RUAF Foundation
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RESOURCE BOOK ON CITY FARMING IN SOUTH INDIA

Surya Gunjal

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Publishers and Disclaimers

Publishers

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Foreword

Rapid urbanization in most of the Asian countries including India grows together with urban poverty and food insecurity. One estimate states that by the year 2020, the developing countries of Asia, Africa and Latin America would be home to 75% of the urban population, and more than 9 mega cities with populations over 20 million each would be found on the global map. More than 50% of the poor in Asia and Africa would be concentrated in towns and cities.

In this context, the importance of urban agriculture is increasingly recognized by international communities and organizations like the Food and Agriculture Organization of the United Nations (FAO) and the Consultative Group on International Agriculture Research (CGIAR). The contribution of urban agriculture or city farming to food security for the urban poor is a most vital dimension of city farming. Food prices all over the world are soaring owing to removal of subsidies and price control that have denied poor people access to adequate food.

City farming can be a viable solution to grow food for people and fodder for animals in and around cities on a limited scale. City farmers can grow and market surplus food to local communities. It is estimated that nearly 15% of the world's food produced in urban areas is in the form of fresh fruits, vegetables, cereals, pulses, fishery, poultry, mushroom, etc. The World Bank (2000) estimates that nearly 50% of the poor live in urban areas. Urban agriculture may improve both food intake and quality of food available in fresh form.

The future of city farming in cities is very bright and promising because 50% of the world's population lives in cities. Those involved in city farming in the world number 800 million and they produce nearly 15% of the food through city farming using natural resources like organic waste, waste water and wasted human power available in the cities. City farming expands the socio-economic base of the city through production, processing, packaging and marketing of consumable products that reduce food cost and increase employment opportunities, particularly for womenfolk.

Social benefits that have emerged from city farming practices are better health and nutrition, increased income, employment, and food security within the household. This is why city farming in fast-growing cities and countries like India has a promising future. I would like to complement the efforts exerted by Dr. Surya Gunjal, Professor and Director, School of Agricultural Sciences, Yashwantrao Chavan Maharashtra Open University, Nashik, India for creating such valuable practical learning resources for city farmers. I am sure this resource book on City Farming in South India will prove beneficial to all the stakeholders involved in urban agriculture.

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Preface

City farming is a practice of farming in the city or an urban agriculture that deals with growing food crops like fruits, vegetables, cereals, pulses, and practising goat-raising, poultry, duckery, piggery or producing mushrooms to ensure access to food and nutrition within the city areas. City farming constitutes many forms and structures depending on the space used for food production like the kitchen garden, terrace garden, balcony garden, rooftop garden, container garden or vertical farming.

City farming is closely related to food security of cities facing the dual problems like scarcity of food for consumption and disposal of organic city waste. India is designated as the fruit and vegetable basket of the world having the status of the largest vegetable producer accounting for 16% of the world's production. India produces 41% potato, 23% mango, 24% banana, 36 % cashew nut, and 10% green peas in the world where it is second largest onion grower. However, the fact remains that a large majority of the Indian population remain below the poverty line and survive on a dollar a day owing to limited access to food, especially fruits and vegetables.

In understanding facts and harmonizing the situation in South Asian cities regarding food and nutritional security, the Resource Book on City Farming in South India is written in a self-instructional format for city farmers. The chapters are highly elaborative and written in lucid language, so that the city farmers can learn and practice to produce nutritive food for his family and balance his budget on domestic food. The chapters would equip the stakeholders in using eco-friendly and wasted natural resources and human resources to produce food in cities. The chapter on plant protection and plant nutrition advocates only bio-dynamic and ecological processes in safe food production.

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UNIT 1: Introduction to City Farming

1.1 Introduction

Rapid urbanization in most of the Asian countries including India is taking place and it grows with urban poverty and food insecurity in urban pockets. It is estimated that by the year 2020, the developing countries of Asia, Africa and Latin America would be home to some 75 percent of all urban populations of the world. More than nine mega cities with populations more than 20 million each would be soon arising on the global map. It is reasonably expected that more than 50 percent of the poor in Asia and Africa would be concentrated in towns and cities.

The importance of urban agriculture is being increasingly recognized by international organizations like the Food and Agriculture Organization of the United Nations (FAO) and the Consultative Group on International Agriculture Research (CGIAR), which comprises 58 governments, private foundations, and international and regional organizations that fund institutes like the International Rice Research Institute (IRRI), Philippines and the International Water Management Institute (IWMI), Sri Lanka. The contribution to food security and supportive nutrition for the urban poor is the most vital dimension of city farming or urban

agriculture. Nutrition-supportive food production in the city area is the response of the urban poor to inadequate and irregular access to food. Food prices all over the world are soaring owing to the removal of both subsidies and price control that has eliminated access to adequate food by the poor people.

City farming can be a viable solution to grow food for the people and fodder for the animals in and around city areas on small scales to feed the urban poor in addition to producing food for their own consumption. City farmers can grow market-surplus food like fruits and vegetables, mushroom, poultry and piggeries to their communities. It is estimated that 15 to 20 percent of the world's food is produced in urban areas in the form of fresh fruits, vegetables, cereals, pulses, fishery, poultry, mushrooms, etc.

At the end of this unit, you will be able to know and understand

- The meaning and significance of farming in urban areas.
- How city farming practices can help keep our environment clean, green and ecofriendly.
- How city farming can generate employment to the urban poor and solve their health and nutritional problems.
- The future of city farming in the world including that of third world countries like India.

1.2 Contents

1.2.1 What Is City Farming?

City farming is a practice in the city or an urban agriculture that deals with growing crops like fruits, vegetables, cereals, pulses, etc., and raring domestic animals like poultry, duckery, piggery, etc., to ensure access to adequate food and nutrition within the city limits. City farming has many forms and structures depending on the space used for food production like the kitchen garden, terrace garden, balcony garden, roof top garden, container garden or vertical farming.

- kitchen garden/terrace garden/pot culture garden

The most striking feature of city farming which distinguishes it from rural farming is that it is integrated, embedded and interacting

with the urban socioeconomic and ecological system. Such linkages include viable use of human and natural resources like unemployed youth as a working force, organic solid waste as manure and waste, and wastewater for irrigation. The city farming practices become integrated with part of urban consumption, urban ecology and the urban food supply system.

1.2.2 City Farming and Clean and Green Environment

City farming is part of the urban ecosystem that plays an important role in the management of the urban environmental system. Fast-growing cities of the world produce, on a daily basis, more organic solid waste and wastewater than stabilised urban areas and most of them face problems of their disposal which is a costly affair. City farming can effectively help solve such problems by turning urban waste into productive manures. In many cities of South India, initiatives of the Municipal Corporations necessarily exist to collect household waste and organic refuse from vegetable markets and agro industries to produce compost or animal feed. Quality-compost is an important input that can fetch good prices in the local market. The use of compost can prevent or reduce the use of chemical fertilizers and help prevent contamination of groundwater. In addition to this, initiatives in making city compost and vermicompost can effectively convert city-borne solid waste into environment-friendly manures and fertilizers thereby keeping the city environment clean and green.

City farmers can use wastewater for irrigating their kitchen gardens without depending on potable drinking water available for family consumption. The fresh wastewater contains many nutrients and organic impurities that can serve as nutrients for crop growth. However, without proper guidance and treatment of wastewater, the use of wastewater can lead to health and environment related problems like transportation and translocation of heavy metals in the human and animal bio system. Modern farming technologies such as hydroponics, drip-irrigation and zero-tillage farming substantively reduce water needs and health risks involved in this process. In many cases, partial treatment of wastewater can be sufficient for agricultural reuse.

City farming certainly has a positive impact on cleaning and greening of the city by turning open spaces into green zones with a favourable impact on the micro-climate free from pollution. Degraded open spaces and vacant lands are often used as dumping grounds for

solid waste materials and are locations of crime and sources of health hazards. The creation of green zones and community nutrition gardens within the city limits, and the natural waste material found and generated also within the city limits can ensure community participation for productive endeavours that could ensure a clean and green environment for all citizens.

1.2.3 City Farming and Nutritional Security

City farming has close relations with the food and nutritional security of cities and towns that face dual problems like disposal of organic city waste and scarcity of food. It has a predominant consideration for rational and equitable distribution of food among the population. Let us consider the situation in a democratic country like India and see its statistics regarding food production and its availability.

India is designated as the fruit and vegetable basket of the world having the status of the largest vegetable producer accounting for 16 percent of the world's production. India ranks fifth in potato production and produces 41 percent of the world's mangoes, 23 percent of banana, 24 percent of cashew nut, 36 percent of green peas, and 10 percent of onions and is the second largest onion-growing country in the world. However, the hardest fact is that a large majority of the Indian population remains below the poverty line (an average person survives on a dollar a day) because they have limited access to food, especially fruits and vegetables.

The contribution to food security and healthy nutrition is the most important aspect of city farming. In many cases, food production in cities is a response of the urban poor with inadequate and irregular access to food and lack of purchasing power. The World Bank (2000) estimates that nearly 50 percent of the poor people live in urban areas. Urban agriculture may improve both food intake and quality of available food in fresh form.

In addition to production for their own consumption needs, large amounts of food can be produced for other sections of the population. It is estimated that a population of more than 800 million (16% of the world population) is involved in urban agriculture or city farming in one way or another. These city farmers produce substantial amounts of food for urban consumers. A global estimate indicates that 15 percent of the world's food is produced in urban areas. Growing our own food saves household expenditure on food and poor people in poor countries generally spend more than

60 percent of their income on food requirements. Thus, city farming activities can empower urban poor in producing their own food, fruits and vegetables and safeguard their critical food security in critical times.

1.2.4 City Farming and Employment Generation

Besides economic benefits to city farmers, city farming activities stimulate the development of related microenterprises, such as the production of necessary inputs like poly bags, earthen, cement and plastic pots and containers, fabrication of hand tools and implements, production of vermicompost manure, botanical and organic pesticides, bio-fertilizers and packaging materials and a network chain of transport and marketing.

City farming generates an important strategy for poverty alleviation and employment generation, particularly for womenfolk who cannot leave home for earning their livelihood owing to various responsibilities including raring of children and guarding the house. In developing countries like India, poor women are mostly illiterate and assigning them with responsibilities at home can become an important part of the city farming programme. Womenfolk can contribute 50 percent labor power of the family to be productively utilized for urban food production thereby generating self-employment right at home.

One estimate indicates that a self-employed woman at home partly supported by her school going children can earn more than her husband employed outside. This indicates that nearly 50 percent of employment can be generated in city farming using natural resources available in the vicinity like wastelands, wastewater, kitchen waste and other city waste including night soil without much significant additional cost.

1.2.5 Future of City Farming

The future of city farming in densely populated countries and fast-growing cities is no doubt very bright and promising owing to the fact that 50 percent of the world's population live in cities, 800 million of whom are involved in city farming around the world contributing to feeding the urban residents. Low-income urban groups spend more than 60 percent of their income on food and by the year 2015 about 26 cities in the world are expected to have a

population of more than 10 million each. To feed a city like this size, we require at least 6,000 tons of food every day; out of this, a good proportion of food has to be imported from outside the city or at least 20 percent of it should be supplemented by growing food in city farming, using natural resources like organic waste, wastewater and wasted women power available in the cities.

City farming expands the socioeconomic base of the city through production, processing, packaging and marketing of consumable products that reduce food cost and increase employment opportunities for the idle in general and for women in particular. Social benefits that have resulted from city farming practices are better health and nutrition, increased income, employment, and food security within the household and communities. In addition to this, city farming enterprises are low-cost energy efficient farming systems owing to non transportation of inputs from outside and using no-cost to low-cost organic waste freely available in the cities. This is the reason the city farming in fast-growing cities and countries like India has a very promising future.

1.3 Glossary

Kitchen Garden: It is the practice of growing fruits, vegetables and other forms of food in the free area around the house.

Terrace Garden: It is the practice of growing fruits, vegetables and ornamentals on the terrace of the house.

Balcony Garden: It is the practice of growing fruits, vegetables, flowers and foliage plants in the balcony.

Rooftop Garden: It is the practice of growing fruits, vegetables, flowers and foliage plants rooftop of houses.

Vertical Garden: It is the practice of growing fruits, vegetables and other plants on any part of the house except on the ground.

Hydroponics: It is the practice of growing vegetables in pots and containers filled with water containing plant nutrients without the use of soil as the medium of growth.

Drip Irrigation: It is a type of plant watering system used when the water availability is limited and the plant needs to be given measured quantities of water.

ZeroTillage Farming: It is the farming system where tillage operations are not carried out. Nature takes care of all these operations as in natural or organic farming practices.

Green Zones: It is the area in the cities earmarked for tree planting to help generate sufficient oxygen to the areas.

Food Security: It is the process of ensuring supply of the minimum quantity and the maximum quality of food available to people in particular regions.

Microenterprises: It is the network of small jobs created around the main activity.

1.4 Points to Remember

- City farming is nothing but growing food, fruits, vegetables and animalbased produce in and around the city areas.
- City farming is the most viable solution for producing food in cities, using freely available natural resources like organic waste and wastewater.
- City farming can include an economical solution to recycle badly placed organic waste, which is otherwise a nuisance to the city.
- More than 16 percent of the population in the world are involved in city farming, vertical farming, kitchen gardening and related enterprises around the world.
- Increasing urban population in cities has a direct and positive bearing on the future of city farming as it boosts under increase of population.

1.5 Self Check Questions

i What is the definition of city farming or urban agricultural system?

ii How are city farming and urban food security mutually dependant?

iii How can city farming be helpful in employment generation to the womenfolk?

iv How do you envision the future of city farming in India?

1.6 Do It Your self

- A visit to a well-established kitchen garden/terrace garden in the city area.

Before you plan to venture into various forms of city farming like kitchen gardening or terrace gardening, you must visit a type of city farming in your city or any other cosmopolitan area so that you can observe these farming practices. With the confidence you thus gain, you can go for city farming without risk of losses.

While visiting such gardens you must observe and study the following:

1. You must spend at least one full day at such places to observe minute details, and some garden operations and discuss various aspects of garden planning and layout with the owner.
2. Observe, and if possible, measure the total area under cultivation of fruits and vegetables and their orientation.
3. Observe types of fruits and vegetables and the selection of the varieties grown according to climate and season, and their economics of production.
4. Observe the source of irrigation water to the garden and how the wastewater is treated for irrigation.
5. Observe the source of manure and methods of composting undertaken inside the garden. Also note the quantity of manure being produced.
6. Observe the complete method of vermicompost production in containers and in pits or heaps and handle earthworms gently.
7. Observe the tall and dwarf growing vegetables and their layout in the garden and ask the garden owner for justification for a particular layout.
8. Observe stages of fruit and vegetable growth, manuring, watering and intercultural operations in the garden.
9. Observe the incidence of insect pests and diseases on fruits and vegetables and consult the owner as to how he manages the problems of pests and diseases.

10 Observe and study biological and botanical pesticides used in the garden to keep away insect pests and diseases.

11 Observe the preparation of neemseed extract in the garden for spraying on vegetables.

12 Try to help the garden owner in picking fruits and vegetables and buying them for your consumption so that the owner will be happy to extend more cooperation.

UNIT 2: Nutritional Garden Resources, Tools and Implements

2.1 Introduction

There is comparatively less difference between a nutritional garden and a kitchen garden. On the other hand, a kitchen garden is predominantly cultivated with a variety of vegetables so that it is also called a nutritional garden. A nutritional garden needs great care while selecting the type of vegetables and their cropping patterns to feed the family with fresh vegetables throughout the year.

A nutritional garden in city areas has special significance as far as supportive nutrition of the resource poor population is concerned. Such a garden can be developed on small spaces in and around the houses; housing societies in the urban habitat can use wastewater generated on a day-to-day basis.

At the end of this unit, you will be able to know and understand:

- Physical and financial resources required to establish a nutritional garden under city farming practices.

- The availability of natural resources in your surroundings to be used for kitchen gardening to save cost of cultivation.
- Garden tools and implements used in a kitchen garden under city farming practices.
- How to design and develop a nutritional garden with fixed and recurring annual costs of cultivation.

2.2 Contents

2.2.1 Physical and Financial Resources

Physical Resources: Although the design, development and operation of a kitchen garden require comparatively less physical and financial resources they require more passion and mental resources. Basically, one must have passion and interest to undertake this activity initially for pleasure and later for profit and do not compare physical efforts put in and the profits gained. There are nonvisible profits that can be accrued through physical exercise and engagement of mind for productive purposes.

For establishing a nutritional garden, you should think and plan for availability of both physical and financial resources at optimum level from you own home. Physical resources include the availability of land around your home or home terrace or big balcony as a space for a nutritional garden of your own. A list of inputs will include the cheap availability of inputs in and around your home like organic kitchen waste and grass and weeds for converting to compost or vermicompost and a highly motivated and interested housewife and her children to support her in daily operations like digging, planting, watering, weeding and picking operations. You should ensure that the partially treated wastewater is available in sufficient quantity and the space available to treat the wastewater is near the house.

Financial Resources: As regards financial resources, these are very necessary at the initial stage till your garden is established and starts yielding some produce. Cash flow to a certain extent is needed to purchase seed, manure, garden tools and implements to work efficiently in the garden. The need for physical and financial resource depends on the area of land available for vegetable cultivation or the land available to take on lease for vegetable

production. However, on average, initially you need nearly INR. 2,500 (US$ 60 in 2008) for essential garden tools and implements and another INR. 2,500 to buy seeds, manure, organic pesticides and hire other essential services from market.

2.2.2 Application of Natural Resources

The availability of natural resources like a municipal wastewater stream and other organic waste, the presence of neem trees in the surroundings for collecting neem seeds and preparing the neemseed extract for insect control are very important considerations to reduce the cost of vegetable growing in a kitchen garden. You can harvest grass and weeds from banks of a water stream and convert them into compost or vermicompost for your vegetable garden.

If your garden is near a dairy farm, you can collect the cow dung released by cattle on the road that will be your cost free manure. You can also purchase manure and cow dung from a nearby dairy farm and save on transport cost. The water stream may carry a lot of silt, clay and fertile soil and deposit them along the bank side, which can not only be a cheap source of garden soil but can be lifted and filled in your garden beds.

You can also collect seeds of neem trees and store them in gunny bags. This can be used as rich manure as well as for preparing neemseed extract to spray on vegetables in case the crop is attacked by insect pests. Care must be taken to avoid the use of direct drainage water and water mixed with chemical industries in affluents that can create problems to soil, and can be harmful for our consumption because vegetables grown may be contaminated with heavy metals.

All organic materials including kitchen waste, farm waste, surrounding grasses and weeds must be recycled into organic manure through compost or vermicompost and then used for manuring. This can greatly reduce the harmful microbial count due to decomposition of the material. If you can identify the value of natural resources available in your surrounding and can handle them efficiently, you can grow all your vegetable in your garden without spending on manures.

2.2.3 Hand Tools and Implements

City farming needs a few hand tools and implements for carrying out day-to-day garden operations like digging, leveling, handling, cutting, spraying, pruning, mixing and transporting manure and water, etc. A number of multipurpose garden tools are available in the market. Multipurpose tools are preferred to single purpose tools for garden operations. The commonly used hand tools and implements and their applications are given below.

Pick Axe, Spade and Crowbar

- **Pick Axe:** It is a relatively heavy tool used to dig trenches, make water channels and put earthen support to walls. It has various shapes, sizes and weights with a long wooden handle.
- **Spade:** It is a hand operated tool designed for digging or removing the earth. It has a long handle and a thick flat blade that can be pressed into the ground with the help of the foot.
- **Crowbar:** It is an approximately 120 to 150 centimetres (cm) long steel bar usually approximately 3 to 5 cm in diameter and sharp at one end and blunt at other. It is used to dig holes in the ground to fix poles for pulling overhead trellis.

Hand Cultivator, Hand Fork and Hand Hoe

- **Hand Cultivator:** It has three to five round shaped blades and is used for stirring and pulverizing soil before planting seeds or transplanting seedling in a kitchen garden. It

can also be used to remove weeds from the garden and aerate and loosen the soil in the standing crop.

- **Hand Fork:** It is made up of steel and normally has four prongs with a wooden handle and is used in pulverizing and stirring subsoil in the kitchen garden beds.
- **Hand Hoe:** It is made of a sharp metal blade attached to a long wooden handle, used for removing weeds and unwanted plants. Along with the spade and fork, the hoe is also considered as a basic garden tool.

Garden Rake, Secateur and Hand Saw

- **Garden Rake:** It is a garden hand tool made up of a toothed bar fixed with a metal pipe to a long wooden handle and used to collect leaves, grasses and hay. It is most useful for loosening soil, light weeding and leveling.
- **Secateur:** It can also be called a hand pruner. It is very hard and can prune hard branches of trees and shrubs up to 2 cm thickness. A secateur has two blades and a short handle and is operated by one hand. The powerful spring between the two handles causes the jaw to open again and again after pruning. When not in use it can be locked with a safety catch.
- **Hand Saw:** It is one of the very useful garden tools used for pruning unwanted branches of growing trees in the garden. It has a serrated broad blade usually ranging from 30 to 60 cm long with a handle at one side.

Hand Spray Pump, Watering Can and Wheelbarrow

- **Hand Spray Pump:** It is a round bottomed plastic pot fitted with a nozzle at the top of the pot and a handle at the side of the body. It usually accommodates 1 to 2 liters of water used for spraying plain water or pesticides on garden vegetables.
- **Watering Can:** It is a metal pot attached with a handle at one side and a long pipe with a broad sieve at the other end and used to water or irrigate crops in the kitchen garden. Its water carrying capacity varies from 5 -10 liters.
- **Wheelbarrow:** It is a rectangular vehicle with one wheel or two normally pushed forward. It is used to transport garden soil, manures, earthen pots and other heavy materials in the kitchen garden.

2.2.4 Design and Layout of a Nutrition Garden

All types of gardens that come under city farming like kitchen gardens, terrace gardens, balcony gardens and vertical gardens are basically different forms of nutritional gardens. The basic need of any kitchen garden or terrace garden under city farming operations is the design and layout of the available space. There is no hard and fast rule for design and selection of fruits and vegetables for cultivation. It depends upon location of space, size of space, daily requirement of vegetables and personal liking, etc. However, care must be taken to locate dwarf growing vegetables at the east side and tall growing vegetables at the west side so that both vegetables can receive sufficient sunlight for better growth.

Design and Layout for a Kitchen Garden:

A kitchen garden is an essential part of city farming and would need great care in planning and designing so that the garden can supply essential vegetables on a daily basis. The type of vegetables that will grow in the kitchen garden will depend on the orientation of your plot and the availability of sunlight in the garden. Leafy vegetables, pumpkins and gourds can also grow under partial shade while others require full sunlight.

Vegetables which the family likes to consume raw and fresh, like carrot, cucumber, peas, radish and tomato may be given preference over other vegetables which are taken in cooked form. Vegetables

which are not readily available in the market but which you are fond of like celery, parsley, red cabbage, etc., could be another consideration for selection.

Another consideration in planning would be to try to ensure supply of vegetables at a time when these are scare and expensive in the market. If a kitchen garden is fairly large, say larger than approximately 300 m^2 , then more emphasis should be given to vegetables that can be stored for a long time like onion, garlic, potato, sweet potato, beans and peas. It is better to have separate areas for growing fruits in the kitchen garden. The fruit trees to be planted in a small kitchen garden should be dwarf in height and placed in the corner or border areas to prevent other vegetables not getting sunlight. The best location to place fruit trees in a kitchen garden is at the north and northeast directions.

One of the most important features of planning a vegetable garden is rotation of vegetables. The nutritional requirement of each vegetable or group of vegetable is different and if you grow the same vegetable or same group of vegetables again and again in the same plot then the nutrients in the soil in the plot may likely be exhausted. The basic principle of vegetable rotation is to follow shallow rooted vegetables with deep rooted vegetables. Similarly root and tuber crops should be followed by nitrogen fixing leguminous vegetables. Rotation of vegetable crops is useful for the management not only of soil fertility but also of pests and diseases in a kitchen garden. If any disease appears in the plot it indicates that this vegetable should not be grown in the same plot the following year.

Design and layout of kitchen garden

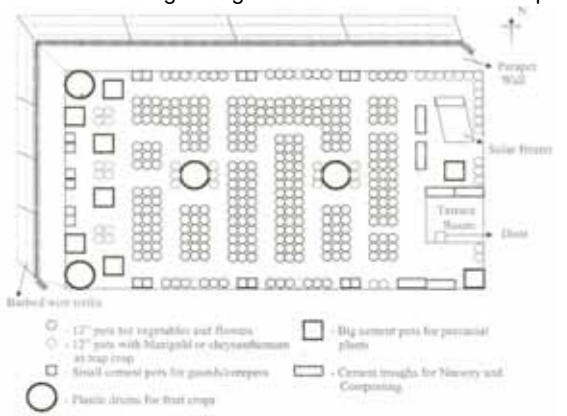
The best sowing season for vegetables:

According to their temperature requirement, vegetables can be grouped into three seasons like the rainy season, winter season and summer season vegetables. However, some vegetables with wider adaptability can be grown year-round. The following table shows the month of vegetable sowing or plantation.

Vegetable crop	Months											
	Jan.	Feb	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Coriander			✓	✓	✓	✓	✓	✓	✓	✓		
Spinach									✓	✓	✓	
Fenugreek								✓	✓	✓	✓	
Gourd	✓	✓				✓	✓			✓	✓	
Cucumber	✓	✓			✓	✓						
Water melon	✓	✓										
Radish	✓	✓				✓	✓			✓	✓	
Carrot	✓	✓				✓	✓			✓	✓	
Beetroot						✓	✓			✓	✓	
Onion	✓	✓				✓	✓		✓	✓		
Garlic						✓	✓			✓	✓	
Cabbage						✓	✓			✓	✓	
Cauliflower								✓	✓	✓	✓	
Knol khol						✓	✓			✓	✓	
Tomato	✓	✓				✓	✓			✓	✓	
Brinjal	✓	✓				✓	✓			✓	✓	
Chili	✓	✓				✓	✓			✓	✓	
Capsicum								✓	✓	✓	✓	
Okra	✓	✓				✓	✓					
Cowpea	✓				✓	✓	✓					✓
French bean	✓	✓				✓	✓			✓	✓	
Garden pea						✓	✓					
Drumstick						✓	✓					

Design and layout for a terrace garden:

A terrace of any length and width and measuring approximately 100 m^2 can be sufficient to grow daily vegetables for one family of four persons besides growing some short duration fruits plants.



Design and layout of a terrace garden

Arrange 30 cm diameter, earthen, cement or plastic pots filled with good garden soil mixed with well decomposed organic manure or cow dung in three rows on the center of the terrace. The number of pots depends on space available and requirement of the vegetable. These three rows of pots are used for staggered planting of each crop so as to have a particular crop throughout the year. The first row of pots is planted with seed or seedling of one crop. The second row is planted as soon as the first row of plants starts flowering or near to harvesting in case of leafy vegetables. Similarly, the third row of pots should be planted when the second row starts flowering. By doing so, year-round production of a particular vegetable is ensured.

The entire terrace is placed with three rows of a convenient number of pots by leaving sufficient space for walking between each row of pots. This walking space is utilized for watering and weeding plants as and when necessary. The long duration fruit plants like papaya, banana, lime, drumstick and curry leaves should be grown in bigger cement pots, tins or plastic barrels with drainage holes located at the bottom of containers.

The long durational plants should be placed at the western side of the terrace so that the shade does not affect the growth and productivity of other crop plants. The parapet wall of the terrace will provide protection to plants from speedy wind damage. A barbed wire fence could be erected on the parapet wall that can be used for trailing or creeping types of vegetables like cucumber, smooth gourd, bitter gourd, snake gourd, small gourd and vines like passion fruit.

2.2.5 Cost of Cultivation in City Farming

The cost of cultivation in city farming is a relatively vague concept and it all depends upon the resources readily available with you and the resources to be purchased from the open market. The cost of cultivation always varies from cultivator to cultivator and vegetable to vegetable and even from location to location. However, broadly speaking, a kitchen garden or a terrace garden under city farming consists of two types of expenditure, e.g., fixed expenditure and recurring expenditure.

Fixed Expenditure: This expenditure is required for the initial purchase of garden tools and implements, providing fencing to the garden, erecting poles for overhead trellis stretching wires, earthen/

cement/plastic pots and trays, ropes and tarpaulins, making availability of water and initial skilled labour cost for erecting and establishing a kitchen garden. Normally, this can be heavy expenditure and can be the same for a small or a large kitchen garden. This is an initial and onetime expenditure and normally requires no replacement for the following 5 years if used carefully.

It is very difficult to calculate the initial cost. It may vary from the cost of locally fabricated tools and implements to that of tools and implements bought from an established company. However, on average for a kitchen garden with an area of approximately 100 to 300 m^2 , the fixed expenditure can be in the range of INR 5,000 to 6,000. It can be covered for the next 5 years; thus annual cost may be around INR 1,000 to 1,200 (US$ 25 to 30 per annum)

Recurring Expenditure: This is the expenditure incurred on purchasing garden inputs like seed, manure, botanical pesticides and specialized labor other than family labor. This expenditure can again depend on type of vegetables grown and market cost of their seed and area of each vegetable to be grown, size of kitchen garden and efficiency of the kitchen gardener. The seeds of exotic vegetables are very costly whereas those of local vegetables are relatively cheaper and are available with relatives of the gardener.

On average, the annual recurring cost of a kitchen garden of approximately 100 to 300 m^2 can be in the range of INR 1,000 to 1,200. Thus an average size kitchen garden annually requires INR 2,000 to 2,500 for both fixed and recurring costs. This can produce fruits and vegetable worth nearly INR 8,000 to 10,000 every year.

2.3 Glossary

Nutritional Garden: This is a type of kitchen garden that ensures year-round cultivation and supply of vegetables to the family for optimum nutrition.

Natural Resources: These are the resources like soil, manures, water, organic matter, grasses and weeds that can be used as inputs for growing vegetable crops in the home garden

Garden Layout: This is the orientation or system of placing pots, beds and containers for plants grown in the garden.

Kitchen Garden: It is a home garden used to grow fruits, vegetable and flower plants.

Parapet Wall: It is an approximately 75 to 90 cm tall wall built at the periphery of the terrace to protect ourselves and materials kept on terrace from falling down.

Recurring Expenditure: It is expenditure incurred on a day-to-day basis for garden inputs and garden operations.

2.4 Points to Remember

- A nutritional garden is established to provide continuous supply of fruits and vegetables from the home garden.
- Use of natural resources available in the surroundings like soil, manure, water, grasses can reduce the cost of cultivation in a kitchen garden.
- Garden tools and implements reduce the hard labor and save time in garden operations.
- Design and layout of a kitchen garden depends on space and types of vegetables to be grown.
- The cost of cultivation in a kitchen garden varies from location to location but it should not exceed 30% of the final receipt (total gross income) derived from the kitchen garden.

2.5 Self Check Questions

i List the names of types of physical resources required for establishing a kitchen garden?

ii What are the natural resources available in your surroundings that can be used for growing vegetables in your kitchen garden?

iii List the names of hand tools used for soil preparation for vegetable cultivation?

iv What are the vegetables that can be grown under partial shades under trees?

2.6 Do It Yourself

- Preparation of layout for a medium size kitchen and terrace garden.

Kitchen Garden:

1 To begin with, observe your garden plot where you want to lay out your kitchen garden; measure the length and width of the plot and find out the total area available for crop growing.

2 If the total area available for actual cultivation of fruits and vegetables is less than approximately 100 m^2 then you can go for a small scale kitchen garden and avoid including fruit trees as they take more space denying space for seasonal vegetables.

3 If the total area is in the range of approximately 100 to 300 m^2 then you can plan for a medium scale kitchen garden and include fruit crops like papaya, lemon, passion fruit and strawberries besides all seasonal vegetables.

4 If the total area is more than approximately 300 m^2 then you can practice almost all types of major fruits including papaya, lemon, guava, Sapota and mango and vegetable cultivation, like drumsticks, without any major constraints.

5 Place all fruit crop trees at the west side of the garden to avoid shading effects of tall growing trees on dwarf growing vegetables.

6 Fruit trees like guava and vegetable trees like drumstick that can be pruned every year can be planted at the south and north sides of the garden keeping the east side completely open to receive a sufficient quantity and quality of sunlight for your seasonal vegetables.

7 The vine and creeper group of fruits and vegetables like passion fruit, gourds and cucumber are planted near the fence and allowed to grow on fences to make use of vertical space and avoiding crowding on the land.

8 Select one low-lying end corner to dig an approximately 150 cm long, 150 cm wide and 100 cm deep pit to dump all organic and kitchen waste to convert into compost or vermicompost.

9 Select a space close to your bathroom where waste and used water flows out. Create one channel approximately

60 to 90 cm wide and 180 cm long, the first 60 cm with brickbats mixed with course sand, the second 60 cm with charcoal bats and the third 60 cm with fine sands to be used as a partial filter for wastewater before it is used for your kitchen garden.

10 Before you plan to plant fruit trees please keep in mind that fruit trees require deep pits for their root growth; otherwise, the growth of these trees will remain stunted and will not bear fruits.

11 For fruit trees with a tap root system as in guava, mango and Sapota, you need to dig a pit at least 60 cm long, 60 cm wide and 60 cm deep and for trees with a shallow root system like papaya and drumstick; the corresponding measures for a pit are 45 cm each.

12 The pits should be filled with good garden soil added with 20 kilograms (kg) of well decomposed compost and 2 kg of Azarachta indica seed cake (neem seed cake) or Pongamia pinnata seed cake (*karanj* seed cake*)* or groundnut cake.

Terrace Garden:

1 To begin with, observe the total area of the terrace available for a terrace garden excluding area used under the water tank or for other personal commitment.

2 If you have an area less than approximately 50 m^2 please plan for a small-scale terrace garden and that can accommodate a few selective vegetables.

3 If the area is in the range of approximately 50 to 150 m^2 you can plan for a medium type of terrace garden accommodating a fairly good number of vegetables and corners for a few fruit crops like one papaya and one banana.

4 If the area is more than approximately 150 m^2 with full natural sunlight then probably you can plan for a full-fledged terrace garden with a lot of choices in growing most of the seasonal vegetables along with a fair number of fruit trees like papaya, guava, banana, etc., in big containers.

5 While you lay out your terrace garden care should be taken to place fruit trees and tall growing vegetables like

drumstick, vines and creepers at the west side to avoid shading on dwarf growing vegetables.

6 Place earthen pots filled with garden soil mixed with compost and seed cakes in rows in the middle part of the garden keeping space for a walking path in all directions.

7 The parapet walls should be fitted with vertical iron bars and wire trellis should be stretched so that vines and creepers like gourds and cucumber can be grow on them.

8 During the hot summer the vegetable block on the terrace can be provided with partial shade by covering it with a shading net for a particular period. This can be good protection to tender vegetables on a cement terrace.

9 If your terrace is facing west and you do not expect to receive sufficient and good quality sunlight then you can avoid growing vegetables like cucumber and cucurbits that are highly susceptible to powdery mildew and downey mildew that attack severely in high humidity conditions.

10 Root and tuber vegetables like carrot, radish, beet root and potato should be grown on deep and flat crates like containers which can provide sufficient space for root growth underground.

11 The garden should be given less but frequent irrigation avoiding seepages of excess water flowing over to the terrace and parapet wall that can waste precious water and spoil external wall color reducing the life of your house.

12 Vegetable must be strictly selected on the basis of season and space and inputs available with you; otherwise, efforts exerted on your preference without climatic support can be fruitless.

UNIT 3: Crop Manuring and Water Management

3.1 Introduction

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 amounts of manuring while others require large amounts for their good growth.

A plant requires 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), which are secondary nutrients 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.

Soil can be enriched by adding organic or inorganic manures. 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 fruits and vegetables based on home and kitchen gardens. However, these are not available in large fields in large quantities for commercial production. Whenever there is a shortage of organic manures, they are mixed with small quantities around 5 percent of chemical fertilizers to meet the nutritional requirement of various fruit and vegetable plants grown in kitchen or terrace gardens.

Manures and fertilizers should be applied at the time of a) sowing seeds, b) seedling planting, and c) flowering and fruiting stages to get more yields of good quality. With the action of earthworms the low nutrient content in organic matter can be converted to quadruply enriched organic compost when the final product is called vermicompost. Vermicompost is fertile with the enriched excreta of earthworms.

The watering of plants with safe water is one of the most important parts of fruit and vegetable growing in kitchen gardens and in city farming. We can use wastewater created through household activities from the kitchen or bathroom that can be effectively recycled for irrigating fields with fruit and vegetable cultivation. The recycling of wastewater can save the available potable water.

At the end of this unit, you will be able to know and understand:

- The importance of manuring and watering for fruit and vegetable cultivation in home gardens.
- Types of organic and inorganic manures and fertilizers and their methods of preparation.
- Methods, time and quantity of application of manures and fertilizers for fruits and vegetables in home gardens.
- Recycling of wastewater and its application to pots, beds and land planted with fruits and vegetables.

3.2 Content

3.2.1 Manures and Fertilizers

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.

1. Organic Manures: These are derived from biological resources like plant and animal based waste and human excreta that contain a low amount of plant nutrients. Organic manures include bulky organic manures like farm yard manures (FYM), compost and green manures and concentrated organic manure like oilseed cakes, neem cakes, bone meal, blood meal, fish meal, etc.

Farm Yard Manure (FYM): It is a decomposed mixture of cattle dung, urine, litter and residues of cattle fodder. The material is allowed to decompose undisturbed for 3-4 months in an open space after which it can be used as manure. The FYM contains 0.5 percent nitrogen, 0.2 percent phosphorus and 0.5 percent potassium as major plant growth nutrients.

Compost: Organic residue like straw, dry fodder, stubbles, tree branches, twigs and vegetative refuse contain a high ratio of carbon to nitrogen (C:N) and that is why it cannot be used as manure until it is be decomposed. The material can be decomposed through microbial decomposition for 3-4 months. The final ready to use compost would turn brown to black and contains up to 1.5 percent nitrogen, 0.8 percent phosphorus and 1.2 percent potassium.

Vermicompost: Vermicompost is a method of mass multiplication of earthworms and using them to convert organic waste material into finegrainenriched manure. Vermicompost is nothing but excretal casting of millions of earthworms working together. Good vermicompost contains 2.5-3.0 percent nitrogen, 1.0-1.5 percent phosphorus and 1.5-2.0 percent potassium. Application of vermicompost is highly recommended for organically grown fruits and vegetables either in home gardens or in open fields.

Green Manuring: It is a nature friendly method of growing leafy and leguminous crops in the field. It should be ploughed into the soil at the flowering stage and allowed to decompose under the soil to make it soil enriched with essential plant nutrients. The green manuring crops can be also harvested and used for mulching of the soil surface around fruit trees to conserve soil moisture.

Concentrated Organic Manures: These are the by-products of plant and animal based agro industries. The product is organic in nature

and contains higher percentages of plant nutrients. The common and popular concentrated organic manures are oil seed cakes like groundnut cakes, neem cakes, karanj cakes, cotton seed cakes, and animal based by products like bone meal, blood meal, fish meal, etc. Normal nutrient contents of cakes are 3.0-8.0 percent nitrogen, 1.0-2.8 percent phosphorus and 1.0-2.0 percent potassium.

2. Inorganic/Chemical Fertilizers: Inorganic fertilizers are chemical fertilizers, highly rich in major nutrient content and classified into three categories based mainly on their nutrient contents. Chemical fertilizers are manufactured in industries through chemical processes and are harmful to agro ecosystems when used without scientific knowledge or used in excess. Chemical fertilizers are normally not recommended for home gardens or for organic production of fruits and vegetables.

Nitrogenous Fertilizers: These are inorganic substances containing large amounts of nitrogen in two forms like nitrate nitrogen form and ammoniacal nitrogen form. Both forms of nitrogen are readily absorbed by plant roots and show fast effects like allopathic medicine. Nitrogen is essential for vegetative growth and for the above ground parts of plants. The popular nitrogenous fertilizers are sodium nitrate (16% nitrogen), calcium nitrate (15.5% nitrogen), ammonium sulphate (20.6% nitrogen), ammonium phosphate (20% nitrogen), ammonium nitrate (33% nitrogen) and calcium ammonium nitrate (25% nitrogen).

Phosphoric Fertilizers: These are inorganic fertilizers that contain large amounts of phosphorus. Phosphorus is essential for the development of roots and underground parts of plants. Phosphorus is expressed in terms of phosphorous pentoxide. The phosphorus in these fertilizers is soluble in water or citric acid. Water-soluble phosphoric fertilizers are normally used in neutraltoalkaline soils. The popular water-soluble phosphoric fertilizers are single superphosphate (16-18% phosphorus), double superphosphate (32-34% phosphorus) and triple superphosphate (46-48% phosphorus). The citricacidsoluble phosphoric fertilizers are suitable for acidic soil. Due to the low pH of soil the citratesoluble phosphorus is converted to monocalcium phosphate and cannot be fixed into soil and always remains available to the plant. The popular fertilizers are dicalcium phosphate (14% phosphorus) and basic slag (17-20% phosphorus). There are both water and citratesoluble phosphoric fertilizers that are recommended for all types of soils. The phosphorus released into the soil remains there for a long time. The important fertilizers are rock phosphate (20-30% phosphorus) and bone meal

(21-25% phosphorus).

Potassium Fertilizers: These are chemical fertilizers that contain large amounts of potassium normally expressed in terms of dipotassium oxide and commonly called Potash, which is essential for the development of flowers and fruits. Fruits get their natural colors because of potash metabolism. These fertilizers are manufactured from minerals and ores. These are readily water soluble salts of chlorides and sulphates. Popular potassium fertilizers are potassium chloride or muriate of potash (60-62% potash) and potassium sulphate or sulphate of potash (48-52% potash).

3. Bio-fertilizers: These are liquid or powder based microbial preparations containing active strains of micro-organisms like bacteria, fungi, actinomycetes and blue green algae, etc. Bio-fertilizers are living products that can regenerate in the soil and continue to support plant growth by supplying essential nutrition through nitrogen and phosphorus. Moreover, these are the cheapest and most eco-friendly sources of plant nutrition.

According to their speciality in soil, these microorganisms fix atmospheric nitrogen with or without association with plants or dissolve phosphorus fixed in the soil. There are various types of microorganisms like asymbiotic nitrogenfixing bacteria that fix atmospheric nitrogen without any association with plants, e.g., Azotobacter, symbiotic nitrogenfixing bacteria that form nodules on the growing roots of leguminous plants and fix nitrogen in association with growing plants on a mutually beneficial basis, e.g., Rhizobium. Some bacteria fix atmospheric nitrogen in weak association with the host plant and is, therefore, called associative symbiotic bacteria, e.g., Azospirillum.

Some bacteria like phosphorbacteria and fungilike mycorrhiza act on soil phosphorus that is fixed in the soil and make it available for plant growth while some actinomycetes like frankia fix nitrogen in the roots of nonleguminous tree plants while the bluegreen algae fix nitrogen in wetland areas like rice fields and supply 50 percent of the nitrogen requirement of plants.

3.2.2 Production and Application of Organic Manures

Using organic manures is the best way to return to soil what has been removed from it through crop production. These manure supply nutrients in small quantities and that is the reason they are required in bulk quantities. They are essential for keeping the porosity of soil where plant roots can be grown easily and profusely to

support above ground parts of plants.

Preparation of 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. FYM preparation in trenches is more scientific than preparing it in the heap method. The trenches method reduces nutrient losses through leaching.

A trench or a pit the size of approximately 6 m long, 2 m wide and 1m deep is the ideal size to accommodate approximately 5-6 tons of FYM. The daily generated material should be put in the trench layer by layer till it fills 45 to 60 cm above ground level. The top of the heap should be made domeshaped and plastered with cow dung and earth slurry from all the sides so as to hasten anaerobic microbial decompotion. The well decomposed FYM can be ready to be used after 2-3 months.

Compost Making: 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 humusrich substance called compost.

The common method of compost making practiced by farmers is to fill up the organic waste in the pits, heap it and leave it for 23 months for natural decomposition. However, it is not considered a good method of composting as it is exposed to the sun and rain and cannot produce enriched compost. NADEP is one of the most scientific methods of compost making that can preserve nutrients intact. However, these methods are normally used for preparing large-scale compost for large cultivation areas.

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 nonplastic 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 decomposi-

tion. 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 evapotranspiration.

3.2.3 Production and Application of Vermicompost

Vermicompost can be produced using earthworms for eating vegetative waste and converting it into enriched biomanure. This biomanure is nothing but nutrientrich excreta of earthworms containing three times more nitrogen, phosphorus and potash than the normal compost material.

Small-scale vermi composting: This activity can be undertaken at individual level using household organic waste like kitchen waste, vegetable waste, garden litter and any other plant and animal based organic waste.

1. For small-scale composting at household level, wooden or plastic bins, containers, tubs, barrels or crates can be used according to the volume of garbage available for composting. The bins or wooden boxes of various shapes and sizes, but preferably with a 90 cm x 60 cm x 30 cm size, are selected for composting.
2. The bins and boxes are drilled to make a number of 1 to 1.5 cm diameter holes normally one for each area of approximately 10 cm^2 area at the bottom of a container to drain extra water from the container and prevent suffocation of active earthworms inside the compost box.
3. The bottom of the container should be covered with cardboard, then with corrugated box paper, then with newspapers and the material to be vermicomposed is shredded and spread layer by layer on the bottom of the container box.
4. Each time, on each layer, nearly 100 grams of earthworms are scattered on the organic waste already moistened but free flowing water should not be poured on this waste. The completely filledin container should be covered with a gunny bag to conserve moisture and protect living earthworms from light. Earthworms are always happy with darkness and cannot survive in bright light.

Small-scale vermi composting bins

5 When earthworms grow and multiply on a large scale, they eat away almost all organic material and convert it into stable fine granular organic matter rich in humus.

6 The manure produced within a month or two depends on the quality of organic material and the quantity of earthworms commissioned into it. Material rich in mineral nutrients, vitamins, antibiotics and plant growth hormones free from pathogens can be directly used for crop manuring.

Large-scale vermi composting: Large-scale vermi composting requires a continuous supply of inputs like organic waste and water. Agro based organic waste and kitchen waste sorted and made free from nondegradable plastic, stones and glass should be properly treated to provide the desirable carbon: nitrogen ratio. Earthworms are highly sensitive animals to both direct sunlight and rain; therefore vermicomposting should be done in proper sheds and with protection from direct rain.

1 Select a level ground with a gentle slope towards one direction to drain the excess water and prepare raised beds of soil by spreading soil with 1 m width and 0.3 m raised; the length may be kept according to the requirement and availability of inputs and space.

2 Moisten the soil surface by sprinkling water, taking care to avoid stagnation of water in and around the raised bed area.

3 Spray a layer of organic waste mixed with cow dung over the soil to a height of 15 cm and moisten the layer with moderate application of water.

4 Mix the earthworms in the bedding material and thus fill up the bed with 2-3 layers of organic waste followed by the release of earthworms and moderate spraying of water to moisten the dry material.

5 The earthworms will eat organic waste, leaf litter and cow dung and produce brown granular castings. One kilogram of earthworms can produce 10 kg of excreta casting in 1.5 to 2 months.

Large scale vermicomposting under shed

6 When the feeding material disappears, stop watering the beds, let bedding material dry to some extent so that live earthworms can go down deep into bottom, then remove the fine grained vermicompost material and store it in the shed covered with gunny bags. This can prevent nutrients and moisture losses from the vermicompost.

7 Fill the bed again with same organic material and repeat the procedure to provide feeding material to earthworms and get the second lot of vermicompost.

8 As the population of earthworms grows faster, the second lot of vermicomposting takes less time and covert the same amount of material within one month to produce good vermicompost.

3.2.4 Application of Manures and Fertilizers

The application of manures and fertilizers depends on the essential nutrients already available in the soil and the additional requirement of nutrients for the growing crop. There are several visual and laboratory methods to find out nutrient requirements of crop plants. These are visual deficiency symptoms, chemical analysis of soil,

chemical analysis of leaf petiole and leaf lamina and measuring plant response to added manure and fertilizer. However, often, these techniques are mostly useful in correcting deficiencies in the next crop because it is often too late to correct the damage that has already occurred to prevailing crop.

The amount of manure or fertilizer applied to the crop plant greatly varies with soil type, soil fertility and productivity, age and canopy of plant and climatic conditions of the area. However, often, manures and fertilizers are applied on the basis of a moderate set of conditions when information on soil nutrient status is not available. It has been a growing concern that the crop manuring and fertilizing program should ensure sustained crop productivity and at the same time not pollute the surroundings with excessive application of manures and fertilizers.

The combined application of manures (80%) and fertilizers (20%) is most effective combination for a good quality bumper yield safe for human consumption. The action of organic manures is fairly slow but long lasting and that of chemical fertilizers is fast but non sustainable. The fertilizers act as a nutrient booster before the nutrients from organic manures become active in the soil ecosystem to support crop growth.

For one fruit tree in the soil, usually 20 kg of FYM or compost or 10 kg of vermicompost can be applied at the time of planting, mixed with 100 g of chemical fertilizers to boost initial plant growth. The quantity of manures should be increased 20 percent each year with increase in age of the plant till it becomes fully mature. The manuring dose may be kept constant for full-grown tree plants. The dose of manures for pot or container grown fruit trees can be halved owing to the limited space for root development.

Time of application of manure and fertilizer: 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. It is also good practice to apply manures and fertilizers at the outset of the monsoon for some fruit crops like citrus, papaya and banana as their flowering coincides with the onset of the monsoon. However, as a rule of thumb, 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.

Method of applying manures and fertilizers: Manures and fertilizers must be applied within the root zone of the growing crop. In the early stages of plant growth, fertilizers mixed with manures should be applied in the area around the tree where feeding roots are largely concentrated. The water-soluble fertilizer nutrients percolate largely vertically down and slightly in lateral directions into the soil. Therefore, in the application of manure and fertilizers one must ensure even distribution in the moist soil for access to the plant root.

Generally, for fruit crops with fewer number of plants per unit area, the manures and fertilizers are applied individually in rings or trenches dug around the tree trunk but below the tree canopy, where 80 percent of the roots of plant are concentrated. Vegetable crops have a larger plant population per unit area and therefore manures and fertilizers are generally applied through surface application by mixing in the soil and evenly distributing in the growing area.

3.2.5 Recycling of Waste water for Irrigating Pots and Beds

Water is an essential component of crop growth. No living plant or animal can survive without water. Watering or irrigation is the method of providing moisture to the plant for its sustainable growth to produce edible flowers, fruits or seeds and other parts as the final product. For a homebased kitchen garden, we can use partially treated bathroom and kitchenused wastewater by allowing it to pass through layers of soil, sand, brickbat and charcoal so that the physical and chemical impurities can be separated from water to make it safe for irrigation. However, it is not a bad idea to mix and supplement raw drinking water with partially treated wastewater for homebased fruit and vegetable production for domestic consumption.

Watering of Pots and Beds: Under city farming practices, pot based fruits and vegetables are normally grown on terraces and balconies while soilbased fruits and vegetables are grown in the soil in kitchen gardens. Pot culture require a less volume of soil and hence a few but frequent watering applications while 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 homebased 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. One family of five persons on average generates 200,000 to 250,000 litres of kitchen and bathroom wastewater every year. After partial treatment of the water, it is sufficient to grow at least three crops on an approximately 1000 m^2 area, which can produce nearly 1,000 kg of fruits and vegetable, more than sufficient for the five in a family to maintain their health.

3.2 Glossary

Manures: This is the decomposed part of organic material generated on the farm that contains most of the plant nutrients in low quantities.

Fertilizers: This is industrially manufactured chemical substances containing essential plant growth nutrients in high concentrations.

Irrigation: This is the process of watering a crop in the field.

Wastewater: This is the water that passes after use through the kitchen and the bathroom and after other domestic uses.

Nutrients: These are inorganic mineral elements that support plant growth.

Vermicompost: This is compost prepared through the actions of earthworms.

Green manure: This is a leguminous crop grown and ploughed in soil at maximum vegetative growth.

Microorganisms: These are microscopic living organisms like bacteria, fungi, actinomycetes, algae, etc.

FYM: As already mentioned this is manure prepared from farm wastes like cattle dung, litters, bedding material, and wasted fodder mixed with cattle urine.

Surface irrigation: It is the method of watering crop plants with free flowing water.

Sprinkler irrigation: It is the method of watering crop plants by spraying water through a water jet.

Drip irrigation: It is the method of watering crop plants through lateral pipes and drippers.

3.3 Points to Remember

- Manures and fertilizers are the feeding material for good growth of fruits and vegetable plants.
- Manures contain a lower percentage of plant nutrient than fertilizers but are highly ecofriendly.
- Organic manures and fertilizers may be mixed in 80:20 proportions and applied to fruit and vegetable cultivation.
- Bio-fertilizers are nature friendly microbial preparations that fix atmospheric nitrogen and break down fixed phosphate phosphorus in soil and make them available to growing plants.
- Vermiculture is the process of culturing earthworms that converts organic waste into enriched bioorganic manure.
- Manures and fertilizers shall be applied to crops at the time of planting, maximum vegetative growth, flowering and fruiting.
- Manures and fertilizers shall be applied in the root zone of growing plants.
- Partially treated kitchen and bathroom water can be safe for use in home based kitchen gardening.

3.4 Self Check Questions

i What is the difference between manures and fertilizers?

ii What is vermicompost and what is its significance?

iii How is vermicompost prepared in wooden boxes?

iv What is the difference between symbiotic and nonsymbiotic bacteria?

v When is it suitable to irrigate fruit and vegetable crops in a pot and bed culture?

3.5 Do It Yourself

- Preparation of compost and vermicompost from kitchen waste

Compost Preparation:

1 Select a suitable corner at the extreme end in your garden and, according to availability of space and requirement of compost for your garden, dig a 3 m long, 2 m wide and 1 m deep compost pit.

2 Fill the bottom of the compost pit with 6 inches thick, hard and fiberbased organic material like pigeon pea and cotton stems at the bottom followed by a 6 inches. layer of other organic material like kitchen waste, leaves, weeds, stubbles and straw and level it.

3 Spray sufficient water on this layer to make it soft while maintaining the moisture level in the range of 50 to 60 percent.

4 Repeat the filling and watering process layer by layer till the compost pit filled is 30 cm above the ground level.

5 Then plaster the dome of trench with the help of soil mud or cow dung slurry to prevent nutrient losses through evaporation and transpiration.

6 Wait for 2.5 to 3 months, then open the compost pit and use the welldecomposed compost for you garden.

Vermicompost Preparation in a Bin:

1 Select wooden bins or a box with dimension of 90 cm long. 60 cm wide and 30 cm deep and make provision for at least three to four drainage holes at the bottom of the bin.

2 Cover the bottom of the bin with a 1 cm thick layer of newspaper followed by 5 cm layer of hard sticks of crop residues like pigeon pea sticks and a 10 cm layer of garden soil. This will act as bedding material for earthworms.

3 Add your daily kitchen waste, layer by layer in the bin, spray a little water and cover with thick cloth or a gunny bag for a few days till the material starts decomposing.

4 Add 50 to 100 full-grown earthworms in the upper layer of the compost in the bin and again cover with a gunny bag.

5 Go on adding kitchen waste and other available organic material, layer by layer in the bin followed by spraying a little water to provide sufficient moisture for earthworms to work.

6 Earthworms will eat all the organic materials provided to them and breed and multiply themselves inside the bin resulting in the fast decomposition of the organic material.

7 After 2 months' feeding and watering of the bin may be stopped and allow all surfacedwelling earthworms to go down to the bottom in search of moisture.

8 The welldecomposed vermicompost materials can be harvested and used immediately or stored in the shade for future use in the garden.

Vermicompost under Shade:

1 Select a level ground with a gentle slope towards one direction to drain the excess water and prepare raised beds of soil by spreading soil with 90 cm width and 30 cm raised; the length may be kept according to the requirement and availability of inputs and space.

2 Moisten the soil surface by sprinkling water, taking care to avoid stagnation of water in and around the raised bed area.

3 Spray a layer of organic waste mixed with cow dung over the soil to a height of 15 cm and with moderate spraying of water moisten the dry material.

4 Mix the earthworms with the bedding material and fill up the bed with 2-3 layers of organic waste followed by the release of earthworms with moderate spraying of water to moisten the dry material.

5 Earthworms will eat the organic waste, leaf litter and cow dung and produce brown granular castings. One kg of earthworms can produce 10 kg of excreta casting within 1.5 to 2.0 months.

6 When the feeding material disappears, stop watering the beds and let bedding material dry to some extent so that live earthworms can go down deep into the bottom; then remove the fine-grained vermicompost material and store in a shed covered with gunny bags. This can prevent nutrient and moisture losses from vermicompost.

7 Fill the bed again with the same kind of organic material and repeat the procedure to provide feeding material to earthworms and get the second lot of vermicompost.

8 As the population of earthworm grows faster, the second lot of vermicompost takes less time; so cover the similar material within one month to produce good vermicompost.

UNIT 4: Pest, Diseases and Crop Protection

4.1 Introduction

Most of the time, we are not concerned about the quality and source of food we consume, in spite of numerous and regular reports in the media about the presence of deadly pesticides and other chemical contaminants in our fruits and vegetables. We urban people are almost isolated from the food production process in rural areas. We need to understand that the present system of chemical based farming has negative effects on our health and the environment. The chemicals used in modern agriculture in the form of pesticides and fertilizers have already ruined our natural resources like soil, water and air besides our food chain.

The approach and outlook towards modern agriculture as a system of food production has changed worldwide over the last 10 years. In earlier days, season and climate of a particular area was used to determine the types of crops to be grown. However, nowadays market forces determine types of crops to be grown. Now more emphasis is given to quantity and external appearance of fruits and vegetables. This has promoted indiscriminate use of chemical fertilizers and pesticides which have increased the quantity of food but greatly reduced its nutrition value resulting in malnutrition and deficiency diseases with reduced immunity.

The application of chemicals for pest control leads to food poisoning and the pollution of soil, water and the environment. These chemicals have created an ecological imbalance and allowed insect pests to develop resistance to deadly chemicals in nature. At this juncture, biological crop protection can play a key role in producing chemical free food that is good for our health.

At the end of this unit, you will be able to know and understand:

- Different insect pests and diseases of vegetable crops grown in the kitchen garden and the terrace garden.
- Importance of biological pesticides and their methods of preparation for controlling pests and diseases on vegetable crops.
- Application of natural pesticides in vegetable growing practices in the kitchen garden.

4.2 Contents

4.2.1 Pests and Diseases of Crops

The city farmers and gardeners who grow a variety of fruits and vegetables in their kitchen gardens face fewer problems from pests and diseases. Insect pests are likely to concentrate in particular seasons and particular locations. Most of the pests and diseases can be managed by following proper management practices without using any chemical pesticides.

The basic difference between insect pests and diseases is that insect pests are generated from insects. Their various life stages feed on growing vegetables in a variety of ways. While plant diseases are caused by various microorganisms like bacteria, fungi, viruses, nematodes and mycoplasma or more specifically called plant pathogens. These pathogens are generated from soil, water or air and spread through a number of ways in nature. Some important pests and diseases of vegetables in the kitchen garden are enumerated below.

Aphids

White Flies

Fruit Borer

Caterpillar

Insect pests like aphids, white flies, pod borer, leaf eating caterpillars

Powdery mildew

Leaf spot

Rust

Blight

Wilting

Root rot

Plant diseases like powdery mildew, leaf spot, rust, blight, wilting, root rot

Major insect pests

1.	Cabbage	Aphids, Mustard saw fly	Damping off, Downy mildew
2.	Cauliflower	Aphids, Mustard saw fly	Damping off, Downy mildew
3.	Knol khol	Aphids, Mustard saw fly	Damping off, Downy mildew
4.	Spinach	Aphids, Leaf eating caterpillar	Wilting, Leaf spot
5.	Fenugreek	Aphids, Leaf miner	Wilting, Leaf spot
6.	Coriander	Aphids, Leaf eating caterpillar	Wilting, Leaf spot
7.	Garden peas	Aphids, Pod borer	Wilting, Powdery mildew
8.	Cowpea	Aphids, Pod borer	Wilting, Powdery mildew
9.	Chickpea	Pod borer	Wilting
10.	French bean	Aphids, Pod borer	Wilting, Powdery mildew
11.	Drumstick	Stem borer	Leaf roller
12.	Asparagus	Beetles, Centipedes	Rust
13.	Groundnut	Army worm, caterpillar	Tikka, Collar rot
14.	Tomato	Fruit borer, White fly	Damping off, Blight
15.	Okra	Thrips, Fruit borer	Powdery mildew, Virus
16.	Brinjal	Fruit borer, Jassids	Damping off, Powdery mildew

Major Diseases

1.	Chilli	Thrips	Fruit rot
2.	Cucumber	Fruit fly, Red beetle	Powdery & Downey mildew
3.	All gourds	Fruit fly, Red beetle	Powdery & Downey mildew
4.	Radish	Aphids, Mustard saw fly	Rust, Blight
5.	Carrot	Weevil, Leaf hopper	Blight, Powdery mildew
6.	Beet root	Aphids, Leaf miner	Root rot
7.	Onion	Aphids, Thrips	Blast, Blight
8.	Garlic	Aphids, Thrips	Blight, Pink root
9.	Potato	Aphids, Cutworms	Blight, Tuber rot
10.	Sweet Potato	Weevil, Leaf eater	Wilt, Black rot

4.2.2 Bio-pesticides and Insecticides

Biological control is a method of controlling insect pest or plant pathogen using another selective and beneficial insect or microorganism to counterattack the pest or disease. The microorganism, also called antagonist has the potential to interfere with the growth and survival of the plant pathogen which can damage or kill the plant pathogen and contribute to biological control of the crop pest.

1. **HNPV Viral Biopesticide:** This is the short form for Heliothis Armigera Nucleopolyhedrosis Virus that can be isolated from infected larvae and used to prepare NPV formulations as an effective insecticide against most of the leafeating larvae and caterpillar pests like pod borer, stem borer, fruit borer, etc. Water suspension of this virus is extracted from diseased larvae and used for spraying on crops. When larvae of pests eat leaves the virus enters the body of the larvae. The virus infects the whole body inside and larvae die within 5 to 6 days.

   Methods of Application: HNPV formulations are available in liquid forms in the market or in agricultural universities. Mix 1 ml of HNPV liquid in 1 liter of water and spray twice at 10 day intervals. Spraying should be carried out in evening time or when eggs and larvae are visible on leaves.

2. **B.T. Bacterial Bio-pesticide:** This is the short form for a soilborne beneficial bacterium called *Bacillus thuringiensis*. It can effectively control common insect pests like hairy caterpillar, stem borer, fruit borer, pod borer, cut worm, army worm, leaf roller and leaf miner and other leafeating insects. The bacterial toxin called delta

endotoxin causes disintegration of larval midgut leading to starvation and paralysis of the larval body resulting in the death of larvae. Simultaneously, the spores of the bacterium germinate inside the body of larvae and multiply to produce more endotoxins.

Methods of Application: The BT Bacterial culture is sold in the form of a powder or granules or suspension consisting of endotoxin crystals and living bacterial spores. Mix 2 g of BT bacterial powder or granules in 1 liter of water and spray on vegetable gardens during evening time. If larval population is still observed repeat the spraying.

3. **Trichoderma Fungal Biopesticide:** *Trichoderma* is a formulation of beneficial fungus that can kill another diseasecausing fungus on crop plants. It is effective against soilborne plant pathogens like *Pythium*, *Phytophthora* and Fusarium. Rhizoctonia fungi cause wilt and rootrot diseases in crops. These biopesticides are applied to seed and planting material at the time of planting to reduce insurgence of soilborne plant diseases. The trichoderma fungus is not harmful to plants, insects or animals and can be used safely against targeted fungal pathogens causing plant diseases. It does not grow at temperatures above 28°C.

   Tricoderma adversely affect other plant pathogens using different modes of action like antibiosis, competition, mycoparasitism and detoxification. All these mechanisms are operated together or independently resulting in the suppression of pathogen growth.

   Method of Application: The seeds of vegetable crops can be treated with tricoderma powder at the rate of 5 g per one kilogram of seed or the tricoderma is mixed with small a quantity of water to prepare paste. The paste is applied evenly to the seeds. The seeds are then dried in the shade and sown. Secondly, for treating seedlings of vegetables, take 10 g of tricoderma in 10 liters of water and make a solution. Dip the roots of seedlings into this solution before transplanting. This can prevent infection of root pathogens in the soil. Thirdly, for treating perennial crops, take 25 g of tricoderma in 5 liters of water and apply to the plant using the ring method around the trunk of the plant or trees. Five g of tricoderma mixed with 1 liter of water can be sprayed

on infected crops at evening time. It can control blast and blight diseases in vegetables.

4. **Verticillium Fungal Bio-pesticide:** It is a type of fungus that kills insects and serves as a very effective ecofriendly biological insecticide. It is effective against insect pests like Aphids, Thrips, White flies and other sucking types of pests. When the Verticillium fungal preparation is sprayed on vegetables the spores of fungi germinate on the insect body and the fungal filaments penetrate it and destroy the internal parts and the insect dies.

   Methods of Application: Mix 5 g of Verticillium powder in 1 liter of water and spray on the vegetable crop including leaves, stem, flowers and fruits from all sides so that no insect and its growth stages remain untouched from bio-pesticide. Care must be taken to refrain from mixing any other chemical fungicides with Verticillium bio-pesticide.

5. **Beauveria bassiana Fungal Bio-pesticide:** It is another type of fungus based bio-pesticide that kills and controls chewing type of insect pests like white flies and insects of the beetle class. The fruiting bodies of fungi called conidia attached to the insect body start germinating and the filamentous growth of fungi penetrate the insect body within 24 to 48 hours under high humidity conditions. The infected insects may live for 4 to 5 days and then die due to severe internal infection.

   Method of Application: Mix 6 ml of bio-pesticide powder in 1 liter of water and add 2 g of soap powder as a sticking agent and sprayed on vegetable crops. The bio-pesticide can effectively eliminate white flies and beetlelike insect pests within a week's time. This bio-pesticide powder should not be mixed with other chemical fungicides for pest control.

4.2.3 Preparation of Homemade Botanical Pesticides

Neem Extract (Neemark): The word neem is derived from Sanskrit nimba meaning bestowed of good health. Neem leaves, seed and the stem contain an alkaloid called azadirachtin, which is basically responsible for insecticidal properties. Extracts of neem seeds or leaves have many effects on insects. The anti-feeding and insect growth regulating and altering properties have a great valuable

effect in pest management. Besides this, there are other beneficial effects like repellency, sterility, fecundity reduction, loss of flying ability, disturbances in sexual communication and reduction in mobility.

Preparation of Neem Extract: The neem extract can be prepared from seeds, leaves and the bark of the neem plant. The neem seed extract is one of the most effective extracts against leaf eating, sap sucking and fruit and podborer insects and their larval stages, which damage the crop.

1. The neem fruits are collected, washed under water to remove the pulp and seeds separated after which the latter should be dried in the sun for 5 to 6 days and then stored in gunny bags at places which are free of moisture.
2. While preparing neem seed extract, seeds are crushed along with the seed coat or sometimes the seed coat is removed and only kernels are crushed to obtain a concentrated extract.
3. Crush 50 g of neem kernel in mortar finely and mix with 1 liter of water, stir and mix vigorously and keep overnight so that active ingredients can dissolve in water.
4. The suspension is again mixed and filtered through muslin cloth or any fine holed cloth to obtain the dark yellow extract. This extract can be directly sprayed on vegetables.
5. The effect of this spray will remain effective for the following 5 to 6 days. If neem seeds are not available, the second most option available is to use neem seed cakes. Mix 500 g of neem cake with 1 liter of water and repeat the procedure to obtain a botanical pesticide.
6. If neither neem seed nor neem cake is available the third option is to use the neem bark and leaves. Though it is less effective than the seed extract it can have comparatively good benefits over no application.
7. Crush 5 kg of neem leaves in mortar and mix the paste with 5 liters of water and keep overnight for proper mixing. The following day, the mixture should be filtered through muslin cloth and sprayed on vegetable crops to control insect pests.

4.2.4 Application of Natural and Botanical Pesticides

Chili – Garlic Extract: Chili and garlic extract has insecticidal properties. It is very useful against sucking and eating pests like aphids, white flies and caterpillars. The toxic and corrosive action of sulphur from garlic and capsicum from chili cause severe itching in the epidermis of the insect pests resulting in their death on dry sunny days.

Preparation of Extract: Mix 500 ml water with two heads of garlic and 10 hot green or red chili, crush them and keep overnight. Filter the mixture through muslin cloth, fill in spray bottles, add a few drops of nondetergent liquid soap in the solution and spray on the vegetable crop.

Wood Ash: Wood ash or cow dung ash is very effective in controlling insect pests like Aphids, Thrips and other insect pests that live on onion, garlic and cucurbit crops. The ash is very dry in nature. When it is dusted on the vegetable crop it falls on the insect body causing desiccation of the insect body resulting in its death.

Tobacco Decoction: Tobacco contains nicotine sulphate which has insecticidal properties that kill insect pests. Mix 5 liters of water with 500 g of second grade or a rejected lot of tobacco and keep it overnight. Filter the solution, add few drops of nondetergent soap and spray on desired vegetable crops to control leaf eating and sap sucking insect pests.

Indigenous Technology and Plant Protection: There are several methods and practices that local people use to manage their pest problems in the kitchen garden to protect vegetables from diseases without using any chemical pesticides. These practices have variable effects from location to location and nature of infestation of the crop pest. Some indigenous practices are enumerated below.

- Spraying of cow urine or wood ash or sour butter milk on vegetables like tomato, chili and brinjal reduces the attack of virus diseases by the controlling action of insects on these crops.
- Soilborne diseases of vegetable crops like root rot and collar rot can be controlled by mixing neem cake or karanj cake or castor cake in the soil.

- A milk solution prepared by mixing 1 liter of milk in 9 liters of water is found to be very effective in managing diseases like powdery mildew and spreading of viral infections.
- Mix a solution of 50 ml of lemon juice, 50 ml tamarind juice and 5 liters of water. The mixture can effectively control hairy caterpillars and other leafeating caterpillars in vegetable crops.
- A solution prepared from 100 g of Tulasi leaves (Oscimum Spp) crushed and mixed in 1 liter of water can effectively control aphids, army worms, bugs and mosquitoes.

4.3 Glossary

Bacteria: These are unicellular microscopic organisms found almost everywhere, in soil, water, air, food and the stomach.

Fungi: These are multicellular microorganisms filamentous in nature and found almost everywhere, in soil, water, air and food.

Viruses: These are very minute particles that can be seen under electronic microscopes and that cause diseases in plants and animals.

Pests: These are insects that cause damage to crop plants like fruits, vegetables and flowers resulting in economic losses.

Disease: It is a sort of damage caused to the plant due to infection by harmful microorganisms like bacteria, fungi, viruses or others.

Biological control: It is the process of controlling pests or diseasecausing organisms with the help of their enemy organisms.

Microorganisms: These are minute organisms that cannot be seen with naked eye and are present in soil, water and air.

Plant pathogens: These are harmful microorganisms causing diseases in plants and animals.

Antifeedant: This is the substance or insecticide that stops the insect from feeding on its host plant.

Repellent: The substance or insecticide that repels the insect from its host plant.

Resistance: It is the capacity of insects to resist or survive harmful chemicals used against them.

Indigenous methods: These are local methods used in particular geographical regions.

Pest management: It is the combination of all efforts to check the spread and damage from insect pests to crop plants.

4.4 Points to Remember

- Pest and diseases cause economic loss by harming fruits and vegetable crops in the kitchen garden.
- The leaf eating caterpillar and sap sucking pests are common insect pests in vegetable crops.
- Bio-pesticides are eco-friendly and natural pesticides are used in pest management.
- Botanical pesticides are easy to prepare and are effective against vegetable pests in the kitchen garden.
- Indigenous methods of pest management are time-tested and effectively used by local communities.

4.5 Self Check Questions

i What is the difference between insect pests and diseases?

ii List the names of various bio-pesticides.

iii List the names of various botanical pesticides.

iv List the names of various natural pesticides.

v Explain the preparation of neem seed extract for controlling insect pests.

4.6 Do It Yourself

- Preparation of neem seed/cake. Leaf extract as a botanical pesticide

1 For preparing the neem seed extract, finely crush 50 g of neem kernel in mortar and mix with 1 liter of water, stir and mix vigorously and keep overnight so that active ingredient can dissolve in water.

2 Mix the suspension again and filter through muslin cloth or any fine holed cloth to obtain the dark yellow extract. This extract can be directly sprayed on fruits and vegetables.

3 Effects of this spray will remain active for the following 5 to 6 days. During this period insect pests will not feed on vegetables.

4 For preparing a neem cake extract, take 500 g neem cake, make a fine powder with it, mix with 1 liter of water, keep the solution overnight, filter through muslin cloth and spray on fruits and vegetable crops.

5 For preparing a neem leaves extract, take 5 kg of neem leaves and crush in mortar and mix the paste in 5 liters of water and keep overnight for proper mixing. Filter the mixture next day through muslin cloth and spray on vegetable crops to control insect pests.

UNIT 5: Leafy and Legume Vegetable Cultivation

5.1 Introduction

Kitchen gardening has been practiced since time immemorial but much attention has not been paid to growing nutrition rich vegetables. Vegetables in kitchen and terrace gardens are cultivated to fulfil day to day needs of the family, and the surplus can be sold to earn extra income to support other family needs.

Since vegetable cultivation in the kitchen garden is restricted to a small area, a kitchen gardener requires good imagination, knowledge and skill to select high value and high nutritive vegetables that can be grown in a limited area so that family requirements can be met without any wastage.

According to experts on nutrition, a balanced human diet should contain 300 g of vegetables per person everyday. However, in India the average consumption of vegetables is around 210 g per day and that too with a highly erratic distribution. Some people eat 600 g of vegetables while those living in slum areas cannot eat even 100 g of vegetables owing to the difficulty in the availability and affordability of vegetables.

The majority of the Indian population are vegetarians and the protein requirement of vegetarians can only be met only by eating legume vegetable and pulses. Various leguminous vegetables contain 25 to 45 percent proteins, besides a good amount of carbohydrates, minerals and vitamins.

One effective way of making fresh and nutrition rich vegetables available to the common man and that at affordable cost is to grow them in his kitchen garden, terrace garden and wastelands around their houses.

Night blindness is emerging as one of the major deficiency diseases in children caused because of the deficiency of vitamin A. Anemia in children and pregnant women is caused due to deficiency of iron. One of the cheapest solutions is to grow leafy vegetables in the kitchen garden and make them available to the common man.

At the end of this unit, you will be able to know and understand

- The importance of leafy and leguminous vegetables in the human diet.
- Nutritive value of all these leafy and legume vegetables.
- Package of practices of vegetable cultivation in the kitchen garden.

5.2 Contents

5.2.1 Cultivation of Cabbage, Cauliflower and Knol khol

Cabbage Cultivation:

Nutritive value: Cabbage is one of the most important leafy vegetables grown in the kitchen garden all year round. Cabbage contain 92 percent water, 4.6 percent carbohydrates, 1.8 percent protein and is a rich source of vitamins A and C, calcium, potassium, phosphorus and iron. Raw green cabbage is considered highly effective as a remedy for stomach ulcers.

Soil and Climate: Cabbage requires a well drained medium to heavy soil having a soil pH value in the range of 6.0 to 6.5. Light soils applied with a lot of compost materials can well support cabbage growth. Acidic soils prevent the availability of boron and molybdenum to the crop causing deficiency diseases.

Cabbage is generally cultivated in the winter season because cabbage prefers a cool climate. However, under a mild climate, it can be grown all year round. Cabbage heads develop well in temperatures between 15 and 25°C.


Cabbage crop grown in basket

Important Varieties: Golden Acre, Pride of India, early drumhead, etc., are the popular varieties of cabbage grown in almost all seasons.

Planting and Irrigation: Cabbage is grown in all the seasons. However, the best season for cabbage seedling transplanting is from October to January. Seedlings require 3 to 4 weeks to become ready for planting. The process of seedling raising should be started one month before plantation. Cabbage is a shallow rooted short duration vegetable crop producing a large quantity of biomass that require a large quantity of compost mixed with bone meal and neem seed cakes. Care should be taken to mix organic manure in the upper layer of soil specifically in the root zone. The crop should be provided with irrigation immediately after transplanting. Watering should be done once in 7 to 8 days in winter and once in 5 to 6 days in summer.

Plant Protection: The cabbage crop is mostly attacked by aphids, leaf miners and leafeating caterpillars that can be controlled initially by spraying systemic insecticides and, at later stages, when the crop grows towards maturity botanical insecticides can be used to protect the vegetable from insect infestation.

Harvesting: At harvesting time, the cabbage heads become compact and the outer leaves turn yellow. According to the variety grown, cabbage harvesting starts from 60 to 90 days on transplanting the seedling. Cabbage heads are cut at the stem base and outer loose leaves are removed before the head is used as a vegetable.

Cultivation of Cauliflower:

Nutritive Value: As a member of the Cole crop vegetable, cauliflower is one of the important vegetable that can be used in various formulations of mixed vegetables in the kitchen. It can be grown in soil as well as in pots on terraces. Cauliflower contains 91 percent water, 4.0 percent carbohydrates, 2.6 percent protein and is rich in vitamins A, B, C, phosphorus, calcium and iron.

Soil and Climate: Cauliflower can be grown in heavy to medium welldrained soils having little acidic soil, the pH value ranging from 5.5 to 6.6. It is basically a cool climate crop of European origion and is well grown in the temperature range of 25 to 27 °C.

Cauliflower crop grown in basket

Important Varieties: Pusa snowball, Pusa early synthetic, Early kuwari and Pusa deepali are popular varieties of cauliflower grown under South Indian climatic conditions.

Planting and Irrigation: The seeds of early maturing varieties of cauliflower are sown in the month of June to July, mid season varieties in July to August and late season varieties in September to October in the South Indian plains to raise seedlings. Three grams of seed are needed for approximately 1 m^2 size area on a raised bed. For transplanting, seedlings of 1.0 to 1.5 months are used followed by supporting the planted seedlings with soil, which is highly beneficial for establishment of seedlings in the soil. Manure in the form of compost mixed with bone meal and oil seed cakes like neem cake, karanj cake, etc., are applied at the time of transplanting. Since the cauliflower crop is shallowrooted, less irrigation water with more frequency should be given.

Plant Protection: The cauliflower crop is mostly attacked by aphids, leaf miner and leaf eating caterpillars that can be controlled initially

by spraying systemic insecticides. At later stages when the crop grows towards maturity botanical insecticides can be used to protect the vegetable from insect infestation. Besides that, poor nutrition, sudden climatic changes and transplanting overage seedlings cause bolting and buttoning in cauliflowers.

Harvesting: The quality of head which is also called as curd of cauliflower can be protected by covering the lower leaves of the same plant on head and tied with leaves only. Head or curd of cauliflower can be harvested after 60 to 90 days in early maturing varieties while it takes 90 to 120 days in mid and late maturing varieties.

Cultivation of Knol khol:

Nutritive Value: Knol khol is another member of the Cole crop family that forms edible and bulbous stems above the ground. Knol khol contains 93 percent water, 3.8 percent carbohydrates, 1.1 percent proteins and is rich in vitamins A and C, and potassium, phosphorus, calcium and iron.

Soil and Climate: Knol khol requires medium to light welldrained soil. It cannot survive in heavy, loamy and poorly drained soils. It is basically a cool climate crop, which originated from the European region, and can grow well in the temperature range of 10 to 20°C.

Knol khol

Important Varieties: White Vienna and Purple Vienna are the popular varieties of knol khol grown on a wide scale in various parts of South India.

Planting and Irrigation: In the plains of South India, knol khol seeds are sown in September-October to grow seedlings. However, direct

seeding in the field has also shown results similar to those of seedling transplanting. About 5 g of seeds are sufficient to raise seedling on an area of 10 m^2. Sowing on a raised bed can be done by keeping a distance of 20 cm between two rows. The seedlings are ready for transplanting in 1.0 to 1.5 months after sowing. Manuring and irrigation can be done as in the case of cultivating cabbage and cauliflowers.

Plant Protection: Knol khol crop is mostly attacked by aphids, leaf miner and leafeating caterpillars that can be controlled initially by spraying systemic insecticides and, at later stages, when the crop grows towards maturity by using botanical insecticides can be used to protect it from insect infestation.

Harvesting: Tender leaves of knol khol are nutritive and can be cooked as a leafy vegetable. Tender, succulent and bulbous knobs are uprooted and used for vegetables. If harvesting is delayed by 15 days, fibrous tissues develop inside the bulb and the quality of the vegetable is reduced considerably.

5.2.2 Spinach, Fenugreek and Coriander

Cultivation of Spinach:

Nutritive Value: Spinach is a short duration leafy vegetable, generally recommended to anemic patients to be eaten in abundance. It contain 86 percent water, 6.5 percent carbohydrates, 3.4 percent proteins, 0.8 percent fats and 0.7 percent fibers, 2.2 percent minerals like phosphorus, calcium and iron, and is rich in vitamins A and C.

Soil and Climate: Spinach can be grown in all types of soil. It performs well in light soil containing good organic matter. Spinach is a short duration vegetable which is ready for harvesting within 25 to 30 days of planting. It can be grown year-round.

Spinach Crop at Harvest

Important Varieties: All Green, Pusa Jyoti, Pusa Harit are the popular varieties of spinach grown in tropical regions.

Planting and Irrigation: Spinach seeds are sown 2 cm deep and 20 cm apart in weed free soil and covered with soil. Seeds germinate 8 to 10 days after sowing. Well composed farm yard manure should be mixed with soil before sowing the seeds. Since spinach is a succulent vegetable crop, it should be irrigated every 5 to 6 days in summer and every10 to 12 days in winter, and each cutting should be followed by manuring and watering.

Plant Protection: Spinach is generally attacked by insect pests like aphids, leaf miner and leaf eating caterpillars that can be controlled by spraying neem cake extract or neemark. Wilting is one of the major diseases of spinach caused by the fusarium fungus which can be prevented by treating seeds with Trichoderma biocontrol agent before sowing.

Harvesting: When spinach leaves attain a 20 to 30 cm height in 25 to 30 days after sowing it is ready for the first cutting. The first cut should be given at 5 cm from ground level. keeping the stem part intact. Second and successive cuttings should be done at 10 to 15 day intervals.

Cultivation of Fenugreek:

Nutritive Value: Fenugreek is an iron rich green vegetable that can be cultivated in soil as well as in pots. It contain 86 percent water, 6.0 percent carbohydrates, 4.4 percent proteins, 0.9 percent fats and 1.1 percent fibers, 1.5 percent minerals and is rich in vitamins A and C, calcium, potassium, phosphorus, magnesium, sulphur and iron.

Soil and Climate: Fenugreek can grow from heavy to medium black soil with good drainage. Fenugreek is a cool season crop but due to the wide adaptability it can also be grown under warm climates.


Fenugreek Crop at Harvest

Important Varieties: Kasuri Selection, Pusa early bunching, Methi No. 47 are popular varieties of fenugreek.

Planting and Irrigation: Fenugreek can be sown in June-July in the rainy season and in September-October in the winter season. However, protected cultivation of fenugreek can be done throughout the year. Seeds are broadcasted over the soil bed prepared by mixing sufficiently well decomposed manure (1 part manure with 10 parts of soil for filling pots and crates) and gently mixed with soil.

Seeds can also be sown in shallow open furrows 15 cm apart. Seeds germinate 7 to 10 days after sowing. For an area of 10 m^2 50 g of seed are required. For tender leaves, irrigate vegetables after 4 to 6 days (of what?) and each cutting of the vegetable should be followed by light irrigation.

Plant Protection: Aphids and leaf miner are the major insect pests of fenugreek that can be controlled by mixing neem cake in soil at the time of seed sowing and if an attack is observed on the vegetable undertake sprayed with neem cake extract.

Harvesting: Fenugreek can be harvested 30 to 35 days after sowing. It can be harvested by directly uprooting the plants or by cutting the plants at ground level or cutting only leaf branches and allowing the same plant to produce successive crops. However, the vegetable must be harvested before flowering to avoid over maturing.

Cultivation of Coriander:

Nutritive Value: Coriander, popularly known as *dhania* forms an important ingredient of salads and is used to flavor soups and snacks. The dried seeds of coriander are used as a homemade medicine and as spices to give better taste and flavor to the food.

Coriander contains 86 percent water, 6.3 percent carbohydrates, 3.3 percent proteins, 0.6 percent fats and is rich in calcium, iron, carotene, and vitamins B and C.

Soil and Climate: Coriander is grown on fertile soil. Sandy loam soil is the best for its cultivation. As it is a cool season crop it should be cultivated in winter. High temperatures can cause stunted growth.

Coriander crop grown in plastic pot

Important Varieties: CIMPOS-33, CO.2 and Lam C.S.6 are the major coriander varieties grown in South India. Lam C.S 6 is a bushy and foliagetype plant that can be harvested within 30 days of planting the seeds.

Planting and Irrigation: Before planting, coriander seeds are soaked in water for 12 hours which reduces the seed germination period from 15 to 7 days. It is sown on beds keeping two rows that are 10 cm apart. Welldecomposed farm yard manure should be mixed with soil before sowing the seeds. Immediately after seed sowing the area should be watered. Coriander requires frequent watering during its vegetative growth period. Irrigation should be given at 46 day intervals.

Plant Protection: Coriander is a comparatively pest and diseasefree crop. However, at the initial stages wilting can be observed in illdrained and heavy soil which can be controlled by treating seeds with trichoderma biofungicide before sowing.

Harvesting: Coriander is normally harvested by uprooting the whole plant or by picking only tender leaves as a leafy vegetable 30 days after sowing but before flowering. For seed production the crop is harvested at full maturity after 130 to 150 days depending on the variety grown.

5.2.3 Garden Pea, Cowpea and Chickpea

Cultivation of Garden Pea:

Nutritive Value: Garden pea is a favorite leguminous (Pods) vegetable grown in the kitchen garden. Peas contain a high percentage of digestible protein and a good amount of vitamins and minerals. It contain 72 percent water, 16 percent carbohydrates, 7.2 percent proteins, 4 percent minerals including magnesium,

phosphorus, sodium, calcium, potassium, sulphur and iron, and is rich in vitamins A and C.

Soil and Climate: Peas require porous, fertile and siltrich soil with a pH of 6.0 to 7.5. Peas need calcium and phosphorus rich soils. It is a cool season crop but requires relatively warm weather during ripening of pods for seeds. The vegetable is very sensitive to frost and drought conditions.

Garden Pea grown in plastic crates

Important Varieties: Bonville, Arkel, Arka Ajit, Meatier and Little Marvel are the important varieties of garden peas grown in South India. All varieties start yielding pods 60 to 75 days after sowing, depending on the varieties grown.

Planting and Irrigation: Peas are grown during August-October in the South Indian region. Pea is fond of calcium and phosphorus nutrients and care should be taken to mix gypsum and bone meal in the soil along with compost to get a higher pod yield. Before sowing, seeds are treated with Rhizobium biofertilizer and sown 5 cm apart in pots and 15 to 20 cm apart in beds. Irrigation should be provided after seed sowing. Care must be taken to irrigate this vegetable crop at critical growth stages like flowering, pod formation, filling and maturity.

Plant Protection: Aphids and pod borer are the major insectpests attacking peas. Spraying of neem cake extract and hand picking of green caterpillars like the pod borer can greatly help reduce the losses from these insect pests. Powdery mildew is an important fungus disease of pea that can be controlled by treating seed with trichoderma biofungicide powder before seed sowing. If powdery mildew occurs on the standing crop it can be controlled by dusting sulphur powder or spraying wettable sulphur on the vegetable.

Harvesting: Pods of peas are available for picking 60 to 80 days after sowing or 20 days after flowering. Pods are handpicked when they are properly filled but still tender, green in color and sweet in taste. Picking should be done in the morning hours. Matured pods should be kept for seed production or making vegetable curries.

Cultivation of Cowpea:

Nutritive Value: Cowpea is an annual vegetable with a weak trailing stem. It is delicious in taste and rich in proteins. It contains 84 percent water, 8 percent carbohydrates, 4.3 percent proteins, 2 percent dietary fibers, 0.9 percent minerals including calcium, phosphorus and iron, and is rich in vitamins A, B and C.

Soil and Climate: Cowpea requires light to medium but fertile soil with a good drainage capacity. Cowpea is a warm season vegetable crop. The crop cannot flower below 20°C and hence cannot be grown under severe cold climatic conditions.


Cowpea Pods at Harvest

Important Varieties: Pusa Phalguni, Pusa Barsati, Pusa Dophasli and Arka Suman are popular varieties of cowpea. Pusa Phalguni is a bushy dwarf variety best suited to grow in the winter season while Pusa Barsati is an early maturing variety grown in the rainy season. Pusa Dophasli variety can be grown in the rainy as well as the winter season.

Planting and Irrigation: Cowpea can be grown in bot rainy and summer seasons. For the rainy season, seeds should be sown in June-July and for summer vegetable seeds should be sown in February-March. Seeds are sown 30 cm apart from two rows with a distance of 10 cm between two plants. Cowpea is a shallow rooted vegetable, if grown in light soil; frequent irrigation should be given to maintain adequate soil moisture in the soil.

Plant Protection: Aphids and pod borer are the major insect pests attacking cowpea. Spraying of neem cake extract and handpicking of green caterpillar, pod borer can greatly help reduce the losses from these insect pests. Powdery mildew is an important fungus disease of cowpea that can be controlled by treating seed with trichoderma biofungicide powder before sowing seeds. If powdery mildew occurs on the standing crop it can be controlled by dusting sulphur powder on the vegetable.

Harvesting: Tender green pods are harvested by handpicking of vegetables 40 to 50 days after sowing. Several handpickings will be available for the following one month. Unharvested pods can mature and give seeds that can be used as a vegetable year-round.

Cultivation of Chickpea:

Nutritive Value: Chickpea is popularly known as green gram and is an excellent source of protein. Matured and dried grains of chickpea contain 8 percent water, 60 percent carbohydrates, 20 percent proteins, 5 percent fats and 6 percent crude fibers, and is rich in minerals like calcium, phosphorus, magnesium and iron.

Soil and Climate: Chickpea requires a medium to black soil with a good drainage system. Ill drained soil causes wilting of plants. It is a cool climate crop and hence should be grown in the winter season with residual moisture from rains. The crop grows well at a temperature range of 20 to 25 °C.

Chickpea grown in the bed

Important Varieties: Vijay, Vishal, Digvijay and Virat are popular varieties of chickpea grown as a vegetable and for seed production at maturity.

Planting and Irrigation: Chickpea is sown in the winter season in between 15 October and 15 November. Seeds should be treated with trichoderma biofungicide to control fusarium wilt disease and with Rhizobium biofertilizer for better nitrogen fixation and then sown at 5 to 6 cm depths. Chickpea can withstand conditions of water stress but irrigation should be provided at critical growth stages like post sowing, flowering and pod filling stages for better yield.

Plant Protection: Pod borer is a serious insect pest that attacks chickpea. It appears at the flowering stage, initially feeds on tender leaves and later enters the pods and feeds on it. Green caterpillars can be controlled by handpicking the caterpillar and killing them or spraying neem cake extract or neemark solution. It can also be controlled by nucleo polyhydrosis virus (NPV) suspension.

Wilt is a dangerous disease of chickpea caused due to fungal infection from the soil to the root system where whole plants get wilted and dried. Wilt can be controlled by treating the seed with trichoderma before sowing.

Harvesting: Chickpea is harvested for green vegetables at full grown but tender stage. For seed and grain, the crop can be harvested at full maturity when all leaves would turn yellow and fall down on the ground. Cut or uproot the plants at ground level, dry in the sun, beat with a stick and separate seeds by winnowing in air.

5.2.4 French Bean and Drumstick

Cultivation of French Bean:

Nutritive Value: French bean is the most popular vegetable among all beans. Green tender pods are used as vegetables and dried grains are used as protein rich pulses. Green pods of French bean contain 91 percent water, 4.5 percent carbohydrates, 1.7 percent proteins and 1.4 percent fibers, 0.5 percent minerals including calcium, potassium, phosphorus, sulphur and iron, and is rich in vitamins A, B and C.

Soil and Climate: French bean grows well in light to medium well drained soil with slightly acidic soil pH ranging from 5.5 to 6.0. It grows very well in sandy loam soils but saline and alkaline soils are unfit for French beans.

French bean requires a cool to mildly warm growing season. It is very sensitive to very cold and very hot temperatures. Flowers and small pods drop in the hot summer.

French Bean crop and Harvested pods

Important Varieties: Contender, Arka Komal, Tender green, Pusa Parvati and Kentucky Wonder are popular varieties of the French bean. Kentucky Wonder is a runner type while others are bushy types.

Planting and Irrigation: French bean can be grown throughout the year in mild climatic conditions. Seeds are treated with Rhizobium bio-fertilizer culture, dried in the shade and sown in pots or beds at a spacing of 30 cm between two rows and a 10 cm space between two plants. Runner type varieties should be given more space and provided support for growth through staking or hanging on walls.

Plant Protection: Aphids and pod borer are the major insect pests attacking French beans. Spraying of neem cake extract and handpicking of green caterpillars and pod borer can greatly help reduce losses from these insect pests. Powdery mildew is an important fungus disease contracted by the French bean that can be controlled by treating the seed with trichoderma biofungicide powder before sowing the seeds. If powdery mildew occurs on the standing crop it can be controlled by dusting sulphur powder on the vegetable.

Harvesting: Under good growth condition French bean pods get ready for harvesting within 45 to 60 days in bushy type varieties and 70 to 90 days in case of runner type varieties. Pods should be hand picked and stored in cool places.

Cultivation of Drumsticks:

Nutritive Value: Green pods and flowers are used as vegetables. The green pod contains 87 percent water, 3.7 percent carbohydrates and 2.5 percent proteins, and is a rich source of minerals like calcium and iron and is rich in vitamins B and C.

Soil and Climate: It can be grown in all types of soil with a good drainage. If it is grown in very heavy and deep soil, vegetative growth becomes profuse and yields lesser number of pods providing more fodder for domestic animal.

It can grow in all types of climate but is best grown in a humid climate with temperatures ranging from 25 to 30°C. It is observed that flowers drop at temperatures above 40°C.

Drumstick Pods at Harvest

Important Varieties: Jaffna, Coimbtore 1, PKM 1 and PKM 2 are the most popular drumstick varieties grown in South India. Jaffna is a Sri Lankan variety extensively grown in South Indian states and yield 60 to 90 cm long very tasty pods.

Planting and Irrigation: Drumstick is propagated by seed as well as by stem cutting. Seeds are collected from selected healthy pods in summer months. Fresh seeds are directly sown in pots or in soil or, often, seeds are sown in polybags to produce seedlings. Seedlings get ready within 30 days after sowing. Seedling or prerooted cuttings are planted in the 30.48 cm (1 ft.) long, 30.48 cm (1 ft.) wide and 30.48 cm (1 ft.) deep pits filled with garden soil mixed with a lot of farm yard manure. After sowing or transplanting they should be watered. The drumstick crop requires a lot of water but excess watering may cause rootrot disease. Direct contact of irrigation water with the stem can cause rotting of the stem.

Plant Protection: Stem borer and leaf roller are the important insect pests that attack drumstick. Stem borer bores the stem enters it and eats its internal parts. It can be controlled by putting a petrol soaked cotton plug in the hole bored by the stem borer while the leaf roller insect attacks tender leaves, roll them and eat them. This pest can be controlled by spraying neem cake extract or neemark based insecticides on the entire plant.

Harvesting: Twisted pods on plants are immature and distinct ridges on pods are overmatured and should not be harvested. Full grown and tough but not overmatured pods are harvested. One full grown drumstick plant can yield 15 to 20 kg of pods a year, sufficient for one family and its friends.

5.2.5 Asparagus and Groundnut

Cultivation of Asparagus:

Nutritive Value: Asparagus is grown for its soft and tender shoots and are directly used as a vegetable or can be converted to a delicious and nutritive soup. Tender shoots contain 93 percent water, 2.6 percent fibers, 2.0 percent proteins and 0.25 percent fats and is rich in minerals like sodium, calcium, potassium, phosphorus and iron and vitamins like B and C.

Soil and Climate: Asparagus is grown best in well grained sandy loam soil with neutral pH in the range of 6.5 to 7.5. It is a temperate region crop grown in the cool climate in hilly areas with very mild climatic conditions.

Asparagus Shoots at Harvest

Important Varieties: Merry Washington and Perfection are important asparagus varieties grown in hilly and cool climatic areas.

Planting and Irrigation: Asparagus can be raised by direct sowing of seeds or by raising seedlings and transplanted in pots or soil beds. Seedlings are planted on ridges prepared at 60 cm apart and spacing between two plants can be kept at 10 cm. Before preparing ridges, the soil should be mixed with a lot of organic manure to maintain sufficient porosity in the soil. Watering should be provided in furrows and direct contact of water with the growing plant should be avoided.

Plant Protection: The asparagus vegetable is comparatively free from pests and diseases. However, in ill drained soil, the crop is infected by fungal diseases causing wilting of the whole plant.

Harvesting: Tender shoots can be harvested after 2 years of growth. Soft and tender shoots, called spears, are cut below the soil surface with the help of a sharp knife. Spears are harvested at a height of 20 to 25 cm before they are converted to vegetative leafy plants.

Cultivation of Groundnut:

Nutritive Value: Groundnut is an oilseed crop grown mostly for protein and fat to supplement human food. Groundnut kernel contains 10 percent water, 16 percent carbohydrates, 26 percent protein and 45 percent fats, and is a very rich source of minerals like calcium, magnesium, potassium, sodium, manganese and iron.

Soil and Climate: Well drained, light color, loose sandy loam and friable soil are considered best for groundnut cultivation. Soil with illdrainage and acidic or alkaline soils are unfit for cultivation of groundnuts.

Groundnut Crop with Pods

Important Varieties: JL24, TAG24, TPG41 and VRI2 are important varieties of groundnut grown.

Planting and Irrigation: Groundnuts can be grown in the rainy season and the summer season. Seeds are treated with Rhizobium bio-fertilizer culture and sown at 5 to 6 cm depth in soil. Seeds are planted in pots or trays or in soil at a spacing of 30 cm between two rows and a spacing of 15 cm between two plants. The groundnut crop should be provided with irrigation to maintain an optimum moisture level in the soil. The crop must be irrigated at critical growth stages like branching, flowering and pod formation.

Plant Protection: The groundnut crop is attacked by leafeating caterpillars that can be controlled by handpicking them in small plots and by spraying neemcake extract on bigger plots. At a later stage, this crop is infected by the Leaf spot (*tikka)* disease, where brown to black spots occur on the leaf lamina causing severe necrosis and preventing photosynthesis by leaf lamina, leading to reduced pod yield.

Harvesting: The groundnut crop is grown for matured pods and kernels. When leaves of the plant turn yellow and start dropping after 120 to 140 days, the crop can be harvested by hand pulling at the appropriate soilmoisture level to avoid uprooting of the plant without pods. In hard soil, the pod remains in the soil and one can lose the edible part of the crop. Pods are separated from the plant, sundried and stored in gunny bags for future use.

5.3 Glossary

Soil pH: It is an active hydrogen ion concentration of the soil solution. A pH below 6.5 means acidic, from 6.5 to 7.5 means neutral and above 7.5 means alkaline.

Seed: It is a dormant and rudimentary plant protected inside the seed coat.

Seedling: It is a small, tender, juvenile plant grown from the seed.

Day Neutral Plant: This is a type of plant where light or sunlight duration does not make any influence or effect on the plant growth

Long Day Plant: The plants requires more than 12 hours of light or sunlight for their optimum growth and development.

Drainage: It is the process of removal of excess water from the active root zone of the plant in the soil surface or subsoil layers.

Curd: It is the head or edible part of the cauliflower vegetable crop.

Germination: It is resumption of growth of the rudimentary embryo under favorable atmospheric conditions like suitable media and moisture.

Saline Soil: The soil which with a pH more than 8.5, more than 4 ds/m electrical conductivity and less than 15 percent exchangeable sodium.

Minerals: These are organic substances found in the plant body and often required for optimum growth and development of plants.

Vitamins: These are organic substances found in grains, fruits and vegetable in very small quantities but very necessary for human health, growth and development.

5.4 Points to Remember

- One person should eat at least 300 g of vegetables every day to keep him physically and mentally fit for work.
- Cabbage, cauliflower and knol khol are the vegetable crops grown in the winter season.
- All insect pests and diseases in the kitchen garden should be controlled by using organic, biological, botanical or plant extract based pesticides to avoid chemical pollution.
- Spinach, fenugreek and coriander are short duration leafy vegetables grown in the kitchen garden.
- Garden peas, cowpea and chickpea are proteinrich vegetables grown in the kitchen garden.
- Drumstick trees are grown as vegetable crops near the home and are harvested with elongated pods.
- Asparagus can be grown on ridges or raised beds prepared from loose, sandy and porous garden soil mixed with farm yard manure.

- Leaf eating and pod boring caterpillars on vegetables grown in the kitchen garden must be controlled by hand picking to avoid the use of chemicals.

5.5 Self Check Questions

i What is the important nutrient content of cabbage, cauliflower and knol khol vegetable crops?

ii What is the average period of harvesting leafy vegetables from the kitchen garden?

iii How can you differentiate between cowpea and chickpea in terms of leaf, flower and fruit?

iv Name the popular varieties of drumstick grown in South India. What are the characteristics of green pods?

v Why is seed treatment of Rhizobium biofertilizer culture necessary for all peas and beans?

5.6 Do It Yourself

- Bio-fertilizer treatment to cowpea and chickpea seed

1 Purchase Rhizobium bio-fertilizer specifically recommended for cowpea or chickpea and keep it in cool places in the house.

2 Select cowpea or chickpea seed; clean the seed by separating pieces of debris, other seeds, off colour and abnormal seeds from the lot.

3 Take 10 g of bio-fertilizer powder and mix it with a little water to make it slurry, and add a little gum Arabic as a sticker in the slurry.

4 Take seed to be treated in a flat tray and sprinkle the slurry on the seed, smear the slurry to seeds from all sides.

5 Keep the treated seed in the shade by spreading on cloth for half an hour and then use it for sowing in the soil.

UNIT 6: Fruity and Tuberous Vegetable Cultivation

6.1 Introduction

Nothing tastes better than vegetables picked up from your own garden. There is always a certain level of satisfaction in harvesting and eating our own food from our own garden. In olden days, tubers formed an important source of human food. In the modern era, the dependence on tubers is reduced owing to increased availability of food grains along with the misconception that tubers are a food of the poor and tribal people.

Even today, tuber crops are a major food for the people living in tropical regions. Tuber vegetables have a very high importance in the human diet owing to high productivity, rich in carbohydrates and other nutrients.

Fruity vegetables have a special importance in the human diet. Different processed products can be prepared from tomato or consumed raw as salads. Tomato is rich in minerals, vitamins and organic acids that are essential for our dietary requirements. Brinjal has medicinal properties. White brinjal is used as a medicine against diabetes. Chili has an important place in food preparations as spices can be dried and stored for long without deterioration.

Okra is a delicious and digestive vegetable rich in minerals and vitamins.

At the end of this unit, you will be able to know and understand:

- Importance of fruity and tuber vegetable crops in our diet.
- Soil and climatic requirements of fruity and tuber vegetable growing.
- Production practices in fruity and tuber vegetables in terrace gardens, kitchen gardens and waste lands.
- Maturity indices, harvesting time and harvesting method in fruity and tuber vegetable.

6.2 Contents

6.2.1 Tomato, Brinjal and Chili Cultivation

Cultivation of Tomato:

Nutritive Value: Tomato is a very popular vegetable in all kitchen gardens and can be grown in pots and containers. It contains 93 percent water, 3.6 percent carbohydrates and 1.9 percent proteins, 0.6 percent minerals like potassium, sodium, calcium, phosphorus, sulphur, iron and chlorine, and is rich in vitamins A and C.

Soil and Climate: Tomato is best grown in welldrained and fertile soil with a pH ranging from 6.0 to 8.0. However, soil rich in organic matter is good for tomato cultivation. Tomato requires full and clear sunshine for its growth. Heavy rains and chilling cold are very harmful for growth. Temperatures ranging from 13 °C to 38 °C are ideal for fruit setting, however fruit setting and color development are adversely affected when temperature exceeds 38 °C.


Tomato grown in the plastic pots

Important Varieties: Pusa Ruby, Arka Sourabh, Arka Vikas and Arka Meghali are popularly grown tomato varieties in South India.

Planting and Irrigation: Tomato seeds are sown on raised beds. When seedlings become 4 to 6 weeks old, they are transplanted in pots or fields at a spacing of 45 cm between two rows and 45 cm between two plants. An indeterminate type is growing vine like tomato varieties which are supported with ropes or poles to grow vertically and give better yields. Watering should be done immediately after transplanting and irrigation should be provided as and when soil in the pot or otherwise becomes partially dry. The soil or plot to be used for tomato cultivation should be mixed with a sufficient quantity of compost to feed the crop for a longer period.

Plant Protection: Tomato vegetable is mostly attacked by insect pests like the fruit borer whose larvae feed on tender leaves and after fruit setting it enters the fruit and feed on its internal parts. It can be controlled by hand picking the larvae and destroying them or spraying neem cake extract or neemark on the plant. Tomato can also be attacked by white flies that suck sap from leaves and stems. This can be captured and killed by placing yellow cards spread with grease, when white flies landing on these cards remain their till their death.

Harvesting: The tomato fruit is ready for harvesting 60 to 80 days after transplanting, depending on the variety planted. Fruits that turn their color from yellowish to reddish are harvested and used as vegetables.

Cultivation of Brinjals:

Nutritive Value: Brinjal is one of the medicinal vegetables grown in the kitchen garden. The brinjal fruit contains 93 percent water, 4.0 percent carbohydrates, 1.4 percent protein, 1.3 percent fibers and 0.3 percent fats, and is rich in minerals like calcium, magnesium, phosphorus, sodium, potassium, sulphur and iron and vitamins A and C.

Soil and Climate: Brinjal can be grown in a variety of soils from light to heavy but sandy loam soil is good for brinjal. It can tolerate slightly acidic soil. Brinjal requires a warm climate and can be grown year round in tropical regions. However, a dry and warm climate with temperatures ranging from 13 to 21 °C is bestsuited for good growth.

Brinjal grown in plastic pots

Important Varieties: Pusa Kranti, Arka Kusumakar, Arka Shirish and Arka Navaneeth are popular and highyielding varieties of brinjal grown in South India.

Planting and Irrigation: Brinjal can be grown in pots or beds. Seeds are sown during February-March for the summer crop, June-July for the rainy season crop and October-November for the winter crop. Seedlings become ready for transplanting in 3 to 4 weeks after sowing. Seedlings are transplanted on 45 cm apart between two rows and 45 cm between two plants. Irrigation should be followed immediately after transplanting. Water stress should be avoided at the flowering stage.

Plant Protection: Brinjal, like tomato, is mostly attacked by insect pests like the fruit borer whose larvae feed on tender leaves and it enters the fruit and feed on its internal parts. It can be controlled by hand picking the larvae and destroying them or spraying neem cake extract or neemark on the vegetable. Brinjal can also be attacked by white flies that suck sap from leaves and the stem. The insect flies can be captured and killed by placing yellow cards spread with grease; when they land on these cards they get stuck there and die.

Harvesting: Brinjal fruits are ready for harvesting 90 to 100 days after transplanting. Full grown but still tender fruits are harvested. It is a long season vegetable crop and harvesting can be continued for 2 to 3 months.

Cultivation of Chilli and Capsicum:

Nutritive Value: Chilli increases the palatability and taste of cooked vegetable and other food, while capsicum can be used as a

vegetable or salad to eat raw with meals. Green chilli contains 86 percent water, 3.0 percent carbohydrates, 3.0 percent proteins and 6.8 percent fibers, 1.0 percent minerals like sulphur, chlorine, calcium, magnesium, sodium and potassium, and is rich in vitamins A and C.

Soil and Climate: Medium to heavy soil with good drainage is ideal for chilli cultivation. But ill drained and water lodged conditions are bad for cultivating. Chilli requires a hot and humid climate, and a temperature of 25 to 30 °C is ideal for it. Temperatures below 25 °C can severely affect vegetable growth and production.

Chilli at grown in plastic pots

Important Varieties: Byadagi, Sankeshwari and Pusa Jwala are popular and high yielding varieties of chilli and California Wonder, Arka Mohini, Yellow Wonder and Bharath are popular varieties of capsicum grown in South India.

Planting and Irrigation: Chilli can be grown throughout the year. Seeds are sown in January-February for summer chilli, October-November for winter chili and June-July for the rainy season crop. Seedling of 4 to 6 weeks should be transplanted in a pot, a container or in the soil bed at 45 cm x 45 cm distance for chilli and at 60 cm x 60 cm distance for capsicum followed by irrigation. Chilli and capsicum crops should be watered at 56 day intervals in summer and 10 to 15 day intervals in the winter season. Often, capsicum requires support by tying with a rope or thread.

Plant Protection: Chilli and capsicum crops are generally pest and disease free. However, sometimes it is attacked by a virus causing shrinking of leaves leading to stunted growth. It can be managed by selecting disease free seeds from reliable sources and if diseases occur, it can be managed by spraying insecticides

that will kill the diseases preading insects like aphids and white flies.

Harvesting: Chilli can start yielding fruits 90 days after transplanting. Fruits can be hand picked for green chilli for vegetable preparations and ripe chilli for storage and making red chilli powder. Capsicum is harvested only for vegetables and salads, and cannot be converted to powder.

6.2.2 Cultivation of Okra, Cucumber and Smooth Gourd

Cultivation of Okra:

Nutritive Value: Okra is commonly called *bhendi* or ladies fingers and is a favorite vegetable which is an excellent source of iodine that can effectively cure goiter. Okra contains 90 percent water, 6.4 percent carbohydrates, 1.9 percent proteins and 1.2 percent fibers, 0.7 percent minerals like calcium, magnesium, phosphorus, iodine, potassium, iron and sulphur, and is rich in vitamins A and C.

Soil and Climate: Light loamy soil is good for okra cultivation. Okra can be grown successfully in slightly acidic soil with a pH of 6.0 to 6.5. It is a deep rooted warm season vegetable crop. Seeds fail to germinate at temperatures below 20 °C. Crop is susceptible to frosty cold climates.

Okra at Harvest Stage

Important Varieties: Pusa Sawani, Arka Anamika and Pusa Makhamali are popular varieties of okra grown in South India.

Planting and Irrigation: Okra is planted by direct sowing of seed at 2 to 3 cm depth with a spacing of 30 cm . between two rows and 15 cm between two plants in line. The summer crop can be sown during January-February and the rainy season crop during June-July followed by irrigation. In the summer months, the plant should be regularly watered.

Plant Protection: Thrips and fruit borers are the major insect pests, and the powdery mildew and yellow vein mosaic are the major diseases of okra. Thrips suck sap from leaves and the stem while the fruit borer bore holes into the fruit and eat its internal parts. This insect pest can be controlled by spraying neemseed extract and hand picking fruit borer larvae and affected fruits and destroying them.

Powdery mildew is a fungal disease of okra that creates whitish fungal powder on leaf surfaces damaging leaf lamina tissues. It can be controlled by dusting sulphur powder on the leaf lamina. Yellow vein mosaic is a viral disease that can be controlled by killing insect attacking the crop.

Harvesting: Okra plant starts giving fruits within 50 to 60 days of sowing of the seeds. Five to 6 cm long full grown but still tender fruits are harvested by hand picking or cutting with a sharp knife or a pair of scissors. Harvesting can be continuing in 10 to 15 pickings in 1.5 to 2.0 months.

Cultivation of Cucumber:

Nutritive Value: Cucumber is eaten as a fresh fruit or used as a salad which has a cooling effect and medicinal properties in our diet. Cucumber contains 96 percent water, 2.5 percent carbo-hydrates, 0.4 percent proteins and 0.4 percent fibers, 0.3 percent minerals like calcium, phosphorus and iron, and is very rich in vitamin C.

Soil and Climate: Cucumber requires well drained sandy loam soil. It is grown in hot and dry regions. It performs best in ample sunlight and requires frost free periods for its growth. Temperatures from 35 °C to 38 °C are good for cultivation of cucumber.

Cucumber at Harvest Stage

Important Varieties: Pusa Sanyog, Poona Khira, Himangi and Sheetal are popular varieties of cucumber in South India.

Planting and Irrigation: Cucumber seeds are sown during January-February for the summer season and during June-July for the rainy season crop. Seeds are sown 90 cm apart from two rows and 90 cm apart between two plants. The cucumber creepers if directed to climb on supports of walls can give yields of good quality and quantity. Cucumber requires frequent irrigation to give higher yields.

Plant Protection: Powdery mildew is a major disease of cucumber causing white cottony fungal growth on leaf surfaces reducing the process of photosynthesis and thereby the yield. It can be controlled by dusting sulphur powder on the cucumber crop.

Harvesting: Fruits are harvested 50 to 60 days after sowing of seeds. Fully developed, terminal flowers drop but fruits still tender and green are harvested and used in green salads.

Cultivation of Smooth Gourd:

Nutritive Value: Smooth gourd is also called bottle gourd and is one of the popular vegetable in the kitchen garden and requires less space on the ground as it is a creeper and can grow any where on the wall or on over head trellises. Smooth gourd fruit contains 93 percent water, 3.0 percent carbohydrates, 1.2 percent proteins and 2.0 percent fibers, and 0.5 percent minerals like calcium, phosphorus and iron.

Soil and Climate: All cucurbit family vegetables require welldrained sandy loam soils with a good amount of organic matter in it. Smooth gourd requires a hot and dry climate. Cold and frosty climate is unsuitable for cultivation of smooth gourd vegetables.

Smooth Gourd at Harvest Stage

Important Varieties: Pusa Summer prolific long, Pusa summer prolific round, Pusa Meghdooth, Pusa Manjari and Arka bahar are popular varieties of smooth gourd grown in South India.

Planting and Irrigation: Smooth gourd is cultivated in the rainy and summer seasons. Seeds are sown during June-July with a distance of 90 cm between two rows and 60 cm between two plants. It is a shallow rooted vegetable that needs light but frequent irrigation.

Plant Protection: Powdery mildew is a major disease of all cucurbit vegetables causing a white cottony fungal growth on leaf surfaces reducing the process of photosynthesis there by the yield. It can be controlled by dusting sulphur powder on the crop foliage.

Harvesting: Smooth gourd starts yielding from 80 to 90 days after sowing deeds. Full grown and tender fruits are harvested by cutting fruits, keeping a one inch stem intact without causing injury to other parts of the creeper and stored in the shade.

6.2.3 Cultivation of Carrot, Radish and Beetroot

Cultivation of Carrots:

Nutritive Value: Carrot is the most preferential salad candidate in vegetables. Carrot contains 86 percent water, 10.6 percent carbohydrates, 0.9 percent proteins and 1.2 percent fibers, 1.1 percent minerals like calcium, phosphorus and iron, and is rich in vitamins A and C.

Soil and Climate: Carrot can be grown in loose, porous, deep and welldrained soil. Compact and hard soil is not good for the growth and development of carrots as their shape does not remain normal

in compact soil. It is a cool season crop. A temperature of 20 °C to 25 °C is ideal for growth and development of the root.

Carrot crop grown in pot and soil bed

Important Varieties: Pusa Kesar, Pusa Meghali, Giant Chantini and Nantes are popular varieties of carrot grown in South India.

Planting and Irrigation: Carrot seeds are small in size and light in weight. Therefore, they should be mixed with soil before sowing from September-November. In hilly areas, sowing can be done in March-April. Sowing at 15 day intervals in the same plot can provide carrot for longer periods. Sowing should be followed by watering.

Plant Protection: The carrot crop is generally free from insect pests and diseases and need not be taken care of for plant protection from pests and diseases.

Harvesting: Carrot becomes ready for harvesting within 60 to 70 days of sowing. Watering should be stopped 15 to 20 days before harvesting to develop sweetness in the carrot. Harvesting should be carried out by uprooting with leaves intact or by digging.

Cultivation of Radish:

Nutritive Value: Radish is one of the most preferred vegetable for salads. Radish contains 94 percent water, 3.4 percent carbohydrates, 0.7 percent proteins and 0.8 percent fibers, 0.6 percent minerals like calcium, phosphorus and iron, and is rich in vitamins A and C.

Soil and Climate: Radish can be grown in loose, porous, deep and well drained soil. Compact and hard soil is not good for the growth and development of radish as its shape does not remain

normal in that type of soil. It is a cool season crop. A temperature of 20 °C to 25 °C is ideal for the growth and development of the root.

Harvested Radish transported to market

Important Varieties: Pusa Reshmi, Arka Nishanth and Japanese White are important varieties of radish grown in South India.

Planting and Irrigation: Radish is grown mostly in the winter season. Seeds are sown at 1 to 2 cm depth in the soil followed by irrigation. Irrigation should be provided 4 to 5 day intervals in the summer season and 7 to 8 day intervals in the winter season.

Plant Protection: Radish is mostly attacked by mustard saw fly insects that can be controlled by spraying neem seed extract on the vegetable.

Harvesting: Radish becomes ready for harvesting 45 to 60 days after sowing of the seeds. Harvesting is done by uprooting the plant. If harvesting is delayed, the root becomes mature and the central part of radish turns spongy and pithy and becomes useless for eating.

Cultivation of Beetroot:

Nutritive Value: Beetroot is eaten as a salad but it can also be pickled and eaten throughout the year. Beetroot contains 88 percent water, 8.8 percent carbohydrates and 1.7 percent proteins, 0.8 percent minerals like calcium, potassium, phosphorus and iron, and is rich in vitamin C.

Soil and Climate: Beetroot grows well in light and sandy soil. This is the only vegetable that can be grown in saline and alkaline soil with a pH up to 10. It is a cool to warm weather crop. Mild climatic

conditions are good for beetroot; the optimum temperature for its growth is 18 - 21 °C. Temperatures below 10 °C for more than two weeks result in bolting which decreases the quality of the produce.

Beetroot grown in pot

Important Varieties: Crimson Glory, Detroit Dark Red, Ruby Queen and Golden Beet are the popular varieties of beetroot grown in South India.

Planting and Irrigation: Beetroot is planted by direct sowing of seeds. Seeds are soaked in water and kept over night for better germination. Beet root is sown in March-April in hilly areas and in August-September in other regions. Sowing should be followed by irrigation. The beetroot crop should be irrigated every 7 to 8 days in the winter season to maintain a sufficient moisture level in the soil.

Plant Protection: Beetroot leaves are affected by leaf miner insect pest. The larvae of pest mines the subsurface of growing leaves, eats the leaf from the inner side and hamper the photosynthesis leading to reduction in yield. The pest can be controlled by adding neem cake in soil before sowing and spraying neem seed extract on leaves.

Harvesting: Beetroot becomes ready for harvesting 60 days after sowing. Harvesting is done by pulling or uprooting the whole plant; the edible part is separated from the foliage.

6.2.4 Cultivation of Onion and Garlic

Cultivation of Onion:

Nutritive Value: Onion has several medicinal properties and is used as a vegetable, a salad and a condiment. Onion contains 90 percent water, 6.4 percent carbohydrates, 1.9 percent proteins

and 0.6 percent fibers, 0.4 percent minerals like calcium, phosphorus, potassium, sulphur and iron, and is rich in vitamins B and C.

Soil and Climate: Light to medium fertile and porous soil with good drainage and a soil pH ranging from 6.5 to 8.5 is ideal for growing onions. Onion is a winter season vegetable crop. It grows well in temperatures of 15 - 25 °C and a humidity of 70 percent.

Onion grown in soil bed

Important Varieties: Pusa Red, Pusa White, Nashik Red, Arka Nikethan, Arka Pragathi and Arka Kalyan are popular varieties of onion grown in South India.

Planting and Irrigation: Onion is grown by seedlings. Seeds are sown from September to November for the winter season crop and from May to June for the rainy season crop. Two months' seedling with a height of 15 to 20 cm can be transplanted on beds at 20 x 10 cm distances. The home gardener will definitely like to grow different colored varieties of onion in the same bed.

Plant Protection: The onion crop is mostly attacked by insect pests like thrips. This pest sucks the sap from leaves and leaves look like scraping with the upper surface that reduces the capacity for photosynthesis. This pest can be controlled by spraying neem seed extract on the crop.

Harvesting: It is advantageous to bend the necks of fully matured onion 8 to 10 days before harvesting. Doing so can stop the growth of leaves and the sap is diverted to the bulb and bulbs become fully matured and filled to its maximum with the outer skin becoming dry. Bulbs are harvested by manual uprooting.

Cultivation of Garlic:

Nutritive Value: Garlic is not a vegetable as such but it can be used to add flavor to vegetables, pickles and curry. It has many medicinal properties. Dried garlic bulbs contain 62 percent water, 29.0 percent carbohydrates, 6.3 percent proteins and 0.8 percent fibers, 0.1 percent minerals like calcium, phosphorus and sulphur, and are rich in vitamin C.

Soil and Climate: Sandy loam soil having a pH in the range of 5.0 to 7.0 is most suitable for garlic cultivation. Heavy deep clay soils are avoided as they yield only vegetative growth. Garlic is grown under a mild climate; however, a dry climate with long days of sun light is ideal for the growth of garlic.

Garlic Bulb ready to harvest

Important Varieties: Godavari, Shweta, Agrifound White are important varieties of garlic grown under warm and dry climatic conditions.

Planting and Irrigation: In garlic, an individual clove is planted as seed material normally from September to November in the winter season. Garlic is a shallow rooted crop and therefore light irrigation is needed. As soon as maturity arises, irrigation should be prolonged and then stopped.

Plant Protection: The garlic crop is mostly attacked by thrips. The pest sucks the sap from leaves and they look like scraping with the upper surface that reduces the capacity of photosynthesis. This pest can be controlled by spraying neem seed extract on the crop.

Harvesting: Garlic bulbs can mature within 130 to 150 days of planting. Bulbs are harvested manually or with the help of a *kudali* or shovel and kept along with dried leaves for 8 to 10 days. The

bulbs are then tied in bunches and staked or hanged in cool dry places for long.

6.2.5 Cultivation of Potato and Sweet Potato

Cultivation of Potato:

Nutritive Value: Potato is a most important vegetable crop around the world. It can be used as a rich vegetable food or can be converted to by-products like potato chips, potato flour and other cookies. Potato contains 76 percent water, 22 percent carbohydrates and 1.6 percent proteins, and is rich in minerals like calcium and iron and in vitamins A, B and C.

Soil and Climate: A rich, friable, welldrained soil having a pH in the range of 5.0 to 7.0 is good for potato growth. But heavy loam soils are unfit for potato cultivation. Potato prefers a temperate to subtropical climate with an optimum temperature in the range of 16 to 21 °C. Underground tubers develops fast under short sunlight days.

Potato crop

Important Varieties: Kufri Chandramukhi, Kufri Lavakar, Kufri Alankar, Kufri Bahar, and Kufri Jyoti are shortduration and popular varieties of potato.

Planting and Irrigation: Small to medium sized sprouted tubers of potato are selected for planting. Often, big size tubers are cut in to two to four pieces taking care that each piece has at least two active eye buds. The cut tubers are allowed to remain under the shade for some time to complete the process of suberization (healing of exposed surfaces) before plantation. This would prevent tubers from rotting under soil. Planting should be followed by irrigation.

Plant Protection: Care must be taken to protect the growing potato tubers by earthing up with soil (earthing up is a practice of covering growing potato tubers with loose soil layer). When potato tubers are exposed to sunlight their skin can turn to green and become unfit for consumption. Potato is attacked by leaf eating caterpillar and blight disease. The caterpillar eats green leaves and can be controlled by hand picking them or by spraying neem seed extract. The blight can be avoided by using sundried soil as a medium for potato cultivation in pots or containers.

Harvesting: Potato can be harvested 60 days after planting in the early varieties and after 90 days in the mid and late varieties. In the kitchen garden, harvesting can be done many times. Each time harvest only full grown potato without disturbing smaller ones or the plant root system. After 15 days, a second harvesting can be carried out and if necessary a third one on full maturity of all tubers.

Cultivation of Sweet Potato:

Nutritive Value: Sweet potato tubers are mostly consumed raw or boiled or roasted during fasting periods. Tubers with yellow and orange colored flesh are rich in carotene content. Sweet potato contains 70% water, 27% carbohydrates, 2.0% protein and 1.0% fibers, and is rich in minerals like potassium, calcium, sodium, phosphorus, magnesium, chlorine and iron, and in vitamin C.

Soil and Climate: Sweet potato is grows well in light and porous soil with a slightly acidic pH in the range of 6.0 to 6.5. It requires a tropical and subtropical climate and can be grown as a rainfed crop in forest soil.


Harvested Sweet Potato

Important Varieties*:* Pusa Lal, Pusa Safed, Pusa Sundri are popular sweet potato varieties grown in South India.

Planting and Irrigation: Sweet potato is mainly planted by vine cuttings and sometimes from sprouted tubers of sweet potato. The previous crop vines are cut into 30 to 40 cm long pieces having five to seven nodes on it. Vines are planted in such a way that both ends of the vine remain above ground while keeping the middle portion underground.

Vines of sweet potato have a tendency to form roots from their nodes and anchor into the soil. To avoid anchoring of soil with additional roots, care should be taken to turn the vines at specific intervals to increase tuber yield.

Plant Protection: Sweet potato is mostly a hardy crop free from pest and diseases. If the crop is taken year after year in the same soil then the insect pest like sweet potato weevil can attack the under ground tubers. This pest can be avoided by changing cultivation plots after each crop.

Harvesting: When leaves show a pale yellow color and the soil near the base of the plant shows cracks, then it is the right time to harvest tubers. It takes about 120 to 180 days depending on the type of variety grown. While harvesting the sweet potato tuber, all vines are removed and then tubers are harvested through digging with a kudali or shovel.

6.3 Glossary

Bolting: Premature flowering and seed stock formation leading to seed development in biannual crops.

Bulb: A specialized underground storage stem containing eye buds and fleshy scales/leaves e.g., onion.

Eye Bud: A bud on the tuber that can transform it into a shoot and leaves.

Season: A period of crop growth during the year like the rainy season, winter season and summer season.

Tuber: Enlarged and fleshy under ground storage stems bearing eyes or buds on it, e.g., potato.

Fruit Borer: It is an insect caterpillar that bores holes in the fruit and eats away the inside parts of fruits.

Cucurbits Crops: The vegetable crops that grow like creepers on the ground or when directed, on trellises and wires.

Vines and Creepers: Vines are the stems of vegetable crops that grow on solid supports with the help of tendrils (thread parts of plant) while creepers are running stems of vegetable crops growing on the ground.

6.4 Points to Remember

- Tomato, Brinjal and Chili are cultivated by transplanting seedlings.
- Loose, friable and well drained soil is necessary for tuberous vegetables to grow like onion, garlic, carrot, radish and beet root.
- Avoid water stress during critical growth stages like branching, flowering and fruiting in fruity vegetables.
- It is better to handpick and destroy larvae and caterpillars on vegetables grown in the kitchen garden and keep away from chemical insecticides.
- All cucurbit crops are susceptible to cold and frosty climates and hence should be avoided in growing in cold climatic conditions.

6.5 Self Check Questions

i What is the difference between chili and capsicum plants and fruits?

ii Why are cucurbit vegetables not recommended to be grown under cold and frosty climates?

iii How can you select soil as a medium of growth for tubers and bulb vegetables?

iv How are potato and sweet potato vegetables propagated for plantation?

6.6 Do It Yourself

- Preparation of Container and Raised Bed for Vegetable Plantation

Container Preparation

1 Select a 30 cm diameter earthen pot or a container having a drainage hole at the bottom and clean it with tap water

and keep in the sun for some time.

2 Take this sun dried container and put pieces of broken concave earthen pots on the drainage hole.

3 Fill 10 kg of garden soil mixed with 1 kg of compost or vermicompost or cow dung and 100 g of neem cake or *karanj* cake or cotton cake.

4 Make sure that the containers should be filled up to the brim keeping some space to accommodate irrigation water.

5 Keep all containers under the shade to avoid nutrient losses from the container before sowing seeds or transplantation of seedlings.

Preparation of the Raised Bed

1 Select 3 m long and 1.2 m wide piece of land from your kitchen garden and clean all weeds and grasses from the plot.

2 Loosen all the soil in the plot with the help of a spade and prepare channels from all sides of the plot by putting the soil at the inner side of the channel.

3 Channels will consume 15 cm space from all sides leaving an approximately 90 cm wide and 270 cm long space for raised beds.

4 Level all soil from the bed area to form a gentle slope in one direction taking care that the height of the raised bed is more than 15 cm.

5 Take a garden rake or strong stick and mark lines 2 to 3 cm deep across the length of the bed to sow the seeds.

UNIT 7: Fruit Growing in City Farming

7.1 Introduction

The principles applied in fruit growing are basically more or less the same as those in the cultivation of vegetables. However, there are certain practices that need to be followed in city farming conditions regarding the selection of the crop and its suitability under terrace gardening. It is always advisable to select dwarf varieties of fruit trees with a fibrous root system. The fruits with a tap root system should be avoided in growing in pots and containers owing to the limitation for deeper penetration at the bottom.

In the terrace or kitchen garden, fruits trees like papaya, citrus lime, water melon, musk melon, strawberries and passion fruits can be grown. These fruits are rich in vitamins, minerals and amino acids essential for human nutrition. Papaya is very rich in vitamin A and bears fruits within 1012 months of planting. Citrus trees bear fruits throughout the year and are rich in vitamin C. Strawberries are rich in vitamin C and are grown easily in pots and crates on terraces and roof tops of houses.

At the end of this unit, you will be able to know and understand:

- The importance of fruits and their nutritional values in the daily human diet.
- The selection and scope of growing fruits in home based kitchen gardens.
- The care and management of some important fruit crops in kitchen gardens.

7.2 Contents

7.2.1 Cultivation of Papaya

Papaya is an important fruit crop easily grown in tropical and sub-tropical climates. The fruit tree deserves more attention due to the high nutritive value of the fruit and production potential in a comparatively shorter duration. Papaya is the most common fruit tree in the kitchen garden owing to its adaptability to climatic variations.

Papaya Tree in Full Bearing

Nutritive Value and Uses: The ripe papaya fruit is eaten as a dining table delicacy while the raw fruit is diuretic and mildly laxative and can be used in vegetable preparations. Papaya fruit is a rich source of carbohydrates, minerals (calcium, phosphorus, iron), vitamin A and ascorbic acid.

A ripe papaya fruit contains 89.60 percent water, 9.50 percent carbohydrates, 0.5 percent proteins and is rich in minerals and vitamins like calcium, phosphorus, iron, carotene, riboflavin, etc.

Soil and Climate: Papaya cultivation requires good fertile soil with good drainage. Papaya has a soft single stem, prone to rotting

when it comes in direct contact with irrigation water. That is why papaya needs well drained alluvial soil with neutral pH ranging from 6.5 to 7.0.

Papaya requires a warm and humid climate for its normal growth. Temperatures below 10 °C are bad for growth as they inhibit plant growth, maturity and fruit ripening. Papaya can be grown from the sea level to an elevation of 1,000 m above sea level but it cannot withstand frost conditions.

Papaya Varieties: Several varieties of papaya are grown in South Indian cities like Honey dew, Coorg honey dew, *coimbtore1, coimbtore2, Pusa* dwarf and Washington. However, Pusa varieties are very common. Taiwan varieties of papaya are very dwarf and bear fruits at 60-90 cm above ground level and are very popular because they are free from wind damage.

Propagation: Papaya is a cross-pollinated crop normally propagated by seeds. It is advisable to collect seeds from the best quality ripe fruits, clean and dry in the shade before sowing. If stored properly in an airtight container, the seed can remain viable for 6 to 9 months. Seeds can be sown at any time of the year except during very hot, very cold and heavy raining periods of the year.

Seeds can be sown on raised beds or in polythene bags prepared with drainage holes at the bottom of the poly bag. Seedlings can become ready for transplanting in the field within 1.0 to 1.5 months, when it has 5-6 leaves and is 5-6 cm height. The soil of the raised beds should be mixed with farm yard manure and sand to facilitate drainage of excess water. Similarly, poly bags should be filled with equal quantities of alluvial soil, sand and farm yard manure.

Plantation and Manuring: A single papaya plant can be planted at any location where sufficient sunlight and space for growth are available. However, since papaya is a cross pollinated crop, it is advisable to plant a minimum of 3-4 plants at nearby locations so that there are chances of generating at least one male plant. Plants are planted at least 2 m apart to provide sufficient space for canopy growth. The best season for planting is from the beginning of June till October.

For planting in the soil, 30 cm long, 30 cm wide and 30 cm deep pits are dug which should be filled with a mixture of three parts of top soil, one part of farm yard manure mixed with 1 kg of bone meal or 100 g of single superphosphate. Seedlings should be planted

at the center of the filled pit keeping the soil mass around the root system below the ground and the stem above the ground. Care must be taken to provide supply soil to the stem and avoid direct contact of irrigation water.

Male and female plants in papaya can not be differentiated at the seedling stage. Therefore, if the planted seedlings happen to be male plants, then they will not bear any fruits and your efforts may be lost. So it is advisable to plant two seedlings at one spot or go for bisexual (hermaphrodite) varieties of papaya that consist of both sexes in a single plant and where every plant can bear fruits. Since papaya is an evergreen plant and can grow continuously, it also requires continuous feeding. Therefore each plant should be fed with 5 kg of compost mixed with 100 g of complex fertilizer containing nitrogen, phosphorus and potassium.

When papaya is planted in big earthen or cement pots, care should be taken that at least 50 kg of well drained alluvial soil is available for the plant to absorb essential nutrients. Otherwise, papaya will become bonsai and will not bear good and healthy fruits.

Plant Protection: No serious pests attack the papaya crop; however the crop is affected by a serious virus disease called yellow vein mosaic virus. It can spread through insect bites like aphids, jassids and white flies. The insects can be controlled by spraying any insecticide at the beginning of plant growth but botanical pesticides like Neemark, Neembin, Neembidin, etc., should be used when the plant is in the fruit bearing stage.

Papaya infected with yellow vein mosaic virus

Harvesting: The papaya tree starts bearing fruits when it is 12-14 months. The color of the fruit changes from green to yellowish and the milky latex turns waterish indicating that the fruit is ready for harvest. Papaya fruits on the plant matures and become ready for

harvesting one by one; therefore, matured fruits should be harvested individually by hand picking, avoiding all possible damage to other fruits on the tree. Under good feeding and management, one papaya tree can produce 20-30 fruits weighing about 40-60 kg in the first 16-8 months.

7.2.2 Cultivation of Kagzi Lime

The citrus group of crops constitutes major fruit crops like sweet orange, mandarin orange and kagzi lime cultivated in a variety of climatic conditions. However, Kagzi lime is popularly grown in the kitchen garden, terrace garden and in isolated places. It is suitable to grow in small pieces of land or even in earthen or cement pots on terraces of houses.

Kagzi Lime

Nutritive Value and Uses: Kagzi lime is an excellent source of vitamin C. It also supplies fruit sugar, minerals and alkaline salts as health promoting substances. By taking the juice of one small lemon every day through meals and tea, one can keep away from all skin problems.

Soil and Climate: Citrus lime can be grown on a variety of soils ranging from heavy black to shallow soil, moderate in organic matter content, but soil with stones, rocks and high ground water table are not suitable as the growth is stunted and nutrient deficiency symptoms are developed in trees. Slightly acidic soil with a pH ranging from 5.5 to 6.5 is considered highly suitable.

Lime trees can grow in tropical and subtropical climates and can withstand cold waves and light frost to some extent. Average temperature for good growth is about 16 to 20 °C. Low temperatures below 10 °C and high temperature above 40 °C can reduce production and productivity drastically. Heavy rains at the time of flowering can induce vegetative growth and reduce flowering.

Lime Varieties: Lime and lemon are used as fresh fruits that are grown as stand alone plants or in groups of plants. The important commercial varieties are Kagzi lime, Pati Nimboo, Eureka, Italian Lemon, Seedless lemon, Sai sarbatti, etc.

Propagation: Citrus lime can be propagated by seeds as well as by budding. However, plants propagated by seeds take more time to bear fruits. In commercial propagation, lime seedlings are grafted with T-shaped or shield shaped budding on *Jambheri* (Jambheri is wild tree plant used as root stock in propagation of citrus) root stock. Budding is carried out during July-September and January-March. However, it is always better to purchase and plant successfully budded seedling from a certified nursery to save time requires to perform budding operations at household level.

Planting and Manuring: The most suitable time for planting lime is August to September. Budded plants are planted in previously dug and filled pits measuring 45 x 45 x 45 cm^3. The pits are filled with top fertile soil added with 20 kg of compost and mixed with 1 kg of bone meal and neem seed cake.

At the time of planting, care should be taken to plant budded seedlings at the center of the pit keeping bud union 15 cm above the ground to avoid soilborne fungal infection to the bud joints. Soil around the plant is firmly pressed without damaging the roots and the plant should be watered immediately after planting.

Organic manure like farm yard manure, compost or vermicompost supplemented with mineral nutrients results in a healthy growth and high yields in citrus lime. Manure and fertilizer doses should be increased by 25 percent every year till the maturity of plant is achieved at the fifth year. Care must be taken to irrigate the plant immediately after manuring and fertilization when there is no rain.

Normally, citrus lime trees are moderately irrigated everyday in summer, twice a week in winter and as per requirements in the rainy season. If the basin of the tree, around the trunk, if covered with rice or wheat straw, irrigation intervals can be prolonged resulting in saving of considerable amounts of water.

Plant Protection: Citrus lime plant is comparatively free from frequent attacks of pests and diseases. Citrus Psylla is a major pest and Phytophthora and citrus canker are major diseases of

citrus lime. Citrus Psylla is an insect pest. Adult insects and nymphs suck the sap from tender parts of buds, leaves and branches. In severe infestation stages, leaves get distorted, curled and fall down resulting in complete defoliation of the plant. The pest can be controlled by spraying a botanical insecticide like neemark at the rate of 30 ml in 10 liters of water and simultaneously mixing 2 kg neem cake in the basin of a growing tree.

Phytophthora is a fungal disease causing stem rot, oozing out a gummy substance from the bark. Citrus canker is a bacterial disease that causes development of woody raised spots on leaves and fruits deteriorating the quality of fruits with a reduction of juice. These diseases can be controlled by spraying 1 g of streptocycline mixed with 0.5 g of copper sulphate in 10 liters of water. Drenching with neem cake solution in the basin can greatly reduce infection of these diseases.

Lime Fruits Infected with Citrus Canker

Harvesting: Flowering of lime and lemon trees occurs more than once a year and fruits require 5-6 months to mature after fruit setting. Fruits are harvested at full maturity when their color starts turning from dark green to light green or light yellow. One can get around 200-300 fruits from a full grown lemon plant.

7.2.3 Cultivation of Strawberry

Strawberry is a small and important fruit tree in the world. Fresh strawberry fruit is rich in vitamins and minerals particularly vitamin C. It is mostly eaten as fresh fruit but also processed on a large scale in preparing jam, jelly and ice scream.

Nutritive Value and Uses: Strawberry is a highly delicious and nutritive fruit that contains 89.90 percent water, 8.4 percent carbohydrates, 0.7 percent protein and high a percentage of vitamins A and C, and potassium, phosphorus, riboflavin. etc.

Strawberry Plant Grown in Pots and hanging basket

Soil and Climate: Strawberry grows well in light, porous and well drained soil having a slightly acidic pH of 4.5 to 6.5. Heavy deep black soil is not suitable for growing strawberry as it inhibits root development of runners. Most of the roots of the plant are found to grow in the top 15 cm layer of soil while lateral roots spread 30 to 90 cm in the form of runners.

Strawberry is a most suited crop in temperate (cool climate) to subtropical (warm and humid) climates. It is grown in hilly areas of subtropical regions. A day temperature in the range of 22 to 23 °C can be ideal for its optimum growth and production.

Varieties under Cultivation: There are two types of strawberry grown. The varieties which can grow under short duration sunlight are Chandler, Pajero and osho grandi while the other varieties of strawberry, like Selva, Fern, Ayarwin, are dayneutral and can grow any time during the year irrespective of day light duration.

Propagation: Strawberry is normally propagated by runners. Each plant can produce 10 to 15 rooted runners that can be separated and used as seedlings. Now a days large scale commercial propagation is done by tissue culture.

Strawberry Rooted Runners Serve as Seedling

Plantation and Manuring: Strawberry seedlings separated from the main plant can be planted on raised beds keeping a distance of 90 cm between two rows and 45 cm between two plants. If planted in pots or crates, one seedling should be planted per square foot and full-grown plants can be allowed to hang from the pots or crates to use the surrounding space.

Sufficient manure (about 10%) and low quantities of fertilizers (about 1%) mixed with soil is good for strawberry growth. On average, 1 kg of compost mixed with groundnut or neem seed cakes should be applied to each plant. Moderate irrigation to pots and beds should be provided after manuring and fertilizer applications. Manuring applications should be repeated at the end of fruiting to provide feeding for the next flowering and fruiting flush.

Plant Protection: When strawberry is grown on raised beds care should be taken to cover the ground under the trees with polythene films or spread grassbased mulch to protect tender fruits from touching wet soil. If strawberry plants are grown in pots care should be taken to remove fruits away from the pot and allow them to hang over to protect from touching soil surfaces. Miner insect pests can be controlled by spraying neembased insecticides like neemark, which acts as an antifeeding to these insects that eat leaves, branches and fruits.

Harvesting and Yield: Developing fruits of strawberry are usually green but when close to maturity they turn pinkish and then reddish. Fruits are harvested when 50-75 percent of the fruit becomes red. Harvesting can be carried out as and when fruits turn red. Strawberry fruits have a short lifespan. Matured fruits, if not harvested on time, get over matured and become instantly spoilt.

7.2.4 Cultivation of Water Melon

Water melon is a very common cool and delicious summer fruit that generally grows in light and welldrained soil. Traditionally, water melon is grown in sandy soil or sand in riverbeds. Water melon belongs to the cucurbits family that grows as long vines on the soil surface.

Good quality Fruit of Water Melon

Nutritive Value and Uses: Water melon contains the highest percentage of water among all fruits. However this water contains a lot of minerals and vitamins that have a cooling effect on our body. Water melon contains 95.60 percent water and the remaining 4.40 percent contains small proportions of protein, fats, minerals, vitamins, fibers, phosphorus, calcium, magnesium, sodium, potassium, copper, sulphur, thiamine, etc.

Soil and Climate: Water melon is grown in sandy soil with soil pH ranging from 5.5 to 7.0. It can be grown well in river beds on sand ridges where water is provided through trenches to avoid direct contact with growing vines and developing fruits.

Water melon requires a relatively warm temperature and has a long growing season. That is why water melon is grown in summer months. The seed does not germinate satisfactorily below 21 °C and below 9.5 °C the plant can be severely damaged.

Varieties under Cultivation: There are two important varieties of water melon grown. Asahi Yamato has heavy fruits weighing, on average, 5 to 7 kg each. Fruits have green to light color stripes outside and blood red color flesh inside. This is a high yielding variety with small seeds. Sugar Baby is another variety having dark green to black skin color outside and dark red flesh inside. Fruits weigh, on average, 3 to 5 kg each.

Sugar Baby and Asahi Yamato Varieties of Water Melon

Plantation and Manuring: Seeds of water melon are sown directly in the raised bed prepared for cultivation from November to March. Three to four seeds are sown at each spot and after germination and some growth, plants are spread thin keeping one plant at each spot. If we want a limited but good quality fruits, then fruits on vines are also spread thin, keeping a limited number of fruits on a vine.

Use 2 kg of well decomposed farm yard manure or compost mixed with 1 kg of neem seed cake or ground nut cake applied in rings around the plant which can boost the growth of the plant. The concentrated manure cakes applied two to three times play an especially important role at the time of fruit setting, growth and development.

Plant Protection: Water melon is attacked mostly by insect pests like beetles, cutworms and aphids found underneath the leaves. Beetles eat the leaves, cutworms cut leaves and stems and aphids suck the sap from the tender leaves and the stem of the vine. Neem cake at the rate of 200 g per plant mixed with soil in the basin of the plant can provide adequate protection from these insect pests.

All member crops of the cucurbit family including water melon can be affected by powdery mildew and downy mildew diseases which cause a powdery growth and tissue necrosis on leaf lamina resulting in total failure of the crop. These diseases can be controlled by spraying a Bordeaux mixture prepared from an equal quantity of copper sulphate and calcium carbonate.

Harvesting: When the outer skin of water melon fruits changes color from green to light and shining. The stem starts developing cracks at the base of the fruit and when gently beaten, the fruit gives a metallic sound indicating it is ready for harvesting. Fruits should be harvested keeping 2 cm of the stem intact. On average, depending on feeding, one vine can produce as many as 5-6 average size fruits.

7.2.5 Cultivation of Passion Fruits

Passion fruit is a vine crop grown on overhead trellis. The fruit is nearly round to oval in shape having amazing nutritional and medicinal properties. Fruits are filled with an aromatic mass of

doublewalled membranous sacs containing pulpy orange color juice containing many dark brown to black seeds.

Passion Fruit Vine at the Fruit Bearing Stage

Nutritional Value and Uses: Passion fruits are very rich in vitamins A and C. They also contain a good amount of potassium, calcium, iron and other micronutrients required for the human body. It is also popular for its medicinal properties and that is why passion fruit juice is served as refreshing and calming beverages.

Soil and Climate: Passion fruit grows well in fertile, porous and welldrained soil with neutral soil pH. A moderate climate is good for the growth of passion fruits but climatic extremes like chilling cold or scorching heat is dangerous for their cultivation.

Varieties under Cultivation: Panama and golden passion fruit are the best suited varieties under tropical climates in South India. Passion fruit is propagated by seeds and stem cuttings; however, vegetative propagation with cuttings can bear fruits earlier than propagation with seeds.

Plantation and Manuring: Passion fruit can be planted during January-February or June-July when the temperature is relatively warm with a good amount of relative humidity. Plants grow on vigorous vines that climb on the supports with the help of tendrils. It is always good to provide a wiremesh overhead trellis to support to vines that can ensure air circulation and does not block the sunlight. Passion fruit bears fruits on new branches of the vine. Therefore, the pruning or cutting of old vines is necessary to boost up growth of new vines to bear fruits.

Manuring can be done with 5 kg of welldecomposed compost mixed with 1 kg of neem cake at the time of planting with light, but frequent, manuring in the fruiting stages. The manuring dose should be repeated after each heavy pruning each year. After each manuring the vines should be irrigated as well as at particular intervals while observing the soilmoisture condition in the basin of the growing

plant. As a rule of thumb, plants may be irrigated 4-5 days in summer, 8-10 days in winter and as per need in the rainy season.

Plant Protection: If the bottom of the passion fruit vine is exposed to direct contact with water it can be infected by phytophthora and Fusarium fungus causing wilting of the whole vine. This can be prevented by avoiding direct contact of irrigation water with the vine and, if already infected, drenching of Bordeaux mixture or copper fungicide can control the disease.

Passion fruit is also attacked by insect pests like sucking bugs, mealy bugs that suck sap from leaves and vines and fruit flies that damage the growing fruits. These insect pests can be kept under control by spraying plantbased insecticides like neemark and applying a sufficient quantity of neem cake as manure to the growing plant.

Harvesting: When passion fruits get matured the skin color of fruits turns from green to yellow. Over matured fruits will drop off the vines automatically. The peak season for harvesting is November-December. On average, each vine can bear 150-200 fruits every year for 3-4 years.

7.1 Glossary

Tap Root: The root of growing plants goes vertically down the soil, having a limited number of root branches.

Fibrous Root: The number of roots of the growing plant that grows and spreads horizontally in the soil.

Tropical Climate: Relatively hot to very hot and humid climate.

Subtropical Climate: Moderately warm and humid, but not a hot, climate.

Well Drained Soil: Soil that can become wet on irrigation but cannot hold excessive water in it.

Pusa Varieties: Crop plant varieties that are developed at the Indian Agricultural Research Institute (IARI), New Delhi, popularly called as the Pusa Institute.

Plant Propagation: Multiplication of plants for planting in the field.

Cross Pollination: When same plant does not have both the male and female sex organs then the plant is pollinated

by borrowing pollen grains from other plants through the action of wind or insects like honey bees.

Hermaphrodite: The same plants having both male and female sex organs that can facilitate self pollination.

Irrigation Water: Water used for irrigating the crop plant on a large scale.

Bonsai: Stunted growth of plants owing to nutrient deficiency and starvation.

Budding: It is the practice of grafting one plant with the help of the eye bud from another desirable plant.

Defoliation: Removing all leaves from the plant.

Runners: These are parts of growing stems of some plants like strawberry that can be used as seedlings.

Bordeaux Mixture: It is a mixture of copper sulphate and calcium carbonate having fungicidal properties that can be used to control fungal diseases of crop plants.

Soil pH: It is a measure of soil condition that indicates the given soil as acidic, neutral or alkaline in nature.

7.2 Points to Remember

- Fruit crops with a tap root system should not be grown in terrace gardens and only plants with a fibrous root system should be planted in pots and crates.
- Papaya, strawberry and passion fruit can be cultivated in terrace and kitchen gardens.
- The papaya stem should be protected from direct contact with irrigation water to avoid infection from phytophthora fungus.
- Hermaphrodite / bisexual varieties of papaya should be planted to avoid growing non-bearing male plants.
- In tropical regions like South India, kagzi lime should be budded on Jambheri root stock.
- Botanical based insecticides like neemark should be used to control insect pests in the kitchen garden.
- A wiremesh mandapam should be erected for passion fruit cultivation in the kitchen or terrace garden.

7.3 Self Check Questions

i What are the common varieties of papaya grown in South India?

ii How can papaya yellow vein mosaic disease be controlled in the kitchen garden?

iii What are hermaphrodite varieties of papaya?

iv Why is lemon used in our daily meals?

v Name the insect pest on citrus lemon that can defoliate the plant?

vi What are maturity indicators of strawberry fruits?

vii What is the significance of mulching in strawberry cultivation?

viii Why is water melon grown in riverbeds and sandy soils?

7.4 Do It Yourself

- **Preparation of Seedling for Papaya Cultivation**

1 Select 4 cm wide and 6 cm long polythene bags and punch at least four to six holes at the lower side of the bag to serve as drainage outlets.

2 Fill all the bags to the brim with garden soil mixed with compost and neem cake.

3 Prepare one small bed in the corner of the kitchen garden to receive sufficient sunlight and keep all polythene bags in the bed.

4 Sow certified or reliable seed of the designated variety of papaya in the bag 1 to 2 cm deep and cover the seeds with soil.

5 Water the polythene bags slowly and gently till water drains through the holes at the bottom.

6 Seeds will germinate after 5 to 6 days and will be ready for transplanting in the garden after 1.0 to 1.5 months.

While watering young seedlings care should be taken to see that the stem of seedlings are not bent or broken during rough watering.

UNIT 8: Fruits, Vegetable Harvesting, Packing and Marketing

8.1 Introduction

In general, it is estimated that we lose almost 30 percent fruits and vegetables due to bad handling practices of the postharvest produce. If this can be saved then another 30 percent more vegetables will be available for our consumption. Since fruits and vegetables are perishable commodities, post harvest techniques are of paramount importance. People in cities prefer clean and fresh fruits and vegetables at their door steps and they also need off season, canned and preserved vegetables in the off season period.

This has created a golden opportunity for those city farmers who produce more vegetables than their daily requirements. The additional vegetables can be marketed through social networking and what remains can be dried, preserved and stored for home consumption or for sale in off seasons during the year.

The post harvest value addition is carried out to prolong (life of product) and enhance quality of products and this process includes various operations needed to perform on fresh farm produce like fruits and vegetables, like cleaning, grading, processing, packing, transporting and storing. Post harvest handling does not mean

carrying all operations for all vegetables. Some operations like cleaning, grading and packing are common to all vegetables but processing and preservations are selective operations performed for selective fruits and vegetables.

At the end of this unit, you will able to know and understand:

- The importance of postharvest handling of fruits and vegetables in city farming.
- Different maturity indicators and methods of harvesting fruits and vegetables in the kitchen garden.
- Principles and practices in fruit and vegetable processing and value addition.
- Marketing of fresh and processed kitchen garden fruits and vegetables through social networks.

8.2 Contents

8.2.1 Maturity Indicators in Fruits and Vegetables

Maturity of fruits and vegetables 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 vegetables, it should be harvested at full maturity but still succulent and tender without the development of fibers. If we want to prepare 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 fruits and vegetables are harvested at an immature stage then they become susceptible to shrinking and the quality of the produce becomes inferior when ripe. On the other hand, over ripe fruits tend to become soft. Both early and late harvesting of fruits and vegetables results in extremely poor quality and life span. Therefore, it is extremely necessary to harvest fruits and vegetables at the right stage of maturity which cannot be decided by a rule of thumb.

There is always confusion between maturity and ripening because of lack of understanding between the two terms. Maturity is described as an attainment of a particular size, shape, color and

internal biochemical features essential for ripening. Some tropical fruit crops like papaya and vegetable fruits like tomato and chili can be harvested matured as well as ripe. While fruits like water melon cannot become ripe after harvesting they should be harvested when ripe on the vine.

Color, flavor and texture determine the quality of fruits and vegetables for fresh consumption or processing of surplus produce. While determining the physiological maturity of fruits and vegetables for harvesting there are various morphological features which need to be taken into account before the produce is harvested. These are the number of days from flowering to setting of the fruit, size and shape of the fruit, color and firmness of the fruits and leaves of vegetables.

Maturity Indicators of Major Fruits and Vegetables

- **Papaya:** Fruits are ready for harvesting when their color turns from dark green to light yellow with a clear skin with oily spots on. Bright yellow to reddish spots on matured fruits are a good indicator of maturity. It normally takes 10 to 12 months from flowering.
- **Lime and Lemon:** The fruits are mature when their color changes from dark green to shining yellow. It takes 4 to 5 months from flowering.
- **Strawberry:** Fruits start turning from light green to red. When 75 percent of the fruit has a red surface and 25 percent a green surface the fruit is harvested. This stage requires 45 to 50 days from flowering.
- **Passion Fruit:** When the color of the fruit turns yellow and the fruit shines, it is harvested along with part of the stalk to maintain quality.
- **Water Melon:** When the color of the fruit changes, the fruit begins to shine more, it gives a metallic sound on beating, and pedicels develop cracks at the base of the fruit the fruits are harvested.
- **Tomato:** Full grown fruits turn light yellow to reddish tint. Fruits can be harvested at various maturity stages for different purposes.
- **Spinach:** Four weeks after sowing, when leaves are dark green, tender and full grown it is ready to harvest leaves or the whole plant..

- **Asparagus:** When the stem becomes branchy and thick at the bottom 7 to 9 inch sized spears start emerging from the soil, which should be cut at the base under the soil.
- **Onion:** At the harvesting stage, leaves turn yellow and dry and the top shoot falls down, and 3 to 4 months would have elapsed after transplanting. Onion bulbs are uprooted manually and kept for curing in the shade for 5 to 6 days.
- **Garlic:** The leaf top turns yellow to brown and shows signs of drying. Bulbs are uprooted, tied in bundles and dried in the shade for 2 to 3 days.
- **Radish:** Depending on the variety, the radish root becomes ready for harvest in 25 to 60 days. Light irrigate crop and harvest manually. 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.
- **Potato and Sweet Potato:** Leaves turn pale yellow, tubers grown fully with yellow shining skin in potato and red shining skin in sweet potato. Both are harvested through digging with a kudali or shovel. While digging tubers care should be taken to avoid bruising the skin of tubers that will reduce their market value.

8.2.3 Harvesting Time and Methods

The purpose of harvesting is to collect maximum produce with minimum losses in handling it. Manual harvesting is the most cost effective method of harvesting fruits and vegetables by which injury to fruits and vegetables can be avoided. Harvesting of fruits and vegetables is recommended to be carried out in the morning or evening hours to avoid loss of weight in the hot sun. The produce harvested should be immediately shifted to relatively cooler places under the shade.

Harvesting of fruits and vegetables at the right time and with the right method can save huge post harvest losses. Fruits and vegetables required immediately can be harvested full grown and ripe; however, those that require distant transportation before marketing may be harvested a little unripe to allow them to take sufficient time to ripen without losses in transit.

There are different methods of harvesting of fruits and vegetables. However, hand picking is the most popular method of harvesting in

the kitchen garden or city farming owing to the small size of the plot and the produce. Fruity vegetables like tomato, chili and brinjal can be easily harvested by handpicking. Leafy vegetables like coriander, fenugreek, spinach, and root vegetables like carrot, radish and beetroot can be harvested by pulling them out manually. Tuber crops like potato and sweet potato can be harvested by digging with hand tools like kudali or shovel or trowel to avoid injury to underground tubers.

8.2.3 Packing and Packing Materials

Packing and transporting are relatively, not a big issue in city farming owing to the small scale production necessary to distributed throughout the year. However, when family consumption is limited and there are surplus vegetables then they need packing or preservation or sometimes simple processing like sundrying.

Packing materials are selected on the basis of their ease of usability, cost and handling. However, bamboo baskets are very popular and a cheap option for packing. Corrugated boxes are a little costly but they are very safe and scientific packing materials while plastic crates and containers are very costly but a onetime investment can be used a number of times. Netlon bags are very popular now a days for vegetable packing owing to full aeration to vegetables like potato, onion, garlic, carrot, radish, beet root and leafy vegetables.

8.2.4 Processing and Preservation

Fruits and vegetables contain 70 to 95 percent water and are very susceptible to microorganism infection and spoilage. If we reduce the moisture content from fruits and vegetables to a certain level we can prevent these products from spoilage and they can be preserved for a long time in storage. The excess moisture can be removed through sun drying or passing it through flow of hot air under controlled temperature and humidity. This practice is called dehydration.

Sun drying is one of the most widely accepted methods of vegetable preservation owing to the availability of abundant sun light at almost no cost any where. The drying process of preservation has the added advantages like the fact that the dried product can be reduced in volume and stored in less space and used in the off season and times of scarcity. It can also be transported to distant markets for sale anytime during the year without any recurring losses.

Preservation by Sun drying: The process of dehydration or sun drying of selected fruits and vegetables is enumerated below.

1 The vegetable to be sun dried is selected, cleaned properly and washed under clean running water.

2 The skin (epidermis) of vegetables like potato, sweet potato, carrot, radish and beetroot is peeled off and the vegetable cut in to slices or pieces while leafy vegetables like fenugreek, coriander and spinach can be cut into little bigger pieces.

3 The cut pieces of vegetables except onion and garlic are tied in muslin cloth and dipped in boiling water for 3 to 5 seconds for surface sterilization. This practice is called blanching of vegetables.

4 The surface sterilized vegetables are spread in to a tray and subjected to sulphur fumigation or without sulphur fumigation (2 g of sulphur burn for 1 kg vegetables) and kept under the sun for natural drying.

5 The vegetables should be given occasional turning to ensure that the moisture inside the vegetable is removed uniformly.

6 While drying vegetables under sun, you cannot control temperature but you can correlate your common sense while exposing tender vegetables to sunlight; otherwise, the tender leafy vegetables burn to ashes.

7 When you are using machine dryers for this purpose you can adjust the temperature of drying as per specific requirement of the vegetable.

8 Cabbage, cauliflower, onion and garlic require a temperature of 55 °C, Papaya, carrot, okra, green peas and spinach require a temperature of 60 °C while potato requires a temperature of 65 °C.

9 The rule of thumb for good drying is to reduce moisture in the vegetable to less than 10 percent.

10. The sun dried vegetables are then packed in air free polythene bags or in metallic containers or even in earthen pots whose mouths should be tied tightly with a double layer of cloth.

Use of Permitted Preservatives: There are a few organic and inorganic chemicals which are officially permitted to be used as food preservatives and are safe for our health. Preservatives are

chemical substances which retard, hinder or mask undesirable micro-biological or enzyme related changes in food, fruits and vegetables in storage.

The permitted food preservatives are classified as class I and class II preservatives. Class I preservatives include common salt, sugarcane, glucose, dextrose, vinegar, acetic acid, honey and spices while class II preservatives include benzoic acid, sulphur dioxide, sodium nitrates and potassium nitrates and their salts. The most common class II preservative used in food preservation like fruit and vegetable juices, squashes, cordials, crushes, pulp, syrups and beverages is sulphur dioxide in the form of sodium or potassium benzoate and meta bisulphide.

The preservatives prevent the growth of microorganisms like bacteria, fungus mould and yeast which cause spoilage in stored food products. Class II preservatives are used in small quantities ranging from 300 to 2,000 parts per million (ppm). Class I preservatives are natural preservatives and are safe for health.

Sugar syrup up to a concentration of more than 70 percent can be used in preserving food items like jam, jelly and candies. Common salts with concentrations of 15 to 20 percent are used for preservation of pickles. Normally, we can get a limited quantity of fruits and vegetables from kitchen gardens, and their distribution and consumption can be managed through sharing among peers or marketing through our social networking in our city and need no preservation.

8.2.5 Sharing and Marketing through Social Networking

Marketing in city farming is not a big issue owing to the limited quantity of production. However, the basic principle of city farming is to share the produce and experiences among city dwellers and form social networking of like minded people for promotion of city farming practices in the form of kitchen gardening, Terrace gardening and community based gardening.

Since city farming fruits and vegetables are organically grown very safe and healthy to produce for our family, we can consume enough and then share the rest with our friends and neighbors on a reciprocal basis. This practice of social sharing will promote your own circle of friends.

Whenever we have a surplus quantity of vegetables we can resort to various methods of personal and social marketing in our area. We can put up boards with the words *"Organically Grown Healthy Farm Fresh Vegetable Are Available Here"* in front of our houses. So interested parties can approach us for their vegetable needs. We can also pack our surplus vegetables nicely putting labels of organically grown vegetables and send them to social groups like Rotary Club, Lions Club and other social and professional associations for perusal. This may promote marketing for our vegetables and we can receive more profit than sharing vegetables among our close social group.

The oral publicity of our genuine vegetable produce among the city dwellers will provide us more customers than actual publicity in newspaper and magazines. But newspaper or magazine publicity at the initial phase of marketing will pay good dividends.

8.3 Glossary

Maturity Indices: These are morphological and physical indicators like shape, size, color and density which indicate the right stage for harvesting of fruits or vegetables.

Postharvest Technology: These comprise processes and techniques in handling agricultural produce like fruits, vegetables, flowers and grains after they are harvested till they reach market.

Physiological Maturity: This is the right stage to harvest fruits and vegetables which are ready for consumption.

Physical Maturity: This is the stage where the produce is completely matured and the plant has completed its life cycle.

Bruises: These are the scratches on the skin of fruits, tubers and bulbs caused due to their wrong handling.

Dehydration: This is the process of removing or reducing moisture from food, fruits or vegetables before they are stored for long periods.

Blanching: This is the process of dipping fruits or vegetable in boiling water for a few seconds to kill harmful surface microorganisms.

Sulphuring: This is the process of fumigating food with sulphur vapors to increase the life span of the product in preservation.

Sterilization: This is the process of killing all micro-organisms from the food product to avoid its spoilage.

Chemical Preservatives: These are chemical substances used, mixed with food products in storage to keep away harmful microorganisms.

Social Marketing: This is a method of marketing goods and products among your close relatives, neighbors and friends.

Network Marketing: This is the method of selling your goods, product and produce through networking with your social and professional groups.

8.4 Points to Remember

- The post harvest losses of fruits and vegetables are estimated to be more than 30 percent.
- The size, shape, color and density are the physical parameters of maturity in fruits and vegetables.
- The fruits and vegetables should be harvested during cooler times in the morning or evening.
- Dehydration or drying under the sun is most popular and a cost effective method of preserving vegetables.
- The natural food preservatives used are common salt, sugar, vinegar and spices.

8.5 Self Check Questions

i What is the definition of maturity indicators?

ii Differentiate between physiological maturity and physical maturity.

iii What is dehydration? Explain the process of dehydration.

iv Why is blanching carried out before preservation of fruits and vegetables?

v What is social and network marketing?

8.6 Do It Yourself

- **Preservation of Green vegetables by sundrying**

1 Select green and leafy vegetables like cabbage, cauliflower, spinach, fenugreek and coriander to be sundried. They should be cleaned properly and washed under clean running water before being sundried.

2 Cut these vegetables into medium sized pieces and tie them in muslin cloth and dip in boiling water for 3 to 5 seconds for surface sterilization. This practice is called blanching of vegetables.

3 The surface sterilized vegetables are spread in a tray and subjected to sulphur fumigation or without sulphur fumigation (burn 2 g sulphur for 1 kg vegetable) keep under the sun for natural drying.

4 Turn the vegetables occasionally to ensure the removal of excess moisture inside the vegetable.

5 In drying vegetables under the sun, try to correlate your common sense with the outside temperature while exposing tender vegetables to sunlight; otherwise the tender leafy vegetables get burnt to ash.

6 If you are using a machine dryer then adjust the temperature to 55 °C for cabbage, and cauliflower, 60 °C for spinach and green peas for 65 °C.

7 Make sure that the moisture in vegetables should be reduced to less than 10 percent.

8 Pack the sundried vegetables in air free polythene bags or in metallic containers or even earthen pots whose mouths should be tied tightly with a double layer cloth.

Appendices: Success Stories of City Farming in South India

9.1 Trivandrum

Village in the City Program:

Background: Trivandrum, the capital of Kerala is densely populated. The majority of the population are employees in government and private sector offices. The value of land is very high as compared to that in nearby semi-urban and rural areas. The houses in the city have very little or no vacant spaces for doing any sort of farming. Fruits and vegetables consumed in the city generally come from the adjoining towns and villages.

Kerala has a very high literacy rate reaching almost 100 percent in Trivandrum and at the time, people are highly health conscious. So a major concern has been to fully well where their fruits and vegetable come from. This worry has been increased after the Department of Entomology, Kerala Agricultural University published that high levels of pesticide residues exist in the fruits and vegetables consumed by the citizens, well above the permitted limits of pesticide residues in vegetables like bitter gourd, cowpea, okra and other vegetables tested for pesticide residues. The report also clearly outlined the types of short and long-term health hazards.

Dawn of Terrace Farming: For some time, there have been a few unknown farmers and enthusiasts around the city producing vegetables organically. However this has been largely unorganized and isolated efforts. It was after the abovementioned warning on health hazards that some individuals and residential associations thought more seriously about growing vegetables in their kitchen gardens and house terraces. They collectively approached the Department of Agriculture, Government of Kerala for advice and help.

The Department of Agriculture mooted an idea and launched a new scheme called *Village in the City* in 2002 to help the city farmers. This has proven to be a great success as many residential associations and individuals registered and participated in this city farming cum terrace farming program.

Under this program, vegetable seeds, plastic bags, gunny bags, garden pots together with hand tools and implements are supplied to terrace cultivators at half of their cost. Cement tanks made out of rings are also supplied at half price encouraging new urban farmers to recycle organic city waste and convert it in to vermicompost in these cement tanks and make it available for terrace farming.

The Department of Agriculture has simultaneously organized study classes and exposure visits of individuals in association with residential associations free of cost once in 3 months. Theory classes are necessarily supported by slide shows on a general package and practices in urban farming. An article during the peak season published on terrace gardening in a newspaper attracted more than 10,000 enquiries from the Trivandrum city and adjoining areas.

Urban Agriculture: At the moment, 2,000 families are practicing terrace farming and gardening in Trivandrum as part of this program and many more are doing so on their own. The practice most commonly adopted requires filling gunny bags or earthen pots with a mixture of 50 percent good garden soil, 25 percent fine sand and 25 percent vermicompost/compost/farm yard manure/goat manure/poultry manure/cow dung depending on their availability. These gunny bags are mostly placed on brick pads to avoid contact with the terrace surface.

Many different vegetables like tomato, brinjal, okra, cabbage, cauliflower, beetroot, cucurbits, potato, sweet potato, onion, garlic, carrot, radish, leafy vegetables like spinach, coriander, fenugreek

and even crops like papaya, yam, tapioca and banana can be planted in gunny bags. Cow dung, vermicompost and neem cake are generally used for manuring while crop rotation and neemseed extract were used for pest management. Since vegetables are grown on terraces, it was found that there were very minor to no incidence of pest and diseases, may be owing to the scarcity of spaces available on the terraces for hibernation of insect stages like eggs, larvae and adults.

Urban Rural Linkages: Farmers in rural areas are aware of the changes in consumption trends and public preferences. They understand that terrace farming is gaining popularity because of health concerns. Some farmer groups have started to restrict the use of chemical fertilizers and pesticides and begun learning about organic farming practices in their fruit and vegetable cultivation. Some producers are even marketing their produce as organic produce, even though it is not certified as organic produce. It is a common belief among the consumers that organic produce cannot be plump and may have some insect bite spots but they are much tastier.

Evaluation of Program for Benefits: A review of results of Village in the City Program had clearly shown how terrace cultivators get fresh fruits and vegetables from their own gardens. It is estimated that all terrace gardens put together have harvested more than 1,000 tons of vegetables in one year and manage to recycle 1,000 tons of kitchen organic wastes. It is also estimated that the average cost of cultivation for 10 m^2 is about INR 1,250 per year (US$30) for growing vegetables while the produce has a market value about INR 10,000 with a benefit: cost ratio of 1:8.

Inspired by the success of the terrace farming program, the municipal corporation of Trivandrum has launched new initiatives covering 20 schools in the city where school children are given free terrace garden kits consisting of vegetable seed, dried organic manure powder and two banana suckers. The aim is to involve children in terrace farming in their houses thereby practicing terrace gardening to learn skills, earn money, help parents and work in close association with nature and learn from nature.

Role Model of Mr. KP Pillai: Mr. Pillai has been growing fruits and vegetables on his terrace for the last 30 years. He served as a role model for other city farmers under this program. His home terrace measured 800 m^2 where he grows vegetables in cement pots and old rubber tyres filled with good garden soil. He collects goat

manure from nearby villages and powders it to store in gunny bags. That is the main source of nutrients for his crops. In addition to that, he also uses cow dung powder, bone meal and groundnut and neem cake powder mixed with soil to manure his vegetable crops at critical growth stages. Mr. Pillai was the first to join the urban farming program and now he produces his own vermicompost. He controls pests by spraying a soap solution prepared by mixing 4 to 5 spoons of soap powder in one bucket of water. Covered trellis are made on the terrace for trailing crops like cucurbits and gourd crops like ash gourd, bottle gourd, bitter gourd, sponge gourd, etc.

Fruit crops like banana and papaya are planted on the ground so that the fruits can be harvested easily from the terrace. Both his wife and he devote one hour every morning or evening for their terrace garden. Building on Pillai's experiences, many families also stretch tarpaulin sheets to provide shade on terraces under which Azolla as green manure and poultry birds can be reared. Pillai said that since his terrace is fully exposed to bright sunlight, the incidence of pest and diseases is almost close to nothing.

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9.2 List of cities in South India suitable for city farming practices

The general criteria for practicing city farming or Urban Agriculture are shortage of land and availability of plentiful kitchen and city waste for growing fresh and chemicalfree vegetables within the ambit of the growing city. The list of potential cities and towns from four South Indian states like Andhra Pradesh, Karnataka, Tamil Nadu and Kerala is given below.

- **Andhra Pradesh**: Hyderabad, Vishakapattanam, Vijaywada, Warangal, Nizamabad.

- **Karnataka**: Bangalore, Dharwad, Mysore, Gulbarga, Belgaum, Mangalore.
- **Tamil Nadu**: Chennai, Madurai, Coimbatore, Trichirapalli, Dindigul, Dharampuri.
- **Kerala**: Trivandrum, Cochin, Kottayam, Thrissur, Kosaragod.

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