Chapter - 4

URBAN HORTICULTURE

OBJECTIVES

After reading this chapter, students will be able to:

- Elaloorate urban and peri-urban horticulture (UPH)
- Identify & enlist different and basic components of UPH
- Understand the benefits and challenges of UPH
- Practise UPH in their towns and/or cities

INTRODUCTION

During the recent years, there has been a rapid increase in urbanisation and industrialization throughout the world, due to which the cultivable land for horticultural crops is also diminishing day-by-day. As a result, the concept of unban and peri-urban horticulture came in to existence. Although, it has become an integral part of several advanced countries, but in India, it has also started expanding because of great desire of urban population for safe food and pollution-free environment. Urban and peri-urban horticulture opportunities are emerging in urban areas as demand for fresh fruits, vegetables are increasing. Roof and terrace gardening is finding now place to get fresh fruits, vegetables and flowers, and also for environmental services. Vegetable production has expanded in and around cities in many developing countries as an informal activity practiced by poor and landless city dwellers. The broad diversity of horticultural crop species allows year-round production, improved employment and income. Growers have realised that intensive horticulture can be practiced on small plots, making efficient use of limited water and land resources. Horticultural crops, as opposed to other food crops, have a considerable yield potential and can provide up to 50 kg of fresh produce per m^2 area per year depending upon the technology applied. In addition, due to their short cycle, they provide a quick and emergency needs for food. Leafy vegetables provide a quick return to meet a family's daily cash requirements for purchasing food. Leafy vegetables are particularly perishable and post-harvest losses can be reduced significantly when production is located close to consumers. Mushroom centres, which do not need land, can be a

most promising activity in urban and peri-urban areas. Evidently, there is an accelerated production of mushroom around metropolitan cities. There are new practices to grow cucurbits on the arches created on the pathways, utilising the zero-land for additional production.

In this chapter, you will learn about the components of UPH, its benefits and challenges. Read it carefully and adopt this type of culture to boost production and productivity of horticultural crops for your own benefit and for the benefit of society and surroundings.

What is UPH?

Growing of horticultural crops in towns and cities is called as urban horticulture whereas growing of horticultural crops on the periphery of towns and cities is called as peri-urban horticulture. In urban areas, horticultural activities are primarily restricted to kitchen gardening, landscape gardening, roof gardening, terrace gardening whereas in pre-urban localities, large scale cultivation of fruits, vegetables and flowers can be adopted. UPH is a highly profitable venture, which not only helps in increasing the food and nutritional security but creates employment opportunities to rural and urban youths, and makes our surroundings more attractive and beautiful.

Points to remember

- Growing of horticultural crops in towns and cities is called as urban horticulture, and
- Growing of horticultural crops on the periphery of towns and cities is called as peri-urban horticulture.
- Several activities related to fruit, vegetable and floricultural crops can render UPH as one of the best business opportunities in our country.
- Think positively and act accordingly in this direction.

Some important components of urban and peri-urban horticulture (UPH)

1. Cultivation of fruits, vegetables and flowers

India is fortunate to have varied agro-climatic conditions, which facilitates cultivation of a wide range of horticultural crops. Among the horticulture produce, fruits and vegetables together have the largest share of production (78 %). Fruits and vegetables not only contribute to the food basket of the country but are also a highly remunerative crops, which are greater in urban areas, as these form one of the most important components of a balanced diet. In urban and pre-urban areas, there is always a scarcity of land, hence conventional/traditional system of growing horticultural crops can't be adopted, rather intensive system of growing should be

followed. Thus, production of horticultural crops and profitability of farmers can be enhanced by encouraging 'off-season' production of such crops under protected cultivation in green houses, shade and net houses, etc. For peri-urban and urban areas, fruit crops such as papaya, strawberry, papaya, phalsa, aonla, Amrapali mango, pomegranate, bael etc. can be grown with minimum available water conditions. The package of practices for the cultivation of above mentioned fruits is the same as discussed in chapters on production technology of these fruit crops.

Almost all the vegetables can be grown in urban and peri-urban areas, depending upon tha availability of land, resources and demand of consumers in such areas. For instance, in metropolitan cities like Delhi, Mumbai, Chennai, Kolkata etc., vegetables remain in high demand and farmers of peri-urban areas of such cities can get premium price for the vegetables they grow. Similarly, near cities, there is always a great demand for cut flowers. Hence, farmers near big cities or towns should grow roses, gladiolus, gerbera, carnation etc. on a large scale to meet the demand of such cities. It will help not only the consumers for getting fresh produce but farmers will also get premium price of their produce. The package of practices for growing above mentioned vegetables or flowers have been discussed in different books on horticulture.

2. Roof gardening

In big towns and cities, availability of cultivable land is a big problem. In spite of this, horticulture can be taken as one of the enterprises in such areas as well by growing horticultural plants on the roof of house or balcony. Roof garden is one of popular alternatives in urban areas, because of the limited available space in the grounds of a house. However, care should be exercised to confirm that the roof of the house is strong enough to bear the heavy load of soil and potted plants. In roof garden, potted plants like cacti and succulents, chrysanthemums, dahlias, orchids, bougainvillea, roses, seasonal flowers and several kinds of shrubs and herbs can be grown. Besides, the vegetable crops such as tomato, brinjal, chillies, beans, leafy vegetables and gourds can also be grown. In a strong roof structure with waterproof system, the area can be laid out with lawns and herbaceous borders which require at least 30 to 45 cm soil depth. Such planting can be done by

A view of roof garden

placing the soil between the outer wall or the parapet and the wall built on the inner side of the roof. To prevent seepage of water, the roof is to be treated with a bitumen compound or fitted with moisture-proof wood shutters. Polythene sheets may also be used for this purpose. It is a good idea to have some other colour of the roof than the traditional off-black on the surface. Colours like green, brown or soft red can be a good choice. Similarly, some framework or screening devices can also be used for enhancing the beauty of the roof garden. Hence, free-standing trellis or wall-attached trellis may be erected for supporting plants.

In the roof garden, few large permanent shrubs and climbers should also be grown. For this, tubs and boxes of different sizes and shapes are helpful for growing such plants. With main tubs and boxes, smaller pots and boxes can be arranged along with hanging basket, which will further aid in the beauty of roof garden. Similarly, ornamental stones, sculptures and other decorative pieces may be suitably arranged in the roof garden. However, all this depends on the interest of the growers/gardener, availability of material in the vicinity and financial status of the grower.

3. Kitchen gardening

Kitchen gardening is growing of fruits, vegetables or ornamentals on a piece of land near to your kitchen. Basically kitchen gardening is done for the consumption of your own family and not for commercial purposes. However, if there is availability of good land, for larger cultivation, one can use that piece of land for commercial production of horticultural crops.

A view of modern kitchen garden

A well maintained kitchen garden can provide fruits, vegetables and cut flowers throughout the year. In kitchen garden, intensive system of planting is followed. On bunds, vegetables like carrot, radish, and in the fields cabbage, cauliflower, and dhania can be easily grown. Near the wall of house, some trailing type bean should be grown. Among fruits, choice is limited but strawberry, Amrapali mango, Kagzi Kalan lemon and papaya can be easily grown. Similarly one grapevine can be trained to wall of house. On side rows of kitchen garden, a row of roses, gladiolus or chrysanthemum or any other seasonal flowers can be grown to make kitchen garden more attractive and to meet the demands of your family.

4. Terrace gardening

Terrace gardening refers to growing of horticultural crops in an area, which is in the immediate vicinity of a building or of your house. This is a raised ground space constructed around a dwelling house or on the sides of a hill. The terrace forms a link between the house and the rest of the outdoor living space and must, therefore, be designed in harmony with the plan of the house. However, terrace gardening is a highly specialised job for landscape gardeners and civil engineers. It involves land raising and construction of steps, ramps, walls and paved paths as well as planting of lawn grasses and other plants. Such gardens are mainly for relaxation; hence all arrangements should be made in a way to provide both sunny and shady areas in the terrace garden and must offer a fine year-round view of the entire garden. Addition of sculptured rocks, a small lily pond with a fountain and water plants will add more beauty to such gardens.

Terrace garden

5. Landscape gardening

In the recent years, landscape gardening as emerged as one of the finest components in beautification of towns and cities. It includes growing and utilisation of garden flowers, turf grass, bedding plants, potted plants, hedges, edges, water garden, rock garden etc. Landscape gardening has made appreciable growth in the last two decades as commercial venture. Floriculture has now become as an integral part of modern lifestyle and floral products are being utilised in floral decorations, floral craft, and beautifying commercial premises. At present, landscaping is in demand for public offices (e.g., government offices, hospitals, courts, private offices, corporate houses, cinemas, hotels), educational institutes (e. g., like university campus, research institutes, pvt. institutes, schools, colleges etc.), factories, places of historical importance, places of worship (e.g., temple, mosque, church). In addition, landscaping of highways, railway stations, railway lines, bus terminus, airports, etc., is also very important. Similarly, there is a great demand for landscaping of golf industry, lawns for cricket grounds and pitches etc.

Bonsai of banyan tree

6. Bonsai, a challenge for UPH

Bonsai is a Japanese art of growing huge trees in containers under controlled nutrition. Bonsai can be

an integral part of UPH in countries like India. In India, trees like banyan, peepal (*Ficus religiosa*), pilkhan (*Ficus infectoria*), maple, juniper are well suited to bonsai.

7. Window gardens, need of the hour

In window gardening, plants are grown in containers, which are attached to house or window. The best suited plants for window gardening are seasonal annuals, petunias, pansies and miniature roses.

8. Living walls, an important consideration in UH

Living walls are nothing but walls covered with living plants. They are also referred to as vertical gardens. Usually climbers are used for creating living walls.

9. Hanging baskets, an integral part of UH

Hanging baskets with training of cascading plants are suited for indoors as well as outdoors. Such baskets can be hanged at the entrance of the house or can be kept in the lawn or in a hall or can be suspended from trees, electric poles or fences. Plants like petunias, salvia, pansies and geranium are suitable for hanging baskets.

Annuals in hanging basket

Water management in UPH

We have always witnessed hue and cry for drinking water especially during summer in big towns and cities in India. People strive hard for getting drinking water. Hence, growing of horticultural crops in UPH with meager amount of irrigation water poses a great problem to the grower. Hence, growers are forced to use untreated waste water for irrigation. Another reason for using such type of water is that farmers find it cheaper than pumping ground water to irrigate crops. However, re-use of wastewater for irrigation is likely to be most prevalent in areas where water from other sources is scarce for part or all of the year. High content of nutrients in wastewater, particularly nitrogen and phosphorus, which can increase the productivity of farming provides another strong incentive for re-use of such water. However, it is strongly emphasized that due to scarcity of water, emphasis should be given on water harvesting, recycling and re-use of water in urban and peri-urban areas to grow different horticultural crops satisfactorily. Similarly, to prevent potential negative impacts on human health and the environment, the importance of waste water reuse in urban and peri-urban horticulture has to be recognised and clear cut policy guidelines for reuse of such water need to be established by the government.

Integration of post harvest processing industry with UPH

To make UPH a viable enterprise, we need to integrate the production system of UPH with processing and value addition because the demand for some of the processed fruits and vegetables products has increased significantly in our country, especially in urban and peri-urban localities. After having critical evaluation of such situations in urban and peri-urban areas, the buk production of horticultural commodities can be processed using drying, and developing fermented products, which plays an important role in horticultural crops. For example, in the recent years, some new products like juice punches, banana chips and fingers, mango nectar and fruit kernel derived cocoa substitute, fruit wines, dehydrated products from grape, pomegranate, mango, apricot and coconut, grape and fruit wines, value-added coconut products like snowball tender coconut, coconut milk powder and pouched tender coconut water (Cocojal) etc., have become quite popular in our country. Similarly, people in urban areas are now shifting towards the use of convenient foods, the demands for products like pre-packed salads, frozen vegetables, half processed vegetables, minimally processed vegetables etc., are increasing. Consumer friendly products like frozen green peas, ready-to-use salad mixes, vegetable sprouts, ready-to-cook fresh cut vegetables are now major retail items in metropol cities. Hence, producers can also think of using the valuable horticultural produce to convert it in to valuable processed product, which will definitely add value to the fresh produce.

Benefits of urban and peri-urban horticulture (UPH)

- UPH can contribute in increasing food and nutritional security.
- No problem of marketing of the produce as it can easily be sold in a local market even at higher rates.
- People having little or no land can adopt part-time farming of vegetables by use of hydroponics or substrate culture in beds, which provides food and income.
- UPH enhances the freshness of perishable fruits and vegetables reaching urban consumers, because crops are produced in close proximity to the consumers, which does not travel long distance.
- In urban horticulture, women can combine food production activity with child care and other household responsibilities.
- There is significant reduction in post harvest losses as the fresh produce is sold in the market immediately.

- UPH can provide raw material to processing factories immediately, which will reduce the transportation cost significantly.

Challenges in UPH

- Greater competition for natural resources like soil and water.
- There is a greater risk to health and environment due to inappropriate or excessive use of pesticides, nitrogen, phosphorus, raw organic matter containing undesireable residues such as heavy metals.
- Chances of microbial contamination of soil and drinking water are more, which may lead to cause several fatal diseases.
- Chances of air pollution are more in UPH due to production of carbon dioxide and methane from organic matter, ammonia, nitrous oxide and nitrogen oxide from nitrates.
- In some cases, odour nuisance is created in UPH.
- For the viability of UPH, availability of sufficient and good land is must, which will become a limiting factor due to increased urbanization.

ACTIVITIES/EXERCISES

1. Make a list of horticultural plants grown in a well maintained kitchen garden of your locality.
2. Visit a flower show and make a list of plants grown in hanging baskets, potted plants and flowering annuals.
3. Plan a visit to some big town or a city and observe some building where roof gardening is practiced. Make a list of plants grown in it.

CHECK YOUR PROGRESS

1. Define UPH. Enlist various components of UPH and describe briefly about bonsai, kitchen and roof gardening.
2. Describe briefly the benefits and challenges of UPH.

WRITE TRUE (T) AND FALSE (F) FOR THE FOLLOWING STATEMENTS

i. In UPH, extensive system of planting is followed.

ii. Availability of cultivable land and quality irrigation is not a limiting factor in UPH.

iii. In villages, UPH is a common practice.

iv. UPH helps to increase food and nutritional security.

v. UPH can help in increasing air and water pollution.

vi. On one side, consumption of fruits and vegetables is good for health, yet on another side fruits and vegetables produced in UPH may deteriorate it.

vii. Availability of sufficient and good land will become a limiting factor for UPH in the years to come.

SUGGESTED FURTHER READINGS

- Sumangla, H.P., Malhotra, S.K. and Chowdappa, P. (2013). Urban and peri-urban horticulture- a perspective. Confederation of Horticulture Associations of India, New Delhi.

Chapter - 5

WEEDS OF HORTICULTURAL CROPS AND THEIR MANAGEMENT

OBJECTIVES

After reading this chapter, students will be able to:

- Recall harmful effects of weeds
- Classify herbicides on the basis of their mode of action and life cycle
- Elaborate methods of weed control in horticultural crops

INTRODUCTION

When you visit any vegetable garden, fruit or vegetable or ornamental plants nursery or a fruit orchard, you might have observed that few plants are growing in such places other than main crop. Such odd plants can be found growing in between the interspaces of tress, on bunds or in a vegetable garden or a fruit plant nursery. These plants are of no economic importance to a grower because they compete for several amenities such as water, nutrition with main crop and may also harvour several insect-pest and pathogens, resulting in reduction in the yield of main crop. Such unwanted plants, growing out of place are called as *'weeds'*. In this chapter, you will read about weeds, their classification, herbicides used for control of weeds and several other methods of weed control in horticultural crops.

Points to remember

- Weeds are unwanted plants growing in a vegetable field, nursery or a fruit orchard.
- Weeds cause enormous losses to main crop by competing for water and nutrition.
- Weed can be controlled by different means but use of weedcides is the best possible method.

What is a Weed?

Any plant growing out of its proper place or where it is not wanted/ desired is called as a weed or weeds are the plants out of place in cultivated fields, lawns or orchards etc.

Disadvantages of weeds

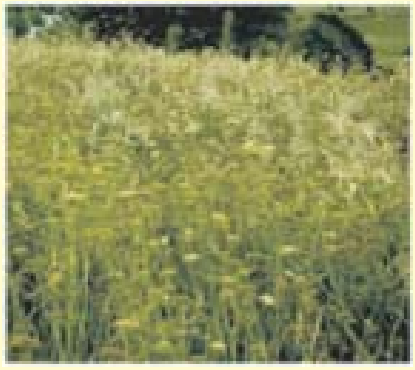
- Weeds reduce the economic yield by competing for water, nutrition, light, space and air with main crop.
- Weeds create difficulty while carrying out cultural practices like hoeing, irrigation and harvesting in the field.
- The weeds are very competitive in nature and are better adapted to the areas, where they grow. For example, dib grass *(Typha latifolia)* and motha *(Cyprus rotundus)* are capable of suppressing the growth of horticultural plants in early years of planting. Some climbers as weeds like chhibber *(Cucumis trigonus)* spread on the canopy of fruit plants and check the light penetration completely in the fruit plants. Most of the newly planted fruit plants get killed due to the over powering of Karari *(Convolvulus arvensis)* and chhibber *(Cucumis trigonus)* climbers.
- Some weeds due to their rhizomes in soil like baru grass *(Sorghum halepense)* and knots of motha *(Cyprus rotundus)* resist their eradication. Weeds like Itsit *(Trianthema portulacasirumi)* and chulai *(Amaranthus viridis)* have very high rate of seed production.
- Several weeds act as alternate hosts to many serious pests and diseases. They may harvour insects-pests and act as secondary hosts for spread of several diseases. For example, *Cynodon dactylon* (doob grass) and *Cyprus rotundus* (Motha) are alternate hosts of grass hopper. Similarly, 'wild senji' and 'maina' are hosts of aphids. *Parthenium hysterophorus* (congress grass) acts as alternate host for mealy bugs, which attack mango, guava, pear and many other horticultural plants.
- Some weeds are injurious to animal and human health. For example, Parthenium and Datura seeds are poisonous in nature and may cause allergy to human beings.

Classification of weeds

On the basis of life cycle, weeds can be grouped as annual, biennial and perennial.

A. Annual Weeds

Weeds, which complete their life cycle in one season and reproduce mainly through seeds. These can further be divided into two groups i.e., Kharif and Rabi weeds.



Wild carrot

(i) **Kharif Annuals :** These weeds generally emerge in monsoon, i.e., from June to October e.g., *Cyprus rotundus* (Motha/Deela) and *Trianthema postulacastrum* (Itsit).

(ii) **Rabi Annuals :** Rabi weeds start growing at the end of October and set seeds before summers (April-May). For example, *Chenopodium album* (Bathu), *Amaranthus viridis* (Chulai) and *Medicago denticulata* (Maina).

Sorghum helpense

Cyprus rotundus

Wild senji

Parthenium

B. Biennial Weeds

These weeds take two seasons to complete their life cycle. In the first season, vegetative growth is completed and in the second season, flowering and seeding take place. These weeds are found in abundant in the orchards. For example, *Daucus carota* (wild carrot) and *Launea nudicaulis* (wild cabbage) (Table 1 and 2).

C. Perennial Weeds

Such weeds grow for two or more years in orchards or on their boundries, paths and along roads sides. These weeds propagate through stolons, root cuttings, suckers, rhizomes or seeds. For example, *Sorghum helpense*, *Cyprus rotundus*, *Convolvulus arvensis* and *Parthenium hysterophorus* (Table 1 and 2).

Table 1. Important weeds of horticultural crops in India

Common name	*Botanical name*	*Common name*	*Botanical name*
Wild senji	*Melilotus parviflora*	Wild palak	*Rumex dentatus*
Maina	*Medicago denticulaia*	Chibber (climber)	*Cucumis irigonus*
Pitpapra	*Fumaria paroiflora*	Amarbel	*Cuscuta sp.*
Bathu	*Chenopodium album*	Gutputna	*Xanthium sirumarium*
Karund	*Chenopodium morale*	Kahi	*Saccharum spontaneum*

Common name	Botanical name	Common name	Botanical name
Karari	*Convolvulus aroensis*	Bhang	*Cannabis sativa*
Itsitl chupati	*Trianthema portulacastrum*	Khabbal grass	*Cynodon dactylon*
Dodhak	*Euphorbia hirta*	Baru grass·	*Sorghum halepense*
Chulai	*Amaranthus virdis*	Motha	*Cyperus rotundus*
Bhakhra	*Tribulus terristris*	Parthenium or	*Parthenium hyterophorus*
Puthkanda	*Achyranthus aspera*	Lantana	*Lantana camara*
Dib (Dab)	*Typha latijoiia*	Jangli gobhi	*Launea nudicaulis*
Bhoorni aonla.	*Phyllanthus niguri*	Jangli gajjar	*Daucus carota*
Kana	*Saccharum munja*	Khat yay	*Portulaca sp.*
Dhatoora	*Datura stramonium*	Peepal	*Ficus religiosa*
Tahli	*Dalbergia sissoo*	Toot	*Morus sp.*

Table 2: Some predominant weeds of fruit crops

Fruits	Monocot weeds	Dicot weeds
Mango	*Cynodon dactylon, Cyperus rotundus*	*Bidens pilosa, Tridax procumbens, Phyllanthus maderaspatensis*
Banana	*Cyperus rotundus, Cynodon dactylon, Digitaria marginata*	*Mimosa pudica*
Pineapple	*Cyperus rotundus, Cynodon dactylon, Digitaria marginata*	*Portulaca oleracea, Mollugo pentaphylla*
Grape	*Cyperus rotundus, Cynodon dactylon, Digitaria marginata, Eleusine indica, Setaria glauca*	*Oxalis corniculata, Polygonum sp., Euphorbia geniculata, Amaranthus viridis, Portuluca oleracea*
Papaya	*Cynodon dactyion, Chloris barbata, Digitaria marginata*	*Parthenium hysterophorus, Lagasca mollis, Euphorbia geniculata, Phyllanthus niruri*
Citrus	*Cynodon dactylon, Cyperus spp., Digitaria marginata, Eleusine indica, Setaria spp., Imperata cylindrica*	*Amaranthus caturus, Bidens pilosa, Lagasca mollis, Euphorbia spp.*

Fruits	*Monocot weeds*	*Dicot weeds*
Sapota	*Setaria glauca, Digitaria marginata, Androprogon spp*	*Bidens pilosa, Blumea spp., Oxalis corniculata*
Guava	*Cynodon dactylon, Cyperus rotundus*	*Bidens pilosa*
Litchi	*Cynodon dactylon, Cyperus spp.*	*Lagasca mollis, Ageratum spp.*
Apple	*Cynodon dactylon, Cyperus rotundus*	*Rosa rubignosa, Berberis sp., Oxalis latifolia, Elymus repens*
Strawberry, Raspberry, Blue berry	*Cyperus compressue, Digitaria ciliaris, Eleusine indica, Heteropogon contortus*	*Oxalis sp.*
Pomegranate, Custard Apple, Aonla,	*Aristida adscencionis L., Cymbpogon caesius, Commelina nudiflora*	*Argemone mexicana, Celosia argentea, Rosa moschata Ipomoea sp. Zizyphus sp, Mimosa pudica, Amaranthus caturus, Convolvulus arvensis, Parthenium hysterophorus*

Methods of Weed Control

Weeds of the horticultural crops can be controlled by by (i) Chemicals and (ii) Non-chemical methods. Non-chemical method includes (a) biological, (b) mechanical and (c) cultural techniques.

1. Preventive Methods

The best method is to prevent the entry of new weed and weed seeds in the cultivable area. While sowing seeds of annuals or any vegetables or while purchasing nursery plants, ensure that none of the planting material contains any seed or plant of any kind of weed. No weed plant should come along the earth balls of fruit plant sapling. It has been observed that new weeds come along with the seeds of vegetables, annuals or earth balls of fruit sapling at the time of planting. Similarly, weeds growing in the garden, nursery or in orchard should not be allowed to flower and set seeds. Do not use farm yard manure, which may contain weeds seeds. Clean the machinery/tractor while using it in an orchard so that weeds seeds do not enter in the orchard. Keep water channels, paths, roads and boundaries of beds clear of weeds. This will prevent the infestation of weeds in the nursery, gardens or orchards.

2. Eradication

Complete elimination of weeds plants, plant parts and seeds from the vicinity of a nursery, field or orchard and its vicinity, shall help in the eradication of weeds. However, it is not possible to eradicate all the weeds from any area. However, one may attempt/try and achieve some result in doing so.

3. Control

For weed control, some practices, such as, chemicals or non-chemical are used, which may reduce the weed population to the lowest level. The weed control method may comprise of physical, mechanical and chemical means.

In general, complete eradication of weeds is a difficult and costly proposition. To get weeds under control to a level, which does not adversely affect the health of fruit plants, a combination of methods may be adopted. Some of the measures are as follows:

A. Mechanical Methods

This involves hand pulling, hoeing, tillage, mowing and smothering of weeds with non-living mulches. This is a very effective method of weed control from nurseries, fields and orchards. No injury is caused to the foliage of main plants. Hand pulling involved uprooting of weed manually or hoeing with *khurpi* or spade. The basins of the tree can be covered with black polythene (plastic film) after hoeing, which will prevent photosynthesis in the sprouting weeds and check further growth and reproduction of weeds. Simultaneously, polythene film shall check the loss of moisture from plant basins and shall help in moisture conservation as well.

B. Biological Methods

Some insects as natural enemies, disease organisms, parasite plants and selective grazing by livestock come under this method of weed control. Insects and disease organisms have been the most successful natural enemies of weeds. The principles involved in selection of biotic agent are:

- Biotic agent should be host specific. The agent should not attack any plant species other than those for which it is released.
- Introduction and multiplication of bioagent should be easy.
- Bioagent should be easily available.

- Bioagent should be from an area that is climatically similar to the area where it is to be released.
- Bioagents should be of different feeding habits (plant parts) so that a weed is completely killed. This will also avoid competition between two more agent released for the same food/crop.
- Bioagent should not be host specific.
- It should be active against a wide range of weeds.

C. Chemical Methods

Only those chemicals are used for which the standing crop has a high degree of resistance or tolerance. Several types of chemicals may be used on the basis of their effect on weeds and crops as discussed below.

a. **Contact herbicides:** These chemicals kill the plant tissues with which they come into contact, but do not move in the plant to any extent. Such herbicides are either (a) selective or (b) non-selective. A selective herbicide kills certain weed species with little or no injury to other plant species. A nonselective weedicide kills all the weeds covered by spraying e.g., chlorates, dinitrophenol and pentachlorophenol.

b. **Translocated herbicides:** These herbicides are usually applied to the leaves or stem of the plant and sometimes to the roots. Such herbicides are absorbed by the plant and then distributed to all plant parts where they accumulate. These herbicides may either be selective (e.g., 2,4,D; 2,4,5-T; MCPA) or non- selective (e.g., sodium arsenate).

c. **Soil applied or residual herbicides:** Such herbicides when present in the soil check the growth of plants. These are applied to soil and are primarily effective against germinating seeds, seedlings. Examples of such herbicides are CIPC, TCA tec.

Time of application of herbicides

The time of application may largely determine the effectiveness of herbicides in various crops as under:

i. *Pre-planting :* Any herbicide treatment given before the crop is planted or sown is known as pre-planting treatment. Eptam is normally incorporated into the soil before sowing of crops.

ii. *Pre-emergence :* Any herbicide treatment made prior to emergence of a specific crop or weed is known as pre-emergence treatment. For example, simazine may be applied before the germination of the crop and weeds.

iii. *Post-emergence :* Any application of herbicide made after emergence of crop is known as post-emergence treatment.

Formulation and classification of herbicides

Most herbicides are usually commercial formulations that contain the herbicides and can be (i) dissolved, emulsified or suspended in a liquid carrier, or (ii) distributed dry by a spreader or by hand, and (iii) injected into soil for vaporization and fumigation. Herbicides belong to the following major groups:

A. Phenoxyacetic acids

2,4-D; 2,4, 5-T and MCPA are most important selective herbicides used to control broad-leaved weeds in horticultural crops. The toxic symptoms of this group are visible within a few hours of application as bending and twisting of shoots, dropping of leaves and yellowing. Phenoxy compounds are formulated as under:

a. *Amine salts :* Amine salts of 2,4-D are commonly used as liquids. These are highly soluble in water and have a power of penetration more than sodium salt but less than ester.

b. *Ester formulations :* These are also available as liquids, when properly formulated and mixed with water, esters from emulsion; these appear milky and are not clear. Ester formulations of 2, 4-D have a tremendous knock down effect if sprayed post-emergently.

c. *Phenoxypropionic acids :* The most important herbicide of this group is Silvex or Fenoprop 2-(2, 4, 5-tricplophenoxy) propionic acid, which is more effective than 2,4,5- T. It is used for the control of woody bushes and certain aquatic weeds of horticultural crops.

d. *Phenoxybutyric acids :* MCPB, 4-(2 methy-4-chlorophenoxy) butyric acid and 2, 4-DB, 4 (2, 4-dichloro-phenoxy) butyric acid belonging to this group have shown promise for the post-emergence control of broad-leaved weeds of horticultural crops.

e. *Phenoxyethyl (X)* : Sesone (2, 4, dichlorophenoxyethyl hydrogen sulphate) is formulated as the sodium salt and is a white crystalline powder that is soluble in water. When applied to moist soil, Sesone is converted into a herbicide with properties similar to 2, 4-D. It is effective as pre-emergence herbicide.

f. *Phenylacetic acids :* 2, 3, 6-TBA (2, 3, 6-trichlorobenzoic acid) and Amiben (3, amino-2, 5-dichlorobenzoic 'acid) are some examples of this group, which are used as pre-emergence application for control of deep rooted noxious perennial weed as Convolvulus in the field of tomatoes, and sweet potato. Its action is similar to 2, 4-D but it is much more persistent in the soil than phenoxyacetic acid.

g. *Sodium salts :* The sodium salt of 2, 4-D is only four per cent water soluble and hence is less likely to penetrate through either cuticle or stomatas of the plants.

h. *Halogenated aliphatic acids :* These are more toxic to grasses than broad leaved weeds. TCA (Trichloroacetic acid) and Dalapon (2, 2-dichloropropionic acid) are examples of this group, which are applied to the soil and the foliage depending upon their solubility in water. These are generally used in uncropped lands for the control of deep rooted weeds like *kans, baru* and *doob* in the orchards.

B. Amids

CDAA or Randox and and MH (maleic hydrazide) are important chemicals of this group.

Dalapon : This herbicide is similar to TCA in properties. It has proved less erratic and more effective than TCA when applied as a foliage-spray for the control of most of the annual grasses. It is much more effective on *doob, baru* and other perennial grasses.

Trichloroacetate : The sodium salt of TCA is widely used. It has shown varying degrees of effectiveness in controlling doob, baru and other annual and perennial grasses. Best results are obtained when it is applied in combination with tillage and cultural practices.

C. Substituted urea

Substituted ureas are listed below:

Cotoran : It is a selective herbicide with a long residual action, lasting over 2-5 months and specially recommended for the control of weeds in perennial plants.

Diuron : It has been used successfully in horticultural plants @ 0.5-5.0 kg/ha. It is also being effectively used as soil sterilant and is preferred over monuron in areas of high rainfall or on light sandy soils.

Fenuron : It is widely used as a soil treatment to kill woody plants.

Monuron : It is used both as soil sterilant and for selective annual weed control in resistant crops. For selective weed control purpose, the rate varies from 0.5-5:0 kg/ha as pre-emergence and as soil sterilent, the rate varies from 5-10 kg/ha.

Tenoron : It is a selective pre-emergence herbicide for the control of annual broad-leaved weeds, annual grasses under moist soil conditions. It is recommended for use in carrots, beans, peas, onion, garlic, tomatoes, chillies and fruit orchards of mango,citrus, apple etc.

D. Carbamates

These are effective through soil medium, are highly volatile and are therefore incorporated immediately after application. These are grouped as below:

CDEC : It has shown promise for the pre-emergence control of certain weeds in vegetable crops. It is more effective on grasses than on broad-leaved weeds.

Eptam: It has been successfully used as a pre-sowing herbicide for control of grassy weeds as they germinate.

Active chemical content in herbicides

The containers for all commercial herbicides have label expressing the amount of active chemical contained in the particular product either in percentage of active ingredient (a.i.) or acid equivalent (a.e.).

Calculation for herbicide doses

All recommendations of herbicide treatments are made on the basis of active ingredient (a.i.) or acid equivalent (a.e.). The following formula may be used to calculate the quantity of a commercial product required to give a specific dose of the active ingredient.

$$\text{Weight of commercial material required} = \frac{\text{Dose of a.i. required} \times 100}{\%\ \text{a.i. in commercial product}}$$

For example, if a herbicide with 50% active ingredient (a.i.) has to be applied @ of 1.0 kg a.i./ha then 1 x 100/50 = 2 kg of the commercial product will be required.

Precautions for safe use of herbicides

- Avoid spray drift of herbicides to other plants as it may cause injury.
- Sprayer used for herbicides should not be used for any other kind of spray on crop or ornamental plant.
- It is necessary to clean the sprayer with warm water every time after use.
- Do not store herbicides near seed, feed, fungicide, or insecticides.
- Spray should be done as per recommendations in respect to stage of crop and weed growth only.
- Avoid inhaling herbicides at any instance.
- Wash your hands thoroughly with soap and water.
- Put mask on your nose and cover your mouth with mask during spray.
- Keep the herbicides away from children and pets.

Weed Management in Horticultural Crops

Although, there is no clear cut recommendation for the use of herbicides on the basis of the response of horticultural plants because there is a long list of horticultural plants, their weeds and recommended herbicides. However, horticultural plants have been classed into six categories depending on their response to herbicides. Among the monocotyledonous plants there are three classes :

(i) **Annual crops** (e.g., Flowering annuals.): For control of weeds, use of chlorophenoxy, substituted ureas, triazines and benzoic is recommended. Although, it is very difficult to give some clear cut recommendation.

(ii) **Tree-like perennials** (palms, banana, bamboo): Herbicides like triazines, chlorophenoxys, paraquat may be used to kill the weed in these crops without harming them. Bamboos and palms coming under this group are susceptible to amitrole, aliphatic acids.

(iii) **Herbaceous perennial** (e,g., pineapple, asparagus, ornamental and edible bulbs). The herbicides, which can be used in these crops to kill the weeds without injuring the crops are chlorophenoxy, substituted ureas, triazines. The perennial grasses like Johnson grass, canary grass, Agropyron etc., are susceptible to amitrole, and chlorinated aliphatic acids.

Among the dicotyledonous plants again three classes have been suggested on the basis of their response to herbicides :

(i) *Herbaceous annuals* (tomatoes, potatoes, cucurbits, cole crops, bulbs etc.): The weeds in these crops can be controlled by using carbamates, phenols, substituted ureas etc. The weeds put under this category viz. pigweed, knotweed, nightshades, mustards, borages, mallows, fennel etc., are susceptible to chlorophenoxys, benzoic acids and picloram.

(ii) *Herbaceous perennials* (e.g., mint, alfalfa, and strawberries): Weeds of these crops can be controlled by using substituted ureas, triazines, carbamates, phenols. Weeds like bindweed, thistles (*Cirsium* sp.), knapweeds, perennial nightshades, lettuce are susceptible to chloropheroxys, benzoic acid, picloram. The weeds like gorse, poison-ivy, honeysuckle, blackberry, dogbane, brainbles are also susceptible to chlorophenoxys, picloram besides those listed earlier.

(iii) *Woody perennials* (e.g., fruit trees, forest trees, rubber, tea, coffee, fruiting and ornamental shrubs). Herbicides, which may be used with safety are triazines, substituted ureas, phenols, amitrole (avoid foliage).

Use 2, 4-D, simazine, diuron, amitrole, paraquat and dalapon for controlling weeds round plantation tree crop like rubber, tea, coffee, cocoa etc. The trees may be killed with 2, 4, 5-T or arsenic. For berries and grapes triazines, substituted ureas, and dinitrosas are safe herbicides for the control of weeds in their orchards. Plants are usually resistant when dormant or after fruit harvest be the best time for herbicide application for bushy fruits, which have shallow root system. Avoid the time when the plants are in bloom, fruit formation stage or in active vegetative growth. Chemicals should be used around the base of trees where cultivation is undesirable. Citrus trees are very susceptible to dalapon but resistant to diuron. Oils fortified with DNBP (4, 6-dinitro-O- butyl phenol) may be used in citrus orchard. Strawberries may be treated with sesone and simazine as pre-emergence treatments and with 2, 4-D as dormant sprays.

Perennial weeds in apple orchards can be controlled by growth regulators but the chemicals must not reach the tree foliage. Blossoming period should be avoided in this treatment. Dalapon can be effective against weeds in well established pear and apple orchards. It is not safe for plums and cherries. Low rates of simazine (1-3 kg/ha of active ingredient) may be used to control annual weeds in established plantings of bush and cane fruits through the summer to clean ground in the spring. Soil should be moist to have full effect of simazine but it must be kept off the fruit

plants as much as possible. Simazine is not harmful to maize and may be used to control all types of annual weeds in maize fields. Use of dalapon is done only when the trees are dormant. Glyphosate is useful against perennial weeds, and can be effectively used in citrus, and grape orchards. Currant bushes may tolerate 10 kg/ha, gooseberries and raspberries tolerate much less (only 1 kg/ha).

ACTIVITIES/EXERCISES

1. Visit a fruit plant nursery and make a list of odd plants (weeds) and find out the local names of the weeds.
2. Go to a horticulture department of an Agricultural university or an ICAR research institute, visit the fruit orchard and make a list of weeds, their names and control measures used for the control of weeds.
3. Go to a market and make a list of herbicides specially used for the control of weeds in horticultural crops.

CHECK YOUR PROGRES

1. What are weeds? Write disadvantages of weeds in horticultural crops.
2. Classify weeds on the basis of their life cycle.
3. What is a herbicide? Classify herbicides on the basis of their modes of action.
4. Write short note on weed management in horticultural crops by weedicides.
5. What care will you take while using bioagents for controlling weeds?

WRITE TRUE (T) OR FALSE (F) FOR THE FOLLOWING STATEMENTS

- All weeds grown in crops are harmful.
- Parthenium is also called as congress weed.
- 2,4-D is used for killing narrow-leaved weeds.
- Weedicides can be used during flowering period of the main crop.
- All recommendations of herbicide treatments are made on the basis of active ingredient (a.i.) only.
- *Cyprus rotundus* is the commonest weed of fruit orchards.
- Spray drifts of herbicides may cause injury to plant on which they fall.

SUGGESTED FURTHER READINGS

- Chadha, K.L. (2001). Text book of Horticulture. ICAR, New Delhi.
- Chadha, K.L. and Awasthi, R.P. (2005). Apple. Malhotra Publishing House, New Delhi.
- Chadha, T.R. (2000). Textbook of temperate fruits, ICAR, New Delhi.
- Bal, J.S. (2007). Fruit growing. Kalyani Publishers, Ludhiana, India.
- Sharma, R.R. (2006). Fruit production: Problems and solutions. Intl. Book Distributing Co., Lucknow, India.
- Sharma, K.K. and Singh, N.P. (2011). Soil and orchard management. Daya Publishing House, New Delhi.
- Sharma, R.R. (2009). Adhunik phalotpadan. Kalyani Publishers, Ludhiana, India.
- Singh, S.P. (2000). Commercial fruits. Kalyani Publishers, Ludhiana, India.
- Singh, A. (2000). Fruit physiology and production. Kalyani Publishers, Ludhiana, India.