




# BASIC AGRICULTURE

## Student Handbook

## NSQF Level-2

## Class X


**CENTRAL BOARD OF SECONDARY EDUCATION**

Shiksha Kendra, 2, Community Centre, Preet Vihar, Delhi-110092


केन्द्रीय माध्यमिक शिक्षा बोर्ड
दिल्ली
असतो मा सद्गमय

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**Basic Agriculture**

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Price: ₹

First Edition:

Copies:

Paper Used: 80 Gsm CBSE Water Mark White Maplitho



**Published By** : The Secretary, Central Board of Secondary Education, Shiksha Kendra, 2, Community Centre, Preet Vihar, Delhi - 110092

**Designed & Layout by** : India Offset Press, A-1, Mayapuri Indl. Area, Ph-I, N.D. - 110064 www.indiaoffsetpress.com

**Printed By** : M/s.

# भारत का संविधान

## उद्देशिका

**हम, भारत के लोग, भारत को एक सम्पूर्ण [1]प्रभुत्व-संपन्न समाजवादी पंथनिरपेक्ष 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 सब में व्यक्ति की गरिमा**
**[2]और राष्ट्र की एकता और अखंडता**
**सुनिश्चित करने वाली बंधुता बढ़ाने के लिए**

**दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 ई॰ को एतद्द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।**

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1. संविधान ( बयालीसवां संशोधन ) अधिनियम, 1976 की धारा 2 द्वारा ( 3.1.1977 ) से "प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य" के स्थान पर प्रतिस्थापित।
2. संविधान ( बयालीसवां संशोधन ) अधिनियम, 1976 की धारा 2 द्वारा ( 3.1.1977 ) से "राष्ट्र की एकता" के स्थान पर प्रतिस्थापित।

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## भाग 4 क

# मूल कर्त्तव्य

**51 क. मूल कर्त्तव्य** – भारत के प्रत्येक नागरिक का यह कर्त्तव्य होगा कि वह –

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज 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 प्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण 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 हों, ऐसी प्रथाओं का त्याग करे जो स्त्रियों के सम्मान के विरुद्ध हैं;

(च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्त्व 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 प्राणी मात्र 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 उंचाइयों को छू ले;

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

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1. संविधान ( छयासीवां संशोधन ) अधिनियम, 2002 की धारा 4 द्वारा प्रतिस्थापित।

# 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 CONSTITUTION.**

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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)

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# THE CONSTITUTION OF INDIA

## Chapter IV A

## FUNDAMENTAL DUTIES

### ARTICLE 51A

**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;

[1](k) to provide opportunities for education to his/her child or, as the case may be, ward between age of 6 and 14 years.

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1. Subs. by the Constitution (Eighty - Sixth Amendment) Act, 2002

# Preface

Agriculture is the backbone of Indian economy, as we are growing hundreds of cereals, pulses, oil seeds, fruits and vegetables. In addition, rearing of milch animals, fishes, honeybees and silk worms has become an integral part of our economy. By virtue of hard work of the Agricultural Scientists and farmers, we have attained green revolution, white revolution, brown revolution and golden revolution. Now, we are talking of rainbow revolution and it is hoped that we are approaching towards it with great sincerity and the day is not far when we will achieve it. Now, mushroom growing, honeybee rearing (Apiculture), sericulture, aquaculture, dairying, piggery, ornamental fish culture, processing of fruits and vegetables are few important areas where our policy makers and planners are giving utmost attention. Therefore, our students should have some preliminary knowledge on these aspects.

Considering the importance of Agriculture, CBSE has introduced some preliminary courses entitled 'Basic Agriculture' for class X students under NSQF. So that students could understand something about Agriculture at entry level. This course has been introduced with the following objectives:

- To create awareness about cereals, pulses, oilseed crops, important fruits, vegetables and flowers.
- To create awareness about various breeds of animals, poultry, fushes and their importance.
- To impart knowledge about package of practices for growing various crops.
- To impart basic knowledge on major insect-pests and diseases of various crops, animals and measures to protect them by various means.
- To create awareness about post-harvest management, value addition and its importance in our daily life.
- To provide basis knowledge on entrepreneurship skill in different Agri-Business.

I am fully confident that after getting basic knowledge, students will get several ideas and opportunities which Agriculture can offer them in their future life. They can also think of joining this sector in their future life and can develop themselves as successful entrepreneurs in several such areas.

It is hoped that this book will be an asset for the students.

**Chairman, CBSE**

# Acknowledgements


### *Advisors*

- **Sh. R.K. Chaturvedi,** IAS, Chairman, CBSE
- **Sh. K.K. Choudhury,** Controller of Examinations, CBSE

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- **Dr. Biswajit Saha,** Additional Director, (V.E.), CBSE

# Contents

## Learning Outcomes

| Unit Code: 01 | Unit Title: Agricultural Production and Management | | | |
|---|---|---|---|---|
| **Location: Classroom, laboratory and field** | **Learning Outcome** | **Knowledge Evaluation** | **Performance Evaluation** | **Teaching and Training Methods** |
| | • Understanding about our major foodgrain crops including cereals, oilseeds, pulses and commercial crops. | • What are major agricultural crops of India and their classification?<br>• What are major crop production seasons in India?<br>• What are major *Kharif* season crops of India? What are their soil and climate requirements?<br>• What are major *Rabi* season crops of India? What are their soil and climate requirements?<br>• What are major *Zaid* season crops of India? What are their soil and climate requirements? | • Enlist the major states producing cereal, pulse, oilseed and other commercial crops.<br>• Enlist soil and climate requirements of different crops.<br>• Demonstrate major crop management practices in field crops.<br>• Demonstrate application of various herbicides, fungicides and pesticides in some selected crops.<br>• Enlist seed rates and fertilizer requirements of various field crops.<br>• Enlist major weeds, diseases, insect-pests of crops. | **Interactive lecture:**<br>• Different crop management practices of agricultural crops.<br>**Activity:**<br>• Visit some village nearby to school premises. Also interact with farmers and learn about crop production practices. |
| | • Gain a science-based overview of agriculture and food systems. | • What are major crops and cropping systems of India? What are their major varieties and soil and climate requirements? | • Enlist major crops and cropping systems in India and their important varieties. | **Interactive lecture:**<br>• Different cultural requirements of cereal, pulse, oilseed and other commercial crops grown in India. |

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| | | • What are major cereal crops of India? What are their major cultural practices?<br>• What are major pulse crops of India? What are their major cultural practices?<br>• What are major oilseed crops? What are their major cultural practices?<br>• What are commercial crops? What are their cultural hints? | • Enlist major pulses of India and their major problems.<br>• Enlist major oilseed crops of India and their major cultural practices.<br>• Enlist major commercial crops and their major cultural practices.<br>• Enlist sugar producing crops. | • Identification of major weeds, diseases and pests.<br>**Activity:**<br>• Plan a visit to some village and interact with farmers for identification of crops, weeds, pests, diseases and disoders. Also learn about transplanting of rice seedlings. |
| | • Enrich themselves about production technology of major food crops of India. | • What is the recommended crop production technology for major crops of India?<br>• What is the recommended crop production technology for major cereals of India?<br>• What is the recommended crop production technology for major pulses of India?<br>• What is the recommended crop production technology for major oilseeds of India?<br>• What is the recommended crop production technology for major commercial crops of India? | • Enlist major crop management practices of various agricultural crops.<br>• Tabulate fertilizer management technology of major agricultural crops.<br>• Demonstrate puddling and transplanting operation in rice.<br>• Demonstrate top dressing of N fertilizers in agricultural crops.<br>• Demonstrate seed treatment operations in crops.<br>• Demonstrate herbicide application methods in crops. | **Interactive lecture:**<br>• Different crop management practices of various agricultural crops.<br>**Activity:**<br>• Interact with farmers of your area and learn crop management practices of various agricultural crops. |

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| | • Disseminate the knowledge about agricultural production and management at household and village level. | • What are the major production constraints of major agricultural crops of your area/village and at household level? | • Enlist crop-wise production constraints of major agricultural crops of your area/household.<br>• Enlist the potential technologies for tackling these constraints.<br>• Prepare the charts on technology interventions in relation to above context in your area/household level. | **Interactive lecture:**<br>• Enlist major crop production constraints, technology gaps and lack of awareness about crop management practices of various agricultural crops of your area and at household level.<br>**Activity:**<br>• Interact with farmers of your area and also at household level and learn about major crop production constraints, technology gaps and lack of awareness about crop management practices of various agricultural crops. |
| **Unit Code:02** | **Unit Title: Production and Management of Horticultural Crops** | | | |
| **Location: Classroom and field** | **Learning Outcome** | **Knowledge Evaluation** | **Performance Evaluation** | **Teaching and Training Methods** |
| | • Cultural hints for growing major fruits grown in India | • What are major temperate fruits of India? What are their soil and climate requirements?<br>• What are major tropical fruits? What are their major varieties and insect-pests and diseases?<br>• What are major sub-tropical fruits? What are their major problems? | • Enlist the major states producing tropical and sub-tropical fruits.<br>• Enlist major propagation methods of fruits.<br>• Demonstrate training in grape and apple.<br>• Demonstrate foliar application of pesticides in some selected fruits. | **Interactive lecture:**<br>• Different cultural requirements of temperate, tropical and sub-tropical fruits. |

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| | | | • Enlist major varieties of fruits.<br>• Enlist major insect-pests of fruits.<br>• Enlist major diseases and disorders of fruits. | **Activity:**<br>• Visit some orchards of temperate, tropical or subtropical fruits and learn training and pruning etc. Also interact with gardener and learn propagation techniques of fruits such as budding, grafting, air layering etc. |
| | • Cultural hints for growing major vegetables grown in India. | • What are major Solanaceous vegetable crops of India? What are their major varieties and soil and climate requirements?<br>• What are major Cucurbitaceous vegetables of India? What are their major cultural practices?<br>• What are major Cole vegetable crops of India? What are their major cultural practices?<br>• What are major leafy vegetables? What are their major cultural practices?<br>• What for peas and beans are known? What are their cultural hints. | • Enlist the major Solanaceous vegetables grown in India and their important varieties.<br>• Enlist major Cucurbitaceous vegetables of India and their major problems.<br>• Enlist major Cole vegetable crops of India and their major cultural practices.<br>• Enlist major leafy vegetables and their major cultural practices.<br>• Enlist major beans and their diseases. | **Interactive lecture:**<br>• Different cultural requirements of Cole, Solanaceous, Cucurbitaceous, and leafy vegetables and peas and beans grown in India.<br>• Identification of major diseases and pests.<br>**Activity:**<br>• Plan a visit to some vegetable growing areas and interact with growers for identification of pests, diseases and disoders. Also learn about transplanting of seedlings. |

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| | • Cultivation of major flower crops. | • What are important flower crops of India and their cultural requirements. | • Enlist major varieties of rose, tuberose and marigold.<br>• Demonstrate pruning in rose.<br>• Demonstrate disbudding in flowers. | **Interactive lecture:**<br>• Different cultural requirements of flowers like rose, marigold, tuberose etc.<br>**Activity:**<br>• Interact with gardener of your area and learn budding, pruning, disbudding in roses and other floricultural crops. |
| | • Cultivation of spices. | • What major spices and their cultural requirements? | • Enlist major spices grown in India.<br>• Enlist atleast one variety of major spices grown in India.<br>• Enlist major problems of seed spices. | **Interactive lecture:**<br>• Different cultural requirements of spices such as coriander, black pepper, turmeric etc.<br>**Activity:**<br>• Interact with some grower and learn how to plant these crops. |
| **Unit Code: 03** | **Unit Title: Animal Husbandry and Dairying** | | | |
| **Location: Classroom and field** | **Learning Outcome** | **Knowledge Evaluation** | **Performance Evaluation** | **Teaching and Training Methods** |
| | • Nutritional requirement of livestock. | • What are different types of nutrients required by livestock?<br>• What are different factors affecting nutritional requirement of livestock? | • Enlist important nutrient required by livestock.<br>• Enlist factors affecting nutritional requirement of farm animals. | **Interactive lecture:**<br>• Study of different nutrients required by livestock and factors which affect it<br>**Activity:**<br>• Visit some dairy/ goat/sheep/ poultry farm and learn about feed and fodder given to them. Also note down the nutrients and their compositions of |

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| | | | | feed in the dairy. Also interact with animal owners/ rearers to learn about water and feeding requirements of cow, buffalo, sheep, goat and poultry. |
| | • Breeding of livestock. | • What are different breeding methods of livestock?<br>• What are advantages and disadvantages of inbreeding and outbreeding? | • Describe different methods of breeding of farm animals.<br>• Enlist advantages and disadvantages of inbreeding and outbreeding. | **Interactive lecture:**<br>• Study of different breeding methods of livestock and their advantages and disadvantages.<br>**Activity:**<br>• Visit some livestock farm and learn about semen collection for breeding of livestock. |
| | • Product and byproducts of livestock and their untilization. | • What are major byproducts of livestock?<br>• What are major nutrients present in byproducts of meat?<br>• How best the byprodcuts are utilized? | • Enlist major byprodcust of meat industry and poultry.<br>• Enlist major nutrients available in the meat byproducts.<br>• Discuss the utilization of meat byproducts. | **Interactive lecture:**<br>• Study different byproducts of meat, fish and poultry industry and their nutritional composition.<br>**Activity:**<br>• Visit some unit/ industry which is utilizing the byproducts of meat, fish or poultry industry. |
| | • Major diseases of livestock and their management. | • What are major diseases of livestock and how these are managed? | • Enlist major diseases of livestock and their management methods. | **Interactive lecture**<br>• Study of symptoms of major diseases of cow, cattle and poultry and methods to control them. |

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| | | • What are major diseases of poultry and how these are managed?<br>• What vaccines and what do's and don'ts are required in immunization of livestock? | • Enlist major diseases of poultry and their management methods.<br>• Vaccination of livestock and do's and don'ts in vaccination. | • Vaccination of livestock.<br>**Activity:**<br>• Plan a visit to dairy/goat/ sheep/poultry farm and observe symptoms of different diseases Also interact with animal owners/ rearers and learn about the vaccination of livestock. |
| **Unit Code:04** | **Unit Title: Post Production Handling, Packaging and Processing of Animal Products** | | | |
| **Location: Classroom, laboratory and field** | **Learning Outcome** | **Knowledge Evaluation** | **Performance Evaluation** | **Teaching and Training Methods** |
| | • Understanding about major food products obtained from animals. | • What are major food products obtained from animals?<br>• Importance of foods of animal origin. | • Enlist the major products obtained from animals.<br>• Nutritional importance of animal foods. | **Interactive lecture**<br>• Foods obtained from animal sources.<br>**Activity:**<br>• Visit a market and find out the various foods available of animal origin. Find out the preferences of individuals for these foods. |
| | • Overview of milk and milk products. | • What is milk? Why is it termed as a complete food?<br>• What are the factors that govern the classification of different types of milk? | • Enlist various animals from where milk can be procured.<br>• Give the classification of milk. | **Interactive lecture:**<br>• Classification of milk.<br>• Processes involved in liquid milk handling.<br>• Major processed dairy products. |

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| | | • How is liquid milk processed?<br>• What are the major milk products? | • Enlist the major steps involved in milk handling.<br>• Give different ways of thermal processing of milk.<br>• Enlist the major milk products. | **Activity:**<br>• Plan a visit to a milk collection centre at the village level. Observe the mode of transportation of the milk to the processing plant and observe the various unit operations involved in milk handling. |
| | • Technical know how of the processing steps involved for developing various dairy products. | • What are basic steps of cheese manufacture?<br>• How is ice cream made?<br>• Discuss the steps involved in milk powder manufacture.<br>• Which are the indigenous dairy products?<br>• What is paneer and how is it made?<br>• How are dahi and shrikhand made?<br>• What are the steps involved in butter and ghee manufacture?<br>• How do you classify khoa? | • Define cheese and ice cream.<br>• Enlist the major steps involved in manufacture of cheese.<br>• Give a flowsheet for the ice cream manufacture.<br>• Give details of milk powder manufacture.<br>• Describe the technology of paneer manufacture.<br>• Differentiate between sweet and sour dahi.<br>• Describe the BIS standards for these products.<br>• Enumerate the steps involved in butter and ghee manufacture.<br>• Classify khoa on basis of its usage. | **Interactive lecture:**<br>• Development of different milk products.<br>**Activity:**<br>• Plan a visit to a milk processing plant and observe the scheme of operations involved for development of various dairy products. |

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| | • Understanding the processing technology for meat and meat products. | • What is the importance of meat in the diet?<br>• What are the steps involved in chicken production?<br>• What is mutton? Discuss the steps involved in its manufacture. | • Highlight the significance of meat in the diet.<br>• Enlist the steps involved in chicken production.<br>• Draw a flowsheet for the manufacture of mutton. | **Interactive lecture:**<br>• Importance of meat and the major meat products available.<br>**Activity:**<br>• Visit a meat processing plant and observe the various unit operations involved in its manufacture. |
| **Unit Code: 05** | **Unit Title: Seed Production and Nursery Management** | | | |
| **Location: Classroom and field** | **Learning Outcome** | **Knowledge Evaluation** | **Performance Evaluation** | **Teaching and Training Methods** |
| | • Quality seed. | • What is seed?<br>• Quality seed and its role in agriculture.<br>• What is the difference between seed and grain. | • Defined the seed.<br>• Attributes of quality seed and major role of quality seed in agriculture.<br>• Different aspect of seed will be compared with grain. | • Different definition of seeds.<br>• Explanation of various attributes of quality seed and importance of quality seed in different situations.<br>• Discussion on vitality, purity, objectivity and treatment etc. |
| | • Flower biology. | • Wheat are the part of flower, types of flower and pollination. | • Part of the flower, perfect or imperfect flower.<br>• Definition of pollination and types of pollination. | • Different part of the flower will be demonstrated.<br>• Pollination and its different types with suitable example will be discuss.<br>**Activity:**<br>• Visit of flowering plants in garden and fields to demonstrate the attributes of the flowers. |

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| | • Mechanism favored self and cross pollination. | • What are the different mechanism favored self pollination?<br>• What are the different mechanism favored cross pollination? | • Different mechanism responsible for self pollination with example.<br>• Different mechanism responsible for cross pollinate with example. | **Interactive lecture:**<br>• Different mechanism favored self and cross pollination will be explained with appropriate example.<br>**Activity:**<br>• Plan a visit to some crop growing area. |
| | • Stage of seed multiplication. | • Different stage of seed multiplication. | • Multiplication and tag of different stage of seed. | **Interactive lecture:**<br>• Different stage of seed multiplication in practice shall be discussed with the responsibility of production and colour/size tag etc.<br>**Activity:**<br>• Plan a visit of seed production farmer or seed processing unit. |
| | • Requirement quality seed production. | • Different steps involved in seed production and quality control. | • Enlist major steps in seed production.<br>• Enlist methods of drying.<br>• Seed testing. | **Interactive lecture:**<br>• Various steps involved in quality seed production under field condition will be discussed.<br>**Activity:**<br>• Plan a visit of seed testing laboratory |
| | • Rearing of honeybees. | • What are major types & castes of honeybees and which is best suited for domestication? | • Enlist major species & castes of bees.<br>• Enlist major items required for bee rearing. | • Different types & castes of honeybees and material required for rearing of honeybees. |

| Unit Code: 06 | Unit Title: Entrepreneurial Skill Development | | | |
|---|---|---|---|---|
| **Location: Classroom and field** | **Learning Outcome** | **Knowledge Evaluation** | **Performance Evaluation** | **Teaching and Training Methods** |
| | | • What are the major requirements for apiculture? | • Demonstrate extraction of honey from beehive. | **Activity:**<br>• Visit some Apiculture unit and learn about extraction of honey from a beehive. |
| | • Rearing of lac insects. | • What are major lac insects and host plant for their rearing?<br>• What are the major lac products? | • Enlist major lac insects and their host plant used for lac culture.<br>• Enlist major lac products?<br>• Demonstrate extraction of lac from lac-infected twig. | • Different species and host plants for lac insect.<br>**Activity:**<br>• If possible arrange visit for some lac culture unit and learn about extraction of lac. |
| | • Rearing of silk worms. | • What are major host plants for silkworm rearing?<br>• What are the major steps for silk worm rearing? | • Enlist silk worms and host plants for sericulture.<br>• Enlist steps involved in silk worm rearing.<br>• Demonstrate extraction of silk from silkworm cocoon. | • Different steps of sericulture.<br>**Activity:**<br>• Arrange a visit of sericulture farm and learn the how worms eat and make cocoons which are at last used for extraction silk. |
| | • Rearing of fishes. | • What are major fishes selected for pisciculture?<br>• What are important points to be considered for pisciculture? | • Enlist major fish species used in pisciculture.<br>• Enlist major points considered during pisciculture. | • Different requirements for pisciculture.<br>• Different points to be remembered for pisicuclture.<br>**Activity:**<br>• Plan a visit to a pisiciculture unit and learn about feeding, cleanliness, egg laying etc. |

| | | | | |
|---|---|---|---|---|
| | • Growing of mushrooms. | • What are different types of mushrooms and their cultivation requirements.<br>• What are different methods of preservation of mushrooms. | • Enlist major species of mushrooms grown in India.<br>• Enlist major methods of preservation of mushrooms.<br>• Demonstrate preparation of compost and sowing of mushroom seed. | • Different steps for growing mushrooms.<br>**Activity:**<br>• Plan a visit to a mushroom growing unit and learn the process of compost making and sowing seeds of mushrooms. |
| | • Importance of biogas & biofertilizers. | • What are major advantages of using biogas.<br>• What is the importance of biofertilizers & their different types. | • Enlist major advantages of using biogas.<br>• Enlist different types/sources of biofertilizers. | • Different microbes used in making biofertilizers.<br>**Activity:**<br>• Take the students to an institute which makes biofertilizers and try to learn the process of using microbes for making biofertilizers. |
| | • Value addition in horticultural produce | • What are different value products of horticultural produce and how they differ from each other. | • Enlist different value added products which can be made from different produced from different fruits & vegetables.<br>• Differentiate between jam and jelly, preserve and candy; and glazed fruit and crystallized fruit.<br>• Demonstrate making of jam in the class. | **Activity:**<br>• Go to market and make a list of value added products seen there.<br>**Activity:**<br>• Go to a processing unit and learn to make jam, jelly, preserve, candy, pickle and suace etc. |

| | | | | |
|---|---|---|---|---|
| | • Terrarium and ornamental fish farming | • What are different components of a terrarium?<br>• What are advantages of ornamental fish farming? | • Enlist the components of terrarium.<br>• Enlist major countries of world and cities of India where ornamental fish farming is an emerging enterprise. | **Activity:**<br>• Plan a visit to garden where terrarium is available and learn how to make it.<br>**Activity:**<br>• Go to Aquarium where ornamental fishes are available. Make a list of ornamental fishes available there and the basic requirements for their farming. |

# CHAPTER – 1

# AGRICULTURAL PRODUCTION AND MANAGEMENT

## Learning objectives

After reading this chapter, students will be able to:

- Understand about major food grain crops including cereals, oilseeds and pulses as well as fodder and commercial crops.
- Gain a science-based overview of agriculture and food systems.
- Enrich themselves about production technology of major food crops of India.
- Disseminate the knowledge about agricultural production and management at household and village level.
- Contribute in agricultural production at household and community level.

## Introduction

Agricultural production and management emphasizes the application of the principles of science and management to agricultural production operations. Agricultural production and management involves the combination of land, water, labour, and other inputs such as seeds, nutrients, pesticides, and machinery in the production of food and fiber crops. Agricultural production and management deals with how the farmers combine land, water, farm inputs, labour, and their management skills into practices to produce agricultural crops. During post green revolution era, India has become self-sufficient in food-grain production when considerable advances in crop improvement and crop production were made by the agricultural scientists. In the nutshell, agricultural production and management has a vital role in food production, farm income enhancement, food security, nutritional security poverty alleviation, rural employment and sustainable agriculture in the developing world.

## Crop Production Practices

Crop production practices are of utmost importance for successful and economic cultivation of field crops and national food security at large. Current agriculture direly needs scientific and rational crop production practices to enhance farm productivity with long-term sustainability. Crop production practices can be divided into various categories that farmers make to produce food, fodder and fiber, etc. The major ones are:

**Soil and crop management:** It deals with deciding what crops and varieties to grow and in what sequence to utilize the soil's productive capacity, and what tillage, cultivation, and soil conservation measures to undertake to physically till and preserve the soil and conserve moisture in a particular agro-ecology.

**Nutrient management:** It deals with determining the additional nutrients the soil needs for crop growth, and applying agricultural resources, animal manure, compost, or commercial fertilizers in appropriate forms, amounts, and ways that foster crop yields and farm profitability, while reducing nutrient loss to the environment.

**Water management:** It deals with determining the water needed for crop growth and applying that water efficiently, considering water availability, drainage, and offsite water quantity/quality impacts.

**Weed management:** It deals with determining the weed threats to crop growth, yield, and quality and the management practices to control them in field crops.

**Pest management:** It deals with determining insect-pest and disease threats to crop growth, yield, and quality and the preventive or remedial measures to control them besides keeping the food and environmental safety.

## Crop Production Seasons

Primarily, there are three crop production seasons in India *viz. Kharif, Rabi and Zaid*.

***Kharif* season crops:** The *Kharif* crop is the summer crop or monsoon crop in India. *Kharif* crops are usually sown with the beginning of the first rains in June-July, during the south-west monsoon season. Major *Kharif* crops of India include: rice, maize, sorghum, mungbean, groundnut, cotton, soybean, etc.

***Rabi* season crops:** The *Rabi* crop is the winter season crop in India. It is sown in October-November and harvested in March-April every year. Major *Rabi* crops in India include: wheat, barley, oats, mustard, peas, etc.

***Zaid* season crops:** This crop is grown in some parts of the country during March to June. Major *Zaid* crops in India include: frenchbean, muskmelon, watermelon, bittergourd, pumpkin, ridgegourd, etc.

## Classification of Agricultural Crops

The broader classification of the agricultural crops on the basis of their economical use is described as under:

- **Cereal crops:** Rice, wheat, maize, sorghum.
- **Pulse crops:** Pigeonpea, urdbean, mungbean, kidneybean, cowpea, chickpea, lentil, pea, etc.
- **Oilseed crops:** Soybean, rapeseed & mustard, groundnut, sunflower, sesame, safflower, etc.
- **Fodder crops:** Berseem, red clover, lucerne, etc.

- **Fibre crops:** Cotton, jute, mesta, etc.
- **Commercial crops:** Sugarcane, tea, coffee, etc.

## Production and Management of Cereal Crops

Cereals crops are members of the grass family and refer to crops which are harvested for dry grains only For example, rice, wheat, maize and sorghum. Among these cereals, rice, wheat, maize are the major cereal crops of India. Cereals are high in carbohydrates and protein along with traces of minerals and vitamins. The agricultural production and management of three major cereal crops viz. rice, maize and wheat is described as under:

## RICE

Rice (*Oryza sativa*) is the staple food for more than 3 billion people in the world. Globally, rice is grown in more than 100 countries, with an area of 154 million ha and production around 600 million tonnes and productivity is 3.9 tonnes/ha. Among the rice growing countries (Fig. 1), India has the largest area under rice in the world. In respect of production, however, India takes second position with 131.2 million tonnes of coarse rice. In India, rice is cultivated on 44.6 million ha area with a production of 132 tonnes and average productivity of 2.97 tonnes/ha. It is grown in almost all the states in India, with Uttar Pradesh, West Bengal and Punjab being leading states in area, production and productivity, respectively (Fig. 2). Punjab has the highest productivity of rice among all the states. Around 90% of the rice in the World is grown in Asia. Rice provides about 29.4% of total calories/capita/day in Asian countries. Milled rice contains usually 6-7% protein. The fat content in rice is low (2.0-2.5%) and much of fat is lost during milling.

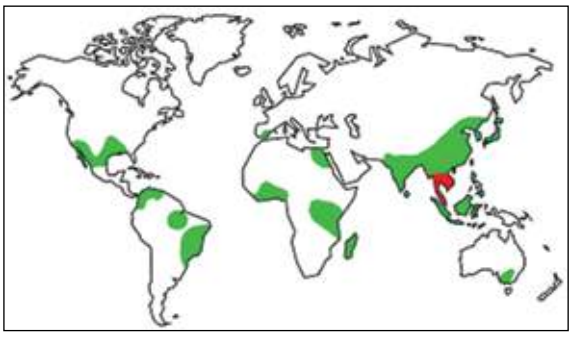


*Fig. 1. Global rice growing areas.*

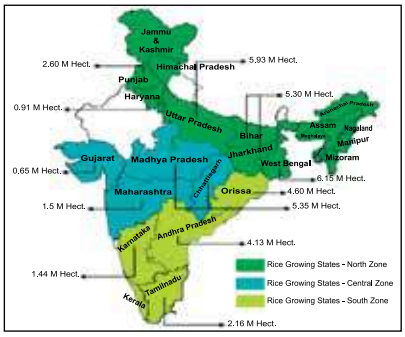



*Fig. 2. Major rice growing states of India*

## Climatic and Soil Requirements

Rice cultivation extends from sea level to as high as 3000 m above mean sea level (amsl) in India. High temperature, high humidity and high rainfall have considerable effect on growth and development of rice plant. Rice crop is grown during *Kharif* season in

north-western plains zone, but in south and north-eastern parts of the country, it is grown in all the three seasons, as these areas do not have very cold weather during winter. Rice crop needs a hot and humid climate. It is essentially a $C_3$ plant.

The wide range of agro-climatic conditions suggests an equally wide variety of soils. As regards texture, rice is grown on loamy sands in Punjab to heavy clay loams or clays in Andhra Pradesh and some other states. Soils having good water holding capacity with good amount of clay and organic matter are ideal for puddled rice.

## Rice Eco-systems in India

Rice farming is practiced in several agro-ecological zones in India. No other country in the world has such diversity in rice ecosystems than India. Rice cultivation in India is done in four distinct types of ecosystems:

- Irrigated rice eco-system
- Rainfed upland rice eco-system
- Rainfed lowland rice eco-system
- Flood prone rice eco-system

*A view of rice based cropping systems in India*

Rice cropping pattern in India vary widely from region to region and to a lesser extent from one year to another year depending on a wide range of soil and climatic conditions. Some of the rice based cropping patterns being followed in the country are: Rice-wheat, rice -wheat-mungbean, rice-toria-wheat, rice-toria/chickpea, rice-wheat/barley/potato, rice -potato-blackgram, rice -pea-greengram and rice-rice-rice

## Recommended Varieties

A good number of rice varieties/hybrids having resistance to various biotic and abiotic stresses and grain quality have been developed in India (Table 1). Some of the improved cultivars of rice are described as under:

**Table 1. Important rice cultivars recommended for different states.**

| Cultivar type | Rice cultivars |
|---|---|
| Hybrids | APHR 1, DRRH-3, PA 6201, Pusa RH 10, HRI 120, Sahyadri-2, UPRH 27, Rajalaxmi, Pant Sankar Dhan 1, Pant Sugandh Dhan-17, PHB 71 |
| Basmati / scented varieties | Basmati 370, Pusa Basmati 1, Taraori Basmati (Karnal local), Pusa Sugandh 3, Pusa Sugandh 4, Pusa Sugandh 6, PRH 10, Pant Dhan 15, Punjab Basmati-1, Pusa Basmati 1121, Pusa Basmati 6, Pusa Basmati 1509 |
| Other improved varieties | Mahamaya, GK 5003, Pusa 33, Pusa 169, Mehsuri, JKRH-401, Gurjari, GR-6, Dandi, HKR-127, Bhrigu Dhan, Himalaya 2216, SKAU 23, SKAU 27, GK 5003, Gauri, Sweta , Ratnagiri 24, Rajeshwari, PR 108, PR 109, PMK 2, Pant Dhan 10, Pant Dhan 11, VL Dhan 221, IR 20, Jayanthi |

## Methods of Cultivation

Rice is generally grown under dry or wet cultivation methods, which are briefly described below:

**a. Dry cultivation**

1. Direct seeded rice

Rice is sown directly in dry soil (dry seeding) or wet soil (wet seeding), and irrigation is given to keep the soil sufficiently moist for good plant growth, but the soil is never flooded. Dry system of rice cultivation is followed in uplands. Sowing of rice is usually done in May-June in the case of the crop dependent on south-west monsoon and in September for the crop dependent on north-east monsoon. Three methods are commonly followed in sowing dry and semi-dry crop. These are broadcasting, drilling or sowing in furrows behind country plough, and dibbling in general, a seed rate of 30-50 kg $ha^{-1}$ is required for drilling, while 60-100 kg $ha^{-1}$ is required for broadcasting. A row spacing of 15-20 cm is optimum for upland rice. There are mainly two methods of direct seeding.

- **Dry seeding:** In dry seeding, seed is directly sown in dry soil either by seed drill or broadcasting of un-sprouted seed in well prepared and leveled dry soil.
- **Wet seeding:** In wet seeding, seed is directly sown in puddled soil either by drum seeder or broadcasting of sprouted seed in wet soil.

2. Aerobic rice

It is a high-yielding rice, grown in non-puddled, aerobic soils under irrigation and high external inputs. Irrigation is applied when the soil becomes dry, and the quantity of

applied water is sufficient to bring the soil to field capacity. The realization of water savings combined with high yields depends on good water management. Dry seeding of rice can be done by drilling the seed into a fine seedbed at a depth of 2–3 cm. Weed management is a critical factor in aerobic rice. Timely application of herbicides and two or three hand-weeding may provide effective control. Seeding under dry situations is done in three different ways viz. drilling, dibbling, and broadcasting.

**b. Wet cultivation**

Conventional rice cultivation

The conventional rice cultivation is a wet system of cultivation and rice is grown under wet season right from the start. In this system, the field is brought to a soil puddle by repeated ploughing with 5-7 cm standing water. After getting the requisite puddle, rice seedlings are transplanted or sprouted seeds are direct seeded. The seedlings of rice are grown in nursery before transplanting.

**Transplanting operation**

Time of planting is the most important factor influencing the yield of the crop. In general, timely transplanting of 20-25 days old seedlings in wet season is ideal. In general, 20 cm × 10 cm, 20 cm × 15 cm or 15 cm × 15 cm spacing is ideal in transplanted rice. For realizing the yield potential of high yielding varieties of rice, 2-3 seedlings per hill is generally recommended. In rice hybrids where the tillering is more profuse, 1-2 seedlings per hill is sufficient. Depth of transplanting rice seedlings is 2-4 cm.

**System of Rice Intensification (SRI)**

SRI is an unusual innovation that can raise productivity of land, labour, water, and capital invested in irrigated and rainfed rice production. SRI has evoked considerable interest among Agronomists over last decade and posed interesting research issues. SRI may prove as a boon to enhance productivity while using less seed and irrigation water than conventional rice farming. The SRI essentially comprises the following methodological components:

- Shallow (1–2 cm) transplanting of young seedlings at the two-leaf stage into a moist seedbed.
- Transplanting of single rice seedling at 25 cm × 25 cm spacing.
- A minimum of three hand weedings at 10–12, 22–25 and 40–42 days after transplanting.
- Farmers may use mechanical weeding tool called weeder to remove weeds and aerate soil surface.
- Alternation of wetting and drying of the field for soil aeration during vegetative growth.

- Addition of organic manures to supply adequate nutrients and to improve soil structure. If necessary, chemical fertilizers may be used as a supplement.

*A view of field showing system of rice intensification (SRI)*

## Nutrient Management

Adequate supply of all the essential plant nutrients is a must for getting good yield of rice. A dose 100-150 kg N/ha is generally recommended for high yielding varieties of rice. A dose of 45-60 kg $P_2O_5$/ha and 40 kg $K_2O$/ ha is generally recommended for rice. Zn deficiency in rice-growing areas of India is widespread. Zinc sulphate @ 20-25 kg/ ha is generally recommended in zinc-deficient soils.

## Water Management

Rice is the largest consumer of water; about 3000-5000 litres water is required to produce 1 kg rice. The principal water loss processes from paddy fields are *via* run-off, percolation, seepage and evapotranspiration or consumptive water use. The submergence (2-5 cm) throughout the crop growth period is conducive to higher yields. Under water scarcity, the practice of intermittent submergence during the critical stages (tillering, flowering) and maintenance of saturation or field capacity in rest of the growth stages is recommended.

## Weed Management

Hand weeding is most widely used method for controlling weeds in rice. Normally two weedings are done. Time of weeding slightly varies in different regions but weedings are generally done within 15 to 45 days after sowing. Weeding with some implements such as hand hoes, weeders and bullock drawn desi plough can be done to control weeds in rice. Use of herbicides is gradually increasing in rice culture. Herbicides are expensive to small farmers but not to the large farmers who face the problem of labour shortage (Table 2).

**Table 2. Chemical weed management in rice**

| Rice | Herbicides | Dose (kg a.i./ha) | Application time and remarks |
|---|---|---|---|
| Rice nursery | Butachlor | 1.0-1.5 | Pre-emergence at 5-6 days after sowing (DAS); If moisture is less in soil, irrigation should be done immediately. |
| | Pendimethalin | 1.0-1.5 | Pre-emergence at 5-6 DAS; If moisture is less in soil, irrigation should be done immediately. |
| | Pretilachlor (S) | 0.3-0.4 | Pre-emergence at 3-5 DAS. |
| Direct-seeded upland rice | Butachlor | 1.0-1.5 | To be applied before emergence of crop; One hand weeding at 30-35 DAS will supplement herbicide treatment. |
| | Pendimethalin | 1.0-1.5 | To be applied before emergence of crop; One hand weeding at 30-35 DAS will supplement herbicide treatment. |
| | Pretilachlor (S) | 0.3-0.4 | Pre-emergence at 3-5 DAS. |
| | Metsulfuron-methyl | 0.010-0.015 | Post-emergence at 30-35 DAS; basically a broad-leaved weed killer and recommended as a substitute of 2,4-D. |
| Direct-seeded puddled and transplanted rice | Butachlor | 1.0-1.5 | Pre-emergence at 3-5 days after transplanting (DAT) on saturated soil; No irrigation or standing water impounded for at least 3 days after treatment. |
| | Pendimethalin | 1.0-1.5 | Pre-emergence at 3-5 DAT on saturated soil; No irrigation or standing water impounded for at least 3 days after treatment. |
| | Pretilachlor (S) | 0.3-0.4 | Pre-emergence at 3-5 DAT. |
| | Metsulfuron-methyl | 0.010-0.015 | Post-emergence at 30-35 DAS; basically a broad-leaved weed killer and recommended as a substitute of 2,4-D. |

## Disease Management

To overcome the diseases, the seed should be disease free. For fungal and bacterial diseases, seed should be treated with bavistin @ 2g kg-1 seed. Fungicides can be sprayed to control a diseases (Table 3).

**Table 3. Symptoms and management of important diseases of rice in India**

| Disease and its causal organism | Symptoms | Management |
|---|---|---|
| Leaf and neck blast | Initial symptoms on the leaves are white to grayish green circular lesions/spots with dark green borders, which may enlarge and coalesce to kill the entire leaves. Lesions on the neck cause the girdling of the neck and the panicle to fall over. | • Early sowing of seeds and balanced use of fertilizers.<br>• Planting resistant varieties against the rice blast is the most practical and economical way.<br>• Systemic fungicides are effective against the disease. |
| Bacterial leaf blight | Water-soaked to yellowish stripes on leaf blades or starting at leaf tips. Severely infected leaves tend to dry quickly. | • Field sanitation such as removing weed hosts, rice straws, ratoons, and volunteer seedlings.<br>• Use of resistant varieties.<br>• Seed treatment with bleaching powder (100µg/ml) and zinc sulfate (2%) reduce bacterial blight. |

## Pest Management

Most of the rice pests are distributed throughout India, however, only a few pests are economically important in different regions. Agronomic practices and use of resistant cultivars should be given preference for pest management. The use of selective pesticides should also be stressed for efficient pest management (Table 4).

**Table 4. Important insect pest, nature of damage and pest management in rice**

| Insect-pest | Nature of damage | Management |
|---|---|---|
| Stem borer (yellow) | Symptoms of stem borer damage are deadhearts and whiteheads. Whiteheads are discolored panicles with empty or partially filled grains. Larvae feed on the tissues around the node. | • Adopt seedling root dip treatment in 0.05% chlorpyriphos emulsion for one minute before transplanting in endemic areas.<br>• Apply carbofuran 3G @ 20 kg $ha^{-1}$ or phorate 10 G @ 12.5 kg $ha^{-1}$ or fenitrothion 50EC @ 0.1%. |

| | | |
|---|---|---|
| Leaf folder | Caterpillars fold a rice leaf around them and attach the leaf margins together with silk strands. Folded leaves restrict photosynthesis. | • Use cultural practices like crop rotations, reduced planting density and balanced nutrition. |

### Harvesting, Threshing and Yield

The plant should be cut close to the ground at ripening and left for drying. Threshing can be accomplished by manual methods, pedal threshers or power driven stationary threshers. Combine machines can be employed for combined harvesting and threshing. The produce should be properly sun-dried. The optimum moisture content for storage of rice grains is 12%. A well managed crop of mid-late duration (135-150 days) varieties and hybrids yield about 6–7 t/ha, whereas short duration cultivars yield about 4.5–5.5 t/ha.

## WHEAT

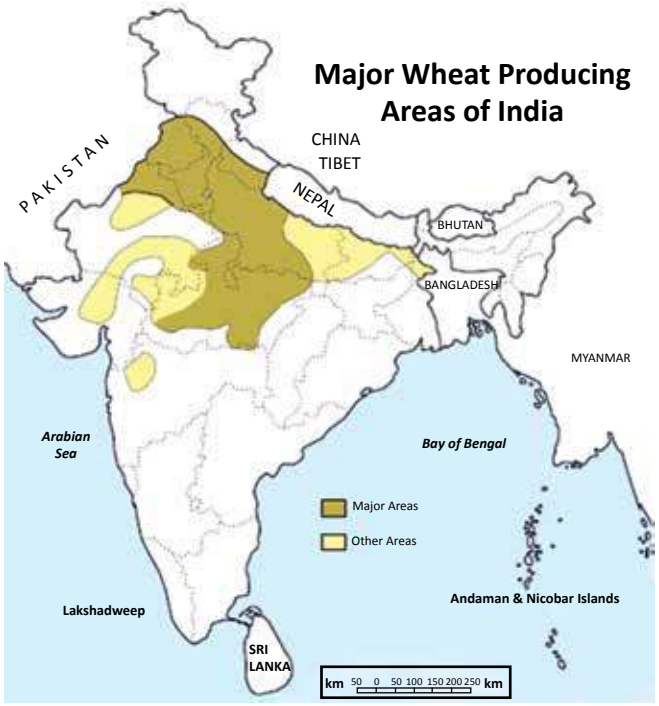
Wheat *(Triticum aestivum)* is the main *Rabi* cereal crop in India. The total area under the crop is about 29.8 million ha in the country. The production of wheat in the country has increased to an all time record high of 94.88 million MT in 2011-12. The productivity of wheat is 3140 kg/ha in 2011-12.

### Climatic and Soil Requirements

Wheat is grown over a wide range of latitudes ranging between 60°N and 60°S and altitudes ranging from sea level to 3500 m amsl in the tropics and subtropics. Normally, the most ideal conditions for wheat cultivation are cool and moist weather during the vegetative growth period and warm and dry weather during grain formation. The optimum temperature for the germination of wheat is between 20-22°C, though wheat grain can also germinate at 4°C. The optimum temperature for vegetative growth ranges from 16 to 22°C. During the grain development, wheat requires a mean maximum temperature of about 25°C for at least four to five weeks. Wheat grows well in those areas where annual rainfall ranges between 250 and 1800 mm. Wheat crop also cannot withstand extended periods of soil moisture stress. Rainfed wheat requires a minimum evenly distributed winter rainfall of 15 to 20 cm. Wheat is grown on a wide variety of soils.

### Major Cultivated Species of Wheat

- Common wheat or bread wheat (*T. aestivum*): A hexaploid species that is the most widely cultivated in the world.
- Durum wheat (*T. durum*): The tetraploid form of wheat and the second most widely cultivated wheat today.




## Seed and Sowing

Under irrigated timely sown condition, wheat sowing may be done in the first fortnight of November in north India and the middle of November in north-east and central India. Under late sown conditions, the wheat is sown in first fortnight of December. Rainfed wheat is generally sown from second fortnight of October to early-November to get maximum benefit from residual soil moisture. Seeds can be sown through broadcasting or in lines in rows 20 cm apart. Under normal conditions, a seed rate of 100 kg/ha is sufficient. Under late sown conditions, seed rate should be increased by 25 per cent. Irrigated wheat is spaced 22.5 cm between rows and 8-10 cm between plants. Rainfed wheat is spaced 25-30 cm between rows and 5-6 cm between plants. Seed depth should be around 5 cm.

*A wheat field*

## Nutrient Management

The general $N+P_2O_5+K_2O$ recommendations for irrigated and rainfed wheat are 120+60+30 kg/ha and 80+40+20 kg/ha, respectively. Full dose of phosphorus and potassium and half of nitrogen should be applied at the time of sowing, while remaining half dose should be top dressed in two equal splits one at first irrigation and other at flowering stage. Farmyard manure (FYM) or organic manures @ 10 t/ha at the time of sowing is beneficial for long-term fertility maintenance.

## Water Management

Wheat requires about 300-400 cm of irrigation water (4-6 irrigations), depending upon climatic factors, soil characteristics and the duration of the variety. If irrigation water is a constraint, then apply irrigation at critical stages (Table 5).

**Table 5. Number of irrigations based on the availability of water.**

| No of irrigations | Critical stages for irrigation |
|---|---|
| 1 | CRI |
| 2 | CRI + LJ |
| 3 | CRI + B + M |
| 4 | CRI + LT + F + M |
| 5 | CRI + LT + LJ + F + M |
| 6 | CRI + LT + LJ + F + M + D |

CRI – Crown root initiation (21 DAS), LT – Late tillering (42 DAS), LJ – Late jointing (60 DAS), F – Flowering (80 DAS), M – Milk (95 DAS), D – Dough (115 DAS).

## Weed Management

The critical period of weed competition in wheat is 30-45 days after sowing (DAS). Hand weeding with a *khurpi* or hand hoe after 20-25 DAS is used as conventional practice. A pre-emergence application of pendimethalin (Stomp 30 EC) @ 1 kg a.i./ha in 500-750 L/ha of water within 3 DAS provides a broad spectrum control of weeds in wheat. However, post-emergence application (25-30 DAS) of herbicides like sulfosulfuron @ 25 g/ha or fenaxaprop-p ethyl @ 100-120 g/ha is necessary for effective weed control.

## Disease Management

**Rusts:** Wheat is infected by brown, yellow and black rusts. Brown or leaf rust is caused by a fungus known as *Puccinia recondite tritici*. Yellow or stripe rust is caused by the fungus, *Puccinia striiformis*. Black or stem rust of wheat is caused by the fungus *Puccinia*

*graminis tritici*. For controlling rusts, treat the seed with *Trichoderma viride* @ 4 g/kg seed. Late sown crop is more susceptible to rust. Hence avoid late sowing of wheat. High nitrogen dose favours rust infection, whereas high potash dose reduces rust infection. Hence there is need for balanced fertilization. Spray the crop with propiconazole (Tilt 25 EC) @ 0.1% at yellow rust initiation. This spray will also help in the control of powdery mildew and Karnal bunt diseases. Second and third spray may be repeated with an interval of 10-15 days.

*Yellow rust*

*Loose smut*

*Karnal bunt*

**Loose smut:** Loose smut is caused by fungus *Ustilago nuda tritici*. Terminal symptom of loose smut is the production of black powder in place of wheat grains in the ears. As the ear formation starts, fungus accumulates in the floral parts, which are completely destroyed due to formation of the black powder. Loose smut can be controlled by growing loose smut resistant varieties. Seed treatment should be done with carboxin (Vitavax 75 WP) @ 1.25 g/kg seed. Uproot the infected plants, bury them underground or burn to avoid further field infection.

**Karnal bunt:** Karnal bunt or partial bunt is caused by fungus *Neovossia indica*. A portion of infected grain along its groove is converted into a black powdery mass. The black powder gives a foul smell due to presence of trimethylamine. Do not grow highly susceptible wheat varieties. One spray of propiconazole (25 EC) @ 0.1% at ear head emergence stage can be given to attain near complete control.

## Pest Management

**Termites:** The damaged plants dry up completely and can be easily pulled out. Infestation is heavy under unirrigated conditions and in the fields where undecomposed FYM is applied before sowing. Termites can be controlled by seed treatment with fipronil (Regent 5FS @ 0.3 g a.i./kg seed).

## Harvesting, Threshing and Yield

The most suitable stage for harvesting wheat is when plants are completly dry and the grains becomes hard and contain 20-25% moisture. Wheat crop harvested manually or by reapers, is dried for 3-4 days on the threshing floor and then threshing is done by threshers. A well managed crop may yield about 3.5 to 4.5 t grains/ha.

# MAIZE

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. It is the only grain crop with many types and grown for diverse purposes like normal yellow/white grain, sweet corn, baby corn, popcorn, quality protein maize (QPM), waxy corn, high amylase corn, high oil corn, fodder maize etc. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. In India, maize is the third most important food crops after rice and wheat. According to latest data of 2011-12, it is cultivated in 8.78 m ha mainly during *Kharif* season which covers 80% area. Predominant maize growing states collectively contributing to more than 80% of total national maize production are Andhra Pradesh (20.9%), Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%) and Himachal Pradesh (4.4%).

*A view of maize field*

## Climatic and Soil Requirement

Maize is grown globally from 50°N to 40°S, and from sea level up to 4000 m altitude. Maize crop requires good amount of moisture and can be grown in areas receiving well distributed rainfall of 500 to 1000 mm. It uses water more efficiently and relatively drought resistant from establishment to tasseling stage of the crop where it can stands with less moisture. Maize is relatively well adapted to a wide range of soils with pH 5.0 to 8.0. Maize can be grown successfully in a variety of soils, ranging from loamy-sand to clay-loam. Being a sensitive crop to excess soil moisture; it is desirable to have provision of proper drainage in maize.

## Maize Based Cropping Systems in India

Maize-wheat is the 3rd most important cropping systems after rice-wheat and rice-rice that contributes about 3% in the national food basket. The other major maize systems in India are maize-mustard, maize-chickpea, maize-maize, cotton-maize etc.

### Time of Sowing

Maize can be grown in all seasons viz; *Kharif* (monsoon), post monsoon, *Rabi* (winter) and spring. The optimum time of sowing are given below:

| Season | Optimum time of sowing |
|---|---|
| Kharif | Last week of June to first fortnight July |
| Rabi | Last week of October for inter cropping and up to 15th of November for sole crop |
| Spring | First week of February |

### Seed Rate and Plant Geometry

The seed rate depends on purpose, seed size, plant type, season, sowing methods etc. The following crop geometry and seed rate should be adopted.

| S. No. | Purpose | Seed rate (kg/ha) | Plant geometry (plant × row in cm) |
|---|---|---|---|
| 1 | Normal grain maize | 20 | 60 × 20 |
| 2 | Quality protein maize (QPM) | 20 | 60 × 20 |
| 3 | Sweet corn | 8 | 75 × 25 |
| 4 | Pop corn | 12 | 60 × 20 |
| 5 | Green cob (normal maize) | 20 | 60 × 20 |
| 6 | Fodder maize | 50 | 30 × 10 |

### Tillage and Crop Establishment

Generally, the raised bed planting is considered as best planting method for maize during monsoon and winter seasons both under excess moisture as well as limited water availability/rainfed conditions. Maize can also be successfully grown without any primary tillage under no-till situation with less cost of cultivation, higher farm profitability and better resource use efficiency.

### Nutrient Management

Application of 10-15 t FYM/ha alongwith NPK fertilizers @ 120-150 kg N, 60-80 kg $P_2O_5$, 60-70 kg $K_2O$ and 25 kg $ZnSO_4$ /ha is recommended in general for getting higher yield of HYV/hybrid maize. Full dose of P & K and half of N should be applied at the time of sowing, while remaining half N dose should be top dressed in two equal splits one dose at around knee high stage and other dose at tasseling stage of the crop keeping in view moisture availability in the field.

## Water Management

The irrigation water management depends on season as about 80% of maize is cultivated during monsoon season particularly under rainfed conditions. In general, the irrigation should be applied in furrows up to 2/3$^{rd}$ height of the ridges/beds. Young seedling, knee high stage, flowering and grain filling are the most sensitive stages for water stress and hence irrigation should ensured at these stages.

## Weed Management

Weeds are serious problem in maize particularly during *Kharif* season and they cause upto 35% yield losses. Thus, timely weed management is must to achieve higher yields. Pre-emergence application of atrazine (Atratraf 50 WP) @ 1.0-1.5 kg a.i./ha in 600 L water or pendimethalin (Stomp 30 EC) @ 1-1.5 kg a.i./ in 500-750 L is effective way for weed control. One-to-two hoeing are recommended for aeration and uprooting of the remaining weeds, if any.

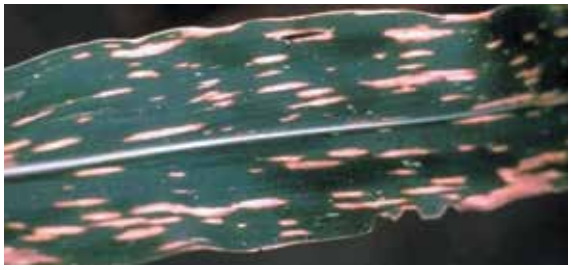
## Disease Management

The major diseases of maize and their management practices are described below:

***Turcicum* leaf blight**: The disease is prevalent in cooler conditions or with high humidity. Long, elliptical, grayish-green or tan lesions (2.5-15 cm) appear on lower leaves progressing upward. Resistant varieties alongwith need-based sprays of mancozeb @ 2.5 g/L (with adjuant @ 0.05%) at 8-10 days interval decreases its incidence.

***Maydis* leaf blight**: It is a major disease in the areas having warm humid temperate to tropical climate. Lesions on the leaves elongated between the veins, tan with buff to brown or dark reddish brown borders. Growing of resistant varieties with need based sprays of mancozeb or zineb @ 2.5g/L of water are recommended to control this disease.

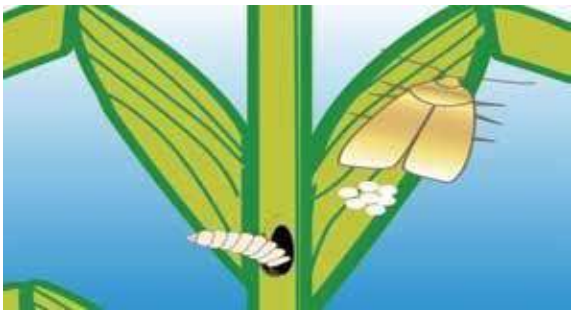
*Turcicum leaf blight*



*Maydis leaf blight*

## Pest Management

**Stem Borer**: Major pest of maize in India is stalk borer. Its attack occurs during monsoon season. It lays eggs 10-25 days after germination on lower side of the leaves. The larva of the *Chilo* enters in the whorl and cause damage in the leaves.



*Maize stem borer*

*Termites*

**Termites**: Termite is also an important pest in many areas especially zero-tilled maize. For control of termite, fipronil granules @ 20 kg/ha on termite appearance followed by light irrigation is the recommended practice. If the termite incidence is in patches, the spot application of fipronil @ 2-3 granules/plant should be done.

### Harvesting, Threshing and Yield

The crop acquires physiological maturity when black layer starts forming on the tip of the grains. The crop must be harvested at less than 22 to 25% moisture in grains with husk colour turning pale brown. The harvesting of the cob is done manually. After de-cobbing and threshing, the maize grains must be dried upto 12% moisture level for safe storage. A well managed maize HYV's and hybrid maize may yield about 4-5 and 5-7 t grains/ha, respectively.

## CHICKPEA

Chickpea (*Cicer arietinum* L.) is commonly known as gram or bengal gram in English and Chana in Hindi. It is predominantly grown as a rainfed crop, but irrigated in areas where irrigation facilities are available. Chickpea is mostly consumed in the form of processed whole seed or dal or as dal flour (besan). Chickpea is a good source of protein (18-22%), carbohydrate (52-70%), fats (4-10%), minerals (calcium, phosphorus, iron) and vitamins. Chickpea is known to have originated in western Asia (probably eastern Turkey). Desi types are grown predominantly in Indian sub-continent, East Africa and Australia. India ranks first in area and production of chickpea at world level. Chickpea in India occupies 7.89 million ha area, producing 7.06 million tonnes and a productivity of 895 kg/ha. The major chickpea producing states are Madhya Pradesh, Rajasthan, Uttar Pradesh, Maharashtra, Haryana, Karnataka, Andhra Pradesh, Gujarat, Bihar and West Bengal.

*Different types of chickpeas*

*A view of Chickpea field*

## Climatic and Soil Requirements

Chickpea is essentially a subtropical crop; it grows well in a wide range of climates. Chickpea is grown between 10°N to 32°N latitude in the country in the winter season. This crop with deep rooted system can be grown on residual soil moisture in areas with 600-1000 mm annual rainfall. Heavy rains at germination and flowering are detrimental to the crop. Chickpea is a long day plant requiring 12-16 hrs bright sunshine per day.

Chickpea is grown practically on a variety of soil types ranging from very light to heavy ones. In north India, it is cultivated on sandy-loam to clay-loam soils whereas in south on Deccan plateau and central India or Maharashtra, gram is raised on black cotton soils. The clay-loams are the best.

### Cropping Systems

Gram is grown mixed with wheat, barley, rapeseed and mustard crop. It is grown mixed with toria in tarai region. Gram is sown after the harvest of *Kharif* crops like paddy, maize, sorghum, pearlmillet etc. Gram in rotation with several crops helps in controlling soil-borne diseases. The most common rotations are: paddy-gram; pearlmillet-gram; sorghum-gram; maize-gram; *kharif* fallow-gram (in drylands).

### Improved Varieties

Some of the recently released varieties have resistance/tolerance to major diseases like wilt (Avrodhi, KWR 108, JG 74, JG 315, Vishal, Vijay, Pusa 391, Bharti, ICCC 32, Pusa 244) and *Ascochyta* blight (C 235, Pusa 261, Gaurav, GNG 146, GNG 469) besides being more productive. Early maturing varieties (PBG 1, Udai, Pusa 372) amenable for late planting under rice production system have been developed. Emphasis has also been laid on developing bold seeded genotypes both of Kabuli (Pusa 1003) and desi types (K 850, Pusa 256, Vishwas, Vishal, Pusa 362). Other important varieties of chickpea for different zones are: tolerance to salt (Karnal *chana* 1) and non-lodging under high input management (DCP 92-3) have also been released.

## Land Preparation

Gram needs cloddy and rough seed-bed for good aeration in root zone. Hence, little land preparation is required. Desired seed-bed may be obtained by a deep ploughing followed by two harrowing. A deep summer ploughing is essential for higher retention of moisture in soils where, the crop is grown on residual soil moisture as in *Haveli* system of Madhya Pradesh.

## Seed Rate and Spacing

Optimum plant spacing is 30 cm × 10 cm. The seed rate varies from 80-100 and 50-70 kg/ha in *kabuli* and *deshi* chickpeas. Under late sown conditions, the seed rate may be increased by 25-40%. *Kabuli* types are sown in rows 45 cm apart, while *deshi* types and late sown chickpeas are sown in 30 cm rows. Normally, 2-3 g fungicide (Carbendazim/ thiram/captan) per kg seed is recommended for seed treatment. The seed treatment of legumes is also done with *Rhizobium* culture to capitalize upon their intrinsic capability and potentiality to trap atmospheric nitrogen in the root nodules through biological nitrogen fixation (BNF).

## Time of Sowing

Planting time is the most important non-monetary input having profound effect on crop growth, phenological development, occurrence of pests and crop productivity. The sowing time varies in different states as given below.

| State | Rainfed | Irrigated |
|---|---|---|
| Punjab and Haryana | Second to third week of October | Fourth week of October to 15 November |
| Rajasthan | First to 15 October | 15-30 October in south and south-eastern Rajasthan; 25 October-15 November in Ganganagar district |
| Bihar and Gujarat | 15 October to first week of November | First fortnight of November |
| Madhya Pradesh Maharashtra, Uttar Pradesh, Karnataka, Jammu-Kashmir and Tamil Nadu | First fortnight of October | End of October to first week of November |

## Nutrient Management

Chickpea requires about 15-20 kg N, 30-60 kg $P_2O_5$ and 20-40 kg $K_2O$/ha as basal dose. Being legume, it fixes atmospheric nitrogen in association with *Mesorhizobium ciceri*. In order to meet the initial N requirement, a starter dose of 15-20 kg N is sufficient at the

time of sowing. Phosphorus is the most critical nutrient limiting chickpea production. In general, *kabuli* types require more P fertilizer than *deshi* chickpeas. Application of 20-30 kg/ha gypsum in acidic soils and sulphur in non-acidic soils is also necessary. Soil application of 20 kg $ZnSO_4$/ha is necessary for better crop performance in Zn deficient soils.

Dual inoculation with *Rhizobium* and phosphate solubilizing bacteria (PSB) is beneficial in chickpea cultivation. *Bacillus polymixa* and *B. megaterium* cultures are being commercially produced for inoculation. The symbiotic association between plant roots and mycorrhizal fungi has received greater attention in recent years. Dual inoculation with *Rhizobium* and VAM further increases root nodulation and yield.

### Water Management

Gram is mostly sown as a rainfed crop and is capable of extraction moisture from a depth >1 m, with most of its roots confined to top 2 feet soil. However, where irrigation facilities are available, give a pre-sowing irrigation (*palewa*). If winter rains fail, give one irrigation at pre-flowering stage and one at pod development stage. In no case, first irrigation should be given earlier than 4 weeks after sowing. The water requirement of the crop varies from 250-400 mm. Based on critical stages of irrigation, irrigate the crop at 4-6 leaves stage, at branching and pods formation stage.

### Nipping

To get maximum yield from irrigated gram crop, the nipping (removal of the top auxillary buds) is an essential operation. In this process, the apical buds of the crop is plucked, when the plants get height of 15-20 cm i.e. 50 days after sowing. By doing this, vegetative growth of plant stops and lateral branching is enhanced, thus the plants become more vigorous and produce more flowers and pods.

### Weed Management

Gram suffers severely by infestation of weeds. Planting time considerably influences the occurrence and manifestation of weed species. The initial four-to-eight weeks are most critical for weed competition and the first mechanical weeding has been advised 25-30 DAS, and the second at 45-50 DAS. Chemical weed control with pendimethalin as pre emergence @ 1.0 kg a.i./ha followed by one hoeing it 45 DAS has been proved effective. Intercropping chickpea with mustard reduces weed menace drastically.

### Disease Management

Some important diseases causing substantial loss in chickpea production in India are as follows:

**Wilt:** The disease generally appears after three weeks of sowing. Internal tissues from the collar region downwards become dark and discolored. The petioles and rachis

alongwith leaflets droop down. Dropping starts from the upper part of the plant but soon the entire plant droops down. Sometimes only partial wilting of plants may occur. Crop rotation, rouging out the infected plants from the field, and treating the seeds before sowing with 0.2% thiram or captan or bavistin 50% @ 250 g/q seed minimizes disease infestation.

***Ascochyta* blight**: It is an air-borne fungal disease caused by *Ascochyta rabiei*. Small circular brown spots appear on the leaves. These spots have discoloured margin. Later black minute dots appear on necrotic lesions arranged in circles. High humidity favours this disease. Use of tolerant varieties, rouging out the infected plants, seed treatment and spraying the crop with 0.2% captan or dithane Z-78 are the recommended control measures. Seed treatment with bavistin @ 2.5 g/kg seed or with *Trichoderma viride* @ 4 g + vitavax @ 1 g by making a paste in 5 ml of water per kg seed is also effective for root rot and blight.

### Pest Management

**Gram pod borer**: The young larvae feed for a short period on tender organs of the plant. With the pod formation, larvae feed on developing seeds after cutting a round hole in the pod and pushing its head inside the pod. Pod borers generally feed on the leaves, buds and pods. Spraying of the crop with insecticides such as chlorphyriphos 0.07% or with botanical pesticides like neem seed kernel extract 5%, nimbecidin, neemex, achook or other neem based products or microbiol products like NPV 250 LE per hectare provides effective control against gram pod borer.

**Cutworm**: The insect remains hidden during day and becomes active during night. The caterpillar cut the plants at the base, below or just above the soil surface or may even cut branches. Cut worm and pod borer are major pest of chickpea. The cultural practices involve ploughing up the field after harvesting the crop to expose hibernating pupae of *Agrostis* and *Helicoverpa*, clean cultivation, removing plant debris, early planting, intercropping with mustard, linseed, safflower etc. Need based application of insecticides at appropriate time is necessary.

### Harvesting, Threshing and Yield

In north Indian plains, crop matures in 150-160 days, whereas in central and south zone crop matures in 120 to 125 days. Crop becomes ready for harvest when leaves turn reddish-brown and start shedding. Plants are either plucked out by hand or cut with sickle. The crop is allowed to dry in sun and on threshing floor in about 5-6 days. Therefore, threshing is done either by beating the plant with stick or by trampling under the feet of bullocks. A well managed *deshi* chickpea yields about 20-25 q grain/ha, while *Kabuli* types yield 25-30 q/ha under irrigated conditions. Under rainfed conditions, the crop yields 30-50% of that of irrigated crop.

# PIGEONPEA

In India, pigeonpea (*Cajanus cajan* L.) occupies about 90% of global area and 85% of world production. Pigeonpea or redgram is commonly known as *arhar* or Tur in Hindi. It is the second most important pulse crop in India next to chickpea with respect to area and production. Pigeonpea seeds used as *dal* are rich in protein (21%), iron and iodine. They are also rich in essential amino acids like lycine, tyrocene, cystine and arginine. Pigeonpea being a legume possesses valuable property as restorer of nitrogen in soil. It is mainly a *kharif* crop. With the development of short duration varieties, the cultivation of pigeonpea in summer season is also receiving attention particularly in the intercropping systems in north and north-eastern states. India has the largest area (3.38 million ha) under pigeonpea. Maturity duration of pigeonpea varies from about 90 days for extra-early varieties to more than 260 days for late maturing varieties that fit well in various niches and cropping systems.

*A view of Pigeonpea field*

## Climate and Soil Requirements

Pigeonpea is a crop of arid and semi-arid climates grown between 30°N and 35°S latitudes and thrives well in areas with 500-1000 mm of rainfall. Its drought hardy nature due to deep tap root system makes it a crop of low rainfall situations. It is grown in the temperature ranges of 20-40°C and can withstand a minimum temperature of 10°C and maximum temperature of 40°C.

Sandy-loam to loam soil with sufficient organic matter content is ideal for cultivation of pigeonpea. The soil should be deep, well-drained and free from soluble salts. It can be grown on soils with a pH range of 5.5-8.0 successfully, but most favourable pH for its growth and development is 6.0–6.5.

## Varieties

Based on time required for maturity, all the varieties have been classified into 3 groups viz.

(i) Short duration (120-150 days)
(ii) Medium duration (150-180 days)
(iii) Long duration (180-300 days)

Selection of varieties should be done carefully keeping in mind the climate, water retention capacity of the soil, water availability and irrigation conditions. In case of rain-fed conditions with low to no moisture availability beyond October and poor soils, early maturing varieties (120-150 days) should be preferred over medium and long duration. Some of improved pigeonpea cultivars are: Pusa 855, Pusa 991, Pusa 992, Pusa 2001, Pusa 2002, UPAS 120, Manak, AL-15, and AL 201. For arhar -wheat rotation, Pusa 991, Pusa 992, Pusa 2001 and Pusa 2002 are suitable cultivars.

## Sowing Time

Redgram is grown during June to July. Ideal time for sowing is second week of June to second week of July. Under delayed monsoon conditions, it can be sown up to end of August. Treat the seeds with Trichoderma *viride* (8 g/kg of seed). Dry the seeds in shade. Then again treat the seeds with redgram *Rhizobium* and PSB biofertilizer (5 g/kg seed) and dry the treated seeds in shade. Such treated seeds should be sown within 4-6 hour of treatment.

## Seed Rate and Sowing

In general, a seed rate of 8-10 kg for long duration, 10-12 kg for medium and 12-15 kg/ha for short duration varieties is sufficient in pigeonpea. Seeds are sown 4-6 cm deep, when the soil is wet. In short duration varieties, a row spacing of 40-60 cm and intra-row spacing of 10-15 cm is optimum. While long duration varieties require 60-120 cm inter-row and 10-20 cm intra-row spacing. Quantity of seed and spacing depending upon the variety and its crop duration are as follows:

| | | |
|---|---|---|
| Very early maturing: | Monocrop: | 20 kg/ha, spacing 120 × 30 cm |
| Early maturing: | Monocrop: | 20 kg/ha, spacing 120 × 30 cm |
| Medium duration: | Monocrop: | 15 kg/ha, spacing 60 × 20 cm |
| | Intercrop: | 5 kg/ha, spacing 30 × 20 cm |
| Long duration: | Monocrop: | 12 – 15 kg/ha, spacing 60 × 20 cm |
| | Intercrop: | 5 kg/ha, spacing 90 × 20 cm |

## Cultural Operations

Between 50 and 60 days of germination, the main shoot tip and the secondary branch tips are pruned. This promotes development of large number of tertiary shoots, which bear more number of pods, thus increasing the yield by 30-50%.

## Nutrient Management

As redgram is a deep-rooted crop, it requires at least one deep tilling up 1 to 1.5 feet and one shallow tilling. Application of 5-10 t FYM mixed with 5 kg PSB during last tilling, when soil is wet is highly beneficial. Apply 20 kg nitrogen, 50 kg $P_2O_5$, 20-30 kg $K_2O$ + 20 kg sulphur per ha as a basal dressing. Fertilizer should be broadcasted evenly and mixed thoroughly in the soil at the time of final preparation of land before sowing.

## Water Management

Redgram requires 35-40 cm water during its entire growth period. Optimum moisture is necessary during budding, flowering and pod formation stages. Red gram grown in assured rainfall areas, usually it does not require any irrigation. If there is water stress, protective irrigation may be given in alternate rows at these three stages. Use harvested intercrops' biomass as mulch to preserve soil moisture and to maintain microbial activity.

## Weed Management

Weed management is required only up to 60 days of crop growth, as this is the time when weeds compete with the crop for nutrients. First weeding is done at 20-25 DAS, while second hoeing is done at 50-60 DAS. Pre-emergence application of pendimethelin @ 1.0 kg a.i./ha is quite effective in controlling weeds.

## Disease Management

During the growing phase, incidence of yellow mosaic can be seen. The affected plants show yellow mottled symptoms. These plants can be rouged out as and when they appear. White fly is known to spread this disease; hence after removal of the affected plants, an insecticide spray is important. Apart from this, redgram is also affected by root rot and wilt, where the affected areas are sprayed with 0.1% bavistin solution.

## Pest Management

**Pod borer**: *Pod borer* survives on many host plants across different seasons, including cotton and legumes. Redgram is its preferred choice. Monocrotophos (0.04%) spray at pre and post-flowering stage is effective in controlling this pest.

## Harvesting, Threshing and Yield

When most of the leaves are shed and 80% pods turn brown, is the best time for harvest. A grain yield of 15-20 q/ha as rainfed intercrop and 25-30 q/ha as irrigated monocrop can be obtained. Very early and early varieties yield 20-30% less. Dry clean seeds in sun to ensure moisture below 8%. Beetles affect redgram in storage. Mix crushed neem leaves with grain and store in gunny bags. Gunny bags can also be treated with 5% neem oil.

# PEA

Pea (*Pisum sativum* L.) is an important pulse crop in India. There are two types of cultivated pea i.e. gardenpea (*Pisum sativum* var. *hartamse*) and fieldpea (*Pisum sativum* var. *aliense*). The field pea is generally grown for dry seeds, which are used for a variety of snack preparations and dal. The mature pea is highly nutritive containing high proportion of digestive proteins (22.5%), carbohydrates (62.1%), fats (1.8%), minerals (calcium, iron) and vitamins (riboflavin, thiamin etc). In India, fieldpea occupies an area of 0.62 million ha with an annual production of 0.56 million tonnes. The average productivity is 906 kg/ha. The major fieldpea growing states are Uttar Pradesh, Madhya Pradesh, Bihar and Maharashtra.

## Improved Varieties

Some prominent varieties of fieldpea recommended for cultivation in different states of India are Pant P 5, DMR 11, VL-1, T 163, Rachna, PG 3 and Pusa Prabhat.

*A view of garden pea and field pea*

## Climate and Soil Requirements

Peas require a cool growing season with moderate temperatures and relatively high humidity. Most cultivars have light frost tolerance, however, temperature > 27°C adversely affects the crop. Peas are most sensitive to moisture stress at flowering stage. High humidity associated with cloudy weather results into spread of fungal diseases like damping off, powdery mildew etc.

A well-drained sandy-loam or sandy clay loam is required for successful production of peas. It prefers soil with pH 6.5-7.5.

### Cropping systems

Peas are generally grown mixed with wheat, barley, oats, rapeseed and mustard crops. It is also raised as an intercrop in autumn sugarcane. The most popular rotations involving pea are: paddy-pea, maize-pea, sorghum-pea, pearlmillet-pea, cotton-pea, maize-early pea-sugarcane, and maize-pea-okra etc.

## Seed and Sowing Method

The optimum time for sowing field peas in north Indian conditions is second fortnight of October. Seed rate for pea varies with the varieties, sizes of seeds and method of sowing. A seed rate of 60-80 kg/ha is required when the crop is sown for grain crop. Before sowing, the seed should be treated with thiram @ 0.25%. For good nodulation, seed should be treated with *Rhizobium leguminosarum* culture. Fieldpea is sown at a spacing of 30-45 cm apart.

## Nutrient Management

Being a legume, it requires a starter dose of about 20 kg N/ha, besides 50-60 kg $P_2O_5$ and 30-40 kg $K_2O$/ha at the time of planting.

## Water Management

Drought is major constraint for pea plantation in India. The crop is generally sown after irrigation. Special precaution should be taken while irrigating a pea crop, light and uniform irrigation should be given. Irrigation at branching and flowering stages is critical for optimum yields.

## Weed Management

The crop suffers from a severe weed competition in its early growth with 30-45 DAS as critical period of crop weed competition. The field should be kept free from weeds by giving 2 weedings and hoeing after 3 and 6 weeks of germination. Pre-emergence application of pendimethelin @ 1.0 kg a.i./ha is quite effective in controlling weeds.

## Disease Management

**Powdery mildew:** White powdery growth or fungus mycelium and spores develop on leaves, branches, stems, tendrils, petioles and pods. Pods get loose, bright green, have shiny surface and look dull. Several powdery mildew resistant varieties such as Rachna, Pant Matar 5, DMR 7, HUP 2 are available. In case of occurrence on susceptible varieties, spray wettable sulphur 70 WP (Sulfex) 0.3% at 10 days interval on the susceptible varieties.

## Pest Management

Major insect-pests causing damage to pea crop are leaf miner and pea pod borer. For pea pod borer, crop may be sprayed with monocrotophos 0.04% at 10 to 15 days interval beginning with pod formation.

## Harvesting, Threshing and Yield

Field peas should be harvested when they are fully ripe and threshed after sufficient drying in the sun. By adopting improved package of practices, the crop can yield 10-12 t green pods/ha. Field peas can yield about 2-3 t grains/ha.

# LENTIL

Lentil (*Lens culinaris Medik*.) is commonly consumed as dal. Dehulled lentil seeds contain 24-26% protein, 1.3% fat, 2.2% ash, 3.2% fibre and 57% carbohydrate. It is a rich source of Ca (68 mg/100 g seed), P (300 mg/100 g seed) and Fe (7 mg/100 g seed). In India, major lentil producing areas are situated in Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal. In India, lentil is the second most important winter pulse crop after chickpea. The area, production and productivity of lentil is around 1.34 million ha, 0.88 mt and 660 kg/ha, respectively.

## Climatic and Soil Requirements

Lentil does not respond to temperatures above 27°C, hence it is grown as a winter season crop in semi-arid tropics. It can be raised with the moisture conserved in the soil during the monsoon season. It is very hardy plant and can tolerate frost and severe winter to a great extent. It is moderately drought tolerant crop.

*A view of lentil field*

Soil should be made friable and weed-free so that seeding could be done at an uniform depth. In the case of light soils, less tillage is required to prepare an ideal seed-bed. On heavy soils, one deep ploughing followed by 2-3 cross harrowings should be given.

### Improved Varieties

Some of the prominent lentil cultivars are Vipasha, WBL 58, Pant L 406, Pant L 639, Malika, VL Masoor 4, Sapna, Pant L 4, DPL 15 and DPL 62.

### Cropping Systems

Lentil is grown mixed with barley, *toria*, rape and mustard crops. It is also raised as an intercrop in autumn sugarcane. Intercropping of linseed + lentil (2:1), lentil + mustard (4-6:1) in Bundelkhand region of Uttar Pradesh is also promising. Rice-lentil is the most common rotation. Other rotations are groundnut–lentil, sorghum–lentil,

pearlmillet–lentil, maize–lentil, cotton–lentil, *kharif* fallow–lentil (rainfed areas), rice-lentil + mustard – maize (fodder).

### Seed and Sowing Method

Optimum seed rate for normal sown crop is 30-40 kg/ha. Seed rate should be increased to 50-60 kg in case of late sowing. Treat the seed with thiram @ 2 kg/kg seed before sowing. The lentil seed should be treated before sowing with *Rhizobium* culture. Crop is sown at a spacing of 30 cm apart in rows using seed drill. The crop may be sown in the second fortnight of October. Delay in planting causes reduction in yield. Lentil seeds should be sown at a depth of 3-4 cm.

### Nutrient Management

Apply 20-30 kg N/ha as starter dose, besides 40-60 kg $P_2O_5$ and 20-30 kg $K_2O$/ha as basal dose in lentil. The crop also responds to 20 kg sulphur/ha both under rainfed and irrigated conditions.

### Water Management

The crop requires 200 mm of water depending on soil and climate. Lentil requires 1-2 irrigations during the growing season. Apply first irrigation at 6 weeks after sowing and second at flowering or pod formation stage.

### Weed Management

The period from 30 to 60 DAS is most crucial for competition with weeds. Two weedings at 30 and 60 DAS are enough. Pre-emergence application of pendimethelin @ 1.0 kg a.i./ha in 750 litres of water is quite effective in controlling weeds.

### Pest Management

Aphid is major pest of lentil. In case of severe infestation, leaves and shoots get deformed and stunted and sticky honeydew may be deposited over the leaf surface. Usually, only one spray of cypermethrin 0.004%, is sufficient to control aphid damage.

### Disease Management

The major diseases of lentil are wilt and rust. Seed treatment with systemic fungicides such as thiram + carbendazim (1:1) @ 2.5 g/kg seed and crop rotations help in minimizing incidence of wilt, root rot and collar rot. Foliar spray of mancozeb at 50 DAS has been found very effective against rust.

### Harvesting, Threshing and Yield

Lentil crop should be harvested when the plants dry up and pods are mature. Threshing is done either by beating the plants with sticks. Clean and dry the seeds in sun to bring moisture content down to 12% for safe storage. A well-managed crop yields about 1.5-2.0 t grains/ha.

# BLACKGRAM

Black gram (*Vigna mungo*) is popular as *Urad dal*. India is major producer and consumer of black gram in the world. It is an important pulse crop and serves as a major source of dietary protein for majority of people. It contains about 25-28% protein, 1.0-1.5% oil, 3.5-4.5% fiber, 4.5-5.5% ash and 62-65% carbohydrates on dry weight basis. Main use of blackgram is to make Dal. Apart from this, it is also used in making *uttappa, dosa, idali, vada, dal makhhani* etc.

It is grown all over the country in *Kharif* and summer seasons. It is cultivated over an area of about 29.68 lakh ha with total production of 12.45 lakh tonnes. In India, blackgram is very popularly grown in Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Punjab, Haryana and Karnataka.

*A field view of blackgram*

## Climatic and Soil Requirements

Most suitable climate to cultivate blackgram is 27-30° C with heavy rainfall. It is grown as rainfed crop in the warm plains as well as in the cool hills, up to an altitude of 2,000 metres.

It is highly drought resistant but susceptible to frost, water logging and salinity. A well distributed 60-75 cm rainfall is highly suitable. It prefers water retentive, stiff loamy or heavy soils, and does well on both black cotton soils and brown alluvium.

### Cropping Systems

It is cultivated in three different seasons' *viz. Kharif, Rabi* and summer; but maximum area is occupied under *Kharif* season mostly as intercrop with sorghum, pearl-millet, maize, cotton, castor, pigeonpea etc. Some suitable intercropping systems are: Paddy-wheat-urdbean, Maize-rapeseed- urdbean, Urdbean-wheat-mungbean, Urdbean-mustard-mungbean/urdbean, Potato-wheat- urdbean, etc.

## Varieties

The resistant varieties to yellow mosaic virus are Uttara, Narendra urd 1, Pant U 19, Pant U 30, UG 218 and WBU 108. The resistant varieties to powdery mildew are LBG 402, TPU 4 and LBG 17. Other varieties are Pusa-1, UPU-1, UPU-2, T.P.U.-4, T.A.U.-1, T.A.U-2 etc.

## Seed and Sowing Method

The seed treatment with fungicides like captan, thiram or bavistin @ 2-3 g/kg seed before sowing effectively controls diseases. Seed treatment with *Rhizobium* has been found to improve yields of pulses. A seed rate of 15-20 kg/ha for *kharif* and 25 kg for summer season has been recommended for blackgram. Sown with the onset of monsoon i.e., June-July.

## Nutrient Management

The starter dose of N @ 20-25 kg/ha besides 50-60 kg $P_2O_5$ and 30-40 kg $K_2O$/ha as basal application has been found optimum for blackgram. Seed treatment with *Rhizobium* is also beneficial.

## Water Management

Irrigations during flowering, pod formation and seed development are must. In heavy rainfall areas, crop needs proper drainage as the crop is very sensitive to water logging.

## Weed Management

One or two hand weeding at 20-30 and 40-45 DAS give better weed control. Among chemical weed control method, pre-emergence application of pendimethalin @ 1.0 kg a.i./ha in 750 litres of water is quite effective.

## Disease Management

**Cercospora Leaf spot :** Angular brown or red spots, with grey or brown centre and reddish-purple border on leaves, stalk and pods. Spray with Bordeaux mixture (5:5:50) or 0.2% ziram.

**Powdery mildew :** White powdery patches on leaves and other green parts, later becoming dull coloured and are studded with black dot. Dust the crop with finely powdered sulphur (200-mesh) @ 20 kg/ha.

**Viral diseases** : These diseases can be minimized by controlling their vector through spraying metasystox (0.01%) and uprooting and destroying the infected plants.

## Pest Management

**Pod borer :** Caterpillars feed on tender foliage and young pods. They make holes in the pods and feed on developing seeds. Spraying the crop with 0.05% quinalphos can successfully control the pest.

### Harvesting, Threshing and Yield

Crop is harvested before it is dead ripe. The plants are cut with sickle, dried for 7-10 days and threshed by beating with sticks and then winnowed. The seeds should be dried to around 10-12% moisture. A good crop of blackgram may yield 1.0-1.5 t grains/ha.

## GREENGRAM

Greengram (*Vigna radiata*) is the third most important pulse crop after chickpea and pigeonpea. Green gram or moong is a protein rich staple food. It contains about 25% protein. It is a drought resistant crop and suitable for summer cultivation, dryland farming and predominantly used as an intercrop with other crops being a short duration crop. In India, it is grown on 3.11 million ha area in almost all the states.

*Greengram*

### Climate and Soil Requirements

Greengram is a tropical crop, but can also be grown in subtropical region and cultivated in areas between 30°N and 30°S latitude. It is cultivated all the year round in peninsular India, and during *Kharif*, spring and summer seasons in north-India. It is grown in the areas having an annual rainfall of 50-75 cm. It can be grown from sea level to an altitude of 2,000 m.

A well drained loamy to sandy-loam soil is the best soil for its cultivation. The crop does not grow well on saline and alkaline soil or waterlogged soils. Water logging affects the crop adversely.

### Varieties

Some promising varieties are CO 4, Pant Moong 2, TAP 7, BM 4, MUM 2, LGG 407, LGG 450, TARM 1, TARM 2, PDM 11, PDM 54, PDM 139, Pusa 105, Pusa Baisakhi, Pusa Vishal, SML668, Pusa 672 and Pusa 9531.

## Seed and Sowing Method

The quantity of seed required is about 12 kg/ha for *Kharif* crop and 20 kg/ha for *Rabi* crop. Seed should be treated with captan or thiram @ 2.5 g/kg seed as precaution against any seed borne disease. In north India, this crop is sown with the onset of monsoon i.e., second fortnight of June to first fortnight of July. In south India, it is sown during the month of Oct.-Nov. In summer season, it is sown from March-April. The line sowing is done at a spacing of 30-45 cm.

## Weed Management

One or two weedings or hoeings are done at about 20 and 25 DAS depending on weed growth. Pre-emergence spray of pendimethalin 30 EC @ 1.0 kg a.i./ha is recommended for chemical weed management.

## Nutrient Management

The crop requires 20 kg nitrogen and 50 kg phosphorus/ha at the time of sowing.

## Water Management

Normally, greengram is grown under rainfed conditions. The right stages of irrigation are branching stage, full bloom stage and pod formation stage. Excess irrigations result in delayed maturity and poor yield. About 4-5 irrigations are enough during whole crop period. Water logging in the field should be avoided.

## Disease Management

**Cercospora Leaf spot:** Angular brown or red spots, with grey or brown centre and reddish-purple border on leaves, stalk and pods. Spray with Bordeaux mixture (5:5:50) or 0.2% ziram. Spray dithane Z-78 @ 2 kg or dithane M-45 @ 2 kg in 750 litres of water/ha.

**Yellow mosaic:** This disease is caused by a virus. It is more common in northern India. Yellow, diffused round spots scattered in the leaf lamina are initial symptoms. These spots expand rapidly. Viral disease can be minimized by controlling the vector through spraying metasystox (0.01%).

## Pest Management

**Pod borer:** Caterpillars feed on tender foliage and young pods. They make holes in the pods and feed on developing seeds. Spraying the crop with 0.05% quinalphos can successfully control the pest.

## Harvesting, Threshing and Yield

Shattering of pods is a great problem in this crop. Thus, picking should be done as the pods mature. Harvesting should be completed in 2–3 pickings. The pods after complete drying should be threshed manually. A good crop of greengram may yield about 1.0–1.5 tonnes of grain/ha.

# SOYBEAN

Soybean (*Glycine max* L.) is the most important oilseed crop of India and the world. Soybean contains 20-25% oil and 40-45% poteins. India ranks fourth in acreage and fifth in production of soybean in the world. It contributes greatly to the edible oil pool of the country and also earns sizeable amount of foreign exchange. Soybean production in India at present time is restricted primarily in Madhya Pradesh, Maharashtra and Uttar Pradesh.

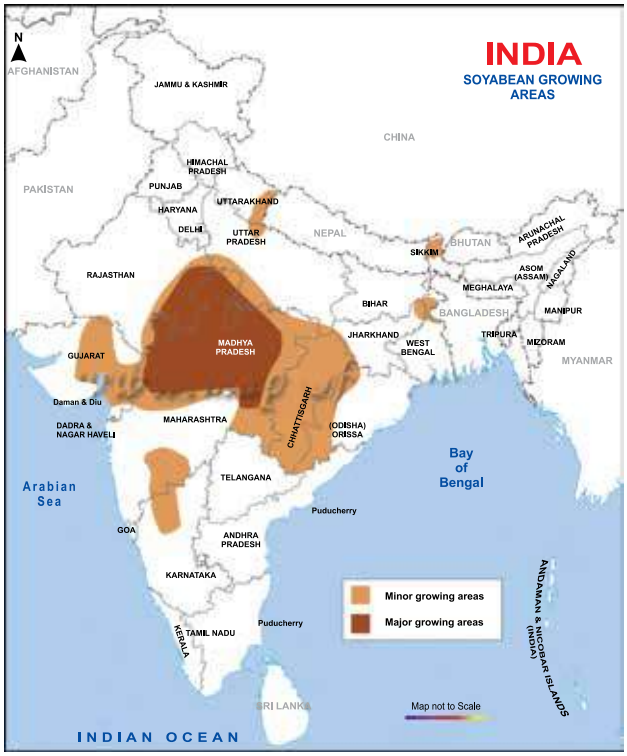



*Fig. 1. Soybean production areas in India.*

## Climatic and Soil Requirements

Soybean grows well in warm and moist climates from sea level to an elevation of 3,000 m. The crop cannot tolerate frost and water logging. It is grown in areas receiving 40-75 cm annual rainfall. It is a short day plant and requires a photoperiod of 13-14 hours.

Soybean performs better in well-drained sandy-loam to clay soil with medium water holding capacity. Acidic and alkaline soils inhibit the germination of seed. Water logging is injurious to the crop. Soil depth should be adequate.

### Cropping Systems

Soybean-wheat, soybean-chickpea, soybean-potato, soybean-mustard, soybean-lentil are major crop rotations. Soybean can be grown in intercropping systems like soybean+pigeonpea, soybean + sorghum, soybean + maize, soybean + pearlmillet, soybean + cotton.

## Varieties

Some promising varieties are Pusa 9712, VL Soya 2, Palam Soya, PS 1241, VLS 65, Pusa 22, Pusa 16, Pusa 24, Pusa 37, Gujarat Soybean 1, and Birsa Soybean 1.

*Yellow Soybean*

## Seed and Sowing Method

Optimum seed rate is the pre-requisite to have good yields of soybean. Seed can be treated with thiram 75 WP + carbendazim 50 WP (2:1) @ 3 g/kg seed or *Trichoderma viride* @ 4-5 gm/kg seed for reducing the incidence of insect-pests and diseases. Following seed rates should be used in soybean cultivars:

| | |
|---|---|
| Bold seeded varieties | : 80-85 kg/ha |
| Medium seeded varieties | : 70-75 kg/ha |
| Small seeded | : 60-65 kg/ha |

Timely sowing is very important to harness full yield potential of soybean. Sowing of rainfed soybean should start with the onset of rainy season. Generally, soybean is plated during June – July. Recommended sowing time for *kharif* season soybean in different parts of the country is June – July. Soybean should be planted in lines at distance of 40-60 cm and plant to plant distance of about 5 cm. Seeding depth should be 3-4 cm.

## Nutrient Management

Soybean is a heavy nutrient feeder and requires 20-25 kg N, 60-80 kg $P_2O_5$ and 40-50 kg $K_2O$/ha besides 20-25 kg Sulphur/ha as basal dose. About 5-10 t/ha well decomposed FYM should be incorporated well in advance to sowing. Seed should be treated with relevant *Rhizobium* culture.

### Water Management

Soybean is grown as rainfed crop during rainy season in northern India, as summer irrigated crop in central India and post rainy season crop on stored soil moisture in black cotton soils and as irrigated crop during summer in northern parts of the country. Adequate soil moisture is vital at critical growth periods for soybean specifically at sowing, flowering; and pod formation stages.

### Weed Management

Soybean is a very vigorous crop that can compete many weeds while achieving full canopy. Two hand weedings at 20-25 and 40-45 DAS are sufficient for control of weeds. Pendimethalin @ 1 kg a.i./ha or metolachlor @ 1 kg a.i./ha are used as pre-emergence herbicides in 750 L water/ha. Imazethapyr @ 75 to 100 g a.i./ha or quizalofop-ethyl @ 50 g a.i./ha are used as post-emergence (15 -20 DAS) herbicides in 750 L water/ha.

### Disease Management

**Downy mildew:** Small chlorotic spots appear on the upper surface of the leaves, which later turn greyish to dark brown with downy growth on the lower surface of the leaves. For control, the seed should be treated with captan @ 3.0 g/kg seed before sowing. Spraying the crop with copper oxychloride 50 % @ 5.0 g/L water has been found effective in controlling the disease.

**Yellow mosaic virus:** Yellow mosaic is an important virus disease. It is transmitted by white fly. The affected leaves become yellow with a slight crinkling and reduction in size. Regular spraying of the crop with methyl demiton 25 EC (Metasystox 25 EC) @ 1.5 ml/L water starting from third week onwards at an interval of 10-15 days keep the white fly population under control and the crop becomes free from the incidence of yellow mosaic virus.

### Pest Management

**Gram pod borer:** The caterpillar makes holes in the pod and feeds on the ripening grains. The caterpillar, as it grows, bores into green pods and destroys the seeds completely. It can be controlled by dusting the crop with monocrotophos 36 SL @ 1.5 ml/L water. The insecticide is applied at the fruiting stage and it may be repeated at the interval of 10 days.

### Harvesting, Threshing and Yield

The plant is harvested when the leaves turn yellow and finally drop and only the pods remain on the stalk. Harvesting is done either by cutting the plants close to the ground with sickles. The harvested plants are carried to the threshing floor and dried in the sun about a week. It can also be threshed by wheat thresher after some adjustments. A moisture content of 13-14% is ideal for threshing with thresher. A good crop of soybean may yield about 2.0–2.5 t grains/ha.

## RAPESEED AND MUSTARD

The rapeseed-mustard group broadly includes Indian mustard, yellow sarson, brown sarson, raya, and toria crops. Indian mustard (*Brassica juncea*) is predominantly cultivated in Rajasthan, UP, Haryana, MP and Gujarat. Brown sarson is cultivated in Assam, Bihar, Orissa, and West Bengal. Gobhi sarson (*B. napus* L.) and karan rai (*Brassica carinata*) are the new emerging oilseed crops. In India, rapeseed-mustard is grown on an area of 5.53 m ha with production and productivity of 6.41 mt and 1157 kg/ha, respectively.

*A view of mustard field*

### Climatic and Soil Requirements

Rapeseed-mustard crops are basically cultivated in temperate region, however they have wider adaptability. Rainfall, high humidity and cloudy weather are not favourable for the crop. Rapeseed and mustard are long day plants. They require an annual precipitation of 40-100 cm.

Rapeseed and mustard may grow under sandy-loam to clay loam-soils but they thrive well on light-loam soils. These crops also do not tolerate water-logging.

#### Cropping Systems

Rapeseed and mustard are generally grown mixed with *rabi* crops like wheat, barley and chickpea. Some of cropping sequences in major rapeseed mustard cultivated states are: Rice-toria, rice-toria-mungbean, maize-toria-wheat, groundnut-mustard, cotton-mustard/gobhi sarson, rice-gobhi sarson-mungbean, maize-toria-sugarcane, rice-mustard/yellow sarson, black gram-sarson or raya, guar-sarson or raya, maize-sarson or raya.

## Varieties

Some promising varieties of rapeseed and mustard group are as under:

| S. No. | Crop | Varieties |
|---|---|---|
| 1 | Indian mustard (*Brassica juncea*) | RH 9304, RH 9801, RH 30, RH 819, T-59 |
| 2 | Karan rai (*Brassica carinata*) | Pusa sawarnim, Pusa Aditya |
| 3 | Brown sarson (*Brassica rapa* var. brown sarson) | BSH-1, Pusa Kalyani, KBS-3 |
| 4 | Toria | TH 68, Sangam and TL 15, Bhawani |
| 5 | Yellow sarson (*Brassica rapa* var. yellow sarson) | YST 151, Type 42, K-88, YS 24, PS 66, NDYS 842 |
| 6 | Gobhi sarson (*Brassica napus*) | Neelam, Sheetal, ONK-1, Hyola 401 (Hybrid) |
| 7 | Black mustard (*Brassica nigra*) | Surya |

## Seed Rate and Sowing Method

Generally, under irrigated condition, 3-4 kg seed is sufficient for sowing of one ha area whereas, the seed rate can be increased to 5 kg/ha under rainfed condition depending upon the availability of soil moisture. The rapeseed-mustard is small seeded crop. Therefore, the field should be well prepared for uniform germination. Rapeseed-mustard seedlings are very susceptible to crusted soil. It requires fine seed bed. Field should be ploughed by mould board plough or tractor drawn harrow. Before pre-sowing irrigation followed by two ploughing with cultivator are required to prepare good seed bed. There should be no clod or weeds at sowing time.

The crop of toria is to be sown in the last week of August to mid-September. Whereas, 25$^{th}$ September to the first fortnight of October is the most appropriate time of sowing mustard crop in conserved moisture. Under irrigated conditions, the sowing of raya should be completed by 20$^{th}$ October. Rapeseed-mustard crop should be sown in lines 30 cm apart with plant to plant distance of 10-15 cm and at a depth of 4-5 cm under irrigated conditions; whereas a row spacing of 45 cm is beneficial and practical in rainfed conditions. In order to maintain the proper plant population, thinning is to be done after 20-25 days of sowing.

## Nutrient Requirements

For rainfed crop, apply 40 kg N and 20 kg $P_2O_5$/ha. In irrigated areas apply 60 kg N, 20 kg $P_2O_5$ and 25 kg $K_2O$/ha for toria and mustard, 80 kg N, 40 kg $P_2O_5$ and 25 kg $K_2O$/ha for raya. Apply half dose of nitrogen and full dose of P & K at sowing time and remaining half N is top dressed at the time of first irrigation. Rapeseed-mustard is highly responsive to P, S, Zn and Boron. It is advisable to apply phosphorus through single super phosphate because it contains 12% sulphur, which is required for increasing the oil content. Seed treatment with Azotobacter has been found beneficial to the crop.

## Water Management

Two irrigations, one at flowering and another at siliquae development stage, are recommended. If irrigation water is available for one irrigation only, then the crop should be irrigated at the time of flowering.

## Frost Management

Occasionally, frost prevails from last week of December to January end in north and north-western parts of the country resulting into considerable yield loss. Irrigate and smoke the fields when the temperature is low. Usually 30-45 days after anthesis is most sensitive.

## Weed Management

Hand weeding twice at 30 and 45 DAS and application of pendimethalin at 0.75 to 1.0 kg a.i./ha as pre-emergence is effective in weed management.

## Disease Management

**White rust** (*Albugo candida*): The dangerous stage is floral infection in which the floral parts are malformed and become thick leathery green. The branches become zig-zag in structure and white growth of the fungus can be seen on these affected branches.

**Alternaria blight**: Small light brown round spots develop on the lower leaves first and then on upper leaves after 40 DAS. Later on, these spots develop into big circular dark coloured with concentric rings clearly visible in these spots. When the temperature ranges from 18- 25°C with high humidity (80%), dense crop canopy and rains during February increases the disease at faster rate.

**Downey mildew**: At flowering stage, the whole inflorescence is malformed and becomes thick green, twisted and covered with white cottony growth. Disease development is favoured by a temperature 10-20°C and wet weather. For the control of white rust, *Alternaria* and downy mildew spray mancozeb 1.5 kg/ha at initial appearance of white rust or *Alternaria* and repeat the spray 1-3 times after 15 days.

## Pest Management

**Mustard aphid**: This is the most important pest of rapeseed and mustard. Spray the crop with 625 to 1000 ml oxydemeton methyl (Metasystox 25 EC) or dimethoate (Rogor) 30 EC after diluting it in 625 to 1000 L water/ha.

## Harvesting, Threshing and Yield

Usually rapeseed-mustard crops are harvested as soon as 75% of the pods turn yellow and moisture content of the seed is around 30 to 40%. Bundles of the harvested plants are staked and dried in the sun for a few days. Threshing is done by the usual method of threshing by bullocks or running a tractor over the dried plants. Moisture

content of the seed must be less than 8% at the storage time. Under normal conditions, rapeseed yields about 1.4-2.0 t/ha of seed, while mustard may give 2.0-2.5 t/ha. Average yield in rapeseed & mustard group are: toria (12-15 q/ha), yellow or brown sarson (12-15q/ha) and rai (15-20 q/ha).

## GROUNDNUT

Groundnut (*Arachis hypogaea* L) is also called peanut or mungfali. Groundnut seed contains about 45% oil and 26% protein. Peanuts are a good source of niacin, folate, fiber, magnesium, vitamin E, manganese and phosphorus. Globally, India occupies the first place in acreage and second in production. In India, groundnut occupies an area of 5.86 m ha with production and productivity of 8.26 mt and 1411 kg/ha, respectively. The main groundnut growing states are Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka and Rajasthan. Morphologically, groundnuts have been divided into two groups: (i) erect or bunch type (*Arachis hypogaea* subspecies *fastigiata*; (ii) trailing or spreading type (*Arachis hypogaea* subspecies *procumbens*).

*Groundnut plant*

### Climatic and Soil Requirements

Groundnut is grown in the tropical and subtropical countries and up to an altitude of 1000 m. The crop can be grown successfully in places receiving a minimum rainfall of 500 mm and a maximum of 1250 mm. The rainfall should be well distributed during flowering and pegging stages. The groundnut cannot withstand long and severe drought

or water stagnation. During ripening period, it requires about a month of warm and dry weather.

Most suitable soils for groundnut production are well-drained, light-textured, loose sandy-loam or sandy clay loam with good drainage. Soils should have reasonable high calcium, pH 5.5 to 7.0 and a moderate organic matter.

### Cropping Systems

Groundnut is grown in rotation with wheat, lentil, chickpea, pea, barley, etc. It is grown as a mixed crop with pearlmillet, maize, sorghum, castor and cotton. The most common cropping systems are: groundnut-wheat/barley/chickpea/field pea/lentil.

### Varieties

Some promising varieties recommended for different states are ICGS 76, Tirupati 2, Girnar 1, ICGS 37, ALR 3, ICGS 11, HNG 10, Punjab Mungphali 1, Mukta, Chitra, Jyoti, RS-1, M-335, MH-4, BG-2, TG-1, and TMV-6.

### Seed Rate and Sowing Method

A seed rate of 80-100 kg/ha is enough for bunch type and 60-80 kg/ha for spreading type groundnut cultivars. In bunch types, the row to row distance is kept 30-40 cm and in spreading types 45-60 cm. Plant to plant distance would be 15 and 20-22.5 cm for bunch and spreading types, respectively. Sowing can be done through tractor-mounted groundnut planter. The depth of sowing should be 5 cm. One ploughing with soil turning plough followed by two harrowings would be sufficient to achieve a good surface tilth up to 12-18 cm depth. In India, groundnut is grown over four seasons. Sow the rainfed crop with the onset of monsoon in the last week of June to first week of July. In irrigated conditions, sow in last week of June. In *rabi*, groundnut is sown during November-December. Summer groundnut is sown during mid-February. For seed purposes, pods should be shelled by hand one week before sowing. Hand shelling ensures little damage to seeds. Treat the selected kernels with thiram or captan or ceresan @ 5 g/kg kernels to check seed and soil borne diseases.

### Nutrient Requirement

Groundnut, being legume, needs more phosphorous, and being an oilseed requires more sulphur. Seed should be inoculated with efficient strains of *Rhizobium* culture. Well decomposed FYM or compost @ 5-10 t/ha should be applied about 15-20 days before sowing. Apply 15 kg N, 50 kg $P_2O_5$ and 25 kg $K_2O$/ha at the time of sowing. Use of gypsum @ 100-150 kg/ha during field preparation can add to the yield. Calcium too has pronounced effect on proper development of pods and kernels.

### Water Management

Being a rainy season crop, groundnut does not require irrigation. The field should be well drained. Flowering and pegging are the most critical stages for irrigation.

### Weed Management

Two weedings 20 and 45 DAS are recommended. Pre-emergence application of pendimethalin @ 1 kg a.i./ha in 800-1000 L water/ha along with 2 intercultures at 30 and 45 DAS have been recommended in irrigated conditions.

### Disease Management

**Tikka disease or leaf spot (ansal organisation):** The spots on leaves are circular to irregular and are surrounded by a yellow halo. The spots on the upper surface look like reddish brown to black, whereas on lower surface these spots are smooth and light brown in colour. Spray the crop two to three times with dithane M- 45 or blitox-50 @ 1.5-2.0 kg/ha at 10-15 days interval starting from the first appearance of spot.

### Pest Management

**White grub:** The young grubs are white and translucent. Fully grown larvae are larger than a thumb. The larvae feed on soil organic matter for a few weeks and then they eat roots. They also damage pods. The grubs cut and eat the plant roots, and consequently the plants wilts and dies. White-grub is a menace in the light soils, which can be controlled effectively by treating seed with chlorpyriphos 20 EC @ 15 ml/kg seed.

### Harvesting, Threshing and Yield

Harvesting of groundnut should be done at blackening of inner shell and development of testa colour. Harvest the crop at 80% pod maturity. After harvesting, the pods are dried in sun to reduce moisture content to 20-25% for threshing. After threshing, kernels are dried to reduce the moisture content to 8-10%. Under normal conditions, groundnut yields about 15-25 q pods/ha with shelling percentage of 68-69.

## SUNFLOWER

Sunflower (*Helianthus annuus* L.) also known as *Surajmukhi* is an important oilseed crop of India. It is a rich source of high quality edible oil (40-43%) and also suitable for edible refined oil and vanaspati because of high degree of polyunsaturated fatty acids, pleasant odour and nutritional value. Its oil has anti-cholesterol properties and contains vitamins A, B, D and E. During 2012-13, sunflower was grown on 0.73 million ha in India with a production of 0.54 mt with an average yield of 739 kg/ha. Sunflower holds great promises because of its short duration, photo-insensitiveness and wide adaptability.

### Climatic and Soil Requirements

The crop requires a cool climate during germination and seedling growth. It requires warm weather from the seedling stage up to flowering stage and warm and sunny days during flowering to maturity. Sunflower can be grown successfully in any season *viz. kharif, rabi* and spring throughout India. It takes about 80-90 days in *kharif*, 105-130 days in *rabi* and 100-110 days in spring season.

*A Sunflower field*

Sunflower can be grown on a wide range of soils and tolerates a moderate pH range and some salinity. It thrives best on deep loam soils having good drainage and irrigation facilities.

## Cropping Systems

Sunflower is grown in rotation with several crops. Some of the important crop rotations are: maize-sunflower, maize-potato-sunflower, paddy-sunflower, maize-potato-sunflower, arhar (ageti)-sunflower, sunflower-safflower, maize-toria-sunflower, cotton-sunflower, maize-toria-sugarcane-ratoon-sunflower, basmati rice-sunflower etc.

## Varieties/Hybrids

A good cultivar should be high yielding and exhibit stable performance across a range of environments with uniform growth behaviour. Some of promising HYVs/hybrids of sunflower are as under:

| | |
|---|---|
| **Varieties** | CO-5, TAS-82, DRSF-113, DRSF-108, TNAU SUF-7, GAU SUF-15 |
| **Hybrids** | KBSH-41, KBSH-42, NDSH-1, RSFH-1, APSH-11, Suryamukhi, BSH-1, MSFH-1, MSFH-8, MSFH-17, LSH-1, LSH-3, PSFH-67 |

## Seed Rate and Sowing Method

Seed rate of 8-10 kg/ha is sufficient to ensure good crop stand. Sunflower should be sown 60 cm apart in lines with a plant to plant spacing of 20 cm. The seed should be sown at 3-4 cm depth for better stand. The seed should be treated with captan or ceresan @ 3 g/kg seed. Sowing can be done by corn planter in the furrows. After 10-12 days of germination, extra seedlings should be uprooted to provide a space of 20 cm between plants in rows. Sunflower requires a well pulverized and weed free land with adequate moisture supply. The optimum time of sowing of sunflower in north India for

*kharif, rabi* and z*aid* crops is the first fortnight of July, second fortnight of October and the first fortnight of March, respectively.

### Nutrient Management

Sunflower is an exhaustive crop and responds well to NPK. A dose of 60-80 kg N, 60 kg $P_2O_5$ and 40 kg $K_2O$/ha has been found optimum for sunflower. Two-third N and whole P & K is applied as basal dose. Remaining N should be top-dressed at the time of second irrigation (flowering stage).

### Water Management

Usually, no irrigation is needed for *kharif* crop. Pre-sowing irrigation is necessary for *rabi* and *zaid* crops to get uniform germination and better stand. *Rabi* crop may be irrigated thrice after 40, 75 and 110 DAS coinciding to 4-5 leaf stage, flowering and grain filling stages, respectively.

### Weed Management

Weed-free conditions till 60 DAS result in better yield performance. When the plant attains a knee high stage, earthing up should be done along the rows. Use of sirmate @ 4 kg/ha as pre-emergence in 800-1000 L water/ha has been found effective in controlling weeds in sunflower.

### Disease Management

**Stem rot:** The pathogens attack basal part of the stem, including the head with white cottony growth. Treat the seed with thiram @ 2g/kg seed.

### Pest Management

**Cutworms**: The insect may be serious during March-April in fields where sunflower follows potato. Caterpillars cut the seedlings at the ground level. Apply chlorpyriphos @ 5 L/ha mixed in 10 kg fine soil and broadcasted uniformly before sowing in the field after last ploughing but before planking.

### Harvesting, Threshing and Yield

The sunflower crop is ready when back of the head turns yellowish-brown and the moisture in seed is 20%. The harvested heads should be dried well in sun and then threshed manually or using threshers. Further, sun-drying of the seed is desirable before storage or oil. A good crop of sunflower yields about 2 t grains/ha.

## BERSEEM

Berseem (*Trifolium alexandrinum* L.) is a most important winter forage legume in India, commonly cultivated as winter annual in the tropical and subtropical regions. It provides nutritious, succulent and palatable forage for milch animals. Berseem forage contains about 20% crude protein with high digestibility (up to 65%) and palatability.

*A view of berseem field*

## Climatic and Soil Requirements

Berseem is adapted to cool and moderately cold climate. Such conditions prevail during winter and spring seasons in north India, which is considered as favourable and productive zone for this crop. It can be grown successfully in areas which receive annual rainfall of 150-250 cm or even lower but the irrigation must be assured.

Berseem can be grown on all types of soils except very light sandy soils. Well-drained clay to clay-loam soils rich in humus, calcium and phosphorus are suitable for berseem.

### Varieties

Some of the promising cultivars of fodder berseem are Pusa Giant, Mescavi, Berseem Ludhiana-1, Jawahar Berseem-1, Wardan, BL-10, BL-22, UPB-10, Bundel Berseem-2, Bundel Berseem-3, BL-180, Hisar Berseem-1 and JB-5.

### Seed Rate and Sowing Method

The optimum seed rate is 25 kg/ha, which may be increased up to 35 kg in early or late sown conditions. For yield compensation in first cutting, 1.5 kg mustard should be sown alongwith berseem. Being a legume, berseem enriches the soil with biological nitrogen fixation. Therefore, berseem seed should be inoculated with *Rhizobium trifollii*. The seeds being very small, berseem requires a fine seedbed. After the arrest of rains, sowing of berseem can be done from last week of September to first week of December in north-west to eastern and central India.

### Nutrient Management

Top dressing of 10 kg N/ha is done after each cut in addition to 30 kg N/ha basal dose to encourage good regeneration, quick growth and high yield. In general, the crop responds significantly upto 80-90 kg $P_2O_5$/ha. The potassium requirement of berseem has been found to be 30 to 40 kg $K_2O$/ha in low potassium soils.

### Water Management

Berseem requires huge quantities of water for producing high succulent biomass. Normally, the crop should be irrigated after each cutting. About 12-15 irrigations will be needed during the entire crop season.

### Weed Management

The major associated weed of berseem is chicory (*Chicorium intybus*). Chicory infestation can be minimized by seed cleaning in 10% solution of common salt, besides deep summer ploughing.

### Cutting Management and Forage Yield

The first cutting should be taken at 50-55 days after sowing of crop. The subsequent cuttings should be taken at 25-30 days interval. The number of cuts depends upon rate of growth and temperature during the life cycle of the crop. The crop is capable of producing 100 to 120 t/ha of green forage and 15-20 tonnes/ha dry fodder under improved agronomic management practices and favorable weather conditions.

## COTTON

Cotton (*Gossypium spp.*) considered as white gold, is one of the most important commercial crops in India. It is a major fibre crop, but its seeds are used as source of oil. Cottonseed oil is a cooking-oil extracted from the cotton seeds. *Gossypium hirsutum* and *Gossypium herbaceum* are grown for cotton fibre. The genus *Gossypium* belongs to Malvaceae family and has 52 species in which 4 are commercially grown worldwide *viz. Gossypium arboreum, G. herbaceum, G. hirsutum* and *G. barbadense*. In India, *G. hirsutum* and *G. arboreum* are grown in all the major cotton growing states. India has the world's largest acreage of 11.99 m ha with production of 6 MT and average yield of 512 kg/ha.

*A view of cotton field*

## Climatic and Soil Requirements

Cotton is a warm season loving shrub, adapted to a wide range of climate. A frostless season of 180-240 days is required for successful cotton production. The cotton-picking period from mid-September to November must have bright sunny days to ensure a good quality of the produce. Abundant sunshine during the period of boll maturity and harvesting is essential to obtain a good quality produce.

It is raised mainly as a rainfed crop in the black cotton and medium soils and as an irrigated crop in the alluvial soils. Proper drainage of excess water during rains is essential. Soils with a pH >9.0 and <6.5 and $CaCO_3$ content>10% are not suitable for cotton cultivation.

### Cropping Systems

Cotton–fallow, cotton–wheat/barley, cotton–sunflower, cotton–senji/barseem/oats, cotton–sunflower-paddy-wheat, cotton–raya.

### Varieties

Cotton varieties recommended for different zones are as under:

| Zone | *G. arboreum* | *G. herbaceum* | *G. hirsutum* | *G. barbadense* |
|---|---|---|---|---|
| North Zone | Lohit, Shyamali, RG 1, LD 230, HD 11 | Digvijay | Ganganagar Ageti, Pusa 31, Pusa 8-3, H 1117 | - |
| Central Zone | Sanjay, G 22, AKH 4, AKA 1 | F 46, V 797, Digvijay, CNH 36 | Laxmi, Badnawar 1, Nimbakar 1, Deviraj | Suvin |
| South Zone | Nardium, Srisailam, Mahanandi | Jayadhar, Raichur 51, Ajanta | Laxmi, Mysore Vijay, Hampi, Krishna, Supriya | Suvin, Sujata, TNB 1 |

### Hybrids

The currently cultivated hybrids include H6, H8, H10 in Gujarat; DCH 32, DHB 105 and DHH 11 in Karnataka; Savita, TCHB 213, Surya and Sruthi in Tamil Nadu, LAHH 4 and JKHy-1 and JKHy-2 in Madhya Pradesh.

### Seed Rate and Sowing Method

The seed rate varies with species, growing zone and irrigation availability. The general seed rate for different specis/cltivars is as under:

| Varieties/hybrids | Seed-rate (kg/acre) |
|---|---|
| American Cotton Bt Hybrids | 0.750 |
| Non Bt Hybrid: LHH 144 | 1.5 |

| | |
|---|---|
| Varieties: LH 2108, LH 2076 and F 1861 | 3.5 |
| Desi Cotton Hybrid | 1.25 |
| Varieties | 3.0 |

Time of sowing is first April to 15th May. Sowing during this period ensures better yield and escapes the attack of insect pests and diseases. Sowing should be done in morning and evening hours. Sow in lines 67.5 cm apart with a cotton sowing drill. The plants within rows be kept 45-60 cm apart by thinning. However for hybrids (both Bt and non-Bt), the plant to plant distance should be kept at 75 cm. It may be done after first irrigation or heavy shower. For desi cotton hybrid, the plant to plant spacing should be kept at 60 cm. A fine seed-bed is essential for securing a good plant stand.

### Weed Management

A deep summer ploughing is desirable once in 3 years to kill perennial weeds, pests and disease propagules hibernating in the soil. For this, hoeing should be done two or three times. The first hoeing should be done before first irrigation. For chemical weed control, apply pendimethalin @ 1.0 kg a.i./ha as pre-emergence spray.

### Nutrient Management

Apply 75 kg N/ha, 30 kg $P_2O_5$/ha in HYVs and 150 kg N/ha, 60 kg $P_2O_5$/ha in Bt and non-Bt hybrids. Apply whole P & K as basal dose while half N is applied at thinning and the remaining half N at flowering. Apply 20 kg muriate of potash in soils medium in available potassium and 25 kg zinc sulphate heptahydrate (21%) per ha to cotton on light soils.

### Water Management

Cotton requires four to six irrigations, depending upon the seasonal rainfall. The first irrigation should be given 4 to 6 weeks after sowing and the subsequent ones at interval of two or three weeks. Sowing of cotton on ridges and irrigation in furrows save considerable amount of water. In cotton, four critical stages of irrigation have been identified *viz.* commencement of sympodial branching (60-70 DAS), flowering (90-100 DAS), boll formation (125 DAS) and boll bursting (140 DAS). Drain out the stagnant water, if such a situation arises.

### Disease Management

**Root rot:** The loss in yield occurs due to reduction in sudden death of plants. Due to this disease, healthy plants may wilt within 24 hr with leaves drooping without showing any discoloration. Soil should be drenched with 0.2% carbendazim.

***Fusarium* wilt:** In young as well as old plants the initial symptoms are stunning followed by yellowing, wilting and dropping of most of the leaves. Soak 4 kg seed in 8 L water containing 8 g of bavistin for 6-8 hr and 2-3 hr in case of delinted cotton.

### Pest Management

**Pink boll worm:** It is a notorious pest of cotton in all cotton growing areas. Bt cotton provides effective protection against all cotton bollworms.

### Harvesting Threshing and Yield

Cotton is harvested in 3-4 pickings by hand as the bolls mature. By adopting improved technology, it is possible to harvest about 1.5-2 t/ha of seed cotton (kapas). However, much higher yields may be obtained from hybrid cottons. Cotton lint production is 33% of kapas production, while cotton to seed production is 66% of *kapas* production. Oil to seeds crushed is 14-18% and cake to seeds crushed is 82-86%.

## JUTE

Jute (*Corchorus spp.*) is a fibre crop belonging to family Sparrmanniaceae with two major species: white jute (*Corchorus capsularis*) and Tossa jute (*Corchorus olitorius*). White jute fibre is superior quality fibre used to make Hessian or gunny cloth. Jute is one of the most affordable natural fibers. The fibers are off-white to brown, and 1–4 m long. Jute production in India is concentrated mostly in Assam, Odisha, Bihar and West Bengal.

*A woman harvesting jute*

### Climate and Soil Requirements

Jute is the crop of hot and humid climate. It requires high temperature varying from 24°C to 35°C and heavy rainfall of 120 to 150 cm with 80 to 90 per cent relative humidity during the period of its growth.

Alluvial sandy loam, clay loamy soils are best suited for jute production. *Capsularis* jute can grow even in standing water especially towards the latter part of its growth.

*Olitorius* jute will not thrive in standing water. The latter is more drought resistant and is therefore grown on lighter soils.

### Varieties

***Capsularis* varieties:** JRC 212, JRC 321, JRC 7447

***Olitorius* varieties:** JRO 524, JRO 878, JRO 7835

### Seed Rate and Sowing Method

*Capsularis* jute requires 7-10 kg seed/ha and sown at a spacing of 30 × 5 cm. *Olitorius* jute requires 5-7 kg seed/ha and sown at a spacing of 25 × 5 cm. It is sown in February month. Fine tilth is required since the seeds are very small. Crop duration is120 to 140 DAS.

### Nutrient Management

Well decomposed FYM @ 5 t/ha should be applied during last ploughing. Besides, 20 kg/ha each of N, $P_2O_5$ and $K_2O$ is applied basally. Beds and channels are formed depending on water resources. Apply 10 kg N/ha at 20-25 days after first weeding and then again on 35-40 days after second weeding as top dressing. During periods of drought and fertilizer shortage, spray 8 kg of urea as 2% urea solution on jute foliage on 40-45 as well as 70-75 DAS.

### Water Management

Jute crop requires 500 mm of water. First irrigation is given fourth day after sowing. Afterwards, irrigation can be given at 15 days interval.

### Weed Management

Hand weeding twice on 20-25 and 35- 40 DAS. Pendimethalin @ 1 kg a.i./ha can be sprayed as pre-emergence herbicide. Post-emergence application of fenoxaprop-tp-ethyl @ 75 g $ha^{-1}$ or quizalofop ethyl @ 50 g $ha^{-1}$ at 21 DAS (when the grass weeds are 3-4 leaf stage) is effective against grassy weeds.

### Harvesting Threshing and Yield

Jute crop can be harvested from 100 to 110 DAS but can be extended from 120 - 135 DAS depending on local cropping systems. Jute plants are left in the field for 3 - 4 days for leaf shedding. Then thick and thin plants are sorted out and bundled in convenient size. Green plant weight yield is 45-50 t/ha. Fibre yield is 2.0-2.5 t/ha.

### Retting

Retting is the process of extracting fibre from the long lasting life stem. The available retting processes are: mechanical retting (hammering), chemical retting (boiling & applying chemicals), steam/vapour/dew retting, and water or microbial retting. Among them, the water or microbial retting is a century old but the most popular process in extracting fine bast fibres.

# SUGARCANE

Sugarcane belongs to genus *Saccharum,* which has five important species *viz. Saccharum officinarum, S. sinense, S. barberi, S. robustum,* and *S. spontanuem*. The first three species are the cultivated species and the last two are wild ones. Highly prized cane is *S. officinarum* because of high sucrose content. Sugarcane is a tall perennial plant growing erect even up to 5-6 m and produces multiple stems. Sugarcane is a C4 plant having high efficiency in storing solar energy and most efficient converter of solar energy to sucrose. Brazil is major sugarcane producing country followed by India.

*A view of sugarcane*

*Sugarcane harvesting in progress*

## Climatic and Soil Requirement

In the tropical region, sugarcane gets more or less ideal climatic conditions for its growth. The different critical stages are germination, tillering, early growth, active growth and elongation. Optimum temperature for sprouting (germination) of stem cuttings is 32° to 38°C. For ripening, however, relatively low temperatures in the range of 12° to 14°C are desirable. Sugar recovery is highest when the weather is dry with low humidity; bright sunshine hours, cooler nights with wide diurnal variations and very little rainfall during ripening period.

A well drained, deep, loamy soil with ample available water holding capacity is considered ideal for sugarcane cultivation. The optimum soil pH is about 6.5 but sugarcane can tolerate considerable degree of soil acidity and alkalinity. Hence, it is found growing in soils with pH in the range of 5 to 8.5.

### Seed Rate and Sowing Method

Seed rate in sugarcane varies from region-to-region. In north India, seed rate generally varies from 35,000 three budded sets/ha while in south it ranges between 25,000 to 40,000 three budded sets/ha. The row spacing in subtropical part ranges from 60 to 120 cm whereas, it is 90-150 cm in tropical regions.

Sugarcane take generally one year to mature in subtropical states called "Eksali" however in some tropical states, it matures in 18 months called "Adsali". In India planting seasons of sugarcane in subtropical regions are September to October (Autumn) and February to March (spring). Whereas in tropical regions, it is June to August (Adsali) and January-to-February and October-to-November (Eksali). Sugarcane can be planted by improved method of planting like, deep furrow, trench methods, ring pit method and paired row method instead of furrow system.

### Cultivars

Some of the promising sugarcane cultivars are: COS 687, COS 8436, COS 767, BO 106, BO 108, BO 90, CO 7508, CO 7704, CO 1108, COJ 83, CO 89003, CO 29, CO 997, CO 527, CO 775, CO 419, CO 775, CO 8021, CO 8011, CO 671, CO 8208, COG 93076.

### Nutrient Management

The NPK recommendation for sugarcane crop varies from region-to-region. The recommendation of N is from 70-400 kg/ha, $P_2O_5$ is 27-74 kg/ha and $K_2O$ is 25-141 kg/ha. Apply FYM or compost @ 10-15 t/ha. Recommended dose of bio-fertilizers for sugarcane crop is 10-12 kg/ha. *Acetobacter, Azotobacter, Azospirillum* and PSB are the major biofertilizers, which are being used in sugarcane crop.

### Water Management

In tropical area, irrigations are to be given once in 7 days during germination phase, once in 10 days during tillering phase, again in 7 days during grand growth phase and once in 15 days during maturity phase, adjusting it to the rain fall pattern of the area. About 30 to 40 irrigations are needed. Whereas in subtropics, about 7-10 irrigations are being given to the sugarcane crop. Sugarcane is a high water requirement crop. About 250 tonnes of water is needed to produce one tonne of sugarcane. Methods like alternate furrow irrigation, drip irrigation and trash mulching could be of use to economize irrigation water during water scarcity periods.

### Weed Management

In pure crop of sugarcane spray atrazine 2 kg or oxyflurofen 750 ml/ha mixed in 500 L water as pre-emergence herbicide on 3rd day of planting. Pre-mergence application of thiobencarb @ 1.25 kg a.i./ha under intercropping system in sugarcane with soybean, blackgram or groundnut gives effective weed control.

### Plant Protection

Sugarcane is liable to be attacked by a number of insect-pests and diseases. Due to diversity in agro-ecological conditions, the importance of insect-pests and diseases varies and therefore, management strategy should be adopted accordingly. Top borer and stalk borer are found pre-dominantly in sub-tropical areas whereas early shoot borer and among diseases rust & eye spot are prevalent in tropical region.

### Harvesting and Yield

Harvesting and collection of cane should either be mechanical or manual. In subtropical India, it has been shown that spring harvested crop would result in a better ratoon than that obtained by harvesting in the autumn. Sugarcane crop is harvested after attending maturity, generally it starts from the month of October and continue till the month of May in sub-tropical states whereas in Tropical states, it starts from the month of December and continues till the month of May. Cane tonnage at harvest with best management practices can vary between 120 and 150 t/ha, which depends on the length of the total growing period and whether it is a main or ratoon crop. The sugar recovery in sugarcane varies from state-to-state. Average sugar recovery in the country is 10.25%.

## COFFEE

Coffee (*Coffea spp*) is the second important beverage, ranking second among traded commodities. Its dried beans are roasted, ground and brewed to make a stimulating and refreshing beverage. Nearly 80% of the world coffee is produced from *Coffea arabica*, 20% from *Coffea camephora* and 1% from *Coffea liberica*. There are approximately 250,000 coffee growers in India; 98% of them are small growers. India grows both Arabica (around 1/3 of production) and Robusta (around 2/3 of production) varieties of coffee. The total planted area of coffee covers around 380,000 ha mainly in the traditional coffee growing states of Karnataka (58%), Kerala (22%) and Tamil Nadu (8%).

*Full bearing a tree of coffee*

*Coffee beans*

### Climatic and Soil Requirements

The *Coffea arabica* is grown at an elevation of 1000-1500 m altitude and requires high annual rainfall of 1600-2500 mm than Coffea robusta, which can be grown at lower elevations (500-1000 m altitude).

Soil should be deep, friable, and rich in organic matter with a pH of 6.0-6.5. In April, pits of 45 × 45 × 45 cm may be dug at an appropriate spacing (2-3 m). In June, the pits are

covered with top soil and staked. In poor soils, 250 g of FYM or compost per pit may be added before filling.

### Cultivars

The four main botanical cultivars of India's coffee include Kent, S-795, Cauvery and Selection 9.

### Propagation and Planting

In coffee, generally the propagation is done through seeds and of late in robusta, the clonal propagation is also done. Disease-free and vigorous seedlings are selected for planting. Rooted plants (aged 16-18 months) with and without ball are planted during June and bag plants are generally planted during September-October. The seedlings are provided with cross stakes to prevent wind damage and mulched properly.

### Planting Shade Trees

Dadap (*Erythrina lithosperma*) is generally used as a lower canopy shade-plant. Stakes of 2 m length are planted for every two plants of coffee. Silver oak and dadap are planted during June when the southwest monsoon commences.

### Training and Pruning

The coffee plant is trained either on single stem or multiple stem system. Under south Indian conditions, periodical handling and pruning are essential. Centering and desuckering are to be carried out for about 5-6 years after planting. Usually coffee, both *arabica* and *robusta*, is trained on single stem. When the plants reach a desired height of 75 cm for *arabica* and 105-120 cm for *robusta*, they are topped.

### Water Management

Wherever water is available, overhead irrigation by sprinkler system is adopted to a greater advantage during November-January to keep the soil moisture level and in February-April for ensuring blossom as well as backing, if necessary.

### Fruit Ripening

Hastening of fruit ripening in coffee could be achieved by spraying ethephon (Ethrel) on mature berries when 10% natural ripening is observed. The following concentrations are standardized for *arabica* and *robusta* plants.

***Arabica:*** 100 to 120 ml per 200 litres of water per 400 plants.

***Robusta:*** 40 to 54 ml per 200 litres of water per 267 plants.

### Harvesting

Two harvesting systems are used most widely in coffee growing.

- **Picking:** Coffee picking is a totally manual process in which the ripe cherries are selected and picked one-by-one, requiring pickers to rotate through the crop several times. This yields a more uniform high-quality crop.

- **Stripping:** Coffee stripping is a process that may be manual or mechanised in which all the fruit is removed in one go when it is of average ripeness. It often requires a further check to eliminate impurities and under-ripe or already fermented cherries.

### Disease Management

| Disease | Symptoms | Control measures |
|---|---|---|
| **Dieback** | Dieback refers to death of younger tertiary branches starting from apex progressing downwards. | 1. Removal of dead and whippy wood.<br>2. Providing judicious shade.<br>3. Conservation of soil moisture with thick mulch.<br>4. Foliar application of nutrients.<br>5. Correcting the soil acidity by application of lime. |
| **Leaf rust** | This disease cause economic loss particularly in *arabica* coffee. Lower leaves have small pale yellowish spots. | Spray with 0.5% Bordeaux mixture or 0.03% oxycarboxin 20 EC, 3-4 times a year. |

### Pest Management

| Pest | Symptoms | Control measures |
|---|---|---|
| **Coffee berry borer** | The female beetle bores into the berries through the navel region and makes tunnels in the hard bean and lays eggs. A typical pinhole at the tip of the berries indicates the presence of the pest, and it damages young as well as ripe berries. | Timely and complete harvest, burying the infested berries and maintaining optimum shade and good drainage can control the pest. Spraying quinalphos 0.05% along with wetting agent 120-150 days after flowering can control the pest. |
| **White stem borer** | The adults have two flight periods as they emerge from the pupae during April-May and in September to December/ January. As the beetles are active and females lay eggs in the crevices on the main stem of coffee. | Swabbing the main stem and the thick primaries with carbaryl 50 WP @ 4 kg in 200 L water once or twice in April-May or October to December. |

# TEA

Tea (*Camellia sinensis*) belongs to family Camelliaceae or Theaceae, is the most popular and the cheapest beverage consumed by two-thirds of the world population. Majority of the tea producing countries are located in the continent of Asia where China, India, Sri Lanka are the major producers. In India, It is mainly grown in Assam, West Bengal, Tamil Nadu, Kerala and Karnataka. Some of tea is produced in Uttarakhand and in Kangra Valley and Mandi district of Himachal Pradesh.

*Harvesting of tea in progress*

## Climatic and Soil Requirements

Tea bush is a tropical and subtropical plant and thrives well in hot and humid climate. There is a very close relation between climate, the yield and the quality of tea. The ideal temperature for its growth is 20°-30°C and temperatures above 35°C and below 10°C are harmful for the bush. It requires 150-300 cm annual rainfall, which should be well distributed throughout the year. Tea is a shade-loving plant and develops more vigorously when planted along with shady trees.

Tea bush grows well in well-drained, deep, friable loams. However, virgin forest soils rich in humus and iron content are considered to be the best soils for tea plantations. Relatively large proportion of phosphorus and potash in the soil gives special flavour to tea as is the case in Darjeeling. The soil should be acidic (around pH 5.0) having good drainage facility.

### Varieties

Clones: UPASI-2, UPASI-8, UPASI-9, UPASI-17, BSS-1, BSS-2.

## Propagation and Planting

The seed viability extends up to 6 months. Before sowing, seeds are put in water and only the sinkers will be used and floaters rejected. Seeds germinate in 4-6 weeks and the cracked seeds are transplanted in polythene sleeves. The plants will be ready for planting in the main field in 9 months.

In the case of new planting, in order to avoid the incidence of root diseases, after felling the trees, remove the root system to the extent possible. Clear the jungle growth but do not burn, the ash being alkaline will increase the pH. Pits of size 30 × 45 cm are dug one. Keep the top and bottom soil separately. In clayey soil and drought-prone areas, deeper pits (60 cm) or trench planting will be advantageous. In south-west monsoon areas, June-July and in north-east monsoon areas, the September-October are ideal months for planting.

## Nutrient Management

Apply 100 g of powdered aluminium sulphate per pit and thoroughly mix with soil. Select seedlings of 12 months old. After planting the seedling, compact the soil surrounding the plant and apply mulch @ 25 t $ha^{-1}$. The 4 year old and above plants are applied with 300: 300: 50 kg NPK/ha, respectively in 6 splits.

## Special operations in tea garden

| | |
|---|---|
| **Training of young tea plants** | Proper training of young tea plants is essential to encourage good spread of the bushes, proper development of frames and high density of plucking points. |
| **Centering** | Cut the leader stem of the plants with secateur to arrest the apical dominance and to induce the secondary branches. Cut as low as possible leaving 8-10 mature leaves below the cut. Ensure proper recovery. Centering should be done 4-6 months after planting during humid weather when there is adequate moisture in the soil. |
| **Tipping** | First plucking of the periodic shoot is done after centering/ pruning. Two-tier tipping ensures proper spread. First tipping at 35 cm height will induce the tertiaries. Second tipping at 50 cm height will increase the density of plucking points. Tipping should be done at green, semi-hardwood branches. Tipping should be done in shoots having 3-4 leaves and a bud. |
| **Plucking** | Mother leaf / step-up plucking is practiced during lean seasons. Level plucking is done during high cropping months. This is essential for better frame development. |

| | |
|---|---|
| **Shade management** | The best permanent shade tree for tea plantation in south India is silver oak (*Grevillea robusta*). Tea requires only sparse shade. So retain optimum stand of shade-based on the growth of the tree, altitude of the garden and aspect of the field (south and west slopes require more shade). Always thin out shade prior to pruning. |
| **Pollarding** | Cutting the main stem with the objective of developing lateral branches is called pollarding. Commence pollarding when the trees attain a girth of around 50 cm at elbow level. Pollarding depends on altitude (8 m height for higher altitude, 9 m for low elevation). Leave one branch in each direction and 3 to 4 tiers of branches, below the pollarding height. |
| **Annual lopping** | Cutting the erect growing branches on the laterals is called lopping, which should be done before the onset of monsoons and lop only the erect branches and retain the laterals. |
| **Plucking** | • Harvest 2-3 leaves and a bud.<br>• Pluck the mother leaf during January-March.<br>• Pluck the new level during rest of the month.<br>• Pluck at 7-10 days interval during high cropping months.<br>• Pluck at 12-15 days interval during low cropping months.<br>• Do not pluck below the level.<br>• Leave immature shoots.<br>• Shear-harvest during rush periods.<br>• Cut lanes in older fields. |

*Harvesting in tea*

*Freshly harvested tea leaves*

### Important disease and their management

| Disease | Symptoms | Control measures |
|---|---|---|
| **Black root disease** | The common symptoms are wilting, chlorosis, drying without defoliation and death of bush. | Remove surface mulches around 10 m. Drench soil with mancozeb 30 g/10 L water. Follow phytosanitary measures. |
| **Collar canker** | The main symptoms are chlorosis, cessation of growth, profuse flowering and canker on stem. | Remove affected portion by pruning the healthy wood and apply copper fungicide to cut ends. |
| **Blister blight** | The fungus affects only tender leaves and stems. Stem infection leads to goose-neck shape, dieback and snapping at the point of infection. | Spray of copper oxychloride 350 g + plantomycin 70 g/ha at 3-4 days interval can control the disease. |

### Important pest & their management

| Pests | Symptoms | Control measures |
|---|---|---|
| **White/ cockchafer grubs** *(Holotrichia* sp.*)* | The creamy white grub eats away the roots. Main symptoms are ring barking of stem, chlorosis and defoliation. The pest is a serious problem in areas where un-decomposed FYM is used. | Heat treatment of soil is effective. Drench 0.05% chlorpyriphos or quinalphos. |
| **Root mealy bug** *(Dysmicoccus* sp.*)* | The pest is a problem in nursery. It sucks sap from the callusing region, mother leaf petiole and axillary buds. This arrests root development; leads to mother-leaf fall and finally death of plant. | It can be controlled by spraying and soil drenching with chlorpyriphos or quinalphos 0.05 per cent. |

## EXERCISES

## Activities

1. Go to a nearby village and make a list of crops grown by the village farmers. Also, classify them as cereal crops, pulse crops, oilseed crops, fodder crops, fiibre crops and commercial crops.

2. Make a season-wise list of crops grown in your village/locality (*kharif* season crops, *rabi* season crops and *zaid* season crops)
3. Go to a nearby village and make a list of major pests and diseases of the major crops. Also, make chart for their management:
4. Plan a visit to a nearby State Agricultural University/ICAR institute of your area or Krishi Vigyan Kendra of your district. Make a technology inventory (report) of recently developed crop production technologies of major crops of your area by these institutes.
5. List the major pulse crops of India. Discuss their seed rate, fertilizer and water management practices.

## Check Your Progress

1. Write a paragraph in your own words on each of the following:

   (a) Sowing, (b) Nutrient management, (c) Weed management, (d) Disease management, (e) Pest management.
2. Write a short note on crop production technology in wheat.
3. Define harvesting, threshing and winnowing.
4. Why does time and frequency of irrigation vary from crop to crop?
5. Write major rice based cropping systems of India.
6. Write a paragraph on the various methods used to replenish the nutrients in the fields.
7. What are weeds? How can we control them?
8. List the major coffee and tea growing states in India.
9. List major fiber crops of India and their production areas/states.
10. Write a short note on berseem fodder crop.
11. What is the significance of nipping in chickpea?
12. What is the significance of retting in jute?
13. What is the significance of climatic and soil requirements in crop production?
14. Mention the seed rate and nutrient management in maize.
15. List the major oilseed crops of India. Discuss their fertilizer and water management practices.

## Fill in the blanks

1. Promising basmati rice cultivars are……..
2. Wheat is a…… season crop.
3. Examples of specialty maize types are ……..
4. Soybean contains ……% protein and …..% oil content.

5. Critical stages of irrigation in wheat are……..
6. Legume root nodules contain Rhizobium bacteria, which are responsible for ……..
7. India ranks …….. in area and production of chickpea at world level.
8. Botanical name of pigeonpea is ……..
9. White grub is a major pest of ……..
10. Average sugar recovery from sugarcane in India is……..

## Match the statement given in column A with the statement of column B.

| Column A | Column B |
|---|---|
| *Kharif* crops | Wheat, gram, pea |
| *Rabi* crops | Urea and super phosphate |
| Chemical fertilisers | Rice, maize, soybean |
| Organic manure | FYM, compost |

| Column A | Column B |
|---|---|
| Rice | Crown root initiation (CRI), tillering, flowering, milking, grain filling |
| Wheat | Tillering, panicle initiation, heading, flowering, grain filling |
| Maize | Flowering and pod development |
| Pulses | Knee high stage, tasseling, silking, early grain formation |

## Suggested Further Readings


- Textbook of Field Crops Production-Foodgrain Crops (Vol-I), ICAR Publication, New Delhi.
- Textbook of Field Crops Production-Commercial Crops (Vol-II), ICAR Publication, New Delhi.
- Handbook of Agriculture, ICAR Publication, New Delhi.
- Rana, K.S., Choudhary, A.K., Sepat, S. and Bana, R.S. 2014. Advances in Field Crop Production. [ISBN: 978-93-83168-08-8]. Post Graduate School, IARI, New Delhi. pp 475.
- Choudhary, A.K., Rana, D.S., Bana, R.S., Pooniya, V., Dass, A., Kaur, R., Rana, K.S. 2015. Agronomy of Oilseed and Pulse Crops. [ISBN: 978-93-83168-21-7]. Post Graduate School, IARI, New Delhi & ICAR, DARE, New Delhi, India. pp 206.

# CHAPTER – 2

# PRODUCTION AND MANAGEMENT OF HORTICULTURAL CROPS

## Learning Objectives

After studying this chapter, students will be able to:

- Know important fruits and their cultivation hints
- Identify the problems of fruits and their management
- Identify the major insect-pests and diseases of temperate fruits and their integrated control measures
- Start agribusiness in horticultural crops

## Introduction

Whenever you go to a market, you might have seen several types of fruits, vegetables, flowers, condiments and spices. Have you ever thought about their areas of production, and specific climate or soils in which they grow? I don't think you have ever thought about it. You may have several such queries in your mind. In this chapter, you will come to know about major fruits, vegetables, flower crops and some plantaion crops, condiments and spices and their cultural hints.

## A. Cultural Hints for Major Fruits Grown in India

## APPLE

### Apple (*Malus domestica* Borkh.)

Apple is the most important fruit among the temperate fruits grown throughout the world. It belongs to genus *Malus*, family Rosaceae with basic chromosome number, x = 17 and commonly called as king of temperate fruits. In India, apple is cultivated in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Nagaland and Sikkim. Some low chilling varieties are also cultivated in Nilgiri hills and eastern Himalayan ranges.

### Soil and Climatic Requirements

Apple can grown on a wide range of soils. Well-drained, deep, fertile, slightly acidic, clay loam soils with pH 6.0-6.8 are considered ideal for apple cultivation. Sites with gentle slope are generally more suitable than too steep areas. Apple requires about 1,000 to 1,500 hours of winter chilling for breaking the bud dormancy.

## Planting

The systems of planting apple in flat areas are square, rectangular, quincunx and hexagonal. However, in hilly areas, contour or terrace planting is convenient. A planting distance of 8 x 8 m for vigorous and 5 x 5 m for dwarf cultivars is recommended in India. In general, pits of 1 x 1 x 1 m size are dug and filled at least one month before planting by mixing 40-50 kg FYM or compost, 500 g superphosphate and 50 g insecticidal dust like metacid dust or folidol dust at the time of pit filling. Early planting should be done preferably in December.

## Commercial Varieties

According to the time of harvesting, apple varieties can be categorized as early, mid and late.

| | |
|---|---|
| Early | Red June, Tydeman's Early Worcester, Kings Pippin, Summer Queen |
| Mid season | Starking Delicious, Red Delicious, Richared, Black Ben Davis, Red Gold, Mclntosh, Golden Delicious, Lord Lambourne |
| Late | Granny Smith, Ruspippin Yellow, Winter Banana |

## Flowering, Pollination and Fruit set

Most of the apple cultivars especially of the Delicious group are self-infertile and hence require cross pollination for satisfactory fruit set. Therefore, pollinizing varieties such as Tydeman's Early Worcester, Red Gold and Golden Delicious should also be grown along with commercial variety.

## Rootstocks and Propagation

Traditionally seedling rootstocks are used.Standard clonal rootstocks such as Malling (M) series (M9, M27) and Malling Merton (MM) series rootstocks (MM106, MM109, MM111) are used.

## Training and Pruning

Modified central leader system of training is most suitable for developing framework of the tree in standard plantations on seedling rootstock. The proportional heading back and thinning out system of pruning is adopted to maintain the balance between the reproductive and vegetative growth. Apple requires regular moderate annual pruning. In the aged plantations, spur pruning is advisable to encourage the vegetative growth and new spur development.

## Manures and Fertilizers

In general, 10 kg FYM, 70 g N, 35 g $P_2O_5$ and 70 g $K_2O$ should be applied to one-year-old plants. FYM, $P_2O_5$ and $K_2O$ should be applied during the winter before snowfall at the time of basin preparation whereas nitrogenous fertilizers should be applied one month before bud break.

## Maturity and Harvesting

It is important to harvest the fruits at proper stage of maturity. Immature fruits are of poor flavour and quality and shrink during storage. Over mature fruits are also poor in quality and are more prone to storage disorders. The important picking indices for apple are, change of seed colour to brown, change of ground colour from green to pale or red, TSS of 11 to 14.5, firmness of flesh (16-18 lb/square inch), easy separation of fruit from the spurs, T stage ,starch index and 90-180 days from full bloom to maturity depending on variety.

## Grading and Packaing

The harvested fruits are graded according to size and colour. In India, apples are graded in seven size grades *viz.* super large (85 mm diameter), extra large (80 mm), large (75 mm), medium (70 mm), small (65 mm), extra small (60 mm) and *pittoo* (55 mm and below). The fruits can be packed in telescopic fibre board cartons or wooden boxes for transportation and storage. Apple fruits can be stored at -1.1 to 0°C at 85-90 per cent relative humidity for 4-6 months.

## Plant Protection

### a. Insect Pests and their Control

| Insect-pest | Control measures |
|---|---|
| San Jose Scale | Application of 2 per cent miscible oil or 5 per cent summer oil during February-March efficiently controls the pest. |
| Woolly apple aphid  | Soil application of phorate or carbofuran granules during May and October-November checks its incidence and spread of this pest. The foliar spray of chlorpyriphos (0.02%), fenitrothion (0.05%), dimethoate (0.03%) or phosphamidon (0.03%) also controls the pest effectively. |
| Root borers | Drench tree basins with chlorpyriphos (0.04) or dusting with folidol dust at the rate of 25 kg/ha during September is quite effective for the control of root borers. |

## Diseases and their Control

| | |
|---|---|
| Apple scab | The disease is caused by a fungus, *Venturia inaequalis*. It is most serious disease of apple and causes serious losses to the growers. It mostly affects leaves, buds and fruits. On the affected parts olive coloured spots appear, A spray schedule of different chemicals has been recommended for its effective control. |

| | |
|---|---|
| Powdery mildew | In this disease, whity powdery mass grows on leaves and other ariel parts. It can be kept under control by pruning and destroying affected terminals and spraying of wettable sulphur (0.2-0.3%), carbendazim (0.05%) or karathane (0.05%) during late dormancy, bud swell, petal fall and two weeks later. In nursery, spraying of fungicides at 7 days interval is recommended. |

# MANGO

Mango (*Mangifera indica* L.), belongs to family Anacardiaceae and genus *Mangifera* with basic chromosome number, X = 20. The choicest fruit of India, ambasedor fruit of India, is said to be the king of fruits. It is an outstanding source of vitamin A, a good source of vitamin C, apart from normal minerals and other vitamins.

## Soil and Climatic Requirements

Mango can be grown in a variety of soils but clay-loam, well-drained soils with a pH range of 5.7 to 7.5 are considered to be the best for its cultivation. A temperature range of 24-27°C throughout the growing season is the best for its cultivation.

### Commercial Varieties

In India, there are several varieties of mango but only 10-12 are grown commercially. For example, Dashehari, Langra, Chausa and Bombay Green are grown commercially in north, Banganpalli/Baneshan, Neelum, Totapuri in south, Alphonso and Kesar in west and Langra, Himsagar etc. in the east. On the basis of embryos, mango varieties have been classified as monoembryonic (Most of the varieties) and polyembryonic (Bapakai, Vellary, Chandrakaran, Kurrukan, Goa, Olour, Carabao, Paho, Peach, Apricot, Strawberry etc.)

### Propagation

Mango can be propagated both by sexual and asexual means but it is mainly propagated by veneer grafting, stone grafting and soft-wood grafting in different parts of India.

### Planting Distance and Time

Planting distance varies from variety-to-variety and locality-to-locality. In general, a planting distance of 10-12m is recommended for commercial varieties like Dashehari, Langra, Chansa, Alphonso, Banganpalli etc. Pits of 1 x 1 x 1 m size are dug out and kept open during May, which are refilled by the end of the June with the mixture of top soil and Farm Yard Manure in the ratio of 1: 1. The best time for planting mango is the monsoon season.

## Manures and Fertilizers

In general, ammonium sulphate, super phosphate and sulphate of potash should be mixed in the ratio of 1: 3: 1 and applied @ ½ kg in the first year, which should be increased by kg every year up to 15$^{th}$ year, and then 6-10 kg afterwards. Farm yard manure (FYM) is generally applied in September-October every year.

## Irrigation

Young plants should be irrigated at weekly intervals in summer and at fortnightly intervals in winter. However, the bearing plants should be irrigated at 10-15 days interval from fruit set stage to maturity. It is, however, advised to withheld irrigation during flowering as it may result in shedding of flowers.

## Plant Protection

| Insect-pest | Control measures |
|---|---|
| Mango leaf hopper | Mango hoppers can be controlled by two sprays of carbaryl (0.1%) or diazinon (0.2%) during January-February at fortnightly intervals. |
| Mango mealy bug | Kill nymphs and females by spraying metasystox (0.2%). Follow banding of tree trunks with 30 cm wide alkathene. |
| Stone weevil | Difficult to control, however, bagging of fruits, destruction of affected fallen fruits and disposal of debris, etc., can bring out reduction in the insect number. |
| Fruit fly | Collect and destroy the affected fruits. Use baits (malathion (0.05%) + jaggery+eugenol) at 4-5 places in open containers to attract the adult flies, and control them effectively. Raking of soil in May-June is equally useful as it helps in the killing of pupae. |

## Diseases

| | |
|---|---|
| Powdery mildew | Two sprays of karathane (0.1% ) at fortnightly interval completely control this disease. One preventive spray of karathane (0.1%) as soon as cloudy weather appears during flowering time. |
| Anthracnose | Spray zineb (0.2%). However, a preventive spray of Bordeaux mixture (4:4:50) is always useful in humid areas before panicle emergence. |

## Physiological Disorders

**Malformation:** It is most dreaded disorder of mango in northern parts of India, the causal agent of which is still unknown. Most of the commercial varieties in subtropical parts of India are affected by malformation and southern parts are virtually free from it. Plants both in nursery and field are affected by this malady. The symptoms of this

malady are characterized by the transformation of inflorescence into compact mass with predominating male flowers.

This disorder is commonly related to the prevailing environmental temperature. Panicles emerging during late-December or early-January (when the environmental temperature is comparatively low) are worst affected by malformation. The following control measures reduce the incidence of malformation:

*Malformed mango panicle*

*Mango malformation is the most dreaded malady of mango in north India; its causes are not yet known, however, temperature plays a vital role. De-blossoming of malformed panicles during December-January is most useful solution.*

1. Remove and burn all the affected malformed panicles and branches as and when they emerge.
2. Follow up de-blossoming in January.
3. Application of methanol leaf extract of *Ruelia tuberosa* (12 g leaf per litre solution) reduces malformation in cv. Dashehari. However, the concentration is variety specific, which needs to be standardized.
4. Spray NAA (200 ppm) in October.

*Spongy tissue is one of the most serious disorders of Alphonso mango, which hinders its export from India.*

**Spongy tissue:** Spongy tissue disorder accounts for more than 30 per cent loss in Alphonso mango. In this disorder, a non-edible, sour, yellowish and sponge like patch develops in one part of the fruit during ripening. The fruit pulp remains unripe but the fruits look normal in external appearance. On cutting, the fruits emit bad odour and are unfit for human consumption. The precise cause of this malady is still unknown. However, recent studies indicate that fruits low in Ca content are worst affected by spongy tissue disorder and the convecteric heat of the soil adds more to this disorder. Use of sod culture, green vegetation, leguminous crop cover or mulching at pre-harvest stage are some measures to reduce this disorder to some extent.

## Maturity and Harvesting

Depending on variety and growing environment, mango fruits take 90-120 days to reach harvest maturity. Various indices have been suggested to determine the harvest maturity of mango, e.g., change of peel colour, natural falling of some fruits from the tree (*tapka*) formation of abscission layer at pedicel joint, specific gravity of fruits (1.01-1.02), etc. Harvesting is done manually. The most useful tool for this purpose is a long bamboo pole fitted with a cutting shear and a collecting net below it at the distil end of the pole.

# BANANA

Banana belongs to family Musaceae and genus *Musa* with basic chromosome number, X = 11. On the basis of genomic constitution, banana has two species, *Musa acuminata* and *M, balbisiana*. All edible bananas have been developed from these two species. Banana is one of the oldest and most popular fruits. It is a good source of carbohydrates and minerals like potassium and sodium. It is widely used as a fresh fruit, but several value added products like chips, puree etc. can also be made from it. India ranks second among the banana growing countries after Brazil. In India, Kerala, Maharashtra and Tamil Nadu account for major share in area and production of banana.

## Soil and Climatic Requirements

Clay to sandy clay-loam soil is the most suitable for banana cultivation. However, the best soil is medium textured soil, having pH between 5.5-8.0. It enjoys an annual rainfall ranging from 100 to 325 cm. Banana is well adapted to areas with temperature between 21-32°C, and annual rainfall between 1,000-2,000 mm.

### Commercial Varieties/Clones

The major varieties are Poovan, Basrai, Monthan, Harichal, Rasthali, Hill Banana, Nendran, Sevazhai and Kunnan.

### Propagation

Bananas are propagated from offshoots (suckers) or rhizomes.

### Planting System

Square, rectangle and triangle system are recommended systems for banana planting. For mono-cultured cropping system, the recommended planting distance is 3.0 x 1.5 m. For high-density planting, distance is reduced significantly.

### Thinning of Suckers or Desuckering

Thinning of suckers involves removal of unwanted suckers; normally weak unhealthy, mainly water sucker using sharp knife at the ground level, leaving 1 bearer, one follower and one sucker per clump at any time.

### Fertilizer Application

Banana requires high fertilization due to its rapid and vigorous growth and high fruit yield. It removes nearly 250-300 kg N, 25-40 kg P and 800-1200 kg K, 150-180 kg Ca, 40-60 kg Mg and 14-20 kg S per hectare. Usually, 300 Kg N, 40-50 Kg P and 250-300 K should be given per ha.

### Water Management

Banana plant should be irrigated to encourage development and healthy growth especially in the early years of growth. Micro-sprinkler or drip irrigation system is

recommended. Areas with frequent flash flood, construction of in-field drainage is recommended.

### Plant Protection

| Insect-pests | Control measures |
|---|---|
| Corm weevil | Use healthy materials and treat rhizomes with hot water for 5-10 minutes. Ensure good sanitation. Drench with dieldrin. |
| Stem borer weevil | Ensure good sanitation. Spray with dieldrin. |
| Nematode | Hot water treatment. Sanitation. Drench with fenamiphos. Wrapping of fruit with polyethylene bags. |

| Diseases | Control measures |
|---|---|
| Leaf spot | Used resistant cultivar. Spray with benomyl (0.03%). |
| Panama disease (Fusarium wilt) | Use resistant variety. Ensure good sanitation. Use disease free planting material. |
| Bunchy top | Adoption of strict quarantine measures, destroy infected plant material. Control aphid by spraying metasystox or dimecron (0.01%) |

### Maturity, Harvesting and Yield

Depending on the variety, banana starts to bear fruit in 6-8 months after planting. It is ready for harvesting in about 7-11 weeks later.

## GUAVA

Guava (*Psidium guajava* L.), belongs to family Myrtaceae and genus *Psidium* with basic chromosome number (n) = 11. It is also known as the 'apple of tropics' and 'poor man's fruit' in India. It is a rich source of vitamin C and pectin, and good source of vitamins, minerals like calcium and phosphorus. Being rich in pectin, excellent jelly is made from guavas. In India, it is mainly grown in Uttar Pradesh, Madhya Pradesh, Bihar and Maharashtra. In Uttar Pradesh, Allahabad region has the reputation of growing the best quality guavas in the world.

### Soil and Climatic Requirements

Guava is a hardy fruit plant and can thrive on all types of soils, ranging from heavy clay to light soils. However, the clay loam, deep, friable and well-drained soils are best. It can be grown in soils having pH up to 9.0, though the optimum range is 4.5 to 7.5. Under highly waterlogged, saline and alkaline conditions, its cultivation is adversely affected. However, both yield and fruit quality are better in areas with distinct winter.

### Commercial Varieties

Important varieties of guava are Allahabad Safeda, Sardar (Lucknow-49), Behat Coconut, Seedless, Apple Colour, Banarasi Surkha, Chittidar, Arka Kiran, Swetha.

### Propagation

Guava can be propagated both by seed and a sexual means. Most important methods of vegetative propagation are air layering/gootee, stooling, softwood grafting and budding. Now-a-days, stooling is preferred.

### Planting

The pits of 1 x 1 x 1 m size should be dug out at appropriate distance in a square system before monsoon. The pits are refilled with 25-30 kg well decomposed farm yard manure, mixed with top soil and irrigated. The best planting time is onset of monsoon. Guava is usually planted at a distance of 7 to 8 m.

### Irrigation

Guava is a hardy fruit plant and requires very less water. However, in the early stages of orchard establishment, plants require frequent irrigation. Later, more frequent irrigation (fortnightly interval) is required from April to June for good growth and fruit yield. Due to regular growth, flowering and fruiting in south India, guava requires irrigation throughout the year.

### Manuring and Fertilization

Ten-year-old guava tree should be given about 80 kg of FYM, 1 kg of ammonium sulphate or 800 g of calcium ammonium nitrate, 3kg of super-phosphate and 2 kg of potassium sulphate.The fertilizers should be applied in two split doses (June and October) when there is sufficient moisture in the soil.

### Flowering and Crop Regulation

Guava flowers twice a year in north India. First flowering takes place in April-May, which gives fruits in rainy season. The second flowering takes place in August-September to give fruiting in winter season. The rainy season crop is generally avoided as most of the fruits are infested by fruitfly and the fruits are insipid and of very poor quality. The winter crop is virtually free from fruitfly and the fruits are of high quality. Winter crop is therefore, preferred as it gives very high returns to the farmers. In central-southern India, guava flowers thrice a year, with flowers appearing in October also. In West Bengal, guava flowers once in April-May and again in September-October.

*Under certain climatic conditions, guava plants may flower twice or thrice a year. Under these conditions, regulation of flowering is required, to get fruits of desirable quality. Regulation of flowering can be achieved by exposure of roots, root pruning and with chemicals, which is called as bahar treatment.*

In areas where guava flowers twice or thrice a year, we need to regulate crop in such a way that only quality crop is harvested. In this process, winter and rainy season crop is avoided. This can be done by forcing the plants to take rest in the undesired season by stopping irrigation, and then applying fertilizers and manures in the desired season. De-blossoming can be done by spraying NAA (100 ppm) or 2,4-D (30 ppm) in summer.

## Plant Protection

| Insect pests | Damage | Control measures |
|---|---|---|
| Fruit fly | Most serious pest of rainy season crop, renders whole crop unfit for consumption. Maggots on hatching, enter the fruits, and feed inside. | Soil raking, destruction of infected fruits, use of baits (sugar + malathion) and spraying plants with malathion (0.05%) or dimecron (0.03%) during oviposition period are some useful measures. |
| Mealy bug | Causes damage by sucking cell sap from tender leaves, shoots, flowers and fruits. The affected leaves dry up and the fruits drop off, resulting in poor yield. | The banding of the tree trunk with polyethylene film or Ostico-sticky bands is the best method to prevent them climbing up the tree. Further, treatment of soil with aldrin or malathion is also effective. |

| Diseases | Symptoms | Control measures |
|---|---|---|
| Wilt | This disease is characterized by yellowing of leaves, followed by drying of the leaves. The twigs start drying from tip downwards. The plant may collapse slowly in several or within 15-20 days. | Remove and burn the infected plants, maintain proper drainage, grow wilt resistant varieties (L-49, Banarasi), avoid planting in highly alkaline soils, disinfect soil with 2 per cent formaldehyde solution before planting, and drench soil with brassicol or spray bavistin (0.1%) at an interval of 15 days at early stages of disease infection. |
| Anthracnose | Die-back starts from top of the branch. Other plant parts, like shoots, leaves and fruits are readily affected. High humidity and frequent rains favour the spread and intensity of disease. | Spray dithane-Z-78 or phytolan (0.2%) at fortnightly interval. |

## Maturity and Harvesting

Seedling guava plants have 5-6 years juvenile phase whereas the grafted or layered plants start bearing after 2-3 years. Change in fruit colour is usually taken as harvesting index. As soon as colour starts turning from greenish-to-yellowish, the fruits should

be harvested. Hand picking of fruits at regular intervals is preferred. Harvesting by shaking of tree may cause severe damage to fruits and the tree. Guava starts giving economic yields after 8-10 years of planting. In general, grafted plant of 8-10 years age can yield 400 to 800 fruits weighing 80 to 100 kg. Guavas are highly perishable and must be marketed immediately after harvest.

## CITRUS

Citrus comprise a group of fruits such as mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*), lemon (*Citrus limon*), lime (*Cirus aurantifolia*), pummelo (*Citrus grandis*) and grapefruit (*C. paradisi*), belonging to family Rutaceae, with basic chromosome number, X=8. Juice present in the vesicles is the edible portion of the citrus fruit. The juice contains 12-14 per cent sugars, citric acid, and ascorbic acid (Vitamin C). In India, Maharashtra, A.P., Punjab, NE states, Karnataka and Bihar are the major citrus producing states.

### Soil and Climatic Requirements

Commercial citrus cultivation in India is done on soils ranging from coarse sands to heavy clays, Ideal pH ranges from 5.5 to 6.0. The growth and development in citrus is optimum in temperature regimes ranging from 25 to 30°C to minimum of l3°C. Annual rainfall of 800-900 mm, well distributed throughout the year is optimum for citrus growth and production.

#### Commercial Cultivars

| | |
|---|---|
| **Sweet oranges** | Mosambi, Sathgudi, Valencia, Pineapple, Jaffa, Hamlin, Shamouti, Malta, Malta Blood Red, Ruby etc. |
| **Mandarins** | Owara, Silver Hill, King, Willow Leaf, Nagpuri, Khasi, Coorg, Kinnow and Satsuma. |
| **Lemon** | Eureka, Lisbon, Assam lemon, Pani Jamir, Meyer lemon, Karna Khatta, and *galgal* (hill lemon). |
| **Lime** | West Indian lime, Kagzi, Tahiti lime (Persian), Pond, etc. |
| **Grapefruit** | Duncan, Foster, Marsh Seedless Thompson Seedless, Red Blush. |
| **Pummelo** | Nagpur (chakotra), Common pummelo. |

#### Propagation and Rootstock

Citrus trees are propagated by both vegetative mean and sexually by seeds. Vegetative methods are preferred because they ensure uniformity in quality and bearing. Seeds of several citrus species are polyembryonic and nuclear seedlings, which produce true-to-type plants. Mandarins and acid limes are mostly propagated as seedlings. Lemons, citrons, sweet limes are easily propagated by stem cuttings. Air-layering is mostly practiced in pummelo, mandarin, acid lime and seedless lemons. Most of citrus cultivars are propagated by 'T' budding on a suitable rootstock.

## Rootstock and Polyembryony

Rootstocks commonly employed for citrus propagation are rough lemon, sour orange (*C. aurantium* L.), Karna Khatta (*C. karna*), Rangpur lime (*C. reticulata*), sweet orange (*C. sinensis* L. Osbeck), Citranges like Troyer, trifoliate orange (*Poncirus trifoliata* L. Raf.), and Cleopatra mandarin.

## Planting

Commonly planted in a square or rectangular system. In square system, the planting density of 4 x 4 m, 5 x 5 m, 3 x 3 m can accommodate 625, 400, 1111 plants/ha, respectively. Pits of size 50 x 50 cm are dug in summer according to the layout plan and mixed with 15-20 kg well rotten FYM and 50 g chloropyrophos (to kill white ants) and filled tightly with top soil. The best planting time is beginning of rainy season.

## Nutrient Management

For sustainable production of fruits and for proper maintenance of plant and soil health, efficient nutrient management programme must be adopted. Citrus is a nutrient exhaustive crop as plants in the population density of 400 plants/ha can remove about 200 kg N, 50 kg $P_2O_5$ and 200 kg $K_2O$/ha. Foliar spray of micronutrients has given beneficial effect on improving the yield and quality. One to 2% urea, alongwith $ZnSO_4$, $MnSO_4$, $MgSO_4$ (each 0.5%) and $CuSO_4$ (0.25%) is beneficial for all citrus cultivars.

## Physiological Disorders

**Granulation:** This is the major disorder of sweet orange, mandarin wherein the juice sacs become tough, enlarged, colourless and tastelss. There is a marked increase in the pectic substances, gels etc. and marked decline in sugars, organic acids and carotenoids. These fruits are insipid and fetch poor price in the market. Some of the factors associated with it are: high soil humidity, high relative humidity and temperature during fruit growth. Hamlin and Mosambi orange are highly prone to granulation. This malady can be kept under control with the application of 16 ppm of 2,4-D on developing fruits. Similar, effect was also noted with the spray of $ZnSO_4$ + $CuSO_4$ + KCl each at 0.25% at monthly interval from August to October.

**Fruit cracking:** This is a common disorder of sweet orange and acid lime. The splitting starts at stylar end and progresses towards the pedicelar end. Splitting is basically caused due to factors like deficit soil moisture, atmospheric temperature and relative humidity. Borax (0.2%) spray can check splitting and timely application of irrigation water must be ensured.

*Fruit cracking/splitting is a serious problem in lemon. It can be reduced by regular irrigation and spraying borax and calcium chloride.*

## Plant Protection

| Insect-pest | Damage | Control measures |
|---|---|---|
| Aphids (Several species) | Aphids suck sap from young leaves and twigs thereby causing severe curling of leaves, stunting of plant and facilitate sooty mould growth by excreting honeydew. These aphids act as vector for Tristeza virus. | Sprays of monocrotophos (0.025%), phosphomidon (0.03%) or parathion (0.03%) are useful for the control of aphids. |
| Citrus psylla | Suck sap from young leaves and act as a vector for transmitting greening disease | Spray systemic insecticides like phosphomidon (0.03%), monocrotophos (0 025%) or oxydemeton methyl (0.03%). |
| Leaf minor | Young ones cause damage by mining the leaves | Synthetic pyrethroids viz., fenvalerate (0.01%), permethrin (0.005%) or cypetnethrin (0.001%) are most effective. |
| Lemon butterfly | Caterpillars defoliate entire leaves. | Dusting and spraying with sevin (0.1%) has been found very effective. |
| Fruit sucking moth | Adult insects suck sap from mature fruits, thereby leading to fruit rot and drop. | Use light traps |

| Diseases | Symptoms | Control measures |
|---|---|---|
| Tristeza | Symptoms like stem pitting, seedling yellows, etc. infected plants show poor growth, die back, defoliations and ultimately death. | Use tolerant rootstock like Rangpur lime, Cleopatra mandarin, Trifoliate orange, use certified bud-wood, control aphids by insecticides. |
| Greening | The symptoms appear as chlorosis resembling Zn deficiency, short twigs with upright yellow leaves, leaf drop, dieback, formation of multiple buds and disfigured fruits. | Tree injection with tetracycline or employing cross protection is found to be effective. Control citrus psylla by suitable insecticides. |
| Phytophthora rot or gummosis | Symptoms are noted as root rot, gummosis, blight of seedlings and fruit rot. | Use resistant rootstocks like *Poncirus trifoliata* or sour orange. Soil drenching with foltaf (0.2%) or avoiding water stagnation around tree trunk is widely adopted practices. |

| | | |
|---|---|---|
| Bacterial canker | Acid limes are most susceptible. Development of lesions with halo on leaves, twigs and fruits. | Spray 1% Bordeaux mixture or 500 ppm streptomycin sulphate and control of leaf miner (insect vector) by metasystox (0.1%). Prune infected portions. |

### Maturity, Harvesting and Yield

*Citrus canker*

Time of harvest in citrus varies with the region (tropical and subtropical) and the species. Marketable maturity is generally judged with the change in rind colour. Commercially, TSS: acid ratio is the most reliable method and it ranges from 10:1 to 16:1, depending upon citrus species and flush. 'Khasi mandarin' in Northern-Eastern states is harvested during October-January, while 'Darjeeling' mandarin is harvested during November-December. Kinnow in Punjab is harvested during January-February; Nagpur mandarin is harvested during April-July. Mosambi is harvested in April-June (1st crop) in Maharashtra. Hand picking is the most popular method to collect fruits while in some regions, harvesting by shaking of main trunk is also done. Maximum productivity in citrus ranges from 700 to 1,000 fruits per tree which depends on the age of plant, cultivar, rootstock and management practices. Kinnow plant can yield 300 to 800 fruits/plant, mandarin give 500 fruits per plant.

## GRAPES

Grape (*Vitis vinifera* L.) is one of the most delicious, refreshing and nourishing fruit, which belongs to the family Vitiaceae. The fruit is utilized in many ways. About 80 per cent of the grapes are used for wine making and the remaining 20 per cent are used for raisin, juice and canning purpose. France, Italy and Spain are the leading producer of wine. In India, grapes are mainly consumed as fresh fruit.

*A view of profuse bearing in grape*

### Soil and Climatic Requirements

Well drained sandy-loam soil and fairly fertile soil, having good amount of organic matter is best for cultivation of grapes. Heavy clay, sand or slit are unsuitable for grape. Grape is relatively tolerant to soil salinity and alkalinity.

Grape requires a long, dry and moderately hot season during cane maturity and ripening of berries followed by cool winter. Rains during growing season are useful,

but continuous rains, make it difficult to control diseases. Rains at the time of berry ripening are harmful as even a single shower of rain during berry ripening can destroy the whole crop. Bright sunny days help in accumulation of sugar in berries.

### Commercial Cultivars

| | |
|---|---|
| **Table grapes** | Thompson Seedless, Pusa Seedless, Perlette, Beauty Seedless, Pusa Urvashi, Bhokri, Cardinal and Black Muskat. |
| **Raisin grapes** | Black Corinth, Thompson Seedless, Muscat of Alexandria, Sundekhani, Pusa Seedless and Kismish Beli. |
| **Juice grapes** | Early Muscat, Black Champa, Concord, Bangalore Blue, White Riesling, Arka Hans, and Pusa Navrang. |
| **Wine grapes** | White Riesling, Pinot Noir, Cabernet Sauvignon, Black Cheaper, Rubired, Madeleine Angevine, Cheema Sahebi and Pusa Navrang. |
| **Canning grapes** | Thompson Seedless, Pusa Seedless and Perlette. |
| Grape varieties cane be seeded or seedless, as grouped hereunder: | |
| **(a) Seeded cultivars** | Anab-e-Shahi, Bangalore Blue, Bhokri (Panchdraksha), Cardinal, Cheema Sahebi, Gold, Gulabi, Pearl of Casaba, Pinot Noir, Arka Kanchan, Arka Shyam, Arka Hans, Pusa Navrang etc. |
| **(b) Seedless cultivars** | Beauty Seedless, Pusa Seedless, Perlette, Thompson Seedless, Delight, Himrod, Kishmish Charni, Arkavati, Pusa Urvashi etc. |
| **(c) Selections** | Some selections have been made by farmers. Tas-e-Ganesh, a selection from Thompson Seedless is popular in Maharashtra. Dilkush, Manik Chaman and Sonaka have been selected from Anab-e-Shahi. |

### Propagation and Rootstock

Grape is commercially propagated through hardwood cuttings. The length of cuttings should be 25-30 cm, having at least 4 buds and of pencil thickness. The best time for preparation of cutting is north India is at the time of annual pruning in mid-January. Under certain specific conditions to impart protection from soil borne diseases and advance soil conditions (e.g, salinity), commercial varieties are budded or grafted on desired rootstocks (e.g., Dog Ridge, Salt Creek). 'T' and 'Chip' budding are successful methods for grape propagation.

### Planting

Normally, a spacing of 2 m x 2 m is recommended for head system, 3 x 3 m for trellis and bower system, for low and medium varieties. The poles should be fixed at a specific distance, depending on the training system. Usually, one-year-old rooted cuttings are planted. The planting is done during January-February in north India and during March-April and September-October in southern India.

## Training

Training is done to give proper shape and desired growth for good quantity and quality of fruiting. The different training systems are bower, head, kniffin, trellis, telephone, etc. The most commonly followed training system is bower system, which is also called as Arbour or Pergola system of training. It is best suited for vigorous cultivars like Thompson Seedless, Anab-e-Shahi, Cheema Sahebi and Bhokri.

## Pruning

Judicious removal of any plant part for increased productivity, facilitation of various cultural operation, regulation of crop and maintenance of vitality of vine is referred to as pruning. In north India, it is done during dormant season, from late-December to end-January, and in south, pruning for fruiting cycle is done during October-November and the foundation pruning for vegetative growth is done in April. After pruning, a single spray of blitox (0.2 per cent) should be done to avoid fungal attack on the cut portion of the vines. By staggered pruning, Bangalore Blue, Panch Drakshi and Anab-e-Shahi cultivars give two crops in a year.

## Irrigation

In north India, the grape is irrigated at 7-10 days interval during growing season until beginning of sugar formation in berries.

## Manuring and Fertilization

(a) Vines under the age of 3-5 years, should be given 40-50 kg well rotten FYM, and fertilizer combination of 500 g N + 300 g $P_2O_5$ + 700 g $K_2O$.

(b) Vines above 5 years of age, should be given 50-70 kg well rotten FYM and fertilizer combination of 500 g N + 700 g $P_2O_5$ + 1000 g $K_2O$ per year.

## Crop regulation and quality improvement

**(a) Pruning and thinning:** A sizeable number of canes should be retained during pruning. In general, 60-70 clusters are considered optimum on Bower system at 3 x 3 m spacing. Berry thinning helps in proper development of berries, good colour, ripening and quality.

**(b) Girdling:** It consists of removal of a complete ring (0.5 cm) of bark from the shoot, trunk or cane of a plant. The stage of girdling depends upon the cultivar and the grower's interest. For example, to improve berry set and yield, girdling is done one week before flowering, for increasing berry size, it is done at berry set or just after set and for advancing ripening, uniform colour and quality development, it is done at verasion (colour change) stage. Girdling wounds heal

*Girdling in grapevine trunk*

within a month. This technique is very effective if integrated with pruning, thinning or growth regulators sprays.

**(c) Growth regulators:** $GA_3$ has been found to be highly beneficial in loosening the bunches, increasing berry size and yield and in improving fruit quality in seedless varieties like Thompson Seedless, Beauty Seedless, Pusa Seedless etc.

### Plant protection

| Insect-pest | Damage | Control measures |
|---|---|---|
| Chafer beetle | It feeds on buds, young and old leaves, eating away whole lamina, leaving only the skeleton of veins. | Dust chloropyriphos dust on plants. |
| Thrips | Thrips suck sap from the lower leaf surface, producing silvery blotches, affected parts turn brown, dry and brittle, which later drop off. | Spray malathion (0.5%) during March. |

| Causal Diseases | Symptoms | Control measures |
|---|---|---|
| Powdery mildew | Virulent in south India. Powdery growth of fungus develops on the leaves and berries, which may drop. Berries do not ripen properly, become hard and crack. | Sulphur dusting or spraying wettable sulphur (0.2%) or karathane (0.1%) protect the vine from powdery mildew. |
| Downy mildew | Initially, light-yellow translucent spots appear on the upper surface of leaf. Afterwards, white mould patches develop on the lower surface of the leaf. Severely affected leaves, flowers and young berries may dry and drop off. | Spraying Bordeaux mixture (1%) at a weekly interval or fytolan (0.25%) holds good for control of downy mildew. |
| Anthracnose | There is development of erupted brown to black spots on all green parts of the vine. The growth is completely checked, resulting in death of affected parts and splitting of bark. | Destroy affected plant parts. Spray 0.2 per cent copper oxychloride or blitox (0.3%) or fytolan (0.3%) or bavistin (0.2%) at fortnightly interval during rainy season. |

### Maturity, Harvesting and Yield

Grape is a non-climacteric fruit and does not ripen after harvest. Therefore, fully ripe fruits are harvested. Most commonly used maturity index is colour change, depending upon the cultivar. The bunches after harvesting should be kept in shade. Grading is done considering size, colour and variety. Packing is done in hard cardboard boxes with appropriate cushioning or packing material. Well-maintained vineyard of Perlette, Thompson Seedless may yield about 25-30 and 15-20 t/ha, respectively.

## POMEGRANATE

Pomegranate (*Punica granatum* L.) belongs to the family Punicaceae and genus *Punica* with basic chromosome number, x = 12. Pomegranate is a juicy fruit which can be processed into different beverages with the addition of sugar and preservatives. Sun-dried grains from cultivars having high acidity, is known as *"anardana,"* are used for garnishing curries and for culinary purpose. It is a delicious table fruit, rich in B complex vitamins and minerals like calcium, phosphorus and iron. In India, it is cultivated in Maharashtra, Karnataka, Gujarat, Rajasthan, Andhra Pradesh and Himachal Pradesh.

*Bearing plant of pomegranate*

### Soil and Climatic Requirements

Although, pomegranate is not specific to soil requirement but fluctuations in atmospheric humidity cause fruit cracking.

#### Commercial Cultivars

The popular cultivars of pomegranate are Ganesh and Muskat in Maharashtra, Bassein Seedless in Karnataka, Dholka in Gujarat, Kabul Red and Vellodu in Tamil Nadu and Kandhari, Jalore Seedless and Jodhpur Red in Rajasthan. Some promising clonal selections like Arkata, Bhagwa, Sindhuri, or hybrids like Mridula, and Ruby are also becoming popular.

#### Propagation

Pomegranate is commercially propagated through semi-hard and hardwood cuttings treated with 1,000 ppm IBA as basal dip.

#### Planting

Pomegranate is planted at 5 x 5 m spacing. Pits of 60 x 60 x 60 cm size are dug about one month before planting and filled with top soil, pond silt and FYM mixture in 1:1:1 proportion, adding 50 g methyl parathion to protect them from termite. Rainy season is the best time of planting.

### Water Management

Although pomegranate is a drought hardy fruit plant but to obtain good yield and fruit quality, assured irrigation is essential. Water requirement of pomegranate largely depends upon the desired *bahar*. For *ambe bahar*, 13 irrigations are considered enough for good growth and yield. For *mrig bahar*, 9 irrigations are found to be sufficient. In *ambe bahar* crop of Ganesh, regular irrigations from March to July at 7-10 days interval increased the fruit yield.

### Nutrient Management

In normal soils, yearly dose of 10 kg FYM alongwith 125 g nitrogen, 50 g phosphorus and 50 g potash should be applied per plant up to five years of age.

### Training and Pruning

Multiple stem training is allowed to avoid shoot borer damage. Pomegranate bears fruits on terminal and axillary short spurs arising from the mature shoots and thus does not require regular annual pruning. However, water sprouts, diseased and pest affected or dried branches should be removed.

### Crop Regulation

Pomegranate has three main flowering and fruiting seasons or *bahars* such as *ambe bahar* (spring season flowering), *mrig bahar* (June-July flowering) and *hasth bahar* (September-October flowering). For commercial production, only one crop in a year is desirable. Therefore, by crop regulation, the tree is forced to rest by different ways and then it produces profuse blossoms and fruits during the required *bahar*. Selection of the *bahar* depends mainly on the availability of irrigation water, risk of damage by diseases and pests and market factors. In dry areas of north-western India, with limited irrigation resources, *mrig bahar* is preferred to utilize the water available during the monsoon period. In irrigated parts of Maharashtra and Gujarat, respectively *ambe bahar* and *hasth bahar* is preferred since the fruit yield, quality and profitability from other *bahars* are impaired by the incidence of insect -pests and diseases and market factors. The operation, thus, maximizes production from the available inputs and also avoids fruiting during the period when insect-pests and disease infestation are common. For this, operations like withholding irrigations, root exposure, root pruning and spray of chemicals (thiourea, NAA or potassium iodide) are practiced to induce leaf drop and cessation of growth during the period of the unwanted *bahar*.

*In India, pomegranate flowers thrice a year in certain localities, called bahars. Fruits of all the bahars may not be commercially desirable. Hence, regulation of flowering is desirable to produce fruits in desirable bahar. It can be done by forcing the plants to rest by different ways in unwanted bahar. After rest, plants produce profuse flowers during the required bahar.*

This is followed by application of normal irrigation, fertilizer and tillage operations one month prior to the desired *bahar* to induce new growth, flowering and fruiting. In order to increase proportion of good size grade fruits, number of fruits on a tree is regulated to retain 50-60 fruits on one bush by hand removal or by chemical floral thinning by spray of 2,000 ppm ethephon or 500-3000 ppm Alar.

## Plant Protection

| Insect-pest | Damage | Control measures |
|---|---|---|
| Pomegranate butterfly | Caterpillars enter the developing fruits during July and feed on the seeds resulting in rotting and premature drop of fruits. The holes made by caterpillars can be seen on the fruit. | Bagging of fruits with butter paper. Two sprays, one each with 0.002% deltamethrin and 0.2% carbaryl at 21 days interval in rotation after fruit set. |
| Bark eating caterpillar | Eats bark and enters the stem by making holes. | Training of bushes and keep only 3 to 4 stems. Spray dichlorvos (0.08%), or fenvalerate (0.04%), or carbaryl (1 %) or quinalphos (0.08%). |

| Diseases | Symptoms | Control measures |
|---|---|---|
| Fungal leaf and fruit spot | Development of brown spots on leaves, which not only affects leaf vitality and number but also affects fruit growth and spoils their appearance and market value. | Four sprays of copper oxichloride (0.4%) or thiophenate methyl (0.1%) or mancozeb (0.2%) or zineb (0.2%) at an interval of 15-20 days, starting from the initiation of disease have been highly effective. |
| Bacterial leaf and fruit spot | Occurs in more humid areas. Affected fruits become unmarketable. | Three sprays with 500 ppm pausamycin + 0.2% copper oxychloride at 15 days interval, starting from the initiation of the disease significantly reduce the incidence. |

## Fruit Cracking and its Control

Fruit cracking is a major problem in pomegranate, which can be reduced to some extent by maintaining optimum moisture level in soil by frequent irrigation, spraying PGRs like NAA (20 ppm), or 2,4-D (10 ppm) or $GA_3$ (40 ppm) or by the application of borax (0.4%).

### Maturity, Harvesting and Yield

Fruits generally mature in 6-8 months after fruit set. Being non-climacteric, tree ripen fruits are harvested. Change in rind colour from light green-to-yellowish pink or red with waxy shining surface and a cracking sound of grains on pressing the fruit indicate fruit maturity. Ripe fruits are individually picked. A full grown pomegranate bush normally produces 40-50 fruits. However, as high as 100 fruits per bush can be obtained under good management.

## CASHEWNUT

Cashewnut (*Anacardium occidentale* L.) belong to family Anacardiace, to which mango and *Pistachia* belong, with chromosome number 2n = 42. Cashew is the most versatile of all nuts. It is an important crop earning foreign exchange and having considerable employment potential. Cashew nuts are rich source of fats, proteins and carbohydrates. They also contain an ample amount of mineral like phosphorus and calcium.

### Soil and Climatic Requirements

Cashew can be grown successfully in almost all soil types, from sandy to lateritic soils. Cashew is insensitive to depth, stoniness and fertility of soil and availability of water. However, it cannot withstand water logging and excessive salinity or alkalinity. In India, cashew is mainly grown in laterite, red sandy loam and coastal sandy soil. Cashew is essentially a tropical crop and grows best in the warm, moist and typically tropical climate. Most favourable temperature lies between 24°C to 28°C. The major limiting factor in cashew cultivation is that it can't tolerate frost and extreme cold for a long time.

#### Important Varieties

Ullal – 1 , Ullal – 2, Ullal – 3, Ullal – 4, VRI – 1, VRI – 2 , VRI – 3, BPP-4, BPP-6, BPP-8 are some excellent varieties of cahsewnut grown in different parts of India.

#### Plant Propagation

Nowadays, softwood grafting method has been commercially used in cashew propagation. Soft wood grafting can now be done round the year. However, during summer months (January-May) grafted plants should be protected by providing partial shade by erecting pandal of dry coconut fronds or nylon nets.

#### Planting

The land is prepared with the onset of pre-monsoon showers by clearing bushes and wild growth, digging of pits, terracing the base of the trees etc. The square system of planting can be followed. The ideal time for planting is usually monsoon season when the moisture is air surcharged (June-August) both in the west coast and east coast. If irrigation facilities are available, planting can be done throughout the year except

winter months. Planting is done at 7.5 x 7.5 m or 8 x 8 m spacing to accommodate 156-175 plants per hectare.

### Manuring

Application of 10-15 kg FYM and 500 g N (1 kg urea), 125 g $P_2O_5$ , and 125 g $K_2O$ per tree applied twice a year, i.e., during pre-monsoon (May-June) and post-monsoon (September-October) period.

### Irrigation

Cashew needs irrigation during summer months particularly at seedling stage. Protective irrigation especially summer months during January-march at fortnightly intervals @ 200 litres/plant improves fruit set, fruit retention, thereby increasing nut yield. It cannot withstand water stagnation and hence adequate drainage should be provided.

### Plant Protection

| Major disease | Damage | Control measures |
|---|---|---|
| Powdery mildew | Prevalent during rainy season, generally appears when the weather becomes cloudy. | Dusting with 2% sulphur W.P. is effective |

| Major pests | Damage | Control measures |
|---|---|---|
| Tea mosquito bug | Most serious pest, responsible for a damage of nearly 25-30%. Both nymphs and adults suck sap from the leaves, young shoots, inflorescence, developing young nuts and apples. | Spray endosulfan or monocrotophos (0.05%) or carbaryl (0.1%) or quinalphos (0.05%) before infestation. |
| Stem and root borer | The grubs cause the damage, making tunnels in irregular directions. As a result of injury, trees show different degrees of foliar yellowing, leading to shedding of leaves, drying of twigs and gradual death of the tree | Remove and burn all the affected trees to avoid further spread of the pest. Inject 10 ml of dichlorvos (0.1%) per hole and plaster them with mud. |

### Harvesting and Yield

The tree starts bearing from the third or fourth year, but full bearing is attained at 10$^{th}$ year and continues for another 20-25 years. The tree begins to flower in December and

the flowering, continues for about three months. The fruits ripen during March to May or early June. Fully mature fruits are collected every day and the nuts are separated. A fully developed tree yields about 25-30 kg of nuts per annum.

## COCONUT

Coconut is is one of the important member of mocotyledons. It is botanically, called as *Cocos nucifera* L. and belongs to family Arecaceae (Palmae). The basic chromosome number (n) is 16 and 2n = 32. The coconut palm is considered to be one of the five legendary divine trees as stated in Indian classics and is extolled as *Kalpavriksha* - the all giving tree. Kerala, Tamil Nadu, Karnataka and Andhra Pradesh are the four major coconut producing Indian states, accounting for more than 90 per cent of total area and production. The wet meat or kernel is rich in fat, carbohydrate, protein, fibre and moderate in its mineral content. Coconut water is rich in minerals and has a caloric value of 17.4 per 100gm of water. It is also a rich source of fats, carbohydrates and minerals like phosphorus and calcium.

### Important Varieties

West Coast Tall, Andaman Ordinary, East Coast Tall and Philippines Ordinary are some important varieties of tall group. Similarly, Chowghat Green Dwarf, Chowghat Orange Dwarf and Gangabondam, Malayan Yellow Dwarf, Malayan Orange Dwarf and Malayan Green Dwarf are important varieties of dwarf group.

## Soil and Climatic Requirements

Palm prefers a well drained light soil permitting free root development and aeration. It grows best on coastal alluvial and sandy soils with an optimum pH ranging from 5.2 to 8.0. and a well distributed rainfall of 1270-2500 mm per annum is ideal for coconut cultivation

### Plant Propagation

Coconut propagation is usually done by seed. In seed propagation, selection of mother plant from which nuts have to be collected, has great bearing on the productive life of palm.

### Manures and Fertilizers

The optimum dose of fertilizer recommended for an adult palm is 0.5 kg N, 0.32 kg $P_2O_5$ and 1.2 kg $K_2O$/year. The first dose of fertilizer is applied 3 months after planting and the dosage is increased every year and the full dose of the fertilizer is applied from 4th year onwards. One third of the fertilizer is applied immediately after the onset of south-west monsoon and the remaining 2/3 towards the end of the monsoon.

### Plant Protection

| Major diseases | Damage | Control measures |
|---|---|---|
| Root wilt | Most important disease of coconut. The earliest diagnostic symptom is the abnormal inward bending of leaflets termed as ribbing or flaccidity, followed by root decay. | Complete eradication of all the disease affected palms, mixed cropping with cocoa and intercropping with tapioca, are some good measures. At initial stage of the disease, spray the crown and drench the basin with 500 ppm tetracycline. |
| Thanjavur wilt | Root decay. | Cut and remove all dead roots, cut ends of roots should be drenched with a mixture of 1.5g of aureofungin +1 g copper sulphate. |

| Major pest | Damage | Control measures |
|---|---|---|
| Red palm weevil | Most destructive pest of coconut. Grubs cause damage inside the stem or crown by feeding on soft tissues. | Practice clean cultivation, avoid injury to trunk, attract weevils by smearing coconut toddy and destroy them. Injection of carbaryl (1%) to the infested trunk through a hole is also useful. |
| Rhinoceros beetles | Adult beetles usually cause damage, which bore into the tender fronds and spathes, unopened leaves and inflorescences. | Burn all dead trunks, leaves and logs. Spray carbaryl (0.1%) to kill the larvae. |

### Maturity, Harvesting and Yield

The tall varieties of coconut start flowering from 5$^{th}$ year and the dwarfs and hybrids flower from 3rd to 4th year. With scientific management, the West Coast Tall yields on an average 80 nuts/palm/year in coastal Kerala and Karnataka and the hybrids yield from 100 to 140 nuts/palm/year. Coconut palm can produce 12 inflorescences/ year, but generally number of inflorescence per palm are less than 12. For obtaining maximum yield of copra and oil, only fully mature nuts should be harvested.

## B. Cultivation of Vegetables

## POTATO

Potato (*Solanum tuberosum* L.) which belongs to family Solanaceae, is the staple food of many European countries of the world. It is an important source of starch. It is a rich source of carbohydrates, vitamins ($B_1$, $B_2$, $B_6$ and C), minerals (Ca, P and Fe) and protein.

## Soil and Climatic Requirements

It can grow in almost all types of soil. The well-drained clay-loam soil is considered as ideal for its cultivation.

It is a cool season crop and can tolerate moderate frost. It requires 20°C soil temperature for better germination. Young plant growth is good at 24°C but later growth is favoured by a temperature of 18°C. No tuberization takes place when the night temperature exceeds 23°C. Maximum tuberization occurs at 20°C. Tuber formation stops completely at about 29-30°C.

### Varieties:

**Early varieties:** These varieties are ready for harvest in 70-80 days such as Kufri Ashoka, Kufri Chandermukhi, Kufri Jawahar, and Kufri Lauvkar.

**Main season varieties:** They are ready for harvest in 90-95 days. Among the white coloured varieties, Kufri Jyoti, Kufri Sutlej, Kufri Pukhraj, Kufri Megha, Kufri Badshah, Kufri Anand, Kufri Bahar, Kufri Sadabahar, Kufri Deva, Kufri Sherpa are important.

**Late varieties:** Kufri Jeevan, Kufri Neelamani, Kufri Khasigaro, Kufri Naveen.

**Processing varieties:** Kufri Chipsona 1, Kufri Chipsona 2, Kufri Chipsona 3, and Kufri Himsona.

### Soil Preparation and Planting

A well prepared soil provides sufficient room for the development of tubers and also helps to retain moisture. The fields are ploughed to a depth of 20-35 cm first with soil turning plough and afterwards by 4 to 5 ploughings with country plough/disc harrow. Clods must be broken to make the field well pulverized and levelled.

### Planting Time

| Region | Season | Planting time | Harvesting time |
|---|---|---|---|
| **North western hills** | | | |
| Very high hills | Summer | April-May | September-October |
| High hills | Summer | Mid-March-April | September-October |
| Mid hills | Spring | Jan-February | May-June |
| North western plains | Early | Mid-September | Mid November-December |
| | Autumn | Mid-October | February-March |
| | Spring | January | April |
| North Central Plains | Winter | Mid-October | February-March |
| | | | |
| North eastern plains | Winter | October end to 2nd week of November | January-February |

## Seed Rate and Propagation

25-35 q tubers/ha. Potato is traditionally propagated through tubers. The eyes on the tuber surface contain axillary buds. The tubers have a dormancy of nearly 8-10 weeks after harvesting. The axillary buds on the tubers start germinating by producing sprouts only when this dormancy is over. The sprouted tubers put up fast and vigorous growth when planted in the soil.

## Breaking of Dormancy

This dormancy can be broken by dipping cut tubers for 1-1½ hours in thiourea @ 1-2% solution or treating tubers with 5ppm solution of $GA_3$ for 10 seconds.

## Seed Size and Spacing

Planting 40-50 g tuber with 40-50 mm diameter at a spacing of 45-60 cm between rows and 20-25 cm between the tubers within the rows. Tuber cutting is not recommended especially for the production of a seed crop as it transmits viruses and bacteria.

## Manures and Fertilizers

Apply farmyard manure @100q/ha at the time of field preparation. However, fertilizers are applied @ 120:80:60 kg N: $P_2O_5$:$K_2O$/ha, respectively. Full dose of farmyard manure, phosphorus and potassium and half of N should be applied at the time of planting. Remaining part of N should be top dressed at the time of earthing up for effective utilization by the crop.

## Irrigation

Water is applied effectively and economically at critical stages in crop development *i.e.* stolon formation, tuber initiation and tuber development stages of the crop. Irrigation is stopped about 10 days before harvesting of crop, to allow firming of tuber skin.

## Plant Protection

| **Major diseases and their management** | | |
|---|---|---|
| **Early blight** | Concentric rings of brown to black colour are formed on the leaves. Heavily infected leaves fall off after drying. Spots also appear on stems. | Destroy crop debris. Spray ridomil MZ @ 2g/l or 0.3% blitox or 0.25% dithane - M - 45 / dithane - Z - 78 at fortnight intervals 3-4 times. Grow resistant varieties e.g. Kufri Naveen, Kufri Jeevan. |
| **Late Blight** | Lower leaves are infected having cottony growth. Water soaked lesions appear on the margins. Tubers decay under severe infection. | Use disease-free seed. Spray ridomil @ 2g per litre of water. Grow resistant varieties like Kufri Jawahar, Kufri Himsona, Kufri Jyoti, Kufri Swarnima, Kufri Kanchan. |

| Insect-pests and their management | | |
|---|---|---|
| **Cut worm** | Adult moths cause extensive damage by cutting the plants. | Flood the infested fields, hand pick and destroy the larva, set up light trap @ 1/ ha or pheramone traps @ 10/ ha to attract male moths and spray insecticides or chlorpyriphos 20EC @ 1 lit/ha or neem oil 3% @ 5.0ml/ lit. |
| **Potato tuber moth** | It causes damage to tubers in the field and storage by tunneling the foliage, stem and tubers. | Avoid shallow planting of tubers, plant the tubers at depth of 10 - 15 cm, collect and destroy the infested tubers, and fumigate the stores with carbon disulphide. |

### Harvesting and Yield

The crop is harvested when it is fully matured, which can be characterized by yellowing of haulms and no pulling out of skin on rubbing of tubers. At the time of harvesting, field should not be too wet or too dry. Tractor operated potato diggers are available for digging the tubers from the fields. Early varieties may produce 200 q tubers/ha, and late varieties produce about 300 q tubers/ha.

## CAULIFLOWER

Cauliflower (*Brassica oleracea* var. *botrytis* L.) belongs to family Brassicaceae. It is an important Indian vegetable.

### Soil and Climatic Requirements

Cauliflower can be grown in all types of soil with good fertility and good water holding capacity. It prefers a soil reaction ranging from pH 6 to 6.5.

Climatic factors play an important role during transformation from vegetative to curding and curd development stages. Temperature range of 10-21°C is good for germination and favourable temperature range is 17-20°C. On the basis of maturity, cauliflower varieties have been grouped as under:

| Maturity group | Nursery sowing | Transplanting time | Opt. temp. range for curding | Varieties |
|---|---|---|---|---|
| Early I (A) Sept. maturity (mid Sept-mid Nov.) | Mid May | July beginning | 20-25 °C | Early Kunwari, Pusa Early Synthetic, Pant Gobhi-3, Pusa Meghna, Pusa Kartik Sankar |

| | | | | |
|---|---|---|---|---|
| Early I (B) Oct. maturity (Mid Oct-mid Nov) | May end to Mid June | Mid July | 20-25°C | Pusa Katki, Pusa Deepali, Pant Gobhi-2 |
| Mid Early (II) Nov. maturity (Mid Nov-mid Dec) | July end | Sept beginning | 16-20°C | Improved Japanese, Pusa hybrid-2, Pusa Sharad, Pant Gobhi-4 |
| Mid late (III) Dec maturity (mid Dec-mid Jan) | Aug end | Sept end | 12-16 °C | Pusa Synthetic, Pusa Subhra, Palam Uphar, KT-25, Pant Subhra, Pusa HimJyoti, Pb Giant 35, Pusa Paushja, Pusa Shukti |
| Late (IV) Snowball (Jan-March) | Sept end to mid Oct | Oct end-mid Nov | 10-16 °C | Snowball 16, Pusa Snowball-I, Pusa Snowball K-1, Dania, Ooty-1, |

### Seed Rate and Spacing

The seed requirement for raising nursery for early varieties is 600-750g per hactare and for late varieties is 300g per hectare area. Early varieties 45cm × 30cm and mid and late season varieties 60cm × 45cm.

### Soil Preparation and Transplanting

The soil should be well prepared by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. The manure should be applied at the time of field preparation. Drainage is a problem for early and some times for mid season crop when rains coincide with cropping period. Therefore, early crop should be transplanted on ridges or raised beds while the mid and late cultivars can be planted on flat beds. Transplanting should be done during late afternoon to avoid losses due to sun heat.

### Manures and Fertilizers

Mix 200-250 q FYM/ha at the time of field preparation. Application of nitrogen, phosphorus and potash @ 120-180: 75-80: 60-75 kg per hectare, respectively is required to raise a healthy crop of cauliflower.

### Irrigation

Cauliflower needs very careful irrigation that should be applied at right time and in sufficient quantity as both overwatering and insufficient irrigation are harmful to the standing crop. First light irrigation is given immediately after transplanting of the seedlings.

### Maturity and Harvesting

The harvesting of curds is to be done as soon as the curds attain prime maturity and compactness. It is better to harvest little early than late if there is any doubt about the maturity. Delayed harvesting leads to the elongation of flowering stalk, loose, ricey, and fuzzy and over matured curds which deteriorates the quality of the curd. The curd should be cut-off with stalk along with sufficient number of jacket leaves to protect the curd. Severe trimming of leaves is to be done after unloading or before marketing.

### Physiological Disorders

**Buttoning:** It means development of small curds or buttons. Planting of over-aged seedlings, which do not get sufficient time to initiate growth before transformation to curding or selection of wrong cultivars (planting early variety late) or root injury by insects or diseases result in buttoning.

**Riceyness:** A premature initiation of floral buds or elongation of peduncle stalk of inflorescence is characterized by riceyness. The curds are considered to be of poor quality for marketing. Temperature higher or lower than the optimum required for curding or application of high nitrogen results in riceyness.

**Blindness:** Blind plants are those, which are without terminal bud. They do not form curd. It is due to poor fertility of the soil or damage to the terminal portion during handling at the time of planting or by insects, diseases etc.

**Whip tail:** It is caused by the deficiency of molybdenum (Mo). Young plants become chlorotic and turn white particularly along the leaf margins. In older plants, the lamina of the newly formed leaves is irregular in shape and leaves have only a large bare midrib. This is because of this condition, the disorder is called as “Whip tail”.

## CABBAGE

Cabbage is a famous vegetable of Indians. Its botanical name is *Brassica oleracea* var. *capitata* and it belongs to family Brassicaceae.

### Varieties

**Early Group:** It takes 55-70 days for maturity. The commonly grown varieties are Golden Acre, Pride of India, Copenhagen Market, Pusa Ageti, Pusa Mukta, Pusa Sambandh (Synthetic variety).

**Mid season Group:** The cultivars fall between early and late maturity groups. September, and Pusa Drum Head are the common varieties from this group.

**Late Group:** It takes about 85-130 days for maturity *e.g.* Late Large Drum Head

## Soil and Climatic Requirements

The soil requirement for cabbage is almost same as that of cauliflower. On heavy soils, plant grows slowly and the keeping quality is improved because of compactness. Most cabbages are some what tolerant to salt. It can withstand extreme cold and frost better than cauliflower.

### Planting Time

In the Northern Indian plains, transplanting of different varieties can be done from October –January.

### Seed Rate and Spacing

Early season varieties need 600-800 g/ha & main season varieties need 200-500 g/ha. Late varieties 60cm × 45cm & for early varieties 45cm × 30cm.

### Nutrient Management

Mix 200-250 q/ha farmyard manure thoroughly at the time of field preparation. Application of 120-180 kg nitrogen, 75-80 kg phosphorus and 60-75kg potassium per hectare is required to raise a healthy crop of cabbage.

### Water Management

Cabbage is very sensitive to soil moisture. Irrigation may be applied at 10-15 days interval according to the season and soil but optimum soil moisture should be maintained regularly.

### Maturity and Harvesting

In general, the heads are harvested when they are firm and solid. The heads are cut with a knife, frequently attached with some non-wrapper leaves. These non-wrapper leaves give protection to the heads from bruising injury.

### Diseases and Insect-pests of Cole Crops

| **Major diseases and their management** | | |
|---|---|---|
| **Black leg** | It is a seed borne disease and hence infest crop plants at an early stage. Stem of the affected plant shows severe black discolouration. Whole root system decays from bottom upwards. Often, the affected plants collapse in the field. | Hot water treatment of seed before sowing. Spray the seed crop with copper oxychloride or with an organomercuric compound. Grow resistant varieties like Pusa Drum Head. |

| | | |
|---|---|---|
| **Downy mildew** | It causes serious damage at all stages of plant growth. Discolouration occurs in the young seedlings and in severe cases, whole plant perishes. | Spray ridomil @ 0.5 g/litre of water at 10-15 days intervals or with dithane-M-45 @ 1.5-2.0 g/ litre of water. |
| **Black rot** | The tissue at the leaf margin becomes yellow; chlorosis progresses towards leaf center creating a V-shaped area at the mid rib. | Spray streptocycline @ 5g and blitox @ 100g per 10 litre of water after transplantation. |
| **Bacterial soft rot** | The affected plants show a soft, slimy, bad smelling rot that rapidly spreads throughout the plant under favourable conditions. | Control measures adopted for other diseases can check this disease as well. Spray 100-200 ppm streptocycline or plantomycin combined with copper oxychloride (0.3%) at 15 days interval. |
| **Insect- pests and their Management** | | |
| **Diamond back moth** | Spindle shaped pale yellowish green caterpillars feed on the lower side of leaves but later feed on the exposed leaves and enter the head/ curd affecting the produce as well as quality. | Grow Indian mustard as a trap crop. Spray of malathion (0.05%) or deltamethrin (0.028%), or cypermethrin (0.0075%) is very effective. |
| **Aphids** | Aphids cause serious damage by sap sucking. Seed setting stage is seriously affected. | Foliar application of malathion (0.05%) at 15 days interval is quite effective. |
| **Cabbage butterfly** | Damage is caused by caterpillars. The white winged butterflies deposit yellow coloured eggs in clusters on the undersurface of leaves. | Collect and destroy yellow egg masses and early stage larvae of cabbage butterfly. Spray of malathion (0.05%)/ deltamethrin (0.0028%)/ cypermethrin (0.0075%) and fenvalerate (0.01%) is quite effective. |

# PEAS

Pea (*Pisum sativum* L.) is highly nutritive crop which is rich in protein, carbohydrates, vitamins A and C and minerals such as Ca and P. It belongs to family Fabaceae.

## Soil and Climatic Requirements

Pea can be grown on all kinds of soils but the best crop can be taken from well-drained and fertile loam soil. The soil pH 6-7.5 is the best for its proper growth and development.

Pea is a cool season crop and requires frost-free weather particularly at flowering and pod formation stage, though vegetative growth is not affected by the frost. The optimum temperature for its germination is about 22°C and that for better growth and yield is 13-19°C.

### Varieties

1. **Early wrinkle seeded:** Arkel, Early Badger, Little Marvel, Early December, Palam Triloki.
2. **Main season wrinkle seeded varieties:** Bonneville, Lincoln, Punjab-89, Palam Priya.
3. **Edible poded peas:** Sylvia, Punjab Mithi Phali, Alaska, Early Superb, Meteor.

### Sowing Time

In North india early varities sown during September & Main season varieties are sown during first fortnight of October–end November and in South India early varities sown are during June- July.

### Seed Rate and Spacing

Early varieties: 120-130, Main season varieties: 75-100. Spacing for early varieties: 30cm × 5cm, main season varieties: 45-60cm × 10cm. Inoculation of seeds with *Rhizobium* culture can be helps to fix the atmospheric nitrogen. The seeds may be treated with fungicides like thiram or captan (3g/kg of seed) or bavistin (2.5-3 g/kg of seed) to save the crop against wilt disease.

### Manures and Fertilizers

Full dose of farmyard manure @ 20 tonnes, 20-50 kg nitrogen, 30-60 kg phosphorus and 30-60 kg potassium per hectare should be applied at the time of sowing based on fertility status of the soil.

### Maturity and Harvesting

The peas are harvested when the pods are fully green and well developed. The seeds should be fully developed but tender *i.e.* should not harden. Picking should be done as soon as green ovules are fully developed and pods still not over mature. Early varieties give 2-3 pickings while 3-4 pickings at 7-10 days interval are taken from main season varieties. Early varieties may yield 60-85 q pods/ha and main season varieties may produce 100-150 q green pods/ha.

### Plant Protection

| Diseases and their management | | |
|---|---|---|
| **Powdery mildew** | First symptoms appear on the upper surface of the leaves as very small and discoloured spots, which soon give rise to enlarged white powdery areas on the leaf, stem and pod. Multiple infection may cover the whole plant. | Grow resistant varieties like Palam Priya. Spray dinocap or bitertanol or hexaconzole @ 0.05% as the initial symptoms appear on the leaves. |
| **Fusarium wilt** | Wilt attacks young plants. The affected plants show yellow-orange internal discolouration in the lower internodes. | Grow resistant varieties, maintain good drainage. |
| **Root rot** | The vascular tissue shows red discolouration extending upward 1-3 nodes above soil surface. Diseased plants appear unthrifty, variously dwarfed, depending upon the severity of infection, and may wilt and die. | Seed treatment with bavistin @ 3g/kg of seed. Soil drenching with bavistin @ 0.01% or captan or brassicol reduces the disease. Follow long crop rotation. |
| **Major insect-pests and their management** | | |
| **Pea aphid** | It attacks young vines, sucking the juice from growing tip, later covering the whole plant. It causes curling of the leaves and pods. | Spray dimethoate @ 0.01% or spray of 0.06% nicotine sulphate. |
| **Pod borer** | The young caterpillars first feed on the surface of the pods, bore into them and feed on the seeds. | Spray malathion or cypermitherin @ 0.01%. |
| **Leaf miner** | The greenish larvae make serpentine tunnels in the leaves and feed on it. The infested leaves wither and dry. Flowering and pod formation is drastically affected. | Spray cypermethrin or fenitrothion or fenthion @ 0.01%. |

## OKRA

Lady's finger or okra or bhindi (*Abelmoschus esculentus*) is a favorite vegeteable of Indians. Okra is rich in vitamins, Ca, K and is grown for its green, tender and nutritive

fruits, which are cooked in curry and are also used in soups besides being canned and frozen.

## Soil and Climatic Requirements

Okra grows best in light soils ranging from sandy-loam to loam though it gives good crop in heavy soil having efficient drainage facility during rainy season. The most ideal pH range for its cultivation is 6.0 to 6.8. It is a warm season crop, sensitive to fluctuating environment and grows luxuriantly in warm and humid weather. The optimum temperature for better seed germination is 18°C, optimum being 25-30°C. Optimum temperature for its better growth is 24-27°C and temperature above 42°C causes flower drop.

### Commercial Varieties

Parbhani Kranti, Punjab Padmani, P-8, Arka Anamika, Arka Abhay, Pusa Makhmali, Pusa A-4, Varsha Uphar, Azad Kranti, Pusa Sawani, Parbhani Kranti and Varsha Uphar.

### Sowing Times

Spring-summer crop: February-March; Autumn-winter crop: July-September.

### Soil Preparation

Okra should be planted in well pulverized field by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. Ploughing should be followed by levelling.

**Seed Rate and Spacing:** 15-20 kg/ha (Spring-summer crop) and 10-12 kg/ha (Rainy season). The Spacing is 30-45cm × 15 cm.

### Manures and Fertilizers

FYM @200-250 quintals per ha should be applied at the time of field preparation. In addition, apply 60-75 kg N, 50-60 kg phosphorus ($P_2O_5$) and 50-60 kg potassium ($K_2O$) per hectare, depending upon the fertility status of the soil.

### Irrigation

Pre-sowing irrigation is necessary especially in spring-summer crop and the subsequent irrigations are given at 4-5 days interval in summer crop.

### Maturity and Harvesting

The fruits attain marketable maturity in about 45-60 days after sowing. Only tender and small fruits (6-10cm long) should be harvested preferably in the evening or morning.

For export purpose, dark green fruits, about 6-8cm long should be harvested. The yield is 80-100q/ha in spring-summer crop and 120-150q/ha in rainy season crop.

### Plant Protection

| **Major diseases and their management** | | |
|---|---|---|
| **Powdery mildew** | White powdery growth on both sides of the leaf. The diseased leaves drop off from the plant. | The disease can be controlled effectively by spray sulfex (0.2%) or karathane (0.05%) at 10 days interval. |
| **Yellow vein mosaic** | The veins of diseased leaves become yellow. Infected plants remain stunted and bear very few deformed and small fruits. It is transmitted by white fly. | Remove infected plants and destropy them. Keep vector under control by spraying either dimethoate (0.05%) or metasystox (0.02%) or monocrotophos (0.05%). |
| **Insect- pests and their management** | | |
| **Fruit borer** | The larvae bore into the shoots during vegetative stage and feeds inside; as a result, the shoots droop down and dry-up. In the later stages, it infests the fruits, which become disfigured and show holes. | Grow tolerant varieties like Perkins Long Green, Varsha Uphaar. Remove and destroy damaged shoots and fruits. Spray of carbaryl (0.1%) and malathion (0.05%) are effective. |
| **White fly** | It causes chlorotic spots on leaves. Nymphs secrete a sticky substance known as honeydew, which covers leaves and flowers. Plant growth is reduced. | Uproot and destroy the plants affected by yellow vein mosaic. Spray chemicals as prescribed in Yellow Vein Mosaic. |

## TOMATO

Tomato (*Solanum lycopersicum*) belongs to family Solanaceae, is an important ingredient of every vegetable coocked in India. Its fruits are also used for making soup, juice, ketchup, puree, paste and powder. Red colour of tomato is due to lycopene pigment, which has anticarcinogenic properties.The orange colour of fruit is due to carotenoid pigment which is a rich source of vitamin A.

### Plant Growth Habit in Tomato

Tomato varieties are grouped into two broad categories based on their growth habit:

| Determinate (Dwarf growth) | Indeterminate (Tall growth) |
|---|---|
| Inflorescence occurs more frequently on every internode until terminal ones are formed. | Inflorescence cluster occurs at every third internode. |
| Plant growth stops at terminal point with a flower cluster (self topping). | The main branch continues growing indefinitely with fruit formation until frost occurs. |

## Soil and Climatic Requirements

Well drained, fairly light fertile loam with a fair moisture holding capacity is the most ideal soil for tomato cultivation. Tomato is a warm season crop, which requires long season to produce a profitable crop and highly susceptible to frost. High temperature and high humidity favours development of foliar diseases. Night temperature is the critical factor in fruit setting; the optimum range is 15-20°C.

### Varieties

Pusa Rohini, Pusa Early Dwarf, Pusa 120, Pusa Ruby, Pusa Sadabahar, Pusa Uphar, Pusa Sheetal, Pusa Gaurav, Arka Abha, Arka Vikas, Arka Saurabh, Arka Alok, Arka Abhijit, Arka Shreshtha, Arka Vardan, Arka Ananya, Kashi Amrit, Kashi Hemant, Kashi Sharad, Kashi Anupam, Kashi Vishesh are important varieties.

### Hybrids

Kt-4, Pusa Hybrid 1, Pusa Hybrid 2, Pusa Hybrid 4, Arka Vardan, Arka Meghali, Arka Vishal, Arka Samrat, Kashi Hybrid 1, Kashi Hybrid 2 are some hybrids developed in our country.

### Nursery Sowing & Transplanting Time in India

| Crop/Region | Spring-summer | Autumn crop |
|---|---|---|
| North Indian plains | Late Nov (mid Jan) | July-Aug (Aug-Sept) |
| Eastern India | Nov (Late Dec) | Aug-Sept (Sept-Oct) |

### Nursery Raising

For better survival in the field, it is advisable to harden the seedlings. Plants are allowed to nearly wilt for 2-3 days before watering and this practice can be repeated two-three times. Such seedlings can withstand the extremes of temperature. Seedlings become

ready for transplanting in 4-5 weeks time. Seedlings 5mm in diameter are better and about 15cm in length are the best for transplanting.

### Soil Preparation and Transplanting

Tomato should be planted in well pulverized field by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. Ploughing should be followed by leveling. Tomato is normally planted in raised beds of 60-75 cm width. Transplanting should be done during late afternoon and the seedlings are placed on side of the beds. This provides ample moisture for the plants to survive.

### Seed Rate and Spacing

For pen pollinated varieties 400-500g and for hybrids = 150-200g. Spacing of 60 cm × 45cm for determinate varieties & 90cm × 30cm for indeterminate varieties.

### Manures and Fertilizers

Recommended dose of N, P and K fertilizers and their time of application is as under.

| Recommended dose | Farmyard manure (q/ha) | Nitrogen (Kg/ha) | Phosphorus (Kg/ha) | Potassium (Kg/ha) |
|---|---|---|---|---|
| Open pollinated varieties | 250 | 75-100 | 50-75 | 50-60 |
| Hybrids | 250 | 150-180 | 100-150 | 80-120 |

### Irrigation

Careful irrigation is required for better growth of tomato crop which should be sapplied at right time. Both over-watering and insufficient irrigation is harmful.

### Maturity and Harvesting

Tomato fruits are harvested at different maturity stages depending upon the purpose for which these are used and distance over which they are to be transported. Fully developed mature green fruits are harvested for long distance transportation. Such fruits ripen after reaching the market and develop good colour under favourable conditions. Fruits at turning stage ($1/4^{th}$ of the fruit especially at blossom end shows pink colour), pink stage ($3/4^{th}$ of the surface shows pink colour) and hard ripe stage (nearly all red or pink with firm flesh) are harvested for local market. Over ripe fruits (Fully coloured and soft) are suitable for processing, which ensure desired quality and red colour in processed products.

| Major diseases and their management | | |
|---|---|---|
| **Damping Off** | The fungus attack usually starts on the germinating seed, and further spread to the hypocotyl, basal stem, and developing tap-root. | Drench the nursery bed with 5 litre formalin dissolved in 100 litres of water 15 days before sowing. Spray mancozeb or dithane- M-45 (25 gram in 10 litre of water), carbendazim or bavistin (10 gram in 10 litre of water) on nursery seedlings. |
| **Bacterial wilt** | Deadly disease of tomato, which results in wilting of plant, stunting plant growth, yellowing of entire plant, and brown vascular system | Follow crop rotation with Cruciferous vegetables, grow resistant varieties such as Arka Ananya, Arka Rakshak *etc.*, follow hot water seed treatment at 50°C for 25 minutes and spray with streptocycline @ 200ppm at 4-7 days interval. |
| **Insect-pests and their management** | | |
| **Tomato fruit borer** | Initially, the larvae feed on tender foliage but later on, it moves to flower buds, flowers and developing fruits. The caterpillars make holes into fruits and render them unfit for market. | Follow late transplanting. Foliar application of endosulfan (0.07%)/ carbaryl (0.1%)/ deltamethrin (0.0028%) and acephate (0.05%) is effective. |
| **Fruit fly** | The maggots after hatching feed on pulp of the fruits and render them unfit for human consumption. | Remove and destroy affected fruits. Use pheromone traps for monitoring pest population. Spray of fenthion (0.05%)/ fenitrothion (0.05%), or bait spray adding 50 g gur + 10 ml malathion in 10 L water is effective. |
| **Physiological disorders and their management** | | |
| **Blossom end rot** | A very common and destructive disorder. Rotting of fruits starts at blossom end of the fruit. Deficiency of Mg and Ca is the main cause. | It can be managed by spraying calcium chloride @ 0.5% at fruit development stage. Also apply balanced irrigation and ensure proper staking. |

| | | |
|---|---|---|
| **Cracking of fruits** | Cracking of fruits at stem end is common in tomato and often results in large losses. Cracks appear to develop at maturity or ripening stage than mature green or turning stage. Deficiency of boron and long dry spell followed by heavy watering are the main reason of cracking. | Soil application of 20-30 kg of borax per hectare is beneficial. Application of proper irrigation at right stage is also very important. |

## BRINJAL

Brinjal (*Solanum melongena*) belongs to family Solanaceae, is one of the important indigenious vegetable grown in India. It is called as brain tonic due to the presence of nasunine compound.

### Soil and Climatic Requirements

It can be grown practically on all soils from light sandy to heavy clay. Silt loam and clay loam soils are generally preferred and the best pH is 5.5-6.8. It is a warm season crop and susceptible to severe frost. It grows best at a temperature of 21-29 °C.

#### Important Varieties

Pusa Shymala, Pusa Purple Long, Pusa Purple Cluster, Pusa Kranti, Pusa Bhairav, Pusa Anmol, Arka Sheel, Arka Shirish, Arka Kusumkar, Arka Navneet Arka Keshav, Arka Neelkanth, Punjab Chamkila.

#### Nursery Sowing and Planting Time

| Crop/Region | Spring-summer crop | Rainy season crop | Autumn crop |
|---|---|---|---|
| Northern Indian (NI) plains | Nov (mid Jan-Feb) | Mar-May (April- June) | June-July (July-Aug) |

#### Soil Preparation and Transplanting

Brinjal should be planted in well pulverized field by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough.

#### Seed Rate and Spacing

500-700g (OP), 350-400g (hybrids). Spacing for Dwarf varieties-60 × 45 cm and tall varieties- 90 × 60 cm

### Manures and Fertilizers

FYM @200-250 quintals per ha should be applied at the time of field preparation. In addition, apply 75-100 kg N, 50-60 kg phosphorus ($P_2O_5$) and 50-60 kg potassium ($K_2O$) kg per hectare.

**Irrigation:** Apply irrigation at an interval of one week in summer season and 10-15 days during winter.

### Maturity Harvesting and Yield

Fruits should be harvested when they attain a good size, attractive colour and its surface should not loose its bright and glossy appearance. Timely harvesting of tender fruits increases the total growing period and number of pickings alongwith yield. The yield of open-pollinated varieties is 300-500 q/ha and of Hybrids, it is 600-800 q/ha.

### Plant Protection

| Diseases | Symptoms and management |
|---|---|
| **Phomopsis blight** | Portion of fruit is bleached and gives burning appearance. Seed treatment with thiram @3 gm per kg. Spray the crop in the nursery with dithane M-45. Grow resistant variety like Pusa Bhairav. |
| **Bacterial wilt** | Grow resistant varieties such as Arka Nidhi, Arka Keshav, Hisar Shyamal etc. |
| **Little leaf** | Caused by Mycoplasma and transmitted by leaf hoppers. The affected plants are shorter in structure. The leaves are malformed. Floral parts turn into leaf-like structures. No fruit bearing takes place. |

### Insect-pests and their Control

| | |
|---|---|
| **Brinjal fruit and shoot borer** | It is the most serious pest of brinjal crop. Plant shoots wilt and dry. Small holes appear below the calyx of fruits. Fruits are filled with frass. Grow resistant/tolerant varieties like Pusa Purple Cluster, Arka Kusumkar. Foliar application of carbaryl (0.1%)/ endosulfan (0.07%)/ fenvalerate (0.01%) is effective. |

## CHILLI

Chilli (*Capsicum annuum var. hortense*) belongs to family Solanaceae, and gems Capsicum.

### Types of Capsicum

a. **Hot pepper:** Pungent due to crystalline volatile alkaloid capsaicin, located mainly in the placenta of fruit. It is cultivated for vegetables, spices and pickles etc., potential foreign exchange earning crop, and rich source of vitamin A and C.

b. **Sweet pepper (Shimla Mirch):** Bears bell shaped, non pungent/mild and thick pericarp/fleshed fruit. It is mainly used as vegetable.

c. **Paprika:** Mild in taste and slightly pungent than sweet pepper. Used as spice in European countries, gives colour and mild pungent taste to food stuff. It is also used in pickles and sandwiches.

## Soil and Climatic Requirements

Chilli can be grown practically on all type of soils except on saline soils. Soil should be well-drained and well-aerated. Sandy and sandy loam soils are generally preferred for an early crop or where season is short. The most ideal temperature for its better growth and development is 20-25 °C. Excessive rainfall results in poor fruit set, rotting of fruits and defoliation of plant.

### Varieties

Pusa Jwala, Pusa Sadabahar, Bhagya Lakshmi, Andhra Jyoti, Punjab Lal, Punjab Surkha, Punjab Guchhedar, Arka Meghana, Arka Harita, Arka Sweta.

### Planting Time

South India - mainly as kharif season crop (June to October) and northern Indian plains. December: sowing (Feb), May-June (June-July). Seedlings are ready for transplanting when they attain a height of 15cm with 4 leaves in 4-6 weeks.

### Seed Rate and Spacing

One kg/ ha and spacing of 45 × 45 cm or 60 × 45 cm.

### Manures and Fertilizers

Apply FYM @250q/ha, nitrogen @ 75 kg/ha, phosphorus @60-75kg/ha and potassium @ 50 kg/ha. Full dose of farmyard manure, phosphorus and potassium and half of N should be applied at the time of transplanting. Remaining part of N should be top-dressed in two equal parts at an interval of one month each.

### Maturity and Harvesting

The picking of fruits depends upon the type and purpose for which they are grown.

1. **Green fruits:** Fruits are harvested when they are still green but fully grown. It needs 5-6 pickings for harvesting the whole crop.
2. **Pickles:** The fruits are harvested either green or ripe.

3. **Drying:** Red, when fully ripe fruits are picked at an interval of 1-2 weeks and harvesting continues for a period of about three months.

### Diseases and their Management

| Disease | Management |
|---|---|
| **Damping off** | Spray mancozeb/ indofil M-45 (25gm/10 litre of water) or carbendazim/ bavistin (5gm/10 l). Follow five years of crop rotation. |
| **Powdery mildew** | Spray sulphur based fungicide *i.e.* karathane at an interval of 15 days interval @ 0.2 %. |
| **Bacterial wilt** | Grow resistant varieties. Crop rotation with Cruciferous vegetables is recommended. Field sanitation and crop rotation reduces the disease incidence. |

### Insect-pests and their Management

| | |
|---|---|
| **Fruit borer** | Adults lay eggs on the upper and lower side of leaf. Larve bore circular holes and usually thrust only head inside the fruit to another and may destroy many fruits. Spray deltametharin 25 EC or spray 5% neem seed kernal extract to kill early stages larvae Placement of 15-20 bird perches (T shaped) per ha helps in inviting insectivorous birds. |

## Cucurbitaceous Crops

Cucurbits form an important and a big group of vegetable crops cultivated extensively during summer season. These vegetables are used either as salad, pickling (cucumber) or for cooking (all gourds) or preserved (ash gourd) or used as desert fruits (musk melon and water melon). All cucurbits belong to the same family Cucurbitaceae but genera may be different. The cultural requirements of all crops in this group are more or less similar.

### Soil and Climatic Requirements

A well-drained soil of loamy type is preferred for cucurbits. Lighter soils, which warm quickly in spring are usually utilized for early yields while heavier soils are suitable for more vine growth and late maturity of the fruits. In sandy river beds, alluvial substrata and subterranean moisture of river streams support the cultivation of cucurbits. The soil should not crack in summer and should not be water logged in the rainy season. It is important that soil should be fertile and rich in organic matter. The most suitable pH range is between 6.0 and 7.0

Cucurbits are warm season crops. They do not withstand even light frost and strong winds, though cucumber tolerates a slightly cooler weather than melons. Optimum

germination occurs at 18°C temperature. Cucurbits grow best at a temperature range of 18-24°C. Proper sunshine and low humidity are ideal for the production of cucumber. Melons prefer tropical climate with high temperature during fruit development with day temperature of 35-40°C. Cool nights and warm days give better quality fruits in melons.

### Varieties

| Crop/botanical name | Origin | Important varieties |
|---|---|---|
| Cucumber *(Cucumis sativus)* | India | Japanese Long Green, Pusa Uday, Pusa Barkha, Pant Kheera-1, Pusa Sanyog (F1 hybrid), Poinsette, Sheetal, Priya. |
| Bottle gourd *(Lagenaria siceraria)* | Africa | Pusa Naveen, Pusa Samridhi, Pusa Sandesh, Pusa Santushti, Pusa Hybrid 3, Punjab Round, Punjab Komal, Punjab Long, Arka Bahar. |
| Bitter gourd *(Momordica charantia)* | Tropics of the old world | Arka Harit, Pusa Do Mausami, Pusa Vishesh, Pusa Hybrid-2. |
| Summer squash *(Cucurbita pepo)* | Central American and Mexican region | Pusa Alankar, Australian Green, Punjab Chappan Kaddu1, Early Yellow Prolific. |
| Sponge gourd *(Lufa cylindrica)* | India | Pusa Sneha, Pusa Supriya, Pusa Chikni. |
| Ridge gourd *(L. acutangula)* | India | Pusa Nutan, Pusa Nasdar, Arka Sumeet, Arka Sujat, Satputia (hermophrodite flower). |
| Ash gourd *(Benincasa hispida)* | Japan and Jawa | Pusa Ujjawal, CO-1, CO-2, S-1 (PAU), Karikumbala, Boodikumbala, APAU Shakti. |
| Snake gourd *(Trichosanthes anguina)* | India | CO-1, CO-4, TA-19, Chichinda. |
| Water melon *(Citrullus lunatus)* | Africa | Arka Jyoti ($F_1$), Arka Manik, Sugar Baby, Durgapur Meetha, Durgapur Kesar, Asahi Yamato. |
| Musk melon *(Cucumis melo)* | North West India and hot valleys of Iran | Pusa Madhuras, Pusa Sharbati, Hara Madhu, Punjab Rasila, Punjab Sunheri, Punjab Hybrid, Arka Jeet, Arka Rajhans, Hisar Madhu, Durgapur Madhu, Kashi Madhu. |

## Sowing Times

- ❖ Under river-bed cultivation, most of the cucurbits are sown during winter season *i.e.* in the month of November in norther Indian plains.
- ❖ In the garden soils, sowing is done in February end to March.
- ❖ Melons are grown only when the weather is warm and dry during fruit development *i.e.* November to February.
- ❖ For rainy season, grow only those cucurbits, which can tolerate rains. *e.g* bitter gourd in June-July.
- ❖ In southern and central India, winters are not severe and long, therefore, these can be grown throughout the year. November sown crop is over by March-April
- ❖ In northern Indian hills, sowings start from April-May and the crop is over by August-September.
- ❖ In western India, sowings are done from September to February.

## Methods of Planting

In most cucurbits, *in situ* method of sowing is followed. But in certain areas of northern India and hills where the main objective is to get early fruit harvest, the seedlings are raised in polythene tubes and plantation is done in the field when the conditions are favourable without disturbing the soil ball. Transplanting is done at 2 true leaves stage.

**Furrow method:** Furrows are made at 1 to 1.5 m in case of cucumber and bitter gourd. The sowing is usually done on the top of the sides of furrows and the vines are allowed to trail on the ground especially in summer season.

**Bed method:** In some regions, bed system is in fashion where the seeds are sown on the periphery of beds. The width of the bed is almost double to the row-to-row spacing.

**Hill method or raised beds:** The hills are spaced at a distance of 0.5-0.75m and 2-3 seeds are sown per hill. After germination, retain only one or two plants per hill. This method facilitates proper drainage especially in heavy rainfall regions.

**Pit method:** Generally, it is followed in southern India. The pit is lower than the normal bed surface. Training is done by Pargolla or Pandal system.

## Seed Rate, Spacing and Yield

| Crop | Season | Seed rate (kg/ha) | Spacing (m) | Fruit yield (q/ha) |
|---|---|---|---|---|
| Cucumber | Summer/rainy | 2.5-3.5 | 1.5 × 0.60-0.90 | 250-300 |
| Bottle gourd | Summer | 4-5 | 2-3 × 1-1.5 | 300-400 |
| Bitter gourd | Summer/rainy | 4-6 | 1.5-2.5 × 0.60-1.20 | 150-200 |

| Crop | Season | Seed rate (kg/ha) | Spacing (m) | Fruit yield (q/ha) |
|---|---|---|---|---|
| Summer squash (dwarf) | Summer/rainy | 8-10 | 0.60-0.75 × 0.45-0.60 | 250-300 |
| Sponge gourd | Summer/rainy | 2.5-3.0 | 2.50-3.00 × 0.60-1.20 | 150-200 |
| Ridge gourd | Summer/rainy | 3-3.5 | 2.50-3.00 × 0.60-1.20 | 150-200 |
| Snake gourd | Summer/rainy | 4-6 | 1.5-2.5 × 0.60-1.20 | 200-250 |
| Ash gourd | Summer/rainy | 5-7 | 1.5- 3 × 0.6-1.2 | 100-150 |
| Water melon | Summer | 3-4 | 2.5-3.5 × 0.90-1.20 | 300-500 |
| Musk melon | Summer | 1.5-2.0 | 1.50-2.0 × 0.60-0.90 | 150-200 |

### Manures and Fertilizers

| Farmyard manure (q/ha) | Nitrogen (N) (Kg/ha) | Phosphorus ($P_2O_5$) (Kg/ha) | Potassium ($K_2O$) (Kg/ha) |
|---|---|---|---|
| 200-250 | 60-100 | 50-75 | 50-85 |

Full dose of farmyard manure, phosphorus and half of potassium and N should be applied at the time of sowing. Remaining part of N should be top-dressed in two equal parts after one month and at flowering stage, while half of K is applied when good growth takes place.

### Interculture and Weed Management

Thinning of plants should be done 10-15 days after sowing, retaining not more than 2 healthy seedlings per hill. The beds or ridges are required to be kept weedfree in the early stages before vine growth starts. Weeding and earthing up are done at the time of top dressing of split application of nitrogenous fertilizers. Butachlor @ 1 kg/ha or chloramban @ 2-3 kg/ha as pre emergence & naptalam @ 2-4 kg/ha as post emergence after first weeding efficiently helps in controlling the weeds in Cucurbitaceous crops. In general, vertical training is more helpful in increasing the yield of cucumber.

### Irrigation

In spring-summer crop, frequency of irrigation is very important, while in rainy season crop, well distributed rainfall between July to September reduces the frequency of irrigations. Ridges or hills or beds are to be irrigated a day or two prior to sowing of seeds and then light irrigation is to be given 4 or 5 days after sowing.

### Sex Expression and Sex Ratio

- Gibberellic acid (GA) at higher concentration induces maleness but at lower concentration of 10-25 ppm increases the number of female flowers.

- ❖ Two sprays, first at 2-leaf stage and again at 4 –leaf stage with 100 ppm of NAA, 200 ppm of etheral, 3 ppm of boron or 3 ppm of molybdenum can suppress the number of male flowers and increases the number of female flowers, fruit set & ultimate yield.
- ❖ Gynoecious lines (Bears only female flowers) are used for hybrid seed production in cucumber and bitter gourd.
- ❖ Cucurbits are cross-pollinated vegetable crops. There are nine types of sex forms found in these crops, of which monoecious type is the most common.
- ❖ "Satputia" variety of ridge gourd is the only cucurbit, which bears hermaphrodite (bisexual) flowers.

## Maturity and Harvesting

- ❖ Harvesting of crop at right time is very important in cucurbits as in most cases, seed development is undesirable.
- ❖ Harvest cucumber, bottle gourd, bitter gourd, snake gourd, ridge gourd and sponge gourd when they are still young, tender and have soft seeds inside.
- ❖ Harvest before fruit colour changes from green to yellow.
- ❖ **Musk melon:** It is a climacteric fruit, which ripe during transportation and storage. Hence, it should be harvested before it attains fully ripe stage.
- ❖ **Water melon:** It is harvested at fully ripe stage. Maturity signs are withering of tendril, change in belly color or ground spot to yellow and the thumping test produce dull sound on maturity and metallic sound in unripe fruits.

## Disease Management

| Disease | Management |
|---|---|
| Powdery mildew | • Spray karathane @ 0.05% |
| Downey mildew | • Spray dithane-Z-78 (0.25%) |
| Anthracnose | • Grow resistant varieties such as Poinsette, Arka Manik.<br>• Seed treatment with blitox or bavistin (2.5 g/kg of seed). |
| Fusarium wilt | • Follow long term crop rotation.<br>• Seed treatment and drenching of soil with blitox or bavistin (2.5 g/kg of seed). |
| Fruit rot | • Seed treatment with bavistin or thiram or captan (2.5 g/kg of seed). Avoid flood irrigation. |
| Collar rot | • Seed treatment with bavistin or thiram or captan (2.5 g/kg of seed). |

| Disease | Management |
|---|---|
| Angular leaf spot | • Seed treatment with mercuric chloride solution (1:1000) for 5-10 minutes. |
| Cucumber mosaic | • Transmitted by aphids. Control aphids with insecticides |
| Pumpkin yellow vein mosaic | • Transmitted by whitefly. Control fruitfly with insecticides. |

### Insect-pests Management

| | |
|---|---|
| Fruit fly | • Field sanitation should be ensured by removal and destruction of fallen fruits and infested fruits daily to minimize the pest intensity.<br>• Trap crop: Growing 2-3 rows of maize as a trap crop in between the cucurbits. Trap crop acts as resting site for the adult fruit fly. Any contact insecticides can be sprayed on maize during evening hours to kill adult fruit flies.<br>• Use of pheromone traps for monitoring pest population.<br>• Apply cover spray of fenthion (0.05%)/ fenitrothion (0.05%), to kill the insects on contact or a bait spray that attracts and kill the adults. Bait spray is prepared by adding 50 g gur + 10 ml malathion in 10 litre water. |
| Epilachna beetle | • Hand picking and destruction of eggs, grubs and adult beetles is effective.<br>• Foliar application of malathion (0.05%), carbaryl (0.1%) and endosulfan (0.05%) checks the pest. |
| Red pumpkin beetle | • Collection and destruction of beetles in the early stage of infestation.<br>• Spraying with 0.05% malathion gives satisfactory control of the pest. |
| Aphids | • Spray endosulfan or malathion @ 0.1% |

## C. Cultivation of flower crops

## ROSE

Rose (*Rosa* species) is the most ancient and popular flower grown the world over. In India, it is cultivated commercially for cut flowers, both for traditional flower market and florist shops. Rose loose flowers are petals used for making garlands and for offering in temples, and the cut roses with stems mainly used for bouquets and floral arrangements. Besides, the commercial rose, the Damask rose (*R. damascena*)

and Edouard rose (*R. bourboniana*) are cultivated for rose *attar* and other products, *gulkand, gulabjal* and *pankhurj*.

## Soil and Climatic Requirements

Roses are grown in cold climate of the hills as well as in the plains of northern and southern regions and well-drained, medium loam soil having a pH of 6.0–7.5 is ideal for rose growing.

### Varieties

First Red, Grand gala, Gladiator, cocktail.

### Propagation

Rose is commercially propagated through T-Budding.

### Planting

The rose should be planted in pits of 60cm diameter and 60–75cm depth dug at appropriate distances in a bed and in northern plains, mid-October is good time for planting.

### Pruning

The rose bushes are pruned once a year during second or third week of October in the northern plains. After about 6–7 weeks of pruning, the plants start flowering. The time of flowering can be adjusted according to the date of pruning. The pruning in northern plains, is done in October.

### Manuring and Fertilization

Rose being a perennial crop, it requires regular nutrient feeding through manures and fertilizers at the time of pruning, plant growth and at the end of flowering, besides during land preparation and planting of new bushes.

### Irrigation

The frequency of irrigation depends upon the soil texture and climate. Watering is more frequent in sandy soils and hot weather than in clay soils and humid/rainy or cool season. During the rainy season in eastern/southern or coastal areas, it may not be necessary to irrigate the plants. The frequency of watering during summer may be about twice a week, while in winter or cool season, it may be only once a week or 10 days.

### Disbudding and Pinching

The young vegetative buds in the leaf axils of basal and lateral shoots are disbudded to encourage branching at the base and to obtain long terminal shoots. For obtaining long stemmed quality blooms, it is necessary to do disbudding and pinching or removal of side flower buds.

### Harvesting and Postharvest Management

The rose flowers are cut while still in the bud stage after the sepals curl back and the colour is fully showing. In large-flowered roses, flowers along with the stem of prescribed length are cut when the first one or two petals start to unfold but do not open fully. The flowers in small-flowered clustered varieties are cut when these begin to open in the cluster. The flowers are harvested in early morning or late in the afternoon. The cut roses are kept in plastic buckets/containers filled with clean water having disinfectant and preservative (silver thiosulphate) to enhance their shelf-life. These flowers are shifted to precooling chambers having a temperature of 10°C, and kept there for about 12hr. The grading is done on the grading tables. The graded flowers are bunched with 10 or 20 stems in each bunch and sleeved with thick paper or plastic film. These flowers are then packed in telescopic corrugated cardboard boxes.

### Plant Protection

| Pests | Diseases |
|---|---|
| Red spider mite | Powdry mildew |
| Scale | Dieback |
| Aphid | Black spot |
| Leaf eating caterpillar | Nematode |

## MARIGOLD

Marigold (*Tagetes* spp), belongs to family Astreceae. It is grown as an ornamental crop for loose flowers as well as a source of pigment for poultry feed. Flowers are sold in the market as loose or after making into garlands. Other than loose flowers, it can also be used as cut flower. Marigold is used especially for beautification and also in landscape plans due to its variable height and colour of flowers

### Botanical Description

1. ***Tagetes erecta* (African marigold) :** The African marigold plant is hardy, annual; about 90 cm tall erect and branched.
2. ***Tagetes patula* (French marigold) :** The French marigold is a hardy annual, about 30 cm tall, forming a bushy plant.

*Different types of marigold*

## Soil and Climatic Requirements

Marigold is adaptable to different types of soil conditions and thus can grow successfully in a wide variety of soils. However, a deep, fertile, friable soil having good water holding capacity, well drained and near to neutral in reaction (pH 7.0 – 7.5) is most desirable. Marigold requires mild climate for luxuriant growth and flowering.

### Varieties

1. ***Tagetes erecta*** **(African marigold) –** Pusa Narangi Gainda, Pusa Basanti Gainda, Climax, Chrysanthemum, Charm etc.
2. ***Tagetes patula*** **(French marigold) -** Pusa Arpita, Red Brocade, Rusty Red, Butter Scotch etc.

**Plant Propogation**

Marigold is mainly propagated by seeds. The seed rate is 42.5 kg/ha.

**Transplanting**

Mid-July, mid-October and February-March are suitable times for transplanting of marigold at spacing of 40 × 30 cm.

**Nutrient Management**

FYM is given @ 50 tones/ha at the time of field preparation. In African and French marigold, application of 400 kg N, 200 kg P and 60 kg K per hectare should be done.

### Maturity and Harvesting

Marigold flowers are plucked when they have attained full size. Plucking of flowers should be done in cool hours of the day. The field should be irrigated before plucking so that flowers keep well for a longer period after harvest. Plucked flowers are collected in polythene bags or bamboo baskets for carrying to markets.

### Plant Protection

| Pests | Diseases |
|---|---|
| Red spider mite | Damping off |
| Hairy caterpillar | Collar rot |
| Alternaria dianthi | Flower bud rot |

# TUBEROSE

Tuberose (*Polianthes tuberosa* L) belongs to family Amaryllidaceae. It is native of Mexico from where it has spread to the different parts of the world during 16$^{th}$ Century. Tuberose is used for making garlands, floral ornaments and bouquets. The long flower spikes used as cut flowers for table decoration and the flowers emit a delightful

fragrance and are the source of tuberose oil, which is used in high value perfumes and cosmetic products.

## Soil and Climatic Requirements

Fertile loamy and sandy soil having pH range from 6.5 to 7.5 with good aeration and drainage are ideal for tuberose cultivation. In India, commercial cultivation of tuberose is confined to warm humid areas with average temperature ranging from 16° to 30°C.

### Varieties

1. **Single -** Shringar, Prajwal, Rajat Rekha, Hyderabad Single and Culcutta Single are main varieties.
2. **Double -** Swarn Rekha, Hyderabad Double, Culcutta Double, Vaibhav & Suvasini are main varieties.


*Tuberose flowers*

### Propagation

Tuberose is propagated through bulbs and bulbs are planted at a spacing of 20x20 cm at a depth of 4-6 cm. These bulbs are first thoroughly cleaned and treated with bavistin (0.2%) for 30 minutes. Dipping the bulbs in 4% solution of thiourea can break the resting period. Pre-plant storage of bulbs at 10°C for a period of 30 days to improve the plant growth, increased spike and flower yield.

### Nutrient Management

In general, a basal dose of FYM @ 10 kg/sq m, nitrogen @ 15 g/sq m should be applied in three split doses. Single super phosphate and murate of potash each @ 80 g/sq m, 10-15 days prior to the planting of bulbs is recommended.

### Maturity and Harvesting

Tuberose starts flowering 80 to 100 days after planting and flowering time is July onwards and tuberose flowers all the year round. Spikes are harvested at bud-burst stage preferably in the morning before sunrise or late in the evening by clipping with a sharp knife or secateurs that give a clean cut. After harvest, these are immediately immersed in water for prolonging life of spikes.

### Plant Protection

| Insect Pests | Diseases |
|---|---|
| Bud borer | Stem rot |
| Nematodes | Flower bud rot |

## D. Cultivation of Spices

## CUMIN

Cumin (*Cuminum cyminum*) or Safaid jeera is one of the oldest spices known to mankind. It belongs to family Apiaceae. It is the ripe fruit of a slender herb. Cumin seeds are yellowish to greyish-brown and have an aromatic odour due to the presence of an aromatic alcohol, cuminol, and a spicy somewhat bitter taste, and are extensively used as a condiment.

### Soil and Climatic Requirements

Cumin thrives well in tropical and sub-tropical climates and well-drained, medium to heavy textured, medium to highly fertile soil with a good water-holding capacity is ideally suited for its cultivation.

#### Varieties

The important varieties grown in India are: RS-1, Gujarat cumin-1, MC-43 and Vijapur-5 etc.

#### Propagation

Cumin is propagated through seeds. Plots of 2 x 2.5 m are made after the final preparation of land, just before sowing. The best time for sowing is the first fortnight of November.

#### Cultivation

It is recommended to apply well rotten FYM @10-15 t/ha to the field at the time of land preparation. In addition, an application of 25:20:20 or 50:50:80 kg or 30-40 kg each of NPK per hectare is considered to be optimum for the satisfactory growth of the crop.

#### Pests and Diseases

Cumin is often attacked by several species of aphids, which can be effectively controlled by spraying a 0.3% solution of phosphomidon (0.03%), or dimethoate (0.3%). Cumin wilt is a serious diseases caused by *Fusarium oxysporum, F cumini* and *F equisetti*. The

organism can infest the plant at any stage of growth. Organic amendments like neem cake are useful in checking wilt.

### Maturity, Harvesting and Yield

The crop will be ready for harvest in about 80 to 120 days after sowing. At this stage, the leaves of the plant become yellow. The crop is harvested before the fruits shatter, by uprooting the whole plant in the morning. A disease-free field receiving the above package of practice would easily produce 8 to 15 quintals of cumin seeds per hectare.

## BLACK PEPPER

Black pepper (*Piper nigrum*) belongs to family Piperaceae. It is one of the oldest and the world's most important spices. Among all the spice crops, pepper has the highest contribution to foreign exchange. It is duly regarded as the "King of Spices" and "Black Gold". Pepper has its origin in the Western Ghats of India. It occurs wild in the hills of Assam and North Burma. It is a perennial climbing plant, mostly cultivated as a mixed crop in coffee, citrus and arecanut plantations in Kerala and Karnataka. Piperin is the alkaloid responsible for pungency. It's a perennial climber, catkin is the inflorescence type and fruit is single seeded berry.

### Soil and Climatic Requirements

Pepper is essentially a crop of the humid tropics and requires an optimum rainfall of 1250-2000 mm per annum distributed throughout the year is desirable. Pepper thrives best on virgin soils rich in humus and a pH range of 4.5 to 6.5 is ideal.

### Propagation

Pepper can be commercially propagated by cuttings and runner shoots are the most preferred propagating material, but for bush pepper production, plageotropic shoots are used.

### Varieties

Karimunda, Sreekara, Poornima, Panniyur-2, Panniyur-4, Panniyur-6, Subhakara and Panchami are some of the important varieties of black pepper.

### Land Preparation

The pits are prepared well in advance of planting at the base of the standards with a minimum size of 50 $cm^3$. The pits are filled with a mixture of top soil, 5 kg of well rotten FYM/compost, 2 kg neem cake and 150 g rock phosphate. A spacing of 2.7 X 2.7 m is maintained in monoculture.The common live standards used to train pepper vines are *Erythrina indica, Garuga pinnata, Mangifera indica, Anacardium occidentale, Greuillea robusta,* Terminalia *sp.*, etc.

### Plant Protection

| Pests and Diseases | | Symptoms | Management |
|---|---|---|---|
| Insect Pests | Pollubeetle | The external indication of infestation is the presence of dark, drying berries possessing a characteristic circular hole in the midst of green healthy berries. | Spraying vines with, quinalphos (0.025%), dimethoate or monocrotophos (0.05%) twice a year. |
| Diseases | Quick wilt | This is the most serious and dreaded disease affecting the pepper vine. Three types of symptoms, i.e., leaf-rot, collar-rot and root-rot, are generally observed in a quick wilt infected plant. | Application (per vine) of neem cake (1 kg) + *Trichoderma harzianum* + garlic and mustard seed extract |

### Maturity, Harvesting and Yield

Harvesting is done during Nov-Feb in plains and during Jan-Mar in hills. In India, the yield varies from 110 kg to 355 kg/ha.

| Products | Harvest maturity |
|---|---|
| White pepper | Fully ripe |
| Black pepper | Fully mature and nearly ripe |
| Canned pepper | 4-5 months after fruit set |
| Dehydrated green pepper | 10-15 days before full maturity |
| Oleoresin | 15-20 days before full maturity |
| Oil | 15-20 days before full maturity |
| Pepper powder | Fully mature with maximum starch |

## TURMERIC

Turmeric (*Curcuma longa*) is known as the sacred spice which belongs to family Zingiberaceae. It is the plant from which the turmeric of commerce (dried rhizomes) is obtained. The colouring principle in turmeric is curcumin. In addition to its use as a spice, natural source of yellow dye used for dying cotton, silk or wool without a

mordant. Turmeric powder and water are used as cosmetics. Turmeric is considered a carminative, tonic, blood-purifier, vermicide and an antiseptic.

## Soil and Climatic Requirements

Turmeric prefers a warm and humid climate and can be cultivated in most of the tropics and subtropics, provided that the rainfall is adequate or irrigation facilities are available and well-drained loamy or alluvial soils is optimum for the crop.

### Varieties

Kasturi, Balaga, Mundaga, Aleppey, Mannuthy Local etc.

### Propagation

Turmeric is generally propagated by using whole or split mother rhizomes.

### Manure and Fertilizers

FYM at 40 t/ha is applied at the time of land preparation and a fertilizer dose of 30:30:60 or 60:30:90 kg of NPK per hectare is recommended. The field is mulched with green leaves @ 15 t/ha.

### Maturity, Harvesting and Yield

Turmeric comes to harvest in 7-10 months after planting. The yield of about 20-25 tones of raw turmeric per hectare is obtained.

### Value-added Products

The value-added products of turmeric are curcuminoids, dehydrated turmeric, powder, oil and oleoresin.

### Plant Protection

| Pests | Diseases | Symptoms | Management |
|---|---|---|---|
| **Insect** | **Shoot borer** | The larvae bore into the pseudostems and feed on the growing shoots, resulting in yellowing and drying of the infested shoots. | Hymenopteran parasitoids have been identified as bio-control agents for this pest. |
| **Diseases** | **Rhizome-rot** | The leaves of the infected plants become yellow and exhibit gradual drying along the margins. | Planting healthy rhizomes and seed treatment with dithane M-45 (0.25%) + carbendazim (0.1%) for 60 minutes |

# CORIANDER

Coriander (*Coriandrum sativum*) is the dried fruit of *Coriandrum satiuum* L., an aromatic spice crop of the family Umbelliferae or Apiaceae. It is a very old flavouring substance and it usage both for its leaves, as well as fruits.

## Soil and Climatic Requirements

Coriander is best cultivated on heavy black, clayey cotton soils.

### Varieties

RCr-41, Rcr-20, CS-4 (Sadhna), CS-6 (Swathi), RD-44 (Rajendra Swathi)

### Propagation and Seed Rate

Coriander is propagated by seed. Before sowing, the fruits are rubbed until the two mesocarps are separated and then sown. The seed rate requirement in coriander varies from 10-15 kg for irrigated and 25-30 kg per hectare for rain-fed crops.

### Manures & Fertilisers

40:40:40 NPK per hectare are applied depending on the location at the time of sowing.

### Irrigation

The crop is irrigated immediately after sowing in order to ensure even germination, and later irrigation is provided at 7-10 days' intervals, depending upon the soil and climatic conditions.

### Maturity, Harvesting and Yield

The coriander plant matures in 90-120 days for grains and 40 days for greens. On an average, a seed yield of 400 to 500 kg/ha under rainfed conditions and 1,000 to 1,250 kg/ha under irrigated conditions may be obtained.

### Pests and Diseases

| Pests | Diseases | Symptoms | Management |
|---|---|---|---|
| **Insect-Pests** | **Aphids** | The attack of aphids usually occurs at the time of flowering. | This insect is easily controlled by a number of insecticides (0.15% dimethoate at 10 days interval). |
| **Diseases** | **Wilt** | Wilt infection occurs in the roots and drooping, yellowing, wilting and drying symptoms are expressed in the aerial parts. | *T. harzianum* and *Pseudomonas fluorescens* can be used as biocontrol agents and wilt tolerant cultivars, Rcr-41, Rcr 4, GC 1 and 2 and Sindhu, should be grown in wilt-affected plots. |

# EXERCISES

## Activities

1. Plan a visit to some mango orchard. With the help of gardener (*Mali*) make a list of important varieties grown in it. Also try to differentiate the varieties grown in the orchard. Also find some insect or disease infected plant parts. Observe the nature of damage or and note down the symptoms of damage caused by an insect or disease.
2. Go to some guava orchard. Note down the wilt affected plants and symptoms of disease. Also see if fruitfly attack is there in fruits. Cut such fruits into 2 halves and note down the extent of damage caused by the fly.
3. Note the symptoms of guava wilt and panama wilt after visiting orchards of guava and banana, respectively.
4. Attempt to give incisions to immature papaya fruits and collect latex and prepare papain from it after following all precautions.
5. Try to prepare beds of different sizes and sow seeds of different vegetables and seasonal annuals. Also transplant the seedlings in the fileds after they attain appropriate size.
6. Go to Deptt of Vegetable Science and Floriculture of some research institute and/or Agril University near to your home. Note down different diseases of different vegetables and floricultural crops, and make a herbarium.
7. Collect different seed spices in small vials and label them.

## Check Your Progress

1. Discuss soil and climatic requirement of apple and mango.
2. Discuss propagation techniques of mango, grape and citrus briefly.
3. What is maturity? Discuss harvesting and grading in apple.
4. Differentiate between training and pruning. Discuss pruning and training methods in grape and apple.
5. Discuss major insect-pests and diseses of citrus and their management.
6. What is crop regulation? Discuss bahar management in citrus and pomegranate briefly.
7. Discuss cultivation apple under different heads.
8. Name major varieties of mango. Name some hybrids developed by research institutes.
9. List major physiological disorders of mango and pomegranate.
10. Name major diseases of mango, and banana. Write their control measures.
11. Write briefly about regulation of flowering in guava and pomegranate.
12. Enlist major varieties of cabbage, cauliflower, potato, brinjal and tomato being grown in different parts of India.

13. Discuss physiological disorders of cole crops.
14. Write important symptoms of major diseases of cabbage crop and enlist various management practices adopted for their control.
15. Write briefly about harvesting and post harvesting handling of tomato, muskmelon and pea.
16. Discuss major insect-pests of tomato, brinjal, cabbage and potato and their management.
17. Enlist major diseases of okra, caulifliower, potato, and their management.
18. List out the major and important varieties of coconut.
19. Discuss major insect-pests & disease in coconut and cashewnut.
20. List out the value added products of coconut?
21. Discuss different propagation techniques and diseases of rose and tuberose.
22. Mention the soil and climatic requirement and propagation in marigold cultivation.
23. Differentiate between African and French marigold and discuss the pinching in marigold.
24. Enlist the seed spices grown in India. Mention seed rate, method of propagation, major varieties and diseases.

## Fill in the blanks

1. Mango is known a _____ fruits in India.
2. Spongy tissue is a serious disorder in _____ variety of mango.
3. Dashehari is a famous variety of mango in _____ India ( North, South, West)
4. Amrapali is a variety of _____
5. _____acts as vector for bunchy top of banana
6. Papain is obtained from immature _____ fruits
7. Pusa Delicious is a variety of _____
8. Harvesting index of mango_____& _____
9. Pomegranate is commercially propagated trough _____
10. Ultra Dwarf rootstock of apple is _____
11. Grape variety suitable for raisin making_____
12. Alphonso is the variety of _____fruit crop
13. Mosambi is a variety of _____
14. Banana is commercially propagated through_____
15. Scientific name of cauliflower is _____
16. Seed rate of cauliflower is_____
17. Major insect pest of cabbage is _____
18. Fruit and shoot borer is the major pest of _____crop
19. Pea is rich in _____mineral nutrient

20. Coconut is propagated by _____
21. Scientific name of cashew is _____
22. Scientific name for turmeric is _____
23. Shade plant used in the turmeric field is _____
24. Scientific name of tomato is _____
25. Coriander belongs to the family _____
26. Maturity indices for coriander is _____
27. Improved variety of cumin is _____
28. Mention the seed rate for cumin _____
29. Hybrid tea roses are communically propagated through_____
30. Time of pruning in rose is _____
31. Fruits of rose is called as_____
32. Rose belongs to the family_____
33. Gulkand is prepared from_____
34. Mention one veriety of marigold_____
35. Rose is mainly propagated by _____

## Suggested Further Readings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# CHAPTER – 3

## ANIMAL HUSBANDRY AND DAIRYING

### Learning Objectives

After studying this chapter, students will be able to:

- Understand the nutritional requirements of livestock.
- Know breeding methods of farm animals.
- Tell the major diseases of livestock and poultry and their management.
- Know the importance and use vaccination of animals.

### Introduction

Whensoever, we go to a dairy or village, we find that few animals are quite healthy and few are very weak. Similarly, few dairies are neat and clean and producers give utmost care for rearing of animals; yet others are careless. This all depends on the management of nutrition and diseases. Livestock needs to be fed with balance diet like human being. Farm animals also suffer from several diseases like us, and hence, management of their diseases is most important aspect of their rearing. For the management of several fatal diseases, Govt. of India has initiated several vaccination programmes. Similarly, breeding of animals is most important aspect for producing new individuals and increasing the population of wanted breeds. Furthermore, several products and byproducts are produced from the farm animals, and their disposal and/or utilization is a major issue in our country. In this chapter, you will come to know about all these aspects in brief.

### Nutritional Requirements of Livestock

For proper growth, health and reproduction, animals also require several nutrients. The essential nutrients required by animals are water, energy, protein, minerals, and vitamins. These nutrients are needed to maintain body weight, growth, reproduction, lactation, and health..

### Water

Water is the most abundant, cheapest, and least understood of all nutrients required for livestock production. However, it is the most essential for all livestock. The producers should plan for an adequate supply of clean water when designing any type of livestock enterprise. Dirty, stagnant water can lead to inadequate water consumption, which will affect performance of livestock. The amount of water required depends on the age animal, health and the surrounding environment. However, in general, lactating animals require more water, and the amount of water required increases as atmospheric

temperature increases. For example, at temperatures above 35°C, cattle require about 8 to 15 liters of water per kg of dry matter intake. In general, cattle require ~2.6% of their body weight in dry matter (DM) intake per day.

When the weather is hot in the summer, the requirement of the animal for water also increases. A lactating dairy cow requires on average between 15 and 35 gallons of water per day; non-lactating dairy and beef cows require about 15 gallons per day; an adult horse will consume up to 15 gallons per day, which will increase 2 to 3 times when exercising; adult sheep between 1½ and 3 gallons a day; adult swine from 3 to 5 gallons per day; and adult hens about a pint. A quick rule of thumb is that for every 2 pounds of dry feed intake, an animal should receive one gallon of water. This will vary with stress, weather conditions, heat, cold, disease, productive state, work, exercise, etc., as well as the water and salt content of the feed. Often the first sign that water consumption is inadequate is when animals stop eating. Water is essential to maintain adequate feed consumption.

### Protein

In general, the amount of protein supplied in the diet of the animal is more critical than the quality of the protein. Ruminants have the ability to convert low-quality protein sources to high-quality proteins through bacterial action. Protein is required by all grazing animals for growth. Protein required for a 1000 lb non-lactating cow is around 1.6 lb/day. When the cow is lactating, 2.0 lb or 9.6% dietary crude protein is required. If protein is deficient in the diet, animals must break down body tissue to obtain sufficient protein. A protein-deficient animal must break down 6.7 lb of lean body tissue to supply 1 lb of protein, resulting in severe weight loss.

### Energy

Sufficient energy is required for better performance of livestock, which varies greatly with age and type of animal. It is especially important during late gestation and early lactation periods. Energy deficiencies can cause reduced growth rate, loss of weight, reduced fertility, lowered milk production, and reduced wool quantity and quality. Energy is primarily obtained from carbohydrates present in the plant material or feed supplied to animal.

### Vitamins and Minerals

Like human beings, animals also require vitamins and minerals for growth and development. Ruminants require all the fat-soluble vitamins (A, D, E, and K), but they can synthesize the B vitamins in their rumen. Normally, the forage and feed supply contain all essential vitamins in adequate amounts, except vitamin A which is obtained as carotene from green plants. Salt is essential for many body functions and important to maintain intake of feeds and water. Calcium and phosphorus are needed to maintain growth, feed consumption, normal bone development, and reproductive efficiency.

Other nutrients and minerals such as vitamin E and selenium are important for maintenance of healthy bodies and reproduction.

## Factors Affecting Nutritional Requirements of Animals

The nutrient requirements of animals tend to vary only slightly within a given weight, sex, age, and physiological state.

**Physiological stage:** The nutritional requirements of livestock are greatly influenced by the growth stage. The key physiological stages in the life of animals are growth (i.e., young animals), late pregnancy, lactation, and maintenance, and non-lactating periods. In general, the highest nutritional requirements are during lactation period, followed by late gestation, growth, and finally maintenance.

Topography and climatic conditions: The nutrient requirements of the animals are also dependent on environmental and climatic conditions. Grazing and voluntary animals also require substantial increases in energy expenditure. Some animals walk long distances, climb gradients, and ingest herbage often of low dry matter content, thus spending more time eating and foraging for food. It has been estimated that cows grazing use 30% more energy than confined cows because of longer grazing time and longer travel distance. The climatic factors, particularly temperature, also affect the amount of feed an animal needs to maintain its body functions. As ambient temperature drops, an animal's metabolic rate increases, and more energy is needed to maintain internal heat. This effect can be exacerbated by wind or wet hide/hair on the animals.

## Breeding of Farm Animals

Breeding means, the manner in which selected males and females are mated. Breeding makes new combination or sequencing of genes in the individual. The breeders identify and select desirable qualities in animals for future mating and discard less desirable qualities. For the improvement of livestock selection and breeding must be practised simultaneously. Continuous selective breeding leads to homozygosity in a population resulting a loss of variability. If all the individuals are alike, the breeder cannot make progress in future. Hence, there is a need to create a variability in population. This can be achieved by breeding. Therefore, selection and breeding should go hand-in-hand for the improvement of livestock.

## Classification of Breeding Systems

Under the selected breeding system, selected males and females are mated. The breeding system can be classified into five different ways depending on their phenotypic and genotypic relations.

(1) Random mating,

(2) Phenotypic assortive mating,

(3) Phenotypic dissortive mating,

(4) Genetic assortive mating, and

(5) Genetic dissortive mating.

**1. Random mating or Panmixia**

It is a system of mating in which each male individual has an equal opportunity to mate with the female individual and vice versa. This mating system generally takes place in nature where the number of males and females are assumed to be equal.

**2. Phenotypic assortive mating**

In this type of mating, animals which are phenotypically alike are allowed to mate among themselves. This is also called 'like-to-like' mating.

**3. Phenotypic disassortive mating**

In this method, individuals which are phenotypically unlike are allowed to mate. It is also called 'unlike-to-unlike' mating. For example, mating of tall with short individuals.

**4. Genetic assortive mating**

In this system, individuals, which are genetically closely related are allowed to mate. This is also known as inbreeding.

**5. Genetic disassortive mating**

In this system, mating takes place between less-closely related individuals. This is also called as out breeding.

## Breeding Methods

There are two major breeding methods: inbreeding and out-breeding.

**Inbreeding:**

It is defined as 'breeding of more closely related individuals (males and females) than the average relationship of the population'. Depending upon the closeness among mated individuals, inbreeding is of the following three types.

(i) Close inbreeding (mating individuals have relationship above 0.25),

(ii) Mild inbreeding (mating of relatives beyond 2nd generation and upto 6th generation),

(iii) Line breeding (mating of relatives between 4th-6th generations).

**Advantages of inbreeding**

1. Due to increase in homozygosity, the stamping ability or prepotency of inbred line increases.
2. It helps to eliminate lethals and semi lethals due to homozygosity.

3. It increases genetic variance between lines and reduces genetic variance within lines.

**Disadvantages of Inbreeding**

1. Many lines are lost due to homozygous lethals or semi-lethals.
2. Due to loss of heterozygosity, the hybrid vigour is lost.
3. Inbreeding leads to lower birth weight, post natal mortality (baby death after birth), poor growth, reproductive disorder and low resistance to diseases.

**Out-breeding**

It is opposite to inbreeding where unrelated individuals are mated. The breeding individuals have relationship less than the average relationship of the population. Out-breeding results in increase in heterozygosity and decrease in homozygosity. It is of the following two types:

(i) Out-breeding within a breed, and

(ii) Out-breeding between two species/strain/line/breed.

**Advantages of out-breeding**

1. Out-breeding increases heterozygosity which results in hybrid vigour (increase in weight, faster growth, increased resistance to disease, low mortality).
2. It covers the defects of recessive lethals and semi-lethal genes.
3. It increases genetic variance within lines.

## Products and Byproducts of Livestock and their Uses

India is bestowed with vast livestock wealth and it is growing at the rate of 6% per annum. The contribution of livestock industry including poultry and fish is increasing substantially in GDP of country which accounts for >40% of total agricultural sector and >12% of GDP. This contribution would have been much greater had the animal byproducts been also efficiently utilized. Efficient utilization of byproducts has direct impact on the economy and environmental pollution of the country. Non-utilization or under utilization of byproducts not only lead to loss of potential revenues but also lead to the added and increasing cost of disposal of these products.

Non-utilization of animal byproducts in a proper way may create major aesthetic and catastrophic health problems. Besides pollution and hazard aspects, in many cases meat, poultry and fish processing wastes have a potential for recycling raw materials or for conversion into useful products of higher value. Traditions, culture and religion are often important when a meat byproduct is being utilized for food. Regulatory requirements are also important because many countries restrict the use of meat byproducts for reasons of food safety and quality. Byproducts such as blood, liver, lung, kidney, brains, spleen and tripe have good nutritive value. Severla byproducts have medicinal and pharmaceutical uses. Waste products from the poultry processing and egg production

industries must be efficiently dealt with as the growth of these industries depends largely on waste management. Treated fish waste has found many applications among with which the most important are animal feed, biodiesel/biogas, dietectic products (chitosan), natural pigments (after extraction) and cosmetics (collagen).

## By-products of the meat industry & their utilization

Several by-products such as variety of meat, blood, hides and skin, bones, glands & organs and tallow and lard are produced by the mean industry (Table 1). Beside pollution and hazard aspects, in many cases, meat processing waste have a potential for recycling raw materials, or for conversion into useful products of higher value as by product, or even as raw material for other industries, or for use as food or feed after biological treatment. Particularly utilization of meat industry wastes is receiving increased attention in view of the fact that these wastes represent a possible and utilizable resource for conversion to useful products. Fish waste stands for one of the continuously gaining ground waste management fields. Among the most prominent current uses for treated fish waste are collagen, biogas/biodiesel, dietic applications (chitosan) and food packaging.

Meat producers have been using meat byproducts for a long time to process into different products, some edible and some inedible. Today, with the increased concerns over health, technology has been developed to permit more efficient utilization of these byproducts. In India, the slaughter house waste management system is very poor and several measures are being taken for the effective management of wastes generated from slaughter houses. Competition is also a strong incentive for meat industries to use byproducts more efficiently. This is important, because increased profits and lower costs are required in the future for the meat industry to remain viable. These innovations also increase the value of the carcass, and increase the profits of livestock raisers.

Variety of meats are the wholesale edible byproducts. They are segregated, chilled and processed under sanitary conditions and inspected. In some parts of the world, blood is also utilized as an edible product for human beings. In US, meat trimmed from the head is described on edible offal or an edible byproduct. Edible fats are obtained during slaughter, such as the cowl fat surrounding the rumen or stomach, or the cutting fat which is back fat, pork leaf fat or rumen fat. In commercial slaughter house practice in U.K, the offal is divided into red (head, liver, lungs, tongue, tail etc.) and white (fat), plus the set of guts and bladder, the set of tripe (rumen), and the four feet and trimming. Some items may not be used in uncooked products. This list includes mammalian parts such as blood, blood plasma, feet, large intestines, small intestines, lungs, oesophagus meat, rectum, stomach (non-ruminant), first stomach (tripe, after cooking), second stomach (tripe, after cooking), fourth stomach, testicles and udder. It also includes poultry part such as gizzards and necks. The yield of edible meat byproducts from pigs is around 6.7% of the carcasses weight. Whether these products are widely accepted

by consumers depends on various factors. These include the nutrient content, the price and whether there are comparable competing products.

**Table 1: Proportion of byproducts produced by meat industry**

| Item | Pigs | | Cattle | | Sheep | |
|---|---|---|---|---|---|---|
| | % | kg | % | kg | % | kg |
| Market live weight | - | 100 | - | 600 | - | 60 |
| Whole carcass | 77.5 | 77.5 | 63.0 | 378.0 | 62.5 | 37.5 |
| Blood | 3.0 | 3.0 | 18.0 | 4.0 | 2.4 | |
| Fatty tissue | 3.0 | 3.0 | 4.0 | 24.0 | 3.0 | 1.8 |
| Hide or skin | 6.0 | 6.0 | 6.0 | 36.0 | 15.0 | 9.0 |
| Organs | 7.0 | 7.0 | 16.0 | 96.0 | 10.0 | 6.0 |
| Head | 5.9 | 5.9 | - | - | - | - |
| Viscera (chest and abdomen) | 10.0 | 10.0 | 16.0 | 96.0 | 11.0 | 6.6 |
| Feet | 2.0 | 2.0 | 2.0 | 12.0 | 2.0 | 1.2 |
| Tail | 0.1 | 0.1 | 0.1 | 6.0 | | |
| Brain | 0.1 | 0.1 | 0.1 | 6.0 | 2.6 | 0.156 |

## Nutritive Value of Meat By-products

Edible meat byproducts contain many essential nutrients. Some are used as medicines because they contain special nutrients such as amino acids, hormones, minerals, vitamins and fatty acids. Not only blood, but several other meat byproducts, have a higher level of moisture than meat. Some examples are lung, kidney, brains, spleen, and tripe. Some organ meat, including liver and kidney, contains a higher level of carbohydrate than other meat materials.

Pork tail has the highest fat content and the lowest moisture content of all meat byproducts. The liver, tail, ears and feet of cattle have a protein level which is close to that of lean meat tissue, but a large amount of collagen is found in the ears and feet. The lowest protein level is found in the brain, chitterlings and fatty tissue. Some byproducts such as ears, feet, lungs, stomach and tripe contain a larger amount of proline, hydroxyproline and glycine, and a lower level of tryptophan and tyrosine. The vitamin content of organ meats is usually higher than that of lean meat issue. Kidney and liver contain the largest amount of riboflavin (1.697–3.630 mg/100 g), and have 5–10 times more than lean meat. Liver is the best source of niacin, vitamin $B_{12}$, $B_6$, folacin, ascorbic acid and vitamin A. Kidney is also a good source of vitamin $B_6$, $B_{12}$, and folacin. Lamb kidneys, pork, liver, lungs, and spleen are an excellent source of iron, as well as vitamins. The copper content is highest in the livers of beef, lamb and veal. With

the exception of brain, kidney, lungs, spleen and ears, most other byproducts contain sodium at or below the levels found in lean tissue. Mechanically deboned meat has the highest calcium content (315–485 mg/100 g).

Many organ meats contain more polyunsaturated fatty acids than lean tissue. Brain, chitterlings, heart, kidney, liver and lungs have the lowest level of monounsaturated fatty acids and the highest level of polyunsaturated fatty acids. There is three to five times more cholesterol (260–410 mg/100 g) in organ meats than in lean meat, and large quantities of phospholipids. Brain has the highest level of cholesterol (1,352–2,195 mg/100 g) and also has the highest amount of phospholipids compared to other meat byproducts. For this reason, the United States Department of Health recommends that limited amounts of these byproducts be eaten, because of health concerns. The high cholesterol content of many other organ meats, and the possible accumulation of pesticides, drug residues and toxic heavy metals, is another reason for limited consumption.

## Utilization of blood

Animal blood has a high level of protein and heme iron, and is an important edible byproduct. In Europe, animal blood has long been used to make blood sausages, blood pudding, biscuits and bread. In Asia, it is used in blood curd, blood cake and blood pudding. It is also used for non-food items such as fertilizer, feedstuffs and binders.

Blood is usually sterile in a healthy animal. It has high protein content (17.0), with a reasonably good balance of amino acids. Blood is a significant part of the animal's body mass (2.4–8.0% of the animal's live weight). The average percentage of blood that can be recovered from pigs, cattle and lambs are 3.0–4.0, 3.0–4.0 and 3.5–4.0%, respectively. However, the use of blood in meat processing may mean that the final product is dark in color, and not very palatable. Plasma is the portion of blood that is of greatest interest, because of its functional properties and lack of color.

Blood is used in food as an emulsifier, a stabilizer, a clarifier, a color additive, and as a nutritional component. Most blood is used in livestock feed in the form of blood meal. It is used as a protein supplement, a milk substitute, a lysine supplement or a vitamin stabilizer, and is an excellent source of most of the trace minerals. Blood plasma has ability to form a gel, because it contains 60.0% albumin. Plasma is the best water and fat binder of the blood fraction. Blood can be separated into several fractions that have therapeutic properties. Liquid plasma is the largest fraction (63.0%). It consists of albumin (3.5%), globulin and fibrinogen (4.0%).

## Utilization of hides and skins

Animal hides have been used for shelters, clothing and as containers by human beings since prehistoric times. The hides represent a remarkable portion of the weight of the

live animal, from 4% to as much as 11% (e.g. cattle: 5.1–8.5%, average: 7.0%; sheep: 11.0–11.7%; swine: 3.0–8.0%). Hides and skins are generally one of the most valuable byproducts from animals. Examples of finished products from the hides of cattle and pigs, and from sheep pelts, are leather shoes and bags, rawhide, athletic equipment, reformed sausage casing and cosmetic products, sausage skins, edible gelatine and glue.

After the hide is removed from the animal, it should be cured quickly to avoid decomposition by bacteria and enzymes. Gelatin is produced by the controlled hydrolysis of a water-insoluble collagen derived from protein. It is made from fresh raw materials (hides or bone) that are in an edible condition. Both hides and bones contain large quantities of collagen. Gelatin extracted from animal skins and hides can be used for food. The raw material can also be rendered into lard.

Collagen from hides and skins also has a role as an emulsifier in meat products because it can bind large quantities of fat. This makes it a useful additive or filler for meat products. Collagen can also be extracted from cattle hides to make the collagen sausage used in the meat industry. Gelatin is added to a wide range of foods, as well as forming a major ingredient in jellies. Approximately 6.5% of the total production of gelatin is used in the pharmaceutical industry Most of it is used to make the outer covering of capsules. Gelatin can also be used as a binding and compounding agent in the manufacture of medicated tablets and pastilles. It is used as an important ingredient in protective ointment, such as zinc gelatin for the treatment of ulcerated varicose veins. Gelatin can be made into a sterile sponge which are used in surgery, and also to implant a drug or antibiotic directly into a specific area.

A product made from extracted collagen can stimulate blood clotting during surgery. Pork skin is similar to human skin, and can be converted into a dressing for burns or skin-ulcers. Pork skin used as a dressing needs to be cut into strips or into a patch, shaved of hair, split to a thickness of 0.2–0.5 mm, cleansed, sanitized and packaged. It can be used for skin grafting. When used for skin grafting, it is removed from the carcass within 24 h of the death of the pig.

## Utilization of bones

Eleven percent of pork carcasses, 15% of beef carcasses and 16% of lamb carcasses are bone. These values are higher if they include the meat clinging to the bone. The marrow inside some of the bones can also be used as food. The marrow may be 4.0–6.0% of the carcass weight. For centuries, bones have been used to make soup and gelatine.

Meat and bone meal (MBM) was widely recommended and used in animal nutrition as a protein source in place of proteinaceous feeds because of its content of available essential amino acids, minerals and vitamin B12. MBM and related rendered protein commodities have potential for use in applications other than animal feed, including use as a fuel or a phosphorus fertilizer

## Utilization of glands and organs

Animal organs and glands offer a wide variety of flavours and textures, and often have a high nutritional value. They are highly prized as food in many parts of the world, particularly Southeast Asia. Those used as human foods include the brain, heart, kidneys, liver, lungs and spleen. They also include the tongue, the bovine pancreas and udder, the stomach and uterus of pigs, the rumen, reticulum, omasum and absomasum of sheep and cattle, and the testes and thymus of sheep and pigs. The brain, nervous system and spinal cord are usually prepared direct for the table rather than processed for industrial use. They are blanched to firm the tissue before cooking, because of the soft texture.

Heart is used as a table meat. Whole hearts can be roasted or braised. Sliced heart meat is grilled or braised. Kidneys are generally removed from the fatty capsule which holds the kidney in place. Kidneys may be cooked whole or in slices, and are generally broiled, grilled, or braised. Liver is the most widely used edible organ. It is used in many processed meats, such as liver sausage and liver paste. Livers from lambs, veal calves and young cattle are preferred for the table in the United States and Europe, because they have a lighter flavour and texture. Consumers in Southeast Asia, however, generally prefer livers from pigs. Pig, calf and lamb lungs are mainly used to make stuffing and some types of sausages and processed meats. Animal intestines are used as food after being boiled in some countries. Animal intestines are also used in pet food or for meat meal, tallow or fertilizer.

Animal glands and organs are traditionally used as medicine in many countries, including China, India and Japan. The endocrine glands secrete hormones. These include the liver, lungs, pituitary, thyroid, pancreas, stomach, kidney, ovary and follicle. Brains, nervous systems and spinal cords are a source of cholesterol which is the raw material for the synthesis of vitamin D3. Cholesterol is also used as an emulsifier in cosmetics. Bile consists of acids, pigments, proteins, cholesterol etc., and can be obtained from the gall bladder. It is used for the treatment of indigestion, constipation and bile tract disorders. It is also used to increase the secretory activity of the liver. Bile from cattle or pigs can be purchased as a dry extract or in liquid form. Gallstones are reported to have aphrodisiac properties, and can be sold at a high price. They are usually used as ornaments to make necklaces and pendants.

*Different products of farm animals*

The liver is the largest gland in animals. The liver of mature cattle usually weighs about 5 kg, while that of a pig weighs approximately 1.4 kg. Liver extract is produced by mixing raw ground liver with slightly acidified hot water. Liver extract can be obtained from pigs and cattle, and has been used for a long time as a source of vitamin B12, and as a nutritional supplement used to treat various types of anaemia. Heparin can be extracted from the liver, as well as the lungs and the lining of the small intestines. It is used as an anticoagulant to prolong the clotting time of blood. It is also used to thin the blood, to prevent blood clotting during surgery and in organ transplants.

Progesterone and oestrogen can be extracted from pig ovaries. It may be used to treat reproductive problems in women. Relaxin is a hormone taken from the ovaries of pregnant sows, and is often used during childbirth. The pancreas provides insulin, which regulates sugar metabolism and is used in the treatment of diabetes. Glucagon extracted from the cells of the pancreas is used to increase blood sugar, and to treat insulin overdoses or low blood sugar caused by alcoholism.

## Utilization of edible tallow and lard

Animal fats are an important byproduct of the meat packing industry. The major edible animal fats are lard and tallow. Lard is the fat rendered from the clean tissues of healthy pigs. Tallow is hard fat rendered from the fatty tissues of cattle or sheep. Lard and edible tallow are obtained by dry or wet rendering. In the wet rendering process, the fatty tissues are heated in the presence of water, generally at a low temperature. The quality of the lard or tallow from this process is better than that of products from dry rendering. Low-quality lard, and almost all of the inedible tallow and greases, are produced by dry rendering. Rendered lard can be used as an edible fat without any further processing. However, because of consumer demand, lard and tallow are now often bleached and given a deodorizing treatment before being used in food.

Traditionally, tallow and lard were used for deep frying. However, this use is declining in the fast-food industry, due to consumer health concerns. An alternative liquid tallow product has been developed for the preparation of French fries and other fast foods, since less fat is absorbed. Tallow and lard are also used for margarine and shortening. Some edible lards are used in sausages or emulsified products.

## Utilization of poultry byproducts

Waste products from the poultry processing and egg production industries must be efficiently dealt with as the growth of these industries depends largely on waste management. The intensive and large scale production of food animals and animal products has generated an enormous disposal problem for the animal industry. These wastes, including animal excreta, mortalities, hair, feathers and processing wastes are convertible to useful resources. Feather can be fermented by using feather degrading bacterium, Bacillus licheniformis. This bacterium ferments feather to feather lysate, a

digestible protein which is a good source of feed. An enzyme, keratinase, secreted by this bacterium, was purified and characterized. The keratinase is a potent proteinase that hydrolyses collagen, elastin and feather keratin/

Emulsion-based mutton nuggets, incorporating chicken byproducts, i.e., skin, gizzard and heart (SGH) from spent hens have also been evaluated. Incorporation of SGH results in better acceptability of mutton nuggets as compared to that containing mutton fat only. The main byproducts from the poultry have been presented in table 2.

byproducts and their potential uses

**Table 2: Byproducts of poultry**

| Type of by-product | % of live weight | Uses |
|---|---|---|
| Byproducts from production phase | | |
| Poultry litter and manure | – | Recycled feed, surface dressing of agricultural land |
| Hatchery byproducts | | |
| Egg shells, infertile eggs, unhatched eggs and dead as well as culled chicks | – | Hatchery by-product meal upto 3–5% into feed. Egg shell meal as high calcium diet |
| Byproducts of poultry dressing plant | | |
| Feathers | 7–8 | Bedding material, decorative purpose, sporting equipment, manure or fertilizers, feather meal. |
| Heads | 2.5–3.0 | Poultry meal. |
| Blood | 3.2–3.7 | Blood meal. |
| Gizzard and proventriculus | 3.5–4.2 | Edible, source of chitinolytic enzyme. |
| Feet | 3.5–4.0 | Soup, technical fat/poultry grease |
| Intestines and glands | 8.5–9.0 | Sportgats, meat meal, poultry grease and active principles (hormones and enzymes) |

## Fish waste/byproducts utilization

Fish waste is a great source of minerals, proteins and fat. Potential utilization of waste fish scraps is to produce fish protein hydrolysate by enzymic treatment. Fish protein hydrolysate could be used as a cryoprotectant to suppress the denaturation of proteins of lizard fish surimi during frozen storage. Collagen or keratin contained in

livestock and fish waste may be converted to useful products by enzymic hydrolysis, providing new physiologically functional food materials. Collagens containing yellow tail fish bone and swine skin wastes were used as raw materials for production of protein hydrolysates and peptides. These hydrolysates could be of potential use as food ingredients. Auto-hydrolysis of waste fish viscera to produce peptone hydrolysates and their use in bacteriocin production by lactic acid bacteria There are several alternative uses of fish processing waste, like utilization of fish mince, applications of fish gelatin, fish as a source of nutraceutical ingredients, fishmeal production, the possible use of fish and protein concentrate as a food source.

## Common Diseases of Livestock and their Management

Several diseases can infect farm animals and it is impossible to accurately estimate all the losses caused by livestock diseases. However, by and large, the losses are caused by mortality, reduced productivity and lower fertility. Livestock production is an integral part of the way-of-life for the people of the world. Many farmers and ranchers depend upon livestock production for their livelihoods. Consumers expect adequate supplies of meat at economical prices. With livestock mismanagement and spread of diseases, all these are affected.

## Causes of diseases

Disease causes body functions to disfunction or function improperly. Three principal reasons most often cited for the spread of diseases are poor sanitation, improper management, and introduction of new animals into a herd. One or more of the following defects cause diseases.

**Nutritional defects:** An imbalance of required food nutrients in the ration is the cause of nutritional defects. Animals receiving inadequate amounts of vitamins, minerals, fats, carbohydrates, and protein cannot produce efficiently. Therefore, their levels of resistance to disease are lowered.

Physiological defects: These defects cause an improper functioning of glands, organs, or body systems. The relationship between the diet and the proper functioning of body parts is directly related. For example, the thyroid gland regulates the rate of body metabolism and depends upon an adequate supply of iodine to function properly. An improperly functioning thyroid gland may increase the nutritive requirements of animals to the point that very few nutrients are available for growth or production.

Morphological defects (physical defects): An accident or negligence is responsible for physical defects. Cuts, scrapes, scratches, bruises, and broken bones are examples of morphological defects. Any one of these can temporarily or permanently reduce the efficiency of an animal. Good management practices help eliminate defects of this nature.

**Pathogenic defects:** Certain organisms produce toxins or poisons that upset the normal metabolic activity of the animal. Viruses and bacteria are the most common disease-causing pathogens. They are microscopic in size and capable of multiplying rapidly under ideal environmental conditions. Other pathogens are fungi and protozoans. Viral diseases are the most difficult to control because viruses closely resemble the chemical compounds that make up a cell. Another problem in controlling viruses is that the chemicals capable of killing or controlling them also kill or destroy the host cell. Preventive vaccinations are the most successful method of controlling viral diseases. Bacteria are microscopic in size, produce powerful toxins, and multiply rapidly. Many bacteria are capable of forming spores, resistant forms of bacterial cells able to withstand severe environmental conditions. These spores are difficult to control and may lie dormant for years before being provided with the opportunity to cause disease. Antibiotics are used successfully to control bacteria. Fungal diseases are caused by fungi, which are small organisms. Many disease-producing fungi live in the soil. It is often difficult to determine the cause of fungal diseases, because bacteria cause a secondary infection and are often erroneously identified as fungi. Protozoa are one celled and the simplest form of animal life. Some protozoa cannot move themselves and must be transported by other means. Some move by making whip-like lashes or vibrating projections. A number of different kinds of protozoa prey upon animals and cause disease.

The major diseases of the livestock and their management strategies have been described hereunder.

**Anthrax:** Anthrax, a highly infectious and fatal disease of cattles, is caused by a relatively large spore-forming rectangular shaped bacterium called Bacillus anthracis. Anthrax occurs on all the continents, causes acute mortality in ruminants. The bacteria produce extremely potent toxins which are responsible for the ill effects, causing a high mortality rate. The bacteria produce spores on contact with oxygen. Signs of the illness usually appear 3 to 7 days after the spores are swallowed or inhaled. Once signs begin in animals, they usually die within two days. Hoofed animals, such as deer, cattle, goats, and sheep, are the main animals affected by this disease. They usually get the disease by swallowing anthrax spores while grazing on pasture contaminated (made impure) with anthrax spores. Inhaling (breathing in) the spores, which are odorless, colorless, and tasteless, may also cause infection in animals and people. In the case of terrorism, large numbers of anthrax spores may be released into the air.

### Symptoms

Sudden death (often within 2 or 3 hours of being apparently normal) is by far the most common sign;

Very occasionally some animals may show trembling, a high temperature

Difficulty breathing, collapse and convulsions before death. This usually occurs over a period of 24 hours;

After death blood may not clot, resulting in a small amount of bloody discharge from the nose, mouth and other openings

### Treatment and control

Due to the acute nature of the disease resulting in sudden death, treatment is usually not possible in animals even though anthrax bacilli are clines. Treatment is of use in cases showing sub-acute form of the disease.

In most cases, early treatment can cure anthrax. The cutaneous (skin) form of anthrax can be treated with common antibiotics such as penicillin, tetracycline, erythromycin, andciprofloxacin (Cipro).

Black Quarter (Black -leg) : It is an acute infectious and highly fatal, bacterial disease of cattle. It is a bacterial disease caused by Clostridium chauvoei. Buffaloes, sheep and goats are also affected. Young cattle between 6-24 months of age, in good body condition are mostly affected. It is soil-borne infection which generally occurs during rainy season. In India, the disease is sporadic (1-2 animal) in nature.

### Symptoms

- Fever (106-108°F), Loss of appetite, Depression and dullness.
- Suspended rumination
- Rapid pulse and heart rates
- Difficult breathing (dyspnoea)
- Lameness in affected leg
- Crepitation swelling over hip, back & shoulder
- Swelling is hot & painful in early stages whereas cold and painless inter
- Recumbency (prostration) followed by death within 12-48 hrs.

### Treatment

- Penicillin @ 10,000 units /Kg body weight 1M & locally daily for 5-6 days.
- Oxytetracycline in high doses i.e. 5-10 mg/Kg body weight 1M or IV
- Indcse the swelling and drain off
- B.Q. antiserum in large does, if available.
- Injection. Avil / Cadistin @ 5-10 ml IM

**Foot-and-mouth disease :** The foot-and-mouth disease is a highly communicable disease affecting cloven-footed animals. It is characterized by fever, formation of vesicles and blisters in the mouth, udder, teats and on the skin between the toes and above the hoofs. Animals recovered from the disease present a characteristically rough coat and deformation of the hoof. In India, the disease is widespread and assumes a

position of importance in livestock industry. The disease spreads by direct contact or indirectly through infected water, manure, hay and pastures. It is also conveyed by cattle attendants. It is known to spread through recovered animals, field rats, porcupines and birds.

*Symptoms of Foot & Mouth disease*

### Symptoms

- Fever with 104-105° F
- Profuse salivation ropes of stringy saliva hangs from mouth
- Vesicles appear in mouth and in the inter digital space
- Lameness observed
- Cross bred cattle are highly susceptible to it

### Treatment

- The external application of antiseptics contributes to the healing of the ulcers and wards off attacks by flies.
- A common and inexpensive dressing for the lesions in the feet is a mixture of coal-tar and copper sulphate in the proportion of 5:1.

### Precautions

- Heavy milch animals and exotic breeds of cattle bred for milk should be protected regularly.
- It is advisable to carry out two vaccinations at an interval of six months followed by an annual vaccination programme.
- Isolation and segregation of sick animals. It should be informed immediately to the veterinary doctor

- Disinfection of animal sheds with bleaching powder or phenol
- Attendants and equipments for sick animals should be ideally separate
- The equipments should be thoroughly sanitized
- Proper disposal of left over feed by the animal
- Proper disposal of carcasses
- Control of flies

**Rinder pest:** Rinderpest is the most destructive of the virus diseases of cloven-footed animals, such as cattle, buffaloes, sheep, goats, pigs and wild ruminants. Its control was a major issue till recently all over the world. Organised efforts over half a century have brought about a total eradication of the disease in the Western Hemisphere. The disease still persists in the Asian countries. The virus is found notable in the saliva, discharge from eyes and nostrils, and in the urine and faeces. It is present in the circulating blood during the febrile stage and is later concentrated in different organs, especially in the spleen, lymph nodes and liver. Outside the animal body, the virus is rapidly destroyed by direct sunlight and disinfectants. Cold preserves the virus. The virus is usually spread by contaminated feed and water. Rise in temperature up to 104 – 107 0 F. Lacrimation and redness of eye. Foul odour from mouth. Discrete necrotic foci develop in the buccal mucosa, inside lip, and on the tongue. Bloody mucoid diarrhoea is noticed

### Treatment

- Symptomatic treatment with penicillin, streptomycin, sulphadimidine and intestinal antiseptics has no action on the virus, but may help in the recovery of less severe cases of rinderpest, as these control secondary complications caused by bacteria.

*Symptoms of mastitis in cow*

**Mastitis :** Mastitis, or inflammation of the mammary gland, is the most common and the most expensive disease of dairy cattle throughout most of the world. Although stress and physical injuries may cause inflammation of the gland, infection by invading bacteria or ot her microorganisms (fungi, yeasts and possibly viruses) is the primary cause of mastitis. Infections begin when microorganisms penetrate the teat canal and multiply in the mammary gland.

### Treatment

- Success depends on the nature of the aetiological agent involved, the severity of the disease and the extent of fibrosis.

- Complete recovery with freedom from bacterial infection can be obtained in cases of recent infection and in those where fibrosis has taken place only to a small extent.
- Such drugs as acriflavine, gramicidin and tyrothricin have now ceased to be in use, and have given place to the more effective drugs, such as sulphonamides, penicillin and streptomycin.

**Footrot:** Footrot is a common cause of lameness in cattle and occurs most frequently when cattle on pasture are forced to walk through mud to obtain water and feed. However, it may occur among cattle in paddocks as well, under apparently excellent conditions. Footrot is caused when a cut or scratch in the skin allows infection to penetrate between the claws or around the top of the hoof. Individual cases should be kept in a dry place and treated promptly with medication as directed by a veterinarian. If the disease becomes a herd problem a foot bath containing a 5% solution of copper sulphate placed where cattle are forced to walk though it once or twice a day will help to reduce the number of new infections. In addition, drain mud holes and cement areas around the water troughs where cattle are likely to pick up the infection. Keep pens and areas where cattle gather as clean as possible. Proper nutrition regarding protein, minerals and vitamins will maximize hoof health.

**Ringworm:** This is the most common infectious skin disease affecting beef cattle. It is caused by a fungus, and is transmissible to man. Typically the disease appears as crusty grey patches usually in the region of the head and neck and particularly around the eyes.

As a first step in controlling the disease, it is recommended that, whenever possible, affected animals should be segregated and their pens or stalls cleaned and disinfected. Clean cattle which have been in contact with the disease should be watched closely for the appearance of lesions and treated promptly. Proper nutrition, particularly high levels of Vitamin A, copper and zinc while not a cure, will help to raise the resistance of the animal and in so doing offer some measure of control. Contact your vet and or feed store for products to treat this disease. Using a wormer like Ivomec will kill lice and help prevent cattle from scratching causing skin damage and a place for the fungus to enter.

**Milk fever:** Milk fever, also known as parturient hypocalcaemia and parturient paresis, is a disease which has assumed considerable importance with the development of heavy milking cows.

- Decrease in the levels of ionized calcium in tissue fluids is basically the cause of the disease.
- In all adult cows there is a fall in serum-calcium level with the onset of lactation at calving.

- The disease usually occurs in 5 to 10 year old cows, and is chiefly caused by a sudden decrease in blood-calcium level, generally within 48 hours after calving.

### Symptoms

- In classical cases, hypocalcaemia is the cause of clinical symptoms. Hypophosphataemia and variations in the concentration of serum-magnesium may play some subsidiary role.
- The clinical symptoms develop usually in one to three days after calving. They are characterized by loss of appetite, constipation and restlessness, but there is no rise in temperature.

## Nutritional defects in animals

**Anemia:** All farm animals are susceptible. Iron deficiency prevents the formation of hemoglobin, a red iron containing pigment in the red blood cells responsible for carrying oxygen to the cells. Characterized by general weakness and a lack of vigour. A balanced ration usually prevents the occurrence of anemia.

**Bloat:** Typically occurs when animals are grazing on highly productive pastures during the wetter part of late spring & summer. Swollen abdomen on the left side, labored breathing, profuse salivation, groaning, lack of appetite, & stiffness. Maintain pastures composed of 50% or more grass.

**Enterotoxemia:** It is caused by bacteria & overeating. Constipation is an early symptom & sometimes followed by diarrhea. Bacterin or antitoxin vaccine should be used at the beginning of the feeding period. Founder Overeating of grain, or lush, highly improved pasture grasses. Affected animals experience pain and may have fever as high as 106 degrees F. Good management & feeding practices prevent the disease.

## Common Poultry Diseases and their Management

**Fowl Coccidiosis:** This disease is caused by a protozoan parasite of the intestine and can cause very heavy losses in poultry particularly up to the age of 12 weeks

### Symptoms

- The chicks lose weight and their appetites.
- Their feathers become ruffled and soiled.
- Combs are pale and they tend to huddle together in corners.
- Droppings are watery and greenish or brown in colour often containing blood.

### Control Measures

- Use of Bifuran in feed at all times.
- Keep the litter dry and loose and keep chicks isolated in freshly sterilised pens.
- Use Bifuran in the water according to the manufacturer's instructions.
- Isolate sick birds.

- When the attack dies down disinfect litter and sterilize pens.

**Ranikhet:** A highly infectious and fatal viral disease, it attacks poultry of all ages. Also known as New Castle disease.

### Symptoms

- Inactivity, droopiness and sleepiness.
- Pale combs and wattles which later turn blue.
- Full and distended crop.
- Gasping for air, wheezing and coughing.
- Green diarrhoea with foul odour.
- The head may be twisted to the side, drawn back or down between the legs.
- Convulsions, paralysis and incoordination.

### Control measures

- Vaccinate chicks of one day with F-1 vaccine
- Re-vaccinate again at 6 to 8 weeks with Ranikhet vaccine.

**Fowl Pox :** A viral disease that can affect birds at any age resulting in high mortality rates.

### Symptoms

- Formation of greyish spots or blisters on wattles which after several days enlarge and develop into wartlike eruptions with scales.
- Removal of scales results in rough, raw bleeding wounds.
- Formation of hard crust in 10-14 days.

### Control Measures

- Do not overcrowd birds.
- Vaccinate with pigeon pox vaccine at 7 days of age
- Follow this by a further fowl pox vaccine at 6 weeks of age.

**Fowl Coryza:** A bacterial disease contaminated through feed, water and by contact through carriers.

### Symptoms

- Watery discharge from eyes and nose and sometimes sticking of eyelids.
- Noticeable difficulty in breathing, shaking of head and wheezing.
- Odorous, cheesy droppings.
- Soiled feathers under the wings with fowl odour.

### Control Measures

- Observe strict sanitary condition and make certain that an adequate source of Vitamin A is provided in the diet

- Infected birds should be culled and destroyed and the house, feeders and waterers thoroughly disinfected.
- An injection of antibiotics is also helpful.

**Fowl Cholera:** A bacterial disease contaminated mostly through feed and water.

### Symptoms

- Sudden death without any visible symptoms.
- Diarrhoea and fever.
- Swelling of the wattles followed by wrinkles.
- Painful abcesses in the joint of legs and lameness.

### Control Measures

- Affected birds should be segregated.
- Treated with (0.2 per cent) Sod.Sulphamezathine in drinking water or by injecting broad spectrum antibiotic, like 'Terramycin' (40 mg per kg by wt.)
- Control is achieved by timely vaccination.

**Marek's Disease :** The disease is caused by a virus which is spread from an infected chicken to a non-infected one through the air, poultry dust, by contact, sometimes faeces. Greatest susceptibility from 6-26 weeks of age.

### Symptoms

- Paralysis of legs and/or wings
- Laboured breathing
- Whistling and circling movements
- Unilateral and bilateral blindness.
- On postmortem examination whitish nodules in muscles of thigh, neck, kidneys, testes and in ovaries are seen.

### Control Measures

- Immunisation of birds by using vaccines
- Procure genetically resistant chicks
- Super sanitation.

## Vaccination in Farm Animals and Poultry

Farm animals and poultry birds are venerable to several potent diseases. Every year we find several reports of sheep and goat pox (SGP) in sheep and goat, Foot and mouth disease (FMD) in cloven fotted animals particularly cattle, Ranikhet disease (RKD) and Infectious bursal disease (IBD) in poultry and other disease outbreaks in different species of livestock on account of faulty vaccination or non-vaccination leading to huge financial losses to the livestock rearers. Thus before establishing a commercial livestock unit an entrepreneur or a farmer need to know all about vaccination and immunisation

to save livestock from disease outbreaks and have a profitable income generating unit.

### Vaccines

*Vaccination is being done in buffalo*

A vaccine is a biological preparation that improves immunity to a particular disease. A vaccine typically contains an agent that resembles a disease-causing microorganism and is often made from weakened or killed forms of the microbe, its toxins or one of its surface proteins. The agent stimulates the body's immune system to recognize the agent as foreign, destroy it, and keep a record of it, so that the immune system can more easily recognize and destroy any of these microorganisms that it later encounters. Vaccines may be prophylactic for example to prevent or ameliorate the effects of a future infection by any natural or "wild" pathogen or therapeutic e.g. vaccines against cancer are also being investigated.

### Vaccination

Vaccination (immunisation) is a tried and tested method of assisting in the continual fight against disease in man and animals. Vaccination protects hundreds of millions of animals worldwide from disease and possibly death.

Animals, just like humans, suffer from a range of infectious diseases. As veterinary medicine has advanced, prevention of disease has become a priority as healthy food comes from healthy animals. One of the best means of preventing disease is by creating immunity in the animal. This is usually achieved by vaccination.

Animals which develop disease often require treatment with medicines so vaccination helps reduce the amount of pharmaceuticals used in the treatment of animals. Vaccination presents no hazard to consumers of produce from vaccinated animals.

## Major objectives of vaccination

There are three basic objectives in vaccination:-

- To provide immunity to the animal or group of animals (active immunity).
- To provide immunity to the offspring of an animal via vaccination of the dam (passive immunity).

- Or to provide immunity to the animal or group of animals and their offspring (active and passive immunity).

## The Do's and Don'ts in vaccination

### A. Storage of vaccine

- Ensure all vaccines are stored correctly before use.
- Many vaccines require cool storage – ideally have a dedicated refrigerator for vaccines and medicines that can be secured.
- Any vaccine not requiring refrigeration should be stored in a dedicated vaccine store or otherwise the medicines cabinet or store. These must be lockable.
- Keep all vaccines away from children.
- Keep all medicine cabinets, stores and refrigerators clean.
- Where similar vaccines are kept with different expiry dates ensure those with the shortest expiry time are at the front
- Many vaccines only have a short shelf-life, ensure you only use vaccines in date.
- When ordering vaccines ensure only sufficient is ordered to meet the requirements at that time.

### B. Animals to be vaccinated

- Only vaccinate fit and healthy animals.
- Do not vaccinate stressed animals.
- Do not vaccinate exhausted animals.
- Do not vaccinate animals in very late pregnancy.
- Do not vaccinate animals younger than the age given by the vaccine manufacturers without taking advice.
- Elderly animals may not respond in their immunity as well as younger ones
- Do not vaccinate animals that are nutritionally deprived or starved.
- Do not vaccinate animals that are deficient in nutrients including vitamins and minerals.
- Do not vaccinate animals soon after they have been ill without taking advice from the manufacturers.
- Do not vaccinate animals too close to service or in the service period unless it is stated that this is acceptable.
- Do not vaccinate animals that are immune-suppressed.
- When injecting vaccines ensure that the site of injection is clean and dry.
- If animals have had an immunosuppressive disease or illness wait as long as possible before vaccination. Where possible take advice from the manufacturers.

- Do not use more than one vaccine at the same time unless authorised.
- If different vaccines for different diseases need to be given to the same animal, there must be an adequate interval in between each vaccine to ensure that they all produce a satisfactory immune response.
- Do not administer other treatments or do other procedures at the same time as vaccination without taking advice from the manufacturer.
- If other procedures or treatments are of necessity to be given for management purposes as well as vaccination, undertake a risk assessment of the likely effects on efficacy.
- Ensure when feed or water is the vehicle for providing vaccination then it has been correctly prepared so that the vaccine is not negatively affected by the vehicle. Manufacturers provide instructions as how to prepare feed and water appropriately.
- If vaccines are to be given orally via water or feed, manage the animals to ensure all will be able to receive their appropriate amount of the treated feed or water.

## EXERCISES

### Activities

1. Visit a nearby dairy farm and check out for feed and fodder being given to livestock.
2. Identify different diseases of cattle in a dairy and note down the stmptoms of every disease.
3. Visit a veterinary hospital and observe the vaccination of animals. Also note down the names of vaccines available and used in the hospital.
4. Take an appointment of a veterinary doctor, especially to see the semen collection and breeding programmes.
5. Go to a poultry farm and note down the symptoms of dieses in sick flock.

### Check Your Progress

1. Write the major nutrients required by livestock. Discuss the factors affecting nutritional requirement of farm animals.
2. What are major byproducts of meat industry. Discuss briefly about their utilization.
3. Discuss briefly the nutritive value of byproducts of meat industry.
4. Enumerate the major diseases of farm animals. Discus in detail, about foot and mouth disease, rinder pest , black leg and mastitis.
5. What are major diseases of poultry in India. Discuss in detail, the Ranikhet and Fowl coccidiosis.

Q.6. What do you understand by vaccine? Discuss Dos and Don'ts in vaccination programme.

## Fill in the blanks

1. A lactating cow requires about ..... of water per day.
2. An adult sheep requires about ..... gallon of water per day.
3. Ruminants can synthesize Vitamin..... in their rumens.
4. Fowl Coryza is caused by a ..... .
5. Random mating each male individual has ..... to mate with the female individual.
6. ..... has the highest fat content in all meat byproducts.
7. Ranikhet disease is also known as ..... .
8. The major edible animal fats are ..... and ..... .
9. Fowl coccidiosis is caused by a ..... parasite.
10. Animal's body mass contains nearly ..... % blood.
11. The foot-and-mouth disease is a highly ..... affecting cloven-footed animals.
12. Anthrax is caused by a bacterium called .....
13. Black leg is effectively controlled by using .....
14. Potential utilization of waste fish scraps is to produce .....
15. The ..... is the largest gland in animals.

## Suggested Future Readings


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# CHAPTER – 4

# POST PRODUCTION HANDLING, PACKAGING AND PROCESSING OF ANIMAL PRODUCTS

## Learning objectives

After reading this chapter students will be able to:

- State the importance and types of animal foods.
- Explain the differences in various types of milk.
- Know various processes involved in handling of raw milk.
- Differentiate between common milk products such as paneer, dahi, cheese, khoya, srikhand, butter, ghee, ice cream and milk powder.
- Explain the processing technology for meat and meat products mainly chicken and mutton.

## Introduction

Foods from animal such as milk and milk products, meat, eggs, fish and other seafoods play an important role in the diet of human beings. Although, foods of plant origin such as grains, fruits and vegetables continue to constitute the bulk of the diets of most persons, animal foods are also gaining importance. Animal foods are energy dense and excellent sources of protein, fat, minerals, vitamins and essential fatty acids. Animal proteins are considered high quality proteins, superior to plant proteins as they contain balanced proportion of all the essential amino acids. These nutrients are an essential part of a healthy diet and, in some cases, foods of animal origin are the only sources of these nutrients. Widespread malnutrition in the developing countries, which is a manifestation of the deficiency of mainly proteins and micronutrients, can be combated by consuming the foods of animal origin. Since the foods from animal sources are perishable and spoil very fast, continuous access and adequate nutrition can be provided through these animal products by stabilizing them and making value added products that will be more acceptable in the masses. In this chapter, attempts have been made to explain you about the various processed animal products with the underlying technological processes for their development.

### Milk and Milk Products

Milk may be defined as the whole, fresh, clean, lacteal secretion obtained by the complete milking of healthy milch animals excluding that obtained within 15 days before or 5 days after calving or such periods as may be necessary to render the milk

practically colostrum-free and containing the minimum prescribed percentages of milk fat and milk-solids-not-fat. In India, the term 'milk' refers to cow or buffalo milk or a combination of the two.

## Composition of Milk

Milk is almost an ideal food. It has high nutritive value. The principal components of milk include water, fat, protein, milk sugar (lactose) and minerals. The minor constituents include phospholipids, vitamins, enzymes, pigments etc. All the solids in the milk are referred to as 'total solids' and the total solids without fat is termed as 'milk solids-not fat' (MSNF) or solids-not-fat' (SNF). The solids of milk further determine the approximate yields of other dairy products that are manufactured from the milk. The price of milk depends mainly on its fat content.

There occur differences in the milk constituents obtained from different sources (Table 1). The factors that govern the composition of milk include of the animal genetic variation (species, breed), its physiological condition (season, stage of lactation, health of the animals) and other environmental factors (feed, stage of milking, interval of milking).

**Table 1: Average composition of milk from various milch animals**

| Animal | Water | Fat | Protein | Lactose | Ash |
|---|---|---|---|---|---|
| Buffalo | 84.2 | 6.6 | 3.9 | 5.2 | 0.8 |
| Camel | 86.5 | 3.1 | 4.0 | 5.6 | 0.8 |
| Cow | 86.6 | 4.6 | 3.4 | 4.9 | 0.7 |
| Goat | 86.5 | 4.5 | 3.5 | 4.7 | 0.8 |
| Guinea pig | 82.2 | 5.5 | 8.5 | 2.9 | 0.9 |
| Human | 87.7 | 3.6 | 1.8 | 6.8 | 0.1 |

Milk supplies body building proteins, bone-forming minerals and health-giving vitamins and furnishes energy-giving lactose and milk fat. Besides supplying certain essential fatty acids, it contains the above nutrients in an easily digestible and assimilable form. All these properties of milk make it an important food for pregnant mothers, growing children, adolescents, adults, invalids, convalescents and patients alike. The National Institute of Nutrition has recommended a minimum of 300 g daily intake of milk for children between 1-3 years of age and 250 g for those between 10-12 years.

## Class and Type of Milk

Dairies in India have to market milk by standardizing, as per the various types of milk prescribed under Food Safety and Standard Act, 2006. These type of milk differ in their milk fat and milk SNF contents (Table 2).

**Table 2: Classes and types of milk**

| S. No. | Type of milk | Milk fat (% not less than) | Milk SNF (% not less than) |
|---|---|---|---|
| 1. | Double toned milk | 1.5 | 9.0 |
| 2. | Toned milk | 3.0 | 8.5 |
| 3. | Standardized milk | 4.5 | 8.5 |
| 4. | Full cream milk | 6.0 | 9.0 |
| 5. | Skim milk | Not more than 0.5 | 8.7 |

## Raw Milk Handling

Procurement of raw milk is done from individual producers or farmer cooperatives. The milk collected from rural areas is transported in well refrigerated vans under cool conditions to the chilling/processing facilities. Owing to high moisture and nutrient content, milk is prone to attack of various microorganisms. Bacterial growth is accompanied by deterioration in market quality due to development of off-flavours, acidity etc. Therefore, to prevent attack of microorganisms and spoilage of milk, prompt cooling to low temperatures (below 5°C) or application of heat treatment are mandatory.

## Milk Processing

Milk is a highly perishable commodity and contains microorganisms after milking and their load increases with subsequent handling and storage. Therefore, apart from the cold chain to be maintained throughout the processing channel, milk is pasteurized so as to free it from pathogenic microorgansisms.

*Pasteurization:* The term 'Pasteurization' has been named after its inventor, Louis Pasteur of France. The International Dairy Federation, IDF (SDT, 1983: p.99) has defined pasteurization as:

'a process applied to a product with the object of minimizing possible health hazards arising from pathogenic microorganisms associated with milk by heat treatment, which is consistent with minimal chemical, physical and organoleptic change in the product'.

'Pasteurized milk' means that the milk has been exposed to either a High Temperature Short Time (HTST) treatment to a minimum of 71.6°C (161°F) for a minimum holding time of 15 seconds or a Low

**Points to remember**

1. Prompt cooling of milk below 5°C after milking is mandatory to prevent spoilage.
2. Pasteurization with proper time-temperature combinations is required to prevent growth of pathogenic microorganisms.
3. Index organism should be taken into consideration to ensure proper pasteurization.
4. Once opened from packs, pasteurized milk should be used as soon as possible.

Temperature Long Time (LTLT) treatment of 62.7°C (145°F) for holding time of 30 minutes, followed by packaging under clean and sanitized conditions. Holding milk at the prescribed temperatures renders it free from *Mycobacterium tuberculosis*, the index organism for pasteurization and also has minimum effect on organoleptic quality of the milk. After pasteurization, the milk is immediately cooled to 5°C or below. In this process, pathogenic and spoilage organisms are destroyed. Under ideal refrigeration conditions, most pasteurized milk will remain fresh for 2-5 days. Once opened from packs, pasteurized milk should be used as soon as possible for best quality and taste.

*Ultra High Temperature (UHT):* During the process of UHT, milk is heat-treated to temperature of above 135°C for not less than 1 second and cooled instantly. The milk is packed in 6 layer Tetra-pak packaging, which prevents the milk from spoilage due to sunlight, microorganisms and oxygen and retains all the vitamins and nutritional value of milk providing zero bacteria product, which needs no boiling.

### Milk Standardization

Standardization of milk refers to the adjustment i.e., lowering or raising of the fat or SNF of raw or pasteurized milk to desired value so as to ensure that legal requirements are complied with. In the process, whole milk is mixed with skimmed milk with known fat content in the required proportions that will result in milk having desired fat content.

### Homogenization

Milk is an oil-in-water emulsion. To stabilize the emulsion and to prevent separation of fat from the milk, it is subjected to the process of homogenization wherein it is exposed to high pressures to break the fat globules present in milk to less than 2 micron size. This is carried out in a two step homogenizer with pressures of 2000 psi at the first stage and 500 psi in the second.

## Common Milk Products

## CHEESE

Cheese has been defined as 'a product made from the curd obtained from milk by coagulating casein with the help of rennet or similar enzymes in the presence of lactic acid produced by added microorganisms from which part of the moisture has been removed by cutting, cooking and/or pressing, which has been shaped in a mould and then ripened by holding it for sometime at suitable temperatures and humidities.

Differences in manufacturing procedure have led to development of about 400 varieties of cheeses worldwide. The varieties may be classified on basis of their appearance, moisture content, mode of coagulation, ripening characteristics and chemical composition.

## The basic steps in cheese preparation include the following:

### Pasteurization and Standardization

The raw milk is subjected to pasteurization and may or may not be standardized for the relative proportion of casein (the protein in the milk) and fat content. Standardization may be carried out to eliminate seasonal compositional variation and to facilitate the production of desired and consistent quality of cheese, which complies with the specified regulations for fat in dry matter content. Standardization of milk may be achieved by removal of fat, addition of skimmed milk or cream to whole milk.

### Coagulation (or curdling)

This is the curd-forming stage, when the casein is coagulated. It is accomplished by the acid that is produced through addition of bacterial culture or rennet. The choice of starter (bacterial) culture determines the texture and flavour of the developed cheese. The lactic acid bacteria used as starter cultures belong to the genera *Lactococcus, Streptococcus, Leuconostoc and Lactobacillus.* Rennet is another coagulant used in the cheese making, which is procured from calf stomach and comprises of two enzymes, viz., rennin and pepsin. It coagulates the milk to form curd. Plant enzymes obtained from *Withania coagulans,* ficus and papain may also be used as coagulating agents. When the coagulum/curd is ready, it is cut to release the entrapped whey/ liquid.

### Drainage

This step involves removal of whey from the curd and making it firmer. The amount of whey retained in the curd after draining will determine the firmness and texture of the cheese. It is during the draining stage that the curd is shaped in a mold. The final moisture content in the cheese determines whether it is a hard cheese (having moisture 20-42% e.g. Cheddar, Cheshire), semi-hard cheese (having moisture 43-55% eg. Edam, Gouda) or soft cheese (having moisture >55% eg. Cottage, Camembert).

### Salting

Cheese can be salted (1-4%) from the outside (dry salting) or in a brine solution. Salt acts as an antiseptic, prevents development of undesirable microorganisms, improves the storage life of the cheese and speeds up the drying process and the formation of a rind.

### Ripening (or maturing)

It is the process of storage of cheese for at least 2-3 months at low temperature. During the process, the consistency, aroma, flavour and, if desired, the rind of the cheese develop owing to biochemical action of the bacterial flora contained in the cheese. The longer the ripening process, the less moisture the cheese retains, and the firmer and stronger-tasting the cheese will be. Fresh cheese and processed cheese are not ripened.

*Cheese*

## ICE CREAM

According to PFA Rules (1976), ice cream is the frozen product obtained from cow or buffalo milk or a combination there of or from cream, and/or other milk products, with or without the addition of cane sugar, eggs, fruits, fruit juices, preserved fruits, nuts, chocolate, edible flavours and permitted food colours. It may contain permitted stabilizers and emulsifiers not exceeding 0.5 per cent by weight. The product should not contain less than 10 per cent milk fat, 3.5 per cent protein and 36% total solids. Starch may be added not more than 5%, with declaration on the label.

To promote the ice cream industry, 80 ice cream makers from across India have formed the Indian Ice Cream Manufacturers' Association (IIMA) in 2011, which is registered in Ahmdabad (Gujarat).

### The basic steps involved in ice cream manufacture include the following :

#### Mixing of Ingredients

This involves the mixing of wet and dry ingredients continuously for uniformity.

#### Pasteurization and Homogenization

Pasteurization implies the high temperature short time treatment (HTST) given to the ice cream mix to render it free from pathogenic microorganisms. Homogenization of the mix is must to get smoother texture of the final product.

#### Cooling and Ageing of the Mix

The mix is immediately cooled to 0-5°C and is held in tanks for ageing for 3-4 h. The process of ageing helps in proper hydration of the dry ingredients, improves the whipping capacity of the mix and ultimately helps in the improvement of the body and texture of the final product.

#### Freezing

After ageing, the mix is frozen in continuous freezers. The function of this process is to freeze a portion of the water in the mix and to incorporate air. Colour and flavour are added during the freezing process. The volume of ice cream obtained in excess of the volume of mix (expressed as percentage) is usually referred to as the overrun. The increased volume is composed mainly of the air incorporated during the freezing process. In packaged ice cream, the overrun may vary between 70-80 percent whereas in case of softy, it is between 30-50 percent.

#### Hardening

When the mix leaves the freezer, it is in half frozen state. The semi-fluid consistency of the mix is similar to that of soft ice cream. It is hardened after packing in suitable packages at temperatures upto -18°C or below upto 12 h.

### Storage

During storage, the temperature of the room is maintained at below -25°C. The doors of the storage room should not be opened too often to prevent temperature fluctuations and to maintain the product quality.

## MILK POWDER

Milk powder is a product made by evaporation of milk followed by spray drying. Besides reducing the bulk, the product is relatively shelf stable if packed and stored under proper hygienic conditions. Milk powders find application in confectionery, soups, desserts etc. Whole milk powder is made from whole milk standardized to give a fat content of 25-28% in the powder. The standardized milk is preheated at temperatures above 72°C that destroys bacteria and inactivates enzymes. In the evaporator, the preheated milk is concentrated from around 9.0% total solids content for skim milk and 13% for whole milk, up to 45-52% total solids by boiling the milk under vacuum at temperatures below 72°C. Evaporation of the milk prior to drying is done for reasons of energy efficiency as it is far cheaper to evaporate the water than to spray dry it. Spray drying involves atomizing concentrated milk into a hot air stream (180-220°C). By controlling the size of the droplets, the air temperature, and the airflow, it is possible to evaporate almost all the moisture while exposing the solids to relatively low temperatures. Spray drying yields milk powders with excellent solubility, flavour and colour with moisture below 5%. Another method of drying is roller drying, which involves direct contact of a layer of concentrated milk with the hot surface of rotating rollers or drums. This method is not used often because of the adverse affects of heat on milk components. Heat often causes irreversible changes such as browning reactions and protein denaturation. The roller drying process results in more scorched powder particles and poorer powder solubility than spray drying.

Milk powders are hygroscopic and readily take up moisture from the air, leading to a rapid loss of quality and caking or lumping. The fat in whole milk powders can react with oxygen in the air to give off-flavours, especially at higher storage temperatures (>30°C). Packaging is chosen to provide a barrier to moisture, oxygen and light in order to maintain the quality and shelf life of milk powders. Whole milk powders are often packed under nitrogen gas to protect the product from oxidation and to maintain their flavour and extend their keeping quality. Bags generally consist of several layers to provide strength and the necessary barrier properties. Prolonged exposure of milk powder to direct sunshine at elevated temperatures (> 40°C) should be avoided to maintain quality.

# Indigenous Milk Products

## PANEER

Paneer consists mainly of acid-coagulated milk solids and is used extensively as an ingredient in many cooked vegetable preparations in northern India, Pakistan, Afghanistan and Nepal. It is produced at both small scale and industrial level. Cow, buffalo or mixed milk may be used but buffalo milk is preferred.


*Paneer*

An industrial-scale process for paneer making has been developed by the National Dairy Development Board (NDDB). In this process, milk is heated to 85°C and pumped to a cheese vat and then cooled to 75°C. Citric acid solution is added and mixed with the milk to form a coagulum. The curd/coagulum is left to settle for 10–15 min without agitation. The watery liquid, known as whey, is drained off. Curd is filled into hoops lined with muslin cloth and pressed for 10-15 min at a pressure of 3 kg per sq cm. Pressed curd blocks are placed in pasteurized cold water at 4°C for 3 h. The cooled blocks of *paneer* are cut into desired sizes, which are wrapped in vegetable parchment paper before being placed in HDPE or LDPE bags and heat sealed ready for sale. The yield of paneer depends on the quality of milk. It is generally 18 to 20 per cent of the weight of the milk used for its preparation. According to PFA (1976) rules, *paneer* must meet the legal requirements of moisture (maximum) 70 per cent, milk fat in dry matter (minimum) 50 per cent and the protein content upto 20 per cent.

## DAHI

This is a yoghurt-like fermented milk product made in India and neighbouring countries. The sweetened concentrated form of *dahi* consumed in Bengal is known as *mishti doi*. The scale of production ranges from household level to industrial scale. Cow or buffalo milk or a mixture of the two is used in its preparation. Milk is pasteurized and sometimes concentrated before addition of the starter, which is usually a portion of the previous day's *dahi* or buttermilk, which comprises of lactic acid bacteria. The product has a pleasant flavour and a clean acid taste. It has a yellowish creamy-white colour when made from cow milk and a creamy-white colour when made from buffalo milk. The body is firm but not hard and free from gas holes. The *dahi* should have the same fat and SNF as the milk from which it is prepared.

The Bureau of Indian Standards has laid down the following specifications (IS: 7035, 1973) for *dahi*:-

| | Sweet dahi | Sour dahi |
|---|---|---|
| Acidity as % lactic acid (maximum) | 0.7 | 1.0 |
| Yeast and mould count per g (maximum) | 100 | 100 |
| Coliform count per g (maximum) | 10 | 10 |
| Phosphatase test | -ve | -ve |

## SHRIKHAND

*Shrikhand* is a semi-soft whole milk product made from concentrated *dahi* with a sweet and sour taste. *Dahi* is placed in a muslin cloth and drained for 4–8 hours to remove the whey and produce a solid mass called *chakka*. *Chakka* is mixed with the required amount of sugar, condiments and flavour to produce *shrikhand*. An industrial process for the preparation of *chakka* and *shrikhand* has been developed by the National Dairy Development Board (NDDB) of India.

The Bureau of Indian Standards has prescribed the following standards for *shrikhand*:

| | |
|---|---|
| Total solids (per cent by mass) (minimum) | 58.0 |
| Milk fat (in dry matter per cent) by mass (minimum) | 5.0 |
| Milk protein (in dry matter per cent) by mass (minimum) | 10.5 |
| Titratable acidity (per cent lactic acid) (maximum) | 1.4 |
| Sucrose (in dry matter per cent) by mass (maximum) | 72.5 |
| Total ash (in dry matter) per cent by mass (maximum) | 0.9 |
| Coliform count, per g (maximum) | 10.0 |
| Yeast and mould count, per g (maximum) | 50.0 |

## BUTTER

Butter is composed primarily of milk fat. The colour of the butter varies from white to yellow. Yellow colour, annatto or carotene, may be added to the product to maintain uniformity. According to PFA (1976), table butter should not contain less than 80 per cent fat and not more than 3.0 per cent common salt. Butter is made from cream that is pasteurized at a temperature of 95°C or more to destroy enzymes and microorganisms. Cream for butter preparation, is held/ aged at cool temperatures for about 12-15 h to crystallize the butter fat globules, ensuring proper churning and texture of the butter. From the aging tank, the cream is pumped to the churn or continuous buttermaker where it is agitated, and eventually butter granules form, grow larger, and coalesce. At the end of the process, two phases separate out: a semi-solid mass of butter, and the liquid left over, which is the butter milk. The butter milk is drained off. After draining, the butter is worked further to improve its consistency. Salt is used to improve the flavour, acts as a preservative and increases the shelf-life. The butter is finally patted into shape, wrapped in waxed paper and stored in a cool place. As it cools, the butterfat crystallizes and the butter becomes firm.

## GHEE

Ghee is 99.5 per cent milk fat. Ghee is manufactured by either cream or butter. Cream from milk is churned into butter followed by conversion into ghee. When starting the preparation process from butter, the cream is placed in a metal vessel and melted at low heat. Then it is boiled to about 110 to 120°C with constant stirring over a low fire to evaporate the moisture and prevent scorching. There is profuse effervescence alongwith a crackling sound in the initial stages of boiling. When all the moisture has been removed, further heating is fully controlled till the end point of occurrence of second effervescence. This is accompanied by browning of the curd particles and development of the typical ghee flavour. After the residue has settled down on cooling, the clear fat is filtered into plastic pouches containers. The colour of cow ghee is deep yellow while that from buffalo milk is white with a characteristic yellowish or greenish tinge. It has a pleasant cooked and rich flavour. The taste is usually characteristic of the milk fat. In India, grading of ghee has been made through the Agmark Ghee Grading Scheme initiated by the Government of India in 1938. As per Agmark standards, ghee should have moisture (maximum) 3 per cent, free fatty acids (as oleic acid) not more than 1.4 for special quality and not more than 2.5 for general quality.

## KHOA

*Khoa* or *mawa*, is used as a base material for a variety of Indian sweets. This product is obtained from cow, buffalo or mixed milk by continuous thermal evaporation of milk to 65–70 per cent solids in an open pan with simultaneous stirring and scrapping. A five time concentration of milk is normally required for the production of *khoa*. Cow milk usually yields 18 per cent of *khoa*. The yield from buffalo milk is usually 20 per cent. It has a uniform whitish colour with just a tinge of brown, a slightly oily or granular texture, and a rich nutty flavour, which is associated with a mildly cooked and sweet taste due to the high concentration of lactose. Buffalo milk is preferred for *khoa* making because it yields a whiter product with a soft, loose body and a smooth granular texture, which makes it suitable for the preparation of high-grade *khoa* sweets. *Khoa* is preferred for the preparation of various sweets especially, gulab jamun as it gives a grainier texture to the product. Legal requirements state that *khoa* contains a minimum of 20 per cent milk fat. The Bureau of Indian Standards has laid down the following specifications for *khoa* (IS: 4883, 1968): Moisture (maximum) of about 28.0 per cent by weight and fat (minimum) of about 26% db.

*Pedas sweet prepared from Khoa*

*Khoa* is classified in 3 major types viz., depending upon the specific uses *pindi, dhap* and *danedar* with the following compositions:

| Type | Fat (per cent) | Total solids (per cent) | Specific sweets prepared |
|---|---|---|---|
| *Pindi* | 21–26 | 67–69 | Burfi, peda |
| *Dhap* | 20–23 | 56–63 | Gulab jamun, pantooa |
| *Danedar* | 20–25 | 60–65 | Kalakand |

Keeping quality of packaged *khoa* at room temperature is low and therefore refrigerated storage is recommended.

## Processed Meat Products

Meat is an important livestock product, which includes all those parts of the animals that are used as a food by man. It is a highly nutritious food with abundant high quality protein, B-complex vitamins and minerals. It is a highly perishable commodity and sanitary conditions and utmost hygienic measures are necessary to safeguard the quality of the meat products. To cater to this need, Meat Food Products Order (MFPO) was promulgated in 1973 under the Essential Commodities Act, 1955. The Order, now under the umbrella of food safety and standards Act, 2006, aims at maintenance of sanitary conditions in the slaughter houses, ensuring proper antemortem examination, postmortem inspection of carcasses, in-process inspection and final product checking. India with 16% of worlds livestock population produces only 2.2 % of world meat production and average meat consumption as low as 5kg per annum. It produces about 68 lakh tonnes of meat utilizing about 10 crore meat animals such as cattle, buffaloes, sheep, goat and pigs and 21 crores poultry.

## CHICKEN

Chicken is the major species of poultry in India. The top five meat producing countries include USA, China, Brazil, Mexico and India. India's share in world chicken meat production is about 3.3%. It is marketed in ready-to-cook forms i.e. with the removal of head, feet and internal organs (dressed chicken). Before slaughter, birds are kept starved for about 12 hours to ensure that their guts are empty, which helps in a cleaner process. The birds are made unconscious by stunning them with a blow on their heads. To facilitate complete bleeding, the jugular vein is slit and the birds are hanged upside down for about 3 minutes. The birds are then scalded in hot water at temperatures of about 60°C for 45 min. This helps to loosen the feathers which are picked

**Points to remember**

1. Only healthy poultry should be processed.
2. There should be abundant supply of potable water.
3. Great care should be taken during evisceration.
4. Eviscerated carcasses should be chilled as soon as possible.
5. Personnel hygiene and constant cleaning of equipment should be taken care of.

mechanically. The defeathering process is followed by cutting and removal of feet and head. Evisceration is done to remove all the internal organs, which is performed by cutting open the gut. The inedible viscera consist of the spleen, esophagus, lungs, intestines, and reproductive organs. Inspection of the carcass is also performed for signs of disease, which renders the carcass to be rejected. The eviscerated birds are washed thoroughly with water so as to reduce the microbial load. The carcass are rapidly chilled below 4°C to preserve meat quality and keep it tender. On an average, 75-80% of the live animal weight is retained in the carcass. This amount of live weight retained in the carcass is known as the dressing percentage. The dressed chicken is then graded, packed and frozen at -23°C to -18°C. Properly packed and frozen chicken can be stored safely for about 9 months.

## MUTTON

Mutton is the meat that is procured from mature sheep. India is the largest exporter of sheep and goat meat to the world. The country has exported 22,608.94 MT of sheep and goat meat to the world for the worth of Rs. 694.10 crores during the year 2013-14 with the major exporting nations United Arab Emirates, Saudi Arabia, Qatar, Kuwait and Oman (APEDA, 2015).


*Mutton*

Meat processing from sheep involves the following steps: fasting, stunning, bleeding, singeing/scalding, evisceration and inspection. Sheep is collected in the yard and they are generally fasted for a day to reduce the amount of intestinal contents. They are stunned using an electric shock, after which they are bled. Bleeding is carried out using a knife by making a deep cut at the angle of the jaw, which severs all the major blood vessels in the neck. As soon as this cut has been made, the sheep is hung by the hind legs and allowed to drain for a while. Before being processed further, hair is removed from the carcasses, by scalding in hot water followed by scraping. Carcasses are then singed to remove any remaining hair. After dehairing, the carcasses pass to the evisceration area, where the stomachs are opened and the viscera comprising of the heart, liver and lungs are removed. The carcasses are then de-headed and split along the backbone. Finally, the carcasses are chilled rapidly overnight before the subsequent processes of cutting and fragmentation are carried out. The carcasses may be cut into desired portions, vacuum packed and frozen so as to retain their freshness and quality.

# EXERCISES

## Activities

1. Visit a dairy near your house and check out the various value added milk products available.
2. Try to prepare paneer from milk at home.
3. Plan a visit to a slaughter house and view the various unit operations.

## Check Your Progress

1. How do you classify milk on basis of fat and SNF?
2. Which are the coagulated milk products?
3. Write short notes on: khoa, milk powder, thermal treatment of milk and mutton processing.
4. Make a flowchart of ice cream preparation.

## Fill in the blanks

1. Fat content is maximum in _____ milk.
2. Toned milk is having _____ %fat and _____ % SNF
3. HTST processing of milk follows a time-temperature combination of _____for ____.
4. Example of a hard cheese is _____.
5. Ice cream should be stored at _____ °C.
6. Ghee is _____ % milk fat.
7. Kalakand is prepared from _____ khoa.
8. Chicken is made unconscious by _____
9. Paneer is made by coagulation with _____
10. Sweet dahi consumed in West Bengal is known as _____

## Suggested Further Readings


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# CHAPTER – 5

# SEED PRODUCTION AND NURSERY MANAGEMENT

## Learning objectives

After reading this chapter, students will be able to:

- Understand what is quality seed and it's importance in seed production programme.
- Understand different types of pollination and mechanism involved.
- Explain different types of seed and requirement for seed production.
- Prepare nursery and develop seedlings of their own.
- Start business on fruit plants, vegetables and ornamental plant nursery.

## Introduction

We often talk about quality production of crops. For which, seed is the basic unit. If seed is of good quality, it likely to produce good crop. Hence, we should have fairly good knowledge about seed, and how a good quality seed is produced. In this chapter, you will come to know about, seed, characteristics of a quality seed, types of seed and the different methods adopted for production of a quality seed. Similarly, emphasis will be laid on basic principles involved in seed production.

**What is seed?** In broad sense, seed is a material, which is used for planting or regeneration purpose. However, scientifically, seed is a fertilized matured ovule, consisting of an embryonic plant, a store of food and a protective seed coat. Thus, seed is the most vital and crucial input for crop production.

**What is quality seed?** It is seed, which possesses all the good quality characters of improved variety.

## Characteristics/Attributes of Quality Seed

**1. Genetic purity:** Genetic purity refers to the percentage of contamination by seeds or genetic material of other varieties or species. In general, the genetic purity of the seed planted must equal or exceed the final product purity standard required, as purity generally decreases with each subsequent generation of propagation. For example Breeder seed 100%, Foundation seed 99%, certified seed 98%.

**2. Physical purity:** Physical purity of seed is the proportion of pure seed component in the seed lot as well as the proportion of other crop seed, weed seed and inert matter.

Physical purity for most of the crops should be 98% and seed lot should be free from other crop seeds (number/kg), designated inseparable crop seeds, weed seed and other field impurities.

**3. Germination percentage:** The quality seed should have germination percentage according to the standard of Indian Minimum Seed Certification Standard (IMSCS) so that farmers can get optimum plant stand in the field.

**4. Vigour:** Seed vigour is the sum total of those properties of the seed, which determine the level of activity and performance of the seed or seed lot during germination and seedling emergence. In general, it is the potential of seed in terms of better germination, growth and finally good yield.

**5. Viability:** The viability of the seed is a measure of seed alive and could develop into plants, which will reproduce themselves, given the appropriate conditions. It is measured through tetrazolium chloride test.

**6. Moisture content:** The moisture content is the amount of water in the seed and is usually expressed as a percentage. A small change in seed moisture content has a large effect on the storage life of the seeds. Therefore, it is important to have optimum moisture content in good quality seed. For example, cereals: 10-12 %, pulses: 7-9% and oilseeds:6-7%, vegetables: 5-6%.

### Importance of quality seed

1. Seed is a vital input in crop production;
   - It is the cheapest input in crop production and key to agriculture progress.
   - Crop status largely depends on the seed materials used for sowing.
   - Response of other inputs in crop production depends on seed material used.
2. The seed required for raising crop is quite small and its cost is very less compared to other inputs.
3. This emphasis the need for increasing the areas under quality seed production.
4. It is estimated that good quality seeds of improved varieties can contribute about 20-25% increase in yield.

### Role of improved seeds

1. Carrier of new technology.
2. Basic tool for a secure food supply.
3. The principle means to obtain crop yields in less favourable production area.
4. Medium for rapid rehabilitation of agriculture after natural disasters.

### Differences between seed and grain

| Seed | Grain |
|---|---|
| • Seed is produced through scientifically method | • It is produced by general methods |
| • Seed is used for propagation purpose | • Grain is used for consumption purpose |
| • Seed should be viable and vigorous | • Grain may or may not be viable |
| • Seed should be physically pure | • Physical purity is not necessary |
| • It can be treated with pesticide / fungicide to protect it against storage pests and fungi | • It should never be treated with any chemicals, since it is used for consumption |

## Floral Biology

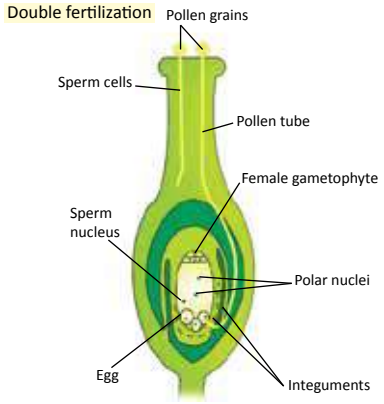
Flower is a reproductive organ of plant bearing pistil, stamens, calyx and corolla. Male part of a flower is androecium consisting of anther sac, anthers and pollen grains, while, female part is gynoecium, having ovary, style and stigma. Inside the ovule, egg cell is present, which forms the embryo part of seed after fertilization with male nucleus.

### Types of flower

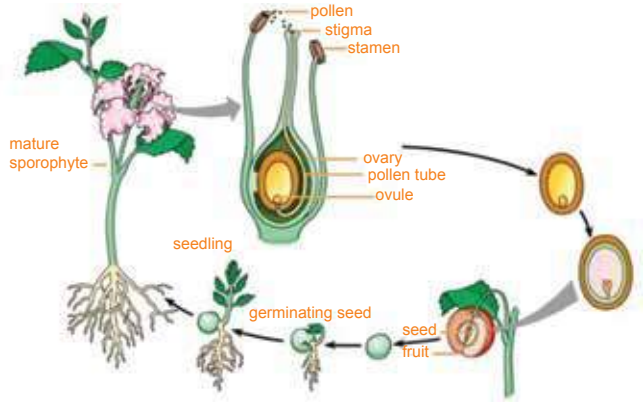
1. **Perfect/ Bisexual:** The flower is said to be **perfect**, when it contains both male and female parts.
2. **Imperfect/Unisexual:** When flower contains either male or female part, the flower is said to be imperfect.

**What is Pollination?** It is the process by which pollen is transferred from the anther (male part) to the stigma (female part) of the plant, thereby enabling fertilization and seed formation inside the ovary.

In angiosperms, fertilization involves the participation of 2 male nuclei of pollen tube. One male nuclei fuses with the egg nucleus to form the diploid zygote and the other with 2 polar nuclei to produce a triploid nucleus, which is called primary endosperm and this whole process is called **double fertilization or triple fusion**.




*Fertilization process*




*Plant life cycle showing fertilization*

## Types of pollination

Based on transfer of pollen from anthers to stigma, pollination is classified into two groups

1. **Self-pollination/ autogamy:** When pollen grains are transferred from an anther to the stigma of the same flower, the process is called **self-pollination**.
2. **Cross-pollination/allogamy:** If pollen grains are transferred to the stigma of another flower, then process is known as cross pollination.

Based on pollination behaviour crops are classified under following three categories.

I. Self-pollinated crops eg. wheat, rice, most of the pulse crops

II. Offen cross-pollinated crops eg. arhar, castor

III. Cross-pollinated crops eg. maize, bajra

## Mechanisms which favour self-pollination

1. **Perfect flower:** It is the presence of both male and female part of the flower which favours the self-pollination eg. rice, wheat, green gram etc.
2. **Homogamy:** Maturation of male and female parts of flower on same time is called homogamy. eg rice wheat, barley and pulse crops.
3. **Cleistogamy:** It is the types of flower in which pollination always occurs inside the closed flowers, which promote the self-pollination. eg. rice, wheat
4. **Flower structure:** Some flowers have special structure around the male part, which promotes the self-pollination eg. tomato and pulse crops.

## Mechanisms which favour cross-pollination

1. **Bisexual flowers:** When both male and female parts are present on the different flowers then it promotes the cross-pollination. eg. castor, papaya etc.
2. **Dichogamy:** Sometimes male or female part mature slightly at different times, it this nature is called as **dichogamy,** which favour the cross pollination and in this process if male part (Anther) of flower matures first then it is called **protandry** (eg. maize) while, if female partmatures (ovary) first, then flower is to be called **protogyny**. eg. Bajra
3. **Herkogamy:** In this types of mechanism, some structures prevent the self-pollination and promote cross pollination in bisexual flowers. eg. Alfa alfa
4. **Male sterility:** Male sterility is defined as an absence or non-function of pollen grain in plant or incapability of plants to produce or release functional pollen grains and this mechanism promote the cross pollination. eg. cotton, bajra etc.

5. **Self-Incompatibility:** It refers to the failure of pollen to fertilize the same flower or other flower of the same plant, or it is the failure of pollen tube to penetrate the full length of style and effect fertilization. eg. mustard, cauliflower and cabbage etc.

## Seed Development

After fertilization, development of fertilized ovule into a mature seed involves several different stages. Seed formation begins within the minute embryo sac with certain expectations, which is about the same in shape, size, and arrangement. In spite of initial similarities, the seed develops according to the genetic specification for each species, which are coded in the nucleus (chromosomes) of each cell.

**What is variety? :** Variety is the group of plants, which have similar morphological characters and belongs to same genus and species.

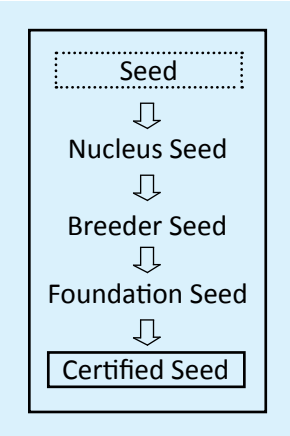
**What is Hybrid?** Hybrid is the product of two dissimilar parents or lines of dissimilar genotype in order to combine desirable characters from both the parents.

**Inbred:** It is plant type in cross pollinated crops, which is produced through continuous self-pollination process, which is further used as parental line for hybrid formation.

### Stages of Seed Multiplication

After the development and release of plant variety, the initial amount of pure seed, which is limited, should be multiplied through scientifically methods under different stages and these stages are called classes of seed multiplications. The following four different classes are used for multiplication of newly released variety.

a. Nucleus seed b. Breeders seed c. Foundation seed d. Certified seed




*Different classes in seed multiplication chain*

**Points to be remember**

- Cross pollinated crops require more isolation distance for seed production than self pollinated crops.
- Bisexual flower is also known as hermaphrodite flower
- Certified seed should not be used for further multiplication in seed multiplication chain
- Certified seed is used for commercial crop production.

**Nucleus seed:** It is the initial amount of pure seed of an improved variety available with plant breeder who has developed it. The nucleus seed is 100 per sent pure genetically as well as physically and it is in very limited quantity.

**Breeder's seed:** It is the seed obtained from the progeny of nucleus seed and produced by the breeder who developed the new variety. It's genetic and physical purity should be 100 per cent and tag colour for breeder seed is golden yellow colour.

**Foundation seed:** It is seed which is obtained from breeder's seed. It is produced on seed multiplication farm of a state govt. or agricultural university. Foundation seed plots are inspected by the SCA (seed certification agency), it is not as pure as the nucleus and breeder's seeds and the bags are sealed with white colored label.

**Certified seed:** It is progeny of foundation class of seed and produced under direct supervision of state seed certification agency. The certified seed bags are scaled with blue colored tag and certified seed is finally distributed to the farmers for crop production.

## Difference between certified seed and truthfully labelled seed

**Certified Seed:** It is the progeny of foundation seed class and produced under direct inspection of state seed certification agency on farmer's field. The tag colour for certified seed is blue colour and it is distributed to the farmers for crop production.

**Truthful labelled Seed (TLS):** It is the category of seed produced by cultivators, private seed companies and is sold under truthful labels. But field standard and seed standard should be maintained as per Seed Act and Indian Minimum Seed Certification Standards. For the TLS, the seed producer and seed seller are responsible for the seed quality attributes.

## Requirements of certified seed production

1. **Source of seed:** Appropriate/proper class of seed need to be obtained from approved source according to stages of seed multiplication. In case of foundation seed, breeder seed with yellow coloured tag is to be used for sowing while, for certified seed production, foundation seed with white tag is to be used.
2. **Land requirement:** The land selected for seed production should be suitable for that crop. It should be fertile, free from soil borne disease & insect pest, free from weed seeds and waterlogged soils should not be selected for seed production. As far as possible, the land selected for seed production should not have same crop grown in the proceeding season.
3. **Isolation requirement:** The seed crop must be isolated from other nearby fields of the same crops and the other contaminating crops as per requirement of the certification standards. Isolation of seed plot can be maintained by two ways i.e

a) **Time isolation:** In case of time isolation, sowing of seed plot is adjusted in such a manner that the seed plot does not come to flowering at the same time with the neighboring crop of same variety.

b) **Space isolation:** Space isolation is the minimum distance kept between the seed plot and neighbouring plot of same crop, which prevents natural cross pollination and physical contamination.

4. **Roughing:** Roughing is the removal of individual plants, which differ significantly from the normal type of the variety.

5. **Field inspection:** As per provisions of seed certification, the seed plots offered for certifications are subjected to field inspection by the staff of seed certification agency. It is the responsibility of the seed producer to follow the instructions given by the field inspector.

6. **Harvesting and threshing:** Seed plot should be harvested at proper stage of maturity and after harvesting the crop, it should be brought to threshing yard for threshing or separation of seed from plant part.

7. **Drying:** The initial moisture content of freshly harvested seed is usually high and its range is between 15 to 25%. It is therefore necessary to dry the seed to bring its moisture content to safe level of 12% or less so that it can be stored for long duration.

8. **Bagging and Tagging:** The seed lot is passed by seed certification agency on the basis of seed testing laboratory report (STL). The processed and treated seed is bagged and tagged with appropriate tags issued by seed certification officer.

**Seed Testing Laboratory:** The seed testing laboratory is the hub of seed quality control. In seed testing laboratory, seed quality attributes are evaluated. Every state in India has a seed testing laboratory.

## Terminology

**Pure line variety:** It is a variety, which consists the progeny of single self-fertilized homozygous plants. All plant within a pure line variety has same genotype as the plants from which the pure lines are derived. The phenotypic differences (variation) within a pure line is environmental and therefore non heritable. The pure line becomes genetically variable with time, due to mechanical mixture, mutation, etc.

**Synthetic variety:** A variety, which is produced by crossing in all combination a number of inbred lines that combine well with each other. Once synthesized, a synthetic is maintained by open-pollination in isolation is referred as synthetic variety.

**Composite variety:** Mixing the seeds of several phenotypically outstanding lines produces a composite variety and encouraging open pollination to produce crosses in all combinations among, the mixed lines. The lines used to produce a composite variety are rarely tested for combining ability with each other like synthetic.

## EXERCISES

### Check Your Progress

1. What is quality seed and what are characteristics of a quality seed?
2. What is pollination? Discuss mechanisms favouring self and cross-pollination in crop plants?
3. Define the terms: variety, hybrid, male sterility, self-incompatibility, certified seed, and truthfully labelled seed.

### Fill in the blanks

1. Breeder seed is progeny of……..
2. Foundation seed is progeny of ……..
3. Certified seed is progeny of ……..
4. Cleistogamy is found in crops like……..
5. Tag colour of certified seed……..
6. Examples of cross pollinated crops are…….
7. Genetic purity of breeder seed is ……..
8. Herkogamy is found in crops like ……..
9. Name of the crops in which male sterility is commercially used……..
10. Isolation distance is maintained to prevent the……..

### Suggested Further Readings


- Copeland, L.O and McDonald, M.B. (1999). Principles of Seed Science and Technology. Springer US.
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# CHAPTER – 6

# ENTREPRENEURIAL SKILL DEVELOPMENT

## Learning objectives

After studying this chapter, students will be able to

- Acquire basic knowledge on rearing of honeybees, silkworms, lac, fish and ornamental fish farming
- Learn mushroom growing, preparation of terrarium and several value-added products from horticultural crops
- Learn importance of biogas and use of biofertilizers
- Start agribusiness on beekeeping sericulture, pisciculture, mushroom farming and proceesing of horticultural crops

## Introduction

Agriculture offers several programmes, which can help the leaners in the development of several skills to establish themselves as a successful entrepreneur in the life. Of the several such skills, apiculture, sericulture, lac culture, pisciculture, mushroom farming, processing of horticulture crops etc., are now emerging fields. Similarly in the cities, ornamental fish culture and terrarium development are achieving new heights among the people. Further, in villages, there is an increasing demand for biogas plants as the fuelwood is becoming scarce in every prural part of India. Hence, it becomes important to impart basic knowledge about these skills so that our students take them as one of their buisness in the future life. In this chapter, a brief introductory information has been given on these issues.

## APICULTURE (BEEKEEPING)

The process of rearing of honeybees for the production of honey, bee wax and royal jelly is known as beekeeping. The honeybee rearing is household practice in India. A location where bees are kept is called an apiary or "bee yard". Honeybees and their usefulness are known to man from prehistoric times. The modern bee keeping became possible after the discovery of movable frame hive in 1851 by Rerd. L.L.Langshoth. In India, beekeeping was introduced in 1882 in Bengal. Retd. Newton introduced beekeeping to south India in 1911. *Apis mellifera* (Italian honeybee) was first introduced in 1962 at Nagrota (Kangra) Himachal Pradesh. At present, this bee species is being used extensively for extraction of honey in India.

Apiculture is a highly specialized skill. It requires knowledge about bee species, the instruments, rearing of bees, management of bees, extraction of honey, cleaning of honey etc. Honey is the major product of Apiculture industry, which is a sweet, viscous fluid, produced by honeybees which is collected as nectar from nectaries at base of flower.

Usually, honeybees collect nectar from the flowers of different plant species. In general, honeybees visit yellow flowers the first, followed by white, blue but they visit red flowers at the last. Usually, bees remain active during daytime, although they do not sleep during night. Workers can take flight for about 3-4 kilometers for the collection of nectar. This nectar is deposited in the frames specially designed for its deposition. This nectar is then extracted by the honey processor.

## Bee species

There are five important species of honeybees as follows.

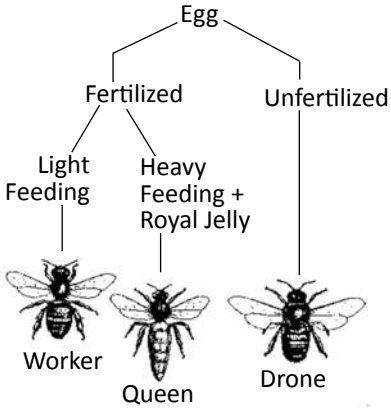
- *Apis dorsata:* The rock bee
- *Apis cerana indica:* The Indian honeybee
- *Apis florea :* The little bee
- *Apis mellifera:* The European or Italian bee
- *Melipona irridipennis:* Danner bee, Meliporidae stingless bee.

## Honeybee castes

Every honeybee colony comprises of a single queen, a few hundred drones and several thousand worker castes of honeybees. Queen is a fertile, functional female, worker is a sterile female and the drone is a male insect.

1. **Duties of a queen -** The only individual, which lays eggs in a colony (Mother of all bees).
2. **Duties of a drone -** Their important duty is to fertilize the queen.
3. **Duties of a worker -** First three weeks- household duty and rest of the life-out door duty i.e. collection of nector.

## Sex differentiation in bees



### Bee behaviour

**Swarming:** Swarming is a natural method of colony multiplication in which a part of the colony migrates to a new site to make a new colony. Swarming occurs when a colony builts up a considerable strength or when the queen's substance secreted by queen falls below a certain level. Swarming is a potent instinct in bees for dispersal and perpetuation of the species.

**Supersedure:** When a old queen is unable to lay sufficient eggs, she will be replaced or superseded by supersedure queen.

**Emergency queen :** In the event of death of the queen, the eggs in worker cells are selected and the cell extended like a queen cell.

### Bee Products

1. Honey
2. Bees wax
3. Royal Jelly
4. Bee venom
5. Propolis
6. Pollen

## LAC CULTURE

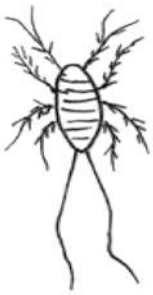
Lac is a resinous exudation from the body of female scale insect. Since Vedic period, it has been in use in India.The English word lac synonyms **Lakh** in Hindi, which itself is derivative of Sanskrit word **Laksh** meaning a lakh or hundred thousand. It would appear that Vedic people knew that the lac is obtained from numerous insects and must also know the biological and commercial aspects of lac industry. With increasing universal environment awareness, the importance of lac has assumed special relevance in the present age, being an eco-friendly, biodegradable and self-sustaining natural material.

### Lac insect

The first scientific name given to it was *Tachardia lacca* following the name of French Missionary Father 'Tachardia'. It was later changed to *Laccifer lacca* Kerr. Lac insect belongs to super family Coccoideae, which includes all scale insects, Phylum Arthropoda, Class Insecta and Order is Hemiptera. There are six genera of lac insects, out of which only five secrete lac, and the commonest and most widely occurring species of lac insect in India is *Laccifer lacca* (Kerr), which produces the bulk of commercial lac. Lac is currently produced in India, Myanmar, Thailand, Malaya, Lao and Yuan province of China. India has prime position in relation to lac production. Over 90% of Indian lac produced comes from the states of Bihar, Jharkhand, West Bengal, Madhya Pradesh, Chattisgarh, Eastern Maharashtra and northern Orissa.

## Life cucle

Lac insect is a minute crawling scale insect, which inserts its suctorial proboscis into plant tissue, sucks juice, grows and secretes resinous lac from the body. Its own body ultimately gets covered with lac in the so called 'CELL'. Lac is secreted by insects for protection from predators and it completes its life cycle in six months.



*Lac nymph*

*Adult lac insect*

*Lac encrusted twig*

## Host plants

Lac insects thrive on twigs of certain plant species, suck the plant sap, and grow all the secreting lac resin from their bodies. These plants are called host plants and commonly used host plants are *Butea monosperma* (palas), *Zizyphus* spp (Ber), *Acacia catechu* (Khair), *Acacia arabica* (Babul), *Acacia auriculiformis* (Akashmani), *Shorea talura* (Sal grown in mysore), *Cajanus cajan* (Pigeon-pea or Arhar) etc.

In India, lac insect is known to have two distinct strains 'kusumi' and 'rangeeni'. Lac cultivation is done by putting brood lac on suitably prepared specific host plants. The brood lac contains gravid females, which are about to lay eggs to give birth to young larvae. After emergence from mother cells, the young larvae settle on fresh twigs of host plants, suck the plant sap and grow to form encrustations.

## Harvesting

Harvesting is the process of collection of ready lac from host trees. It is done by cutting the lac encrusted twigs when crop is mature. It is of two types i.e immature harvesting, the lac is collected before swarming, and lac thus obtained is known as 'ARI LAC' and the drawbacks of immature harvesting is lac insects may be damaged at the time of harvesting and in mature harvesting, lac is collected after swarming. The lac obtained is known as mature lac. The mean lac productivity (per tree and per unit area) is 10-15 kg per tree.

## Lac products and their use

**Lac dye:** Lac dye is a mixture of anthroquinoid derivatives and it is traditionally used to colour wool and silk.

**Lac wax:** Lac wax is a mixture of higher alcohols, acids and their esters. It is used in polish applied on shoes, floor, automobiles, food and confectionary, lipsticks.

**Shellac:** Shellac is a natural gum resin, a nature's gift to the mankind and it is non toxic, physiologically harmless and edible resin. It is used in fruit coatings. Jewellers and goldsmiths use lac as a filling material in the hollows in ornaments and also used commonly as sealing wax.

## SERICULTURE

Sericulture is the rearing of silkworms for the production of silk. The silkworm larve feed on the mulberry leaves and then they spin their silken cocoons on the twigs. This process is achieved by secretion of fluid from its structural glands, resulting in the fiber of the cocoon. The silk is a continuous filament comprising fibroin protein, secreted from two salivary glands in the head of each larva, and a gum called sericin, which cements the filaments and forms the silk. *Bombyx mori* is the most widely used silkworm. Sericulture has become an important industrial business in Brazil, China, France and India etc.

### Stages of production

- The silk moth lays thousands of eggs.
- The silk moth eggs hatch to form larvae, known as silkworms.
- The larvae feed on the mulberry leaves.
- Well grown and moulted silkworm weaves a net to hold itself
- It swings its head from side to side silk.
- The silk solidifies when it contacts the air.
- The silkworm spins approximately one mile of filament and completely encloses itself in a cocoon in about two or three days.
- The silk is obtained by brushing the undamaged cocoon to find the outside end of the filament.
- The silk filaments are then wound on a reel. One cocoon contains approximately 1,000 yards of silk filament.

## PISCICULTURE

Pisciculture is a scientific technology for rearing of fishes for getting maximum fish production from a pond or a tank through utilisation of available food organisms supplemented by artificial feeding. Major species selected for pisciculture are Katla, Rohu, Mrigal, and exotic or common carps. The basic requirements for pisciculture is pond/tank, liming & manuring, fish culture, fish food.

### Points to be considered during pisciculture

1. **Location of pond :** Soil should be water retentive, availability of assured water supply and the area, which is not prone to flood, is selected.

2. **Pond management :** Before stocking, clear the pond of unwanted weeds and fish either by manual using fishnets. Alkaline nature to be maintained by adequately adding lime in the ponds. Fertilize the ponds properly to improve the natural availability of phyto plantation.

3. **Stocking :** Ponds are ready for stocking after 15 days of application of fertilizers.

4. **Harvesting :** Generally done at the end of one year, when fish attain a weight of 750 gm to 1.25 kg.

## MUSHROOM CULTURE

Mushrooms are most important fungi used as a source of human food. They are a rich source of nutrition. While more than 2,000 species of fungi are edible but only 5–6 have been commercially exploited the world over. In India, only three mushroom types—white button mushroom (*Agaricus bisporus*), oyster mushroom (*Pleurotus* spp.) and paddy straw mushroom (*Volvariella* spp.) are being cultivated commercially. Button mushroom comprises more than 90% of India's total mushroom production. All the 3 cultivated mushrooms not only differ in their shape, size, colour and biochemical composition, but they show variations in their requirement for growth medium (substrate), temperature, and other physical factors.

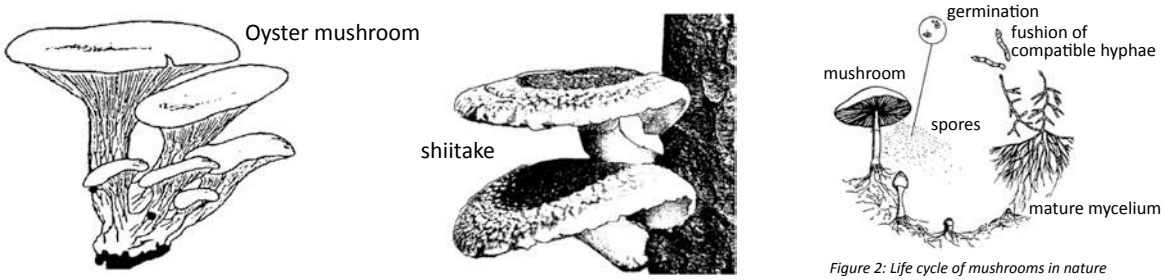


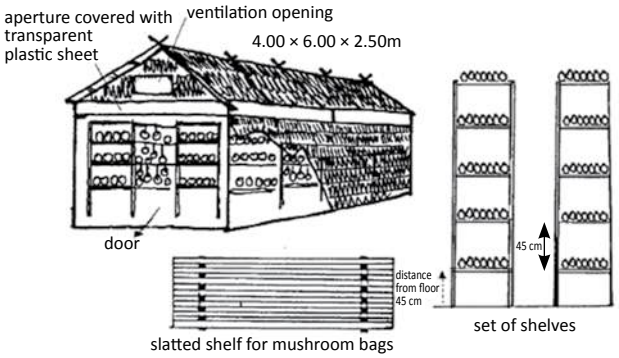

*Figure 2: Life cycle of mushrooms in nature*

### Cultivation

**Spawn:** Mushroom spawn is technically equivalent to seed of a plant, although, in reality, it is a pure mushroom mycelium (vegetative growth) growing on a sterilized grain medium. The grain medium is prepared from boiled grains of cereal or millet like wheat, bajra, jowar and rye mixed with chalk-powder and gypsum. The medium is sterilized after filling in heat resistant glass bottles or polypropylene bags at 121°C and inoculated with pure culture of *A. bisporus*. The medium soon gets impregnated with mushroom mycelium if incubated at 25°C and is ready for use in 2–3 weeks.

**Compost:** The substrate used for button mushroom is a partially decomposed organic matter prepared under aerobic conditions and is generally termed as compost. In India, straw of wheat or paddy have generally replaced horse manure as the base material for mushroom compost.

**Spawning and spawn run:** The compost is filled in trays, or in polybags, after mixing the spawn through compost @ 0.5%. The spawned beds are kept covered with formalin dipped paper sheets or by closing the mouth of the bags. The beds if incubated at 24°C, with relative humidity maintained between 80–85%, get fully impregnated with mushroom mycelium and when the spawn-run is completed (in 2–3 weeks), the compost turns light-brown from deep-brown and is ready for casing.




*A mushroom growing unit*

**Casing and case run:** The spawn run beds are then covered by 1–2" thick layer of casing material, which is necessary to initiate fruiting. Casing material should have the characteristics like poor in nutrient, good water-holding capacity but a texture permitting good aeration and a pH of 7–7.5.

## Harvesting and postharvest management of mushrooms

Harvesting of mushrooms at optimum stage of maturity is of great importance. Harvesting of undermature or over mature fruit bodies results in poor texture, flavour and immediate degradation. Mushroom pin-heads start appearing after 7–10 days.

### Harvesting

**White button mushroom:** They should be harvested when their cap size is 30–45 mm in diameter or when their cap diameter is twice the length of stem. Pre-harvest spraying of 2% ascorbic acid improves their colour by inhibiting the polyphenol oxidase activity.

**Oyster mushroom:** These are harvested, when their fruit bodies have curled under edges with well-formed gills (wrinkled stage of umbrella) because fully mature fruit bodies are fragile and difficult to handle.

**Paddy straw mushroom:** These are harvested at button or egg-sized stage. The deterioration is less in the mushrooms harvested at egg-sized stage because their polyphenol oxidase activity is slow.

### Postharvest Management

**Pre-cooling:** Although, mushrooms are grown at lower temperature, even then they should be precooled immediately after harvesting, to their optimum storage

temperature (5°C) to check the rate of high respiration and changes taking place at ambient room temperatures.

**Sorting:** Sorting is done to remove undesirable fruiting bodies in the produce like discoloured, blemishes and misshapen mushrooms are discarded while sorting.

**Dipping treatments:** To maintain whiteness, dipping of mushrooms in dilute solution of hydrogen peroxide (1:3) for half an hour and then steeping in 0.25% citric acid solution gives significant effect.

**Packaging:** Properly washed mushrooms are packed in suitable containers. Since, mushrooms are very sensitive to desiccation and drought, these are usually packed in polyethylene bags of 200– 500g capacities, 0.5% ventilation is generally recommended for refrigerated storage, whereas for local markets, non-perforated bags should be used. For distant markets, polystyrene or fibre board punnets over-wrapped with partially permeable polyvinyl chloride (PVC) or poly acetate films packing material is recommended.

**Transportation:** Mushrooms being highly perishable and having a high rate of respiration, transportion in refrigerated vans is recommended for distant markets.

**Storage:** Mushrooms cannot be stored for more than 24 hr at room temperature or 1–2 weeks in refrigerated condition. During storage, there is decline in total sugars, soluble proteins and total phenol content, while polyphenol oxidase activity enhances. These changes are aggravated with increase in storage temperature. A temperature of 5°C along with 85–90% relative humidity is generally recommended for their storage.

**Processing:** Pickling and sun-drying are economically-viable methods of preserving mushrooms. However, freezing and freeze-drying give them an excellent quality. They can be used commercially for export market.

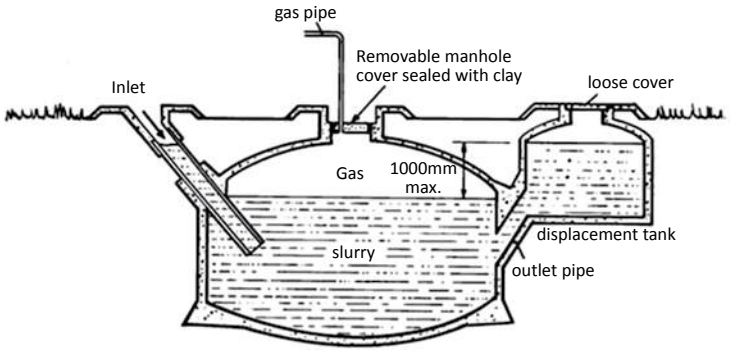
**Pickling and lactic acid fermentation:** Fermentation is a process of anaerobic or partial anaerobic oxidation of carbohydrates. During fermentation, sufficient quantity of lactic acid is produced to prevent the product from further spoilage during storage. Pickle, chutney and ketchup are products having a minimum of 6 months storage life at ambient temperature.

## BIOGAS, BIOFERTILIZERS AND SANITATION

### Biogas

Biogas is a fuel, which is produced from the breakdown of organic matter. These fossil fuels are being continuously used to a large extent because this is non-renewable energy resource. This is produced when bacteria decompose organic material such as garbage and sewage, especially in the absence of oxygen. Biogas is a mixture of about

60 percent methane and 40 percent carbon dioxide. Methane is the main component of natural gas. It is relatively clean burning, colourless, and odourless. This gas can be captured and burned for cooking and heating. This is already being done on a large scale in some countries of the world. Farms that produce a lot of manure, such as hog and dairy farms, can use biogas generators to produce methane.




*A sketch of biogas plants*

## Advantages of biogas

- Biogas-powered electricity construction is quick, easy and low-cost.
- Biogas is a renewable resource.
- Methane is going to be produced by decomposition.
- Methane is also an important greenhouse gas and is a major contributor to the global warming problem.
- Biogas provides an excellent source of energy that is helpful to the environment.
- Residue from the burning of biogas, called activated sludge, can be dried and used as fertilizer.

## Biofertilizers

Biofertilizers are defined as products containing living cells or latent cells of efficient strains of microorganisms that help crop plants uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil.

Use of biofertilizers is one of the important components of integrated nutrient management, as they are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers.

## Nitrogen Fixers

- Free living
  - ✓ Aerobic – *Azotobacter, Beijerinckia, Anabaena*
  - ✓ Anaerobic – *Clostridium Faultative anaerobic*

- Symbiotic - *Rhizobium, Frankia, Anabaena azollae*
- Associative symbiotic - *Azospirillum*
- Endophytic - *Gluconacetobacter Burkholdria*

### Phosphorus Solubilizers

- Bacteria: *Bacillus megaterium var. phosphaticum, B. subtilis, B. circulans, Pseudomonas striata*
- Fungi : *Penicillium sp. Aspergillus awamori*

## Importance of biofertilizers

- Supplement fertilizer supplies for meeting the nutrient needs of crops.
- Add 20 – 200 kg N/ha (by fixation) under optimum conditions and solubilise/ mobilise 30-50 kg phospurus/ha.
- They liberate growth promoting substances and vitamins which help to maintain soil fertility.
- They suppress the incidence of pathogens and control diseases.
- Increase the crop yield by 10-50%.
- Cheaper, pollution free and based on renewable energy sources.
- They improve soil physical properties, tilth and soil health.

### 1. Rhizobium

Rhizobium is a soil bacteria, which lives freely in soil and in the root region of both leguminous and non-leguminous plants. However, they enter into symbiosis only with leguminous plants, by infesting their roots and forming nodules on them. Non legume nodulated by Rhizobia is Trema or Parasponia sp. Legume plants fix and utilise this N by working symbiotically with Rhizobium in nodules on their roots.

### 2. Azotobacter

It is a free living $N_2$ fixer; the cells are not present on the rhizoplane, but are abundant in the rhizosphere region.

### 3. Mycorrhizae

Mycorrhiza (fungus root) is the mutualistic association between plant roots and fungal mycelia. Frank (1885) gave the name "mycorrhiza" to the peculiar association between tree roots and ectomycorrhizal fungi. 95% of the plant species form mycorrhizae. Mycorrhizal fungi are the key components of the rhizosphere are considered to have important roles in natural and managed ecosystems.

### Types of mycorrhiza

1. **Ectomycorrhiza :** The fungal hyphae form a mantle both outside the root and within the root in the intercellular spaces of the epidermis and cortex.

Ectomycorrhizae are common on trees, including members of the families Pinaceae (pine, fir, spruce, larch, semlock), Fagaceae (willow, poplar, chesnut), Betulaceae (birch, alder), Salicaceae (willow, poplar) and Myrtaceae (eucalyptus).

2. **Endomycorrhizae :** The most common mycorrhizal fungi and these fungi produce an internal network of hyphae between cortical cells that extends out into the soil, where the hyphae absorb mineral salts and water for example, *Ericoid mycorrhiza, Arbuscular mycorrhiza*.

## PROCESSING OF HORTICULTURAL PRODUCTS

India is the 2nd largest producer of fruits and vegetables in the world. However, about 30-40% of this produce is lost due to improper postharvet handling. Moreover, several fruits and vegetables are seasonal in nature, which results in price fluctuations, thereby growers get low price of their produce. Therefore, to prevent losses, and avoid glut of fruits in the season, processing of fruits in to stable value-added and processed products is required.

### Different value added products of fruits

**Fruit beverages:** Fruit juices are rich sources of vitamins, particularly vitamin-C and minerals. These are easily digestible, highly refreshing and invigorating, thirst quenchers and far superior to most aerated drinks, which have practically no food value. They are beneficial against a number of ailments and tonics for heart and brain and serve as cold drinks in hot summer. Fruit juices are preserved in different forms such as pure juices, squashes, cordials, and fermented juices etc. These are broadly classified as under:

**Pure fruit juice:** This is the natural, unfermented juice processed out of the fruit and remains practically unaltered in its composition during preparation and preservation. Fruit juices can be prepared from almost types of fruits.

**Ready-to-serve (RTS):** This prepared from fruit juice. It contains minimum of 10% fruit and 10% sugars. It not diluted before serving.

**Fruit juice beverage:** This is a fruit juice, which is considerably altered in composition before consumption. It may be diluted before it is served as a drink.

*Fruit juice*

**Fermented fruit beverage:** This is a fruit juice, which has undergone alcoholic fermentation by yeast. The product contains varying amounts of alcohol. Grape wine,

apple ciders, berry wines etc., are typical examples of this kind of beverages.

**Squash:** This consists essentially of strained juice containing moderate quantity of fruit pulp to which sugar is added for sweetening. Fruit squash can be prepared from mango, lemon, orange etc.

**Cordial:** Sparkling, clear, sweetened fruit juice from which all the pulp and other suspended materials have been completely eliminated (e.g. lime juice cordial, guava).

**Sherbet or Syrup:** Clear sugar syrup, which has been artificially flavoured.


*Fruit Squashes*

**Fruit juice concentrate:** Fruit juice, which has been concentrated by the removal of water either by heat or freezing. Carbonated beverages and other products can be made from this.

## Fruit juice powder

Fruit juice which has been converted into a free-flowing, highly hygroscopic powder to which natural fruit flavour in powder form is incorporated to compensate for any loss of flavour in concentration, dehydration. Freeze dried fruit juice powders makes the best quality products. The powders are reconstituted to yield readily full strength, full fruit, fruit juice drinks.


*Marmalade*


*Apricot butter*

**Preparation:** Fruit juices have their best taste, aroma and colour when they are freshly extracted and used for product making. The important steps in beverage making are selection and preparation of fruits, extraction of juice, de-aeration, straining, filtration, clarification and preservation.

## Jam

Jam is a concentrated fruit pulp, possessing a fairly heavy body and rich in natural fruit flavour. Pectin in the fruit gives it a good set and high amount of sugars (more than 68.5 %) facilities its preservation. It is prepared by boiling the fruit pulp and juice with sufficient quantity of sugar to get thick consistency. A good jam must have bright colour, rich typical fruit flavour, stiff but should not be sticky or crystallization of sugar. Apple jam, pineapple jam, and mixed fruit jam are common in the market.

### Jelly

It is a semi-solid product prepared by concentrating essentially a clear fruit extract with sugar. In jelly making, pectin is the most essential constituent. Good jelly should be transparent, attractive in colour, give strong flavour of the fruit and firm enough to retain a sharp edge when cut. Pectin from cell wall of fruits sugar, acid and water combine together when corked to form jelly. Guava jelly is very popular in all parts of the world.

### Marmalade

It is usually made from citrus fruits and consists of jellies or jam of the concerned fruit containing shreds of peels suspended in them. Usually citrus peel is used for making shreds in marmalade.

### Fruit butter, cheese and toffees

**Fruit butter:** It is a thick product but soft enough to spread easily. The butter can be prepared from any fruit, but most commonly used fruits are apple, pear, plum, peaches, apricot and grapes.

*Fruit cheese*

**Fruit cheese:** This product is commonly prepared from fruits like guava, apple and pear.

**Fruit toffee:** It is prepared by using fruit pulp, sugar, glucose, skimmed milk powder, butter and essence.

### Preserves (*murrabbas*) and candies

**Preserves (*murrabbas*):** It is a matured whole or in large pieces of fruit in which sugar is impregnated till it becomes tender and transparent. It retains the shape of the fruit and does not break or pulped. The preserve should have enough sugar (more than 68% TSS). Murabba can be prepared from amla, apple, mango, petha, grapes, muskmelon, and watermelon.

*Murabbah of Aonla*

**Candied fruit:** A fruit impregnated with sugar, drained and dried is named as candied fruit. They are not sticky and are plump, tender and exceedingly sweet with high flavour.

**Glazed fruit:** A candied fruit dipped for a moment in boiling syrup to impart a glossy finish to it, drained and dried- is called glazed fruit.

*Glazed fruit candy*

**Crystallized fruit:** Candied fruit drained, dried and rolled in crystal sugar is called a crystallized fruit.

## Fermented products

**Wine:** Wine is made by fermenting grape juice with the help of yeasts. Wine can also be prepared by fermentation of other fruit juices such as mango, pineapple, guava, plum, kiwi, apple etc., which will be referred to as wine of that specific fruits (mango wine, pineapple wine etc.). Wine represents a non-toxic healthful beverage, which provides calories, vitamins, minerals and other nutrients.

*Wine*


*Cider*


*Vinegar*

**Vinegar:** The product made from carbohydrates obtained from different fruits by acetic acid fermentation is called vinegar. It can be manufactured as a by – product from the pomace after extracting the juice from fruits. Fruit vinegars will have a unique flavour of the fruits used. Vinegar can be made from apple, grape or other fruits. Vinegar should have atleast 5g acetic acid per 100g.

## Pickles and chutneys

**Pickles:** The preservation of food in common salt or vinegar is called pickling. Spices and oil may also be added in pickles. Pickles are good appetizer aid to digestion and add to the palatability of the meal. In oil pickles, oil provides protection against outside infection. In other pickles, 15 to 20 % common salt is added to prevent spoilage caused by microbes. Moulds and even lactic acid forming bacteria do not grow at this high salt concentration, as a result, pickle remains safe for several months.

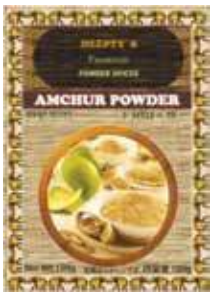

*World famous Pachranga pickle*

**Chutneys:** In general, hot and sweet chutneys are relished by all. Mostly acidic fruits are employed for preparing chutneys. A good chutney is smooth and has a mallow flavour and is spicy. Chutney is mostly prepared from mango.

## Dried products of fruits

It is an oldest and cheapest form of preservation of fruits. Drying can be carried out either in sun or by artificial heat (dehydration). Sun drying is practiced in tropical and sub-tropical regions where there is plenty of sunshine. However, nowadays, drying is done by mechanical dryers because of faster rate of drying and hygiene. Several fruits are used in dry form.

*Anardana*




*Amchur*

***Anardana:*** It is a form of dried sour pomegranate arils used as a souring agent in food preparations. Anardana is prepared from a special wild form of pomegranate, which are highly acidic.

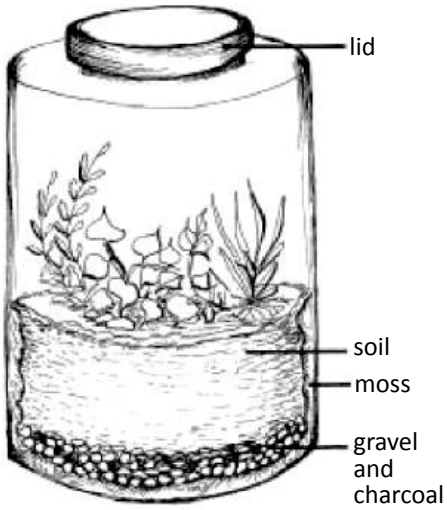
***Amchur:*** It is a product obtained by powdering dry unripe mango pieces of sour nature. It is used as a souring agent in food preparations.

*Apple leather*

**Fruit bar:** Fruit bar can be prepared from the pulp extracted from fully ripe fruits. Fruit pulp dried with suitable quantity of sugar and citric acid along with specified level of chemical preservatives. This product is called as 'intermediate fruit product' but commonly called as leather/papad in our country.

## TERRARIUM PREPARATION

The science of making garden in small glass container is known as terrarium or a terrarium is a collection of plants growing in a glass-enclosed container. The glass walls allow light to reach the plants and give protection from dust, drafts, and temperature changes. The plants usually used are ones that require a high amount of moisture. Therefore, the terrarium is set up to provide a highly humid atmosphere, which means that the air contains lot of water. Plants give off water from their leaves in the form of gaseous water vapour. When air in the container comes in contact with the cooler glass walls, the water vapour condenses, or becomes liquid. This water runs down the sides of the container and soaks into the soil on the bottom. The water is then available for the plants to take up through their roots.




*A sketch of terrarium*

### Plants

Use small plants that grow slowly. Plants should fill the container but not crowd it.

- **House plants:** English Ivy, small Ferns, philodendron, begonias (small-leaved).
- **Woodland plants:** Reindeer lichen, small ferns, mosses, Partridge berry, ground cedar.

## ORNAMENTAL FISH FARMING

The growing of colourful and fancy fishes is known as ornamental fish farming. The growing interest in aquarium fishes has resulted in steady increase in aquarium fish trade globally. Ornamental fish culture is becoming a source of income day-by-day for the rural people. The ornamental fish trade with a turnover of US $ 6 Billion and an annual growth rate of 8 percent offers lot of scope for development. India's share in ornamental fish trade is estimated to be less than 1% of the global trade. Gold fish is the most common and preferred fish because of its varied colouration and morphological charecteristics and the common breeds being grown are comet, lion head, oranda, fringe tail, veil tail, fan tail, telescopic eye. Development of culture technologies is the major answer to a long term sustainable trade of ornamental fishes.

The areas adjacent to the metropolitian cities like Kolkata, Chennai, Mumbai have become major breeding centres for the fresh water ornamental fishes due to the ready urban market and access to export business. In recent years, breeding units for ornamental fishes have been established in states like Kerala, Andra Pradesh, Odisha and Bihar.

## EXERCISES

### Activities

1. Visit some apiary and note down the activities of honeybees, the nearby flowers they visit. Also make a list of machine/equipments required for setting up of an apiary.
2. Make a list of plants used in lac culture. Paste the leaves of such plants in your notebooks.
3. Visit a sericulture farm. Note down the activities of silk worms. Take photographs and paste them in a notebook.
4. Prepare a terrarium at home by taking help of your family members.
5. Visit some mushroom growing unit near to your locality. Make a list of different

steps and machinery required for setting up such unit. Also take part in harvesting and packing of muchrooms.

## Check Your Progress

1. List different types of honeybees found in India, also write the work distribution of different classes of honeybee.
2. Write short notes on: Sericulture, ornamental fish culture and lac culture.
3. What is value addition? Write different dried products which you have seen in the market.
4. Describe briefly different fermented products which can be prepared from fruits.
5. Differentiate between candied, glazed and crystallized fruit.
6. Differentiate between jam and jelly.
7. Discuss in detail the harvesting, postharvest handling and processing of mushrooms.
8. Discuss the steps involved in silkworm rearing.
9. Write advantages of using biofertilizers in our fields.

## Fill in the blanks

1. *Apis mellifera* was first introduced in India at.....
2. .....the major silk produced in India.
3. .....is the major fish used in ornamental fish farming.
4. The science of making garden in small glass container is known as.....
5. *Anardana* is a dried product prepared from .....
6. ..... gave the name "mycorrhiza" to the peculiar association between tree roots and ectomycorrhizal fungi.
7. For jelly making, fruit should have high degree of .....
8. RTS should contain a minimum of .....fruit pulp..
9. Vinegar contains .....
10. White button mushroom should be harvested when their cap size is ..... in diameter.
11. Cider is prepared from .....
12. Petha is prepared from .....
13. Most widely occurring species of lac insect in India is .....

## Suggested Further Readings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