AGRICULTURE SCIENCES

(Grade-X)

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PUNJAB EDUCATION, CURRICULUM,
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Contents

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01 FRUITS PRODUCTION

Student's learning outcomes — **Students will be able to:**

- Define fruit (Botanically and Horticulturally) and explain the importance of fruit production
- Justify that good fruit farming has an impact on the economy of the country.
- Define plant propagation and list different methods of propagation of fruit plants.
- Define rootstock and scion.
- Describe the effect of rootstock on fruit production.
- Explain fruit production with respect to the climate.
- Define temperate fruits.
- Identify varieties of temperate fruits.
- Define tropical and sub-tropical fruits.
- List some common tropical and sub-tropical fruits
- Identify the regions specific for the production of tropical and sub-tropical fruits.
- Name some of the common citrus fruits.
- Recognize the varieties of citrus fruits.
- List some common uses of citrus fruits.
- Describe the propagation and requirements for the growth of citrus fruits.
- Name some of the common mango fruits.
- Recognize the varieties of mango fruits.
- List some common uses of mango fruit.
- Describe the propagation and requirements for the growth of mango fruits.
- Name some of the common guava fruits.
- Recognize the varieties of guava fruits.
- List some common uses of guava fruits.
- Describe the propagation and requirement for the growth of guava fruits.
- Name some of the common date fruits.
- Recognize the varieties of date fruits.
- List some common uses of date fruits.
- Describe the propagation and requirement for the growth of date fruits.
- Name some of the common apple fruits.
- Recognize the varieties of apple fruits.
- List some common uses of apple fruits.
- Describe the propagation and requirements for the growth of apple fruits.

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- Name some of the common banana fruits.
- Recognize the varieties of banana fruits.
- List some common uses of banana fruits.
- Describe the propagation and requirement for the growth of banana fruits.
- Name some of the common grapes.
- Recognize the varieties of grapes
- List some common uses of grapes.
- Describe the propagation and requirement for the growth of grapes.
- State the problems which are being faced during the export of Pakistani fruits.
- Discuss the various factors which affect the success of fruit production.

1.1 Introduction

1. Botanical Definition of Fruit:

In Botany, a fruit is the mature ovary of a flower, usually containing seeds. It develops from a fertilized ovary (sometimes also from accessory floral parts) after pollination and fertilization. Examples: Mango, apple, tomato, cucumber.

2. Horticultural Definition of Fruit:

In Horticulture, a fruit is any edible product of a plant that is usually sweet, fleshy and consumed raw.

This definition is based on use in human diet rather than plant structure.

Examples: Mango, apple, banana, grapes (but not tomato or cucumber, which are treated as vegetables in horticulture).

Fruit production holds great importance as it provides highly nutritious food rich in vitamins, minerals and fibers, ensuring better human health and balanced diets. It generates significant income for farmers through local markets and exports, creating employment opportunities in cultivation, harvesting, storage, processing and transportation. Fruits also serve as raw materials for industries like juices, jams and dried products, thus adding value to the economy. Good fruit farming enhances farm productivity, promotes rural development, saves foreign exchange by reducing imports and earns valuable revenue through exports. Therefore, efficient fruit production not only improves food security and livelihoods but also has a deep and positive effect on the overall economy of the country.

1.2 Methods of Propagation

1. Plant Propagation:

Plant propagation is the process of creating new plants from existing ones through natural or artificial methods. It ensures the multiplication of desired plant varieties and the continuation of their genetic traits.

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2. Methods of Propagation of Fruit Plants:

There are two main categories:

A. Sexual Propagation (by seeds):

- Raising plants from seeds.

B. Asexual (Vegetative) Propagation:

- By cuttings (stem, root, leaf)
- By layering (mound, serpentine, air layering)
- By budding (e.g., T-budding, patch budding)
- By grafting (e.g., whip grafting, cleft grafting, approach grafting)
- By use of specialized structures (rhizomes, suckers, tubers, bulbs)
- By micropropagation (tissue culture).

1.2.1 Rootstock and Scion:

- **Rootstock:** The lower part of a grafted plant, including the root system, on which another plant is grafted.
- **Scion:** The upper part (bud or shoot) of the desired plant that is joined to the rootstock to produce a new plant.

Effect of Rootstock on Fruit Production:

Rootstock plays a vital role in determining the success of fruit tree propagation and productivity. It influences the vigor, size and growth habit of the plant, controlling whether the tree becomes dwarf, semi-dwarf, or vigorous. Rootstock also affects the adaptability of plants to soil type, moisture conditions and resistance to diseases and pests. Properly chosen rootstocks improve early bearing, fruit size, quality and yield. They provide tolerance against drought, salinity and adverse climatic conditions, ensuring long-term orchard sustainability. Rootstocks also help in standardizing plant height for easier management and harvesting. A good rootstock ensures compatibility with the scion, reduces juvenile phase and

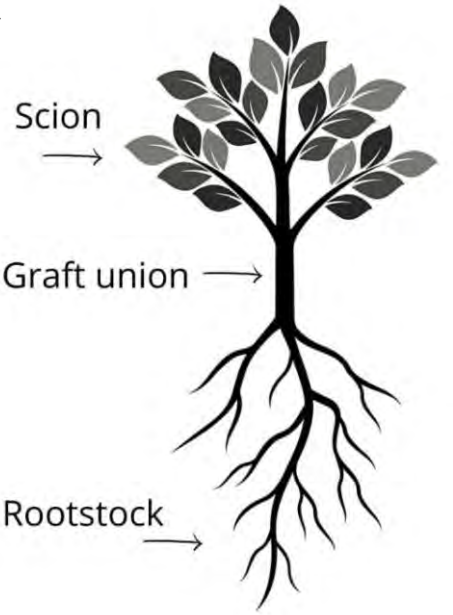

Fig 1.1: Rootstock and Scion

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enhances overall orchard efficiency. Thus, the selection of suitable rootstock is essential for profitable and sustainable fruit production.

1.3 Types of Fruits

Fruit Production with Respect to Climate

Climate is the most important factor influencing fruit production, as it directly affects growth, flowering, fruit set and yield. Each fruit crop has specific requirements of temperature, rainfall, humidity and sunlight for optimum performance. Tropical fruits like mango, banana and papaya require warm climates with little or no frost, while subtropical fruits such as citrus, guava and litchi can tolerate mild winters. Temperate fruits like apple, peach, pear and plum need chilling hours during winter to break dormancy and induce flowering. Rainfall and humidity also play a key role in disease incidence and fruit quality, while excessive rains or drought can damage crops. Proper selection of fruit species according to climatic zones ensures higher productivity, better fruit quality and economic sustainability.

1.3.1 Fruits and Their Climatic Distribution

1. Temperate Fruits

Temperate fruits are those grown in regions with cold winters and mild summers, requiring a period of winter chilling to break dormancy and induce flowering.

2. Common Temperate Fruits

- Apple
- Pear
- Peach
- Plum
- Apricot
- Cherry
- Strawberry

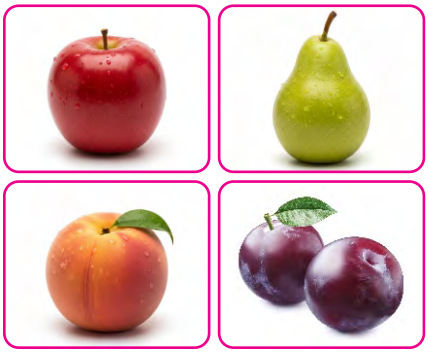

Fig 1.2: Common Temperate Fruits

3. Regions Specific for Temperate Fruits

- Northern areas of Pakistan: Gilgit-Baltistan, Murree Hills, Swat, Chitral, Quetta (Balochistan highlands).

4. Tropical and Sub-Tropical Fruits

- Tropical fruits grow in hot, humid climates without frost, with temperature

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above 18°C year-round.

- **Sub-tropical fruits** grow in regions with **warm summers and mild winters**, tolerating light frost.

5. Common Tropical Fruits

- Mango
- Banana
- Papaya
- Pineapple
- Coconut

Fig 1.3: Common Tropical Fruits

6. Common Sub-Tropical Fruits

- Citrus (orange, kinnow, lemon)
- Guava
- Pomegranate
- Litchi
- Date palm

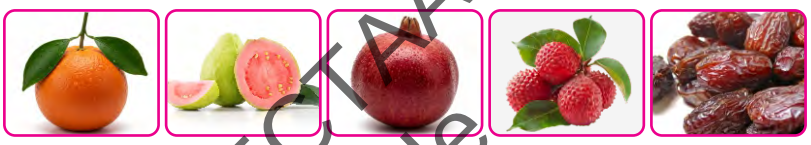

Fig 1.4: Common Sub-Tropical Fruits

7. Regions for Tropical & Sub-Tropical Fruits

- **Tropical fruits:** Sindh, Southern Punjab, Lower Balochistan (hot plains and coastal areas).
- **Sub-tropical fruits:** Punjab plains, Khyber Pakhtunkhwa valleys, parts of Balochistan.

1.4 Major Fruits

Citrus Fruits

1. Common Citrus Fruits

- Mandarin (Kinnow)
- Lemon
- Lime
- Grapefruit
- Sweet orange (Mosambi)
- Tangerine

Fig 1.5: Common Citrus Fruits

2. Varieties of Citrus Fruits

- **Sweet Orange:** Blood Red, Succari, Valencia Late, Mosambi
- **Mandarin (Kinnow):** Kinnow, Feutrell's Early
- **Lemon & Lime:** Eureka, Lisbon, Kagzi Lime

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- **Grapefruit:** Foster, Duncan, Marsh Seedless
- **Others:** Tangelo, Satsuma, clementine

3. Common Uses of Citrus Fruits

Citrus fruits are widely used in our daily life. They are eaten fresh as table fruits and are also processed into juices, squashes and concentrates. Being a rich source of Vitamin C and antioxidants, they provide great health benefits. In addition, they are used for making marmalades, jams, candies and pickles. The peel of citrus fruits is valuable too, as it is used to extract essential oils that are applied in perfumes, cosmetics and medicines.

Propagation and Growth Requirements

- **Propagation:** Mostly done by **budding (T-budding or patch budding)** on suitable rootstocks like Rough Lemon, Sour Orange, or Trifoliate Orange.
- **Climate Requirements:** Sub-tropical climate with hot summers and mild winters. Sensitive to severe frost.
- **Soil Requirements:** Well-drained sandy loam soils with pH 6–7.5 are ideal.
- **Other Needs:** Plenty of sunshine, moderate rainfall or irrigation, protection from waterlogging and salinity.

Fig 1.6: Patch budding

1.4.2 Mango (*Mangifera indica*)

Mango is a highly versatile fruit with many uses. It is commonly eaten fresh as a delicious table fruit and is also processed into juices, nectars, squashes and concentrates. In addition, it is widely used for making pickles, chutneys, jams and dried slices. The pulp of mango is preserved and utilized in ice creams, bakery products and desserts. Even

Fig 1.7: Mango Tree

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the kernel and seed of mango have value, as they are used for oil extraction and as an ingredient in animal feed.

1. Common Mango Varieties

- Chaunsa
- Sindhri
- Langra
- Anwar Ratol
- Dusehri
- White Chaunsa
- Malda
- Fajri
- Gulab Khas
- Sammar Bahisht

Fig 1.8: Common Mango Varieties

4. Propagation and Growth Requirements

- **Propagation:** Mainly by grafting methods such as veneer grafting, side grafting or inarching to maintain desirable traits. Seed propagation is used only for rootstocks.
- **Climate:** Tropical to sub-tropical; requires hot, dry climate during flowering and fruiting. Sensitive to frost.
- **Soil:** Deep, well-drained loamy soil with pH 5.5–7.5 is ideal. Avoid waterlogged soils.
- **Other Needs:** Plenty of sunlight, regular irrigation during fruit development and protection from strong winds.

1.4.3 Guava *(Psidium guajava)*

Importance and Uses of Guava

Guava is one of the most important fruit crops of Pakistan due to its high nutritional and economic value. It is rich in Vitamin C, dietary fiber and minerals, making it a healthy fruit for strengthening immunity and digestion. Guava is eaten fresh as a table fruit and also used for preparing

Fig 1.9: Tree of Guava

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juices, jams, jellies, squashes, candies and guava paste. Its leaves are used in herbal medicines, while the fruit has great demand in both local and international markets. Because of its hardy nature and adaptability, guava is often called the "apple of the tropics."

Varieties of Guava in Punjab

Punjab is the leading guava-producing province in Pakistan, especially in Sheikhupura, Kasur, Gujranwala, Faisalabad, Okara and Sahiwal districts.

Common varieties include:

- **Safeda:** Large, white flesh, sweet flavor.
- **Surahi:** Pear-shaped, medium size, pleasant aroma.
- **China Gola:** Round, small to medium, white pulp.
- **Lalit and Allahabad Safeda (introduced varieties):** Known for sweetness and juiciness.

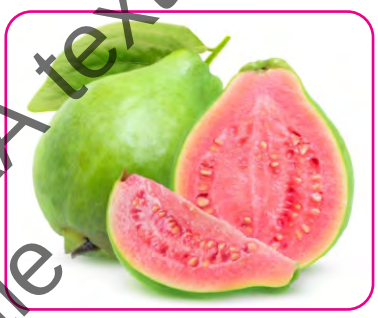

Fig 1.10: Common Guava Fruits

Propagation of Guava

Guava can be propagated both by seeds and vegetative methods. Seed propagation is used only for raising rootstocks, while commercial propagation is done by **air layering, stooling and cutting** to maintain true-to-type plants. Vegetative methods are preferred as they ensure uniformity in plant traits and fruit quality.

Requirements for Growth of Guava

- **Climate:** Sub-tropical fruit that grows well in hot summers and mild winters. It can tolerate drought but is sensitive to frost at young stages.
- **Soil:** Adaptable to many soils, but performs best in deep, fertile and well-drained loamy soils with pH 6–7.5.
- **Irrigation:** Requires regular watering during fruit development, but waterlogging should be avoided.
- **Other Needs:** Requires pruning to maintain shape, proper orchard spacing and protection from fruit flies and wilt disease.

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1.4.4 Date Palm *(Phoenix dactylifera)*

Importance and Uses of Dates

Date palm is one of the oldest cultivated fruit trees and holds great cultural, nutritional and economic importance. Dates are a rich source of natural sugars, fiber, iron and essential minerals, making them an excellent energy food. They are eaten fresh (as table fruit) or dried and are widely used in making sweets, desserts, bakery products, syrups and chutneys. Dates are also exported in large quantities, bringing valuable foreign exchange. The leaves and stem of date palm are traditionally used for making mats, baskets, shelter and fuel. Thus, dates are both a staple food and an important cash crop for many regions.

Fig 111: Date Palm Tree

Varieties of Dates in Pakistan

Pakistan is among the leading date-producing countries, with Sindh, Balochistan, Punjab and Khyber Pakhtunkhwa as major growing provinces. Common varieties include:

- **Aseel (Sindh):** Famous for processing and export.
- **Karbalain (Balochistan, Sindh):** Sweet, semi-dry variety.
- **Begum Jangi (Balochistan):** Rich flavor, soft texture.
- **Dhakki (Dera Ismail Khan, Punjab):** Large-sized, sweet, popular variety.
- **Hillawi (Punjab):** Soft, juicy, used both fresh and dried.

Fig 112: Common Date Palm Varieties

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Propagation of Date Palm

Date palms are propagated mainly through suckers (offshoots) taken from the base of the mother plant, which ensures true-to-type plants and early fruiting. Propagation by seed is not preferred commercially because it produces variable and often inferior plants. Modern techniques like plant tissue culture (micropropagation) are now used to produce disease-free, uniform plants on a large scale.

Requirements for Growth of Dates

- **Climate:** Dates require a hot, dry climate with long summers and plenty of sunshine. Low humidity and absence of rain during flowering and fruiting are essential for good yield.
- **Soil:** Best suited for sandy loam soils with good drainage and high tolerance to salinity.
- **Irrigation:** Needs regular watering, especially during fruit development, but waterlogging should be avoided.
- **Other Needs:** Pollination is usually done manually (artificial pollination) to ensure higher fruit set. Protection from dust storms and proper orchard management are also necessary for good productivity.

Apple *(Malus domestica)*

Importance and Uses of Apple

Apple is one of the most popular and widely consumed temperate fruits in the world. It is highly nutritious, rich in vitamins (especially Vitamin C), minerals, dietary fiber and antioxidants, making it a vital fruit for human health. Apples are eaten fresh as table fruit, while a large quantity is processed into juices, jams, jellies, squashes, vinegar and canned products. Apple also has great commercial importance as a major fruit of temperate regions, providing income to farmers and foreign exchange through exports. Its adaptability and demand make it one of the most valuable fruits worldwide.

Fig 1.13: Apple Tree

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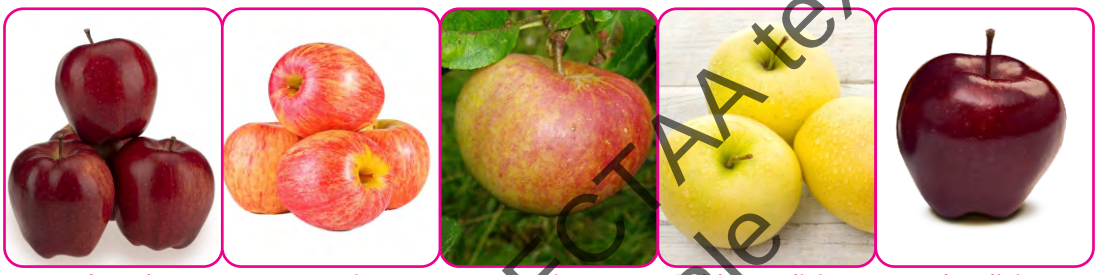
Varieties of Apples in Pakistan

Pakistan produces high-quality apples, especially in the northern areas and Balochistan. Important varieties include:

- **Kala Kulu (Balochistan):** Large, red-colored, sweet.
- **Amri (Balochistan):** Greenish-yellow, crisp, slightly sour.
- **Kaja (Balochistan):** Medium size, red-striped, sweet flavor.
- **Golden Delicious (Northern areas):** Yellow, sweet, juicy.
- **Red Delicious (Northern areas):** Dark red, crisp, widely grown.



Kala Kulu | Amri | Kaja | Golden Delicious | Red Delicious

Propagation of Apple

Apple is mainly propagated by grafting and budding (like tongue grafting, whip grafting and T-budding) using selected rootstocks. Seed propagation is used only for raising rootstocks, not for commercial fruiting. Vegetative propagation ensures uniformity, maintains quality and reduces the juvenile period, leading to early fruiting and better orchard management.

Requirements for Growth of Apple

- **Climate:** Apple is a temperate fruit requiring cold winters with sufficient chilling hours to break dormancy. It thrives in areas with mild summers and frost-free spring for good flowering and fruit set.
- **Soil:** Apple grows best in well-drained loamy soils rich in organic matter, with pH 6–7.
- **Irrigation:** Apple requires regular watering, especially during flowering and fruit development, but waterlogging must be avoided.
- **Other Needs:** Apple orchards need pruning to maintain shape, thinning to improve fruit size and protection from pests like codling moth and apple scab disease.

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Banana (Musa spp.)

Importance and Uses of Banana

Banana is one of the most widely consumed fruits in the world and is a vital food crop in tropical and subtropical regions. It is valued as a staple fruit due to its rich carbohydrate content, natural sugars, vitamins (A, B6, C), potassium and dietary fiber, making it an excellent source of quick energy. Bananas are eaten fresh as a dessert fruit and are also processed into chips, banana puree, flour, jam and baby food. Plantains, a starchy type of banana, are cooked and used as a vegetable in many cuisines. Banana leaves are traditionally used as natural plates and food wrappers, while the pseudostem and peels serve as fodder for animals. Banana fiber is also used in making ropes, mats and handicrafts. Thus, banana is both a nutritious food and a multipurpose crop of great economic importance.

Fig 1.14: Banana Plant

Varieties of Banana in Pakistan

Banana is cultivated mainly in Sindh and some parts of Punjab and Balochistan. Popular commercial varieties include:

- **Basrai (Dwarf Cavendish):** Widely grown in Sindh; short-statured plant, good for high-density planting.
- **Grand Naine (G-9):** A Cavendish type; large bunches, high-yielding, and suitable for export.
- **Williams Hybrid:** Vigorous growth, heavy bunches, and long shelf life.
- **Kluai Khai (Apple Banana):** Sweet, small-sized fruit with a distinct aroma.
- **Red Banana:** Reddish peel with unique flavor, grown on a limited scale.

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Propagation of Banana

Banana is propagated mainly through suckers (offshoots) that arise from the underground rhizome of the mother plant. Healthy sword suckers are preferred as they produce strong plants and ensure true-to-type growth. Water suckers are weaker and less desirable. In modern commercial farming, plant tissue culture (micropropagation) is widely used to produce disease-free, uniform and vigorous plantlets in large quantities.

Fig 1.15: Mothe Plant with suckers

Requirements for Growth of Banana

- **Climate:** Banana requires a warm, humid, tropical to subtropical climate. The optimum temperature range is 20–30 °C. Frost, drought and strong winds adversely affect growth and yield.
- **Soil:** Prefers deep, fertile, well-drained loamy soil, rich in organic matter, with a pH of 5.5–7.5. It is sensitive to waterlogging.
- **Irrigation:** Banana requires regular and adequate irrigation as it is a water-loving crop. Drip irrigation is highly effective. Over-irrigation and stagnant water should be avoided.
- **Other Needs:** Proper orchard management includes desuckering (keeping one follower sucker), propping for support of heavy bunches, removal of dry/diseased leaves and timely application of fertilizers. Artificial ripening with safe methods (ethylene) ensures good fruit quality for the market.

Grapes *(Vitis vinifera)*

Importance and Uses of Grapes

Grapes are one of the oldest cultivated fruits in the world, valued for their delicious taste, nutritional qualities and economic significance. They are a rich source of natural sugars, vitamins (C, B-complex, K), minerals like potassium and

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iron and powerful antioxidants such as resveratrol. Grapes are consumed fresh as table fruit, dried into raisins, or processed into juice, jams, jellies, vinegar and beverages. In many countries, grapes form the basis of the wine industry. In addition, grape seeds and skins are used for extracting oil, animal feed and natural colorants. Thus, grapes are both a valuable food crop and a significant source of income for growers.

Fig 1.16: Grapes

Varieties of Grapes in Pakistan

Grapes are mainly grown in Balochistan, Khyber Pakhtunkhwa and some parts of Punjab. Common varieties include:

- **Kishmishi (Seedless):** Popular for raisin production; sweet and seedless.
- **King's Ruby:** Large, red grapes with good flavor; table variety.
- **Flame Seedless:** Attractive red, seedless variety, suitable for fresh consumption.
- **Perlette:** Early maturing, light green, seedless variety.
- **Thompson Seedless:** Internationally popular; used both as fresh fruit and for raisin making.
- **Black Monukka:** Dark-skinned, sweet and seedless variety.

Propagation of Grapes

Grapes are propagated mainly through **hardwood cuttings** taken from healthy, disease-free vines during dormancy. Cuttings develop roots easily and ensure true-to-type plants. Propagation through grafting and budding is also practiced for introducing improved varieties onto disease-resistant rootstocks. Plant tissue

Fig 1.17: Hardwood Cutting of Grapes

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culture is being explored but is not common commercially.

Requirements for Growth of Grapes

- **Climate:** Grapes require a temperate to subtropical climate with hot, dry summers and cool winters. A short period of winter chilling is necessary for proper bud break. Excess rainfall and humidity during flowering and fruiting cause diseases and reduce fruit quality.
- **Soil:** Grapes grow well in deep, well-drained sandy loam to clay loam soils, with a pH of 6.0–7.5. They are moderately tolerant to salinity and drought.
- **Irrigation:** Grapes require moderate but regular irrigation, especially during fruit development. Excess watering should be avoided as it affects berry sweetness and may cause root rot.
- **Other Needs:** Proper training (on trellises or arbors), pruning, thinning and canopy management are essential for good yields and fruit quality. Disease management (against powdery mildew, downy mildew) and pest control (mealybugs, thrips) are also important.

1.5 Status of Pakistani Fruits in International Market

Pakistan's fruit export sector faces several problems that reduce its international competitiveness. Major issues include poor post-harvest handling, high post-harvest losses (up to 30–40%), lack of modern grading, packaging and cold chain facilities and limited compliance with international phytosanitary standards. Transportation bottlenecks and high freight charges also limit access to distant markets.

To address these challenges, the Government of Pakistan has taken various positive initiatives. Cold storage and fruit treatment plants have been established in major fruit-growing regions and special emphasis has been given to hot water treatment and vapor heat treatment to meet quarantine requirements of importing countries. The Trade Development Authority of Pakistan (TDAP) promotes fruit exports through participation in international exhibitions, branding, and market linkages. Research institutes and universities are working on developing disease-resistant and high yielding varieties of citrus and mango. These initiatives reflect the government's efforts to modernize the fruit value chain and increase export earnings.

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1.6 Factors Affecting the Success of Fruit Production

The success of fruit production depends on a combination of natural, technical and socio-economic factors:

1. **Climatic Conditions:**

   Temperature, rainfall, humidity and sunlight greatly influence fruit growth and yield. For example, mangoes require hot, dry summers, while apples need chilling hours in winter for proper flowering.

2. **Soil and Water Availability:**

   Fruit crops need fertile, well-drained soils rich in organic matter. Soil pH, salinity and nutrient status play a vital role in plant health. Reliable irrigation is crucial, as water scarcity or waterlogging both harm crops.

3. **Varieties and Planting Material:**

   The choice of high-yielding, disease-resistant and climate-suitable varieties is essential. Use of certified, true-to-type planting material ensures uniformity and better yields, while poor-quality plants reduce orchard performance.

4. **Agronomic Practices:**

   Proper land preparation, spacing, fertilization, irrigation, pruning, weeding and pest management directly affect productivity. Negligence in orchard management lowers both yield and fruit quality.

5. **Pests and Diseases:**

   Insect pests (fruit flies, mealybugs, borers) and diseases (fungal, viral, bacterial) can cause heavy losses. Integrated Pest Management (IPM) and disease-resistant varieties are crucial for sustainable production.

6. **Post-Harvest Handling:**

   Harvesting at the right maturity stage, careful handling, proper storage and packaging determine fruit quality. Poor post-harvest practices lead to spoilage, reducing market value and export potential.

7. **Market Access and Infrastructure:**

   Availability of storage, transport, grading and processing facilities, along with fair pricing, motivates farmers to invest in orchards. Weak infrastructure and market fluctuations discourage production.

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8. Socio-Economic and Policy Factors:

Access to credit, government support programs, research and extension services and farmer awareness all affect fruit production. Regions with better institutional support usually achieve higher results.

Exercise

A. Multiple Choice Questions (MCQs)

1. Botanically, a fruit is defined as:

a) A sweet edible plant product
b) The mature ovary of a flower containing seeds
c) A fleshy part of the root
d) A vegetable consumed raw

2. In Horticulture, tomatoes and cucumbers are treated as:

a) Fruits b) Vegetables
c) Root crops d) Oil seeds

3. Which method of propagation ensures true-to-type plants?

a) Seed propagation b) Vegetative propagation
c) Cross-pollination d) Natural fertilization

4. Which of the following is NOT a vegetative propagation method?

a) Grafting b) Budding
c) Pollination d) Layering

5. The scion in grafting refers to:

a) The root portion b) The upper shoot portion
c) The soil medium d) The flowering part only

6. Which fruit requires chilling hours in winter for flowering?

a) Mango b) Apple c) Banana d) Guava

7. Kinnow is a variety of:

a) Apple b) Mango c) Citrus d) Banana

8. Mango is mainly propagated by:

a) Seeds b) Grafting
c) Cuttings d) Layering

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9. **The main propagation method for bananas is:**

a) Seeds b) Rhizome suckers

c) Grafting d) Air layering

10. **Which factor contributes most to post-harvest fruit losses in Pakistan?**

a) Excess fertilizer use b) Lack of cold storage and handling

c) Use of hybrid seeds d) Over-irrigation

B. Short Questions

1. Define fruit Botanically and Horticulturally.
2. List any four vegetative methods of fruit plant propagation.
3. What is the role of rootstock in fruit production?
4. Name two tropical fruits and two temperate fruits.
5. Give two uses of citrus fruits other than direct consumption.
6. Write four common varieties of guava grown in Punjab.

C. Long Questions

1. Explain the effect of rootstock on the growth, adaptability and yield of fruit plants.
2. Describe the climatic requirements and growth conditions of mango and apple in detail.
3. What are the major problems faced by Pakistani fruits in the international market?
4. Explain different methods of propagation of fruit plants with suitable examples.

D. Inquisitive / Critical Thinking Questions

1. Why do you think mango and banana cannot be grown successfully in the same regions as apple?
2. If you were to advise a farmer in Balochistan, which fruit crop would you recommend and why?
3. How does the choice of propagation method affect the uniformity and market value of fruits?

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02 CONDIMENTS AND MEDICINAL PLANTS

Student's learning outcomes — **Students will be able to:**

- Define condiments and medicinal plants.
- Explain the importance of condiments and medicinal plants.
- Enlist different condiments.
- Enlist different types of medicinal plants.
- Identify major medicinal plants.
- Enlist minor medicinal plants.
- Identify different ecological zones of medicinal plants.
- Describe the soil and environmental requirements for medicinal plants.
- Explain methods of cultivation of some major medicinal plants.
- Discuss harvesting techniques for major medicinal plants.
- Describe the methods employed for storage, packing and processing of major medicinal plants.
- Explain the chemical composition of some major medicinal plants.
- Describe the uses of some major medicinal plants.
- Discuss the business model of commercial medicinal plant (Aloe vera).

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2.1 Introduction

Condiments and Medicinal Plants

- **Condiments:**

  Condiments are plant products (such as spices, herbs or seeds) used to add flavor, aroma and taste to food. They are usually not consumed in large quantities but play a vital role in enhancing palatability and digestion.

Examples: Black pepper, turmeric, cumin, coriander and cardamom.

Fig 2.1: Different types of condiments

- **Medicinal Plants:**

  Medicinal plants are those plants that contain bioactive compounds used for preventing or curing diseases. They are natural sources of medicines, widely used in traditional systems like Ayurveda, Unani, and modern pharmaceuticals.

  Examples: Neem, Tulsi (Holy basil), Aloe vera and Ginger.

Fig 2.2 Common Medicinal Plant Parts

Importance of Condiments and Medicinal Plants

Many condiments such as turmeric, garlic and ginger not only improve taste but also provide health benefits due to their medicinal properties, including anti-inflammatory, antibacterial and antioxidant effects. In addition, condiments serve as valuable export commodities, contributing significantly to the national economy.

Medicinal plants are an important natural resource, providing remedies for a wide range of diseases and ailments. They are widely used in both traditional healing systems and modern medicine for drug production. Being natural, they are often considered safer alternatives with fewer side effects compared to synthetic drugs. Medicinal plants are rich sources of essential oils, alkaloids, glycosides and other bioactive compounds. They play a key role in healthcare, especially in rural areas where access to modern medicines is limited, making them vital for both public health and economic sustainability.

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2.2 Types of Condiments and Medicinal Plants

1. Different Types of Condiment Plants:

Fig 2.3 Spices

- **Spices:** Black pepper, cumin, coriander, turmeric, cardamom, cinnamon, cloves and mustard seeds
- **Herbs:** Basil, mint, rosemary, thyme and oregano
- **Others:** Garlic, ginger, chili and fenugreek

2. Different Types of Medicinal Plants

Medicinal plants can be categorized based on the plant part used or their medicinal function:

Fig 2.4 Medicinal Plants Parts

- **Leaf-based:** Tulsi (Holy basil), Neem and Aloe vera
- **Root-based:** Ginger, Licorice and Ginseng
- **Bark-based:** Cinchona and Cinnamon
- **Flower-based:** Chamomile and Saffron
- **Fruit/Seed-based:** Fennel, Cardamom and Fenugreek
- **Whole plant:** Dandelion and Aloe vera

2.2.1 Major Medicinal Plants

1. **Tulsi (Holy Basil)** – Leaves used for respiratory problems, immunity, and stress relief.
2. **Neem** – Leaves, bark and seeds used for antibacterial, antifungal and blood-purifying properties.
3. **Aloe vera** – Leaves used for skin diseases, burns and digestion.
4. **Ginger** – Roots used for digestion, nausea and anti-inflammatory purposes.
5. **Garlic** – Bulbs used to lower blood pressure, cholesterol and for antibacterial effects.

Fig 2.5: Major Medicinal Plants Parts

6. **Licorice** – Roots used for throat infections, coughs and digestive disorders.

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7. **Cinnamon** – Bark used for digestion, controlling blood sugar and as an antimicrobial.
8. **Chamomile** – Flowers used for relaxation, digestion and skin care.
9. **Ginseng** – Roots used for energy, immunity and reducing stress.
10. **Fennel** – Seeds used for digestion, mouth freshening and as a mild diuretic.

2.2.2 Minor Medicinal Plants

1. **Amla (Indian Gooseberry)** – Fruits used for immunity and digestion.
2. **Ashwagandha** – Roots used for stress relief and improving vitality.
3. **Peppermint** – Leaves used for digestion, refreshing aroma and cooling effects.
4. **Holy Thistle (Bitter Gourd leaves)** – Used for blood sugar control.
5. **Hibiscus** – Flowers used for cooling, hair care and cardiovascular health.
6. **Marigold / Calendula** – Flowers used for skin healing and anti-inflammatory purposes.
7. **Coriander** – Leaves and seeds used for digestion and detoxification.
8. **Fenugreek** – Seeds used for digestion, lactation and blood sugar regulation.
9. **Lemongrass** – Leaves used for digestion, fever and as a mild sedative.

2.3 Ecological Zones of Medicinal Plants in Pakistan

1. **Northern Temperate and Alpine Zone**
    - **Location:** Gilgit-Baltistan, Chitral, Swat, Murree, Kaghan, Skardu and Hunza
    - **Climate:** Cold winters, mild summers
    - **Medicinal Plants:** Ginseng, Valerian, Artemisia, Sage, Nettle and Aconitum

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2. Sub-Tropical Hills and Plains

- **Location:** Punjab valleys (Faisalabad, Sargodha and Rawalpindi) Khyber Pakhtunkhwa plains
- **Climate:** Warm summers and mild winters
- **Medicinal Plants:** Tulsi, Neem, Aloe vera, Peppermint and Lemongrass

3. Tropical and Desert Zones

- **Location:** Sindh plains, Southern Punjab and Balochistan deserts
- **Climate:** Hot summers and low rainfall
- **Medicinal Plants:** Fennel, Senna, Ginger and Garlic

4. Coastal and Mangrove Zones

- **Location:** Coastal Sindh, Makran coast (Balochistan)
- **Climate:** Saline soils, high humidity and moderate rainfall
- **Medicinal Plants:** Seaweed species, Mangrove plants (Avicennia, Rhizophora), Aloe vera

2.4 Soil and Environmental Requirements

Soil Requirements for Medicinal Plants

1. **Soil Type:**
   - Well-drained loamy soils are ideal for most medicinal plants.
   - Sandy loam or clay loam can also be suitable depending on the species.
   - Avoid waterlogged or heavy clay soils as they may cause root rot.
2. **Soil pH:**
   - Slightly acidic to neutral (pH 6–7.5) is preferred.
   - Some plants (like Aloe vera) can tolerate slightly alkaline soils.
3. **Soil Fertility:**
   - Rich in organic matter to support healthy growth and higher production of bioactive compounds.
   - Proper nutrients (N, P, K) should be available depending on the plant's requirements.

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Environmental Requirements for Medicinal Plants

1. **Climate:**
   - Varies by species:
     Temperate plants (e.g., Ginseng, Artemisia) need cold winters and mild summers.
     Tropical/sub-tropical plants (e.g., Tulsi, Aloe vera, Ginger) require warm temperatures.
   - Avoid extreme frost or prolonged drought unless the plant is drought-tolerant.
2. **Sunlight:**
   - Most medicinal plants require full to partial sunlight for optimum growth.
   - Shade-tolerant species (e.g., Peppermint, some forest herbs) grow under partial shade.
3. **Water/Irrigation:**
   - Regular watering is needed for young plants.
   - Excessive water should be avoided; many medicinal plants prefer moderately dry conditions once established.
4. **Altitude:**
   - Alpine and temperate medicinal plants thrive at higher altitudes (1500–3500 m).
   - Tropical medicinal plants are suited to plains and low hills.
5. **Air and Humidity:**
   - Good air circulation reduces fungal and bacterial diseases.
   - Some plants prefer moderate humidity (e.g., Mint), while others like Aloe vera prefer dry air.

2.5 Methods of Cultivation

1. Tulsi (Holy Basil) *(Oscimum sanctum)*

- **Propagation:** By seeds or stem cuttings.
- **Sowing:** Seeds are sown in nursery beds or directly in the field.
- **Spacing:** 30–45 cm between plants; 45–60 cm between rows.
- **Soil:** Well-drained, fertile loamy soil; pH 6–7.
- **Irrigation:** Regular watering during early growth; reduce watering at flowering stage.

Fig 2.6: Tulsi

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- **Care:** Mulching, weeding and pruning improve leaf yield.
- **Harvest:** Tulsi plant Leaves are harvested 90–120 days after sowing.

2. Aloe vera *(Aloe barbadensis)*

Fig 2.7: Aloe vera

- **Propagation:** By offsets (suckers) from mature plants.
- **Planting:** Offsets are planted in sandy loam soil with good drainage.
- **Spacing:** 45–60 cm between plants.
- **Climate:** Prefers hot and dry conditions; frost-sensitive.
- **Irrigation:** Moderate watering; avoid waterlogging.
- **Care:** Remove damaged leaves; apply organic fertilizers for better gel yield.
- **Harvest:** Mature leaves are harvested after 12–18 months.

3. Ginger *(Zingiber officinale)*

Fig 2.8: Ginger

- **Propagation:** By rhizomes (pieces of ginger with buds).
- **Planting:** Rhizomes are planted 5–10 cm deep in ridges or raised beds.
- **Spacing:** 20–25 cm between plants; 25–30 cm between rows.
- **Soil:** Fertile, well-drained loamy soil rich in organic matter; pH 5.5–6.5.
- **Irrigation:** Frequent watering, especially during dry periods.
- **Care:** Mulching, weeding and earthing up improve rhizome quality.
- **Harvest:** 8–10 months after planting when leaves turn yellow.

4. Neem (Azadirachta indica)

Fig 2.9: Neem Tree

- **Propagation:** By seeds or grafting for better quality.
- **Planting:** Seeds are sown in nursery beds or directly in the field.
- **Spacing:** 6–8 m between trees.
- **Soil:** Tolerates a wide range, from sandy to clay soils; well-drained is preferred.

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- **Climate:** Tropical and sub-tropical; withstands drought.
- **Irrigation:** Water young plants regularly; mature trees need little irrigation.
- **Harvest:** Leaves, bark and seeds can be harvested for medicinal use after 3–5 years.

5. Garlic *(Allium sativum)*

- **Propagation:** By cloves.
- **Planting:** Cloves are planted vertically in rows with the pointed end upwards.
- **Spacing:** 10–15 cm between plants; 20–25 cm between rows.
- **Soil:** Well-drained loamy soil rich in organic matter; pH 6–7.
- **Irrigation:** Keep soil moist but avoid waterlogging.

Fig 2.10: Garlic

- **Care:** Mulching and weeding enhance bulb development.
- **Harvest:** 6–8 months after planting, when leaves turn yellow and start drying.

2.6 Harvesting techniques for major medicinal plants:

1. Tulsi (Holy Basil)

- **Parts harvested:** Leaves and tender shoots.
- **Technique:**
  - Leaves are plucked by hand to avoid damaging the plant. Harvesting is done early in the morning for maximum essential oil content.
  - Plants can be harvested 2–3 times during a growing season.
- **Precautions:** Avoid harvesting during flowering if leaves are the primary product; use clean tools.

2. Aloe vera

- **Parts harvested:** Mature leaves.
- **Technique:**
  - Leaves are cut near the base using a sharp knife.
  - Outer leaves are harvested first, leaving inner young leaves to continue growth.

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- **Precautions:** Avoid damaging the central growing point; handle leaves carefully to prevent contamination of gel.

3. Ginger

- **Parts harvested:** Rhizomes.
- **Technique:**
  - Harvesting is done when leaves turn yellow and dry.
  - Plants are carefully dug up using forks or spades to avoid rhizome injury.
  - Rhizomes are washed and cleaned before storage or processing.
- **Precautions:** Avoid bruising or cutting rhizomes as it reduces shelf life and quality.

4. Neem

- **Parts harvested:** Leaves, seeds, bark and flowers.
- **Technique:**
  - Leaves: Plucked by hand or using shears.
  - Seeds: Collected after falling or by shaking branches.
  - Bark: Carefully removed in strips from mature trees.
- **Precautions:** Ensure sustainable harvesting to avoid damaging the tree; only mature parts are harvested.

5. Garlic

- **Parts harvested:** Bulbs.
- **Technique:**
  - Harvesting is done when 70–80% of leaves turn yellow and start drying.
  - Bulbs are dug up carefully with a fork or spade.
  - After harvest, bulbs are cured in shade for 2–3 weeks to improve storage life.
- **Precautions:** Avoid direct sunlight and mechanical injury to bulbs during handling.

Key Principles of Medicinal Plant Harvesting

1. Harvest at the correct growth stage for maximum medicinal compounds.
2. Use clean tools and hands to prevent contamination.
3. Avoid over-harvesting to ensure sustainable production.
4. Timing (season and time of day) affects the quality and potency of plant parts.

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5. Proper post-harvest drying, storage and processing maintain bioactive compounds.

2.7 Storage, Packing and Processing Methods for Major Medicinal Plants:

1. Storage of Medicinal Plants

- **Drying:**
  - Fresh plant parts (leaves, roots, bark flowers) are dried under shade or in controlled ovens to reduce moisture content and prevent fungal growth.
  - Temperature and humidity are carefully controlled to preserve bioactive compounds.
- **Cold Storage:**
  - For plants with volatile oils (e.g., Tulsi, Mint) storage in cool, dry places or refrigerated rooms is preferred.
- **Containers:**

  Use airtight containers, glass jars, or moisture-proof bags to avoid contamination and moisture absorption.
- **Precautions:**
  - Avoid exposure to sunlight, high humidity and pests.
  - Label containers with plant name, date of harvest and part stored.

2. Packing of Medicinal Plants

- **Primary Packing:**
  - Plant material is packed in clean, dry and airtight bags.
  - Powdered herbs may be packed in sealed pouches to retain aroma and medicinal properties.
- **Secondary Packing:**
  - For transport or export, materials are packed in cartons or crates with proper cushioning to avoid crushing.
  - Include moisture absorbers if necessary.
- **Labeling:**
  - Name of plant, part used, date of packing, storage instructions and manufacturer/exporter details.

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3. Processing of Medicinal Plants

- **Cleaning:**
  - Remove soil, dust and foreign material from roots, leaves and seeds.
- **Drying/Dehydration:**
  - Shade drying, sun drying or hot-air drying depending on plant sensitivity.
- **Cutting and Grinding:**
  - Leaves, stems or roots are cut into small pieces or powdered for easy use and extraction.
- **Extraction of Active Compounds:**
  - Essential oils, alkaloids, glycosides and other bioactive compounds are extracted using water, alcohol or other solvents.
- **Formulation:**
  - Prepared as tablets, capsules, tinctures, powders, teas or oils for medicinal use.
- **Quality Control:**

Ensure purity, potency and absence of contamination or adulteration.

2.8 Chemical Composition of Some Major Medicinal Plants:

The medicinal value of plants is largely due to **bioactive chemical compounds** (alkaloids, flavonoids, tannins, essential oils and glycosides) which determine their therapeutic uses.

1. Tulsi *(Holy Basil)*

- **Active Compounds:** Eugenol, ursolic acid, rosmarinic acid, flavonoids, tannins and volatile oils.
- **Medicinal Importance:**
  - Eugenol provides antimicrobial and anti-inflammatory effects.
  - Flavonoids and tannins act as antioxidants.
  - Ursolic acid contributes to stress reduction and immunity enhancement.

2. Neem *(Azadirachta indica)*

- **Active Compounds:** Nimbin, nimbidin, azadirachtin, flavonoids, tannins

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and alkaloids.

- **Medicinal Importance:**
  - Azadirachtin is insecticidal and antifungal.
  - Nimbin and nimbidin have antibacterial and antiviral properties.
  - Flavonoids and tannins help in wound healing and blood purification.

3. Aloe vera

- **Active Compounds:** Aloin, aloe-emodin, polysaccharides (acemannan), vitamins (A, C, E), minerals and enzymes.
- **Medicinal Importance:**
  - Aloin and aloe-emodin act as laxatives and antibacterial agents.
  - Polysaccharides enhance wound healing and immunity.
  - Vitamins and minerals support overall health and skin care.

4. Ginger *(Zingiber officinale)*

- **Active Compounds:** Gingerol, shogaol, zingerone, volatile oils, starch and proteins.
- **Medicinal Importance:**
  - Gingerol and shogaol provide anti-inflammatory, antioxidant and digestive benefits.
  - Volatile oils help in treating nausea and respiratory issues.

5. Garlic *(Allium sativum)*

- **Active Compounds:** Allicin, alliin, ajoene, sulfur compounds, vitamins (C, B6) and flavonoids.
  - **Medicinal Importance:**
  - Allicin and sulfur compounds reduce cholesterol, control blood pressure and have antimicrobial properties.
  - Flavonoids act as antioxidants and support cardiovascular health.

6. Cinnamon *(Cinnamomum verum)*

- **Active Compounds:** Cinnamaldehyde, eugenol, coumarin, tannins and essential oils.
- **Medicinal Importance:**
- Cinnamaldehyde provides antibacterial and antifungal activity.
- Eugenol and tannins support digestion and anti-inflammatory action.

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2.9 Uses for Major and Minor Medicinal plants

Plant Name	Part Used	Major Ingredient / Active Element	Major Uses	Category
Tulsi (Holy Basil)	Leaves	Eugenol, Ursolic Acid, Flavonoids	Boosts immunity, relieves stress, treats cold, cough, and respiratory issues	Major
Neem	Leaves, Bark, Seeds	Azadirachtin, Nimbin, Nimbidin	Antibacterial, antifungal, blood purifier, skin diseases	Major
Aloe vera	Leaves (Gel)	Aloin, Aloe-emodin, Polysaccharides	Heals burns, skin care, digestion, immunity	Major
Ginger	Rhizomes	Gingerol, Shogaol, Zingerone	Relieves nausea, aids digestion, anti-inflammatory	Major
Garlic	Bulbs	Allicin, Alliin, Ajoene	Lowers cholesterol, controls blood pressure, antimicrobial	Major
Cinnamon	Bark	Cinnamaldehyde, Eugenol	Aids digestion, lowers blood sugar, antibacterial	Major

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Ginseng	Roots	Ginsenosides, Polysaccharides	Boosts energy, immunity, reduces stress	Major
Chamomile	Flowers	Apigenin, Bisabolol, Flavonoids	Promotes relaxation, improves digestion, soothes skin	Major
Fennel	Seeds	Anethole, Fenchone	Aids digestion, relieves bloating, freshens breath	Major
Amla (Indian Gooseberry)	Fruits	Ascorbic Acid (Vitamin C), Polyphenols	Boosts immunity, improves digestion, rich in Vitamin C	Minor
Ashwagandha	Roots	Withanolides, Alkaloids	Reduces stress, improves vitality, supports nervous system	Minor
Peppermint	Leaves	Menthol, Menthone	Aids digestion, relieves headaches, cooling effect	Minor
Hibiscus	Flowers	Anthocyanins, Flavonoids	Reduces blood pressure, skin care, digestive aid	Minor
Marigold/ Calendula	Flowers	Triterpenoids, Flavonoids	Heals wounds, reduces inflammation, skin treatment	Minor
Fenugreek	Seeds	Saponins, Alkaloids, Flavonoids	Aids digestion, promotes lactation, controls blood sugar	Minor
Lemongrass	Leaves	Citral, Geraniol	Digestive aid, mild sedative, reduces fever	Minor

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Holy Thistle	Leaves	Cnicin, Flavonoids	Helps control blood sugar, digestive aid	Minor
Coriander	Leaves, Seeds	Linalool, Cineole	Aids digestion, detoxifies body, culinary use	Minor

2.10 Business Model of Commercial Aloe vera

1. Overview of Aloe vera as a Commercial Crop

- Aloe vera is a high-value medicinal and cosmetic plant, widely used for its gel in pharmaceuticals, cosmetics and beverages .
- It has short gestation (ready for first harvest in 12–18 months) and high market demand, making it a profitable commercial crop.

2. Cultivation Business Model

a) Land and Site Selection:

- Requires well-drained sandy loam soils having pH 5.5–7.5.
- Best suited for arid and semi-arid regions with hot, dry climate.
- Can be grown on marginal lands not suitable for conventional crops.

b) Planting Material and Propagation:

- It is Propagated through offsets/suckers taken from mature plants.

c) Planting and Maintenance:

- Spacing: 45–60 cm between plants.
- Irrigation: Aloe vera needs Moderate irrigation, one must avoid waterlogging or excess of watering.
- Fertilization: Organic and mineral fertilizers enhance gel yield.
- Weed and pest management required during early growth.

d) Harvesting:

- Mature leaves are harvested 12–18 months after planting.
- Outer leaves are removed carefully to allow regrowth.

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3. Processing and Value Addition

Fig 2.11: Gel Extraction

- **Gel extraction:** Leaves are washed, filleted and processed into pure gel.
- **Value-added products:** Aloe vera gel, juice, powders, cosmetics, ointments and supplements.
- **Packaging:** Airtight containers or sachets for retail; bulk packaging for industrial supply.

4. Marketing and Distribution

- **Direct sales:** To cosmetic, pharmaceutical and beverage industries.
- **Retail market:** Aloe vera gels, juices and skincare products.
- **Export potential:** High demand in European Union, USA, Middle East and East Asia.

5. Revenue and Profitability

- Initial investment includes land preparation, planting material, irrigation and labor.
- Recurring costs: Fertilizers, maintenance, harvesting and processing.
- High returns come from value-added products rather than raw leaves.
- **Break-even**: Typically achieved 2–3 years after initial planting when gel extraction and product sales begin.

6. Risks and Challenges

- Climate sensitivity: Frost or excessive rainfall can damage plants.
- Market fluctuations in gel prices.
- Initial investment in processing facilities can be high.
- Requires proper post-harvest handling to prevent spoilage.

7. Key Success Factors

- Adoption of modern cultivation techniques (drip irrigation, plant tissue culture).
- Investment in value addition and branding.
- Targeting export-oriented markets.
- Sustainable farming practices to maintain long-term productivity.

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Exercise

A. Multiple Choice Questions (MCQs)

1. **Which part of Aloe vera is primarily used for medicinal purposes?**
   A) Roots B) Leaves C) Stem D) Flowers
2. **Which bioactive compound in Tulsi contributes to stress reduction and immunity enhancement?**
   A) Allicin B) Gingerol
   C) Ursolic acid D) Cinnamaldehyde
3. **Neem leaves, bark and seeds are used for:**
   A) Anti-inflammatory purposes only
   B) Antibacterial, antifungal, and blood-purifying properties
   C) Flavoring food D) Energy boosting
4. **Which soil pH range is ideal for most medicinal plants?**
   A) 4–5 B) 5–5.5
   C) 6–7.5 D) 8–9
5. **Which zone in Pakistan is suitable for growing Ginseng and Artemisia?**
   A) Coastal Zone B) Tropical Plains
   C) Northern Temperate and Alpine Zone D) Sub-Tropical Hills
6. **Ginger is propagated commercially through:**
   A) Seeds B) Offsets
   C) Rhizomes D) Cuttings
7. **Which compound in Garlic helps reduce cholesterol and control blood pressure?**
   A) Eugenol B) Allicin C) Aloin D) Cinnamaldehyde
8. **Which of the following is a minor medicinal plant?**
   A) Aloe vera B) Tulsi
   C) Ashwagandha D) Cinnamon

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9. The ideal irrigation practice for Aloe vera is:

A) Frequent heavy watering
B) Moderate watering, avoiding waterlogging
C) No watering needed D) Flood irrigation

10. Which of the following is NOT a primary packing material for medicinal plants?

A) Polyethylene bags B) Kraft paper bags
C) Glass jars D) Metal sheets

B. Short Questions

1. Define condiments and give three examples.
2. List three medicinal plants and the part used from each.
3. Name two bioactive compounds in Ginger and their medicinal uses.
4. Describe the propagation method of Tulsi.
5. What is the key principle of sustainable harvesting of medicinal plants?
6. List two major value-added products of Aloe vera.

C. Long Questions

1. Explain the importance of condiments and medicinal plants in human health and economy.
2. Discuss the ecological zones of medicinal plants in Pakistan and give examples of plants grown in each zone.
3. Describe the cultivation practices, soil and climate requirements and harvesting methods for Aloe vera.
4. Explain the storage, packing and processing methods for major medicinal plants.

D. Inquisitive/Analytical Questions

1. Compare the medicinal benefits of Tulsi and Neem. Which is more versatile and why?
2. How does the ecological zone influence the choice of medicinal plants for cultivation in Pakistan?
3. Why is Aloe vera considered a high-value crop despite its long gestation period?

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03 SEED PRODUCTION

Student's learning outcomes **Students will be able to:**

- Define seed.
- Enlist characteristics of good seeds.
- Explain the importance of seed production.
- Give classification of seeds.
- Define monocot seeds and give examples.
- Define dicot seeds and give examples.
- Draw and label monocot and dicot seeds.
- Describe various types of seeds.
- Define and explain pre-basic seed and give its importance.
- Define basic seed and give its importance.
- Define certified seed and give its importance.
- Define approved seed and give its importance.
- Define seed quality.
- Determine the importance of seed quality in crop production.
- Discuss the process of seed production.
- Define seed storage.
- Discuss the role of seed storage in crop production.
- Define seed certification.
- Define and explain the seed Act.

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3.1 Introduction

Definition of Seed:

A seed is a mature fertilized ovule of a plant that contains an embryo, nutritive tissue and a protective seed coat. It is capable of germinating under suitable conditions to grow into a new plant.

Fig 3.1: A Seed

Characteristics of a Good Seed:

Good seed should have the following traits:

1. **High viability** – Ability to germinate and produce

healthy seedlings.

2. **Purity** – Free from weeds, dirt and other seeds.
3. **Uniform size and shape** – Ensures uniform growth of plants.
4. **Healthy and disease-free** – No infections or damage from pests.
5. **Good germination percentage** – High proportion of seeds that geminate.
6. **Adequate moisture content** – Not too dry or too wet to prevent decay.
7. **Genetic purity** – True-to-type seeds that retain desired characteristics of the variety.

Importance of Seed Production:

Seed production is a vital component of agriculture because it ensures the availability of high-quality seeds, which lead to healthy and high-yielding plants. By maintaining genetic purity, seed production preserves the desired traits of crop varieties, allowing farmers to grow crops with predictable characteristics. It also plays a key role in supporting food security by providing reliable seeds that enable sufficient food production. Furthermore, good seed production promotes uniformity in crop growth, making field management and harvesting more efficient. Using disease-free seeds helps reduce the spread of seed-borne pathogens, protecting crops from potential losses. Additionally, high-quality seeds provide significant economic benefits by increasing crop yield and profitability for farmers.

3.2 Classification of Seeds

Seeds can be classified in multiple ways based on their botany, use, structure and more.

1. Botanical Classification (Based on Number of Cotyledons)

This is the most fundamental scientific classification.

Type	Description	Examples
Monocotyledonous (Monocots)	Seeds with only **one cotyledon** (seed leaf).	**Cereals:** Rice, Wheat, Maize, Barley **Others:** Onion, Grass, Palm, Orchids
Dicotyledonous (Dicots)	Seeds with **two cotyledons**.	**Pulses:** Gram, Lentil, Bean, Pea **Others:** Mango, Sunflower, Mustard, Apple

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Polycotyledonous	Seeds with **more than two cotyledons**.	Pine, Fir, Spruce, Cycads

2. Agricultural & Economic Classification (Based on Use)

This is the most common classification for farmers and the food industry.

Type	Description	Primary Use	Examples
Cereals	Seeds of grass plants.	Staple food; primary source of carbohydrates.	Wheat, Rice, Maize (Corn), Oats, Barley
Pulses	Edible seeds of leguminous plants.	Protein-rich food; "poor man's meat."	Lentil (Masoor), Chickpea (Chana), Kidney Bean (Rajma), Pea
Oilseeds	Seeds rich in oil content.	Source of vegetable oils and fats.	Mustard, Sunflower, Soybean, Groundnut, Canola, Castor
Vegetable Seeds	Seeds grown for edible parts.	Culinary use as food.	Tomato, Chili, Brinjal, Okra, Cucumber, Carrot
Forage Seeds	Seeds of plants grown for animal feed.	Fodder for livestock.	Alfalfa (Lucerne), Clover, Sorghum, Maize
Spices & Condiments	Seeds used for flavoring.	Add aroma, taste, and color to food.	Cumin (Zeera), Coriander (Dhania), Fennel (Saunf), Mustard
Fibre Seeds	Seeds of plants grown for fiber.	Source of textile and fabric.	Cotton, Jute, Flax (for linen)

3. Classification Based on Seed Storage Structure

This refers to the part of the seed we actually eat.

Type	Description	Examples
Endospermic Seeds	The endosperm is the main food storage tissue and is retained in the mature seed.	**Cereals:** Wheat, Rice, Maize **Others:** Castor, Coconut
Non-Endospermic Seeds	The endosperm is absorbed during development, and the food is stored in the cotyledons.	**Pulses:** Gram, Bean, Pea **Others:** Mustard, Sunflower, Groundnut

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4. Classification Based on Germination Requirements

Some seeds have specific needs to break dormancy.

Type	Description	Examples
Orthodox Seeds	Can be dried to low moisture levels (3-5%) and stored for long periods at cold temperatures.	Tomato, Rice, Wheat, Most agricultural crops
Recalcitrant Seeds	**Cannot** tolerate drying and cannot be stored for long periods; they lose viability die if they desiccate.	Mango, Coconut, Cocoa, Tea, Jackfruit

5. Other Important Types

Type	Description	Examples
GM Seeds (Genetically Modified)	Seeds whose DNA has been altered using genetic engineering techniques for desired traits (e.g., pest resistance).	Bt Cotton, Bt Brinjal, Herbicide-resistant Soybean
Hybrid Seeds	Produced by cross-pollinating two different parent plants to get a seed with superior traits (hybrid vigor).	Many modern varieties of vegetables (Tomato, Chili) and cereals (Rice).
Heirloom / Desi Seeds	Open-pollinated seeds passed down through generations, known for their flavor and genetic diversity.	Traditional local varieties of vegetables and grains.
Treated Seeds	Coated with fungicides or insecticides to protect them from soil-borne diseases and pests.	Commonly used for Cotton, Wheat, and other commercial crops.

3.2.1 Monocot Seeds

Monocot seeds are seeds that have only one cotyledon (seed leaf) in their embryo. The cotyledon absorbs food from the endosperm during germination to support the growth of the young plant. Monocot seeds usually have scutellum (a specialized cotyledon) and their vascular bundles are scattered in the stem.

Examples of Monocot Seeds:

- **Wheat**
- **Maize (corn)**

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- **Rice**
- **Barley**
- **Sugarcane**

3.2.2 Dicot Seeds

Dicot seeds are seeds that have two cotyledons (seed leaves) in their embryo. These cotyledons store food, which is used during germination to nourish the young seedling. Dicot seeds usually have net-like (reticulate) leaf venation and their vascular bundles are arranged in a ring in the stem.

Examples of Dicot Seeds:

- **Bean**
- **Gram (Chickpea)**
- **Sunflower**
- **Pea**
- **Castor**

Do you know?

Monocots grow flower parts in multiples of three, while dicots produce flower parts in multiples of four or five.

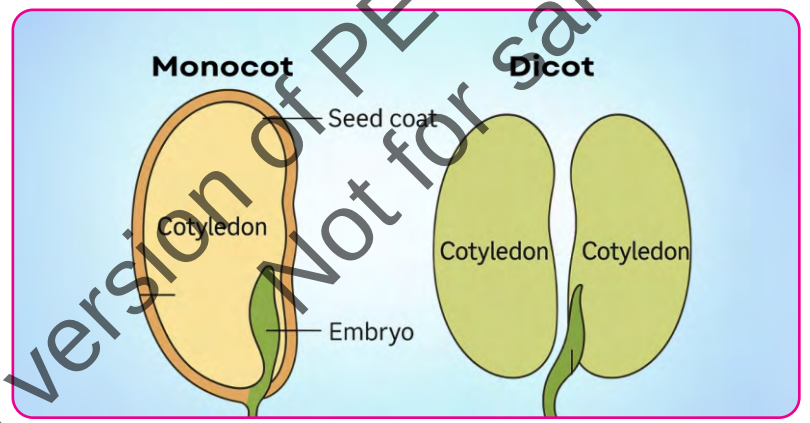

Fig 3.2: Difference Between Monocot and Dicot Seeds

3.3 Classes of Seed

3.3.1 Pre-Basic Seed

A pre-basic seed is the initial generation of seed produced directly from the breeder's seed. It is the first multiplication step in the seed production chain and is produced under strict supervision to maintain genetic purity, quality and identity of a crop variety.

Explanation:

- Breeder's seed → Pre-basic seed → Basic seed → Certified/Commercial

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seed → Farmers' field.

- Pre-basic seed acts as a bridge between breeder's seed and basic seed, ensuring that the desirable traits of the crop variety are preserved during initial multiplication.
- It is usually produced in small quantities under highly controlled conditions to prevent contamination or mixing.

Importance of Pre-Basic Seed:

1. **Maintains Genetic Purity:** Ensures that the variety remains true to type.
2. **Prevents Disease Transmission:** Produced under strict hygiene and isolation to avoid seed-borne diseases.
3. **Foundation for Basic Seed Production:** Provides high-quality seed for the next stage of multiplication.
4. **Ensures Uniform Crop Stand:** Seeds germinate uniformly, resulting in better crop management.
5. **Supports Food Security:** By maintaining quality from the very first stage, it indirectly ensures high yield and quality produce.

Pre-Basic Seed (also known as Breeder Seed or Nucleus Seed) is the highest quality class of seed in the formal seed certification system. It is the first generational step in the seed multiplication chain, produced directly from the nucleus stock of a plant variety by the originating plant breeder or a designated institution.

In simple terms, it is the "parent of all certified seeds," possessing the truest-to-type genetic identity and purity of the developed variety.

3.3.2 Basic Seed

A basic seed is a high-quality seed produced from pre-basic seed under strict supervision to maintain genetic purity, high germination rate and freedom from diseases. It serves as the foundation for producing certified or commercial seeds for farmers.

Importance of Basic Seed:

1. **Maintains Genetic Purity:** It preserves the true characteristics of a crop variety.
2. **High Germination Rate:** Ensures uniform and healthy crop growth.
3. **Disease-Free:** It reduces the risk of seed-borne diseases.
4. **Foundation for Commercial Seeds:** It is used to produce certified seeds

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for large-scale cultivation.

5. **Increases Crop Yield and Quality:** High-quality seeds lead to better productivity and economic benefits for farmers.

3.3.3 Certified Seed

A certified seed is a seed that is produced from basic seed under controlled conditions and is officially inspected and certified by seed certification authorities to ensure its genetic purity, high germination rate and freedom from diseases and weeds. It is the seed that is ultimately sold to farmers for commercial cultivation.

Importance of Certified Seed:

1. **Ensures High Yield:** Certified seeds germinate well and produce healthy and uniform crops.
2. **Maintains Genetic Purity:** It preserves the desired traits of the crop variety.
3. **Disease and Weed Free:** It reduces crop losses due to seed-borne diseases and contamination.
4. **Reliable for Farmers:** It provides confidence in crop performance and profitability.
5. **Supports Food Security:** High-quality seeds lead to better productivity and contribute to stable food supply.

3.3.4 Approved Seed

An approved seed is a seed that is produced from certified or basic seed under recommended conditions and meets minimum standards of purity, germination and physical quality, but may not be officially certified by the seed certification authorities. It is usually used in areas where certified seed is not available.

Importance of Approved Seed:

Approved seed is important because it maintains crop quality by ensuring good germination and healthy growth. It is genetically true-to-type preserving the desired traits of the variety. It also aids in disease and weed management by reducing the risk of seed-borne diseases and contamination. It is accessible to farmers as a quality seed option when certified seed is limited and supports higher productivity, leading to better crop yield and economic benefits compared to farm-saved or uncertified seeds.

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3.4 Seed Quality

Seed quality refers to the overall characteristics of a seed that determine its ability to germinate, grow into a healthy plant and produce a good yield. High-quality seeds are pure, viable, disease-free and genetically true-to-type.

Importance of Seed Quality in Crop Production:

The importance of seed quality in crop production lies in the fact that high-quality seeds are essential for successful cultivation, as they ensure high germination and uniform growth, leading to healthy and consistent crop stands. They maintain genetic purity, preserving the desirable traits of the crop variety and increase crop yield since healthy seeds develop into vigorous plants that produce more. Additionally, high-quality seeds reduce the risk of diseases by being free from seed-borne infections, which helps protect the crop and ensures better plant health. Overall, using quality seeds enhances profitability by minimizing losses, improving productivity and providing greater economic returns for farmers, making seed quality a cornerstone of efficient and sustainable crop production.

3.5 Seed Production

Process of Seed Production:

Seed production is a systematic process aimed at producing high-quality seeds that are genetically pure, viable and free from diseases. The process generally involves the following steps:

1. **Selection of Parent Material:**
   - Choose a high-yielding, disease-resistant and true-to-type variety.
   - The parent plants must have desirable traits such as uniformity, vigor and quality produce.
2. **Isolation of Seed Crop:**
   - Separate the seed crop from other varieties or crops to prevent cross-pollination and maintain genetic purity.
   - Isolation can be done by distance, barriers or time of planting.
3. **Land Preparation:**
   - Prepare well-drained and fertile soil for sowing.
   - Proper land preparation ensures good seed germination and

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growth.

4. **Sowing of Seeds:**
   - Use pre-basic or basic seeds depending on the stage of multiplication.
   - Follow recommended spacing, depth and sowing time to ensure healthy crop establishment.
5. **Crop Management:**
   - Provide adequate water, nutrients and weed control.
   - Monitor for pests and diseases and take timely control measures to protect the seed crop.
6. **Roguing:**
   - Identify and remove off-type, diseased, or inferior plants to maintain genetic purity and quality.
7. **Harvesting:**
   - Harvest seeds at the proper maturity stage to ensure maximum viability.
   - Avoid mechanical damage or exposure to unfavorable conditions.
8. **Processing and Cleaning:**
   - Clean seeds by removing chaff, dirt and damaged seeds.
   - Grading may be done to separate seeds by size and weight.
9. **Drying and Storage:**
   - Dry seeds to the recommended moisture content to prevent spoilage.
   - Store in cool, dry and pest-free conditions to maintain viability until use.
10. **Seed Testing and Certification:**
   - Test seeds for germination rate, purity, moisture content and health.
   - Certified seeds are labeled and ready for distribution to farmers.

The seed production process ensures that the seeds maintain genetic purity, high germination, disease resistance and overall quality, which are essential for successful crop production.

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3.6 Seed Storage

Seed storage is the process of keeping seeds under controlled conditions of temperature, moisture and protection from pests and diseases so that they retain viability, vigor and genetic purity until they are ready to be sown.

Role of Seed Storage in Crop Production:

The role of seed storage in crop production is crucial for ensuring successful and sustainable agriculture. Proper storage maintains seed viability and germination, preventing seeds from losing their ability to geminate and ensuring healthy crop establishment. It also preserves genetic purity by protecting seeds from contamination or mixing with other varieties, maintaining the desired traits. Additionally, controlled storage conditions prevent seed-borne diseases and pest damage, reducing the risk of fungal infections, insects and other pests. Seed storage ensures year-round availability, allowing farmers to access quality seeds regardless of seasonal production cycles and ultimately supports food security and productivity by keeping seeds viable and of high quality, which contributes to higher crop yields and stable agricultural output.

3.7 Seed Certification

Seed certification is the official process in which seeds are inspected, tested and approved by authorized seed certification agencies to ensure that they meet prescribed standards of genetic purity, germination, physical quality and freedom from diseases and weeds. Certified seeds are considered high-quality seeds suitable for commercial cultivation.

Importance of Seed Certification:

The importance of seed certification lies in its ability to ensure genetic purity, maintaining the true-to-type characteristics of the crop variety and guarantee high germination, providing seeds that produce healthy and uniform crops. It also reduces disease and weed contamination, as certified seeds are tested and treated to minimize seed-borne infections and foreign material. Seed certification builds farmer confidence by assuring the quality and performance of the seeds, and it supports higher productivity and profitability, since healthy and true-to-type seeds lead to better yields, economic returns and contribute to overall food security.

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3.8 Seed Act

A Seed Act is a legal framework enacted by a government to regulate the production, processing, labeling, marketing and quality control of seeds. Its main purpose is to ensure that farmers receive high-quality seeds that are true-to-type, disease-free and capable of producing good yields.

Explanation:

- The Seed Act sets standards for different classes of seeds such as breeder, pre-basic, basic, certified and approved seeds.
- It mandates seed certification and labeling to prevent the sale of low-quality or adulterated seeds.
- The Act empowers authorities to inspect seed farms, processing units and markets to enforce quality standards.
- It also penalizes those who sell substandard or misbranded seeds, protecting farmers from losses and promoting trust in the seed industry.

Importance:

The importance of the Seed Act lies in its ability to ensure seed quality, providing farmers with genetically pure, disease-free and viable seeds, while protecting farmers' interests by preventing the sale of inferior or adulterated seeds. It supports agricultural productivity by promoting the use of high-quality seeds that lead to better crop growth and yield, encourages research and development by facilitating the breeding of improved varieties under regulated conditions and maintains market standards, ensuring fair trade and trust within the seed industry.

Do you know?

To modernize the seed sector, the government launched the National Seed Development and Regulatory Authority (NSDRA) and approved the National Seed Policy 2025 to enhance certification and climate-resilient crop yields.

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Exercise

A) MCQs (Multiple Choice Questions)

1. **Which part of the seed contains the stored food in dicot seeds?**

A) Endosperm B) Cotyledons

C) Embryo D) Seed coat

2. Monocot seeds typically have:

A) Two cotyledons B) Reticulate leaf venation

C) One cotyledon D) Taproot system

3. Certified seed is produced from:

A) Pre-basic seed B) Breeder seed

C) Basic seed D) Farm-saved seed

4. Recalcitrant seeds:

A) Can be stored for long periods after drying

B) Cannot tolerate drying

C) Always genetically modified

D) Are high in oil content

5. The main purpose of seed certification is to:

A) Reduce crop price

B) Ensure genetic purity and high quality

C) Increase seed size

D) Produce hybrid seeds only

6. Pre-basic seed is also known as:

A) Approved seed B) Breeder seed or nucleus seed

C) Certified seed D) Farm-saved seed

7. The Seed Act is designed to:

A) Promote organic farming only

B) Regulate production, processing, labeling, and marketing of seeds

C) Sell seeds at subsidized rates

D) Prevent planting of GM crops

8. Which of the following is an endospermic seed?

A) Bean B) Pea

C) Rice D) Mustard

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9. Approved seed is used:

A) When certified seed is not available
B) Only for experimental crops
C) Only in research stations
D) For hybrid seed production

10. A good seed should have:

A) Low viability and mixed size
B) High germination, purity, and genetic purity
C) High moisture content and disease presence
D) Only large size

B) Short Questions

1. Define a seed and list its main components.
2. What are the characteristics of a good seed?
3. Differentiate between monocot and dicot seeds with examples.
4. Define pre-basic seed and explain its importance.
5. What is the role of seed storage in crop production?
6. Define certified seed and mention its two advantages.
7. What is the purpose of the Seed Act?

C) Long Questions

1. Explain the process of seed production step by step.
2. Discuss the classification of seeds based on botanical and agricultural criteria with examples.
3. Describe the different classes of seeds (pre-basic, basic, certified, approved) and their importance.
4. Explain seed quality and discuss its importance in crop production.

D) Inquisitive / Thought-Provoking Questions

1. Why is it necessary to maintain genetic purity from breeder seed to certified seed?
2. In what ways can seed certification improve farmer confidence and profitability?

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04 GRAIN STORAGE MANAGEMENT

Student's learning outcomes

Students will be able to:

- Define grain storage.
- Discuss the significance of grain storage in economy of Pakistan.
- Describe various qualitative and quantitative losses during grain storage.
- Explain the principles of storage.
- List and explain different types of storage.
- Describe different grain storage structures.
- Explain traditional and modern types of storage.
- Enlist various factors affecting grain storage.
- Define and enlist abiotic factors affecting grain storage.
- Discuss the role of temperature in grain storage.
- Explain the role of light in grain storage.
- Discuss the role of humidity in grain storage.
- Define and enlist biotic factors affecting the grain storage.
- List different insect pest damaging the grains in storage.
- List different pathogens affecting grains in storage.
- List different rodents damaging grains during storage.
- Enlist different birds damaging grains.
- Define and explain the importance of food storage.
- Define the stored grain management.
- List different methods of pest control in stored grains.
- Define fumigation.
- List the methods adopted in fumigation.
- State the benefits of fumigation.
- Describe the effect of proper grain storage.
- Suggest suitable steps to be taken to ensure safe grain storage.
- Describe how grain storage affects the prices in Pakistan.

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4.1 Introduction

Grain storage refers to the process of safely keeping harvested grains (such as wheat, rice, maize and barley etc.) in suitable conditions to protect them from pests, moisture and spoilage until they are consumed or marketed. It involves the use of storage facilities like silos, warehouses, godowns, or traditional structures to preserve both the quality and quantity of grains for short-term and long-term use.

Significance of Grain Storage in the Economy of Pakistan

Grain storage is highly significant for Pakistan's economy as it ensures food security, stabilizes prices and reduces post-harvest losses of 10–15%, saving billions of rupees annually. As wheat and rice are staple foods, efficient storage guarantees a steady supply, prevents hunger and protects farmers from distress sales by allowing them to sell later at better prices. It also strengthens the agricultural sector, which contributes about 19–20% to GDP, by maintaining supply chains, reducing imports and supporting exports of rice and maize. Moreover, stored grains also act as emergency reserves during natural disasters and global crises.

4.2 Losses During Grain Storage

Grain storage losses are of two types: Qualitative (deterioration of quality) and Quantitative (loss in weight/volume). Both types reduce the overall value and usability of grains.

1. Quantitative Losses

Quantitative losses in grain storage are the physical reduction in weight or volume of grains, lowering available supply. They occur through spillage and leakage during handling or from damaged containers. Insect pests like weevils and moths directly consume grains, while rodents feed on and contaminate large amounts. Birds also cause losses in open storage by eating exposed grains. Additionally, moisture damage leads to swelling, sprouting, or rotting, further reducing grain weight and usability.

2. Qualitative Losses

Grain quality decreases during storage, which lowers its food and market value. Excess moisture or fungi cause discoloration, making grains

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unattractive. Insects and molds reduce nutrients like proteins, vitamins, and carbohydrates. Seeds lose their ability to germinate if stored in hot or poorly ventilated places. Contamination by insects, rodents, or fungi makes grains unsafe to eat. Aflatoxins and microbial growth can harm both humans and animals. Bad smell and taste also develop, further reducing grain acceptability and price.

Principles of Grain Storage

The main principles of grain storage are based on preserving both quality and quantity of grains for long periods. These include:

1. **Cleanliness** – Storage facilities must be cleaned and disinfected to remove old grain residues, insects and fungi.
2. **Proper Drying** – Grains must be dried to safe moisture levels (usually 10–12%) before storage to prevent mold growth and gemination.
3. **Protection from Pests** – Grains should be protected from insects, rodents and birds through fumigation, sealing and proper packaging.
4. **Temperature Control** – Cool and stable temperatures slow down pest activity and chemical deterioration.
5. **Moisture Control** – Low humidity prevents fungal attack, caking and spoilage.
6. **Aeration and Ventilation** – Ensures circulation of air to avoid heat build-up and maintain grain quality.
7. **Regular Inspection** – Stored grains must be checked periodically for signs of pests, moisture or spoilage.

4.3 Types and Structure of Storage

Types of Grain Storage

Grain storage can be broadly classified into Traditional and Modern methods:

1. Traditional Storage

- **Mud bins / earthen pots** – Used in villages, made from clay, straw, or cow dung; cheap but less effective against pests.
- **Underground pits** – Grain buried in sealed pits; protects from theft but prone to moisture damage.

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- **Bamboo/wooden structures** – Locally made bins and baskets lined with mud or cow dung.
- **Gunny bags** – Widely used; easy to handle and transport, but vulnerable to insects, rodents, and moisture.

Fig 4.1: Bamboo/Wooden Structure

2. Modern Storage

- **Metal bins (silos/drums)** – Airtight, durable, and safe from pests; suitable for farmers at small to medium scale.
- **Godowns/Warehouses** – Large storage structures managed by government or private sectors; allow bulk storage in bags.
- **Silos (vertical structures)** – Silos are used for large-scale and long-term storage. Silos are made of metal or concrete, equipped with aeration and temperature control systems.
- **Cold storage** – Maintains low temperature and humidity; mainly used for seeds to preserve viability.
- **Hermetic storage** – Airtight plastic or metal containers that create a low-oxygen environment, killing insects and preventing infestation.

Fig 4.2: Silos

Fig 4.3: Cold Storage

4.4 Grain Storage Structures in Rural Areas

In rural areas, farmers mostly rely on traditional and low-cost storage structures made from locally available materials. These are suitable for small to medium quantities of grain but have limitations in pest and moisture control. The main structures are:

1. Mud Bins (Kuthla / Kothi)

- Mud Bins are made of clay mud, straw or cow dung.
  Commonly used for storing wheat, maize there are and pulses.
- Mud Bins are cheap and easy to construct but less durable and prone to insect and moisture attack.

2. Earthen Pots (Matkas / Ghara)

- Earthen pots are small storage units made of baked clay.

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- Used for storing small amounts of seeds or grains for household use.
- They are airtight when sealed, but are easily breakable.

3. Underground Pits (Khattis / Bhakharas)

- Grains stored in sealed pits dug into the ground.
- Provide protection from theft and high temperature.
- Risk of moisture seepage and fungal infestation in rainy season.

4. Bamboo / Wooden Bins

- Made by weaving bamboo strips or wood, plastered with mud and cow dung.
- Raised above the ground on a platform to protect from rodents.
- Inexpensive but not fully safe from insects.

5. Gunny Bags (Jute / Cloth Bags)

- Widely used in rural households and markets.
- Easy to handle, stack, and transport.
- Require storage in a dry, rodent-free room or godown, as they are vulnerable to moisture and pests.

4.5 Traditional and Modern Types of Grain Storage in Urban Areas

Traditional Storage in Urban Areas

Although urban centers are more advanced, some traditional storage methods are still practiced, especially for small-scale household use or by small traders. These methods include:

- **Gunny Bags (Jute or Cloth Bags):** The most common method in markets and households; easy to transport and stack in godowns but vulnerable to insects, rodents, and moisture.
- **Earthen Pots and Drums:** Used for small household storage; airtight when sealed but limited in capacity.
- **Wooden or Bamboo Bins:** Occasionally found in older market storage systems; inexpensive but not widely used today due to pest susceptibility.

These traditional methods are low-cost and convenient but have major drawbacks such as high post-harvest losses, poor protection against pests, and limited storage capacity.

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Modern Storage in Urban Areas

Urban regions, especially commercial and industrial hubs, rely more on scientific and large-scale storage structures to maintain grain quality and ensure food supply. These include:

- **Warehouses/Godowns:** Large storage buildings used by government and private sectors to keep grain in bags. They allow fumigation, inspection, and controlled management.
- **Metal Bins/Drums:** Airtight containers that protect grains from rodents, insects, and moisture; suitable for traders and small industries.
- **Silos:** Tall steel or concrete structures designed for bulk storage; equipped with aeration, temperature, and moisture control systems. Widely used for wheat, maize, and rice in urban centers.
- **Cold Storage:** Specialized storage for seeds and perishable commodities; maintains low temperature and humidity, preserving seed viability and food quality.
- **Hermetic Storage Systems:** Airtight bags or containers that limit oxygen, killing pests without chemicals and keeping grains fresh for long periods.

4.6 Factors Affecting Grain Storage

Following factors affect the grain storage.

1. **Moisture Content** – High grain moisture leads to fungal growth, sprouting and spoilage.
2. **Temperature** – Warm conditions increase insect activity, mold growth and nutrient loss.
3. **Relative Humidity** – High humidity causes caking, discoloration and fungal infestation.
4. **Storage Structure** – Poorly constructed bins, bags, or godowns allow entry of pests, moisture and air.
5. **Insect Infestation** – Weevils, beetles and moths damage stored grains physically and nutritionally.
6. **Rodents and Birds** – Rats, mice and birds feed on and contaminate stored grains.
7. **Cleanliness of Storehouse** – Presence of old residues, dust, or waste attracts pests and reduces grain quality.
8. **Handling and Transportation** – Rough handling causes spillage, leakage, and breakage losses.

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9. **Storage Duration** – Longer storage increases the risk of nutrient loss, viability reduction and infestation.
10. **Aeration and Ventilation** – Poor air circulation causes heating, condensation and fungal attack.
11. **Use of Chemicals/Fumigation** – Absence of protective measures increases pest buildup.
12. **Type of Grain** – Some grains (like maize) are more prone to insect and fungal damage compared to others (like wheat).

4.7 Abiotic Factors Affecting Grain Storage

Abiotic factors in grain storage are the non-living environmental conditions that influence the quality, safety and longevity of stored grains. Unlike biotic factors (insects, rodents, fungi), abiotic factors include physical and chemical conditions such as temperature, moisture and humidity that affect storage outcomes.

1. **Moisture Content of Grain** – High moisture (above 12–14%) leads to fungal growth, sprouting and rapid spoilage.
2. **Temperature** – High storage temperature increases insect activity, biochemical changes and nutrient loss.
3. **Relative Humidity** – Excess humidity promotes mold growth, caking and discoloration.
4. **Light Exposure** – Direct light may raise temperature inside storage and reduce seed viability.
5. **Oxygen and Carbon Dioxide Levels** – High oxygen promotes insect and microbial activity, while controlled low-oxygen storage preserves quality.
6. **Storage Duration** – Longer periods increase risk of deterioration due to cumulative abiotic effects.
7. **Ventilation/Aeration** – Poor ventilation causes heating, condensation and fungal infestation.
8. **Physical Condition of Storage Structure** – Cracks, leaks or poor insulation allow entry of moisture and air, accelerating spoilage.

Role of Temperature in Grain Storage

Temperature is one of the most critical factors affecting grain storage. High temperatures accelerate insect multiplication, fungal growth and biochemical

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changes in grains, leading to nutrient loss and spoilage. On the other hand, cooler temperatures slow down pest activity and preserve seed viability. Therefore, maintaining a stable and moderate temperature is essential for long-term storage.

Role of Light in Grain Storage

Light exposure during storage can increase the internal temperature of grains and containers, which indirectly favors insect and microbial activity. Continuous light may also reduce seed germination capacity and cause discoloration, lowering market value. For this reason, grains are usually stored in dark or covered conditions to maintain their quality.

Role of Humidity in Grain Storage

Humidity directly influences the moisture level of stored grains. High relative humidity (above 65%) encourages mold growth, caking, germination and loss of edibility. It also increases the risk of aflatoxin contamination. Low and controlled humidity levels, combined with proper aeration, keep grains dry and safe for long-term storage.

4.8 Biotic Factors Affecting Grain Storage

Biotic factors in grain storage are the **living organisms** that damage stored grains, causing both quantitative (weight/volume) and qualitative (nutritional/market value) losses.

1. **Insects and Pests** – Weevils, beetles, moths and borers feed on grains, reducing both quantity and quality.
2. **Rodents** – Rats and mice consume grains, cause spillage and contaminate storage with droppings and urine.
3. **Birds** – Sparrows, pigeons and other birds feed on exposed grains in open storage areas.
4. **Fungi/Molds** – Species like *Aspergillus* and *Penicillium* grow under damp conditions, causing discoloration, bad odor, and aflatoxin contamination.
5. **Bacteria** – Certain bacteria spoil grains, especially under high moisture conditions, reducing edibility and safety.
6. **Microorganisms in General** – Collectively, they reduce nutrient quality,

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seed viability and may produce toxins harmful to humans and livestock.

Pests and Organisms Damaging Grains in Storage

Grain storage is affected by a wide range of pests and organisms that cause both quantitative (loss of weight/volume) and qualitative (nutritional/market value) losses. These include insect pests, pathogens, rodents and birds.

1. Insect Pests

Insects are the most serious storage pests, as they feed directly on grains and multiply rapidly in warm, humid conditions.

- **Rice weevil** – Bores into whole grains like wheat, rice and maize.
- **Granary weevil** – Destroys stored wheat and maize.
- **Khapra beetle** – Highly destructive, feeds on wheat, rice and pulses.
- **Red flour beetle** – Infests flour and broken grains, causes bad odor.
- **Lesser grain borer** – Attacks cereal grains, making them powdery.
- **Pulse beetle**– Infests pulses like chickpea, lentil, and mung.
- **Indian meal moth**– Damages cereals, nuts and dried fruits.

2. Pathogens (Fungi and Bacteria)

Pathogens spoil grains mainly under high moisture and poor ventilation.

- **Fungi:**
  - *Aspergillus flavus* – Produces aflatoxins, highly toxic for humans and animals.
  - *Penicillium spp.* – Causes discoloration and off-flavor.
  - *Fusarium spp.* – Produces mycotoxins and reduces seed viability.
- **Bacteria:**
  - *Bacillus* and *Pseudomonas* species – Cause spoilage and bad odor in damp grains.

3. Rodents

Rodents consume grains directly and contaminate far more than they eat.

- **House rat** – House rat is common in godowns and households, It damages bags and eats grains.
- **Norway rat** – Larger species, causes heavy losses in warehouses.
- **House mouse**– Small but numerous, contaminates grain with droppings and urine.

4. Birds

Birds feed on exposed grains in markets and open storage areas.

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- **Pigeon** – Feeds on cereals in warehouses and open godowns.
- **Sparrow** – Picks small grains from bags or open heaps.
- **Crow** – Damages stored grains in open fields and markets.

Fig 4.4: Common Sparrow

4.9 Food Storage

Food storage is the practice of keeping harvested food materials, especially grains, under suitable conditions to preserve their quality, safety and edibility for future use.

Importance: Food storage is essential for ensuring food security, reducing post-harvest losses and maintaining a continuous supply throughout the year. In countries like Pakistan, where wheat and rice are staple foods, proper storage helps stabilize market prices, protect farmers' income and safeguard national reserves during emergencies such as droughts or floods. Efficient food storage also reduces dependency on imports and supports exports by maintaining quality standards.

Stored Grain Management

Stored grain management refers to the **systematic handling of grains during storage** to maintain their quality and quantity by controlling environmental conditions and protecting them from pests. It involves regular inspection, moisture and temperature monitoring, fumigation, aeration, cleaning and pest management to minimize losses and ensure safe consumption.

Methods of Pest Control in Stored Grains

1. **Preventive Methods**
   - Cleaning and disinfecting storage structures before filling.
   - Drying grains to safe moisture levels (10–12%) before storage.
   - Using pest-proof structures like metal bins or silos.
2. **Physical Methods**
   - Aeration and ventilation to remove heat and moisture.
   - Low temperature storage or cold storage to slow pest activity.
   - Hermetic storage (airtight bags/containers) to limit oxygen and kill

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insects naturally.

3. **Cultural Methods**
   - Regular turning, sun-drying or exposure of grains to heat/light to kill hidden Insects.
   - Proper stacking of bags on wooden pallets to avoid moisture absorption.
4. **Biological Methods**
   - It is the of natural enemies (predators, parasitoids and pathogens) to control insect pests.
   - Application of biopesticides like *Bacillus thuringiensis* against moth larvae.
5. **Chemical Methods**
   - **Surface sprays** and dusts for bagged grains.
   - **Fumigation** with chemicals like phosphine, methyl bromide in airtight conditions to kill hidden pests.
   - **Insecticides** and protectants applied to grains for long-term safety.

4.10 Fumigation in Grain Storage

Fumigation is the process of exposing stored grains or storage structures to toxic gases or fumes of chemicals in airtight conditions to kill insects, pests and microorganisms. It is one of the most effective methods for controlling hidden storage pests that cannot be eliminated by surface treatments.

Methods of Fumigation

1. **Sheet Fumigation** – Grain stacks or bags are covered with gas-proof plastic sheets and fumigants (e.g., phosphine tablets) are released underneath.
2. **Chamber Fumigation** – Grains are placed in airtight chambers or silos where controlled fumigation is carried out.
3. **Container Fumigation** – Container fumigation is used for export purposes; grains are fumigated inside sealed shipping containers.
4. **Recirculation Fumigation** – In silos or warehouses, fumigant gases are circulated evenly using blowers for uniform treatment.

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Benefits of Fumigation

- It effectively kills all stages of insects (eggs, larvae, pupae, adults) hidden inside grains.
- It provides quick and thorough disinfestation compared to sprays or dusts.
- It maintains grain quality, taste and nutritional value without leaving harmful residues when used properly.
- It reduces post-harvest losses and ensures safe and marketable grains.
- It is essential for maintaining export standards and preventing rejection in international trade.

4.11 Scope of Grain Storage Management

Effect of Proper Grain Storage

Proper grain storage plays a vital role in preserving both the **quantity and quality** of harvested grains. When stored under suitable conditions, grains remain safe from insects, rodents and fungal attack, while their nutritional value and seed viability are maintained. This ensures continuous availability of staple foods like wheat, rice and maize throughout the year, contributing directly to food security. Moreover, proper storage minimizes post-harvest losses, which in Pakistan often reach 10–15% annually due to poor facilities. By reducing these losses, the country saves billions of rupees, enhances export potential and ensures consumer access to safe and healthy food.

Steps to Ensure Safe Grain Storage

To achieve safe and long-term storage, several preventive and protective measures should be followed:

1. **Proper Drying** – Grains should be dried to 10–12% moisture before storage to prevent mold and germination.
2. **Clean Storage Structures** – Warehouses, bins and silos must be cleaned and disinfected before filling.
3. **Pest-Proofing** – Storage facilities should be sealed against rodents, birds and insects; fumigation should be carried out when necessary.

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4. **Aeration and Ventilation** – Regular air circulation prevents heating and condensation inside the grain mass.
5. **Regular Inspection** – Periodic checking for pests, moisture and spoilage ensures early detection and control.
6. **Use of Modern Storage Systems** – Adoption of silos, hermetic bags and metal bins instead of traditional mud bins and gunny bags reduces losses significantly.

Effect of Grain Storage on Prices in Pakistan

Grain storage has a direct impact on the stability of food prices in Pakistan. During harvest seasons, when supply is abundant, prices fall. If proper storage facilities are available, surplus grains can be stored and later released into the market during lean periods, preventing sudden shortages and inflation. This stabilizes prices, protects consumers from high food costs and ensures fair returns to farmers by avoiding distress sales immediately after harvest. In addition, efficient storage reduces dependence on grain imports, saving foreign exchange and shielding the economy from international price fluctuations. Hence, grain storage not only strengthens food security but also plays a crucial role in stabilizing Pakistan's agricultural economy and consumer market.

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Exercise

A) MCQs (Multiple Choice Questions)

1. **Grain storage mainly aims to:**
   a) Increase production of grains
   b) Protect grains from pests and spoilage
   c) Improve soil fertility
   d) Reduce labor cost
2. **In Pakistan, annual post-harvest grain losses due to poor storage are about:**
   a) 2–3%
   b) 5–7%
   c) 10–15%
   d) 20–25%

3. **Which staple crops of Pakistan depend most on efficient storage?**
   a) Wheat and rice b) Cotton and sugarcane
   c) Fruits and vegetables d) Oilseeds and pulses
4. **The most common traditional storage method in rural areas is:**
   a) Silos b) Cold storage
   c) Mud bins / earthen pots d) Hermetic bags
5. **Which modern storage structure is best for large-scale bulk storage?**
   a) Earthen pots b) Silo
   c) Gunny bags d) Bamboo bins
6. **Which abiotic factor is most responsible for fungal growth in stored grains?**
   a) Light exposure b) Low oxygen
   c) High humidity d) Short storage duration
7. **The Khapra beetle is a destructive pest of:**
   a) Wheat and rice b) Cotton
   c) Sugarcane d) Fruits
8. **Fumigation is carried out mainly to:**
   a) Increase germination b) Kill hidden insect pests
   c) Improve grain color d) Reduce transportation costs
9. **Which of the following is an example of hermetic storage?**
   a) Gunny bag b) Cold storage
   c) Airtight plastic container d) Mud bin
10. **Grain storage helps stabilize prices in Pakistan by:**
    a) Increasing imports b) Exporting all grains immediately
    c) Releasing stock in lean periods d) Reducing seed germination

Short Questions

1. Define grain storage.
2. What is the significance of grain storage in Pakistan's economy?
3. Differentiate between quantitative and qualitative losses.
4. Name any three modern grain storage methods.
5. List two abiotic factors affecting grain storage.

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6. What role does fumigation play in stored grain management?
7. How does grain storage help farmers during harvest season?

Long Questions

1. Explain the principles of grain storage with examples.
2. Describe in detail the different traditional and modern methods of grain storage.
3. Discuss the major quantitative and qualitative losses during grain storage.
4. Explain the factors affecting grain storage (abiotic and biotic).
5. Discuss the effects of proper grain storage and its impact on food prices in Pakistan.

Inquisitive / Analytical Questions

1. Why do you think Pakistan still faces 10–15% storage losses despite being an agricultural country?
2. How can modern storage technologies like silos and hermetic bags revolutionize food security in Pakistan?
3. If storage facilities are not improved, what will be the long-term impact on Pakistan's economy and exports?
4. Should Pakistan invest more in storage structures or in increasing crop production? Justify your answer.

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05 CROP NUTRITION

Student's learning outcomes **Students will be able to:**

- Define nutrients and nutrition.
- Describe the importance of nutrition for crop plants.
- List different essential nutrients.
- Explain the criteria of nutrient essentiality.
- Define and list macro nutrients.
- Describe the importance of macro nutrients.
- Define and list micro nutrients.
- Describe the importance of micro nutrients.
- Explain the effects of micro and macro nutrients on the crop production.
- Draw a diagram of plant and show the response of plant to different nutrients.
- Assess the effect of applied nutrients on plant growth.
- Identify different deficiency symptoms in plants and explain how deficiency can be removed.
- Define phytotoxicity.
- Describe the main causes of phytotoxicity.
- Describe the sources of nutrients.
- Differentiate between organic and inorganic sources.
- List some organic and inorganic sources.
- Explain the methods of application of synthetic fertilizers.
- List different factors affecting availability of nutrients.
- Discuss different physical factors affecting availability of nutrients.
- Discuss different chemical factors affecting availability of nutrients.
- Discuss different biological factors affecting availability of nutrients.

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5.1 CONCEPT OF NUTRITION

Nutrients are essential chemical elements or compounds required by plants for their growth, development, reproduction and completion of the life cycle. They are mainly absorbed from soil, water and air. Examples include nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, zinc, etc.

Nutrition is the process by which plants obtain, absorb, transport and utilize nutrients from the environment (soil, water and air) for their metabolic activities, growth and production of food.

Importance of Nutrition for Crop Plants

1. **Growth and Development** – Adequate nutrition helps in proper vegetative and reproductive growth.
2. **Higher Yield** – Balanced nutrient supply increases crop productivity.
3. **Quality of Produce** – Improves taste, color, size and nutritional value of grains, fruits and vegetables.
4. **Disease and Stress Resistance** – Well-nourished plants can better tolerate pests, diseases and adverse conditions like drought or salinity.
5. **Photosynthesis and Metabolism** – Nutrients like nitrogen, magnesium and iron are essential for chlorophyll formation and energy production.
6. **Soil Fertility Management** – Understanding nutrition helps farmers maintain soil fertility for sustainable agriculture.

5.2 Essential Nutrients

1. Macronutrients (needed in large amounts)

a) Primary Macronutrients

Nitrogen (N), Phosphorus (P), Potassium (K)

b) Secondary Macronutrients

Calcium (Ca), Magnesium (Mg), Sulfur (S)

2. Micronutrients (needed in small amounts)

Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo), Chlorine (Cl)

In total, 17 essential nutrients are required by plants:

Carbon (C), Hydrogen (H), Oxygen (O) (from air and water) + 14 mineral nutrients (from soil).

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1. Criteria of Nutrient Essentiality

A mineral element is considered *essential* for plants if it meets the following criteria.

1. **Direct Role in Plant Life Cycle** – The plant cannot complete its vegetative or reproductive phase without the element.
2. **Specific Function** – The deficiency can only be corrected by supplying that element, not by any other.
3. **Metabolic Involvement** – The element must directly participate in plant metabolism (e.g., as a structural component, enzyme activator, or energy transfer agent).

2. Macronutrients

Definition

Macronutrients are mineral nutrients required by plants in **large quantities** (usually more than 1 mg per gram of dry matter).

List of Macronutrients

- **Primary Macronutrients**: Nitrogen (N), Phosphorus (P) and Potassium (K)
- **Secondary Macronutrients**: Calcium (Ca), Magnesium (Mg) and Sulfur (S)

Importance of Macronutrients

- **Nitrogen (N):** Promotes vegetative growth, proteins, chlorophyll, nucleic acids.
- **Phosphorus (P):** Energy transfer (ATP), root growth, flowering and seed formation.
- **Potassium (K):** Water regulation, enzyme activation, improves quality and resistance.
- **Calcium (Ca):** Cell wall strength, root development, nutrient uptake.
- **Magnesium (Mg):** Central atom of chlorophyll, photosynthesis and enzyme activation.
- **Sulfur (S):** Essential for amino acids, proteins, vitamins and oil content in oilseeds.

3. Micronutrients

Definition

Micronutrients are mineral nutrients required by plants in very **small amounts**

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(usually less than 1 mg per gram of dry matter), but they are equally essential for normal growth.

List of Micronutrients

Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo), Chlorine (Cl), Nickel (Ni – added later as essential).

Do you know?

Chlorine is a primary disinfectant used worldwide to purify drinking water and sanitize swimming pools by killing harmful bacteria and pathogens.

Importance of Micronutrients

- **Iron (Fe):** Chlorophyll synthesis, respiration and photosynthesis.
- **Manganese (Mn):** Enzyme activation, nitrogen metabolism and photosynthesis.
- **Zinc (Zn):** Auxin (growth hormone) synthesis, enzyme function and seed development.
- **Copper (Cu):** Photosynthesis, lignin formation and reproductive growth.
- **Boron (B):** Pollen germination, cell wall stability and fruit setting.
- **Molybdenum (Mo):** Nitrogen fixation and nitrate reduction.
- **Chlorine (Cl):** Osmotic balance, photosynthesis, disease resistance.
- **Nickel (Ni):** Required for urease enzyme, nitrogen metabolism.

5.3 Plant Response to Nutrients

1. Effects of Macronutrients on Crop Production

Macronutrients are needed in large quantities and directly influence yield and growth.

- **Nitrogen (N):**
  - It increases vegetative growth, leaf area and chlorophyll → higher photosynthesis.
  - Enhances grain protein content.
  - Deficiency = stunted growth, yellowing leaves and low yield.
- **Phosphorus (P):**
  - Promotes root growth, early maturity, seed and fruit formation.
  - Improves energy transfer (ATP).
  - Deficiency = poor root system, delayed flowering and reduced yield.
- **Potassium (K):**
  - Increases disease resistance, drought tolerance and crop quality (size, color, storage).

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- Regulates water balance in plants.
- Deficiency = weak stems, low-quality grains/fruits, more pest/disease attack.

- **Calcium (Ca):**
  - Improves root development and cell wall strength.
  - Enhances uptake of other nutrients.
  - Deficiency = poor root growth, blossom end rot in tomato.
- **Magnesium (Mg):**
  - Essential for chlorophyll → photosynthesis efficiency.
  - Deficiency = interveinal chlorosis, lower yield.
- **Sulfur (S):**
  - Improves protein and oil content in crops (especially pulses and oilseeds).
  - Deficiency = pale leaves, poor seed quality.

2. Effects of Micronutrients on Crop Production

Even though required in small amounts, micronutrients strongly affect crop health and yield.

- **Iron (Fe):**
  - Promotes chlorophyll formation and respiration.
  - Deficiency = yellowing (chlorosis), poor photosynthesis.
- **Manganese (Mn):**
  - Helps in nitrogen metabolism and photosynthesis.
  - Deficiency = reduced growth, interveinal chlorosis.
- **Zinc (Zn):**
  - Regulates growth hormone (auxin) production → better plant growth.
  - Deficiency = stunted growth, smaller leaves, poor seed setting.
- **Copper (Cu):**
  - Improves reproductive growth, lignin formation (strong stems).
  - Deficiency = wilting, poor seed quality.
- **Boron (B):**
  - Enhances pollen germination, seed/fruit development.
  - Deficiency = flower drop, fruit cracking, low yield.

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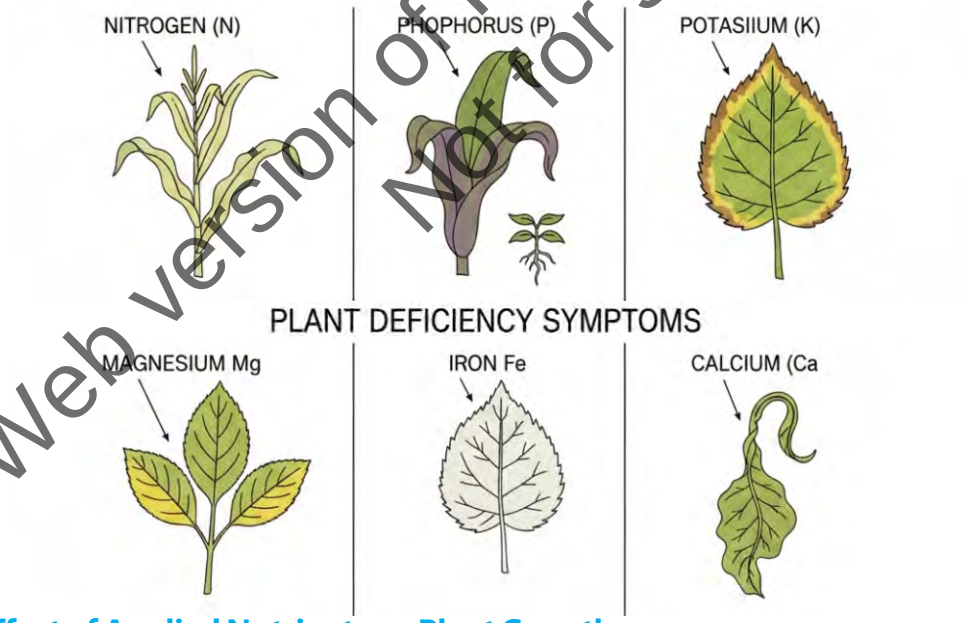
- **Molybdenum (Mo):**
  - Helps in nitrogen fixation (legumes).
  - Deficiency = poor nodulation, nitrogen deficiency symptoms.
- **Chlorine (Cl):**
  - Improves photosynthesis and disease resistance.
  - Deficiency = wilting, reduced growth.
- **Nickel (Ni):**
  - Needed for nitrogen metabolism and seed germination.
  - Deficiency = poor seed development.

Nutrient Uptake, Deficiency Symptoms and Phytotoxicity

1. Nutrient Uptake

Plants absorb nutrients mainly through their roots from the soil solution in the form of ions. Uptake takes place by two processes: passive absorption (diffusion/osmosis) and active absorption (energy-dependent transport). Nutrients move upward through the xylem along with water to different plant parts.



Effect of Applied Nutrients on Plant Growth

- Adequate nutrients ensure vigorous growth, higher yields and better quality of grains, fruits and vegetables.

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- Balanced fertilization improves disease and stress resistance.
- Excessive or imbalanced application leads to luxury consumption, nutrient antagonism, or toxicity.

2. Deficiency Symptoms in Plants

When nutrients are lacking, plants show visible deficiency symptoms, which vary depending on the nutrient.

Common Deficiency Symptoms

- **Nitrogen (N):** Yellowing of older leaves (chlorosis), stunted growth.
- **Phosphorus (P):** Purplish leaves, poor root and seed development.
- **Potassium (K):** Yellow/brown scorching on leaf edges, weak stems.
- **Calcium (Ca):** Blossom end rot (tomato), poor root growth.
- **Magnesium (Mg):** Interveinal chlorosis (yellowing between veins).
- **Sulfur (S):** Uniform yellowing of young leaves, similar to N deficiency.
- **Iron (Fe):** Interveinal chlorosis in young leaves.
- **Zinc (Zn):** Stunted growth, small leaves, poor seed formation.
- **Boron (B):** Flower drop, fruit cracking, poor pollination.
- **Molybdenum (Mo):** Yellowing and poor nodulation in legumes.

How to Remove Deficiency

- **Soil application** of fertilizers (e.g., Urea for N, SSP/DAP for P, MOP for K).
- **Foliar sprays** of micronutrients (e.g., $ZnSO_4$, $FeSO_4$, Borax).
- **Use of organic matter** (farmyard manure, compost) to improve nutrient availability.
- **Balanced fertilization** using soil testing and integrated nutrient management.

3. Phytotoxicity

Phytotoxicity is the toxic effect of certain substances (like pesticides, herbicides, or excess fertilizers) on plants, leading to injury or death.

Main Causes of Phytotoxicity

1. **Excess Fertilizer Application** – High salt concentration damages roots and reduces water uptake.

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2. **Overuse of Pesticides/Herbicides** – Chemicals in higher-than-recommended doses cause leaf burn, necrosis, or growth inhibition.
3. **Contaminated Irrigation Water** – Heavy metals or salts lead to toxicity.
4. **Imbalance of Nutrients** – For example, excess boron or copper is toxic to plants.
5. **Poor Application Practices** – Spraying chemicals at high temperatures or in strong sunlight increases leaf burn.

5.4 Sources of Plant Nutrients

Plants obtain essential nutrients from **three major sources**:

1. Natural Sources

- **Air:**
  - Carbon (C) from Co_2
  - Oxygen (O) from CO_2 and O_2
- **Water:**
  - Hydrogen (H) from H_2O
- **Soil Minerals:**
  - Release nutrients through weathering of rocks and decomposition of organic matter.
  - Provides most of the 14 mineral nutrients (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B, Mo, Cl, Ni).

2. Organic Sources

- **Farmyard Manure (FYM):** Provides N, P, K and micronutrients.
- **Compost & Vermicompost:** Improves soil fertility and microbial activity.
- **Green Manure:** Leguminous plants add nitrogen through biological nitrogen fixation.
- **Crop Residues:** Return nutrients (like K and S) to the soil after decomposition.
- **Biofertilizers:**
  - Rhizobium (N-fixation in legumes)
  - Azotobacter, Azospirillum (N-fixation in cereals)
  - Phosphate-Solubilizing Bacteria (PSB) for P availability
  - Mycorrhiza (helps uptake of P, Zn, Cu).

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3. Inorganic (Chemical) Fertilizers

- **Nitrogen Fertilizers:** Urea, Ammonium sulfate, Calcium ammonium nitrate.
- **Phosphorus Fertilizers:** Single superphosphate (SSP), Diammonium phosphate (DAP), Triple superphosphate (TSP).
- **Potassium Fertilizers:** Muriate of potash (MOP, KCl), Sulfate of potash (SOP).
- **Secondary Nutrient Fertilizers:**
  - Calcium (Gypsum, Calcium nitrate)
  - Magnesium (Magnesium sulfate, Dolomite)
  - Sulfur (Elemental sulfur, Ammonium sulfate).
- **Micronutrient Fertilizers:**
  - Zinc sulfate ($ZnSO_4$), Ferrous sulfate ($FeSO_4$), Borax (B), Copper sulfate ($CuSO_4$), Ammonium molybdate $[(NH_4)_6Mo_7O_{24}]$

Methods of Application of Fertilizers

1. Broadcasting

In this method, fertilizer is spread uniformly over the soil surface, either before sowing (basal) or after crop establishment (top dressing). It is simple and quick, making it suitable for dense crops like wheat and rice, but it has low efficiency and leads to higher nutrient losses through leaching and volatilization.

Fig 5.1: Broadcasting Method

2. Placement Methods

Here, fertilizers are placed close to the seed or root zone, which increases efficiency. Band placement applies fertilizer in narrow strips beside the seed rows, drill placement delivers it along with seeds using a seed-cum-fertilizer drill and deep placement (such as urea briquettes in rice fields) reduces nitrogen losses in flooded soils.

Fig 5.2: Placement Method

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3. Foliar Application

This method involves spraying a fertilizer solution directly onto the leaves. It is particularly useful for supplying micronutrients like Zn, Fe, B, Mn and Cu and for quickly correcting deficiencies. The response is rapid and avoids soil fixation, but only limited amounts of nutrients can be supplied this way.

Fig 5.3: Foliar Application

4. Fertigation

Fertigation is the application of fertilizers dissolved in irrigation water through drip or sprinkler systems. It is widely used in vegetables, fruit crops and greenhouse farming. This method ensures high efficiency, uniform distribution and saves both water and labor, though it requires costly infrastructure and good-quality irrigation water.

Fig 5.4: Fertigation Method

5. Side Dressing

In side dressing, fertilizers are applied along the sides of growing plants near their root zone. It is commonly used in row crops like maize, sugarcane and vegetables and is effective in supplying nutrients during critical stages of plant growth.

6. Top Dressing

Top dressing refers to applying fertilizers, usually nitrogenous, on the soil surface after crops are established. It is practiced in cereals like wheat, rice and maize to stimulate vigorous vegetative growth and improve yield during active growth phases.

7. Seed Treatment (Starter Dose)

In this method, seeds are coated or pelleted with fertilizers before sowing. It is often combined with micronutrients such as Zn and Mo or inoculants. Seed treatment ensures that nutrients are available to seedlings immediately after germination, promoting healthy early growth.

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5.5 Factors Affecting Availability of Nutrients

The ability of plants to absorb nutrients from soil depends on several physical, chemical and biological factors that influence nutrient solubility, mobility and uptake efficiency.

1. Physical Factors

Physical properties of soil greatly affect nutrient availability. Soil texture determines nutrient-holding capacity: sandy soils lose nutrients easily through leaching, while clay and loamy soils retain more. Soil moisture is essential for dissolving nutrients and transporting them to plant roots, but excessive water leads to leaching or denitrification losses. Soil temperature influences microbial activity and root growth—low temperatures slow nutrient release and uptake, while warm soils promote availability, especially of nitrogen and phosphorus. Soil aeration also plays a key role; well-aerated soils enhance root respiration and microbial activity, whereas poor aeration reduces nutrient absorption.

2. Chemical Factors

Soil chemical properties largely determine nutrient solubility and mobility. Soil pH is the most critical factor: acidic soils increase solubility of micronutrients like Fe, Mn, Zn, Cu but may cause toxicity, while alkaline soils reduce their availability and immobilize phosphorus. Cation Exchange Capacity (CEC) affects the ability of soil to hold and supply nutrients; higher CEC (in clay and organic soils) ensures better nutrient retention. Redox potential in flooded soils influences nutrient forms—such as Fe and Mn becoming more soluble under anaerobic conditions. Nutrient interactions also matter; for example, excess potassium reduces magnesium and calcium uptake, while high phosphorus can reduce zinc availability. Fertilizer type, timing and method of application are additional chemical factors that impact nutrient availability.

3. Biological Factors

Biological processes in soil play a vital role in nutrient cycling. Soil microorganisms decompose organic matter, releasing nitrogen, phosphorus and sulfur in available forms. Beneficial microbes like Rhizobium fix atmospheric nitrogen in legumes, while Azotobacter and Azospirillum contribute to nitrogen

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fixation in cereals. Phosphate-solubilizing bacteria (PSB) and mycorrhizal fungi enhance the availability of phosphorus and micronutrients such as zinc and copper. Earthworms and soil fauna also improve nutrient mineralization and soil structure. High biological activity ensures a continuous supply of nutrients, whereas degraded soils with low microbial populations show poor nutrient availability.

Exercise

A) Multiple Choice Questions (MCQs)

1. **Which of the following is a primary macronutrient?**
   a) Calcium b) Magnesium
   c) Potassium d) Sulfur
2. **The central atom of chlorophyll is:**
   a) Iron b) Magnesium
   c) Nitrogen d) Calcium
3. **Boron (B) is mainly required for:**
   a) Chlorophyll formation
   b) Pollen germination and fruit development
   c) Protein synthesis
   d) Water regulation
4. **Which nutrient is supplied to plants by gypsum?**
   a) Nitrogen and Phosphorus b) Potassium and Magnesium
   c) Calcium and Sulfur d) Zinc and Iron
5. **Blossom end rot in tomato is due to deficiency of:**
   a) Zinc b) Calcium
   c) Boron d) Potassium

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6. **Which method of fertilizer application involves dissolving fertilizers in irrigation water?**

a) Broadcasting b) Fertigation

c) Top dressing d) Side dressing

7. **Which of the following is a micronutrient?**

a) Sulfur b) Magnesium

c) Zinc d) Calcium

8. **Soil pH strongly affects nutrient:**

a) Uptake only b) Solubility and availability

c) Storage in plant d) None of these

9. **A nutrient is considered essential if:**

a) It improves taste

b) It increases plant height

c) Plant cannot complete life cycle without it

d) It is absorbed in large quantity

10. **Which biological agent helps in phosphate solubilization?**

a) Rhizobium b) Mycorrhiza

c) PSB (Phosphate Solubilizing Bacteria) d) Azotobacter

Short Questions (7)

1. Define nutrition in plants.
2. List the three criteria of nutrient essentiality.
3. Differentiate between primary and secondary macronutrients.
4. Give any two deficiency symptoms of nitrogen in plants.
5. Name any four synthetic fertilizers.
6. What is phytotoxicity?
7. How do microorganisms influence nutrient availability?

Long Questions

1. Discuss the importance of nutrition in crop plants with examples.

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2. Explain the functions and deficiency symptoms of macronutrients.
3. Describe the effects of micronutrients on crop production.
4. Write detailed notes on the methods of application of fertilizers.
5. Discuss the physical, chemical and biological factors affecting nutrient availability in soil.

Inquisitive Questions Thought-provoking / discussion based)

1. Why do Plants require only small amounts of micronutrients, yet why does their deficiency causes severe effects?
2. How can balanced fertilization contribute to sustainable agriculture?
3. What role does soil pH management play in improving nutrient use efficiency?
4. Why is overuse of fertilizers dangerous for both plants and the environment?

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06 KITCHEN GARDENING

Student's learning outcomes **Students will be able to:**

- Define kitchen gardening
- Describe the significance of kitchen gardening
- Enlist Summer and Winter vegetables for kitchen Gardening.
- Prepare a layout system for the growing of vegetables.
- Raise the nursery for vegetables production.
- Manage the nursery and transplant in the garden
- Prepare the soil for proper plant growth
- Use fertilizers in a balanced manner.
- Use the water in a judicious way for the growth of plant
- Justify the Addition of organic manures and fertilizer.
- Application of required nutrients i.e. N, P, K.
- Application of pesticide to control insect & pests.
- Laying of polyethylene sheets.
- Conserve moisture to reduce the need for irrigation.
- Use of polyethylene sheets to protect vegetables.
- Use of earthen pots/wooden boxes
- System structure & design
- Role of soil less vegetable cultivation
- Understand maturity indices.
- Maturity indices for harvesting time.
- Packaging & storage at home level.

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6.1 Introduction and Importance

Kitchen Gardening

Kitchen gardening is the practice of growing vegetables, fruits and herbs in or around the household premises (such as backyard, courtyard, rooftop, or pots) mainly for family consumption.

Significance of Kitchen Gardening

Kitchen gardening plays an important role in providing a continuous supply of fresh, safe and nutritious vegetables and fruits for household consumption. It helps improve family health by ensuring the availability of essential vitamins and minerals, while also reducing dependence on market produce that may contain harmful chemicals. In addition, it minimizes household expenses on food and makes effective use of available spaces such as backyards, courtyards, balconies and rooftops.

Apart from improving nutrition and saving costs, kitchen gardening contributes to self-sufficiency and food security at the family level. It promotes eco-friendly practices like composting kitchen waste and encourages greenery around the home, which improves the environment. Moreover, it offers a healthy hobby and physical activity for family members, creating awareness about sustainable agriculture and ensuring year-round availability of seasonal vegetables.

Vegetables for Kitchen Gardening

Summer Vegetables (Kharif Season – March to August)

- Tomato
- Brinjal (Eggplant)
- Okra (Ladyfinger)
- Bitter gourd
- Bottle gourd
- Sponge gourd
- Cucumber
- Pumpkin
- Chili

Fig 6.1: Summer Vegetables

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- Beans

Winter Vegetables (Rabi Season – September to February)

- Cabbage
- Cauliflower
- Spinach
- Carrot
- Radish
- Turnip
- Onion
- Garlic
- Peas
- Coriander

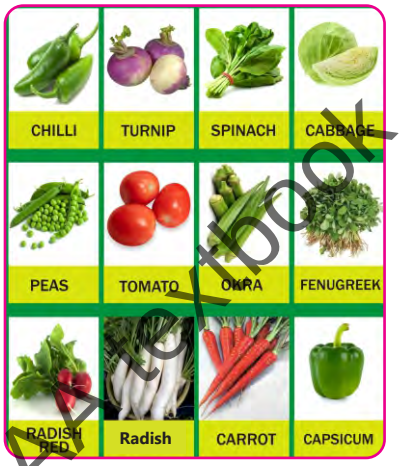

Fig 6.2: Winter Vegetables

Layout System for Kitchen Gardening

A proper layout ensures efficient use of space and year-round vegetable supply.

1. Site Selection

- Choose a sunny location near the house with access to water.
- Soil should be fertile, well-drained and enriched with organic matter.

2. Design and Arrangement

- **Raised beds (1–1.5 m wide)**: For seasonal vegetables (tomato, spinach, peas).
- **Ridges/trellises along borders**: For climbing crops (cucumber, gourds, squashes).
- **Corners**: Plant perennial vegetables or herbs (chili, eggplant, mint).
- **Rows/blocks**: Keep leafy vegetables together for easy harvesting.
- **Succession planting**: Grow short-duration crops (radish, spinach) between long-duration crops (cabbage, cauliflower).

3. Seasonal Rotation

- Use the same beds for summer crops (tomato, okra, gourds) and replace them with winter crops (cabbage, carrot, peas) to maintain soil fertility and avoid pests.

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Raising the Nursery for Vegetable Production

A nursery is a small, well-managed area where vegetable seedlings are grown before being transplanted into the main garden. Raising a nursery ensures healthy, uniform seedlings and saves seeds, time and space.

Fig 6.3: Raising Nursery

Steps for Raising a Nursery:

1. **Site Selection** – Choose a well-drained, sunny site close to water.
2. **Bed Preparation** – Prepare raised beds (1 m wide, 3–4 m long) to avoid waterlogging. Mix soil with well-rotted farmyard manure and fine sand for good texture.
3. **Seed Treatment** – Treat seeds with fungicides (e.g., Captan, Thiram) or bio-agents (Trichoderma) to prevent diseases.
4. **Sowing** – Sow seeds in rows 5–10 cm apart for easy management. Cover lightly with soil and apply water gently.
5. **Irrigation & Care** – Provide light watering with a sprinkler or rose can. Protect from heavy rain, birds, or direct sunlight using a shade net or straw cover.
6. **Vegetable Nurseries** – Vegetable nurseries are also commonly raised in plastic germination trays filled with compost or other growing media.

Management of Nursery

- **Weeding:** Remove weeds regularly to avoid competition.
- **Thinning:** Maintain proper spacing by removing excess seedlings.
- **Irrigation:** Apply light and frequent irrigation to keep the soil moist.
- **Plant Protection:** Spray neem extract or mild pesticides against pests.
- **Hardening:** Before transplanting, reduce irrigation and expose seedlings gradually to sunlight for 3–5 days to strengthen them.

Transplanting in the Garden

1. **Land Preparation** – Prepare the main field with fine tilth and add organic manure.
2. **Marking Rows/Beds** – Keep appropriate spacing depending on the crop (e.g., tomato 60 × 45 cm, cabbage 45 × 45 cm).

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3. **Uprooting Seedlings** – Uproot seedlings carefully from the nursery with soil around roots.
4. **Transplanting** – Transplant healthy seedlings in the evening or cloudy weather to reduce stress.
5. **Watering** – Irrigate immediately after transplanting.
6. **Aftercare** – Replace dead plants, provide staking for climbers (e.g., tomato, cucumber) and protect against pests.

Soil management and planting type

Soil Preparation for Proper Plant Growth

Soil preparation is the first and most important step for successful vegetable and crop production. It improves soil structure, aeration and fertility, helping roots to grow deeply and absorb nutrients effectively.

Steps in Soil Preparation

1. **Clearing the Field**
   - Remove weeds, stones, stubbles and previous crop residues.
   - Ensures a clean bed for sowing or transplanting.
2. **Ploughing/Tilling**
   - Plough the soil 2–3 times to break clods and loosen compact soil.
   - Improves aeration, root penetration and water infiltration.
3. **Harrowing and Leveling**
   - Break fine clods using harrows or rotavators.
   - Level the field with a leveler to ensure uniform irrigation and avoid waterlogging.
4. **Incorporation of Organic Matter**
   - Mix well-rotted Farmyard Manure (FYM), compost, or green manure to improve fertility, structure and microbial activity.
5. **Soil Amendments**
   - Add lime in acidic soils or gypsum in sodic soils for correction.
   - Improves nutrient availability.
6. **Fertilizer Application**
   - Apply basal dose of fertilizers according to crop requirement.
   - Ensures nutrients are available from the early growth stage.

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7. **Bed or Ridge Preparation**
    - Prepare raised beds, ridges, or furrows depending on the crop and season.
    - Facilitates drainage, irrigation and proper root development.

Water & Nutrient management

Judicious Use of Water for Plant Growth

Water is essential for germination, nutrient uptake, photosynthesis and overall plant growth. However, excess or shortage of water can harm plants. Therefore, water must be used efficiently and judiciously to ensure healthy growth and higher yields.

Principles of Judicious Water Use

1. **Right Amount** – Supply water according to the crop's requirement and soil type. Avoid over-irrigation, which causes waterlogging and nutrient loss.
2. **Right Time** – Irrigate at critical growth stages (e.g., flowering, fruiting) to maximize yield.
3. **Right Method** – Use efficient irrigation methods like drip irrigation or sprinklers instead of traditional flooding to save water.
4. **Soil Moisture Conservation** – Use mulching (straw, plastic, or leaves) to reduce evaporation and retain soil moisture.
5. **Scheduling** – Irrigate based on weather conditions, rainfall and soil moisture status rather than fixed schedules.
6. **Avoiding Losses** – Prevent seepage, runoff and evaporation by proper land leveling and maintaining irrigation channels.
7. **Rainwater Harvesting** – Collect and store rainwater to reduce dependence on ground or canal water.

Justification for Addition of Organic Manures and Fertilizers

Organic manures and fertilizers are essential inputs for maintaining soil fertility and ensuring good crop growth. Organic manures (like compost, farmyard manure and green manure) improve soil structure, increase microbial activity and enhance water-holding capacity. On the other hand, chemical fertilizers provide readily available nutrients to plants for faster growth and higher yields. Using both together maintains long-term soil health and ensures immediate

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nutrient supply.

Balanced Use of Fertilizers

Applying fertilizers in a balanced manner is necessary to avoid excess or deficiency. Overuse of one nutrient can cause toxicity and reduce the availability of others (e.g., excess nitrogen reduces uptake of potassium). Balanced fertilization ensures efficient nutrient uptake, prevents soil degradation and sustains crop productivity.

Application of N, P, K Nutrients

- **Nitrogen (N):** Nitrogen promotes vegetative growth, leaf development and chlorophyll formation.
- **Phosphorus (P):** Phosphorus encourages root growth, seed and fruit development and early crop maturity.
- **Potassium (K):** Potassium improves disease resistance, water regulation and quality of produce (size, taste, storage).

Applying N, P and K in the right proportion according to crop requirement ensures optimum growth, maximum yield and maintains soil fertility.

Pest Management

Pest management is the practice of controlling insects, weeds, rodents and diseases that damage crops and reduce yield. Effective pest management aims to protect plants while minimizing harm to the environment, humans and beneficial organisms.

1. Cultural Methods

- Crop rotation to break pest life cycles.
- Timely sowing/harvesting to avoid peak pest periods.
- Field sanitation by removing weeds, stubbles and infested plants.
- Use of resistant/tolerant crop varieties.

2. Mechanical and Physical Methods

- Hand-picking and destroying insect larvae/eggs.
- Using traps (light traps, pheromone traps, sticky traps).
- Barriers, nets and fences to prevent pest entry.
- Solarization (covering soil with plastic sheet to kill pests).

3. Biological Control

- Use of natural enemies like predators, parasites and pathogens.

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- Examples: Ladybird beetles for aphids, Trichogramma for borers, *Bacillus thuringiensis* (Bt) for caterpillars.
- Environment-friendly and sustainable.

4. Chemical Control

- It is the use of insecticides, fungicides and herbicides when pest infestation is severe.
- It should be used judiciously (right chemical, dose and timing).
- It avoids crop loss but may cause resistance and environmental pollution if misused.

5. Integrated Pest Management (IPM)

- Integrated Pest Management IPM is the combination of cultural, mechanical, biological and chemical methods.
- It reduces dependency on chemicals.
- It promotes long-term, eco-friendly and cost-effective pest control.

The application of pesticides is one of the most common methods to control insect pests that damage crops. Pesticides such as insecticides, fungicides and herbicides should be applied carefully in the right dose, at the right time and using proper equipment to ensure effectiveness and safety. It is advised to follow label instructions, wear protective clothing and avoid overuse to prevent resistance, residue hazards and environmental pollution. When used judiciously and in combination with other practices, pesticides provide quick and effective protection against pests, ensuring healthy crop growth and higher yields.

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6.2 Pruning

Effect of Pruning on Plants in Kitchen Gardening

Pruning is the practice of removing unwanted, diseased or overgrown parts of a plant to improve its growth and productivity. In kitchen gardening, pruning helps in maintaining plant shape, allowing better air circulation and sunlight penetration. It stimulates the growth of new shoots, enhances flowering and fruiting and prevents the spread of pests and diseases. For fruiting vegetables like tomato, brinjal and chili, pruning encourages more flowers and fruits, while in leafy vegetables it ensures healthy foliage. Proper pruning also prevents overcrowding, conserves plant energy and results in better quality and higher yields of vegetables in limited garden space.

6.3 Mulching

Use of Polythene Sheets in Kitchen Gardening

Polythene sheets are commonly used in kitchen gardening as a protective covering and soil management tool. They are applied in the form of mulch on the soil surface to conserve moisture, suppress weed growth and regulate soil temperature. This helps in reducing irrigation needs and ensures better root development. Transparent or UV-stabilized polythene sheets are also used to create low tunnels or small greenhouses, protecting vegetables from frost, heavy rain, or insect attack, thus extending the growing season. Additionally, they prevent nutrient losses through leaching and enhance the overall growth and yield of vegetables in limited spaces.

6.4 Protected Structure/Containers

System Structure & Design in Kitchen Gardening

The system of kitchen gardening is designed in a way that ensures maximum use of limited space, easy management and continuous supply of fresh vegetables. Common designs include raised beds, row planting, square foot gardening, vertical gardening and container gardening. The layout should ensure proper sunlight exposure, irrigation channels, pathways and crop rotation planning. A well-structured design improves efficiency, reduces wastage of water and fertilizers and makes pest management easier.

Use of Earthen Pots/Wooden Boxes in Kitchen Gardening

For those with limited land, vegetables can be successfully grown in earthen pots, clay tubs, cement pots, or wooden boxes. These containers are ideal for growing leafy vegetables (spinach, coriander, lettuce), fruiting crops (tomato, chili, brinjal) and even root crops (radish, carrot, beet). Earthen pots keep roots cool and allow aeration, while wooden boxes are durable and suitable for larger plants. This system saves space, allows gardening in balconies, rooftops, or courtyards and makes it possible to grow vegetables year-round even in urban areas.

6.5 Hydroponics system

Hydroponic System of Farming

Hydroponic farming is a method of growing plants without soil, where plants get all their nutrients from a water-based nutrient solution. The plants are usually

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supported by an inert medium like coco peat, perlite, vermiculite, rock wool, or clay pellets. This system allows for faster growth, higher yields and efficient water use.

Vegetables Commonly Grown in Hydroponics

Many leafy and fruiting vegetables are suitable for hydroponic cultivation. Some examples:

- **Leafy Vegetables:** Lettuce, Spinach, Kale, Pak Choi, Arugula
- **Fruit Vegetables:** Tomato, Cucumber, Bell Pepper, Chili
- **Herbs:** Basil, Mint, Coriander, Parsley

Fig 6.4: Hydroponic Plants

Leafy vegetables are most common because they grow fast and adapt well to water-based systems.

How a Hydroponic System is Built

A simple hydroponic setup can be created in these steps:

1. **Support Structure:**
   - A tray, gutter, or container to hold the plants.
   - Plants are placed in holes in a tray or suspended above a nutrient solution.
2. **Growing Medium:**
   - Use inert materials like coco peat, rock wool, perlite, polystyrene foam or clay pellets to anchor plant roots.
3. **Nutrient Solution:**
   - Prepare water mixed with essential nutrients (N, P, K, Ca, Mg, Fe, etc.) according to plant requirements.
4. **Water and Nutrient Delivery:**
   - Use one of the hydroponic systems:
     - **Nutrient Film Technique (NFT):** Thin flowing water layer touches roots.
     - **Deep Water Culture (DWC):** Roots are submerged in nutrient solution.
     - **Drip System:** Nutrient solution drips onto roots.
     - **Wick System:** Nutrient solution is absorbed by a wick.

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5. **Aeration:**
    - Roots need oxygen; use air pumps in DWC or ensure thin solution flow in NFT.
6. **Lighting (for indoor setups):**
    - Plants need sufficient light; LED grow lights or fluorescent lights are used.
7. **Monitoring:**
    - Maintain pH (5.5–6.5) and EC (Electrical Conductivity) levels for nutrient solution.

Advantages: Faster growth, less water use, fewer pests, high yield. **Disadvantages:** Initial setup cost is higher, requires monitoring and nutrient management.

16.3 Harvesting, Post-harvest handling & storage

1. Maturity Indices & Harvesting Time

Maturity indices are signs that indicate when a vegetable is ready to harvest. Harvesting at the right time ensures best taste, quality and shelf life.

Common Maturity Indices: Vegetable Type Maturity Sign Harvesting Time Leafy vegetables (Spinach, Lettuce, Fenugreek): Leaves fully grown but tender, deep green color, 30–50 days after sowing (for most), Fruiting vegetables (Tomato, Chili, Cucumber): Fruits reach full size, color change (green → red for tomato), Tomato: 70–90 days, Cucumber: 50–60 days, Root vegetables (Carrot, Radish, Beetroot): Roots reach typical size and color, Carrot: 70–80 days, Radish: 25–35 days, Onion / Garlic Tops yellow & start falling Onion: 90–120 days, Garlic: 180–210 days

Tips for Harvesting:

- Use a sharp knife or scissors to avoid damaging the plant.
- Harvest early in the morning when plants are turgid and fresh.
- Leafy vegetables can often be harvested selectively (cut-and-come-again method).

2. Packaging & Storage at Home Level

Proper handling after harvest prolongs shelf life and maintains quality.

Leafy Vegetables:

- Wash with clean water to remove soil.
- Pat dry and wrap in damp cloth or paper towel.

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- Store in plastic bags or containers in the refrigerator.
- Usually lasts 3–7 days.

Fruiting Vegetables (Tomato, Chili, Cucumber):

- Keep tomatoes at room temperature until fully ripe, then refrigerate.
- Cucumbers and chili peppers can be stored in plastic bags in the fridge.
- Avoid moisture accumulation to prevent rotting.

Root Vegetables (Carrot, Radish, Beetroot):

- Remove tops to prevent nutrient loss.
- Store in perforated plastic bags or sand-filled boxes in a cool, dry place.
- Can last 2–4 weeks.

Herbs (Basil, Mint, Coriander):

- Wash, dry gently and store in airtight containers or herb jars.
- Some herbs can be frozen in ice cube trays with water.

Tips:

- Harvest vegetables regularly to encourage continuous production.
- Avoid direct sunlight after harvest.

Use clean tools and containers to prevent contamination.

Do you know?

The term "hydroponics" was coined in 1937 by Dr. William Frederick Gericke and is derived from the Greek words hydro (water) and ponos (labor)—literally "water working".

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Exercise

A) Multiple Choice Questions

1. **Which of the following is a winter vegetable suitable for kitchen gardening?**
   a) Tomato b) Brinjal
   c) Cabbage d) Okra
2. **The main purpose of a nursery in kitchen gardening is:**
   a) To store harvested vegetables
   b) To grow healthy seedlings for transplanting
   c) To protect crops from pests
   d) To provide shade for plants

3. **Which nutrient primarily promotes vegetative growth in plants?**
   a) Phosphorus b) Potassium
   c) Nitrogen d) Calcium
4. **Which of the following is a hydroponic system?**
   a) Raised bed gardening b) Deep Water Culture (DWC)
   c) Ridge and furrow planting d) Square foot gardening
5. **The correct spacing for tomato plants in kitchen gardening is:**
   a) 30 × 30 cm b) 60 × 45 cm
   c) 45 × 45 cm d) 90 × 60 cm
6. **Mulching with polythene sheets in kitchen gardening helps to:**
   a) Increase pest infestation
   b) Conserve moisture and suppress weeds
   c) Reduce sunlight
   d) Prevent seed germination
7. **Which of these methods is a biological control method for pests?**
   a) Hand-picking insect larvae
   b) Spraying chemical insecticides
   c) Using Trichogramma against borers
   d) Crop rotation
8. **Which of the following vegetables is commonly grown in hydroponics?**
   a) Onion b) Lettuce c) Carrot d) Garlic
9. **Pruning in kitchen gardening helps to:**
   a) Reduce soil fertility
   b) Improve air circulation and sunlight penetration
   c) Increase pests
   d) Delay flowering
10. **Leafy vegetables can be harvested using which method?**
    a) Complete uprooting b) Cut-and-come-again method
    c) Pulling stems aggressively d) Leaving them uncut

Short Questions

1. Define kitchen gardening and its importance for household nutrition.
2. Name five summer vegetables and five winter vegetables suitable for

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kitchen gardening.

3. List three advantages of using organic manure in soil management.
4. Explain the role of raised beds and trellises in garden layout.
5. What are the critical stages for irrigation in vegetable crops?
6. Mention two advantages and two disadvantages of hydroponic farming.
7. Give two maturity indices for harvesting root vegetables and fruiting vegetables.

Long Questions

1. Describe the steps for raising a nursery for vegetable production, including site selection, seed treatment and care.
2. Explain the principles of judicious water use in kitchen gardening and its importance for plant growth.
3. Discuss the different methods of pest management in kitchen gardening, including cultural, mechanical, biological, chemical and IPM approaches.
4. Elaborate on soil preparation and fertilizer management for successful vegetable production in a kitchen garden.
5. Explain the layout system, seasonal rotation and container gardening for continuous vegetable supply in limited spaces.

Inquisitive/Thought-Provoking Questions

1. How can kitchen gardening help reduce household dependence on chemically grown vegetables from the market?
2. Why is pruning more beneficial for fruiting vegetables than leafy vegetables?
3. In hydroponics, how does the choice of growing medium affect plant growth and yield?
4. How does using mulching and polythene sheets contribute to sustainable water management?

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07 FARM MECHANIZATION

Student's learning outcomes

Students will be able to:

- Define and explain farm mechanization.
- Discuss necessity and objectives of farm mechanization.
- Explain benefits of farm mechanization.
- Enlist various implements used in conventional farming
- Describe the uses of different conventional farming tools
- Define and explain mechanized farming
- Differentiate between primary and secondary tillages
- Draw the structural diagram of Rabi drill and other sowing implements.
- Enlist various implements used for tillage and harvesting.
- Explain land preparation implements for different crops.
- Enlist post harvest machinary
- Explain crop monitoring using imaging technology
- Explain the role of drone technology in agriculture mechanization especially in pesticide and fertilizer application

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7.1 Introduction

Farm mechanization refers to the use of machinery and equipment in agricultural operations to perform tasks that were traditionally done manually or with animal power. This includes equipment for plowing, planting, irrigation, harvesting, threshing and post-harvest processing.

Explanation:

- Farm mechanization aims to increase efficiency, reduce labor intensity and improve agricultural productivity.
- It involves both power-driven tools (like tractors, harvesters and threshers) and manual or animal-operated implements (like plows, sickles and seed drills).
- Mechanization is not limited to field operations; it also includes irrigation pumps, fertilizer spreaders and post-harvest machinery such as grain dryers.

ii. Necessity and Objectives of Farm Mechanization Necessity:

With increasing urbanization, the availability of farm labor has significantly decreased, making mechanization an essential component of modern agriculture. Timely operations such as sowing and harvesting are critical for good crop yields, but these tasks cannot always be accomplished manually, highlighting the importance of efficient machinery. Mechanization allows larger areas of land to be cultivated more quickly and effectively, leading to increased productivity. At the same time, it reduces the physical strain and repetitive work for farmers, minimizing drudgery and improving working conditions. In the long run, the use of machines also enhances economic competitiveness by lowering the cost of production per unit, making farming more profitable and sustainable.

Objectives:

Farm mechanization helps increase agricultural productivity by enhancing crop yield per unit area. It reduces labor costs by substituting manual work with machines and ensures that field operations are carried out on time, preventing crop losses. Additionally, mechanized tools perform tasks more consistently and uniformly, improving the overall quality of work. By supporting modern farming techniques, including precision agriculture, mechanization also promotes sustainable and efficient agricultural practices.

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iii. Benefits of Farm Mechanization

Farm Mechanization has various benefits

1. Tasks like plowing, planting and harvesting are done faster.
2. Timely and uniform operations enhance crop productivity.
3. Reduces the number of workers needed for farm operations.
4. Minimizes physical strain on farmers, improving health and working conditions.
5. Although initial costs are high, mechanization reduces long-term labor costs and increases profitability.
6. Uniform planting, irrigation and harvesting result in better-quality produce.
7. Facilitates cultivation of extensive areas that would be difficult manually.
8. Provides the infrastructure for precision agriculture, automation and smart irrigation systems.

7.1.1 Conventional Farming Implements

Commonly used conventional farming implements include:

1. Plough (Wooden or Iron Plough)	2. Harrow	
3. Cultivator	4. Seed Drill	5. Leveller
6. Sickle	7. Hoe	8. Spade
9. Ridger	10. Cart (Bullock/tractor-drawn)	

Uses of Different Conventional Farming Tools

1. **Plough**
   - Used for primary tillage of soil.
   - Breaks and turns the soil, buries weeds and makes it suitable for sowing.

2. **Harrow**
   - Used after ploughing for breaking clods, leveling soil and preparing a fine seedbed.

3. **Cultivator**
   - Helps in secondary tillage, stirring the soil and controlling weeds.

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4. Seed Drill

- Sows seeds uniformly at proper depth and spacing.
- Ensures better germination compared to manual broadcasting.

5. Leveller

- Levels the soil surface for uniform irrigation and better crop establishment.

6. Sickle

- A hand tool used for harvesting crops like wheat, rice and fodder.

7. Hoe

- Used for weeding, soil loosening and small-scale tillage operations.

8. Spade

- A manual digging tool used for soil turning, planting and small excavation work.

9. Ridger

- Forms ridges and furrows in the field for crops like maize, cotton and sugarcane.

10. Cart

- Used for transporting seeds, fertilizers, harvested produce and farm inputs/outputs.

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1. Structural Diagram of a Rabi Drill

A **Rabi Drill** is used for sowing wheat and other Rabi season crops in lines at uniform depth and spacing.

Main parts:

1. **Seed box** – Stores seed.
2. **Seed metering mechanism** – Regulates seed flow.
3. **Seed tubes** – Carry seed to furrows.

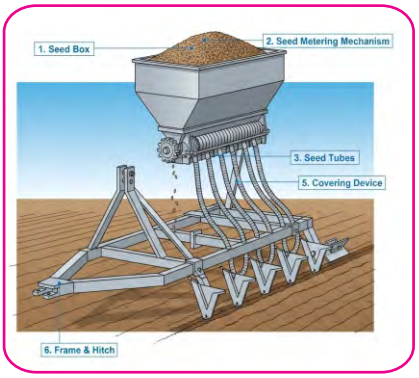

Fig 7.1: Rabi Drill

4. **Furrow openers** – Open the soil for placing seed at proper depth.
5. **Covering device** – Covers seed with soil.
6. **Frame & hitch** – For attaching with tractor/animal power.

7.1.2 Hoeing and Inter-Culturing Tillage Implements

Hoeing and inter-culturing are **secondary tillage operations** carried out after sowing to:

- Remove weeds,
- Stir the soil for aeration,
- Break soil crust,
- Conserve soil moisture,
- Facilitate fertilizer application,
- Encourage better crop growth.

A. Hoeing Implements

1. Hand Hoe

- Simple manual implement with blade and long handle.
- Used for weeding and loosening soil in gardens and small fields.

2. Animal-Drawn Hoe (Gorru, Wheel Hoe)

- V-shaped or flat blade attached to a wooden/iron frame.
- Operated with bullocks.
- Used for inter-row cultivation, earthing up and weed control.

3. Wheel Hoe

- Hand-operated hoe with wheel support.
- Easy to push/pull, reduces drudgery.

Fig 7.2: Wheel Hoe

B. Inter-Culturing Implements

1. Blade Hoe (Tine Hoe)

- Animal or tractor-drawn hoe with narrow blades.
- Cuts weeds and stirs soil between crop rows.

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2. Cultivator (Rigid Tine / Spring Tine)

- Tractor-drawn with multiple shovels/tines.
- Used for intercultural operations like weeding, aeration and shallow tillage.

3. Rotary Hoe / Power Weeder

- Power-operated with rotating blades.
- Removes weeds quickly and pulverizes soil.
- Suitable for row crops like maize, cotton and sugarcane.

Summary Table

Category	Implements	Power Source	Uses
Hoeing	Hand hoe, Animal-drawn hoe, Wheel hoe	Manual/Animal	Weeding, loosening soil
Inter-Culturing	Blade hoe, Cultivator, Rotary hoe/power weeder	Animal/Tractor/Power	Weed control, soil aeration, intercultural tillage

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7.1.2.1 Land Preparation

Land Preparation Implements for Different Crops

Land preparation is the first step before sowing. It involves primary tillage, secondary tillage, leveling and seedbed preparation, depending on the crop.

1. Primary Tillage Implements

Used for breaking and turning the soil after harvesting the previous crop.

- **Wooden (Desi) Plough** – Traditional plough, used for shallow tillage in small fields.
- **Mould Board Plough** – Turns soil completely, buries weeds and stubbles. Suitable for wheat, rice, cotton, maize.
- **Disc Plough** – Works well in hard soils and sticky conditions. Suitable for sugarcane, cotton, maize.

- **Chisel Plough / Sub-soiler** – Breaks hard pan, improves root penetration. Used for deep-rooted crops like sugarcane, cotton, orchards.

Fig 7.3: Chisel Plough

2. Secondary Tillage Implements

Used after primary tillage to pulverize soil, remove weeds and prepare fine seedbed.

- **Harrow**
  - *Disc Harrow*: Breaks clods, incorporates crop residues (for wheat, maize).
  - *Spike Tooth Harrow*: Crushes clods and levels soil (for pulses, vegetables).
- **Cultivator** – Stirs and aerates soil, controls weeds, prepares seedbed for wheat, maize, cotton.
- **Rotavator (Rotary Tiller)** – Tractor-powered implement that pulverizes soil and mixes residues; commonly used for rice, vegetables and sugarcane.

Fig 7.4: Rotavator

3. Land Leveling Implements

Uniform leveling improves irrigation efficiency and germination.

- **Leveller / Planker** – Wooden or iron implement for leveling soil.
- **Laser Land Leveller** – Modern implement using laser technology; suitable for rice, wheat and all irrigated crops.

Fig 7.5: Laser Land Laveller

4. Sowing and Seedbed Preparation Implements

- **Seed Drill / Rabi Drill** – For wheat, pulses.
- **Seed-cum-Fertilizer Drill** – For maize, wheat, cotton.
- **Puddler** – Used for rice cultivation in flooded fields.
- **Ridger / Bed Planter** – For maize, potato, sugarcane.

Fig 7.6: Puddler

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Summary (Crop-wise Examples)

Crop	Main Implements Used
Wheat	Mould board plough, Disc harrow, Cultivator, Rabi drill
Rice	Disc plough, Puddler, Rotavator, Leveler
Maize	Mould board plough, Cultivator, Ridger, Seed drill
Cotton	Chisel plough, Disc harrow, Cultivator, Seed-cum-fertilizer drill
Sugarcane	Disc plough, Sub-soiler, Rotavator, Ridger
Vegetables	Rotavator, Spike tooth harrow, Bed planter

7.1.3 Harvesting and Threshing Machinery

A. Harvesting Machinery

Used to cut and gather crops from the field.

1. **Sickle** – Hand tool for small-scale harvesting.
2. **Scythe** – Manual tool with long handle and curved blade.
3. **Reaper** – Animal or tractor-operated implement for cutting cereals.
4. **Reaper-Binder** – Cuts and binds crops into bundles.
5. **Mower** – Cuts grasses and fodder crops.
6. **Forage Harvester** – Used for harvesting fodder maize, sorghum, etc.
7. **Combine Harvester** – Performs harvesting, threshing and cleaning in one operation.

Fig 7.7: Combine Harvester

B. Threshing Machinery

Used to separate grain from the straw after harvesting.

1. **Beating Method (manual)** – Traditional, labor-intensive.
2. **Pedal Thresher** – Foot-operated small machine.
3. **Animal Treading** – Traditional method (oxen, bullocks).
4. **Power Thresher** – Tractor or motor-operated machine for wheat, rice, maize, pulses.
5. **Multi-Crop Thresher** – Works for cereals, pulses, oilseeds.
6. **Axial Flow Thresher** – Efficient, reduces grain loss.
7. **Combine Harvester (Integrated)** – Harvests and threshes simultaneously.

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7.2 Role of Mechanization in Post-Harvest Management

Post-harvest management includes all operations after harvesting: threshing, cleaning, grading, drying, storage, processing and transportation. Mechanization plays a vital role in making these processes efficient, fast and economical.

1. Threshing and Harvesting

- **Machines:** Combine harvesters, power threshers, multi-crop threshers.
- **Role:**
  - Rapid separation of grain from straw.
  - Reduces grain loss and labor cost.
  - Increases timeliness of operations, important for wheat–rice systems.

Fig 7.8: Thresher

2. Cleaning and Grading

- **Machines:** Winnowers, air-screen cleaners, graders.
- **Role:**
  - Removes dust, chaff, immature seeds.
  - Produces uniform seed size, improving market value and seed quality.

Fig 7.9: Grader

3. Drying

- **Machines:** Mechanical grain dryers (solar dryers, batch dryers, continuous-flow dryers).
- **Role:**
  - Reduces moisture to safe storage level.
  - Prevents fungal attack, sprouting and insect infestation.
  - Saves time compared to traditional sun drying.

4. Storage

- **Machines/Structures:** Silos, bins, cold storage, hermetic storage structures.
- **Role:**
  - Protects grains, fruits and vegetables from pests and spoilage.
  - Reduces post-harvest losses.
  - Maintains quality for longer duration.

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5. Processing and Value Addition

- **Machines:** Rice mills, flour mills, oil expellers, fruit pulpers, juice extractors.
- **Role:**
  - Converts raw produce into marketable and consumable forms.
  - Increases shelf life and farmer's income.
  - Encourages agro-based industries.

6. Transportation

- **Machines:** Tractors with trailers, trucks, conveyor belts.
- **Role:**
  - Quick movement of produce from farm to market or storage.
  - Reduces spoilage during transit.

7.2.1 Post-Harvest Machinery

1. Harvesting & Threshing Machinery

- Sickles, Reapers, Combine Harvester
- Pedal thresher, Power thresher, Axial flow thresher, Multi-crop thresher

2. Cleaning & Grading Machinery

- Winnower
- Air-screen cleaner
- Grain grader / Seed grader
- Specific gravity separator

3. Drying Machinery

- Solar dryer
- Batch-type grain dryer
- Continuous-flow dryer
- Fluidized bed dryer

Fig 7.10:Solar Dryer

4. Storage & Handling Equipment

- Silos (metal, concrete)
- Grain bins
- Cold storage units (for fruits & vegetables)

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- Hermetic storage bags/structures
- Conveyor belts, elevators, augers

5. Processing & Value Addition Machinery

- Rice mill
- Flour mill / Hammer mill
- Oil expeller
- Fruit pulper, Juice extractor
- Dehydrator (for vegetables, fruits, spices)

6. Transportation Equipment

- Tractor with trailer
- Trucks / Lorries
- Conveyor systems

Fig 7.11: Dehydrator

7.3 Post harvest management

Harvesting Implements of Major Crops

1. Cereal Crops (Wheat, Rice, Maize, Barley, Millet)

- **Sickle** (hand harvesting)
- **Scythe** (manual cutting tool)
- **Reaper / Reaper-Binder**
- **Combine Harvester** (harvesting + threshing + cleaning)

2. Sugarcane

- **Hand Cane Knife / Billhook**
- **Sugarcane Harvester** (tractor-mounted or self-propelled)

3. Cotton

- **Cotton Picking by Hand** (traditional)
- **Cotton Picker Machine**
- **Cotton Stripper**

4. Fodder & Forage Crops (Maize, Sorghum, Berseem, Lucerne, Grasses)

- **Mower** (sickle bar mower, rotary mower)
- **Forage Harvester / Chopper**

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5. Potato & Root Crops

- **Digging fork (manual)**
- **Potato Digger / Potato Harvester**
- **Groundnut Digger**

6. Pulses & Oilseeds (Gram, Lentil, Mustard, Sunflower, Soybean)

- **Sickle** (manual harvesting)
- **Reaper**
- **Combine Harvester**

7.4 Imaging Technology & drones

i. Crop Monitoring Using Imaging Technology

Crop monitoring with imaging technology refers to the use of satellite images, drones and remote sensing cameras to assess the condition of crops throughout the growing season. These technologies capture multispectral and hyperspectral images that provide data beyond the visible range of human eyes, including near-infrared and thermal bands. Such images help in detecting crop stress, pest infestation, nutrient deficiencies, water availability and overall plant health.

By analyzing indices like NDVI (Normalized Difference Vegetation Index), farmers and researchers can measure crop vigor, chlorophyll content and biomass growth. Imaging technology enables precision agriculture, where farmers can monitor large fields in real-time, identify problem areas and apply inputs (water, fertilizer, pesticides) only where needed. This reduces costs, saves time, conserves resources and increases yield while minimizing environmental impact.

ii. Role of Drone Technology in Agricultural Mechanization (Pesticide & Fertilizer Application)

Drone technology has revolutionized agricultural mechanization by making crop input application faster, safer and more precise. Equipped with GPS and spraying mechanisms, drones can **uniformly apply pesticides and fertilizers** across large fields, even in difficult terrains where tractors or manual labor cannot reach.

In pesticide application, drones spray chemicals at controlled droplet sizes, reducing wastage and exposure of farmers to harmful chemicals. This ensures effective pest control with minimal health risks. For fertilizers, drones can distribute liquid nutrients or granular formulations evenly, guided by real-time imaging and mapping data. Drones also allow for **variable-rate application**,

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meaning fertilizers and pesticides are applied only where crops actually need them, based on imaging and sensor feedback.

Overall, drones enhance **timeliness, accuracy and efficiency** in farming operations, reduce input costs, conserve resources and support sustainable agriculture.

Fig 7.12: Spraying with Drones

Exercise

A) Multiple Choice Questions

1. **Farm mechanization mainly refers to:**
   a) Use of fertilizers only b) Use of machinery in farming operations
   c) Only irrigation practices d) Use of animals in tillage
2. **Which implement is used for primary tillage?**
   a) Harrow b) Mould board plough
   c) Cultivator d) Rotavator
3. **A Rabi drill is primarily used for:**
   a) Harvesting sugarcane b) Sowing wheat in rows
   c) Cleaning grains d) Applying pesticides
4. **Which harvesting implement performs cutting, threshing and cleaning in one operation?**
   a) Sickle b) Reaper
   c) Combine harvester d) Scythe
5. **The disc harrow is mainly used for:**
   a) Deep ploughing b) Clod breaking and soil pulverization
   c) Harvesting rice d) Irrigation
6. **Which machine is used for drying grains?**
   a) Winnower b) Grain dryer
   c) Reaper-binder d) Sub-soiler
7. **NDVI in imaging technology is used to measure:**
   a) Soil moisture b) Crop vigor and chlorophyll content
   c) Tractor horsepower d) Irrigation flow

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8. Drones in pesticide application are superior because they:

a) Increase wastage b) Expose farmers to chemicals

c) Apply chemicals uniformly and safely d) Replace threshing machines

Short Questions

1. Define farm mechanization and its objectives.
2. List four primary tillage implements.
3. What are the main uses of a cultivator?
4. Write two advantages of drone spraying compared to manual spraying.
5. What are the main uses of a laser land leveler?
6. Enlist three ways farmers dispose of their agricultural commodities.

Long Questions

1. Explain the necessity and objectives of farm mechanization in modern agriculture.
2. Discuss harvesting and threshing machinery with suitable examples.
3. Explain the role of mechanization in post-harvest management.
4. Discuss the application of imaging technology and drones in precision agriculture.

Inquisitive / Critical Thinking Questions

1. How can small farmers with limited resources adopt mechanization without heavy financial burden?
2. Could drone-based spraying completely replace tractor-mounted sprayers in the future? Why or why not?
3. How might integrating imaging technology with post-harvest management systems revolutionize agriculture?

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GLOSSARY OF TERMS

1. **Abiotic Factors** – Non-living environmental conditions (temperature, moisture, humidity, light, oxygen) that affect grain quality during storage.
2. **Active Compounds (Phytochemicals)** – Naturally occurring chemical substances in plants (e.g., alkaloids, flavonoids, tannins, essential oils) responsible for therapeutic properties.
3. **Basic Seed** – High-quality seed derived from pre-basic seed, used as the source for producing certified/commercial seeds.
4. **Biotic Factors** – Living organisms (insects, rodents, birds, fungi, bacteria) that damage grains and cause both quantitative and qualitative storage losses.
5. **Certified Seed** – Seed produced from basic seed, officially tested and approved by seed certification agencies for purity, germination and health, sold to farmers for cultivation.
6. **Condiments** – Plant products such as spices, herbs and seeds used in small amounts to add flavor, aroma and taste to food.
7. **Deficiency Symptoms** – Visible changes in plants (like yellowing, stunted growth, poor fruiting) that occur when essential nutrients are insufficient.
8. **Ecological Zones** – Specific geographic regions with distinct climates and soil types where particular medicinal and condiment plants naturally thrive.
9. **Essential Oils** – Concentrated volatile aromatic compounds extracted from plants (e.g., mint, lemongrass) used in medicine, perfumes and flavoring.
10. **Fruit (Botanical Definition)** – The mature ovary of a flower, usually containing seeds, developed after fertilization (e.g., mango, tomato).
11. **Fruit (Horticultural Definition)** – Any edible plant product that is usually sweet, fleshy and consumed raw (e.g., mango, banana, grapes).
12. **Fumigation** – A pest control method in which stored grains are exposed to toxic gases (e.g., phosphine) under airtight conditions.
13. **Genetic Purity** – The true-to-type nature of seeds that ensures offspring retain the exact desirable traits of the parent variety.

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14. **Grafting** – A method of plant propagation where a scion (shoot) is joined to a rootstock so that both grow as a single plant.
15. **Grain Storage** – The process of keeping harvested grains under safe conditions to protect them from pests, moisture and spoilage.
16. **Harvesting** – The collection of specific plant parts (leaves, roots, bark, seeds, flowers) at the proper stage for maximum quality.
17. **Hermetic Storage** – An airtight storage method (metal bins, plastic bags, silos) that prevents insect growth and spoilage without chemicals.
18. **Hydroponics** – A modern farming system where plants are grown without soil, using water-based nutrient solutions and inert growing media.
19. **Integrated Nutrient Management (INM)** – A balanced approach of using organic sources (manure, compost, biofertilizers) along with inorganic fertilizers.
20. **Integrated Pest Management (IPM)** – An eco-friendly approach to control pests using cultural, mechanical, biological and chemical methods.
21. **Kitchen Gardening** – The practice of growing vegetables, fruits and herbs around the house (in backyard, rooftop, or pots) mainly for family use.
22. **Layering** – A vegetative propagation method in which a stem develops roots while still attached to the parent plant (e.g., air layering in guava).
23. **Macronutrients** – Mineral nutrients required in large amounts, e.g., N, P, K, Ca, Mg, S.
24. **Medicinal Plants** – Plants containing bioactive compounds used in medicine to prevent or cure diseases.
25. **Micropropagation (Tissue Culture)** – A modern propagation technique where plantlets are produced under sterile laboratory conditions.
26. **Micronutrients** – Mineral nutrients required in very small amounts, e.g., Fe, Zn, B, Mo.
27. **Mulching** – Covering the soil surface with straw, leaves, or polythene sheets to conserve moisture, suppress weeds and regulate soil temperature.

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28. **Nutrient Uptake** – The process by which plant roots absorb mineral elements from the soil solution in ionic form.
29. **Nursery** – A small, well-managed area where vegetable seeds are sown and seedlings are raised before transplanting.
30. **Orthodox Seeds** – Seeds that can be dried to low moisture levels and stored for long periods without losing viability (e.g., wheat, rice).
31. **Phytotoxicity** – The toxic effect of excess fertilizers, pesticides, or chemicals on plants, causing damage or death.
32. **Pre-Basic Seed** – The initial generation of seed produced from breeder's seed under strict supervision.
33. **Pruning** – The removal of unwanted, diseased, or overgrown parts of plants to improve yield.
34. **Processing** – Post-harvest treatments such as cleaning, drying, grinding, or extraction of compounds.
35. **Propagation** – The process of creating new plants from existing ones, by seeds (sexual) or vegetative methods (asexual).
36. **Quantitative Losses** – Physical reduction in grain weight/volume during storage due to insects, rodents, or moisture.
37. **Qualitative Losses** – Deterioration in grain quality caused by fungi, insects, or contamination.
38. **Recalcitrant Seeds** – Seeds that cannot tolerate drying or long-term storage (e.g., mango, coconut).
39. **Roguing (Seed Production)** – Removing off-type, diseased, or inferior plants from a seed crop to maintain purity.
40. **Roguing (Storage Context)** – Checking and removing infested or spoiled grains from storage to maintain quality.
41. **Rootstock** – The lower part of a grafted plant, including the root system, onto which a scion is grafted.
42. **Scion** – The upper part (bud or shoot) of a desired plant that is grafted onto a

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rootstock.

43. **Seed** – A mature fertilized ovule containing an embryo, nutritive tissue and seed coat.
44. **Seed Certification** – The official inspection/testing process to ensure seeds meet standards of purity and quality.
45. **Soil Preparation** – Clearing, ploughing, leveling and mixing organic matter in soil to improve fertility before planting.
46. **Storage** – Preserving harvested plant material (e.g., drying, packaging) to maintain potency and prevent spoilage.
47. **Succession Planting** – Growing short-duration crops between long-duration crops for continuous harvest.
48. **Temperate Fruits** – Fruits that require cold winters and chilling hours to break dormancy (e.g., apple, peach).
49. **Tropical Fruits** – Fruits grown in hot, frost-free climates (e.g., mango, banana).
50. **Value Addition** – Converting raw plant materials into higher-value products (juices, powders, oils, capsules).
51. **Viability** – The ability of a seed to germinate and produce a healthy seedling.

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Instructions for Preparation of Exam Paper of Agriculture Sciences for Class 10

ESSENTIAL INSTRUCTIONS FOR PAPER SETTERS

The paper of Agriculture Sciences for Grade-10 will consist of **40 marks.**

Duration of the paper will be **2 hours.**

(Objective Type = 15 minutes + Subjective Type = **1:45 hours)**

Objective Type = 10 marks + Subjective Type = **30 marks.**

The paper will be made as per following details:

Part-I: Objective:	**Q-1:** 10 Multiple Choice Questions (MCQs) will be developed from the entire content of the textbook. One MCQ will be asked from Unit 1,2,3 & 4 while Two MCQs each will be asked from Unit 5,6 & 7 respectively .	1x4=4 2x3=6 Total=10
Part-II: Subjective:	This section will contain two short answer questions. Each short answer question will be asked from the exercises of the textbook. The detail is as follows: **Q-2:** 4 short answer questions have to be answered out of 6. The detail is as follows: Three short answer question should be asked from Unit 1 & 2, Three short answer questions should be asked from Unit 3 &4.	(2 × 4) = 8
	Q-3: 4 short answer questions have to be answered out of 6. The detail is as follows: Three short answer question should be asked from Unit 5 & 7, Three short answer questions should be asked from Unit 6.	(2 × 4) = 8
Part-III: Subjective:	This section will contain three detailed questions and students have to attempt 2 questions carrying 7 marks each. Each detailed question will be asked form the exercises of the textbook. The detail is as follows: **Q-4:** One detailed question will be asked either from Unit 1 , 2 or Unit 5. **Q-5:** One detailed question will be asked either from Unit 3 or Unit4. **Q-6:** One detailed question will be asked either from Unit 6 or Unit 7 .	(2 × 7) = 14

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Model Paper
Agriculture Sciences
OBJECTIVE

Total Marks: 10 **Class: 10th** **Time Allowed: 15 Mins**

Q 1: Choose the correct option. **(1 x 10 = 10)**

i. The scion in grafting refers to
a. The root portion b. The upper shoot portion
c. The soil medium d. The flowering part only

ii. Ginger is propagated commercially through
a. Seeds b. Offsets c. Rhizomes d. Cuttings

iii. Pre- basic seed is also known as
a. Approved seed b. Breeder seed or nucleus seed
c. Certified seed d. Farm saved seed

iv. Fumigation is carried out mainly to
a. Increase germination b. Kill hidden insect pests
b. Improve grain colour d. Reduce transportation cost

v. Blossom end rot in tomato is due to deficiency of
a. Zinc b. Calcium c. Boron d. Potassium

vi. Soil pH strongly affects nutrient
a. Uptake only b. Solubility and availability
c. Storage in plants d. None of these

vii. The correct spacing for tomato plants in kitchen gardening is
a. 30x30cm b. 60x45cm c. 45x45cm d. 90x60cm

viii. Which of the following vegetable is commonly grown in hydroponics
a. Onion b. Lettuce c. Carrot d. Garlic

ix Which machine is used for drying grains
a. Winnower b. Grain dryer c. Reaper-binder d. Sub-soiler

x Drones in pesticide application are superior because they
a. Increase wastage
b. Expose farmers to chemicals
c. Apply chemicals uniformly and safely
d. Replace threshing machine

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Model Paper
Agriculture Sciences
SUBJECTIVE

Total Marks: 30 **Class: 10th** **Time Allowed: 1:45 Hrs**

Part - II

Q 2: Write the answers to any four (04) short questions. **(4 x 2 = 8)**

i. Name any two tropical and two temperate fruits.
ii. Define fruit Botanically and Horticulturally.
iii. List three medicinal plants and the parts used from each.
iv. Write five characteristics of good seed.
v. List two abiotic factors affecting grain storage.
vi. Name any three modern grain storage methods?

Q 3: Write the answers to any four (04) short questions. **(4 x 2 = 8)**

i. What is Phytotoxicity?
ii. List four primary tillage implements?
iii. What are the main uses of a laser land leveler?
iv. Name five summer and five winter vegetables suitable for kitchen gardening?
v. Name three advantages and three disadvantages of hydroponic farming?
vi. Give two maturity indices for harvesting root vegetables and fruiting vegetables?

Part - III

Note: Attempt any two (02) long questions

Q. 4: Explain the effect of Rootstock on the growth, adaptability and yield of fruit plants . **(07)**

Q. 5: Discuss the major quantitative and qualitative losses during grain storage. **(07)**

Q. 6: Explain the layout system, seasonal rotation and container gardening for continuous vegetable supply in limited spaces. **(07)**

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