough until the seeds germinate. Once the plants emerge, begin using the nutrient solution.

The frequency of watering may vary from crop to crop. Usually once in a day is adequate. If the vegetable produces a lot of foliage, twice a day may be necessary. Plants require less water during their slow growth period. At least once a week, it is advisable to leach out the unused fertilizer out of the media by watering with tap water. Sufficient water may be added to the container with free drainage at the bottom. This practice will flush harmful minerals out of the soil mixture. Water with a nutrient solution containing minor elements could also be used occasionally. Using a water-soluble fertilizer that contain iron, zinc, boron and manganese is ideal.

## **Watering**

Proper watering is essential for a successful container garden. Containers with poor drainage will slowly kill the plants. If the mixture becomes water-logged, the plants will die from lack of oxygen. Wetting the foliage of plants should be avoided since wet leaves will encourage plant diseases. Use the nutrient solution for each watering except for the weekly leaching where only tap water is used.

Water holding gels are becoming popular for use in container gardening. These starch-based gels are called hydrogels. They absorb atleast 100 times more water than their weight and slowly release that water into the soil as it dries. To be effective, they should be incorporated in the media before planting. Mulches can also be placed on top of the soil mixture to reduce water loss. Compost, straw, pine needles, grass clippings, shredded bark and moss are examples of mulches and vary in their effectiveness.

## **Light**

Nearly all vegetable plants grow better in full sunlight than in shade. However, leafy vegetables such as cabbage, greens, spinach and parsley can tolerate more shade than root crops such as radishes, beets and turnips. Fruit vegetables such as cucumbers, peppers, tomatoes and eggplant need more sunlight. One major advantage of container garden is that they can be placed in areas where they can receive the best possible growing conditions.

## **Harvesting**

Vegetables are harvested at their maturity when a vegetable's full flavor has developed. At the end of the harvest season, discard the plant and soil from the pot. Do not reuse the same soil for a second season of production. Infected soil or mix will spread disease into the second season crop unless it is properly composted. Properly composted planting media can be reused.

## **2. Cultivation of Cruciferous and Leguminous vegetables(Cabbage, Cauliflower, Knolkhol, Cowpea and French beans)**

### **Selection of varieties**

All the cruciferous and leguminous vegetables grow during cool seasons of the year. Among them, cool season vegetables suited for growing in containers include cabbage, cauliflower, knolkhol and french beans. The process of selection of varieties is extremely important for the terrace grown cool season vegetable crop. The varieties that suited for terrace garden will also do well in container garden.

### **Sowing and transplanting**

Vegetables that are transplanted can also be best suited for container/terrace culture. Seedlings may be purchased from local nurseries or can be grown at home. Seeds can be sown in a plastic tray, pot, or even a cardboard milk carton. The container should be filled with the media and cover most vegetable seed with 1/4 inch to 1/2 inch of media to insure good germination. Landscape cloth or screen in the bottom of the pot will improve drainage and invigorate plant growth. Most cool season vegetables should be transplanted into containers when they develop their first two to three true leaves. Transplanting of seedlings should be done carefully to avoid injury to the young root system.

## **Watering**

Life irrigation on third day is mandatory for potted plants grown / transplanted in the terrace garden. Proper watering is essential for a successful container garden. Containers with poor drainage will slowly kill the plants. If the mixture becomes water-logged, the plants will die due to lack of oxygen. Wetting the foliage of plants should be avoided since wet leaves will encourage plant diseases.

## **Fertilizer application**

Water soluble fertilizers are recommended for cole and legume crops. Many water soluble fertilizers are available in commercial markets. All 18:18:18, 19:19:19 and some of the micronutrient mixtures along with major nutrients can be applied through foliar sprays for the successful cultivation of vegetables in terrace garden. It is good to occasionally water with a nutrient solution containing minor elements. At least once in a week, it is advisable to leach the unused fertilizer out of the soil mix by watering with tap water. Copious water may be given to the container to cause free drainage from the bottom. This practice will flush harmful minerals out of the the soil mixture.

## **Harvesting**

Harvest the vegetables at their peak of maturity when a vegetable's full flavor has developed. Bright white colour heads are considered to be good quality curd than the yellow coloured curd in cauliflower. Size of the knolkhol and tenderness of the beans and cowpeas are very important for harvesting.

## **3. Cultivation of moringa**

*Moringa oleifera* is a fast growing vegetable crop. It grows to a height of 4 to 5 metres with a straight trunk (10- 30 cm thick) with corky whitish bark and an open, umbrella shaped crown. For terrace garden, annual moringa is suitable. After the harvest is over, the plant can be pruned for ratooning and allowed to regrow to encourage vigorous leaf and pod production so that the pods and leaves remain within arm's reach.

Moringa grows best in well drained sandy or loamy soil with a normal pH of 6.2 to 7.0. It can tolerate poor soil including coastal sandy soil. It is of sub-tropical origin and the most important consideration is that the plant can be killed by continuous frost. There are ways of minimising the effect of cold (eg. mulching) but no assurance to increase the warmth. Water stagnation may kill the plant. Hence, sandy well drained soil is suitable for its growth. The seeds can be sown directly (or) 60 days old seedling can be transplanted in big containers with more depth.



The young seedlings must be protected from strong winds. In very hot areas, watering is daily required (making absolutely sure that the roots are not water-logged - ie. the water must be able to drain away). Like other vegetables, addition of organic / inorganic nutrients is essential. They grow best in tropical and sub-tropical climate.

When the seedlings reach a height of-60 cm, pinching of the terminal growing tip 10cm from the top is done. This encourages secondary branches appearing on the main stem about a week later. When they reach a length of 20cm, pinch them back to 10cm. Use a sharp blade or knife / secateurs to make a slanting cut, tertiary branches will appear.

This will encourage the tree to become bushy and produce many pods within easy reach. If pinching is not done then the tree has a tendency to shoot up vertically and grow tall with sparse flowers and few fruits found only at the very top. Annual pruning is advisable. After the harvest is over, the tree is cut back to one metre from ground level and allowed to regrow. This technique is called 'ratooning'.

**Table 10. Common Problems in terrace gardening of leafy and legume crops**

S.No	Problems	Cause	Corrective Measure
1	Plants tall, spindly and unproductive	Insufficient light	Move container to area with more light
		Excessive nitrogen	Reduce feeding intervals
2	Plants yellowing from bottom, lack vigor and poor color	Excessive water	Reduce watering intervals; Check for good drainage
		Low fertility	Increase fertility level of base solution
3	Plants wilt although sufficient water present	Poor drainage and aeration	Use mix containing higher percentage organic matter, increased number of holes for drainage.
4	Marginal burning or firing of the leaves	High salts	Leach container with tap water at regular intervals
5	Plants stunted in growth; sickly, Purplish color	Low temperature	Relocate container to warmer area
		Low phosphate	Increase phosphate level in base solution
6	Holes in leaves, Leaves distorted in shape	Insects	Use recommended insecticide
7	Plant leaves the with spots, dead dried	Plant diseases	Use recommended fungicide

# CULTIVATION OF FRUIT AND TUBER VEGETABLES IN TERRACE GARDEN

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## **1. Cultivation of Solanaceous vegetables in terrace garden (tomato, chilli, brinjal,)**

### **Crop selection**

All the Solanaceous vegetables are well suited for growing in containers, bags or pots *viz.*, tomato, chilli and brinjal. Selection of crops and their varieties depends on the grower or consumer's demand since there are numerous types varying in fruit size, colour and shape.

### **Growing media**

Any growing media with high water holding capacity, provides nutrients and a physical support in order to grow healthy plants. A good growing media must also drain well. Synthetic or soilless mixes are well suited for vegetable container gardening / terrace gardening and may be cocopeat, pot mixture (sand: well decomposed FYM: red earth in the ratio of 1:1:1) or potting media composed of sawdust, wood chips, peat moss, perlite, or vermiculite. The media should be free from disease causing pathogens and weed seeds, should hold moisture and nutrients but drain well and lightweight. Soilless mixture/media can also be prepared by mixing horticultural grade vermiculite, peat moss, limestone, superphosphate and garden fertilizer. The material maybe mixed thoroughly while adding a little water to reduce dust formation. The mixture are to be thoroughly moistened before transplanting. Soil mixtures tend to hold more water than soilless mixes.

### **Sowing of seeds**

Tomato, chilli and brinjal are propagated by seeds and are first sown in protray or cups until the seedlings become 28 days old in case of tomato, 30 days old in case of brinjal and 45 days old for chilli and they are further transplanted in pots or containers. Seeds of high yielding varieties with tolerance to pests and diseases may be selected and should be carefully obtained from certified farms. To raise nursery, the seeds are to be planted at a depth of 0.5 cm to 1 cm. After sowing the seed, a thin layer of soil should be used for covering.

### **Light**

For best growth, the solanaceous crops are to be provided with 6 to 8 hours a day of full sunlight. Balconies are also suitable for growing vegetables, but there should be sunlight for at least 6 hours a day.

## **Fertilizer application**

There are two basic types of fertilizers viz., organic and inorganic. -Organic fertilizers are derived from living organisms, and it adds texture to the potting soil. For instance, bacteria and fungi in the soil break down organic fertilizer, so that the plants can slowly but steadily take up the nutrition from the fertilizer. However, inorganic fertilizer delivers more nutrients more quickly to the plants.

The best organic fertilizers to use include manure, compost, seaweed, vermicompost and bio fertilizers. Organic fertilizers that lasted from 6 weeks to 3 months are recommended before they need to be added again. Inorganic fertilizers are chemical additives, such as nitrogen, phosphorus, potassium which are the three essential nutrients and micronutrients such as calcium, iron, zinc, magnesium and more. Inorganic fertilizers can come in many different forms; such as solids and liquids. Liquid fertilizers release nutrients quickly, while slow-release pellets or granules can be applied fortnightly or monthly or once a season.

Tomato, chilli and brinjal are provided with a constant supply fertilizer by including slow-release fertilizer that is water soluble with a weekly dose of 5:10:10 NPK ratio in the potting soil. A weekly dose of 19-19-19 NPK will give the additional boost for the plant. Nitrogen should be provided adequately as more nitrogen promotes leafy growth and will lead to less flowering and fruit production.

## **Watering**

Plants get their water from the soil through their roots and a small proportion is taken through their leaves. Because plant containers are small, their roots only have a small amount of potting soil to draw water from which is why the container gardener has to carefully check plants for signs of under watering and overwatering and water the plants often, especially on hot, sunny and windy days, when plants and their potting soil can lose dangerous amounts of water. When watering the plants for terrace gardening of Solanaceous crops, make sure that the water penetrates down through the container, rather than just the surface of the potting soil. The best time to water container plants is in the early morning or evening so that the plant roots will have more time to soak in water before the sun comes out and dries out the potting soil.

Mulch or pebbles can be also used which are kept on the surface of soil which can reduce the amount of water that evaporates from the plant container. Water-retaining crystals and hydrogels are used as well that will be hold at least 100 times their weight in water and slowly release that water in to the soil as it dries.

## **Staking**

Staking is done only in tomato where the vines are tied with a rope to the bamboo sticks or poles or cages providing a good support to the plant, keeping it upright and vertical and getting all the sunshine they can soak up.

## **Harvesting**

Tomato and brinjal crop will be ready for harvest in about 70 days after planting. Chilli pods can be harvested at 90 to 100 days after transplanting which can be continued for 2 to 3 months as it is a long duration crop.

## **2. Cultivation of Okra**

### **Crop selection**

Okra grows well in a container and can be easily maintained. Based on the colour (green, light green fruited and dark green) the choice of varieties of okra can be sown directly in containers.

### **Growing media**

Similar to other vegetable crops.

### **Sowing of seeds**

Seeds are sown directly at 2 to 3 cm depth into the container. Two seeds can be sown in one container or bag and after 5 days, germination takes place. The soil should be kept moist after sowing the seeds.

### **Light**

Okra grows best in full sun where it needs at least 6 hours of full sun everyday for a healthy growth and good quality pod production.

### **Watering**

Okra plants should be well watered daily but overwatering should be avoided so as to prevent rotting. It is best to water in the morning and apply a thick layer of mulch to keep the potting soil moist and to reduce the weeds.

### **Fertilizer application**

Since okra requires plenty of nutrients to grow, add organic manure, NPK and micro nutrients to the soil periodically. Absence of nutrients may result in less number of fruit production. Compost or slow release fertilizer, 19-19-19 or 20-20-20 formulation can also be recommended thrice at the time of sowing, during flowering and during pod development phase foliar spray with micro nutrients can be given. Liquid fertilizers can also be used.

### **Thinning**

After the emergence of true leaves, plants are thinned so that one plant per container depending upon the size of container is done so as to give a proper space to grow and to get good yield.

## **Harvesting**

Okra plant starts giving fruits within 50 to 60 days of sowing of the seeds. Five to 10 cm long full grown but still tender pods are harvested by hand picking or cutting with a sharp knife or secateurs. Harvesting could be continued on alternate days in 10 to 15 pickings in 1.5 to 2.0 months. Okra plants have short hairs that may irritate bare skin, so wearing gloves and long sleeves when harvesting is advisable

## **3. Cultivation of root vegetables (radish, carrot, beetroot)**

### **Crops selection**

Growing root vegetables in containers may seem to be odd or even inconceivable, but it is actually very easy and rewarding to plant root vegetables in a container or bags. Root crops are selected based on the size and planting time. Containers for growing carrots should be at least one foot deep. In case of beetroot, there are many varieties, including small varieties, those with good foliage and the best tasty varieties for leaves are 'Early Wonder' and 'Green Top Bunching.' The best plant container varieties are 'Mini Ball' and 'Baby Ball'.

### **Growing media**

Preparation of proper growing media is very important in achieving success with the root crops. They grow best in a deep, loose soil that retains moisture and nutrients and yet well-drained and also free of weeds, insects, and diseases. The growing media used comprises of coco peat, perlite, farm waste compost, vermicompost mixed with bio fertilizers. Compost of leaves, grass clippings, wood waste, and farm animal manures are some of the common ingredients that are combined with water in piles and digested by huge populations of oxygen-loving microorganisms. A good media mixtures of 25% soilless mix+ 25% garden soil+ 50% compost is used as a growing media for root vegetables in terrace gardening.

### **Sowing of seeds**

Root crops are grown in the cooler season and they are propagated by seeds. Seeds are sown at 1 to 2cm depth in the media followed by watering.

### **Light**

To best care for root crops, let them receive full sun (will tolerate light shade) without allowing the roots to be exposed to the sun, so make sure the root is always covered with potting soil. If kept in too-hot weather, the taste of the roots will be more bitter in case of radish.

### **Fertilizer application**

For root crops, it is easier to balance the nutrients needed to sustain their growth. Root crops do not grow well in acidic soils. If a gardener wants to grow root vegetables, balanced fertilizer for best taste should be used. Potting mix can be improved by adding well-rotted manure or compost. Fresh manure should be avoided as it produces heat during decomposition and causes damage to growing plant.

## **Watering**

Proper watering can make the difference between good production and poor production. Root vegetables require deep, regular watering to encourage root growth. The potting media is kept moist but not soggy for best taste and never let the media dry out. Watering should be reduced when the plant matures. There is little or no value in a light watering that only wets the surface of the soil. In fact, light watering often promote shallow root development and can increase the crop's susceptibility to hot weather and drought stress, and reduce product quality. Also, any weeds present should be removed as root vegetables cannot compete with them.

## **Thinning**

At about 3-4 weeks, seedlings are thinned in case of beet. A patch of root vegetables may produce a lot of foliage but will not be able to produce hardy roots if they are fighting for space to grow. Depending on the choice of the grower, if beets are planted for their roots, the plants are thinned out so that they stay healthy and have a good root growth. However, thinning is not necessary if beet plants are grown for their leaves.

## **Harvesting**

Harvesting of root vegetables should be carried out by uprooting with leaves intact or by digging. Radishes should be harvested 45 to 60 days after sowing of the seeds before they become too large and pithy. Carrots can be harvested within 60 to 70 days of sowing. Watering should be stopped 15 to 20 days before harvesting to develop sweetness in carrot and beetroot can be picked after it reaches 50 days of maturity and when the root is of the size 1.5 to 2 inches in diameter and the leaves are harvested when they are young and tender and have reached about 6 inches tall. If harvesting is delayed, the root becomes mature and the central part turns spongy and pithy and becomes useless for eating.

## **4.Cultivation of onion**

### **Crop selection**

There are many onion varieties that suits well for terrace gardening. They are CO1, C02, C03, CO4 and MDU 1, CO (On) 5 (free flowering and seed setting type) are commonly grown onion varieties.

### **Growing media**

Onion plants do best with potting soil that is a bit alkaline, so if the soil is acidic, a bit of lime may be added. And because they produce bulbs underground, plant them in a large plant container (more than 1 foot deep) so the bulbs have room to grow. The seedlings are to be planted in the potting mixture containing *Azospirillum* in sufficient quantity.

## **Sowing**

Medium sized bulbs are to be chosen for planting. In some varieties like Co (On) - 5, seeds are used as propagating material @ 8kg/ha.

## **Raising seedlings and transplanting**

This is the most common method practiced method as it results in high yield and large size bulbs. In plains, seeds are sown during October-November. Seeds are first sown in well prepared nursery beds of 90-120 cm width, 7.5-10.0 cm height and convenient length. Ratio between nursery area and main field is about 1:20. Seed rate varies from 8 to 10 kg/ ha. Seedlings of 15 cm height and 0.8 cm neck diameter are ideal for transplanting and this is achieved in 8 weeks. However, it varies from 6-10 weeks depending on soil, climate and receipt of rain. There is a practice of topping seedlings at the time of transplanting if seedlings are over-grown.

## **Watering**

Irrigation is done after transplanting or planting the bulbs. Complete wetting is necessary to maintain uniform moisture level. Watering should be given once in a day depending on the soil and weather conditions or otherwise, when the soil becomes partially dry.

## **Light**

Full sun is required for planting onion for terrace gardening.

## **Fertilizer application**

Before planting onions, fertilize the potting soil. Then fertilize every 2-3 weeks with a low-nitrogen all-purpose fertilizer. Too much fertilizer will burn the roots and make the leaves droopy or yellow. Too much nitrogen should not be applied as it will delay maturity.

## **Harvesting**

Harvest is done when 75 % of leaves dried off or top fall stage. Bulbs are harvested by uprooting the plants. After harvesting, leave them outside to dry for the rest of the day. Then let the onion bulbs dry for two weeks indoors. Bulbs are to be stored in a cool, dry place. Fresh onion will have the best taste, but they can last for 3-4 months if stored correctly.

## **6. Cultivation of cucurbits (bitter gourd, snake gourd, ribbed gourd and cucumber)**

### **Crop selection**

Selection of desirable crops and their varieties is the basic step of terrace gardening since various varieties, size, shape and colour are present in cucurbits. Gourds like bitter gourd, snake gourd, ridge gourd and cucumber are some of the popular cucurbits which can be easily grown in the roof garden.

## **Sowing and transplanting**

Seeds can be sown directly into the containers. Seeds require the temperature above 20°C for germination. The seeds are sown at 2 cm deep directly in the containers or germinate the seeds separately using paper tea cups, polythene bags and transplant. Seedlings are thinned out to four or five when the seeds germinate if sown directly in the container.

## **Light**

Six to eight hours of full sun should be provided to the vine and the plants will produce heavily.

## **Fertilizer application**

Cucurbits are heavy feeders, so a slow release, all-purpose fertilizer is mixed into the potting soil before planting and then use seaweed combination, once in every other week during the growing season. Enriching the soil with compost or well-rotten aged manure and regular inputs of organic matter will be enough later. Since, the cucurbit grown in containers with a relatively small amount of potting soil, fertilization as often as possible is imperative (at least every week). Overuse of nitrogen-rich fertilizers should be avoided, which could encourage the development of foliage at the expense of fruits.

## **Watering**

The success of cucurbits depends on consistent and ample watering. Cucurbit plants should be watered often to make sure the potting soil never dries out by checking using a finger up to the second knuckle into the soil. If the soil is moist at a fingertip, wait to water. If it is dry, add water very slowly, until it flows out of the drainage hole at the bottom of the container. Dry soil will affect the crop, but overwatering can lead to root rot. If the soil is very dry, it can shrink away from the walls of the pot.

## **Trellising**

There are several reasons to trellis cucurbit vegetables. First, if they are sprawling all over the ground, and most varieties will sprawl. Also, if they are grown on a trellis, they are easier to find and harvest. Also, depending on the set-up, plants that are on trellis can give more leaves when exposed to sun which makes good crop growth and production. A 12 inches deep pot and a sturdy trellis is required. A trellis or any other support structure that is at least 5-6 feet tall is required. Once the vine has reached that height redirection is necessary. The vine can be grown on pergolas, arches or arbor. In the case of growing horizontally on the ground, there is a high risk of fruit rot and fungal infection to the plant in addition to other disadvantage.

Most commonly the gourds are planted in poly bags and kept near the parapet walls or water tanks to make them trail on the walls with the help of GI wires.



## Pruning and training

Pruning and training the vine over the trellis is very important to get maximum yield from the plant. Cucurbit plant produces numerous side shoots, which must be removed to improve yield, remove the side shoots (lateral branches) until the plant reaches the top of the trellis. Only 4-6 laterals are allowed and the tip of the main shoot is pinched to improve the productivity of the plant.

## Harvesting

Cucurbits can grow ridiculously fast. They can go from tiny to enormous in just a few days. In cucumber, fully developed, but tender and green fruits are harvested and used in green salads. Immature tender fruits can be harvested 45 days after sowing. On an average 8 – 10 harvests can be done. Harvesting can be done often, because the more it is harvested the more the yield.

Bitter melon starts to fruit quickly in 2 months. Fruits are harvested when they are green, little pale and unripe and about the size of 3 to 6 inches (depending more on the variety and type). Within 6 to 8 weeks after the germination. The blossoms will be seen and in the next 15 days fruits will be ready for harvest.

Harvest the ribbed melon fruits at young stage before the skin becomes thick, otherwise the fruits will become inedible with lots of fibre.

**Table 11. Common problems found in terrace gardening**

Sl.No	Problems	Physiological disorder	Corrective measures
1	Sunken spot on blossom end of fruit due to Ca-deficiency	Blossom end rot	Provide calcium to the growing media, spray with seaweed extract
2	Malformed fruit with scars near blossom end; due to cool weather	Catface	Avoid varieties that are prone to catface
3	Fruits split open due to warm raining weather after a dry spell	Cracking	Maintain even moisture by watering regularly, mulch potting soil around the plant
4	Yellow patches on fruit due to overexposure to sun	Sun scald	Maintain plant vigour to avoid defoliation

5	flowers fall off before pollination occurs; due to sudden temperature changes lack or excess water and fertilizer	Blossom drop	Maintain growth by adding adequate provision of water and fertilizer
6	Yellowish white patches on the fruit	N deficiency	Use good compost, adequate supply of N-fertilizer
7	Reddish purple leaves	P deficiency	Apply rock phosphate , bone meal
8	Bronze spots between leaf veins, underdeveloped roots	K deficiency	Use granite dust, wood ashes and compost
9	Forked tap root due to hard soil pan	Forking	Loosen soil and apply vermi compost
10	Roots split as a result of sudden increase in soil moisture after drought	Splitting	Keep soil moisture at optimum condition and loose
11	Fruit cracking	B deficiency	Borax must be given

# KITCHEN GARDEN

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## **Kitchen garden**

A home garden or kitchen garden refers to raising of vegetable crops in the back yard. of a house, but with the growing demand for the valuable land in urban areas the city dwellers may not have any land adjoining their apartment, yet the enthusiasts have interest in growing vegetables over the roof or in the verandah. Special arrangements are made on the roof to grow vegetables on soils placed on floors after using water proof cementing. Other vegetables are grown in boxes, pots and such other structures. All these refer only to the kitchen gardening. Growing vegetables in one's own garden is not only an art but also a continuous training for the person and the family. It supplies fresh vegetables. It constitutes a healthy hobby and the spare time of the family is well utilized. The fresh vegetables not only ensure a better balanced diet but there is also a delicate psychology behind the taste as everyone will definitely appreciate the produce obtained by their own Effort.

## **Advantages of Kitchen garden:**

- ❖ Supply fresh fruits and vegetables high in nutritive value.
- ❖ Supply fruits and vegetables free from toxic chemicals.
- ❖ Help to save expenditure on purchase of vegetables.
- ❖ Vegetables harvested from home garden taste better than those purchased from market.
- ❖ Effective utilization of kitchen waste water and kitchen waste materials.
- ❖ Exercise to the body and mind.

## **Size and shape of vegetable garden depends on**

- ❖ Availability of land
- ❖ Number of persons in family and
- ❖ Spare time available for its care
- ❖ Nearly five cents of land (200 m<sup>2</sup>) is sufficient to provide
- ❖ vegetables throughout year for a family consisting of five members
- ❖ A rectangular garden is preferred than a square plot or a long strip of land.

## **Implements used in kitchen garden**

- ❖ Spade
- ❖ Pick Axe
- ❖ Hoe
- ❖ Hand sprayer

- ❖ Rode can
- ❖ Rose
- ❖ Secateurs

### **Selection of site**

There will be a limited choice for the selection of a site for the kitchen garden. It is usually the backyard of the house which is convenient as the members of the family can give a constant care to the vegetables during the leisure time and the waste water from the wash rooms, kitchen *etc.*, can easily be diverted to the vegetable beds. The size of a kitchen garden depends upon the availability of land and number of persons for whom vegetables are to be provided. No choice in the shape of the kitchen garden wherever possible rectangular garden is preferred to a square one. By close attention to succession cropping and intercropping, five cents of land may be adequate to supply vegetables for an average family of five.

The main aim of kitchen garden is the maximization of output and a continuous supply of vegetables for the table throughout the year. By following certain principles in the layout of kitchen garden, the above objective can easily be fulfilled.

1. The perennial plants should be located on one side of the garden, usually on the rear end of the garden so that they may not shade other crops, compete for nutrition with the culture of other vegetable crops.

2. Adjacent to the foot path all around the garden and the central foot path may be utilised for growing different short duration green vegetables like coriander, Ceylon spinach, fenugreek, alternanthera, mint and amaranthus. Each type of this green can be grown along each side of foot path and these crops can be rotated in different seasons.

3. The fence or trellises around the home garden may be utilised for growing light creepers like Basella, Coccinea, sponge gourd and bitter gourd. These may be also rotated in different seasons.

4. The compost pits are placed in two corners of the garden. They are meant for garden wastes and kitchen wastes. Pandals may be erected over the compost pits and trained with the creeper vegetables like lablab, ribbed gourd, snake gourd. This will hide off the compost pits from view.

5. Pandals may also be erected over the central foot path, grapes varieties like Anab-e-Shahi or Black Prince may be trained over it.

6. Both the sides of the central foot path may be utilised to train tomato plants on single stemmed with the support of stakes.

7. The bunds separating the beds may be used for growing root crops or onion.

8. The conveniently divided small plots may be utilised to produce as much as possible by following a very intensive method of cultivation. This is possible by following continuous crop pattern in the form of succession and companion cropping.

**Table 12. Crops suited for Kitchen garden**

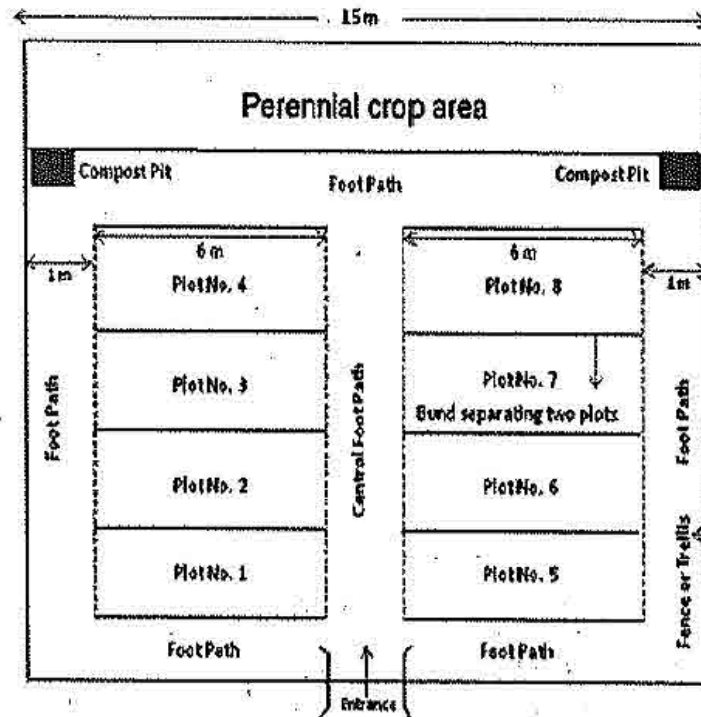
<b>Fruits</b>	<b>Vegetables</b>	<b>Spices</b>	<b>Medicinal</b>	<b>Flowers</b>
Mango	Tomato	Turmeric	Aloe	Rose
Banana	Brinjal	Coriander	Vasambu	Hibiscus
Sapota	Chillies	Mint	Vallarai	Jasmine
Guava	Onion	Fenugreek	Thulasi	Nerium
Papaya	Bhendi	Fennel	Omavalli	Ixora
Acid lime	Bitter gourd		Keelanelli	Barlarea
Ama	Snake gourd		Pirandai	
Pomegranate	Ribbed gourd		Thoothuvalai	
Annona	Bottle gourd		Ponnanganni	
	Amaranthus		Manathakkali	
	Lab lab		Vettiver	
	Beetroot			
	Radish			
	Curry leaf			
	Moringa			
	Spinach			
	Clusterbean			
	Cowpea			

**Model kitchen garden and the cropping arrangements:**

As recommended by dieticians to consume 300 gm of vegetables daily by an adult and based on this, a kitchen garden should supply 1.5kg of fresh vegetables to an average family size of two adults and three children. This quantity of fresh vegetables can be assured from a kitchen garden, laid out in an extent of 5 cents (200 sq.m) following the above principles.

It is advisable to make a plan before undertaking the planting of a garden. The location of plots, crops to be grown, the probable date of planting, spacing between the plants, inter cropping and succession planting should be clearly indicated in the plan. This will guide the gardener to get constant supply of all kinds of vegetables avoiding a glut of any one crop.

A cropping pattern which may prove helpful for kitchen garden under Tamil Nadu condition (excepting the hill station) is suggested below: It may be observed from the above crop arrangements that throughout the year some crop is grown in each plot without a gap between any two crops (succession cropping) and wherever possible two crops (one long duration and the other a short duration one) are grown together in the same plot (companion cropping.)



**Layout of model kitchen garden (Area 200 Sq.m)**

6.	Bhendi	Fruit borer <i>Earias insulana</i> , <i>Earias vittella</i>	The dirty brown & white coloured caterpillar bores into the terminal shoot and results in drying of shoots. Later it bores into the tender fruits plugging the bore hole with its excreta. The infested fruits get disfigured.
7.		Green leaf hopper <i>Amrasca devastans</i>	Causes hopper burn, thickening of veins & leaves drying & leaf fall
8.		Aphid <i>Aphis gossypii</i>	Infests the shoots, flower buds and fruits reducing the vitality of plants
9.	Crucifers	Diamond-back moth (DBM): <i>Plutella xylostella</i>	DBM is a cosmopolitan as well as exotic pest that causes yield loss up to 60 per cent. The caterpillar bites small holes (shot holes) at early stages and causes defoliation later. The infested plants show a withered appearance with whitish patches. The larvae feed the foliage, leading to retarded plant growth and reduction in the size of the heads as well.
10.		Cabbage semilooper <i>Trichoplusia ni</i>	The semi looper larva causes semilooper defoliation. The yield loss may be 30-60%. Caterpillars start scrapping and feeding on the leaves initially and later defoliate entire plant leaving midribs & main veins. More damage is evidenced in nurseries than in main field.
11.		Cutworms <i>Agrotis ipsilon</i> , <i>A. segeturn</i> , <i>Spodoptera litura</i>	Cutworms cause damage to the young seedlings in the nursery or in the mainfield by cutting them in the collar region or surface. The stout brownish moths and the larvae are active at night, hiding in the crevices & clods of the soil during the day time.
12.		Cabbage butterflies: <i>pieris brassicae</i> , <i>P. rapae</i>	The caterpillars alone feed on leaves, young shoots and green pods. When young, they feed gregariously but the grown-up caterpillars migrate from one field to another. The first instar caterpillars just scrape the leaf surface, whereas the subsequent instars eat up leaves from the margin inwards, leaving intact the main veins often, entire plants are eaten up.
13.	Cucurbits	Fruits: <i>Bactrocera</i> ( <i>Dacus</i> ) spp.	Fruit flies can cause 50-80% loss in yield. Musk melon, round melon, bitter gourd and long melon are the most preferred hosts. Ridge gourd, sponge gourd, cucumber, bathe gourd and pumpkin are the least preferred hosts. Water melon is moderately preferred, rotting of vegetables. Maggots feed on the pulp of the fruits. Oozing of resinous fluid from fruits. Distorted and malformed fruits, premature dropping of fruits and also unfit for consumption

14.		<b>Pumpkin beetles:</b> <i>Raphidopalpa faveicollis</i>	These beetles cause damage to cotyledons and young cucurbit leaves, <i>biting holes</i> characteristically. They also feed on the flowers. The grubs feed on roots, stems as well as on fruits touching the ground. <i>R. faveicollis</i> is more widespread than others, more abundant when the weather is warm. The pest emerges as adults over winters. The cucumber green mosaic virus is transmitted by <i>R. faveicollis</i> .
15.		<b>Serpentine leafminer</b> <i>Liriomyza trifolii</i> , <i>Phytomyza horticola</i>	This pest causes linear to blotch leaf mines in the cotyledons or leaves. One to several (0.5-3 mm) mm long larvae can be present inside the mine. The mined leaves are subsequently more susceptible to wind damage. The damage is heavy on young plants which may wilt and die. Gherkins (exported pickle cucumber) suffer the most. Active from July to November.
16.	ONION	<b>Onion thrips:</b> <i>Thrips tabaci</i>	It is a cosmopolitan and polyphagous pest with a wide range of hosts which include cole crops, cotton, cucurbits, tobacco, tomato, turnip, <i>Rosa</i> sp., etc. Small white silvery patches are seen all over the leaves. In severe infestation, leaves dry from tip to downward
17.	Greens	<b>Amaranthus weevil:</b> <i>Hypolixus trauncatulus</i>	The weevils feed on the leaves while the grubs tunnel within the stem causing swelling or gall above the ground level. A single plant may contain 17-18 grubs. The galls may cause the plant to rupture & breakoff.
18.	Greens	<b>Leaf cater pillar or leaf webber:</b> <i>Hymenia recurvalis</i>	The cater pillars web together the leaves and feed from within, skeletonizing the leaves completely. They also soil the leaves with excreta and the foliage loses its market value.
19.	Moringa	<b>Budworm: Noorda moringae</b>	The larva bores into the buds and flowers. Each bud harbours only one larva. The infested buds fall. The problem is more severe in summer during which up to 78% of buds may be damaged. The female moth lays creamy white eggs on the flower buds either singly or in cluster. Pupation takes place in the Soil or on the ground surface in cocoons.
20		<b>Leaf webber :</b> Noorda blitealis	It is a very common pest in south india. The larva webs the leaves by joining the undersurface of leaflets. As it feeds on the chlorophyll, the entire tree becomes papery white and skeletonized. The attack is more in March-April, December – January.



21		Moringa hairy caterpillar: Eupterote mollifera	This is a serious and specific pest of moringa in south India. diurnal in habit, the caterpillars are voracious feeder of the foliage, and sometimes on the bark. The whole tree becomes devoid of leaves in case of infestation. Adult moths are large in size, uniformly faint yellowish in colour with brown wavy markings on the wings. They lay eggs in groups on the shoots and leaves.
22.		Moringa fruit fly : Gitona distigma	This pest causes gummosis on fruits that rot and dry. The pest is more serious during August September when 70% loss may occur. The eggs are laid in the grooves between the ridges of the fruits. The mature maggots pupate in the soil.

## INTEGRATED PEST MANAGEMENT

It is the pest management system that utilizes all suitable techniques and methods in a compatible manner as possible and maintains pest populations at levels below those causing economic injury that will ensure favourable economical, ecological and sociological consequences.

The control measures are termed as (1) Prophylactic or preventive and (2) Curative or direct methods.

**1. Prophylactic or preventive methods:** These are effective against seasonal or persistent pests. Field sanitation, crop rotation, resistant varieties, proper cultural practices (pest free healthy seeds), preventive treatments (seed treatment, swabbing tree trunks, with insecticides or tar, drying of grains, adjusting of sowing time etc.)

### **2. Curative or direct methods:**

**a. Cultural methods:** Crop rotation, trap cropping, mixed cropping, tillage, time of sowing or planting, pruning, fertilization, water management, sanitation, mulching, crop residue destruction.

### **Integrated pest management:**

The wide *range* of IPM options covers cultivation, mulching, physically excluding or removing pests, advancing planting or harvest dates, interplanting, using resistant plant varieties, enhancing the number of biocontrol organisms or environments that support them, and applying environmentally-friendly pesticides

- ❖ Start with healthy plants, buy well-branched, stocky transplants with healthy leaves, sturdy stems and well established root systems..
- ❖ Transplants need good root systems to quickly establish in the garden. Roots should be well formed, whitish and hold the soil mass together.
- ❖ Avoid older, overgrown transplants with flowers or fruit as this will limit yields. Reject plants with soft, brown or rotten roots.
- ❖ Select varieties with multiple disease and insect resistance or tolerance, if possible.
- ❖ Vegetables grow best in well drained soils and full sun – a minimum of six hours a day, ideally eight to 10 hours.
- ❖ Understand that different life stages of pests do not look alike and that not all stages cause damage or can be managed. By understanding their life cycles, you learn the best timing for successful management strategies.
- ❖ Select disease-resistant vegetable varieties and use proper plant spacing in order to allow good air circulation and drying of the foliage
- ❖ Scout for pests, check garden regularly for insects and diseases. Traps such as yellow sticky cards can be helpful in scouting. These can be placed just above the plant canopy and help detect some insects.
- ❖ Keep tools and equipment clean by using a solution of 10 per cent chlorine bleach to disinfest tools after using them on diseased plants.
- ❖ Keep plantings clean by removing and destroying diseased plants or those that are severely infested with insects during the growing season. Do not compost burn or bury instead, remove crop residues at the end of the growing season. This can be a place for certain garden pests to spend their unfavourable conditions.
- ❖ Control weeds all year long. Weeds compete with crops for water and nutrients and often provide a place for pest insects to hide and a good environment for disease organisms.
- ❖ Weeds serve as alternate host for number of insects.
- ❖ Manage weeds by hand-pulling or cultivating the soil with a hoe or apply organic mulches after the soil warms.
- ❖ If using pre-emergence herbicides, always follow label instructions to avoid damaging your garden plants.
- ❖ Rotate the garden location and where you plant crops within the garden every few years if space is available to avoid the buildup of plant diseases and insects.
- ❖ Hand-pick larger insects such as potato beetles and tomato hornworms. Manage diseases by prevention rather than treatment.
- ❖ Manage insects and mites by using insecticidal soaps and horticultural oils on soft-bodied insects and mites.
- ❖ Apply organic mulches when vegetable plants are 2-3 inches tall, leaving 2-3 inches around the plant unmatched. if you apply mulch to a newly seeded area, do

not cover the seed row with the mulch. Before applying mulch, first remove weed seedlings from the area.

- ❖ Keep plantings clean by removing and destroying diseased plants or those that are severely infested with insects during the growing season.
- ❖ **Crop rotation.** If space is available, rotate the location of the garden every few years to avoid the buildup of plant diseases and insects. The least you could do is rotate the location in the garden among plant families. For example, the nightshade or Solanaceous family is made of tomatoes, peppers, eggplant and potatoes. They share several insect pests and diseases, so rotating the family to different locations from year to year can lessen or prevent problems.
- ❖ Use insecticidal soaps and horticultural oils on soft-bodied insects and mites. Always follow label directions for application and use only insecticides that are registered for the crop.
- ❖ Mites - Spraying with wettable sulphur 80WP (2 g/litre of water) or dicofol 18.5EC (2.5 ml/litre of water) or spiromesifen 22.9 SC 40 ml in 50 litres of water effectively control the mites.
- ❖ Japanese beetles can be knocked off plants into a container of soapy water to drown. Gardens managed with minimal insecticides often have abundant natural enemies present to keep some insect pests at bay.
- ❖ Create refuges of nectar and pollen plants for beneficial insects nearby. Floating row covers can be used to exclude insect pests, but will need to be removed before pollination can take place.
- ❖ Use horticultural grade insecticidal soap, 1 tablespoon / 5lit of water.
- ❖ Horticultural grade neem oil, with 1 tablespoon per litre of water, always sprays in morning, before sunrise, or in late evening. *Never* spray in sunlight.
- ❖ Spray plants liberally - soak them- and be sure to get the undersides of leaves where the insects feed. Discard old spray. Clean sprayer well after each use.
- ❖ Conserve predators such as lacewings, lady beetles, spiders, fire ants etc.
- ❖ Foliar spray of NSKE 5%
- ❖ Apply once a week during light pest season or twice a week during heavy pest season.

#### **Organic spray for all worms or caterpillars:**

- ❖ *Bacillus thuringiensis* (Thuricide) 2g/litre of water apply when you first start seeing worms in the areas they are feeding.
- ❖ Soil application of neem cake (once immediately after germination and again at flowering) followed by NSKE @ 4% and neem soap 1% alternately at 10-15 days interval.

## **Cattle-dung and Urine Extract**

- ❖ Mix Cattle-dung (5 kg) and urine (5 liters) thoroughly in 5 liters of water in a container and allow this mixture for 4 days by keeping a lid over the container.
- ❖ After 4 days, filter and add 100 grams of lime to this solution.
- ❖ Dilute the solution in 80 liters of water, which is sufficient for spraying an acre.
- ❖ Spraying cow dung urine solution prevents eggs laying by the moth, e.g. *Helicoverpa* and *Spodoptera*, etc. It is found to give protection against some diseases and the sprayed crop looks green and healthy.
- ❖ Nuclear Polyhedrosis Virus (NPV)
- ❖ Collect 40 NPV infected *Helicoverpa* or 20 *Spodoptera* larvae from field. Grind the collected larvae. Filter the solution obtained using a thin cloth. Dilute the NPV solution to 10 litres and add 10g of Robin Blue to protect from UV light in the field. Spray this solution during evening hours.
- ❖ Insects Controlled: *Helicoverpa*, *Spodoptera* virus of one insect species does not kill the other insect species. Virus infected dead larvae are observed hanging head down from top branches 2-5 days after spraying the solution in the case of *Helicoverpa* and *Spodoptera*.

## **Traps in Pest Management**

**a. Fishmeal trap:** It consists of a plastic jar of 15x40cm size with holes in the middle portion for the flies to enter and a plastic funnel with a collection jar at the bottom. The jar has small dispensers at the top, one with 25gm of decomposed fishmeal and another with insecticide (dichlorvos) soaked cotton. The adult flies that are attracted by the smell of fishmeal are killed by the fumigant action of the insecticide. Fishmeal should be changed once in a week.

**b. Fruit fly trap:** A small plastic container with holes at top has 2 dispensers, one with 5ml of methyl eugenol and another with cotton soaked with dichlorvos.

### **c. Sex pheromone traps (Pheromone of female is used to attract males)**

**Delta trap:** It consists of a triangular paper bowl in which pheromone septum is placed inside. The attracted insects are stuck in the gummy substance pasted inside the trap. It is exclusively used to attract noctuid pests.

**Baffle trap:** It has a baffle at the top with a provision to hold a septum. This is connected to a poly bag having insecticide soaked cotton. It is used to trap and monitor pests like *Helicoverpa*, *Spodoptera* and *Earias*.

## **Plant products and its preparation**

Plant products like neem oil, neem seed kernel extract, pungam oil, illuppai oil, leaf extracts of nochi, neem etc., are used in the pest management. The important active principle in the neem products is 'Azadirachtin'.

**Neem oil (NO):**To get a 3% solution, first thoroughly mix 5ml of sticking agent teepol or 5 g of Khadi soap powder with 50 ml of water and then mix 30 ml of neem oil until white emulsion is formed. Then add 920 ml of water and mix thoroughly.

**Neem seed Kernel Extract (NSKE):**For preparing 5% NSKE, take 50g of powdered seed kernel and soak it over night in 500 ml of water. Filter through muslin cloth and make up the volume to one litre. Add teepol 1-2 ml or Khadi soap powder 1-2g before spraying.

### **Tobacco Decoction**

- ❖ Boil 1 kg tobacco dust in 10 liters of water for 30 minutes to attain coffee red colour.
- ❖ Add water to the boiling solution to make 10 litres volume.
- ❖ Cool and filter the decoction using a thin muslin cloth.
- ❖ Add soap @ 2 g/l and dilute to 80 to 100 litres for spray. This preparation is effective against whitefly, aphids, and leaf hoppers.

Note: Tobacco decoction should not be used for more than once, as it is toxic to natural enemies.

### **SOME USEFUL TIPS IN PEST MANGEMENT**

- ❖ Always use protective clothing while spraying.
- ❖ Avoid spraying insecticides repeatedly. Alternate them with botanicals, wherever possible to prevent development of resistance and pest resurgence.
- ❖ Add 0.5 ml of any sticking agent to the spray solution.
- ❖ Oil should be made into an emulsion before spray by shaking thoroughly in a bottle before dilution and sprayed immediately without any delay.
- ❖ Botanicals may cause phytotoxicity when the temperature is more than 32°C in poly house.
- ❖ Hence, it should be done with caution and only after pre- checking. It is always better to spray botanicals in the evening.
- ❖ After spraying any insecticide keep appropriate waiting period before harvesting fruits.

## Do's

- ❖ Timely sowing
- ❖ Field sanitation
- ❖ Always use freshly prepared neem seed kernel extract (NSKE).
- ❖ Apply pesticides only when required.
- ❖ Wash okra & brinjal fruits in salt water before consumption.

## Don'ts

- ❖ Don't apply more than the recommended dose of the pesticide.
- ❖ Don't repeat the same pesticide consecutively.
- ❖ Don't apply mixture of pesticides.
- ❖ Don't apply highly hazardous insecticides like monocrotophos in vegetables.
- ❖ Don't apply pesticides just before harvesting.
- ❖ Don't consume produce till 3-4 days after application of pesticide.

## Insecticides recommended for Pest control on Vegetables

Sl.No	Common Name	Crop	Target pest	Dose/ha (ai.)
1.	Imidacloprid 17.8% SL	Chilli	Jassid, aphid, thrips	25-20
		Okra	Jassid, aphid, thrips	20
2.	Thiamethoxam 25% WG	Okra	Jassid, aphid, whitefly	25
		Tomato	Whitefly	50
		Brinjal	Whitefly	50
3.	Thiacloprid 21.7% SC	Chilli	Thrips	54-72
4.	Fipronil 5% SC	Cabbage	DBM	40-50
		Chillies	Thrips, aphid, fruit borer	40-50
5.	Indoxacarb 14.5% SC	Cabbage	DBM	30-40
		Chilli	Fruit borer	50-60
		Tomato	Fruit borer	60-75
6.	Spinosad 2.5% SC	Cabbage cauliflower	DBM	15.0-17.5
7.	Spinosad 45% SC	Chillies	Fruit borer	73
8.	Chlorantranilprole 18.5% SC	Cabbage	DBM	10
		Okra	Fruit and shoot borer	9.5-11.0
9.	Emamectin benzoate	Cabbage	DBM	7.5.10.0
		Chilli	Fruit borer, thrips, mite	10

10.	Chlorfenapyr 10% SC	Chilli	Mite	75-100
11.	Spiromesifen 22.9% SC	Brinjal	Red spider mite	96
		Chilli	Yellowmite	96
12.	Diafenthurion 50% WP	Cabbage	DBM	300
		Chilli	Mite	300
		Brinjal	Whitefly	300
13.	Lufenuron 5.4% EC	Cabbage cauli- flower	DBM	30
14.	Novalurom 10% EC	Cabbage	DBM	75
		Tomato	Fruit borer	75
		Chilli	Fruit borer, tobacco caterpillar	33.5
15.	Buprofezin 25 % SC	Chillies	Yellow mite	75-100
16.	Flufenoxuron 10% DC	Cabbage	DBM	40

**Table 14. Identification of diseases in terrace garden grown vegetables.**

Sl.No	Crops	Diseases	Symptoms / Management
1.	Tomato	Damping off	The disease attacks the seedlings before the emergence from the soil (pre emergence damping off) or after the (post emergence damping off) The affected seedlings become pale and suddenly collapse. The basal cortical region begins to rot resulting in toppling of the seedlings. Seed treatment with Thiram / Caplan @ 4g/kg Soil drenching with Bordeaux mixture @ 1.0 %
2.		Early blight	In the affected leaves circular to angular, dark brown to black spots with concentric rings appear. The spots coalesce and cause drying and defoliation of leaves. Dark spots are found at the base of the stem near the ground level and the stem is gradually girdled. <i>Seed treatment with captan @ 4g/kg. Spray, Azoxystrobin (1 min) or Copperoxy chloride@0.25%</i>

3.		Late blight	Infection occurs on all the above ground plant parts. Water-soaked lesions with faded green patches appear on the leaves. Infections spread fast to entire leaf and petiole. Dead areas appear in leaf tip and margins. Destruction of infected plants. Azoxystrobin @ 1ml / l or Copperoxy chloride @0.25% or Mancozeb @0.2%
4		verticillium wilt	Leaves develop dark green patches with interveinal or marginal chlorosis. Affected leaves droop, dry and fall and plants becomes stunted. Many adventitious roots develop at the base of stem of infected plants. Brown discolouration is seen in the xylem vessels on cutting through the stem or root . The browning is lighter in verticillium wilt ( dark brown / black/ pinkish discoloration). deep ploughing. use of healthy seeds, drench with carbendazim @0.1%
5		Leaf curl	Typical upward curling (cupping) and crinkling of leaves with interveinal chlorosis. The size of the leaf is much reduced. Older leaves become leathery and brittle. Primary spread: From susceptible crops and weed hosts. Secondary spread: insect vector, whitefly ( Bemisia tabaci). Growing of resistant varieties, removal of infected plants and spray dimethoate @ 2ml/l
6	Brinjal	Damping off	Pre-emergence damping off results in seed and seedling rot before emergence from Soil. Post-emergence damping off characterized by water-soaked, brown discolouration at collar region followed by softening of tissues and collapse at soil level. Seed treatment with captan @ 4g/kg
7		Fusarium wilt	It attacks seedling as well as matured plants. Leaves become flaccid, hang down and turn chlorotic. Deep Ploughing. Use of healthy seeds Drench with Carbendazim @ 0.1%
8		Little leaf	The infected plants exhibit general chlorosis and reduction in plant height. Leaf size is abnormally reduced. Axillary buds are induced to grow with small narrow and thin leaves. Roguing of infected plants. Spray Imidacloprid @ 0.3 ml/l to control hoppers. Spray Tetracycline @50 – 100ppm
9	Chilli	Dieback and Fruit rot / Anthracnose	Infection at pedicel and tips of branches causes shedding of flowers and flower buds. under favourable condition the infection spreads to stem through the flower stalk and causes die-back of branches. Branches die from tip down ward Seed treatment with captan or mancozeb @4 g /kg. Spraying with copper oxychloride at 0.25% and tebuconazole @ 1ml l or Azoxystrobin @ 1 ml/l



10		Leaf curl	Upward and downward curling of leaves accompanied by puckering and blistering of interveinal areas and thickening and swelling. of veins are the main symptoms. Internodes are shortened & plants are stunted. Raise 2-3 rows of maize or sorghum as border crop to restrict the spread of aphid vectors. spray Dimethoate 2 ml/l of water
11	Bhendi	Powderymildew	White or grayish white patches appear on the lower surface of leaf. Later it covers the entire leaf surface. Spray wettable sulphur @ 0.2% or Azoxystrobin @ 1ml/l
12		Yellow vein mosaic or vein clearing	The green colour of main and lateral veins is bleached and the veins and veinlets exhibit yellow network. Veins are thickened. The interveinal Portions first exhibit small portions of green colour. install yellow sticky traps spray of Dimethoate 0.2% / Methyl demeton 0.2%
13	Cucurbits	Downymildew	Irregular white patches and downy growth are seen in the lower surface of leaves. The corresponding upper surface shows angular yellow patches limited by veins. Entire leaf dries quickly and sheds. seed treatment with metalaxyl @ 2g / kg Spray Azoxystrobin @ 1 ml/l
14		Powdery mildew	White or dirty grey powdery growth is seen superficially on the upper surface of leaves in patches. Later they cover the entire leaf surface. The leaves turn brown and dry. Spray Carbendazim @ 0.1% .
15		Cucumber mosaic	Leaves show clear mosaic symptoms. Affected leaves are Puckered and deformed, internodes are shortened. Leaves attain only half the size of normal leaves, removal of infected plants Eradication of weed hosts, Spray Dimethoate @ 2ml/l or Methyl demeton @ 2ml /l
16	Beans	Dry root rot	It attacks seedlings and grown up plants. Black sunken lesions appear near the base of the cotyledons and it spreads to the stem and first pair of unfolded leaves. Treat the seeds with carbendazim @2g/kg or T.viride @ 4g/kg or P.fluorescens @ 10g/kg. Spot drench with Carbendazim @0.1%.
17.		Anthracoese	The pathogen can cause infection on all above-ground parts, Symptoms on the underside of the leaf appear as dark brown-black, slender lesions that follow the leaf veins. The symptoms are seen in pods also. Collect and destroy infected plants. Seed treatment with Carbendazim@ 2g/kg. Spray Carbendazim @0.1% or Mancozeb or Chlorothalonil @ 0.2%. or Tebuconazole @0.1%.

18.	Onion	Basal rot/ Bulb rot	The disease is seen from 30 days old crop. It occurs in patches. The leaves turn yellow and then dry up slowly. The affected plant shows drying of the leaf tip downwards Diseased dry leaves are to be clipped and burnt Spray Mancozeb 0.25% or Chlorothalonil 0.2% or Tebuconazole @ 0.1%.
19.		Purple blotch/ Scald disease	The infection starts with whitish minute dots on the leaves with irregular chlorotic areas on tip portion of the leaves. Later circular to oblong concentric rings of purple coloured fruiting bodies appear in the chlorotic area. Spray Mancozeb@ 0.2 %1 Tebuconazole@0.1%. three times from the appearance of the disease.