BUILDING SKILLS • BUILDING FUTURE

Basic Horticulture-II

Student Handbook

(Class XII)

Central Board of Secondary Education
2, Community Centre, Preet Vihar, Delhi-110092

नया आगाज़

आज समय की माँग पर
आगाज़ नया इक होगा
निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।

परिवर्तन नियम जीवन का
नियम अब नया बनेगा
अब परिणामों के भय से
नहीं बालक कोई डरेगा

निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।

बदले शिक्षा का स्वरूप
नई खिले आशा की धूप
अब किसी कोमल-से मन पर
कोई बोझ न होगा

निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।
नई राह पर चलकर मंज़िल को हमें पाना है
इस नए प्रयास को हमने सफल बनाना है
बेहतर शिक्षा से बदले देश, ऐसे इसे अपनाए
शिक्षक, शिक्षा और शिक्षित
बस आगे बढते जाएँ
बस आगे बढते जाएँ
बस आगे बढते जाएँ.....

CBSE
CONTINUOUS AND COMPREHENSIVE EVALUATION
KNOW - AS YOU GROW

BASIC HORTICULTURE-II

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Basic Horticulture - II for Class XII

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PREFACE

Horticulture has now become as lifeline of a large population in the world. Even in India, we talk largely about horticulture. Horticulture consists of several branches but fruit cultivation (Pomology), vegetable cultivation (Olericulture) and flower cultivation (Floriculture) are the major branches of horticulture. We need fruits, vegetables and flowers in our daily life. It is a known fact that we are the 2nd largest producers of fruits and vegetables in the world. However, our productivity is dismally low than several other countries of the world primarily because horticulture sectors is encountered with several problems, and to tackle these problems, several technologies have been standardized by the scientists.

Considering the importance of horticulture, CBSE has introduced foundation course in horticulture entitled **'Basic Horticulture-II'** for class XII students with the following objectives:

- This is a basic course on horticulture, which will enlighten the students with the new areas in horticulture and development of skills in different areas of horticulture. Major topics covered in this course are business opportunities in horticulture, principles of preservation and processing, syrups and brines, urban horticulture, weeds of horticultural crops and their management, methods of propagation of horticultural crops and planting material for horticultural crops.
- After studying this course, students will get an idea about several opportunities, which horticulture can offer to them in their future life. Students can also think of joining this sector in their future life and can develop themselves as successful entrepreneurs in the area of horticulture.
- This course has been developed with the aim to sensitize the students about nursery raising, newer techniques of plant propagation, so that they can think of joining hands in nursery business or they can think of choosing horticulture as one of the subjects for their higher studies.
- This course has been designed to provide entry level job skills to the students, which will help to meet the human resource requirements in horticulture sector.

Vineet Joshi, IAS
Chairman, CBSE

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भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक [1]**[संपूर्ण प्रभुत्व-संपन्न, समाजवादी, पंथ-निरपेक्ष, लोकतंत्रात्मक गणराज्य]** बनाने के लिए तथा उसके समस्त नागरिकों को:

सामाजिक, आर्थिक और राजनैतिक **न्याय,**

विचार, अभिव्यक्ति, विश्वास, धर्म और उपासना की **स्वतंत्रता,**

प्रतिष्ठा और अवसर की **समता** प्राप्त कराने के लिए,

तथा उन **सबमें** व्यक्ति की गरिमा और [2]**[राष्ट्र की एकता और अखंडता सुनिश्चित]** करने वाली बंधुता बढ़ाने के लिए

दृढ़संकल्प होकर **अपनी इस संविधान सभा में** आज तारीख 26 नवंबर, 1949 ई. (मिति मार्गशीर्ष शुक्ला सप्तमी, संवत् दो हज़ार छह विक्रमी) को **एतद्द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।**

भारत का संविधान

भाग 4क

नागरिकों के मूल कर्तव्य

अनुच्छेद 51क

मूल कर्तव्य- भारत के प्रत्येक नागरिक का यह कर्तव्य होगा कि वह -

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वजों और राष्ट्रगान का आदर करे;

(ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;

(ग) भारत की संप्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण बनाए रखे;

(घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;

(ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हो, ऐसी प्रथाओं का त्याग करे जो महिलाओं के सम्मान के विरुद्ध हों;

(च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्व समझे और उसका परिरक्षण करे;

(छ) प्राकृतिक पर्यावरण की, जिसके अंतर्गत वन, झील, नदी और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;

(ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;

(झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;

(ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत प्रयास करे, जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई ऊँचाइयों को छू सके; और

(ट) यदि माता-पिता या संरक्षक है, छह वर्ष से चौदह वर्ष तक की आयु वाले अपने, यथास्थिति, बालक या प्रतिपाल्य को शिक्षा के अवसर प्रदान करे।

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1]**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens:

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the [2][unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS i CONSTITUTION.**

1. Subs. by the Constitution (Forty-Second Amendment) Act. 1976, sec.2, for "Sovereign Democratic Republic (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-Second Amendment) Act. 1976, sec.2, for 'unity of the Nation (w.e.f. 3.1.1977)

THE CONSTITUTION OF INDIA

Chapter IV

A Fundamental Duties

ARTICLE 51 A

Fundamental Duties. It SHALL be the duty of every citizen of India

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) To promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.

*(k) a parent or guardian to provide opportunities for education to his child or as the case may be ward between the age of six and fourteen years.

CONTENTS

Chapter - 1

BUSINESS OPPORTUNITIES IN HORTICULTURE

OBJECTIVES

After studying this unit, the students will be able to:

- Identify the different jobs and business opportunities in horticulture sector
- Identify the auxiliary industries based on horticultural production

INTRODUCTION

Dear students, in class XIth, you have read about the meaning of horticulture, its different branches such as Pomology, Olericulture and Floriculture and importance of these branches of horticulture. During this process, you might have come across the question in mind that what for we are reading this subject? Some of you might have thought of neglecting it and some might have thought to leave in between. Dear all, don't worry, it's not true. After reading this chapter, you will come to know that this subject has most valuable business opportunities. For example, you can go for higher studies to become a scientist or a teacher or you can start growing fruits, vegetables, can become consultant, business manager, can open consultancy services or can start business of fruit based processing industry as well. There is a lot of scope for a horticulturist than other subjects. Read this chapter and decide yourself !!!

The following areas related to horticulture can provide business opportunities:

Fruit cultivation: Cultivation of temperate, tropical and sub-tropical fruits is considered as one of the most lucrative enterprises. A horticulture graduate can start his/her own business of fruit growing as a fruit grower because he/she has gained sufficient scientific knowledge on fruit growing during his/her degree programme.

Points to remember

- The subject of horticulture deals with the propagation and production of fruits, vegetables and floricultural plants.
- It offers several business opportunities to the graduates in horticulture.
- It is you who has to grave the opportunity after sincerely studying the subject.

Although, experience is gained only with practice, a graduate should also have full knowledge about package of practices of the fruits to be grown. However, near cities or towns, one can go for the business of growing perishable fruits, and in far a way places, we can grow fruits as per demand of the area or climatic and soil conditions.

Vegetable cultivation: Cultivation of vegetable in peri-urban areas is a demanding area and offers good opportunities. However, one has to prioritize the vegetables in demand over those which are less in demand. Near big cities, exotic vegetables are in demand, hence their cultivation in peri-urban areas can be a good business.

Hybrid seed production in vegetables and flowers: Hybrid seeds of vegetables and flowers are very costly and are usually beyond the reach of a common farmer. It is because of the fact that hybrid seed is usually produced by big multinational companies. These companies are earning million and millions. Our horticulture graduates run for Govt. jobs rather than taking hybrid seed production as business. Our horticulture graduates can go for this as business. It is a little tricky business because we need to have technical knowledge on flowering, emasculation and pollination of crop, of which hybrid seed has to be produced. But, once, this knowledge is acquired, one can take up this as a challenge business.

Cut flower production: This business is flourishing in big cities and towns. Unfortunately, those who are involved in this business are non-horticulture persons, who do not know the basics of proper handling of cut flowers during transportation or display. However, horticulture graduates can take up this business without a second thought.

Fruit plant nursery as microenterprise: In India there are about 4000 Govt. and private nurseries of fruit plants. Still there is always paucity of quality planting material. Moreover, most of the nurserymen engaged in this business are illiterate or nearly so. Although, raising of fruit plants nursery looks quite easy but it requires technical skill for budding, grafting, transplanting or packing of planting material. Hence, fruit plant nursery can be a good business choice for horticulture graduates.

Vegetable and ornamental plants nursery: For fruit plant nursery, one require larger area, whereas for most of the flowering annuals and vegetables, little smaller area is required for nursery. Hence, raising and maintaining of vegetable or ornamental plants nursery can be a good option in such localities. In big cities and town, there is always a great demand for herbaceous perennials, shade loving plants, climbers etc.

Hence, such plants can also be grown along with fruit plants nursery, which can be a good business opportunity for horticulture graduates.

Hi-tech flower and vegetable nursery: Although, several vegetables and flowers are produced by following routine practices but due to rise in technical knowledge and purchasing power of consumers, there is always a demand for nursery plants raised through hi-tech procedures. At several places, such nurseries have come up. However, unfortunately such nurseries are, by and large, run by non-technical personnel rather than horticulture graduates. Thus, hi-tech flower and vegetable nursery can also be a goof business opportunity for horticulture graduates.

Raising plants through micropropagtion: In the modern era, there is a great demand for plants raised through tissue culture techniques. Now micropropagation protocols have been developed for several horticultural crops. Micropropagation is a technical job, which is highly suitable for horticulture graduates. However, before starting this type of business, you should look in to (i) for which fruit, vegetable or ornamental plant demand is (ii) what about marketing channels etc., before starting this business.

Horticulture-based processing industry: During the recent years, there has been significant increase in urbanization. In cities, significant amount of middle class families are living, which demand for processed products of fruits and vegetables such as fruit juices, squashes, jams, jellies, pickles, preserves etc. In our country, about 30-40% of horticultural produce is lost between harvesting and consumption due to improper handling of fruits and vegetables. This loss can be avoided or reduced significantly if fruits and vegetables are processed in to value added products. Horticulture graduates can contribute in this direction by establishing processing units. Although, it requires huge money initially but Ministry of Food Processing Industries, Govt. of India provides subsidy on it. The processing industries are labor intensive and offer high employment potential in collection centers, grading, packing, loading / unloading, storages (warehouses and cold storages), transport, marketing and processing units.

Dry flowers: In towns and cities, there is a great demand for dry flowers. In fact fresh flowers have very short life, so the concept of dry flowers has originated in towns and cities. Moreover, dry flowers can also be used for making file covers, greeting cards, paper weights etc. This industry is flourishing nowadays and horticulture graduates can grave the opportunity of flower drying as one of the businesses.

Business Sales Representative: Horticulture graduates can work/act as business sales representative for several chemicals, fertilizers, pesticides required for growing of horticultural crops. A business sales representative promotes, markets, and distributes fruit related products to retail or wholesale businesses and growers. Such personnel may work for companies, which manufacture or sell chemicals, fertilizers, equipments, or processed/value added products, as well as plant suppliers. However, the educational requirement varies from company-to-company.

Consultant: As horticulturist, one can act as consultant as well. After acquiring suffienct education and experience either on production technology or nursery raising, hybrid seed production technology, one can definitely choose consultancy as his/her business. They provide expert advice to businesses and fruit growers. They may be specialized in one area; e.g. nursery crops. Many are self-employed; others work for equipment companies, pesticide companies or private organizations such as Reliance Foundation. This may require a minimum of a four-year college degree and sometime Master's degree.

Marketing manager of horticultural produce: Marketing of horticulture produce is a major problem in our country. After acquiring sufficient knowledge in horticulture, you can opt the job of marketing of fresh horticultural produce.

Ayurvedic medicines: Several horticultural plants can be used for manufacturing ayurvedic medicines. For example, rose water is used to cure eyes ailments. Similarly saffron is imported ingredient of many medicines, papain is a digestive enzyme, citrus fruit like sweet lime is used for liver ailment, rind of pomegranate and pectin from guava used for stomach upset, bark of arjun trees for heart troubles, neem water for skin irritation and allergies etc. Thus, we also have opportunity to join this business for good survival in the society.

Business of essential oils, flavours and fragrances: Floral extracts like essential oils, alkaloids, pigments, dyes etc., have tremendous demand in both domestic and international markets. In order to produce the highest quality extracts, highly sophisticated extraction methods and qualified personnel are required, for which horticulture graduate can be the best choice.

Lecturer/Assistant Professor/Training Associate: After acquiring P.G. degree, you have the option to join some State Agricultural Universities and College or ICAR Institute as a lecturer, assistant professor or scientist, respectively. They are recruited by State Agricultural Universities and Colleges. For this, a minimum of Master's degree in Horticulture with National Eligibility Test (NET) or Doctoral degree in Horticulture, is required. Indian Council of Agricultural Research, New Delhi recruits scientists for

its research institutes in the field of horticulture through all India competitive test followed by an interview.

Government development departments: A horticulture graduate has full chance to get a state Govt. job as Horticulture Inspector or Hort. Development Officer. The duty of such officers is to take part in all state development programmes related to horticulture. In some states (e.g., Punjab, Himachal Pradesh), this post has been classified as class-1 status.

Ancillary services: For raising, fruits, vegetables or ornamentals or their nurseries several types of fertilizers, tools, insecticides, fungicides, irrigation equipments, chemicals, growth regulators etc. are required. Thus, a horticulture graduate can also start a business for offering such services to the growers or nurserymen.

ACTIVITIES/EXERCISES

- Visit an orchard with school friends or a family member. Make a list of articles/materials and package of practices required for profitable cultivation of fruits, vegetables or flowers.
- Go to a market. Make a list of business opportunities in which yourself fit.

CHECK YOUR PROGRESS

1. What are various business opportunities related to fruits?
2. Describe several business opportunities which are related to vegetables or ornamentals.

SUGGESTED FURTHER READINGS

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Chapter - 2

PRINCIPLES OF PRESERVATION AND VALUE ADDITION OF HORTICULTURAL PRODUCE

OBJECTIVES

After studying this chapter, students will be able to:

- Understand about the importance of processing of horticultural produce
- Know the basic principles involved in preservation and processing of horticultural produce
- Explain the different value added products, which can be made from horticultural produce
- Develop entrepreneurship for processing unit based on raw material obtained from horticultural produce

INTRODUCTION

Whenever you go to any market, you find several products such as jam, jelly, squashes, pickles, *murabbah*, candy and several other such products. I hope that most of students might have enjoyed these products at your homes. Most of us use to purchase these products from shops, however, mothers & sisters of some students might have made some of these products at home. Have you ever thought of their raw material from which these are prepared? How these products keep well for long periods? What processes are involved in their preservation? I hope you might have never thought of it. All such products are prepared through processing, preserved for long time by using several techniques, which are based on certain principles. In this chapter, you will come to know about processing, several principles involved in preservation of fruits and vegetables and different value added products, which can be made from horticultural produce.

HISTORY OF FOOD PROCESSING

Food processing dates back to the prehistoric age when crude processing including various types of cooking, such as over fire, smoking, steaming, fermenting, sun drying and preserving with salt were in practice. Foods preserved this way was a common part of warriors' and sailors' diets. These crude processing techniques remained essentially the same until the advent of the Industrial Revolution. Nicolas Appert developed a vacuum bottling process to supply food to troops in the French army, which eventually led to canning in tins by Peter Durand in 1810. Modern food processing technologies, in the 19th century were also largely developed to serve military needs. In the early 20th century, the space race, change in food habits and the quality consciousness of the consumers in the developed world further added to the development of food processing with advancements such as spray drying, juice concentrates, freeze drying and the introduction of artificial sweeteners, colourants, and preservatives. In the late 20th century, products including dried instant soups, reconstituted fruit juices, and self cooking meals such as ready-to-eat food rations etc., were developed.

IMPORTANCE, SCOPE AND BENEFITS OF PROCESSING OF HORTICULTURAL CROPS

Horticulture sector primarily includes fruits, vegetables, and floricultural crops. Due to lack of adequate post harvest handling, processing and infrastructure facilities, post harvest losses caused by spoilage are very high. It is estimated that post harvest losses of horticultural produce range between 30-35 per cent. Generally losses occur during pre-harvesting, harvesting, transportation, storage, processing, packing, marketing and distribution stages. Even if 10 per cent of these losses could be saved by converting the surplus into processed products, there will be considerable saving to the horticultural wealth in the country. The international trade in preserved horticultural crops consists largely of fruit juices, nectars, juice concentrates, canned pineapple, canned pulps, canned and dehydrated vegetables, instant chutneys and ready-to-use products. Tropical vegetables, fruits, spices and aromatic plants grown in India having nutritional and appetizing appeal have great export potential to the rest of the world because of their medicinal, therapeutic and antioxidant properties as health foods. There is further scope for augmenting exports with respect to tropical fruit juices, pulps and concentrates. Products obtained from fruits like mango, guava, papaya, pineapple and large number of other highly nutritive indigenous fruits, vegetables as well as from floral and medicinal crops have great demand for domestic and export market.

Benefits of Processing

- By processing, raw food and other farm produce is converted into edible, usable and palatable form.
- Processed products can be stored for a longer time.
- There is a significant reduction in post harvest losses.
- Produce is available even during off-season.
- Processing helps to generate employment for rural youth.
- Helps in improving palatability and organoleptic quality of the produce by value addition.
- Helps in easing marketing and distribution tasks.
- Increases seasonal availability of many foods.
- Enables transportation of delicate perishable foods across long distances.
- Makes foods safe for consumption by checking of pathogenic microorganisms.
- Food processing can also bring nutritional and food security.
- Food processing has great potential for export and thereby to fetch foreign exchange.

Importance of processing

The main causes of spoilage of horticultural produce are microbiological (bacteria, yeasts, moulds), chemical (enzymatic discolouration, rancidity, oxidation) and physical (bruising) factors. There are many reasons for processing foods besides the development of a business with a good return on investment for the owners such as to prevent post harvest losses, to eliminate waste, to preserve quality, to preserve the nutritive value of the raw materials, to make seasonal horticultural produce available throughout the year, to put them in convenient form for the user, to safely put the food away for emergencies and to develop new products and to increase the value of the product.

A view of bottling in a fruit processing plant

Food preservation, in the broad sense, refers to all the measures taken against any kind of spoilage in food. It is the process of treating and handling food in such a way so as to stop or greatly slow down spoilage to prevent foodborne diseases while maintaining nutritional value, texture and organoleptic quality as well as increasing shelf life. Proper packaging and storage of processed/preserved products are also important aspects of agro-processing to retain quality of fresh horticultural produce which could be adversely affected by physical damage, chemical reactions, microbiological changes and attack by insects and rodents.

Principles of Preservation

The following principles are involved in preservation of fruit and vegetables

1. Prevention or delay of microbial decomposition

- By keeping out microorganisms (asepsis)
- By removal of microorganisms, e.g., filtration
- By hindering the growth and activity of microorganisms, e.g. by low temperature, drying, anaerobic conditions or use of chemicals
- By killing the microorganisms, e.g., use of heat or radiation

2. Prevention or delay of self-decomposition of the food

- By destruction or inactivation of food enzymes e.g. blanching
- By prevention or delay of purely chemical reactions e.g. prevention of oxidation by means of an antioxidant

3. Prevention of damage caused by insects, rodents, mechanical damage etc.

(I) Physical Approaches to Food Preservation

- Removal of microorganisms, e.g., asepsis and filtration
- Raising the temperature of food, e.g., heating (blanching, pasteurization/ sterilization, flash pasteurization/HTST (high temperature & short time processing)
- Controlled reduction of product temperature, e.g., chilling and freezing
- Controlled reduction in the water content of food products, e.g., dehydration, freeze drying, osmotic dehydration

- Use of protective packaging such as prepackaging and use of modified atmosphere packaging

- Use of radiations such as ionizing radiations

a) Asepsis and filtration: Asepsis means preventing the entry of microorganisms. Maintaining of general cleanliness while harvesting, grading, packing and transportation of horticultural produce increases their keeping quality. Washing and wiping of the fruits and vegetables before processing should be strictly followed to reduce the soil particles, pesticide residues and initial contamination by microorganisms. Filtration of liquid foods through 0.45micron seitz filters helps to remove microorganisms and thus minimizes the chances of spoilage.

b) Thermal Processing: Since many of the processes utilized to preserve food products depend on the addition of thermal energy, it is important to understand its underlying principles. The design of a thermal process to achieve food preservation involves two principles: (a) the use of elevated temperatures to increase the rate of reduction in the microbial population present in the raw food material (Microbial population may refer to the number of vegetative cells existing in food product or to the number of microbial spores in a given mass of food) and (b) the transfer of thermal energy into the food products as required for achieving the desired elevated temperatures.

Points to remember

Blanching is done at about 100°C, pasteurization below 100°C and sterilization above 100°C. Blanching is primarily done to inactivate enzymes, pasteurization to kill maximum harmful microbes, and sterilization for complete killing of microorganisms

Thermal processing used for preservation is usually classified as follows:

i) Blanching : Blanching is a heat treatment given to a fruit or vegetable either in boiling water or microwave above 100°C. Blanching is used to destroy enzyme activity in fruits and vegetables, prior to processing. Blanching helps in several ways as it inactivates enzymes, which prevents undesirable changes in sensory characteristics and nutritional properties that take place during storage, reduces the number of contaminating microorganisms on the surface of foods, leads to softening of vegetable tissues thus facilitating can filling and helps in removal of air from intercellular spaces.

ii) Pasteurization: Pasteurization is a process of heat treatment used to inactivate enzymes and to kill relatively heat sensitive pathogenic microorganisms that

cause spoilage. It is a mild heat treatment, usually performed below 100°C. Pasteurization kills only harmful microorganisms. In practice, therefore, most of the canned foods produced locally in developing countries such as canned peas tomatoes, canned pineapple slices etc. are heated within the package. There are two categories of pasteurization process:

a) Low temperature long time (LTLT): 62.7°C for 30 minutes

b) High temperature short time (HTST): 71.7°C for 15 seconds

iii) **Sterilization:** In this process, food is heated at a sufficiently high temperature (121°C) and for long time (10-15 minutes) to destroy microbial and enzyme activity. As a result, sterilized foods have a shelf life of more than six months. Higher temperature for a short time (140°C/3-4 seconds) is possible if the product is sterilized before it is filled into pre-sterilized containers in a sterile atmosphere. This forms the basis of Ultra High Temperature (UHT) processing (also termed aseptic processing). It is used to sterilize a wide range of liquid foods (fruit juices and concentrates, wine, etc.) and foods that contain small discrete particles (tomato products, fruit and vegetable soups).

Advantages of thermal processing

- Food becomes more tender and pliable with the desired cooked flavour and taste.
- Preservative effect on foods owing to destruction of microorganisms, enzymes, insects and parasites.
- Significant destruction of antinutritional components in food.
- Improvement in bioavailability of some nutrients (for example improved digestibility of proteins and gelatinization of starches etc.).
- Relatively simple control of processing conditions.

c) **Drying/Dehydration:** Preservation of foods by drying is perhaps the oldest method known to us. The weight of the product by drying is reduced to the extent of 1/4th to 1/9th of its original fresh weight. Drying of foods and biological products is a widely applied process for different purposes such as increasing shelf life, reducing packaging costs, making food available during off-season, and maintaining nutritional value. Drying or dehydration of fruits and vegetables can be accomplished with little capital while maintaining high quality and obtaining less perishable food products.

Drying Techniques: Several types of dryers and drying methods, each better suited for a particular situation are commercially used to remove moisture from a wide variety of food products including fruits and vegetables. There are different types of drying processes are as follows:

- Solar drying
- Atmospheric drying including batch (mechanical/cabinet drying) and continuous (fluidized bed, spray and drum drying)
- Osmotic dehydration
- Sub-atmospheric dehydration (freeze drying)

II) Chemical Preservation

- Use of chemical additives such as sugars, salt, acids, spices etc.

a) High sugar preservation: In the food preservation with sugar, the water activity cannot be reduced below 0.70. This value is sufficient for bacteria, yeasts and molds inhibition but does not prevent osmophilic yeasts and xerophillic molds attack. For this reason, various means are used to avoid mould development such as finished product pasteurization (jams, jellies, etc.) and use of chemical preservatives.

b) Use of salt/acid/spices (Pickling): Pickle is an edible product preserved and flavoured in a solution of common salt and/or vinegar. The preservation of fruits and vegetables in common salt and/or in vinegar is called pickling. Spices and edible oils may be added to the product. Raw mango, lime, turnip, cabbage, cauliflower etc., are preserved in the form of pickles, which have become popular in several countries. Apart from having nutritional and therapeutic value, they have appetizing appeal.

c) Use of chemical additives: The Food and Drug Administration (FDA) has defined food additive as a substance or a mixture of substances, other than the basic foodstuff, which is present as a result of any aspect of production, processing, storage or packaging. It comprises of preservatives, antioxidants and many others. According to FDA, 'chemical preservative is any substance which is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food or masking any of the evidence of any such process or of neutralizing the acid generated by any such process but does not include salt, sugars, vinegar, spices or oils extracted from spices'. Chemical food preservatives are added in very

small quantities (up to 0.2 per cent) and they do not alter the organoleptic and physico-chemical properties of the foods. Preservation of food products containing chemical food preservatives is usually based on the combined or synergistic activity of several additives, intrinsic product parameters (e.g. composition, acidity, water activity) and extrinsic factors (e.g. processing temperature, storage atmosphere and temperature). This approach minimizes undesirable changes in product properties and reduces concentration of additives and extent of processing treatments. Chemical food preservatives are applied to foods as direct additives during processing, or develop by themselves during processes such as in fermentation. Certain preservatives have been used either intentionally or accidentally for centuries, which include sodium chloride (common salt), sugar, acids, alcohols and components of smoke. In addition to preservation, these compounds contribute to the quality and identity of the products.

III) Biological Preservation (Fermentation)

- Fermentation technology involving alcoholic or acidic fermentations using selected desirable microorganisms

The various preservation methods discussed so far are based on the application of heat, removal of water, freezing etc. All these methods have the common objective of reducing the number of living microorganisms in foods or at least holding them in check against further multiplication. Fermentation processes for preservation purposes, in contrast, encourage the multiplication of lactic acid forming bacteria and their metabolic activities in foods. But the organisms that are encouraged are from a selected group and their metabolic activities and end products are highly desirable.

IV) Combined Method of Preservation (Hurdle Technology)

- A judicious combination of more than one method mentioned above for synergistic preservation is called hurdle technology.

The trend of using a wide range of mild preservation techniques has emerged to be known as combined preservation or barrier (Hurdle) technology. Hurdle in food is defined as the substance or the processing step or various preservation factors, inhibiting the growth of various microorganisms resulting in the death of microorganisms. It advocates the deliberate combination of existing and novel preservation techniques in order to establish a series of preservative factors (hurdles) that any microorganisms present should not be able to overcome. It requires a certain amount of effort from a microorganism to overcome each hurdle. Higher the

hurdle, greater the effect. Several tropical and sub-tropical fruits and vegetables like carrot, capsicum and coconut are processed by hurdle technique by slight reduction of water activity (a_w 0.92-0.95), lowering of pH (below 4.5) and mild heat treatment (in-pack pasteurization at 85^0C) or treatment with antimicrobial additives with a view to control microbial growth, packed in flexible polymeric pouches and are evaluated for their shelf stability under ambient conditions.

Value Added Products from Horticultural Crops

1. Fruits and Vegetables

i) **Jam, Jelly, Marmalade and Preserve:** Preparation of jam, jelly and marmalade is based on concentrating fruits to nearly 70 per cent solids (TSS) by addition of sugar and heat treatment. The high osmotic pressure of sugar creates unfavourable conditions for the growth and reproduction of most species of microorganisms i.e. yeasts, molds and bacteria, responsible for the spoilage of food. At this concentration of solids, the water activity is reduced (a_w of 0.60-0.75), which ultimately decreases the chances for microbial spoilage.

Jam is prepared by boiling the fruit pulp with sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold fruit tissues in position. It should contain not less than 68.5 per cent soluble solids as determined by a refractometer. Jam may be made from a single fruit (apple, strawberry, banana, pineapple etc.) or from a combination of two or more fruits. The preparation of jam requires several unit operations viz., selection of fruit, preparation of fruit, addition of sugar, addition of acid, mixing, cooking, filling, closing, cooling and storage.

Mixed fruit jam

Jelly is a semi-solid product prepared by boiling a clear, strained solution of pectin containing fruit extract with sufficient quantity of sugar and measured quantity of acid. A perfect jelly should be transparent, well set, but not too stiff and should have the original flavour of the fruit. It should be firm enough to retain a sharp edge but should be tender enough to resist the applied pressure. It should not be gummy, sticky or syrupy or have crystallized sugar. Different fruits like guava, plum, papaya, gooseberry etc. are used for jelly preparation. Low pectin fruits such as apricot,


Amla murabbah

pineapple, raspberry etc. can be used only after adding small amount of pectin powder. The essential substances for manufacture of jelly are pectin, water, acid and sugar. Formation of jelly takes place when the concentrations of water-sugar-acid-pectin mixture attain a certain minimum value.

Marmalade is a fruit jelly in which slices of the citrus fruit or its peels are suspended. Marmalades are generally made from citrus fruits like oranges and lemons in which shredded peels are suspended.

Preserves (*Murabbas*) are prepared from whole fruits and vegetables or their segments by addition of sugar followed by evaporation to a point where microbial spoilage can't occur. The final soluble solids concentration reaches to about 70 per cent. The finished product can be stored without hermetic sealing and refrigeration.

ii) **Chutneys and Sauces:** Chutney is a mixture of fruit or vegetable with spices, salt and/or sugar, vinegar etc. A good chutney is smooth, palatable and appetizing, and has the true single flavour of the fruit or the vegetable used for its preparation. Most popular chutneys are those from tomato, mango, *aonla* etc. On the other hand, a good **sauce** has a continuous flow with no peel, seeds and stalks of fruits and/or vegetables. It possesses pleasant taste and aroma. Sauces are sieved and as a result, are thinner and have smooth consistency than chutneys. Sauces can be prepared from tomato, papaya etc. Vinegar, salt, sugar and spices are the common preservatives, used for the preservation of these products. The chemical preservatives, such as sodium benzoate and potassium metabisulphite are used for long-term storage, wihich helps in retarding the growth of microorganisms without interfering with other physico-chemical and sensory characteristics of the product. Some factors taken into consideration for the selection of a chemical to be used as a preservative include type of organism to be controlled, pH of the product, length and conditions of product storage and physical and chemical characteristics of the food.

Fruit juices prepared from different fruits

iii) **Fruit Juices/Beverages**: Fruit juices are preserved in different forms such as pure juices and beverages. **Fruit beverages** can be classified into two groups:

a) **Unfermented beverages**: Fruit juices that do not undergo alcoholic fermentation are termed as unfermented beverages. They include natural and sweetened juices, ready-to-serve beverage, nectar, cordial, squash, crush, syrup, fruit juice concentrate and fruit juice powder. These beverages can be distinguished on the basis of the differences in total soluble solids (TSS) content and minimum juice percentage as given in (Table 1).

Table 1: Fruit Product Order (FPO) specifications for fruit beverages

Product	Minimum % of total soluble solids (TSS) in final product (w/w)	Minimum % of fruit juice in final product (w/w)
Unsweetened juice	Natural	100
Fruit syrup	65	25
Crush	55	25
Squash	40	25
Fruit nectar (excluding orange and pineapple nectars)	15	20
Orange and pineapple nectars	15	40
Cordial	30	25
Sweetened juice	10	85
Ready-to-serve (RTS)	10	10
Fruit juice concentrate	32	100
Synthetic syrup/sherbet	65	-

b) **Fermented beverages**: Fruit juices, which have undergone alcoholic fermentation by yeast and lactic acid fermentation by bacteria. They include wine, champagne, port, sherry, cider and *kanji*.

Methods of preservation of fruit juices/beverages

A. **Pasteurization**: Preservation by heat is the most common method of fruit juice preservation. It may be done in three ways:

a) **Holding pasteurization:** After filling of the juice in bottles, the bottles are pasteurized at 85°C for 25-30 min. This is usually done at home scale.

b) **Over-flow method:** In this case, juice is heated at a temperature of about 2.5°C higher than the pasteurization temperature and filled into hot sterilized bottles upto the brim. The sealed bottles are then pasteurized at a temperature of 2.5°C lower than the filling and sealing temperature. It thus minimizes the adverse effect of air on quality of the juice.

c) **Flash pasteurization:** In this method, fruit juice is heated for a short time at a temperature higher than the pasteurization temperature and held at that temperature for about a minute and filled into the containers, which are sealed airtight.

B. **Carbonation***:* It is the process of incorporating carbon dioxide in a beverage to impart a characteristic taste. Apart from the distinctive taste, carbon dioxide also inhibits the growth of certain undesirable microorganisms.

C. **Chemical Preservation:** For preserving juices chemically, the addition of 700 ppm potassium metabisulphite or 720 ppm of sodium benzoate (for coloured products) is employed. Chemically preserved juices are bottled leaving a head space of 1.5 to 2.5 cm followed by crown corking/sealing.

iv) **Fermented products:** Fermentation of fruits and vegetables can be classified into three types:

(i) **Alcoholic fermentation-** which has already been discussed under fermented beverages earlier

(ii) **Lactic fermentation** – which involves fermentation of carbohydrates into lactic acid to prepare fermented pickles such as sauerkraut, gherkins, fermented olives etc.

(iii) **Acetic fermentation** – It involves alcoholic fermentation followed by acetic acid fermentation for the manufacture of vinegar, which is used as a condiment. Vinegar contains about 4 per cent of acetic acid in water and can be prepared from a number of fruits such as grapes, apple, oranges etc.

v) **Pickles :** The process of preservation of food in common salt or in vinegar is called pickling. Spices and edible oil may also be added to the product. Pickles may be sour, sweet or mixed and can be prepared easily from different fruits and vegetables at home. They can be grouped as unfermented pickles and fermented pickles. Fermented pickles undergo lactic acid fermentation as discussed

Mixed pickle

earlier. On the other hand, in unfermented pickles, the raw material is preserved by use of various spices and oil. Most popular unfermented pickles are mango, lime and mixed pickles.

vi) **Dried products:** Fruits or vegetables may be dried mechanically or under the sun for increasing their shelf life and for further use. Grapes are dried and converted into raisins, which are very popular high-energy foods. Also dehydrated powders of various citrus fruits are available for reconstitution into a refreshing beverage. Onions and ginger are sold in dehydrated form for use in various curried food preparations.

Amchur : a dried mango product

Floricultural Crops

i) **Dry flowers and pot pourri:** Dry flowers are becoming more popular due to their longer indoor life and non-perishability. The two easiest and least expensive methods to dry flowers are sand drying and air-drying. Another product, pot pourri is a mixture of dried, sweet scented plant parts including flowers, leaves, seeds, stems and roots. These are rich in aromatic oils, which are not confined to the flower only. These are used in naturo-therapy for common ailments (aromatherapy). Fixatives such as salt, gum benzoin etc., are added to make the scent to last longer.

Dried flowers

ii) **Essential oils, flavours and fragrances:** Floral extracts like essential oils, alkaloids, pigments, dyes etc., have tremendous demand in both domestic and international markets. In order to produce the highest quality extracts, highly sophisticated extraction methods such as those based on high pressure extraction and super critical fluid extraction are used. Such methods produce very high purity flavour and spice extracts, fragrant chemicals as well as pharmaceutical substances. Compressed gases like CO_2, combine the advantages of both gas and liquid solvents. They have the density of

Essential oils made from flowers

a liquid but diffuse as a gas and therefore, function like a solvent. This enables the extraction of sensitive raw materials at gentle temperatures. The resulting extracts are further purified by fractionation and separation procedures.

iii) **Pharmaceutical and neutraceutical products:** Plants produce pharmacologically valuable compounds, which are used in medicine and as dietary supplements. Such compounds include pigments, oils and alkaloids.

iv) **Pigments and natural dyes :** The anthocyanins, flavanols, carotenoids and xanthophylls are common plant pigments that are responsible for a variety of hues we normally observe. These valuable pigments can be isolated and used for varied applications including pharmaceuticals.

v) *Gulkand,* **rose water, vanilla products etc.:** *Gulkand* is prepared by mixing rose petals and sugar in the ratio of 1:2 followed by mashing and drying the mixture in sun. It is a laxative and used for flavouring and sweetening pan. It is good for memory, eyesight and blood purification. Rose water is prepared by boiling the rose flowers in water and condensing the steam. It is used as *sherbet*, eye lotion and eye drops.

vi) **Insecticidal and nematicidal compounds:** Natural plant products (secondary metabolites) are insecticides and nematicides. They act as fly and mosquito repellents, kill insects and may be toxic to bees, aphids, caterpillars etc.

ACTIVITIES/EXERCISES

1. Plan a visit to a food processing industry of your area. Note down the products, which are made there. Make a list of raw material used for their manufacturing. Also note down the method of preservation being used.
2. Visit a shop that deals with processed products of fruits and vegetables. Make a list of products. Note down their chemical composition.
3. Attempt to make some products such as tomato ketchup, fruit jam or vegetables pickle at home. Take help of you mother or sister if they know the preparation of any such products.
4. Purchase some samples of jam and jelly and try to differentiate them.

CHECK YOUR PROGRESS

1. What is thermal processing? Describe different methods of thermal processing.

2. Describe briefly different methods of preservation of fruit juices and beverages.

3. Enlist the value added products that can be made from fruits.

4. Breifly discuss about the principles involved in preservation of fruits and vegetables.

FILL IN THE BLANKS

- Jam is cloudy while jelly is .....
- Sterilization of food can be achieved after exposing the food to about ..... degree centigrade temperature.
- Blanching is done to inactivate .....
- *Gulkand* is processed product obtained from.....
- Jam contains .....sugars.
- The process of food preservation in salt or vinegar is called as .....
- RTS should have a minimum of .....fruit pulp.
- In drying/dehydration, the weight of the product is reduced to .....of original weight.
- For preparing carbonated drinks, ... gas is used.
- .....is called as father of canning.

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Chapter - 3

SYRUPS, BRINES AND FOOD COLOURS

OBJECTIVES

After studying this chapter, you will be able to:

- Know how to make different syrups for preservation of fruits
- Diffirentiate between brine & syrup
- Define brining and describe the mehtods of brining
- Know about preservatives, their classification and uses in preservation of fruits, vegetables and flowers
- Classify preservatives
- Elaborate the role of food colours, their classification and uses

INTRODUCTION

In the previous chapter, you have studied about some value added products of fruits, vegetables and flowers. You have also read about some methods of preservation. In this chapter, you will get acquainted with syruping and brining, commonly used practices in preservation of some fruits and vegetables. In addition, we will also discuss about preservatives & their use in preservation of fruit and vegetables products and flowers. Similarly, discussion will also be held on food colours, their uses and limitations. Let us first understand what is syrup or brine and what are their uses in fruit and vegetable industry.

Syrup

A solution of sugar in water is called a syrup and process of adding syrup in fruit product is called as syruping. White, refined sucrose is used for making syrup. Usually, sucrose syrup is used in canning. Syrup is added to improve the

Syruping is commonly done in fruits and brining in vegetables. The objective of syruping and brining is to improve the flavor of product and to serve as a medium of heat transfer during canning. Cane sugar or sucrose is used for making syrup while common salt is used for making a brine solution.

flavour and to serve as a heat transfer medium for facilitating processing. Syruping is done only for fruits.

Strained, hot syrup of concentration 20 to 55° Brix is poured on the fruit. Fruits rich in acid require more concentrated syrup than less acid fruits. The syrup should be filled at about 79 to 82°C, leaving a head space of 0.3 to 0.5 cm. Sometimes citric acid and ascorbic acid are also mixed with the syrup to improve flavour and nutritional value of the product, respectively.

The quantities of sugar to be dissolved in one litre of water to make syrups of different concentrations are given in the table below:

Sugar (kg)	Syrup concentration (%)
0.250	20
0.333	25
0.428	30
0.538	35
0.666	40
0.818	45
1.000	50
1.222	55

Syrups of various strength can be'made by dissolving 1 kg of sugar in different volumes of water as shown shown hereunder:

Syrup strength	Water (litre)
Light	2.0
Medium	1.5
Heavy	1.0

Brining

Brine is a solution of salt in water is called a brine. The objective of brining is similar to syruping, however brining is done only in vegetables. Good quality common salt is used for making brine of different concentrations. However, in general hot brine of 1-3 % concentration is used for vegetables filled at 79-82ºC. Brines of different concentrations can be prepared by dissolving known quantity of salt in one litre of water as under:

Salt (g)	Brine concentration (%)	Salt (g)	Brine concentration (%)
10.0	1	47.33	5
20.4	2	111.11	10
30.92	3	176.47	15
41.66	4		

Use of preservatives

In several food products, chemical preservatives are used to enhance their life and attractiveness. Any substance which is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food or masking is called a preservative. However, salt, sugars, vinegar, spices or oils extracted from spices are not called as chemical preservatives. Chemical food preservatives are added in very small quantities (up to 0.2 per cent) and they do not alter the organoleptic and physico-chemical properties of the foods. Certain preservatives are used either intentionally or accidentally for centuries, which include sodium chloride (common salt), sugar, acids, and alcohols. In addition to preservation, these compounds contribute to the quality and identity of the products.

Preservatives for fruits and vegetable products

Several preservatives are used for keeping fruits, vegetables or flowers in good conditions for longer time. In general, chemical food preservatives can be classified as Class I and Class II preservatives. Class I preservatives include common salt, sugar, dextrose, spices, vinegar and honey. They are mainly natural products, which are used, in comparatively higher concentrations than Class II preservatives. On the other hand, Class II preservatives are synthetic chemicals used in small quantities. Benzoic acid and its salts, sulphur dioxide and salts of sulphurous acid, nitrites and nitrates, sorbic acid and its salts, propionic acid and its salts, lactic acid and its salts are commonly used and are called as class II preservative.

Mode of action of food additives involves alteration of cell wall permeability, alteration of colloidal nature of protoplasm, damage of the cell wall, damage of proteins, inhibition of enzyme activity, disruption of cytoplasmic membrane, bacteriostatic or bactericidal action (toxicity of the antimicrobial agent towards microorganisms) and interference with synthetic processes.

Sulphur dioxide (as potassium metabisulphite) and its derivatives can be considered as "universal" preservative. They have an antiseptic action on bacteria as well as on yeasts and moulds.

The advantages of using sulphur dioxide are : (a) it has a better preserving action than sodium benzoate against bacterial fermentation, (b) it helps to retain the colour of the beverage for a longer time than sodium benzoate, (c) being a gas, it helps in preserving the surface layer of juices also, (d) being highly soluble in juices and squashes, it ensures better mixing and hence their preservation, and (e) any excess of sulphur dioxide present in the food them can be removed either by heating the juice to about 71°C or by passing air through it or by subjecting the juice to vacuum.

A bottle of potassium metabisulphite (KMS)


Sodium benzoate granules

The major limitations of sulphur dioxide are : (a) it cannot be used in the case of some naturally coloured juices like those of *phalsa*, *jamun*, pomegranate, strawberry, coloured grapes, plurn, etc., on account of its bleaching action, (b) it cannot also be used for juices, which are to be packed in tin containers, because it not only corrodes the tin causing pinholes, but also forms hydrogen sulphide, which has a disagreeable smell and reacts with the iron of the tin container to form a black compound, both of which are highly undesirable, and (c) sulphur dioxide gives a slight taste and odour to freshly prepared beverages but these are not serious defects if the beverage is diluted before drinking.

Benzoic acid (as sodium benzoate) and its derivatives have a preservative action, which is stronger against bacteria than on yeasts and moulds. Sorbic acid acts on moulds and certain yeast species, which in higher dosage levels, also acts on bacteria. Formic acid is more effective against yeasts and moulds and less on bacteria.

The preservative should never be added in solid form but should be dissolved in a small quantity of juice or water, and the solution added to the bulk of the product. If this care is not taken, the solid may settle undissolved at the bottom of the container with the result that fermentation may start before the action of preservative begins.

Floral preservatives

In the above paragraphs, we discussed preservatives used for fruits and vegetables products. These preservatives are not used for extending the vase life of flowers. For this, different set of preservatives have been recommended. Although several preservatives have been recommended but sucrose solution, 8-HQC (8-hydroxyquinoline citrate), silver nitrate, aluminium sulphate, cobalt chloride, physan, HQS (8-hydroxyquinoline sulphate), STS (silver thiosulphate), copper nitrate etc., are widely used. These preservatives are used either alone or in combination with other preservative. The concentration of these preservative also varies from crop-to-crop.

FOOD COLOURS

When we go to market for purchasing any fresh fruit or vegetable or their processed products, the first thing, which attracts us, is the colour of commodity. After this, we look for varieties of a fruit or vegetable. Similarly, when we cook food in our kitchen, we add several items to make it attractive and tasty. Sometimes artificial colour is also added (e.g. turmeric powder is added in every cooked vegetable in India) during the processing of fruits and vegetables. Colours are of two types: natural colouring matters and synthetic colours

A. Natural colouring matters

The natural colours (pigments) in fruits and vegetables have been classified as carotenoids (yellow-orange), chlorophylls (green), flavonoids and anthocyanins (red, blue, purple) and anthosanthins (cream-yellow). In plant based foods, the following pigments are present either singly or in combination.

Candy with different colours

a. **Chlorophylls:** These are green coloured, fat soluble pigments, responsible for photosynthesis in plants. Most abundant in leafy vegetables. They are related to porphyrins, an important group of biological pigments which includes haemoglobin. There is always some deterioration of chlorophylls on storage, whatever the processing method is used.

b. **Carotenoids:** Carotenoids are fat-soluble, orange-yellow pigments that are present in many vegetables and fruits such as carrot, pumpkin, mango and orange. The first carotenoid isolated was from carrot and, therefore, was named carotene. The most widely distributed carotenoids are lutein, violaxanthin, and neoxanthin, which are found in green leaves. Lycopene

in tomato, capsanthin in red pepper and bixin in annatto are some predominant pigments found in vegetables. Carotenoids are extracted from annatto, saffron, paprika, tomato, etc., and are used as natural food colourants.

c. **Anthocyanins :** These are the red, blue and purple water-soluble compounds occurring in the cell sap of some fruits and vegetables, e.g., coloured grapes, red cabbage, chery, apple and in most flowers. At low pH, the colour of anthocyanins is an intense red, which changes to orange and red to blue or purple as the pH value rises. Sulphite or sulphur dioxide rapidly bleaches the colour of anthocyanins. Sugars influence the stability of anthocyanins.

Natural colorant from black carrot

d. **Flavonoids :** These are very widely distributed in the plant kingdom. They are water-soluble, polyphenolic substances, similar in structure to anthocyanins, which also occur as glycosides, and include the sub-groups of flavones, flavonols, flavanones, and chalcones. Flavonoids may be the sole pigments in vegetables such as potato, cauliflower and yellow-skinned onion. Flavones and anthoxanthins are responsible for the yellow-white or creamy white colour of potato and cauliflower. Flavanones occur mainly in citrus plants and can be used as synthetic sweeteners. Flavonoids are usually more stable to heat and oxidation than the anthocyanins.

Natural colorant from yellow capsicum

e. **Tannins:** These are colourless or yellow substances, which turn brown when fruits and vegetables containing them (e.g., brinjal, bottle gourd, apple) are cut and exposed to air. Thus, tannins are responsible for enzymatic browning and also for the astringency of foods. Tannins are a complex mixture of polymeric polyphenolics also known as tannic acid or gallotannic acid, and derivatives of flavones. They are divided into two major groups: (i) condensed tannins, e.g., catechins and related compounds, and (ii) hydrolyzable tannins, e.g., gallic acid (gallotannins) and ellagic acid (ellagitannins).

f. **Quinones and Xanthones :** A large number of pigments found in the cell sap of flowering plants, fungi, bacteria and algae are derivatives of anthraquinone, naphthoquinone and benzoquinone and range in colour from pale yellow to almost black. Anthraquinone derivatives are the largest group of such pigments, followed by those of naphthoquinone and benzoquinone. Xanthones are a group of yellow pigments. One well-known member is mangiferin, which occurs as a glucoside in mangoes.

g. **Betalains:** Betalains are a group of red and yellow pigments found in red beet (*Beta vulgaris*) and, to some extent, in cactus fruits, pokeberries and a number of flowers (Bougainvillea). They resemble the anthocyanins and flavonoids in structure but unlike them, contain nitrogen. Betalains are stable in the pH range 4-6 but are degraded by thermal processing as in canning. Colour in the food may not always come from plant and animal pigments. It could be due to browning reactions that may be enzymatic or nonenzymatic.

A number of naturally occurring substances are used for colouring foods. According to the Fruit Products Order, India (1955), the following natural colouring matters are permitted to be added to any food.

- Cochineal or carmine
- Carotene and carotenoids
- Chlorophyll
- Lactoflavin
- Caramel
- Annatto
- Ratanjot
- Saffron
- Curcumin

Dehydrated beet powder, carrot oil and juices of fruits (e.g., strawberries and cherries), which impart a pink colour to ice-crearn are also approved as natural colour additives.

B. Synthetic colours

Only pigments from natural sources were available and used for colouring food till

the coming of the first coal tar dye in 1857. Thereafter, a large number of dyes were synthesized and some were used as food colourants. However, gradually restrictions have been placed on their use as food additives in many countries. In India, no coal tar dyes or a mixture thereof, except the following are permitted to be used in food (F.P.O., 1955).

Colour	Common name	Colour	Common name
Red	Ponceau 4R, Carmoisine Fast Red, Amaranth & Erythrosine	Blue	Indigo Carmine, Brilliant Blue FCF
Yellow	Tartrazine, Sunset Yellow FCF	Green	Fast Green S, Green FCF

How to use food colour?

Colours are generally available in the form of powders or ready-to-use solutions. The powder should first be made into a paste with a little cold water and the requisite quantity of almost boiling water added to the paste with constant stirring. The solution is allowed to stand till cool and any sediment formed is removed by filtration. To prevent sedimentation, glycerine is usually added to the solution to increase its density. About 10 per cent glycerine is sufficient for this purpose. Isopropyl alcohol also helps in increasing the solubility of the powder.

Although colours make the food attractive, it is better to avoid their use as far as possible and educate the consumer to use products not containing colourants. Colours can often be used to cover defects in the natural products.

ACTIVITIES/EXERCISES

1. Plan a visit to a food processing industry of your area. Note down the products which are made there. Note down the colour and whether it is of natural or synthetic origin.
2. Go to a shop, which deals with preserves or pickles. Note down the concentration of syrup in preserve and of brine in pickle if used.
3. Take help of your mother or sister for preparation of syrups and brines at your home. Preserve locally grown vegetable or fruits in these solutions.

CHECK YOUR PROGRESS

1. What is syrup and brine? How can you prepare syrups and brines of different concentration?

2. What is the importance of colour in fruit and vegetable industry? Enlist different colours used in food industry.

3. What is preservative?. Classify them. What are major advantages of using SO_2 as preservative in fruit or vegetable products?

FILL IN THE BLANKS

- Syrup is prepared by dissolving known quantity of ……. in known quantity of water.
- Brine is prepared by dissolving known quantity of ……. in known quantity of water.
- Anthocyanins are ……soluble pigments.
- Red colour of tomato is due to …….
- Chemical food preservatives are added in very small quantities i.e., up to ……per cent.
- Betalains are a group of red and yellow pigments found in ……
- The most widely distributed carotenoids are…..…… and …… which are found in green leaves.
- Class I preservatives include ……. , ……. and ……etc.
- ……. and ……. are examples of Class II preservatives.
- Sulphur dioxide cannot be used in juice of …… and …….on account of bleaching action on colour.

FURTHER SUGGESTED READINGS

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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.

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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

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Chapter - 6

METHODS OF PROPAGATION OF HORTICULTURAL CROPS

OBJECTIVES

After reading this chapter, the students will be able to:

- Enlist the advantages and disadvantages of sexual and asexual methods of propagation
- Explain the principles involved in sexual and asexual methods of propagation
- Demonstrate vegetative propagation methods used in the nursery
- Plan a business based on propogation & nursery management of horticultaral plants

INTRODUCTION

Propagation i.e. multiplication is the law of nature. Every ones, which comes in this universe produces individual of its own kind. Like animals, plants also multiply of their own by one or the other methods. However, man has developed several techniques of multiplication of plants for his own benefits. For propagation of plants, several principles are involved. In this chapter, attempts have been made to tell you about the principles of seed (sexual) and vegetative (asexual) methods of propagation. In addition, light will also be thrown on micropropagation.

Propagation of Fruit Plants

Propagation is an art and science of multiplication of plants. The fruit plants are propagated both by sexual and asexual methods. Most of the fruit plants are now propagated through grafting and budding, few through cuttings, layering, seeds and micropropagation. The propagation methods are broadly classified as sexual, asexual and micropropagation. The details of methods are presented below:

A. Sexual Propagation

Sexual propagation is the raising of plants by means of seed, which is formed by the fusion of male and female gametes within the ovule of a flower. Plants that

are produced from seeds are called seedlings. In ancient times when the asexual methods of plant propagation were not known this was the only commercial method for plant propagation. Papaya, phalsa and mangosteen are still being propagated by seed.

Advantages of sexual propagation

- Seedling trees are generally long-lived, bear more heavily and are comparatively more hardy.
- This is the only means of reproduction, where asexual propagation is not possible or economical, e.g., papaya, *phalsa*, mangosteen etc.
- To develop new varieties, hybrids are first raised from seeds and it is essential to employ this method in such cases.
- It has been responsible for the production of chance seedlings of superior attributes.
- Polyembryonic character exists in many fruit plants such as in some citrus species and some mango varieties and give rise to more than one seedling from one seed. The nucellar seedlings are true-to-type. Therefore, polyembryomic varieties can be propagated by seeds.
- Rootstocks upon which the fruit varieties are budded or grafted are mostly raised from seeds.
- Seedlings are cheaper and easy to raise.
- Seeds can be easily transported to distant places.
- Does not require high technical knowledge and skilled labour.

Limitations of sexual propagation

- Seedling trees are not uniform in their growth, yielding capacity and fruit quality.
- Seedling trees have long juvenile period and take more years to bear the first crop.
- Seedlings become large for economic management.
- It is not possible to maintain the exact character of any superior selection.
- Seed propagation can't be applied in many plants (e.g. banana).

- It is not possible to avail the modifying influence of rootstock on scion or scion on rootstock.
- Since seed-borne viruses exist in a number of fruit plants and the multiplication of such plants by seed is not recommended.

B. Asexual Propagation

Propagation of plants through any vegetative parts is called vegetative or asexual propagation. The goal of vegetative propagation is to reproduce progeny plants identical in genotypes to a single source plant.

Advantages of asexual propagation

- Vegetatively propagated fruit plants are true-to-type, uniform in growth, yielding capacity and fruit quality.
- Vegetatively propagated fruit plants come into bearing earlier.
- Uniformity in fruit quality makes harvesting and marketing easy.
- Modifying influence of rootstock on scion can be profitably availed off.
- It is possible to regulate the tree size, fruit quality, precocity etc., according to one's requirements by using different rootstocks.
- Cross pollination can be effected by grafting shoots of other suitable varieties (pollinizers) on some of the branches of self-unfruitful variety.
- Grafting can be used to encourage healing of tree wounds caused by rodents, implements, etc.
- Composite tree can be raised.
- One can correct (to some extent) the initial mistakes of planting inferior or unsuitable varieties.
- Fruit plants producing seedless fruits such as banana can only be multiplied through vegetative means.

Limitations of asexual propagation

- No new variety can be evolved by means of the vegetative method of propagation.
- It is more expensive than raising new plants through seeds.
- Vegetatively propagated plants are comparatively short-lived.

Propagation by Seed

In fruit plants, the propagation by seed is primarily done to raise rootstocks required for producing grafted or budded plants. However, some fruit plants (papaya) are conventionally propagated by seeds. Propagation through seeds requires a knowledge of several principles as described hereunder:

Dormancy : The dormancy in seeds may be due to hard seed coat, impermeability to water and gases, physiological immaturity of embryo, deficiency of some endogenous growth promoters or excess of endogenous growth inhibitors. Different methods like stratification, scarification and chemical treatment are used for breaking dormancy in seed to improve germination. Stratification consists of keeping seeds at low temperature (around $7^{o}C$) by placing them in alternate layers of moist sand. While, in scarification, the seeds are either treated with concentrated acid (acid scarification) or the seed coat is weakened mechanically, so as to make it permeable to water and gasses. In other instances, seeds can be pre-treated with some chemicals like thiourea or potassium nitrate to improve seed germination. Soaking seeds in water also overcome seed dormancy, if it is primarily due to endogenous growth inhibitors, which leaches due to prolonged soaking of seeds.

Germination : Germination refers to the emergence of a new plant from the mature seed. In other words, the activation of metabolic machinery of the embryo leading to the emergence of a new seedling plant is known as 'germination'. For the germination to be initiated, the seed must be viable, that is, the embryo must be alive and capable of germination and the environmental conditions must be appropriate. Seed germination involves different phases of germination. These phases are characterized by a rapid increase in water uptake during the imbibition phase followed by a period where there is little water uptake called the lag phase. During the third phase, there is increase in fresh weight of seed, which leads to the emergence of roots.

Apomixis : This is a natural mechanism during which vegetative embryo is produced instead of sexual or zygotic embryo. In other words, the apomixis occurs when an embryo is produced from a single cell of the saprophyte and does not develop from fertilization of two gametes. The seedlings produced are thus true-to-type and vigorous as compared to those produced through sexual means. Some species or individuals produce only apomictic embryos and are know as 'obligate apomicts', While other produces both apomictic and zygotic embryos are known as 'facultative apomicts', which occur in citrus.

Polyembryony : Polyembryony, as the name indicates, refers to the seeds having more than one embryo in the seed. One of the embryos arises from the union of

male and female gametes and is called gametic or sexual embryo, whereas the others are produced by simple mitotic division of cells of nucellus without the help of male gamete in their formation. The phenomenon of nucellar embryo is of common occurrence in citrus and mango.

In general, the nucellar seedlings are identified or in other words the zygotic seedlings are rouged out of nursery in step-by-step approach. In this method, the majority of the seedlings, which fall within one vigour group and are more or less of the same size, are considered to be nucellar. Others, which are either too small or too tall than the commonly prevailing type are discarded and considered to be off type or zygotic. To eliminate gametic seedlings, first rouging should be done when they are about 10 to 20 cm tall and ready for transplanting in the nursery. The second rouging should be done at time of budding, while third and final rouging should be done at time of selecting budded plants for transplanting in the field.

Vegetative Propagation

The propagation of plants by the method other than sexual propagation is referred as vegetative or asexual propagation. It involves no change in genetic makeup of the new plant. All the characteristics of the parent plant are reproduced in the daughter plant due to exact duplication of chromosomes during cell division. Thus, the plants are true-to type in growth, yield, ripening, and fruit quality.

Methods of vegetative propagation

There are different methods, which can be used for commercial multiplication of various fruit plants. These include cutting, layering, budding and grafting.

Cuttings

It is the method of propagating fruit plants in which the part of a plant (generally stem) having at least few buds, when detached from parent plant and placed under favourable conditions develop into a complete plant resembling in all characteristics to the parent from which it was taken. This method is commonly used in plants, which root easily and readily, thus, multiplication of plants is very quick and cheap. The fruit plants like phalsa, baramasi lemon and grapes are commercially propagated by cuttings.

Hardwood cuttings

The hardwood cuttings are the common method of propagation, which are prepared from fully mature tissues. Round cuttings are preferred over angular and immature

cuttings. The shoots of about one-year-old or more can easily be used for preparing hardwood cuttings. In case of decidous fruit plants such as grape, pomegranate, *phalsa* and fig, the cuttings are made after pruning. While in evergreen fruit plants like baramasi lemon, the cuttings can be prepared during the spring (February - March) and rainy season (August-September). Generally, the cuttings of 15-20 cm length and having 3-5 buds are made. The lower cut is given in a slanting manner just below the bud to increase the absorption of nutrients. The upper cut is given at a right angle to reduce the size of the wound and as far as possible away from the upper bud to avoid its drying. After the cuttings are prepared, they should be allowed to dry. These cuttings are usually tied in small bundles (20-25 cuttings) and buried in moist soil/sand for a certain period for healing of wounds, which is known as callusing.

Layering

Layering is a method of vegetative propagation, in which roots are induced on the shoots while they are still attached to the mother plants. This is a alternate method of propagation in fruit plants which do not root easily when detached from the mother plants. Most commonly used methods of layering are air layering, ground and mound layering.

Air layering

1. Air layering : As name refers, in this method the layering is done in air. To be more precise, the rooting is forced on the shoot itself when it is still attached to the mother plant. In this method, one-year old, healthy and straight shoot is selected and ring of bark measuring about 2.5 cm just below a bud is removed. Moist sphagnum moss is placed around this portion and is wrapped with a polythene strip. It should be light in weight, and should have a very high water holding capacity. If sphagnum moss is not available, any other material, which can retain moisture for long period, can be used for this purpose. The polythene covering does not allow the moisture to come out but permit gas exchange. Moreover, the layers need not be watered afterwards, which saves a considerable labour. This method of layering is also known as 'goottee' method.

Rooting in apple stool plant

Air layering can be practiced during February-March and July-August in guava, litchi, sapota, lemon, loquat etc. After few weeks, the roots are developed, which are visible through the polythene covering. Then a half way cut should be given to the rooted layers on the parent branch at least 15 days

prior to their permanent removal from the mother plant. At the time of separation, a few leaves or small shoot is retained. It is also advisable to plant these rooted layers in nursery for close attention than to plant them directly in field. These layers can be planted in the fields during the following year in February-March or September-October.

Stooling in guava

2. Ground layering : In this method, a branch of plant, which is near the ground, is chosen and a ring of bark about 2.5 cm is diameter is removed just below the bud. This branch is then bended and buried in soil when still attached to the mother plant. The soil is regularly watered to keep it moist. Within a few weeks, the roots are formed and new plant is separated from the mother plant. Separation should be done in such a way that the roots formed also go with the detached plant. These new plants should preferably be planted in pots or nursery rows for development of better root system and shoot system before planting in the fields. This method is commonly followed for propagation of baramasi lemon.

3. Mound layering : In this method, plant is headed back either in February or in July. The new shoots come out during April and September, from ground level. A ring of bark is removed from these shoots and they are covered with moist soil. The rooted stools of April stooling are separated during rainy season and those of August are removed in the following spring. These stools, after separating from the parent plant are planted in the nursery fields. This method is also known as stool layering and is used for propagation of guava and apple rootstocks.

Budding

Budding is a method in which only one bud is inserted in the rootstock. This method is very easy and fast. This method saves budwood as compared to grafting. As soon as the bark starts slipping both on the stock and scion, this is considered to be the optimum time for budding. This shows that the cambium, which is the tissue responsible for union, is active. This method is generally employed during spring and rainy season. The common methods of budding are T-budding, patch budding, and chip budding.

1. T-Budding : This is also known as shield budding. A horizontal cut about 1/3rd the distance around the stock is given on the stock 15-20cm above then ground level. Another vertical cut, 2-3 cm in length is made down from the middle of the horizontal

T budding in citrus

cut and flaps of the bark are loosened with ivory end of the budding knife to receive the bud. After the 'T' out has been made in the stock, the bud is removed from the budstick. To remove the shield of bark containing the bud, a slicing cut is started at a point on the bud- stick about 1.25 cm below the bud, continuing underneath about 2.5 cm above the bud. A second horizontal cut is then made 1.25 to 2 cm above the bud, thus permitting the removal of the shield piece. The shield is removed along with a very thin slice of wood. The shield is then pushed under the two raised flaps of bark until its upper horizontal cut matches the same cut on the stock. The shield should fix properly in place, well covered by the two flaps of bark, but the bud itself exposed. The bud union should be wrapped with polythene strip to hold the two components firmly together until the union is completed. 'T' budding can be performed at any time of the year provided cell sap flows freely.

In most fruit trees, it is performed either in the spring (March-April) or in rainy season (July-September) period. This is the most common method of propagation of citrus, *ber*, *aonla* plants.

2. Patch Budding : This type of budding is quite successful in guava and it gives 60 to70 percent success during May and June. Freshly cut angular bud-wood from current season's growth should be used as scion. A rectangular or square patch or piece of bark about 1.0-1.5 cm broad and 2.5 cm long is removed from the rootstock at about 15 to 20 cm from ground level. A similar patch with a bud on it, is removed from the bud-stick taking care not to split the bark beneath the bud. This patch is then transferred to rootstock and fixed smoothly at its new position and tied immediately with polythene strip. To have better success, a patch having two buds is used as scion instead of a single bud. This method is termed as improved patch budding method.

Points to remember

- Plants which shed their leaves in winter are easily propagated through hardwood cutting.
- Budding should always be performed when plants have active sap flow.
- Air layering (goottee) is highly successful if relative humidity is high.
- Epicotyl method of propagation is followed for mango in Konkan region of India where relative humidity is very high during monsoon season.
- Sideveneer method of propagation is most successful for mango in wihch scion-sticks are forced to rest about a week

3. Chip Budding : This method is usually employed when the stock and scion are still dormant, that is just before the start of new growth. In this method, one about 2.5 cm long slanting cut is given into the stock followed by another cut at lower end of this first cut, in such a way that a chip of bark is removed from the stock. The bud from the scion wood is removed in the same way so that it matches the cuts given in the rootstock. This chip with a bud on it is fitted smoothly into the cut made in the rootstock taking care that the cambium layers of the stock and scion unite at least on one side. The bud is then tied and wrapped with polythene strip, to prevent drying up of the bud.

Grafting

Grafting is another method of vegetative propagation, where two plant parts are joined together in such a manner that they unite and continue their growth as one plant. In this method, the scion twig has more than two buds on it. Grafting is commonly done in pear, peach, plum, almond, mango etc. In temperate fruits like peach, plum and almond, grafting is done when the plants are dormant while, in mango, it is done when the trees are in active growth. The different methods of grafting are tongue grafting, cleft grafting, approach grafting, side grafting and veneer grafting.

1. Tongue Grafting : This method is commonly used when the stock and scion are of equal diameter. First, a long, smooth, slanting cut of about 4 to 5 cm long is made on the rootstock. Another downward cut is given starting approximately 1/3rd from the top and about 2 centimeter in length. Similar cuts are made in the scion wood exactly matching the cut given in the rootstock. The scion having 2 to 3 buds is then tightly fitted with the rootstock taking care that the cambium layer of at least one side of the stock and scion unites together. This is then wrapped tightly with polythene strip.

Approach grafting in mango

2. Cleft grafting : This is also known as wedge grafting. This method is useful in the nursery where the rootstock is quite thicker than scion and tongue grafting cannot be employed successfully. The stock up to 8 cm in thickness can be grafted with this method. The rootstock to be grafted is cut smoothly with a secateur or saw. It is then split in the middle down to about 4 cm. The budstick having 3 to 4 buds is trimmed like a wedge at the lower end with outer side slightly broader than the inner side. The lower bud on the scion should be located just well in to the stock

making sure that the cambium layers of both the stock and scion are perfectly matched. Cleft grafting is done during dormant period.

3. Approach Grafting : This method of grafting is termed as approach grafting, as the rootstock is approached to the scion, while it is still attached to the mother plant. Alternatively, the mother plants are trained to be low headed and the stock is sown under their canopy. Last week of July or the first week of August is the best period for approach grafting. In this method, the diameter of rootstock and scion should be approximately the same. A slice of bark along with a thin piece of wood about 4 cm long is removed from matching portions of both the stock and the scion. They are then brought together making sure that their cambium layers make contact at least on one side. These grafts are then tied firmly with a polythene strip or any other tying material. The stock and scion plants are watered regularly to hasten the union. The union is complete in about 2 to 3 months. The method is commonly followed in mango. This method is also called inarching.


Side grafting in mango

4. Side Grafting : A three sided rectangular cut about 4 x 1.25 cm is made on the rootstock at a height of about 15-20 cm from the ground level and the bark of the demarcated portion is lifted away from the rootstock. A matching cut is also made on the base of the scion to expose cambium. The scion should be prepared well before the actual grafting is done. The healthy scion shoots from the last mature flush are selected for this purpose. The selected scion shoots should have plump terminal buds. After the selection of the scion shoots, remove the leaf blades, leaving petioles intact. In about 7 to 10 days the petioles shall drop and terminal buds become swollen. At this stage the scion stick should be detached from the mother tree and grafted on the stock. The prepared scion is inserted under the bark flap of the rootstock so that the exposed cambia of the two components are in close contact with each other. The bark flap of the rootstock is resorted in its position. The graft union is then tied firmly with polythene strip.

After the completion of the grafting operation, a part of the top of rootstock is removed to encourage growth of the scion. When the scion has sprouted and its leaves turned green, the root stock portion above the graft union should be cut away. Side grafting can be carried out successfully from March to October; but success during the May and October is rather low. This method of propagation is commonly used in mango.

5. Veneer Grafting : In this method, a shallow downward cut of about 4 cm long is given on the rootstock at a height of about 15-20 cm from the ground level. At the base of this cut, a second short downward and inward cut is made to join the first cut, so as to remove a piece of wood and bark. The scion is prepared exactly as in side grafting. The cuts on the rootstock and scion shoot should be of the same length and width so that the cambial layers of both components match each other. Then, the prepared scion is inserted into the rootstock and tied security with polythene strip. After the union is complete the stock is cut back, leaving time for doing veneer grafting.

Veneer grafting in mango

Propagation through specialized organs

1. Runners : A runner is a specialized stem that develops from the axil of a leaf at the crown of a plant. It grows horizontally along the ground and forms a new plant at one of the nodes (e.g. strawberry). The runner production is favoured by long day and high temperature. The daughter plants are separated and used as new planting material.

A view of runner production in strawberry

2. Suckers : A shoot arising on an old stem or underground part of the stem is known as suckers. In other words, a sucker is a shoot, which arises on a plant below the ground. These shoots, when separated from the mother plant and transplanted produce adventitious roots. The capacity of a plant to form suckers varies from plant to plant, variety to variety and is even climate dependent. The sucker formation is common in fruit plants like pear and banana. In banana, sword suckers are commonly used for propagation of plants.

Formation of suckers at the base of banana plant.

3. Slips : Slips are shoots just arising below the crown but above the ground. Pineapple is commercially propagated through this method of propagation.

Commercial methods of propagation of major fruits in India

Fruit crop	Commercial method of propagation	Fruit crop	Commercial method of propagation
Apple	Whip and tounge grafting, stooling	Grape	Hardwood stem cuttings
Peach	T budding	Grapefruit	T-budding
Plum	T budding	Guava	Stooling, Inarching
Pear	Tongue or whip grafting	Litchi	Air layering
Acid lime	Seed	Mandarin	T/shield budding
Avocado	Layering, T-budding	Mango	Inarching, Veneer grafting, Softwood grafting
Aonla	Patch budding	Pomegranate	Hardwood stem cuttings and Air layering
Bael	Patch budding	Pummelo	Seed, T-budding
Ber	Ring and T-budding	Sweet orange	T-budding
Custard apple	T-budding, Inarching, Offshoots	Date palm	Offshoots

PROPAGATION METHODS OF VEGETABLES

In India, a number of vegetable, plantation, medicinal and aromatic plants are grown commercially. In fact, we have a rich wealth of these plants in our country. These plants are raised from different propagation methods. Most annual vegetables are propagated by means of seeds. In some vegetables, the seeds are sown directly in the field, whereas in others, these are first sown in the nursery and then seedlings so produced are transplanted in the field afterwards. The time taken by the seed to germinate depends on various factors. In general, it takes 10 to 15 days for the seeds to germinate. The seedlings are planted in the field after about a month or nearly so.

The process of germination, factors affecting the germination process and other principles involved in seed propagation are given in detail in the previous chapters. Some vegetables are raised by vegetative methods also (Table 1).

Table 1: A list of vegetable crops raised by vegetative methods of propagation

Common name	Commercial propagation method	Common name	Commercial propagation method
Asparagus	Stem cuttings	Jeruslem artichoke	Sets of tubers with 2-3 eyes
Basella	Seeds; stem cuttings	Kakrol	Tuberous roots
Chow-chow	Whole fruit	Onion	Seeds and bulbs
Colocasia	Corm or cormel	Pointed gourd (Palwal)	Vine cuttings
Drumstick	Seeds and stem cuttings	Potato	Division of tubers; Seed potato weighing 40 to 50 g
Elephant's foot	Offsets of corms	Sweet potato	Vine cuttings with at least 4 nodes (about 40,000 to 50,000 cuttings are required /ha)
Garlic	Cloves and bulbils	Tapioca	Stem cuttings
Horse radish	Root cuttings	Yam	Division of tubers
Ivy gourd (Kundru or tondli)	Stem cuttings		

PROPAGATION METHODS OF FLORICULTIRAL PLANTS

All plants having ornamental value are considered as the floricultural plants. These may be annuals, biennials, perennials, climbers, grasses, bulbous, herbaceous perennials, shrubs or trees. All these are propagated by seeds or some vegetative method of propagation (Table 2).

Ornamental bulbous plants

Many plants of horticultural importance are propagated by specialized structures like bulbs, corms, rhizomes and tubers. Bulbous plants are also commercially propagated from the above mentioned vegetative parts. Apart from these structures, these are

also propagated from other structures like offset, bulblet, cormlet, bulbils and scales etc (Table 3).

Table 2 : Propagation methods of some ornamental crops

Crop	Propagation method	Crop	Propagation method
Bougainvillea	Hardwood cuttings	Cacti and succulents	Seeds, cuttings of stem, leaf, bud cutting
Canna	Division of rhizomes	Carnation	Seed, terminal leaf cuttings
Chrysanthemum	Suckers and terminal cuttings	Climbers	layering or cuttage
Cycads and palms	Seeds, rarely by suckers and division of clumps	Dahlia	Leaf cuttings
Ferns	Spores	Flowering annuals	Seeds
Gerbera	Division of the mother plants	Gladiolus	Corms and cormlets
Herbaceous perennials	Seeds	Jasmine	Stem cuttings
Marigold	Seeds	Orchids	Seeds, tissue culture
Ornamental grasses:	Cuttings, stolon	Rose	T budding and cuttings
Tuberose	Bulbs		

Table 3. Major bulbous plants and their commercial propagation methods

Common name	Specialized structure used for propagation	Common name	Specialized structure used for propagation
Alocasia	Rhizomes	Corn lily	Corms
Amaryllis	Bulbs, bulblets	Crocus	Corms
Begonia	Tuberous roots	Crown Imperial	Bulbs
Belladonna lily	Bulbs and bulblets	Cyclamen	Tubers
Caladium	Tuberous rhizomes	Daffodil	Bulbs
Canna	Tuberous roots	Dahlia	Cuttings and tuberous roots
Gladiolus	Corms	Lily	Bulbs and offsets
Tuberose	Tubers	Tulip	Bulbs

Micropropagation

Propagation of plants under aseptic and controlled conditions of environment and nutrition under lab conditions is called as micropropagation. The vegetative propagation of plants has been practised for centuries and many improvements in conventional methods have been made over the years. Now, the tissue culture technique i.e., micropropagation has expanded their scope and potential on commercial scale. Micropropagation is suitable for the rapid and large-scale clonal multiplication of elite germplasm. The technique has been referred as micropropagation because the size of the tissue in culture is very minute as compared to conventional vegetative cutting or any other plant part. The meristem explant used for micropropagation is about 0.1-0.5 mm size having only one or two leaf primordia. With the advancement in science and technology, micr-opropagation technique has also been standardized for many plants, and it, is now widely used for multiplication of many horticultural plants. The plant part to be cultured is called as explants, for which artificial culture medium is required.

Points to remember

- Propagation of plants through minute part under aseptic and controlled conditions of environment and nutrition under lab conditions is called as micropropagation.
- All micropropagation techniques are based on the phenomenon of totipotency of cell.
- It is a highly successful method of propagation in plants, which are also raised easily by vegetative means.
- Less field survival of tissue culture raised plants in the field is the main hindrance for expansion of this technique in India.

Advantages of Micropropagation

Micropropagation has the following advantages over conventional propagation techniques:

1. Year around production of plants is possible.
2. Small space is required to maintain and multiply a large number of plants.
3. Small tissue is required as an explant, hence saves the scion wood to a great extent.
4. Speedy international exchange of germplasm, requiring minimum quarantine checks is possible.
5. Micropropagated plants exhibit vigorous growth, and higher yields.

6. Micropropagated plants are usually free from viruses.

7. Micropropagation is highly beneficial in dioecious fruit plant species (date palm and papaya), where large-scale production of female plants is possible.

8. It helps in reducing the breeding cycle.

9. Production of homozygous plants is possible under *in vitro* conditions.

10. It is highly beneficial in plants in which vegetative propagation is not possible or the propagation rate is very slow (papaya and date palm).

11. *In vitro* systems have the potential for long-term transportation or shipment of propagation material.

Stages involved in micropropagation

There are four main stages involved in micropropagation of plants, such as explant establishment, shoot proliferation, rooting of shoots, hardening and transfer of plantlets to soil/field.

1) Explant establishment- The establishment of explant depends on several factors such as the source of explant/ genotype, type of explant such as leaf, root, stem from mature or immature plants/seedlings, explant sterilization, the *in vitro* culture conditions such as culture media, composition, temperature, humidity, light etc. The explants showing growth are considered established.

Proliferation of explant

2) Shoot multiplication- The established explants are subcultured after 2-3 weeks, on shoot multiplication medium. The medium is designed in such a way to avoid the formation of callus, which is undesirable for true-to-type multiplication of plants. Thus, careful use of auxins like NAA, 2,4-D and cytokinins like BAP, kinetin is done in culture medium. It is well-established fact that cytokinins enhance shoot multiplication.

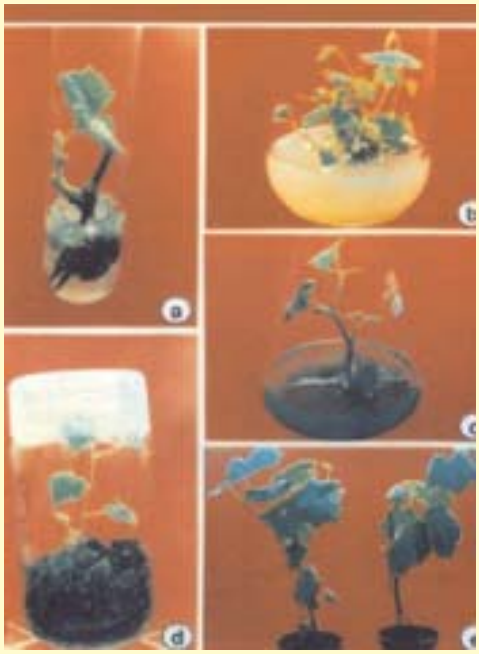
3) Rooting of shoots- The *in vitro* regenerated shoots are rooted in the medium containing auxins like NAA, IBA. The rooting can also be induced when *in vitro* shoots are exposed to stress conditions. The rooting should also be preferably without formation of callus, thus avoiding somaclonal variants.

Rooted plantlets

4) Hardening and transfer to soil/ field- The *in vitro* plantlets thus obtained are hardened/ aclimatized before transfer to the field. The hardening is necessary as the tissue culture derived plants grow under high humidity conditions, have open stomata, lower epicuticular wax, thus leading to increased transpiration losses and resulting in mortality of plants.

Micropropagation Techniques

To produce virus free plants, meristem culture and micrografting techniques have been standardized in different fruit plants. The success varies with the plant species, variety and the culture environment. Different micropropagation techniques are discussed hereunder.



Different steps involved in micropropagation of grape

1. Meristem tip culture : This technique is widely used in horticultural plants like potato, dahlia, carnation and orchids. In this method, the meristem tip consisting of one or two pairs of leaf primordia are cultured in a medium. After a few weeks, the plantlets are re-generated and after hardening of the plantlets, these are transplanted in the soil under natural environmental conditions. Meristem tip cultured plants give rise to polyploid plants instead of diploid plants. Moreover, meristem tip culture is very useful for the elimination of viruses from infected plant material. Rapid multiplication of the plants, which are otherwise not easily propagated by vegetative means, is also possible through meristem culture. Plants produced are free from pathogens and can be stored for longer period and in smaller space.

2. Micrografting : It is difficult to regenerate complete plants from meristem in woody species like most of fruit and forest plants, thus as an alternative micrografting is done to produce virus-free plants. The various steps in micrografting include scion preparation, rootstock preparation, *in vitro* grafting and acclimatization/ hardening of the plants. The *in vitro* raised nucellar seedlings are used as rootstocks. The scion (meristem 0.1-0.4 mm) is obtained either from young growth of field grown trees, defoliated glasshouse grown plants, or *in vitro* proliferated nodal segments obtained from mature trees. The grafting is done with the help of stereomicroscope, under aseptic conditions. Several viruses have been eliminated via micrografting in fruit plants such as Citrus Tristeza Virus, Peach latent mosaic viroid, Pear Vein Yellow virus.

Micropropagation techniques have been successfully adopted in many horticultural crops. Among fruit crops, strawberry was the first fruit to be propagated commercially through micropropagation. Micropropagation techniques have been standardized for many temperate, tropical and sub-tropical fruit crops. In India, tissue culture technique has been perfected in banana, grape and papaya. In banana, shoot tip excised from rhizomes of sword sucker are suitable explants and MS medium supplemented with sucrose (3 per cent), gelite (0.25 per cent), is the best. Shoot tips and two nodal microcuttings are highly suitable explants for faster and disease-free production of grape plants through tissue culture. Shoot tip culture technique has been demonstrated in papaya to produce female plants in the desired ratio.

Problems encountered during micropropagation

The success of micropropagation in several instances is hampered by the following problems:

1) Microbial contamination : Bacterial/fungal contaminations in the cultures do not allow the propagules to grow. This problem can be overcome by growing donor plants in growth chambers, systemic fungicide spray prior to explant removal, effective sterilization of explants, performing inoculations in laminar air flow cabinets fitted with HEPA filters (0.2 m) and using sterilized surgical instruments. Fumigation of inoculation room using dilute formaldehyde solution also helps to minimize this problem.

2) Browning of cultures : The cultured explants of certain plant species exude phenolic substances into the medium, which cause browning due to oxidation of phenols and formation of quinones, the toxins which effect the growth of cultured explants. The use of antioxidants such as activated charcoal (1-2%), citric acid or

ascorbic acid (50-100 mg/l) and polyvinylpyrrolidone (PVP), polyvinylpolypyrrolidone (PVPP) in the culture medium helps to check the browning.

3) Variability in tissue culture regenerated plants : Variability is highly undesirable in the micropropagated plants. It may occur due to callusing and regeneration of plants from callus instead of direct shoot induction and proliferation. Moreover, the plants regenerated through adventitious meristems as compared to axillary meristem are susceptible to mutations, as it is derived from either a single cell or a small group of cells. This leads to variation in regenerated plants. The variation due to callusing, can be overcome by addition of growth substances, such as, triiodobenzoic acid (TIBA), phloroglucinol and phloridzin which inhibit callusing and also by reduction of inorganic salt concentration in the culture medium.

4) Loss of plants due to transplantation shock : Tissue culture regenerated plants have anormal leaf morphology, poor photosynthetic efficiency, malfunctioning of stomata (open), reduced epicuticular waxes and thus are amenable to transplantation shock. Hardening of such plants is thus very essential before transplanting them under field conditions. Conservation of moisture by creating high humidity around the plants, partial defoliation and application of anti-transpirants are useful for hardening of *in vitro* raised plants.

Limitations of micropropagation

Micropropagation has certain limitations also. These are as under:

1. The facilities required are very costly.
2. Technical skill is required to carry out different micropropagation procedures.
3. Pathogens once appeared in the system, also multiply at a very faster rate in a short time.
4. Plants having high levels of phenols (mango. date palm, coconut etc.), usually do not respond to micropropagation techniques.
5. Establishment of laboratory-raised plants in the field is a very difficult task.

Hardening of micrpropagated plants

The tissue culture plants need acclimatization or hardening before they are transferred in the field. The acclimatization is necessary because there is a vast variation in the environment surrounded by *in vitro* plants and the field environment. In culture vessels the *in vitro* plants are exposed to high humidity, hetrotrophic mode of nutrition, high ethylene concentration and constant temperature throughout the year.

These conditions lead to the development of plants having low epicuticular wax, low stomatal density and stomatal malfunction, which make these plants more vulnerable to mortality in field conditions. To prevent this mortality, it is must to harden or acclimatize tissue culture plants.

Approaches for hardening of plants

To have success in hardening of tissue culture plants, the following approaches are adopted:

1. Balanced proportion of roots and shoots should be maintained in micropropagated plantlets.
2. Appropriate rooting media should be used for establishment of plants *ex vitro*.
3. Balanced nutrition should be provided for better survival of rooted plantlets.
4. Simultaneous rooting and acclimatization must be attempted.
5. Cleaning of gelling agents from roots before transfer to rooting media.
6. Moisture content or humidity around the transferred plantlets should be high.

ACTIVITIES/EXERCISES

- Go to a nearby fruit plant nursery. Make a list of plants being propagated there. With the help of the gardener (mali) find out the methods of propagation followed for the propagation of a particular fruit.
- Try to perform 'T' budding, air layering, side veneer grafting in horticultural plants propagated by these methods.
- Plan a visit a tissue culture laboratory of some ICAR institute or Agricultural University of your area. Make a list of instruments in that lab and try to learn about culture media, explants preparation, culture establishment etc.

CHECK YOUR PROGRESS

1. What are the advantages and disadvantages of vegetative method of propagation?
2. What is micropropagation? Discuss its advantages over other methods of propagation.
3. Why micropropagation technique of propagation could not be commercialized in several fruits and vegetables in India?

4. Write short notes on : T budding, air layering, hardwood cutting, side veneer grafting, and problems encountered during micropropagation.

5. Write propagation methods of vegetables and floricultural crops.

FILL IN THE BLANKS

- Citrus plants are primarily propagated by .....
- Grape is commercially propagated by .....
- Micropropagation protocols works on the principle of .....
- Micropropagated plants are free from .....
- Strawberry is propagated through.....
- Banana is propagated by.....
- Scarification is done to .....
- Stratification treatment is given to .....
- In micro-grafting, the size of explants is .....
- Papaya is mainly propagated by .....

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Chapter - 7

PLANTING MATERIAL FOR HORTICULTURAL CROPS

OBJECTIVES

After studying this chapter, you will be able to:

- Understand the need for quality planting material in horticultural crops
- Highlight the components of a model fruit plant nursery
- Perform important nursery practices in modern fruit plant nursery
- Start a fruit plant nursery based agri-business

INTRODUCTION

It is always a matter of discussion among the scientists and farmers that although we are the largest producers of fruits (73.9 MT) and vegetables (139.8 MT) in the world but the productivity of most of the fruits and vegetables in our country is low in comparison to other countries of the world. Several reasons are quoted for low productivity but the major reason is that most of our orchards are old and declining, and quality planting material for new orchards is not available. In spite of having around 440 hundred fruit plant nurseries in our country, paucity of good plant material is really a matter of great surprise. What could be the reasons for it? We do not follow the rules and regulations or we do not use proper nursery production, protection tools for producing quality planting material. In this chapter, we will discuss about the management of modern nursery, nursery registration act, and nursery practices to be followed for producing a quality planting material.

Present status of nurseries and planting material

Planting material is being produced by a number of government nurseries including SAUs and ICAR Institutes as well as private nurseries existing in different states. In India, more than 4409 fruit nurseries including 1575 under government sector and 2834 under private sector, are functioning, which have an annual target of producing 1387 million fruit plants. In view of growing importance of fruit crops, the demand

for quality planting material has increased manifold throughout the country in the recent past. However, the greatest bottleneck in the expansion of area under fruits is the non-availability of genuine and quality planting material in adequate quantity from reliable government nurseries. More often than not, the farmers depend much on the unregulated and unmonitored private sector nurseries and this practice is causing great harm to the fruit industry of the country. The existing nurseries lack modern infrastructure such as greenhouses, mist chambers, efficient nursery tools and gadgets, implements and machinery.

Table1: Status of fruit plant nurseries

Sr. No.	Sector	Number of Nurseries	
		India	H.P.
1.	Public	1575	70
2.	Private	2834	662
	Total	4409	732

Keeping in view the present area and the trends in expansion of area under different fruits in India and also the necessity of renewal of old and non-performing orchards, the requirement of nursery plants of different fruits in India would be very high, which can only be met after following standard practices in nursery for the production of quality planting material. .

Propagules for different horticultural crops

In the previous chapter, you have read about different methods of propagation of horticultural plants. If you have read this chapter carefully, you might have come to know that most of the fruit plants are raised through vegetative methods of propagation such as cutting, layering, budding and grafting because fruit plants are highly heterozygous and propagation through seeds brings about greater variability in the progeny. To remind you about some of most important methods of propagation of fruits are: 'T' budding in citrus and *ber*, air layering in litchi and guava, hardwood cuttings in grape, epicotyl grafting in mango in Konkan region and runners in strawberry. So the above mentioned material is the planting material for these fruit plants. However, some fruit plants such as papaya, *jamun* and *phalsa* are still raised by seeds, because no method of vegetative propagation has been much successful. Similarly, rootstocks for budding and grafting in fruit plants are raised through seeds, yet few rootstocks (e.g. clonal apple rootstocks) are raised by vegetative means, primarily by stooling. Some horticultural plants are raised by micropropagation (papaya,

strawberry, banana etc.) and some by specialized vegetative structures such as corms, tubers, runners, offsets etc.

The planting material for most of annual flowers and vegetables crops is seed only. However, some vegetables such as asparagus, basella, garlic, potato, yam etc., are raised successfully through vegetative methods. Similarly, several ornamental, especially flowering annuals are propagated by seeds, whereas some ornamental plants such as canna (rhizomes), bougainvillea (hardwood cuttings), ferns (spores), dahlia (leaf cuttings), tuberose (bulb) are propagated by vegetative means. Further, ornamental trees and shrubs are propagated by seeds and several methods of vegetative propagation, which act as propagaule for them, respectively.

Model nursery management

Nursery development has great scope for enhancing the production and profitability of fruit crops in India because of poor yields and overall low productivity, year to year fluctuations in production, poor quality of produce and non-availability of quality planting material. The modern era of horticultural development is known for effective utilization of hi-tech interventions for different aspects. Hi-tech interventions in nursery establishment are technological advancements, which are capital intensive, minimally environment dependent and useful in rapid multiplication of planting material of fruit plants.

Nursery management is a technical and skill oriented job, which require proper attention at different stages of production of quality planting material. Setting up of a fruit nursery is a long term and capital intensive venture. It needs lot of planning, expertise and efficient management for the production of quality planting material. Mistakes committed initially in the establishment of a nursery can not be rectified easily at later stages; moreover, it reduces the returns greatly as well, which results in wastage of time and energy. Therefore, careful planning is needed before establishment of a nursery. The nurseryman should prepare a layout of the proposed nursery, which should include allocation of plots/area to different components of the nursery such as mother orchards of different fruits/cultivars, rootstock banks, nursery beds, roads/paths, water channels, drainage system, buildings/other structures, etc. Provision of certain basic pre-requisites must be made for the establishment of a fruit nursery on modern lines.

Components of a model fruit nursery

A genuine prospective nurseryman can earn reputation for production of quality planting material by considering following points before establishing a model nursery :

Technical Knowledge

The knowledge on nursery management before establishing a nursery is pre-requisite for its success. Nursery management is highly skilled and technical job, which requires proper attention and expertise. Therefore, a person who wishes to establish a fruit plant nursery must have technical knowledge on every aspect of the nursery production.

Nursery Registration

Considering the importance of production of planting material of fruit crops, Fruit Nursery Registration Act -1973 has been enforced in India. However, only few states in India have enforced it for quality production and regulation of planting material. As per this act, any nurseryman can not undertake the production and sale of nursery plants or planting materials without getting a nursery registration license. Under the provision of this act, the fruit nurseries are inspected periodically by the officials of Govt. and defects, if any, are pointed out to the nurserymen for rectification or for causing destruction of plants if found infected with certain infectious diseases and pests.

In order to regulate the quality of nursery plants, the fixing of nursery standards and to bring the fruit nurseries under the ambient of nursery certification is very important. Fixing of nursery standard and certification of nursery stock are the twin services, which are highly valuable from customer's point of view. While nursery standards ensure the supply of healthy, disease-free and commercial grade plants to the customers, setting of certified nursery stock protects the customers against planting poor quality and undesirable varieties.

Certification of nursery means that the nursery plants have been checked and identified as true-to-type by the competent authority. For the purpose of certification, the plants shall have to be propagated by using the scion wood and rootstocks material only from the registered trees maintained in the nurseries for the purpose. For producing certified nursery stock, the fruit nursery shall maintain a scion block and stool bed and shall have to use the propagation material only from these sources. For the production of certified nursery plants, certain minimum standards have been fixed for different fruits and the nurserymen are required to adhere to these standards. The general standards for different fruit plants are as under:

- Nursery plants should be true-to-type and raised from healthy, disease-free, high yielding progeny trees of good quality.
- Nursery plants should be raised on recommended rootstocks and should not be raised on old stock.

- The bud/graft union should be smooth and strong enough.
- The bud/graft union should be 15-25 cm from the ground level.
- Nursery plants should be of standard height (60-120) cm depending upon the kind of fruit crops.
- Root system should be well developed and there should be no damage while uprooting the plants from nursery.
- Nursery plants should be healthy and free from diseases and insect-pests.

Besides this, the quality planting materials produced in all the nurseries can thus be regulated under this act by:-

i) Ensuring the maintenance of registered scion block, stool beds in fruit nursery to serve as sources of propagation material.

ii) Rigorous checking and identification of fruit kinds and varieties for trueness and name/type through procedures as prescribed under certification programme.

iii) Rigorous checking/indexing of nursery stock for freedom from viruses and diseases.

iv) Rigorous inspection of nursery plants before sale to ensure the supply of only healthy and disease-free plants to the growers.

v) Bringing the nursery registration and nursery certification programme under one agency and making their implementation mandatory for all the fruit nurseries in the state.

Procedure to get nursery registration license

Any person interested to establish fruit nursery in the particular area are advised to meet the SMS/ Horticulture Development Officer of that area and shall make an application in writing in prescribed form and manner accompanied by the revenue papers of the land and license fee of rupees one hundred only. At present, the license is valid for three years. After the validity period, the license can be renewed on the application of owner with the renewal fee of rupees one hundred only, provided the licensing authority is satisfied after inspection with the conditions available.

Layout of a model nursery

Layout is the arrangement of different essential features of a nursery including

the roads, paths, buildings, beds, irrigation channels, etc. It is prepared for effective utilization of inputs and to do things in proper manner. A location specific model should be designed for nursery establishment as per requirements. Certain important components should be taken into consideration and provision should be made for these during planning and layout of nurseries, which are as follows:

(i) Fencing

Prior to the establishment of a nursery, a good fence with barbed wire must be erected around the nursery to prevent tress pass of animals and theft. The fence could be further strengthened by planting a live hedge with thorny fruit plants.

(ii) Roads and paths

A proper planning for roads and paths inside the nursery will not only add beauty, but also make the nursery operations easy and economical. This could be achieved by dividing the nursery into different blocks and various sections. But at the same time, there should not be wastage of land by unnecessarily laying out of paths and roads. Each road/ path should lead the customer to a point of interest in the nursery area.

Roads in nursery

(iii) Progeny block/Mother plant block

The nursery should have a well-maintained progeny orchards or mother plant block/scion bank of commercial and recommended varieties. The mother plants for establishing progeny orchards should be obtained preferably from the original research institute from where these are released or from a reputed nursery. It is well realized that the success of any nursery largely depends upon the initial selection of progeny plants or mother plants for further multiplication. Any mistake made in this aspect will result in loss of the reputation of the nursery. A well managed progeny block or mother plants block will not only create confidence among the customers but also reduces the cost of production and increases the success rate of grafting/ budding/

Water storage tank in nursery

layering because of availability of fresh scion material throughout the season within the nursery itself and there will not be any lag period between separations of scion and grafting/budding.

(iv) Irrigation system

Nursery plants require abundant supply of water for irrigation. Hence, provision for assured irrigation facilities must be made well in advance to obtain better growth and success in the production of planting material. In areas with low water table and frequent power failures, water storage tanks/ rain water harvesting tanks should be constructed to provide life saving irrigation to the nursery plants. Since water scarcity is a limiting factor in most of the areas in the state, a well laid out PVC pipeline system will solve the problem to a greater extent. An experienced agricultural engineer may be consulted in this regard for layout of pipeline. This facilitates efficient and economic distribution of irrigation water to different blocks in the nursery and also reduces the seepage losses.

Use of sprinkler for irrigation in nursery

A view of office building in nursery

(v) Office cum store

An office-cum-store is needed for effective management of the nursery. The office building may be constructed in a place, which offers better supervision and also to receive customers. The office building may be decorated with attractive photographs and with important characters of fruit varieties propagated in the nursery. A store room of suitable size is needed for storing polybags, tools and implements, packaging material, labels, pesticides, fertilizers etc. There should also be a provision for separate sale counter.

(vi) Seed beds

In a nursery, this component is essential to raise the seedlings and rootstocks. These are to be laid out near the water source, since they require frequent irrigation. The beds should be raised 15 cm from the ground level to ensure good drainage.

These should be located in an open place which receives sufficient sunlight. Beds of 1-meter width of any convenient length are to be made. A working space of 60cm between the beds is necessary. This facilitates ease in sowing of seeds, weeding, watering, spraying and lifting of seedlings. Irrigation channels are to be laid out conveniently. Alternatively, sprinkler irrigation system may be provided for irrigating the beds, which offers uniform germination and better seedling growth.

Preparation of nursery beds

(vii) Nursery beds

Seedlings are taken out from the seed beds and transplanted in the nursery beds. Nursery beds are required for establishing rootstock seedlings for grafting/ budding as well as for planting of cuttings and layered plants. Such beds can be irrigated through sprinkler system.

(viii) Propagation structures

There should be adequate provision for modern propagation structures like mist chamber, poly houses, net houses etc. These structures provide optimum conditions required for seed germination, rooting of cuttings and hardening of plants before transplanting them in the field.

(ix) Potting mixture and potting yard

Preparation of mixes in the nursery

For better success of nursery plants, a good potting mixture is necessary. The potting mixtures for different purposes can be prepared by mixing fertile soil, well rotten farm yard manure, leaf mold, etc., in different proportions. The potting mixture may be prepared well in advance by adding sufficient quantity of super phosphate for better decomposition and solubilization. The potting mixture may be kept near the potting yard, where potting is done. Construction of a potting yard of suitable size facilitates potting of seedlings or grafting/budding operations even on a rainy day.

(x) Packing yard

A packing yard is used for packing the plant material before sale/dispatch to outstations. The yard can be combined with the working shed. There should be plenty of space to enable a number of workers to sort out and pack the plants with care. On the packed bundles, description of the plant variety, name and address of customer should be properly indicated. Packing yard should be located near the sale counter.

Parking yard

(xi) Compost unit

It is an important component of the nursery. A huge quantity of organic manure is required in the nursery for the production of healthy planting material. Therefore, it is advisable to construct vermi-compost pits, where the weeds and waste material can be utilized for the production of organic manure at the nursery site itself. It will reduce the expenditure to be incurred on the purchase of manures. It should be constructed near the potting shed.

Transport of nursery plants

Linkages

Nursery production is a programme, which requires proper planning and monitoring for obtaining quality planting material and better returns. This can be performed by better coordination and linkages with the experts in Universities, State Department of Horticulture, reputed nurserymen as well as concerned stakeholders.

Packed bundles of nursery plants

Finance

Nursery production for horticultural crops is capital intensive intervention. Therefore, nursery growers should be provided with financial assistance for efficient

and smooth working of various units of the nursery. It can be provided through Government sponsored schemes like National Horticultural Board, APEDA, National Horticulture Technology Mission or institutions like Nationalized Banks or Cooperatives.

Hi-tech interventions

Hi-tech interventions like protected cultivation, micropropagation, micro-irrigation, fertigation, use of growth regulators, canopy management, organic farming, and automatic climatic controls measures etc. are used for efficient utilization of inputs and increasing production efficiency. Mechanization for enhanced efficiency is essential. There is need to adopt media siever, media mixer, poly bags filler, automatic grafting machines and electrically/pneumatically/hydraulically operated secateurs etc. for enhancing the efficiency in the large scale production of quality planting material.

Marketing management

The commercialization of nursery production is possible with efficient and organized marketing. This can be promoted by encouraging participation in Agri-fest, seminars and other market linkage activities.

Preliminary considerations for production of quality planting material

Propagation of fruit plants is done by sexual and asexual (vegetative) methods. The propagation of fruit plants through vegetative methods makes them vulnerable to transmission of several diseases and pests. Thus, due attention on quality control must be given at various stages of production of planting material. Coordinated efforts by of ICAR institutes, SAUs, KVKs, State Horticulture departments are required to meet the ever increasing demands of quality planting material in the coming years. The production and distribution of healthy, genuine and elite planting material of commercial/improved varieties of fruit crops in sufficient quantities will help in achieving the fruit production targets required to meet the increasing demand of fruit. No doubt, it is easy to maintain the purity in fruit plants propagated through vegetative means as compared to sexually propagated fruit plants, but a close monitoring at different stages in the nursery is required to avoid mixing with other varieties. Similarly, adequate plant protection measures are required to be adopted in the production of quality planting material free from diseases and pests.

A quality control mechanism is required to manage key production variables in the production of consistent quality planting material of the subtropical fruit plants. There is need to identify and control the variables in the production of nursery

plants; otherwise the quality of planting material would probably be erratic. There are several key steps to initiate a quality control mechanism for the production of planting material in fruit crops, which are given below:

I. Identification of potential areas and production targets

The potential areas for the production of planting material of fruits should be identified and always set realistic production targets on the basis of available resources, particularly the genuine and certified scion /budwood and rootstock as well as skilled manpower.

II. Selection of location and site

Selection of an ideal location and site is of utmost importance in order to achieve the level of sufficient growth to raise good quality plants in the nursery. Keeping in view the variation in the requirement of nursery production as well as to maintain quality, an isolated area is more desirable for nursery raising. The nursery site should be well connected with modern transport and communication facilities and should be located near a city or town, so that it is easily accessible and the customers can visit it conveniently. The area should be receiving adequate sunshine and should preferably be on 'north-western' aspect. It should have access to good water source, electricity, skilled and unskilled labour availability throughout the season as well as professionally qualified and competent manpower. Places with a mild climate, long growing season and even distribution of rainfall are most suitable for planting material production while areas with extremes of temperature or commonly subjected to dry winds, frequent flooding, hail, storms or known to be frost pockets should be avoided as they adversely affect the quality of planting material. Soil should preferably be light-to-medium in texture with good fertility, water holding capacity and drainage, ideally with a pH range of 6.0 to 7.0. Topography should preferably be plain with gentle slope (1 to 2 %); and in very sloppy areas terracing need to be done.

III. Develop flow chart of various nursery practices

In order to meet the production target, develop flow chart of various nursery practices along with time scale involved in the production of planting material. The major considerations in this regard would be propagation method and its seasonal variations for success and quality of the final produce, rootstock to be used, and specifications for the scion / budwood including its genuineness and season of availability.

IV. Requirements of inputs

The inputs required at each stage of production should be identified and subsequently develop quantitative specifications and requirements for each input such as seed, rootstock material, nursery/ seed beds, containers, growing medium (sand, FYM, soil, sphagnum moss), fertilizer, irrigation water, plant growth regulators, fungicides/pesticides and herbicides, etc.

V. Verification of specification standards

The procedures for the verification of specification standards of each input should be developed. The information collected should be quantitative so that the variation can be assessed. The verification procedures should be critical, real time and an integral part of the routine production procedures.

VI. Maintenance of nursery records

Nursery records must be maintained properly by incorporating all the information about the production of planting material and the observations recorded at each stage of production. The nursery records include store/stock of inputs used, nursery raising of seedlings/rootstocks, grafting/budding/layering/cutting, stock and disposal of propagated material. These may be maintained either in the registers and / or in the computer using suitable software such as Excel or MS Access, for monitoring the quality control mechanism. This will prove useful to identify the probable flaws in the production of planting material retrospectively as well as to rectify them subsequently. It would be useful to establish continuous and effective linkage with research organizations for the latest technological development regarding the nursery management aspects to upgrade and perfect the quality control measures.

VII. Labeling of planting material

Planting material produced should be labeled properly as per the records, with necessary information such as crop, variety, rootstock used, date of production, name of the nursery etc., and the planting material may be got certified from the competent authority by constituting committee comprising of a horticulturist, pathologist and entomologist as a part of the quality control mechanism.

PROGENY TREES/MOTHER PLANTS

The ultimate success of orcharding profession largely depends on the quality of planting materials, since nursery plants are the foundation of an orchard. The variation

in the nursery plant material in respect to selection of scion and rootstock used has great influence on productivity of an orchard.

Seeing that the scion maintains its characteristics after grafting/budding, therefore, it is important to take scions from plant, which has been correctly identified. Scion-sticks for multiplication of nursery plants should be taken from healthy and true-to-type progeny trees. These trees should be free from various viruses, diseases and insect-pests. The past history and performance of these trees must be known and records must be maintained in this regard. A nurseryman should have progeny trees of all the promising varieties of fruits that can be grown/multiplied in that particular locality or those, which are in great demand. The progeny trees of the commercial varieties of fruit plants to be propagated must be planted in the budwood orchards for taking scion sticks from these plants.

The progeny plants are the major source for spread of fungal and viral diseases. Thus, it is worthwhile having all parent plants carefully lebeled or otherwise marked. Identified mother trees are used to develop progeny trees in large numbers near to the nursery site. They can be planted at closer distance. The trees are properly labeled and used for scionwood. Adequate plant protection measures should also be adopted to keep these progeny trees free from insect-pests and diseases.

Criteria for selection of mother plants

- Mother plants of the variety should be genetically true-to-type.
- The plants should be healthy and free from diseases, pest infestations and physiological disorders.
- The plants should have known pedigree records regarding bearing potential, fruit quality and problems, if any.
- The plants should be precocious and prolific bearer.

Nursery management practices

Nursery management is one of the important aspects of production of quality planting material. Various nursery management practices have been standardized and sufficient technical knowhow has been generated on the various nursery management practices such as plant nutrition, irrigation, moisture conservation, weed control, plant protection and other cultural practices. Since the nursery management practices play a significant role in the production of healthy and good quality planting material, the available technology should be followed for improving

the quality of nursery plants. Young nursery plants require intensive care to make them grow well. There are various practices which should be paid special attention as discussed hereunder :

i) Mulching

Mulching is an essential practice particularly in the areas of water scarcity in order to promote germination of seed as well as for better establishment of nursery plants. Immediately after sowing of seeds, seed beds should be mulched with 10-15 cm thick dry grass mulch, straw, pine needles, dried leaves or black polythene sheet. can also be used as mulching material. As the germination starts, the mulch from the seed bed should be removed to avoid damage to newly emerged shoots. Similarly, immediately after grafting, nursery plants should be mulched. This practice helps to conserve soil moisture, control weed growth, and maintains soil temperature in the nursery.

ii) Manuring

The commercial manuring and fertilization programme depends largely on the type and fertility of soil. Farm yard manure (60-80 tones/ha) should be mixed in the nursery beds before sowing of seeds or transplanting of plants into nursery beds. Nitrogen @ 60-120kg/ha, phosphorus @ 30 kg/ha and potassium @ 60-90 kg/ha should be added to the soil to get better growth of nursery plants. Half the dose of nitrogen and full dose of phosphorus and potassium should be applied at the time of nursery bed preparation whereas another half dose of nitrogen should be applied at the time of onset of monsoon during the month of July.

iii) Irrigation

Nursery stock and young plants require frequent irrigation to make them grow well. Therefore, provision of assured irrigation is essential for the success of a fruit nursery. In those areas where there is scarcity of irrigation water, it is essential to construct a water storage tank near the nursery area to ensure proper irrigation of plants. Plants should be watered at frequent intervals preferably in the evening, to avoid evaporation of water from the nursery beds. Irrigation may be given by constructing irrigation channel and sub-channels, plastic pipes, water cans and sprinkler irrigation system. However, sprinkler irrigation system has been observed to be the best for nursery plants.

iv) Hoeing and weeding

Nursery area should be kept free of weeds. For this, nursery beds should be dug 5-10 cm deep at least 3-4 times with the help of hand forks for loosening the soil,

removing the weeds and satisfactory growth of plants. If manual labour is not available, the pre-emergence weedicide (Simazine or Atrazine @ 6 kg/ha) is effective in controlling weeds in seedling stocks and grafted plants. Grammaxone @ 2 L/ha as post-emergence application along with pre-emergence application of weedicide reduces the cost by about 60% as compared to hand weeding.

v) Removal of polythene strip

It is very important that the tying material does not girdle the rootstock, as this will delay growth and lower the quality, therefore, the tying material from the grafted plants should be removed timely. This is an important operation of budded/ grafted nursery plants, which must be done timely. After about one month of sprouting when the grafted plants attain 30-45 cm height and the graft union start swelling, polythene strips should be loosened by giving sharp cut on the back side of the graft.

vi) Deshooting

After grafting and budding, the shoots generally arise from the rootstock below the graft union. It is necessary to remove such shoots from the rootstock at regular intervals otherwise it may result in the failure of grafting/budding.

vii) Staking

After removal of polythene strip, staking of grafted or budded plant is must since the unions are tender in summer and the plants are blown off with slightly higher wind velocity in windy situations. Attachment to the stock remains weak and they get easily broken. To protect the plant from breaking and to ensure a single trunk, the plants should be staked with wooden stakes and tied at least at 2-3 places to ensure safety against heavy winds. Problem of breakage is less in much populated nursery beds. In unstaked nurseries, the losses may be as high as 20-30 per cent. Simple wooden stakes can be used for this purpose.

viii) Single stemming

It is necessary to regularly pinch the side shoots coming from the growing scions. Single stemming to a height of at least 45 cm should be done by allowing one sprout to grow properly and rapidly.

ix) Uprooting and packing of plants

The saplings of evergreen fruit plants such as mango, litchi, citrus, guava, papaya and *aonla* are uprooted from the nursery during rainy season (July-August) whereas, peach, apple, pear, plum, apricot and pomegranate during winter

(December-January) when they have entered into dormancy, after all shoot growth has stopped and most leaves have abscised. While uprooting, the nursery plants, care should be taken not to cause damage to the root system. Plants should be uprooted only after rains or after giving irrigation to the nursery beds. Before uprooting the plants, deep furrows should be made on both sides of plant rows. Plants should be uprooted manually without damaging the bud union and root system. After uprooting, the root system should be dipped in a solution of metasystox (1 ml/l water) for 30 seconds before packing. Plants should be properly labeled and packed cultivar-wise in bundles of desirable and convenient size. The roots should be covered with sphagnum moss grass and wrapped securely in gunny bags.

Plant Protection

Nurserymen have to be careful for regular plant protection measures against diseases and pests (Table 1). The efficient management of diseases and pests which attack nursery plants is essential for the production of good quality nursery plants. In nursery, small outbreaks can bring nursery in disrepute and affect sales seriously. It is, therefore, largely a matter of prevention than cure and their management and control measures must be carefully observed.

Table 1: Common insect-pests and diseases of nursery plants

A. Insect-pests	*Management*
Scales	Single spray of rogor or metasystox (0.05 per cent) is quite effective. Repeat it after 15 days interval. Crude oil spray is also useful for controlling the scales.
Thrips	Two sprays either of metasystox or rogor (0.05 per cent) at fortnightly interval on new growth reduces the population of thrips considerably.
Mealy bugs	1. Collect and destroy the adults.
	2. Soil raking in December-January to kill the pupae.
	3. Spray dimethoate (0.05 per cent) on the crawling insects during February-March.
	4. Use ostico sticky bands or polythene sheet on the trunks of the mother plants.
White flies	Spray phosphamidon (0.02 per cent) or other systematic insecticide in the early stages of infestation.
Mites	Give two sprays of acaricides like dicofol (0.05 per cent) and wettable sulphur (0.2 per cent) at fortnightly intervals.

A. Insect-pests	*Management*
Leaf eating caterpillars	Spray sevin/carbaryl (0.1 per cent) at the first appearance of the caterpillars. Neem oil (1 per cent) is also effective.
Cut worms	1. Use light traps for catching the adults.
	2. Use poison baits consisting of malathion (0.1 per cent), wheat bran and jaggery.
	3. Spray malathion or quinalphos (0.05 per cent) before the expected attack of the worms.
Leaf miners	Two sprays of metasystox or rogor (0.05 per cent) at fortnightly interval on newly emerged growth flushes are sufficient for controlling the population of leaf miners in the nursery.
Snails and slugs	1. Hand picking and destruction is most effective method.
	2. Spray of common salt (2 per cent) is very useful in controlling snails and slugs.
	3. Use metalaldehyde pallets.
B. Diseases	**Management**
Damping off	1. Treat seeds before sowing with ceresan, thiram or agrosan @ 2 g per kg seeds.
	2. Spray captan or bavistin (0.2 per cent) in the nursery.
Powdery mildew	Give one prophylactic spray of karathane or calixin or wettable sulphur (0.2 per cent). Repeat it again if cloudy weather persists for a longer period.
Leaf spots	Give a single spray of dithane Z-78 or bavistin (0.2 per cent)
Blights	A single spray of dithane Z-78 or bavistin (0.2 per cent) is very effective to check blight disease in the nursery plants.
Dieback	1. Prune the dead portion of the plant.
	2. Apply blitox or bordeaux paste to the cut portion.
	3. Spray benlate (0.2 per cent) as soon as the symptoms become visible

ACTIVITIES/EXERCISES

- Visit a modern fruit plant nursery. Make a list of its components.

CHECK YOUR PROGRESS

1. Describe briefly the present status of planting material and fruit plant nurseries in India.
2. Write the components of a nursery. Describe each component briefly.
3. Write important nursery management practices to be adopted for quality production of plant material.
4. What is mother plant? Write briefly about criteria to be kept in mind while selecting mother plant.

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

- Grape plants from the nursery should be uprooted in December-January.
- The nursery beds should be little raised than the field.
- All shoots below the graft union should be allowed to grow.
- Simazine is a pre-emergence herbicide commonly used for control of weeds in nursery.
- The mother plant should be true to the type.
- There are about 4400 fruit plant nurseries in India
- Nursery registration act was enforced in India during 2013.

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