Draft Study Material

HYDROPONICS TECHNICIAN

(QUALIFICATION PACK: Ref. Id. AGR/Q0808)

SECTOR: AGRICULTURE

Grades 11

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NCERT

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Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives. The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material. Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material. This material is copyrighted and should not be printed without the permission of the NCERT-PSSCIVE.

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Module 1

Hydroponics and its Importance

Module Overview

In today's world, our global population is increasing day by day, leading to a decline in arable land and water due to urbanization. The demand for food supply is becoming a challenge and will continue to be so in the coming decades. The uncontrolled/injudicious application of chemicals- fertilizers and pesticides on soil has resulted in soil erosion, poor drainage, and reduced fertility along with a decrease in beneficial flora and fauna in the soil. Indiscriminate use of fertilizers and pesticides in present-day agriculture also poses a threat to the environment. Further, the water level is decreasing day by day due to overexploitation of groundwater mainly for agriculture. The above scenario necessitates a shift to soilless cultivation, where problems related to soil and water can be minimized. In soilless cultivation, nutrients are supplied directly to the plants through a nutrient solution, in which water consumption can be reduced by up to 90% with minimum space utilization.

In many developing countries, soilless cultivation is becoming popular because it allows for precise control of nutrients and optimal use of water and land, leading to higher yields as well as better control over environmental factors and soil-borne pathogens.

This module aims to build a foundational understanding of how hydroponics works and why it is gaining significance in modern agriculture. In Session 1, students will explore the concept of hydroponics, its benefits, and its role in addressing challenges like soil degradation, limited space, and water scarcity. Session 2 focuses on identifying crops that are best suited for hydroponic cultivation, providing students with practical insights into crop selection for successful soil-less farming.

Learning Outcomes

After completing this module, you will be able to:

- Define hydroponics, principles, importance in modern agriculture.
- Identify the crops most suitable for hydroponic cultivation, understand their specific growth requirements.

Module Structure

Session 1: Hydroponics and its Importance

Session 2: Suitable Crops for Hydroponic Cultivation

Session 1: Hydroponics and its Importance

The term "Hydroponics" is derived from two Greek words: 'Hydro,' meaning water, and 'Ponos,' meaning labour. Hydroponics refers to the method of growing plants in a nutrient solution without the use of soil. Hydroponics or soil-less culture provides all the essential nutrients required by the plants for their growth and development are supplied through nutrient solutions with or without the use of inert growth media. Growth media contain a variety of nutrients necessary to sustain the growth of microorganisms such as gravel, vermiculite, rockwool, peat moss, sawdust, coir dust, coconut fiber, etc. The nutrients are supplied to the plants in the form of a liquid solution through their roots. Hydroponic systems can be grown in a closed environment, where environmental factors such as light, temperature, and humidity can be managed. The Ph (Potential of Hydrogen) and Electrical Conductivity (EC) of the nutrient solution provided to the plants are controlled for the effective uptake of nutrients.

Historical Background

Soilless cultivation has been popular since ancient times. The Hanging Gardens of Babylon and the floating gardens in Dal Lake, Kashmir, are early examples of soilless cultivation. In 1929, Dr. William F. Gericke, a botany professor at the University of California, coined the term "hydroponics" to refer to the practice of growing plants in water without soil. Dr. Gericke successfully produced tomato plants using this method.

During World War II, the U.S. Army established large hydroponic gardens on several islands to supply fresh vegetables to their troops. Hydroponics proved valuable for growing plants in non-arable areas. Since the 1980s, hydroponic techniques have been widely adopted for commercial vegetable and flower production.

Importance of Hydroponics in India

Hydroponics plays a vital role due to its various benefits. As the population increases, various challenges emerge in agriculture such as climate change, water scarcity, decreasing arable land area and the need to feed a growing population. Amidst these challenges, hydroponics is a promising opportunity to address these issues effectively. Most of the region's agricultural land has turned into concrete jungles, and the construction of multistory buildings has led to declining arable land. The alternative left with us is to utilize degradable lands for more productivity through hydroponic ways of cultivation of crops such as vegetables, herbs, certain fruits, medicinal plants, spices and certain ornamentals. This way of cultivation has several importance:

- Hydroponics allows efficient use of water for the plants. It saves a considerable amount of water lost through evaporation and runoff and enables more efficient water usage by recycling water within the system. This method is especially important in drought-prone areas where water scarcity is a major problem in crop production.
- Hydroponic systems can be grown in a closed environment, providing a favorable environment for plants by controlling temperature, humidity, light, etc.
- Hydroponics allows precise control of nutrient supply to plants. This system ensures plants receive the exact amount of nutrients required, thereby saving on excess fertilizer compared to traditional farming.
- Since it is soilless farming, hydroponics protects crops from soil-borne pathogens. Setting up hydroponic systems indoors or in greenhouses also minimizes the risk of pest infestations, resulting in healthier produce.
- Hydroponic systems effectively utilize space by allowing vertical planting systems in limited spaces, thereby producing high yields per unit area.
- As urbanization continues to expand and available arable land reduces, hydroponics provides a solution by supporting urban farming initiatives even in limited spaces such as rooftops and balconies.
- Hydroponic farming also contributes to cost reduction, particularly notable in savings related to labor-intensive activities such as weeding, digging, and other cultural operations.

Roles and Responsibilities of Hydroponics Technician

Hydroponics technicians play a crucial role in the successful operation of hydroponic systems. Their responsibilities include setting up and installing the hydroponic systems, formulating nutrient solutions, monitoring and adjusting pH levels, selecting suitable crops, supervising germination, transplanting seedlings or mature plants, managing solution levels, light management and overall supervision of crop growth and health. By performing these tasks efficiently, hydroponics technicians contribute to plants' healthy growth and development in hydroponic systems. Their expertise in system management, plant care, and environmental control is paramount to maintaining a healthy and productive growing environment throughout the season.

These technicians are responsible for ensuring the system functions flawlessly. They assemble and install the hydroponic system, ensuring its proper operation. They manage and formulate nutrient solutions for the specific needs of the crops. This involves constantly monitoring and adjusting the pH levels to maintain optimal range for nutrient uptake. They measure and regulate the EC/TDS levels thus ensuring the correct concentration of nutrients in the solution.

Apart from these, hydroponics technicians manage agronomic operations in the hydroponics unit such as selection of suitable systems, transplanting, ensuring proper water flow and optimum nutrient delivery. They also manage and monitor environmental conditions like temperature, light and humidity to create an ideal growing environment necessary for crop growth throughout the season.

Employment opportunities for hydroponics technician

The demand for skilled hydroponics technicians continues to grow as the agricultural industry adopts modern farming methods. Hydroponic systems open the path to employment opportunities for technicians looking to specialize in this modern farming technique. Hydroponics is a growing field with increasing demand for skilled technicians. Here are employment opportunities in two parts:

a. Self-employment opportunities
b. Wage employment opportunities

a. Self-employment opportunities

1. **Consultancy service:** As a hydroponics technician with expertise in designing, setting up and maintaining hydroponic systems, these technicians can offer advice to individuals or businesses interested in hydroponics farming.

2. **Own farming business:** Hydroponics technicians can start their own hydroponic farming business by growing high-value crops for sale to restaurants, grocery stores or directly to consumers.

3. **Hydroponics store business:** Being an expert in this field, technicians can open their own hydroponics store and build an e-commerce platform for supplies, equipment and grow kits which may include nutrient solutions, grow lights, growing media and other essential equipment for hydroponic farming.

b. Wage employment opportunities

1. **Hydroponic technician:** Technicians can work in commercial hydroponic farms, by managing day-to-day operations. Their responsibilities may include planting, monitoring plant health, adjusting nutrient levels, maintaining equipment and harvesting crops.

2. **Hydroponics assistant:** Hydroponics companies hire assistants to help with installations on sites and provide ongoing maintenance guidance. Assistants also play an important role in educating clients on the proper care and operation of their systems and advising on optimizing plant growth for optimum yield production.

ACTIVITIES

Activity 1: Visit a nearby hydroponics unit and collect information from the owner.
Materials Required: Pen, pencil, notebook, etc.

Procedure:

1. Visit a nearby hydroponics unit and note down the following observation:
   - Enlist different crops grown in hydroponic units.
   - Note down the type of hydroponic system.
   - Discuss and note down the function of the hydroponics system.
   - Discuss and note the cost of setting up the hydroponics unit.

2. If you have any queries, discuss them with the hydroponics unit in charge.

Check Your Progress

A. Fill in the Blank

1. Hydroponic systems provide protection from __________borne pathogens
2. Hydroponics is a method of growing plants without using __________.
3. Plants are taking nutrient from __________solutions.

4. To ensure optimal growth, hydroponics technicians monitor and adjust the __________level of the nutrient solution.

B. Multiple Choice Questions

1. What are the two Greek words that form the term "hydroponics"?
   a. Hodos and ponos
   b. Hydros and ponomos
   c. Hudor and ponos
   d. Hydro and ponos
2. In which areas can hydroponics be particularly beneficial due to its water-saving feature?
   a. Regions with abundant rainfall
   b. Drought-prone areas
   c. Coastal regions
   d. Tropical rainforests
3. Compared to traditional farming, hydroponics uses significantly less amount of?
   a. Space
   b. Fertilizer
   c. Water
   d. All of these

Subjective Questions

- Describe the importance of hydroponics in India.

Session 2 - Suitable Crops for Hydroponic Cultivation

Hydroponic cultivation is gaining popularity because it allows crops to be grown in controlled environments or indoors. In hydroponics, plants get the required nutrients, leading to faster growth and higher yields. Selecting suitable crops for the hydroponics system is an important aspect of success in this method. The choice depends on factors such as growth habits, nutrient requirements and adaptability to hydroponic systems. Leafy vegetables can be grown better in hydroponic settings due to their simple nutrient needs and rapid vegetative growth rates. Therefore, it is essential to select the right crop that efficiently utilizes available resources, has a high adaptability rate and exhibits resistance to biotic and abiotic factors. The most commonly grown crops in soilless culture are lettuce, cucumber, strawberry, basil, parsley etc.

Use of Hydroponics Cultivation in Agriculture

Hydroponics addresses challenges related to land scarcity and poor soil quality, making it particularly beneficial in regions where arable land is limited. The system's adaptability to various settings, including urban areas, allows for year-round cultivation without being constrained by seasonal changes. With the ability to control factors such as temperature, humidity, and light exposure, hydroponics provides a level of precision unattainable in traditional farming. This method not only maximizes space utilization but also reduces the environmental impact associated with conventional agriculture making hydroponics a sustainable and resource-efficient solution for meeting the demands of a growing global population. Its application extends across various sectors of agriculture, including protected cultivation and precision farming where it presents unique advantages and opportunities.

a. Use of Hydroponics in Protected Cultivation

Protected cultivation refers to the practice of growing crops within structures such as greenhouses (polytunnels) to protect them from adverse weather conditions and pests. environment for the sustained growth of crops to realize their maximum potential even in adverse climatic conditions. Protected cultivation technology offers several advantages to produce vegetables, flowers, and hybrid seeds of high quality with minimum risks due to uncertainty of weather and ensuring efficient management of resources. It can be used to produce horticultural crops and their planting material of high quality and yields, through efficient resource utilization. Fruits, vegetables and flower crops normally accrue 4 to 8 times higher profits than other crops. This margin of profit can increase manifolds if some of these high-value crops are grown under protected conditions, like greenhouses, net houses, tunnels etc. Such an agricultural production system could provide a more profitable source of income and employment in the rural sector Hydroponics seamlessly integrates into this system, offering numerous advantages.

Protected structures provide a controlled environment where factors like temperature, humidity, light intensity and air circulation are carefully regulated. Hydroponic systems can be vertically arranged in compact configurations, thereby maximizing space utilization within greenhouse structures. The controlled environment of greenhouses further reduces the infestation of pests, leading to decreased dependence on chemical pesticide.

b. Use of Hydroponics in Precision Farming

Precision farming involves the use of various technologies to optimize inputs such as water, fertilizers and pesticides, thereby maximizing efficiency and productivity. Precision farming is a key component of a Hydroponic system that offers precise control and monitoring of nutrient levels ensuring that plants get the exact nutrients they need at each growth stage. This eliminates the overuse of fertilizers and minimizes nutrient runoff, thereby reducing environmental pollution. Integration of sensors and monitoring devices in hydroponic systems enables real-time data collection on environmental parameters and plant health indicators. Hydroponic systems can be automated to a large extent with functions such as nutrient dosing, irrigation and climate control remotely through computerized systems.

Selecting Suitable Systems for Successful Hydroponics Cultivation

When choosing a hydroponic system, various factors must be considered to ensure its suitability for specific crops, available space, budget and desired level of automation. Climatic conditions and water availability play significant roles in system selection ensuring efficient management of environmental factors. Nutrient solution management and crop variety suitability are also the key considerations as these impact the systems' overall success. By carefully assessing these factors, growers can choose a hydroponic system that aligns with their needs and resources, ultimately leading to the successful cultivation of crops in a controlled environment.

Selecting suitable hydroponic systems for various types of cultivation requires careful consideration of multiple factors to ensure optimal crop growth and productivity. Each hydroponic system possesses unique characteristics, and different crops may flourish under specific setups. Thus, choosing the appropriate hydroponic system is critical for successful crop cultivation.

Environmental factors like temperature, humidity, and light availability should also be considered when selecting a hydroponic system. Certain systems are better suited for indoor cultivation in controlled environments, while others can be grown in outdoor settings or greenhouses. Hence, selecting the most suitable hydroponic system involves evaluating crop requirements, available resources, desired automation level, and environmental conditions.

Crop Selection

When choosing crops for hydroponic cultivation, several factors must be considered to ensure a successful and profitable operation. Market demand and climate suitability are key in determining crop selection, essential for a sustainable business. Also, selecting high-value crops that yield high profits and evaluating their yield potential and economic value are important steps in maximizing profitability. Selecting the right crops for hydroponic cultivation is key to ensuring successful growth. It involves considering factors such as temperature tolerance, root depth and nutrient absorption efficiency. Each crop has specific needs in terms of the temperature it can withstand, root depth, and how effectively it can take up nutrients from the solution. A wide variety of vegetables, fruits, herbs and ornamental plants can be grown using hydroponics. However, it is essential to ensure that selected crops match the system's capabilities and not those with conflicting needs in the same unit.

Vegetable Crops: Leafy vegetables like lettuce, chard, spinach, and cabbage can be grown in hydroponic systems due to their high vegetative growth. Vine plants, such as tomatoes, cucumbers, and capsicum, can be grown with trellis support. Broccoli, cabbage, and cauliflower, which prefer cooler temperatures, also do well in hydroponics. Additionally, peppers can be grown in such systems.

Fruit Crops: Fruits like strawberries, blueberries, blackberries, raspberries, and grapes can be grown successfully in hydroponic systems.

Herbs: Herbs, such as basil, mint, cilantro, rosemary, parsley, sage and chives can be grown in hydroponic systems. Herbs that prefer wet conditions are particularly successful.

Flowers: Flowers like roses, gerbera, orchids, anthurium, chrysanthemum, foliage plants, *etc*. can be grown in hydroponic systems adding colour and fragrance to the garden. Proper support and nutrients are essential for their optimal growth and blooming.

ACTIVITIES

Activity 1: Visit a Nearby hydroponics unit and enlist different crops suitable for hydroponics.

Materials Required: Pen, pencil, notebook, etc.

Procedure:

Visit a nearby hydroponics unit and note down the following observation:

- Enlist different crops grown in hydroponic units.
- Note down the type of hydroponic system.

- Discuss and note down the function of the hydroponics system.
- Discuss and note the cost of setting up the hydroponics unit.

Check Your Progress

A. Fill in the Blank

1. Leafy vegetables can be grown better in hydroponic systems due to their vigorous __________growth.
2. __________farming involves the use of technologies to optimize inputs such as water, fertilizers and pesticides, thereby maximizing efficiency.
3. Herbs are particularly successful in hydroponic systems because they prefer __________conditions.

B. Multiple Choice Questions

1. Which type of crop is best suited for a hydroponics system due to its simple nutrient needs?
   a. Root vegetables
   b. Leafy vegetables
   c. Fruit trees
   d. Flowers

2. Which of the following is NOT a suitable crop for hydroponic systems?
   a. Lettuce
   b. Wheat
   c. Tomatoes
   d. Basil

3. Factors to be considered before selecting crops for hydroponic systems?
   a. Temperature tolerance
   b. Root depth
   c. Nutrient use efficiency
   d. All of the above

4. Which of the following fruit plants is suitable for hydroponic cultivation?
   a. Apple
   b. Strawberry
   c. Orange
   d. Mango

Subjective Questions

1. Describe Selecting a Suitable Crop for Hydroponics Cultivation.

Module 2

Different Types of Hydroponic System

Module Overview

Hydroponic systems offer a soil-free method of growing plants using nutrient-rich water solutions to deliver essential minerals directly to the plant roots. Each hydroponics system offers distinct advantages and challenges, affecting the choice of the system based on factors such as crop type, available space, and desired level of automation.

This Module provides students with an in-depth understanding of the various methods used in soil-less cultivation. This module is designed to help students recognize and differentiate between the major hydroponic systems, such as Nutrient Film Technique (NFT), Deep Water Culture (DWC), Ebb and Flow, and others. In Session 1, students will learn to identify the structure, working principles, and suitability of different hydroponic systems. Session 2 focuses on the techniques of growing seedlings within these systems, equipping students with essential skills to successfully establish and manage healthy plant growth from the initial stage.

Learning Outcomes

After completing this module, you will be able to:

- Identify and describe different types of hydroponic systems, their design principles, and their advantages and limitations in various agricultural applications.
- Explain the process of growing seedlings in hydroponic systems, including seed selection, germination techniques, and management practices to ensure healthy seedling development.

Module Structure

Session 1: Identify Different Types of Hydroponic System

Session 2: Growing of Seedlings in Hydroponic System

Session 1: Identify Different Types of Hydroponic System

Types of Hydroponics

The classification of hydroponics depends upon the type of substrate and container, nutrient delivery system to the plant and drainage method. There are several types of hydroponics systems in use; each system has its own unique features and benefits such as the way nutrient solution is delivered to the plant roots or the type of medium used to support the plants.

Generally, hydroponics is classified into three groups, as shown in the flow chart below:

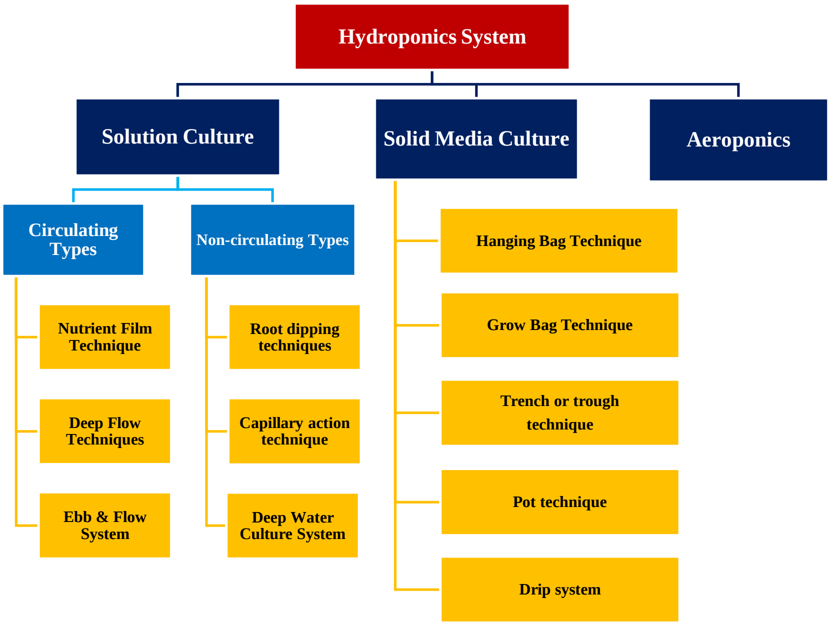

Chart 1.1: Classification of hydroponic systems into three main types

1. **Solution Culture or Liquid Hydroponics**: Liquid systems have no supporting medium for the plant roots. Plant root absorbs nutrients and oxygen from nutrient solutions directly. This can further be divided into two types:

   A. **Circulating types**: In the circulating type the nutrient solution is pumped from a reservoir to the roots of the plants. The excess nutrient is then allowed to drain back to the same reservoir. This recycled nutrient solution is used repeatedly until it is either depleted of essential elements or becomes contaminated, and then it is discarded and replaced with a fresh solution. There are several types of circulating systems.

i) Nutrient Film Technique: In this system, a very thin layer (0.5 mm) of water containing all the dissolved nutrients required for the plant is circulated via watertight grow channels where plants are hung in a net pot with little inert medium in the growing channel. The length of grow channels is kept 5 to 10 meters long with a *1% to 3%* slope between two ends. The flow rate of nutrient solution is adjusted to 2 to 3 litres per minute depending on the length of grow channels. The solution is drained back into the reservoir and recirculated for utilization of the crop. Due to the circulation of a thin layer of nutrient solution, enough air space becomes available in growing channels which provides plenty of oxygen and helps in the promotion of plant growth **(Figure 2.1).**

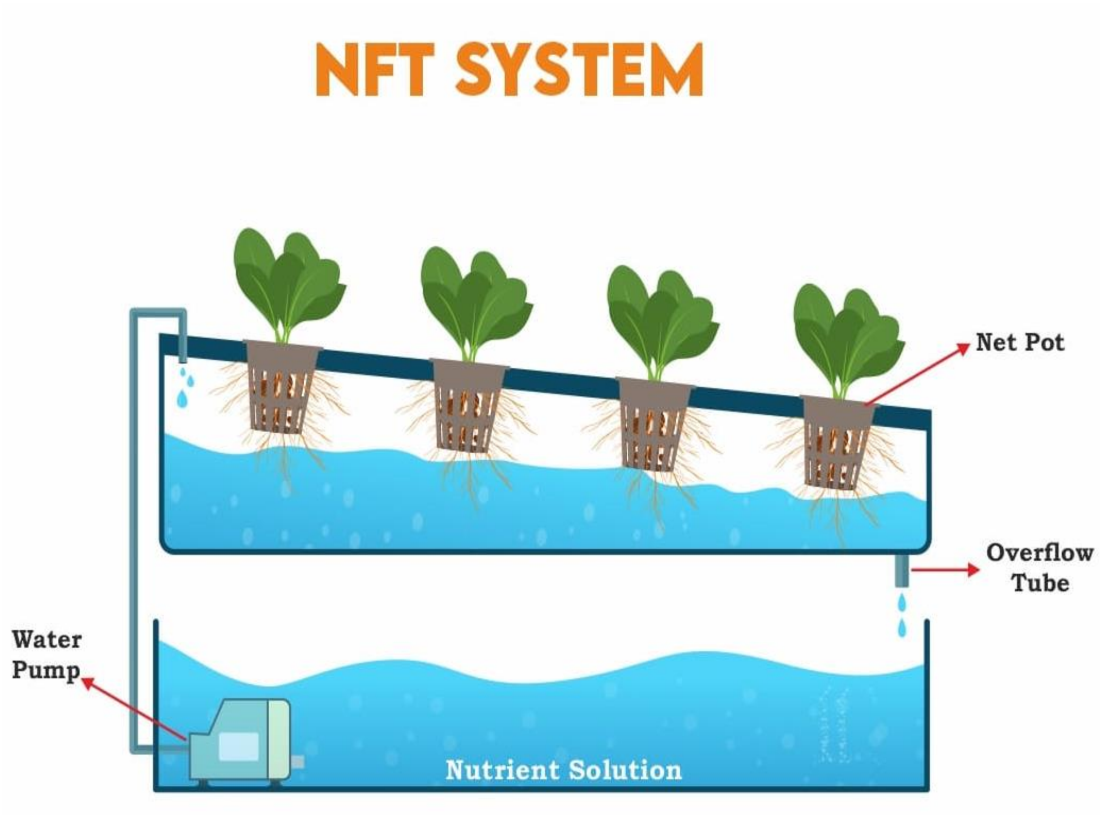

Fig. 2.1: Nutrient Film Technique System

ii) Deep Flow Technique: In this system, a 2-3 cm thick nutrient layer flows in grow channels. Plant roots are suspended in a nutrient-rich water solution in growing channels or trays. The plastic net-pots containing plants with inert medium are hung in grow channels touching to nutrient solution stream at the bottom. The constant flow of nutrient solution in deep flow techniques systems ensures a continuous supply of oxygen and nutrients for plant growth **(Figure 2.2).**

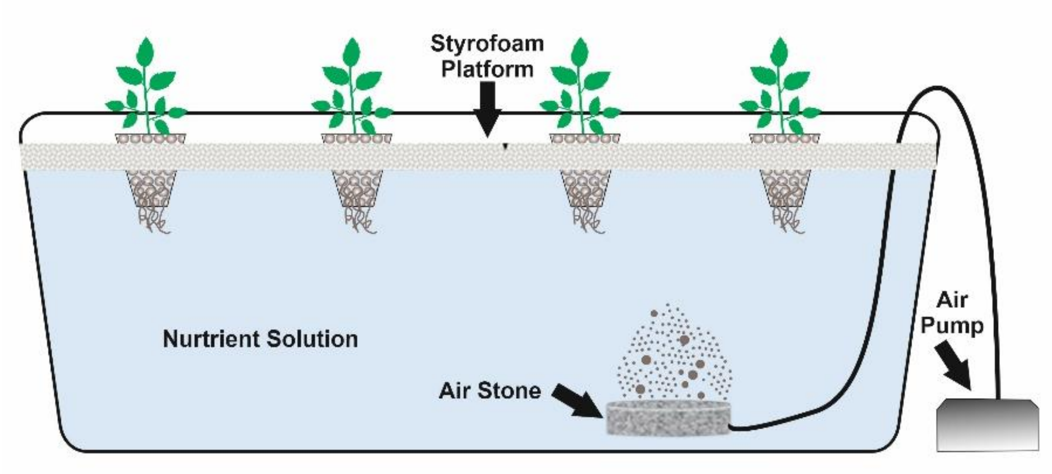

Fig. 2.2: Deep Flow Technique

iii) Ebb and Flow System: Ebb and flow, also known as flood and drain, is a type of hydroponic system that uses periodic flooding and draining of a nutrient solution to plants. This is typically done using a timer and a pump which controls the flow of the nutrient solution. The plants take up the nutrients through their roots which are suspended in the growing medium. The nutrient solution is typically drained back into a reservoir and can be reused **(Figure 2.3)**.

In an ebb-and-flow system, plants are grown in containers filled with an inert growing medium such as coconut coir or perlite which helps to anchor the plants but does not provide nutrients.

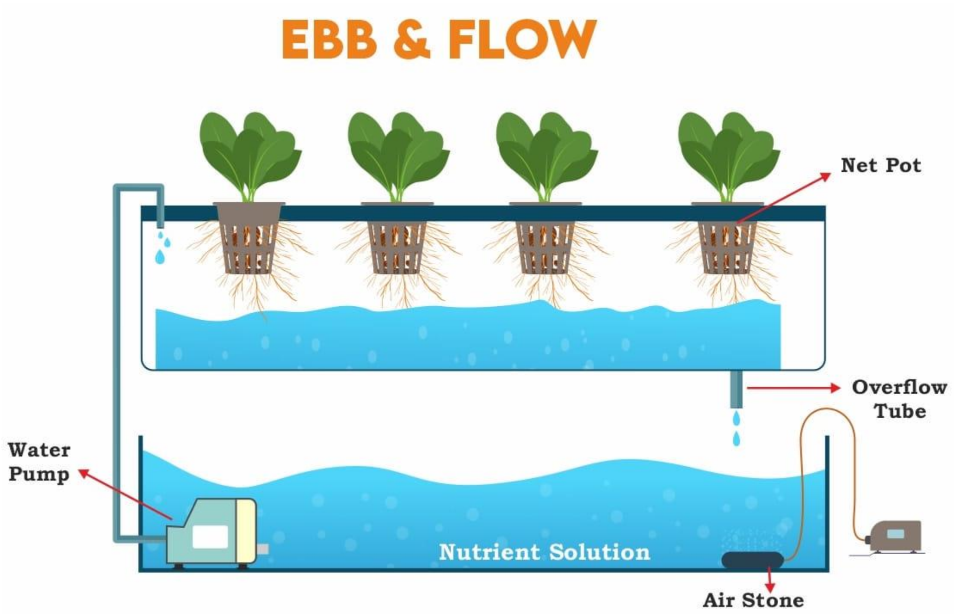

Fig. 2.3: Ebb and Flow System

B. Non-circulating types: Under this, the nutrient solution is not circulated and it is used only once. It is replaced with a reduction of nutrient concentration or with a change of EC (Electric Conductivity) or pH. It also allowed for customized feeding of nutrients based on the specific needs of the plants at different growth stages. There are several types of non-circulating systems:

Root dipping technique: Plants are grown in small pots containing a minimal amount of growing medium. These pots are arranged in such a way that the bottom 2-3 cm is immersed in nutrient solution. It is low cost as it needs no pump and grow channels. For root crops, for example, beetroot or radish, an inert medium is used in net pots to support the root development whereas for non-root crops, any type of container (except metals) like Styrofoam boxes are preferred because they help maintain the temperature of the nutrient solution. Each box is lined with a black plastic sheet at least 0.15 mm thick to prevent leakage and protect the roots from light. The box should be at least 30–35 cm deep to provide adequate space for both the nutrient solution and oxygen-absorbing roots. A board should be placed over the box as a lid to hold the plant pots and to prevent light penetration. The number of holes in the lid depends on the type of crop being grown, with an additional hole for air circulation and nutrient solution refilling. During the growing process, if the nutrient solution level drops or the EC level fluctuates, the solution should be topped up to maintain the optimal EC level for the crop. **(Figure 2.4).**

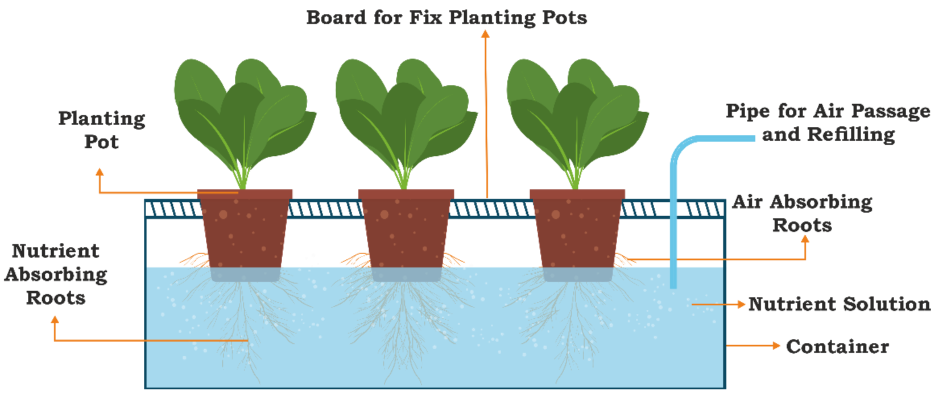

Fig. 2.4: Root dipping technique

Capillary action technique: Aeration is important in this technique. Therefore, pots are filled with highly porous material like old coir dust filled with sand or gravel. Nutrient solution rises to the pots filled with porous material by capillary action. This method is well-suited for indoor plants and ornamental flowers. Artificial aeration is required for the solution. Capillary action is a technique used in hydroponics to transfer nutrients and water from a reservoir to the porous growing medium via a material like a wick, this technique is also known as wick system. This technique is considered as the simplest and most straight forward kinds of hydroponics and it does not require mechanical things like pump. coco coir, perlite and vermiculite are among the most widely used growing media in this hydroponics system. **(Figure 2.5).**

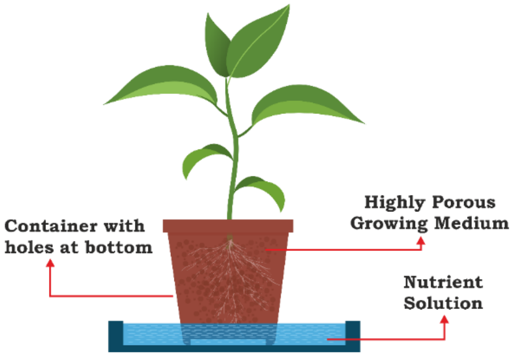

Fig. 2.5: Capillary Action Technique of Hydroponics

Deep Water Culture System (DWC): In a DWC hydroponic system, plants are grown in net pots suspended in the air in a reservoir, with their roots dangling into the nutrient solution below. The water is then oxygenated using an air pump which helps provide plants with the oxygen they need to grow. DWC system is that which is relatively easy to set up and maintain. It is often used to grow leafy greens, especially lettuce and herbs but is not ideal for slow-growing large plants or anything that flowers. **(Figure 2.6).**

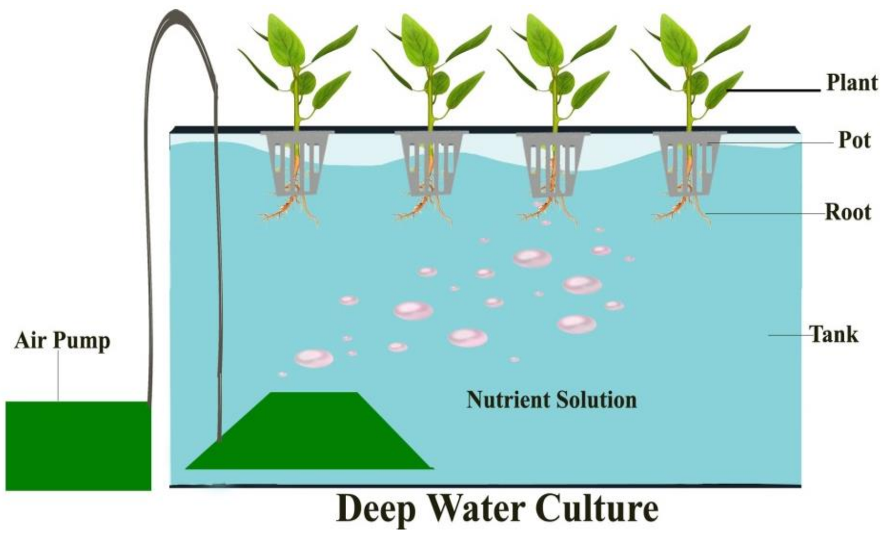

Fig. 2.6: Deep Water Culture System

2. Solid Media Culture (Aggregate systems): Solid media having properties of high porosity, better aeration, high water and air holding capacity and efficient drainage system are used in sterilized form for cultivating plants, such as coco peat, perlite, vermiculite, gravel, Rockwool, sawdust, coconut fiber and peat moss.

i. **Hanging Bag Technique**: In this method, thick UV-stabilized polyethene bags filled with coconut fiber or cocopeat in one-meter-high cylindrical shapes are used to grow plants. The bags are hung vertically and supported from above with a collecting channel placed below for the nutrient solution. Micro-sprinklers are installed inside the hanging bags to deliver nutrients and water to the plants through holes in the bags. This method is suitable for growing lettuce, other leafy vegetables, strawberries and small flowering plants **(Figure 2.7).**

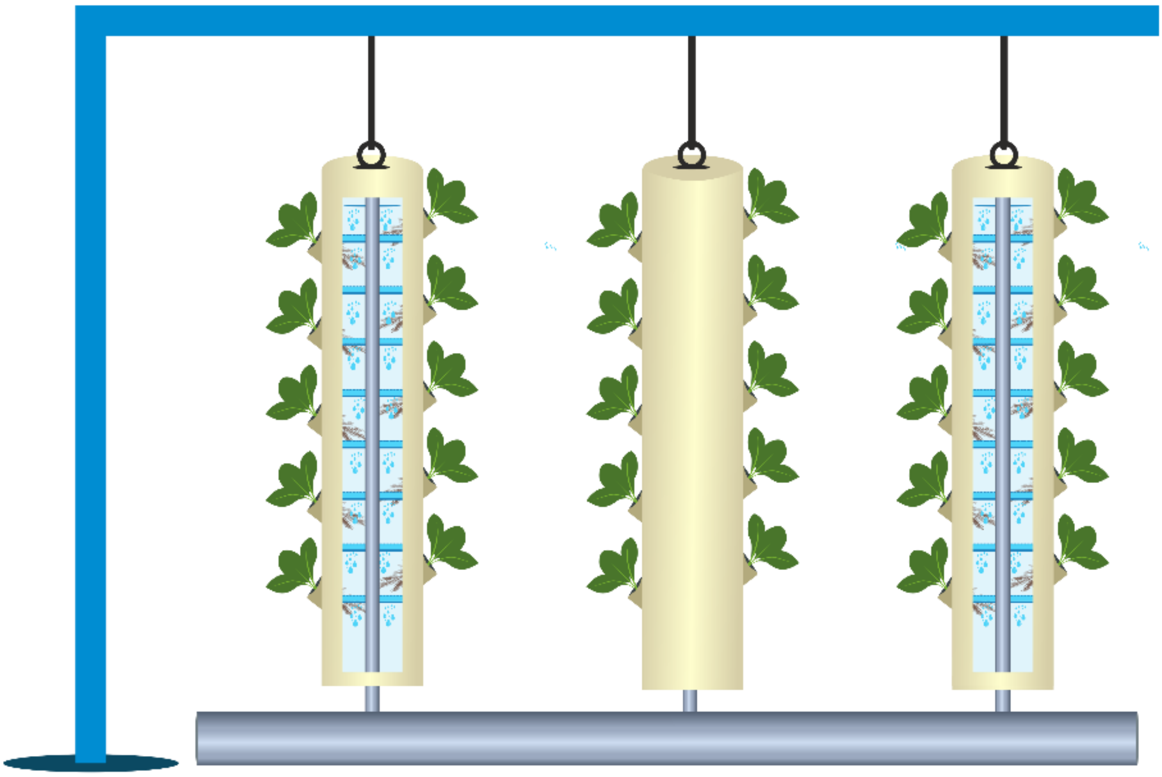

Fig. 2.7: Hanging Bag Technique

ii. **Grow Bag Technique**: This technique utilizes grow bags made from UV-stabilized polyethene sheets measuring 1 meter in length, 15-20 cm in width, and 8-10 cm in height for plant cultivation. Plants can be arranged in single or paired rows with spacing of 30 to 60 cm depending on the crop type. Fertigation is carried out using special stake drippers connected to polytubes and lateral pipes. This method is very common, inexpensive and easy to implement. The entire floor is covered with white UV-resistant polyethene before placing the grow bags to ensure efficient sunlight supply, reduce relative humidity and lower the incidence of fungal diseases **(Figure 2.8).**

Fig. 2.8: Grow Bag Hydroponics Setup

iii. **Trench or trough Technique**: In this technique, plants are grown in trenches or troughs made from UV-stabilized PVC/HDPE sheets, bricks, concrete or other local materials. These trenches or troughs are filled with inert organic, inorganic or mixed materials such as coco-peat, sand, perlite, and vermiculite with depths ranging from 30-60 cm depending on the crop type. Fertigation is performed using special stake drippers connected to polytubes and lateral pipes. Proper drainage is crucial and can be ensured with holes or separate drainage pipes.

iv. **Pot technique**: In this technique, readymade plastic pots ranging from 10-30 cm in diameter are used for growing plants. These pots are filled with inert organic, inorganic or mixed materials such as cocopeat, sand, perlite, and vermiculite. The container size and growing media volume vary from 1 to 10 liters depending on the type of crops. Fertigation is carried out using special single or multiple-outlet stake drippers connected to polytubes and lateral pipes.

v. **Drip System:** A hydroponic drip system involves delivering water and nutrients to the roots of plants using a system of tubes and emitters. In a drip system, a pump is used to circulate the nutrient-rich water from a reservoir to the plants through a series of tubes. The water is then supplied to the plants through emitters which are small devices that release a controlled amount of water onto the growing media around the plants **(Figure 2.9).** Drip systems minimized the wastage of nutrient solution by supplying only a precise amount of solution to the root zone reducing evaporation and weed growth. Recirculating excess nutrients is also possible in this system. However, for home growers, drip systems can be very complex and require a significant amount of maintenance thus making them less appealing than other types of hydroponic systems.

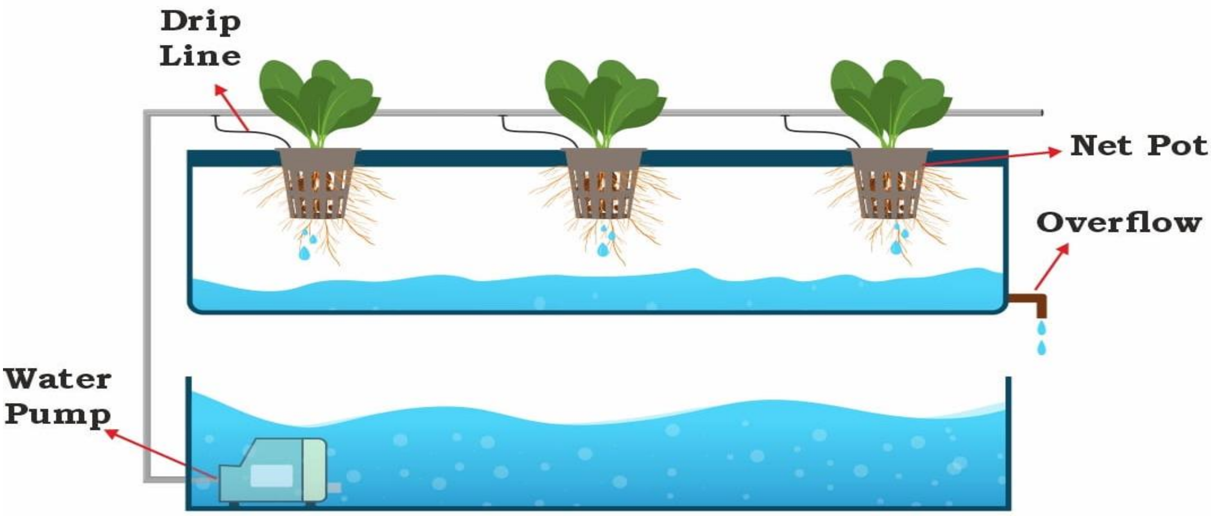

Fig. 2.9: Drip System Setup

3. Aeroponics system: It is a technique for growing plants suspended in air within a dark chamber. The chamber is kept dark to avoid the roots being exposed to light. Plants are supported by net-pot with inert media or low-density foam or rock wool in holes of panels. The nutrient solution is dispersed as a fine mist onto the suspended roots in a controlled cyclic manner, typically for a few seconds every 2-3 minutes. Roots are kept properly hydrated and aerated as per the needs of the plant. The system is divided into two types based on the size of solution particles, i.e. mist hydroponics and fog hydroponics. When mist particles are between 50 to 100 microns that is known as mist aeroponics whereas when mist particles are less than 50 microns in diameter then it is termed as fog aeroponics or fogponics. Fogponics utilize a high-pressure fogging mechanism to supply nutrient-rich water to roots. This results in a more efficient nutrient delivery system due to the enhanced absorption capability of the smaller droplets by the roots. **(Figure 2.10).**

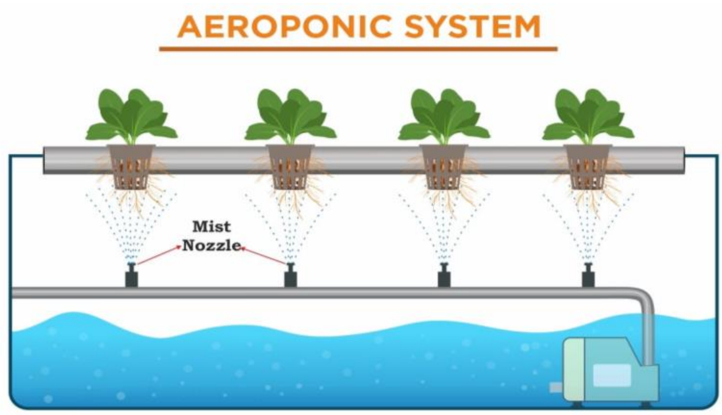

Fig. 2.10: Setup of an Aeroponics System

Components of Different Hydroponic Systems

The hydroponic system consists of different components, each serving a specific purpose. These components are essential for setting up an efficient and successful hydroponic system. The necessary components for setting up hydroponics are listed below:

1. **Water Pump:** It is used for circulating water and nutrient solutions needed for plant growth in a hydroponic system. It pumps and circulates water and nutrients from a reservoir to a grow bed where plants are placed. Some factors like delivery height, output tube size, target flow rate and ease of maintenance must be considered while purchasing and installing it in the system. **Figure 2.11**

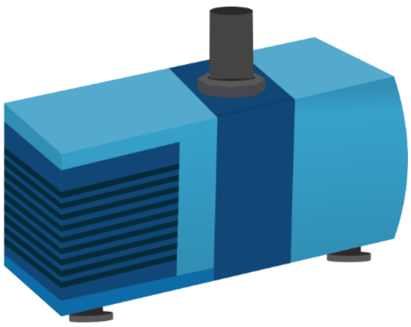

Fig. 2.11 Water Pump

2. **Water Chiller and Heater**

The temperature of solution plays an important role in nutrient availability and its uptake by plant roots. Therefore, it is essential to maintain the solution temperature within the optimum range required for nutrient availability and absorption by plant roots. The ideal temperature for any hydroponic system usually ranges from 22-25^{0}C. The temperature of the solution drops below the ideal temperature range during the winter season, so we must warm the solution to raise its temperature to the desired range. The water heater used for such purpose is of submersible type and it should be connected to timers and thermostats to automate the process. During the summer season, the temperature of the solution rises above its ideal range so it requires cooling to drop down the temperature. A water chiller can be used to lower the solution to bring back the temperature to its ideal range. **Figure 2.12**

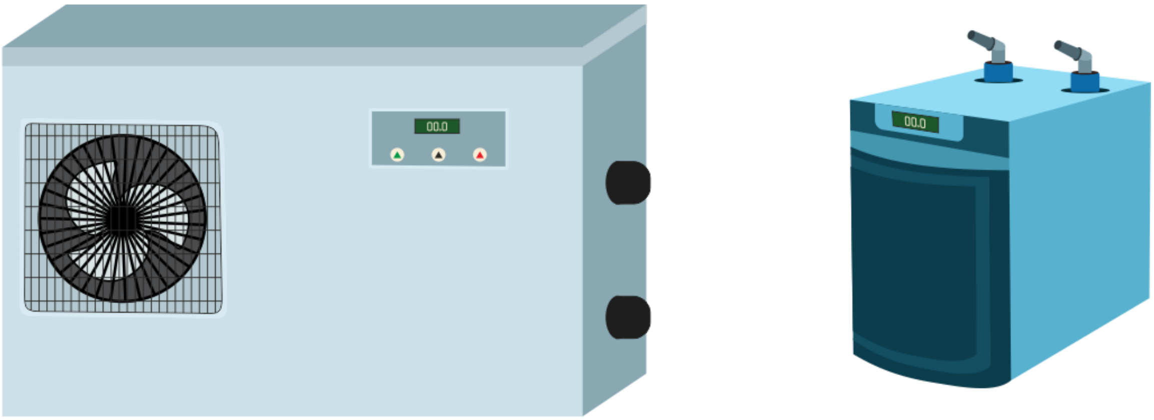

Fig. 2.12 Water chiller and heater

3. **Air Pump:** The air pump acts as a ventilator for plants grown in hydroponics. Oxygen is an important component of plant growth and its different metabolic processes. The plant takes oxygen from water/nutrient solutions through its roots. The air pump enhances root aeration and increases oxygen concentration around the roots. The air pump also helps in the uniform distribution of nutrients in the solution. While purchasing an air pump one must consider its airflow capacity, reservoir size, water temperature and plant type cum age. **Figure 2.13**

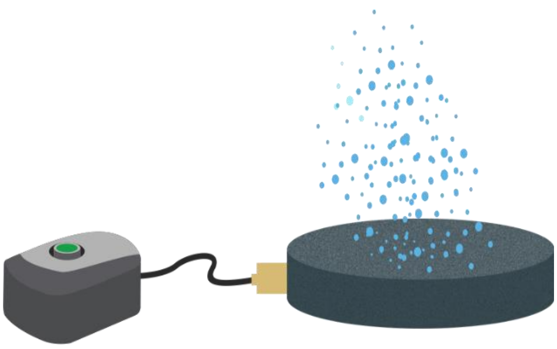

Fig. 2.13 Air Pump

4. Timer and Controller

Timers and controllers are essential in hydroponic systems for the automatic control of equipment, allowing for the programming of specific functions. Some of the equipment controlled by timers and controllers are pumps, fans, misters, air pumps, sprinklers, nutrient flow, mist flow, control of light and temperature, etc. **Figure 2.14**

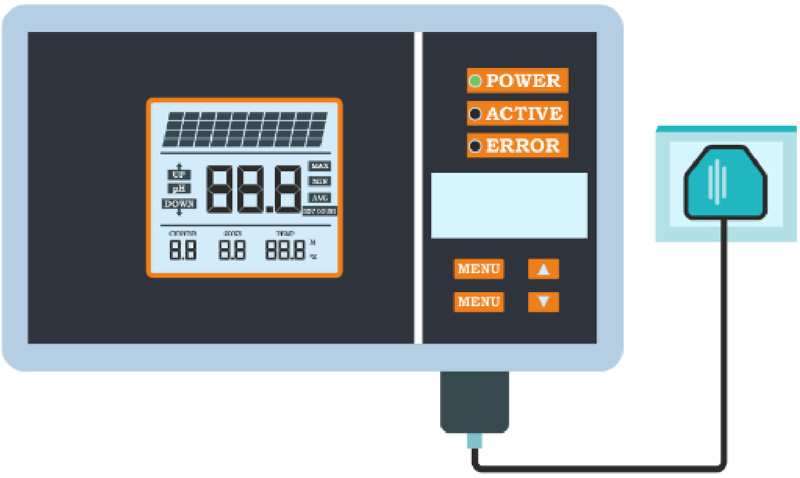

Fig. 2.14 Timer and controller

5. PVC pipes and channel

It is an important component required for building the hydroponic infrastructure. It joints the tray or grow beds with a reservoir and transports water and nutrient solution to plants. Large PVC pipes are used to build the frame of hydroponic units, with holes where plants are established. Small-sized pipes are connected to the water pump, reservoir and grow tray. It transports water and nutrients to plants. **Figure 2.15**

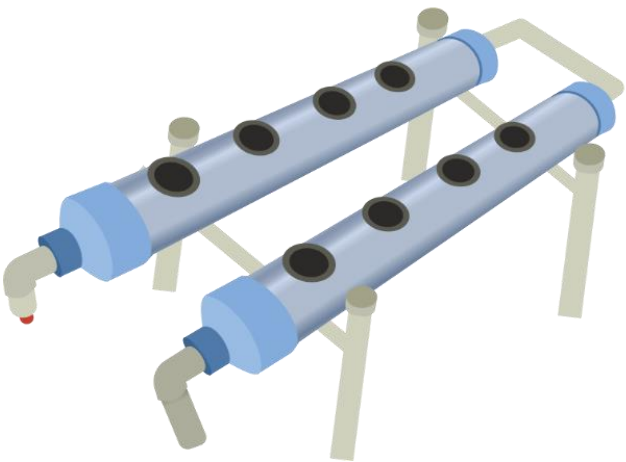

Fig. 2.15 PVC pipes and channel

6. Pots and Trays

These are primarily used as planters in hydroponics and come in various shapes and sizes. They can be purchased based on the specific requirements and available space. Growers typically prefer rectangular or square pots as they save space. Pots and trays are made from different materials such as plastic, clay, and fabric. **Figure 2.16**

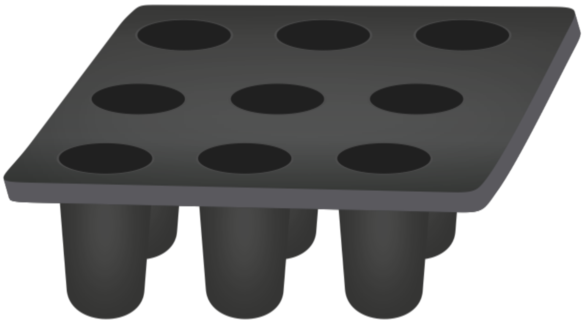

Fig. 2.16 Pots and Trays

7. Net Pots

Net pots are used to hold plants and allow roots to grow through the mesh, improving water and nutrient absorption from the grow trays. They can also be filled with a growth substrate to retain nutrients and moisture for the plants. **Figure 2.17**

Fig. 2.17 Net Pots

8. Hydroponic Substrate (Growth medium)

Substrates are used for nurturing the plants. Apart from providing support, it also serves as a medium through which plants can absorb nutrients and water. Substrates can be made of organic or inorganic material. The substrate has a property of porosity and inertness. A wide range of substrates are available in the market and some of the popular substrates are Rockwool, perlite, hydro ton, pumice, gravel, coconut coir, etc.

9. Nutrient Solution

The hydroponic plant fulfils its nutrient requirement from nutrient solution as the soil is not used in the system. The balanced nutrient solution is prepared by dissolving different essential nutrients as per the needs of a plant. This nutrient solution is filled in a reservoir and pumped to a grow tray where plants are grown so that plants can draw their required nutrients through their roots. Different types of nutrient solutions are available in the market. Growers can either purchase nutrients from the market or prepare them themselves, depending on the plant's requirements. **Figure 2.18**

Fig. 2.18 Nutrient Solution

10. Exhaust Fans

Exhaust fans are used to maintain airflow through the greenhouse or grow room. Exhaust fans help external air to move in and blow out the internal air. The constant airflow prevents detrimental environmental conditions, disease and pest infestation. Exhaust fans should be equipped with HEPA filters (High-Efficiency Particulate Air filters) to trap dust particles, disease-causing organisms, and other contaminants. The fans are available in different shapes and sizes which can be fitted outside so that inner greenhouse space is saved. **Figure 2.19**

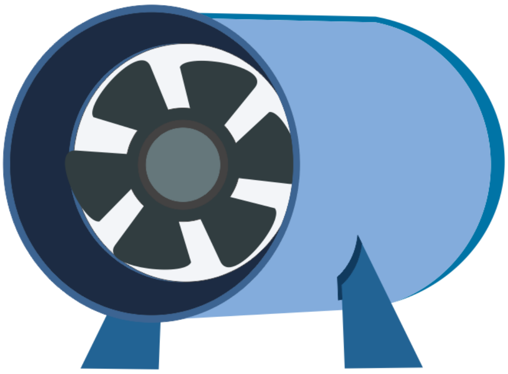

Fig. 2.19 Exhaust Fans

11. Grow Light and Accessories

Hydroponically grown plants need light for photosynthesis and their proper growth. Generally, plants grown in closed hydroponic systems require light for optimal growth. Different types of light are available in the market including fluorescents, high-pressure sodium, metal halides, ceramic metal halides, Light-Emitting Diodes (LED), etc. Among these, LED lights are energy efficient, durable, long-lasting and available in various colors, styles and sizes. LED lights also provide a wide spectrum of light. Fluorescent light is relatively less efficient than LED since it also provides a spectrum of red light though others have only a blue-green spectrum so we must check it before purchasing. Incandescent lights are the cheapest ones though not energy-efficient.

Process for setting up of hydroponic system

There are a lot of different factors that need to be considered for setting up a successful hydroponics system. Depending on need and budget one can plan a large commercial setup or just a small set for own use.

1. Section of site: The site should have proper access to electricity. So that together with proper access to water, vis-a-vis skilled manpower nearby. The selection of the site depends on the target market. It should also be kept in mind that such establishments are installed at a location which has proper access to the larger community or quite near railway stations, community market places and road transport depots. For retail sales, being near urban centers is often advantageous. Certain points concerning its establishment are as follows:

- For a hydroponic system, the site should have gentle-cum-even slope to ensure optimal drainage. Proper drainage is essential to prevent waterlogging.
- Hydroponic sites should have enough light and aeration.
- The sites should have adequate good-quality water availability Therefore; the water quality should be tested before the start of the project.
- Locally available hydroponics components such as racks to hold plants, pipes or channels to deliver water and nutrients, and containers for plant growth should be preferred.
- The site should have a reliable power supply to run lights, pumps and climate control systems.
- The site should be in a strategic area with easy access to markets, suppliers, transportation facilities, etc. to manage the hydroponic system efficiently.

2. Selection of Crops: Select high-value crops suitable for hydroponic cultivation with strong market demand, such as lettuce, cucumbers, tomatoes, herbs, microgreens, blueberries, and strawberries. Consider factors such as estimated demand, available space, and the number of harvest cycles per year. For example, microgreens have a short harvest period of 7-10 days, allowing for multiple cycles annually.

3. Selection of Hydroponics System: As per the requirement of the crop available resources such as water, electricity, market demand of produce, climatic conditions, *vis-a-vis* expertise the hydroponic system is selected. The three most common hydroponic systems are deep water culture, drip irrigation and nutrient film technique (NFT). Deep water culture involves submerging plant roots in oxygenated nutrient solution within large tanks. Drip irrigation uses a timer to deliver nutrients to plants via a drip system. NFT uses narrow channels to flow a thin film of nutrients over roots. NFT requires the least space but needs precise control. Setting up a hydroponic farm demands meticulous planning and design to ensure optimal productivity and efficiency. For this, one should develop an operational plan, identify the target market, create a marketing strategy and prepare financial projections. Key costs to consider include infrastructure, equipment, utilities, supplies, and staffing.

4. Farm Layout: Design the layout to maximize space utilization and facilitate a smooth workflow. It should be optimized for ease of operation and maintenance, considering factors such as crop spacing, the size of growing channels, and the placement of equipment.

5. Infrastructure Arrangement: Various structures from greenhouses to grow shelters are commonly used in hydroponic farming. One should understand essential features such as ventilation, lighting, and climate control systems to create an optimal growing environment for the crops.

6. Nutrient Delivery Systems: Proper nutrient delivery is essential for plant growth and development. It is important to consider the advantages of each method to help growers make informed decisions for their farms.

7. Automation and Control Systems: Technology plays a significant role in modern hydroponic farming. One should implement automation and control systems to streamline operations and enhance crop management. Control systems include environmental sensors, irrigation timers, and nutrient-dosing controllers.

8. Workflow and Standard Operating Procedures: Establishing efficient workflow and Standard Operating Procedures (SOPs) is crucial for maintaining consistency and quality at the hydroponic farm. There should be knowledgeable and experienced guides in developing SOPs for tasks, such as planting, harvesting, pest management and nutrient solution management. By implementing well-defined SOPs one can ensure smooth operations with bare minimum errors.

Growing media for Hydroponics

The growth medium in a hydroponic system is the most important factor for successful cultivation of crops. Before selecting a growth medium for hydroponics, it is essential to ensure that it has good moisture-holding capacity, should drain well, does not prevent aeration in the root zone of the plant, should be easily degradable, and should have pH-stability and nutrient retention capacity. Some of the hydroponic growing media are explained below:

1. Perlite

Perlite is a rock that is fused at high temperatures and serves as a soil-free growth medium **(Figure 2.20)**. It has several beneficial characteristics, including a neutral pH, high porosity, lightweight properties, and the ability to promote long-term aeration. Due to its lightweight nature, perlite tends to float over water thus requiring mixing with other media such as coco-coir or vermiculite. It is environmentally friendly but cannot be used in net pots due to its small size.

Fig. 2.20: Perlite

2. Coco-fiber

It is made from coconut coir which is a natural organic growth medium used in most hydroponic systems. It contains a lot of micro-sponges that allow quick absorption of nutrients and moisture and release them slowly. **(Figure 2.21**. It has a good moisture capacity without affecting fertilizer, making it eco-friendly and providing aeration to the root zone of plants. Coco-fiber does not affect the pH and EC of the nutrient medium, vis-a-vis has anti-fungal properties and beneficial hormones that lead to faster root development.

Fig. 2.21: Coco-fiber

3. Vermiculite

Vermiculite made from volcanic rocks is like perlite. It floats over solution, holds more water than perlite and has a high cation exchange capacity **(Figure 2.22)**. However, its size is too small and it falls from net pots so it cannot be used alone in net pots. It is usually mixed with perlite to provide more oxygen to the root zone and increase water-holding capacity. It is also used with other growth media.

Fig. 2.22: Vermiculite

4. Sand

Sand is the cheapest and most readily available growing medium. It is a heavy medium, so it should be sterilized before use. It does not hold water and can become waterlogged **(Figure 2.23)**. Hence, it is often mixed with vermiculite, perlite, or coco-coir to retain moisture.

Fig. 2.23: Close-up view of sand texture and patterns

5. Gravel

Gravel is easily available in various sizes. It must be cleaned and washed before use. It is not porous; hence, it does not hold moisture. Due to its uneven size, it contains many air pockets providing better oxygenation to the root zone **(Figure 2.24)**.

Fig. 2.24: Natural gravel texture

6. Grow stone

This material, derived from recycled glass, serves as a sustainable and reusable growing medium **(Figure 2.25)**. It is lightweight, porous, and has superior air and water retention compared to perlite and peat, making it suitable for all hydroponic systems. However, its uneven shape and tendency to retain roots after harvest can make it challenging to clean and to transfer plants between grow areas.

Fig. 2.25: Grow stones – lightweight and porous for hydroponics

7. Rockwool

Rockwool is a sterile, porous medium made from melted granite and/or limestone rocks, which are spun into thin, long fibres **(Figure 2.26).** These fibres are then compressed into cubes or bricks. The material has a naturally high pH, which can affect the pH of the nutrient solution. Therefore, it is essential to soak Rockwool in balanced pH water before use. Rockwool is non-degradable, and the dust it produces may irritate. It is recommended to rinse it with water before use.

Fig. 2.26: Rockwool

8. Clay pebble

Clay pebbles, also known as Hydroton or LECA (Lightweight Expanded Clay Aggregate), are small, round balls roughly the size of marbles. They are one of the most preferred hydroponic growing mediums due to their neutral pH and reusability **(Figure 2.27).** The abundant pore space in clay pebbles ensures proper water flow without clogs or blockages and can hold numerous air bubbles, helping to keep the root zones of plants well-aerated and oxygenated. Expanded clay pebbles growing medium is very affordable and can be reused repeatedly. It is produced by heating and expanding clays to form small bubble-shaped balls. Clay pellets are lightweight due to their porous nature. Their round and porous form allows them to balance water and air effectively. However, clay pellets do not hold water well and dry out quickly. These are also heavier compared to other growing media

Fig. 2.27: Clay pebbles

9. Oasis cubes

Oasis cubes are low-density but well-drained grow media for hydroponics. It is sterile-cum-inorganic and suitable for seed germination and rooting of cuttings. It provides 20% air space at saturation points **(Figure 2.28).** It absorbs nutrient solution and retains plenty of oxygen for rapid root growth. The consistency of the media creates more uniform rooting. It requires less misting and eases the growing process. Low cation exchange properties enhance the speed, precision and availability of nutrients. Using sterile media helps reduce disease and insect issues. Additionally, roots remain undisturbed during transplanting thus preventing shocks to plants. It is also easy to separate the cubes. This growing medium is specifically designed for hydroponic seedling production of vegetables, offering lower density and better drainage. The foam structure helps maintain an ideal air-to-water balance, even under heavy watering conditions.

Fig. 2.28: Oasis cubes

10. Rice hulls

Parboiled Rice Husks (PBH) are a byproduct of rice grains used as a growing medium in soilless systems. This material is not pH-neutral, with a pH range of 5.8 to 7.2 **(Figure 2.29).** As an agricultural byproduct, PBH offers an eco-friendly alternative that would otherwise go to waste. It allows for good drainage by retaining less water than grow stones. However, PBH decomposes over time and often requires replacement.

Fig. 2.29: Rice hulls – outer layers of rice grains

11. Pumice

Pumice, like perlite, is a mined mineral formed from super-heated, highly pressurized volcanic activity **(Figure 2.30).** Its colour varies from white to pale gray or yellow, depending on the mineral content, and it is usually darker than perlite. Pumice is a lightweight, porous stone that is slow to break down and holds air well between particles. Although it tends to float in water, it is less buoyant than perlite. It has good water retention, though not as high as vermiculite.

Fig. 2.30: Pumice stones – lightweight volcanic rock for improved aeration.

12. Grow stones

Grow stones are produced from recycled glass sourced from landfills or glass collection and processing facilities. This medium is extremely lightweight and highly porous providing excellent aeration and average moisture retention for the root system. Washing and rinsing the medium thoroughly is necessary to remove small particles and dust. The medium is ideal for use alone or for mixing into peat, coco-coir and other growing media.

Fig. 2.31: Grow stones – recycled, porous medium for aeration

13. Sawdust

Sawdust is an easily available by-product in sawmills. This material is lightweight and retains water well **(Figure 2.32).** It is biodegradable but will decompose over time. Sawdust is not pH neutral so pH monitoring is necessary during use. It is important to know the type of wood the sawdust comes from and it should be ensured that it is free from chemical treatments and contaminants. Sawdust, if chemically treated, should be sterilized before use. Though it compacts quickly, alters pH, and may carry contaminants, it has had limited success in soilless planting

Fig. 2.32: Sawdust – a compactable, pH-altering medium

14. Wood chips/fibers

Wood chips, made from untreated wood, are an effective organic substrate for hydroponics. They retain structure over time, reduce the effects of plant growth regulators, and are ideal for organic growers. Wood chips hold water well without becoming overly compacted or waterlogged, unlike sawdust. For safe use, ensure they are uncontaminated or sterilized.

15. Peat moss

Peat moss makes good use in hydroponics whether alone or in conjunction with other materials. Peat moss is a dead fibrous material that develops in a wet, cold, acidic and lack-of-air environment called peat bogs **(Figure 2.33).** In that environment, sphagnum moss and other living things decompose into a dense dark brown compact mass and this is the peat moss. This process can take thousands of years, so peat moss is not considered a renewable or environmentally friendly medium. However, it is valued in hydroponics for its excellent water retention and nutrient-holding capacity. Peat moss can rehydrate quickly and doesn’t compact or break down easily. It has been reusable for several years it doesn’t contain adverse weed seeds or microorganisms, unlike other organic compost. Peat moss can easily blend with perlite, vermiculite or Styrofoam particles to add aeration and is amenable to adjusting the pH of the medium.

Fig. 2.33: Peat moss – water-retentive, nutrient-rich medium for hydroponics

ACTIVITIES

Activity 1: Visit a Nearby hydroponics unit observe and note down different components of hydroponic systems.

Material required:

Pen, pencil, notebook, etc.

Procedure:

Visit a nearby hydroponics unit and note down the following observations:

1. Enlist different types of hydroponics systems and their components.
2. Identify different types of growth medium used in hydroponics systems.
3. Note down the use of different growth mediums.
4. If you have any queries, discuss them with the hydroponics unit manager.

Check Your Progress

A. Fill in the blank

1. Hydroponic systems use nutrient-rich solutions to grow plants without ______________.

2. The Ebb and Flow system floods and then ______ the plant containers with nutrient solution.

3. Coco-fibre is made from ______ coir.

4. Growbags used in hydroponics are typically made from ______ polyethylene.

B. Multiple Choice Questions

1. Which hydroponic system does not recirculate the nutrient solution?
   a) Nutrient Film Technique
   b) Deep Flow Technique
   c) Ebb and Flow System
   d) Root Dipping Technique
2. Which system uses a fine mist to deliver nutrients to plant roots?
   a) Deep Water Culture
   b) Drip System
   c) Aeroponics
   d) Ebb and Flow
3. What is a main advantage of the Grow Bag Technique?
   a) High cost
   b) Easy to implement
   c) Requires advanced technology
   d) Not suitable for home use
4. What is the purpose of using an air pump in Deep Water Culture systems?
   a) To increase nutrient concentration
   b) To oxygenate the water
   c) To circulate the water
   d) To reduce water pH
5. Grow stone is made from?
   a) Glass
   b) Metal
   c) Plastic
   d) Stone

C. Match the Column

A	B
1. Water Pump	a. Provides essential nutrients
2. Air Pump	b. Circulates water and nutrient solution
3. Net Pots	c. Increases oxygen concentration
4. Nutrient Solution	d. Holds plants

D. Subjective Questions:

- Describe nutrient film techniques in hydroponic systems.
- Explain different components of the hydroponics system.

Session 2: Growing of Seedlings in Hydroponic System

Criteria for selecting a suitable cultivar for hydroponic propagation

Selecting the right cultivar for a hydroponic system depends on various factors such as:

- Crop cultivars should be well-suited for hydroponic and protected environments. Cultivars that exhibit compact growth habits are preferred for hydroponic systems as these utilize minimal space and provide high yields per unit area. Such plants are also easier to manage in hydroponic conditions.
- Hydroponic cultivars require a fast growth rate. Usually, short-duration crops are preferred for hydroponic systems and cultivars should be fast-growing to facilitate easy management and timely transition to the next crop in the system.
- Hydroponic varieties are famous for their high yield therefore select only those varieties that perform well under protected conditions.
- Cultivars should be able to survive in waterlogging conditions. Since nutrients in hydroponics are provided in solution form, cultivars with high nutrient use efficiency and low nutrient requirements are preferable.
- Moreover, since the hydroponic systems are typically set up in controlled environments, cultivars that can tolerate environmental fluctuations such as temperature, humidity and light intensity are best suited for hydroponics.

Process of seed testing

Seed should be brought from reliable sources. Seed testing is the process of checking the quality of seeds such as germination, viability test, etc. Seed testing is a necessary process to ascertain quality seeds before sowing.

Seeds as per their types are soaked in water for a specified period. This helps in softening the seed coat and initiating germination. If there is significant seed germination it shows that seeds are of good health so these can be used as planting material. However, if only a few seeds sprout, it shows poor seed quality. A germination test is a method to assess seed viability. A few seed samples are taken and placed on a moist paper towel or in a germination tray and then kept in a warm and moist area. The germination rate is decided by counting the number of seeds that sprout healthy seedlings within a timeframe.

Seed treatment

Seed treatment involves applying chemicals, such as fungicides, insecticides, or both, to disinfect seeds from harmful organisms. These treatments are applied before sowing to improve germination, enhance vigor, and maintain seed health. Before sowing, it is essential to disinfect the seeds to prevent them from being infected with harmful organisms. Disinfection involves soaking seeds in a diluted solution or treating them with hydrogen peroxide. Some seeds require pre-soaking to soften their seed coats, promoting faster germination.

Hydroponic systems depend on water-based solutions. In this system, plants are sensitive to fungal infections and insect infestations. Before sowing seeds, fungicides are applied to provide protection against various seed, and soil-borne diseases such as seed rots and seedling blight occurring usually after planting. These treatments also help to protect seeds from damping off and other fungal infections damaging the seedlings.

Seeds after germination are also treated with certain insecticides if insects are infesting these; Solar treatment of seeds involves the use of solar energy to discourage seed-borne pathogens thus encouraging germination.

Process of raising seedlings for a hydroponic system

Healthy seeds from reliable sources should be collected and sown in trays, plug trays or directly in the nursery beds.

Starter plugs

Seedlings are prepared in growing media cubes made of rockwool or coco-coir. The cubes known as starter plugs possess a sponge-like structure capable of retaining water and maintaining aeration. Single seeds are placed in each cube hole where regular watering is given to maintain proper moisture for their germination and after germination, these are fertigated for healthy growth. Once the seedlings mature for transplanting, these entire cubes can be directly planted into net pots along with the growth medium. In hydroponic systems, starter plugs are preferred over growing in nursery trays or beds. **Figure** 2.34

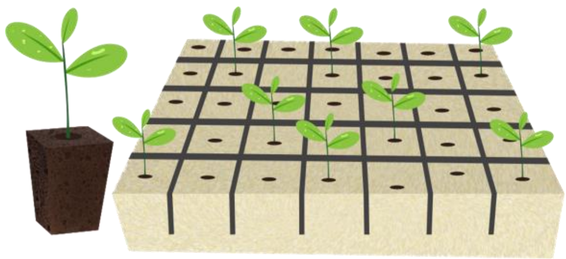

Fig. 2.34 Starter plugs

Grow tray/container

These containers are filled with growth media such as vermiculite, perlite, coco-peat or soil. Grow trays/nursery trays are placed in a shaded area to ensure proper germination. Regular spraying of water on the seedlings aids in moisture retention and uniform growth. Affected plants should be replaced with healthy seeds. For transplanting, seedlings are gently removed from trays. If soil is present in the trays, the roots of the seedlings should be soaked in water and washed carefully to prevent contamination from soil particles. After washing, seedling roots are placed in net pots. **Figure 2.35**

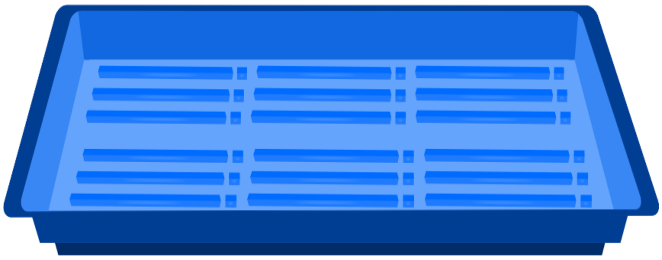

Fig. 2.35 Grow tray/container

ACTIVITIES

Activity 1: Demonstrate the process of seed testing.

Material required:

Pen, pencil, notebook, Petri dish, blotting paper, seeds, etc.

Procedure:

1. Identify and Select the seeds
2. Keep the moist blotter paper in a petri dish
3. Place the seed in a Petri dish
4. Keep the petri dish at room temperature for 2-3 days
5. Observe the time and percentage of seed germinated.
6. Note down factors responsible for poor germination.

Check Your Progress

B. Fill in the Blank:

1. Selecting__________growth habits cultivar for hydroponic systems helps us to optimize space utilization.
2. __________is the process involving assessing seed viability through germination test.

3. __________involves the application of chemicals to disinfect seeds from harmful organisms
4. Hydroponic seedlings can be grown in starter plugs which retain water and maintain __________.

C. Multiple Choice Question

1. Which of the following is NOT a factor considered when selecting hydroponic cultivars?
   a. Root depth
   b. Growth rate
   c. Flower colour
   d. Nutrient requirements
2. Seed testing primarily involves assessing the viability of seeds through?
   a. Fertilization test
   b. Pollination test
   c. Germination test
   d. Photosynthesis
3. Seed treatment involves the application of chemicals to disinfect seeds from?
   a. Microorganisms
   b. Minerals
   c. Sunlight
   d. Carbon dioxide

4. Which is used for raising seedlings in hydroponic system?
   a. Starter plugs
   b. Net-pots
   c. Reservoir
   d. PVC Pipes
5. Solar treatment is used to control against?
   a. Viral disease
   b. Insects
   c. Seed-borne disease
   d. Fungal disease

Subjective Question:

1. Describe the process of seed testing and seed treatment.

2. Discuss the process of raising seedlings in hydroponic systems.

Module 3

Maintenance of the Hydroponic System

Module overview

This unit introduces the principles of maintaining a healthy and productive environment for soilless cultivation. It covers essential aspects such as monitoring nutrient quality and environmental parameters, managing insect pests and diseases in hydroponic crops, and addressing potential issues to optimise plant growth and yield. Regular maintenance of a hydroponic system is urgently required for its overall sustainability.

This Module emphasizes the importance of regular upkeep and nutrient management to ensure a productive and efficient hydroponic setup. In Session 1, students will learn about the routine care and maintenance practices necessary to keep hydroponic systems running smoothly, including cleaning, monitoring system components, and checking for signs of malfunction or plant stress. Session 2 delves into the preparation and correct application of nutrient solutions, highlighting the role of balanced nutrition in plant growth and yield. This module aims to equip students with practical knowledge to maintain system health and optimize plant performance.

Learning Outcomes

After completing this module, you will be able to:

- Explain the care and maintenance of hydroponic systems, including cleaning, monitoring, troubleshooting, and ensuring optimal system performance for sustainable crop production.
- Describe the preparation of nutrient solutions, their composition, and application techniques to meet the nutritional requirements of plants in hydroponic systems.

Module Structure

Session 1: Care and Maintenance of Hydroponic System

Session 2: Preparation and application of Nutrient Solution

Session 1: Care and Maintenance of Hydroponic System

Regular monitoring is required throughout the cropping period for the crops grown in the hydroponics system. Maintenance includes cleaning the reservoir, maintaining water levels, nutrient levels, pH balance, EC level, timely addition of supplementary nutrients, *vis-a-vis* nutrient deficiency symptoms (if any) and adequate oxygenation. Plant growth parameters such as root, shoot and leaf growth should also be monitored regularly.

Important Biotic and Abiotic Factors

Hydroponic crops are highly sensitive in nature and are highly influenced by biotic and abiotic factors. These factors significantly affect the growth, yield, and quality of the crops.

Biotic Factors: Biotic factors include organism that affect crop health, these organisms are pests, diseases, and microorganisms. Biotic factors AR affecting hydroponic crops include pests such as aphids, mites, and whiteflies, as well as diseases caused by fungi, bacteria, and viruses. These organisms can quickly spread in the controlled environment, leading to severe damage if not managed Timely. Harmful microorganisms like Pythium (root rot) and Fusarium can survive in nutrient-rich solutions, attacking plant roots and causing stunted growth or plant death. Algae growth in the Nutrient solution can deplete oxygen level and create an unsuitable environment for plant roots. Regular monitoring, biological controls, and maintaining hygienic conditions are critical to managing these biotic threats.

Abiotic factors:

An abiotic factor is a non-living component of the environment that affects the growth, health, and survival of plant or organisms. Abiotic factors are important factor for hydroponic system as they directly influence plant growth and yield. Abiotic factors such as light, temperature, humidity, Humidity, Temperature, water quality, and nutrient levels, etc. play a significant role in maintaining a healthy crop.

Hydroponic systems offer a revolutionary approach to agricultural practices by growing plants without soil using nutrient-rich water solutions. However, the success of hydroponic farming depends on maintaining optimal environmental conditions.

- **Humidity:** During photosynthesis, plants transpire freely, requiring adequate water to maintain low to moderate humidity levels along with proper aeration. Monitoring and controlling the relative humidity around hydroponic crops is essential, as high humidity combined with low air movement can reduce cooling from transpiration and lead to heat stress in plants. While lower humidity levels or drier air can reduce the risk of fungal diseases, they can also increase the rate of transpiration, potentially causing leaves and growing points to dry out excessively.

- **Temperature:** The decrease in optimal temperature will alter the plant's metabolic systems leading to slow growth. It is observed that the night temperature should ideally be about 5°C lower than the daytime temperature. Plant damage is caused by high as well as low temperatures. In extreme climates, the maintenance of proper temperature is one of the most important aspects of hydroponics systems established in a greenhouse/protected environment.

- **Light:** Photosynthesis plays a vital role in plant growth and development. The optimum light, in the range of 400-700nm wavelength of the visible spectrum (Photo synthetically active radiation-PAR) covering blue to red light is required for photosynthesis for proper growth of plants. Since hydroponic systems are often used in controlled conditions, ensuring adequate lighting is essential for photosynthesis. Various artificial lighting options are used such as LED, Vapour light, Lamps, etc. ranging from fluorescent to high-intensity discharge lighting. However, LEDs are commonly used for indoor hydroponics systems.

- **Carbon dioxide Levels:** Carbon dioxide (CO_2) is essential as a raw material for photosynthesis in plants. The level of CO_2 may need to be properly maintained to enhance plant growth, especially in enclosed spaces where natural air exchange is limited.

Water Quality Parameters

Water quality is crucial in any hydroponic system. Using poor-quality water to prepare nutrient solutions can lead to pH imbalances, toxicity, disease, and clogs in drippers and plumbing. As a major component of plant biomass, water serves as the lifeblood of the plant, carrying essential dissolved nutrients that sustain its growth. The following are the important criteria for water quality:

- **Electrical Conductivity (EC):** EC of water is a critical factor in hydroponic systems because it provides valuable information about the ability of water to conduct electrical current which is directly related to the concentration of dissolved ions including nutrients. The range of EC for the hydroponic solution may vary from 0.5 to 2.5 dS/m, depending on the crops. This parameter holds significance for various reasons in hydroponics. Firstly, EC aids in nutrient management by allowing growers to assess and adjust nutrient solution compositions to meet specific requirements of plants thus ensuring healthy growth and yields. "Monitoring electrical conductivity (EC) helps identify water quality issues, such as excessive dissolved salts or contaminants, enabling timely corrective actions to maintain optimal water quality. Regulating EC levels also prevents nutrient imbalances that could lead to plant deficiencies or toxicities, thereby supporting ideal growth conditions. Maintaining appropriate EC levels promotes healthy root development, efficient nutrient uptake, and overall plant vigour, which enhances productivity in hydroponic environments.

- **Total Dissolved Solids (TDS):** TDS refers to the collective measurement of minerals, inorganic salts and other dissolved substances present in the water solution used in a hydroponic system. These substances include macronutrients such as nitrogen, phosphorus, and potassium as well as micronutrients (Ca, Mg, Fe and others). Assessment of TDS provides an overall understanding of nutrient concentration in hydroponic systems.

- **pH:** Maintenance of pH in hydroponic systems is very important. Any change or disruption in pH may affect nutrient uptake negatively. The pH range should be kept between 5.5 to 6.5 for healthy plant growth. The optimum pH balance in a hydroponic system ensures proper nutrient absorption and good plant health. Therefore, the maintenance of proper pH in the solution is a must for hydroponic systems. pH should be checked through a digital pH meter and it should be adjusted with suitable acids or bases.

- **Air circulation**
  Proper air circulation is essential for the success of a greenhouse/protected grow chamber as it helps maintain the temperature and gas exchange at an optimal level. The aeration of the nutrient solution reservoir provides enough oxygen for root growth while poor aeration causes stunted root growth and rotting. Oxygenation not only supports the proper aeration of plant roots but also aids in the adequate supply of essential nutrients to the plants.

The following three popular techniques can be used for the optimal oxygenation of plants:

- **Air Stones**: These porous stones are placed in the system connected to an air pump which diffuses air into a nutrient solution.
- **Venturi Injectors**: This device pulls air in through a small opening, mixing it with the water flow to produce oxygen-enriched water within the system.
- **Waterfall or Water Spray**: Spraying water from the height can provide more surface area for gas exchange between water and air.

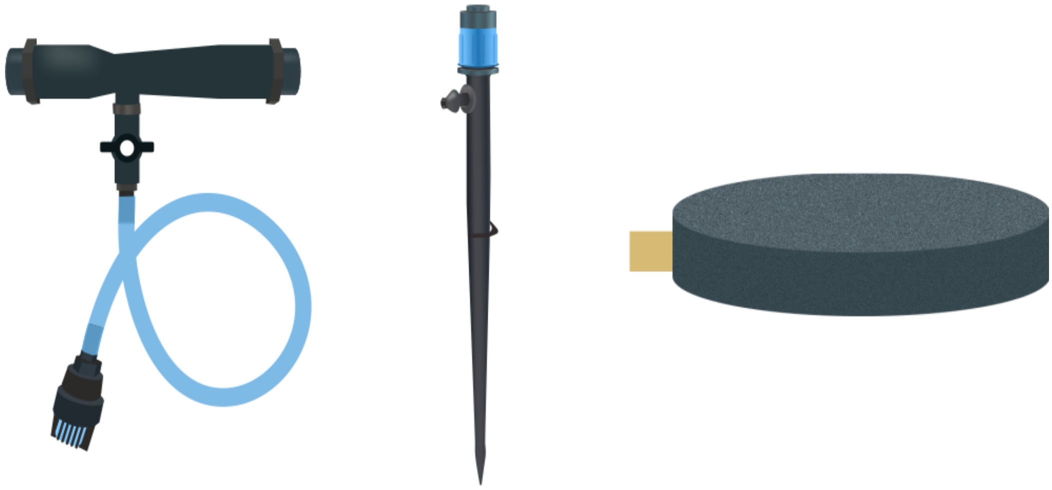

Fig. 3.1: Air Stones, Venturi Injectors, Waterfall or Water Spray

Symptoms of Plant Nutrient Imbalance - Deficiency/Excess

Plant nutrient deficiency and toxicity are critical factors affecting the growth and productivity of plants. Nutrients are essential for various physiological processes and their deficiency or excess can lead to visible symptoms and hinder growth. Nutrient deficiency occurs when a plant lacks one or more essential nutrients for its growth and development. Each nutrient plays a specific role so deficiencies manifest through characteristic symptoms such as yellowing of leaves, stunted growth or abnormal development. Nutrient toxicity occurs when plants are exposed to excessive levels of certain nutrients which can disrupt nutrient uptake and impair physiological functions leading to adverse effects on growth and metabolism. The symptoms observed due to deficiency/ excess of different nutrient elements are mentioned below in **Table 1.1**

Table 1.1: Symptoms of Nutrient Deficiency and Toxicity

Nutrients	Deficiency Symptoms	Toxicity Symptoms
Macronutrients		
Nitrogen (N)	❖ The most noticeable symptom of nitrogen deficiency is chlorosis where leaves turn pale-green or yellowish. This typically starts in older leaves at the bottom of the plant and progresses upward. ❖ Overall restricted growth of tops, roots and shoots. ❖ Yellowing is uniform over the entire leaf including veins. There is no internal striping or yellow patches.	❖ Plants experiencing nitrogen toxicity may exhibit excessively dark green foliage due to accumulation of chlorophyll which can occur when nitrogen levels exceed the metabolic needs of the plants. ❖ Nitrogen-overfed plants may become more attractive to certain pests and disease susceptibility. Excessive nitrogen can promote lush, succulent growth that is more vulnerable to attack by insects and pathogens. ❖ Excessive nitrogen can inhibit root growth and development, resulting in a shallow root system.
Phosphorus (P)	❖ P-deficiency symptoms appear first on older leaves. ❖ P-deficient plants may show characteristic leaf symptoms including dark green or purple discolouration on the leaves, especially on the undersides.	❖ Phosphorus toxicity is uncommon and usually buffered by pH limitations. ❖ Excess phosphorus can interfere with the uptake of other

	❖ Phosphorus is essential for cell division and growth. Plants deficient in phosphorus often exhibit stunted growth with shorter stems and smaller leaves compared to healthy ones. ❖ Phosphorus is essential for root development and function. P-deficient plants often have poorly developed root systems with reduced root branching and elongation.	essential nutrients such as iron, zinc and manganese.
Potassium (K)	❖ Potassium deficiency typically appears first in older leaves, causing yellowing between the veins. The affected areas may then turn dark yellow or brown, with the leaves curling up and eventually dying. ❖ Older leaves are initially chlorotic but soon develop dark necrotic spots. When deficiency becomes more severe, these necrotic spots progress inward and upward in younger leaves. ❖ Its deficiency also causes poor development of roots, *vis-a-vis* the dropping of flowers and fruits.	❖ Excess K can aggravate the uptake of Mg, Mn, Zn and Fe. However, its toxicity is rare.
Magnesium (Mg)	❖ One of the most common symptoms is the development of chlorosis, i.e. yellowing of leaves. Initially, this yellowing may appear between the leaf veins though afterwards spreading across the entire leaf.	❖ Its excess is rare and not generally exhibited visibly.

	In severe cases, leaves may turn almost completely white or brown. ❖ Mg deficiency can cause leaves to curl or cup upwards along their edges.	
Calcium (Ca)	❖ Calcium deficiency can cause distorted or abnormal growth in young leaves. ❖ Ca-deficient plants may develop necrotic lesions on leaves, especially at the tips and margins. These lesions may start as small spots or patches of dead tissue and can expand over time. ❖ Common symptoms of calcium deficiency include blossom-end rot of tomato, tip burn of lettuce, blackheart of celery, etc. All these symptoms show soft dead necrotic tissue in rapidly growing areas	❖ Difficult to identify visually. ❖ Its abundance in early life of plants causes stunted growth.
Sulphur (S)	❖ Its deficiency first appears on younger leaves which become pale yellow with slow growth. ❖ Symptoms of S-deficiency can differ among various plant species in maize its deficiency shows up as interveinal chlorosis while leaf spotting may occur in potatoes.	Leaves stunt and overall growth is reduced along with yellowing or scorching at the edges.
Micronutrients		
Iron (Fe)	❖ Its deficiency signs first appear on younger leaves. ❖ It will mask Mg deficiency.	❖ Excessive accumulation is rare but can cause bronzing or small

	❖ The newer growth exhibits interveinal chlorosis typically differentiating it from a Mg deficiency. ❖ Chlorotic mottling on immature leaves may start first near the bases of the leaflets so that in effect the middle of the leaf appears to have a yellow streak.	brown spots on the leaf surface.
Boron (B)	❖ Its deficiency sign first appears on young growth which may result in limited bud formation, bud break, distorted shoot growth, short internodes, increased branching, falling of floral buds and inhibition of fruit and seed development. ❖ Growing tips may become light green to yellow. ❖ Resetting of terminal growth may occur due to shortening of internodes. ❖ Terminal buds may die and new growth may form at lower leaf axils.	❖ Chlorotic yellowing of leaf tips followed by necrosis of the leaves beginning at tips or margins and progressing inward. Later leaves may fall and in severe cases may cause plant death.
Molybdenum (Mo)	❖ Its deficiency first appears on older leaves. ❖ Mottling of older leaves with veins remaining light green. ❖ Leaf margins become necrotic and may curl upward. ❖ A very distinctive feature is that it occurs in the middle of the plant. It may also spread to the rest of the plant if not stopped, eventually killing the plant.	❖ Excess may cause discolouration of leaves depending on plant species.
Manganese (Mn)	❖ Its deficiency signs first appear in younger leaves exhibiting a general chlorosis, followed by	❖ Chlorosis or blotchy leaf tissue occurs due to insufficient chlorophyll synthesis.

	yellow and necrotic patches between the veins of larger leaves. ❖ Interveinal chlorosis on younger or older leaves followed by leaf shedding. ❖ As the deficiency becomes more severe, the new growth becomes completely yellow.	
Zinc (Zn)	❖ In some plants, its deficiency first appears on older leaves while in others it affects immature leaves. ❖ Its deficiency results in stunting, yellowing and curling (downward direction) of small leaves.	❖ The toxicity level of zinc interferes with Fe causing chlorosis from Fe deficiency. ❖ Its excess can be toxic and may result in plant death.
Copper (Cu)	❖ Its deficiency signs first appear in younger leaves. ❖ Cu deficiency may be expressed as overall light chlorosis along with permanent loss of turgor in young leaves. ❖ Cu- deficiency causes wilting of new growth, *vis-a-vis* irregular growth.	❖ Cu is an essential element but extremely toxic in excess. Its toxicity reduces growth followed by symptoms of Fe-chlorosis, stunting, reduced branching, abnormal darkening and thickening.
Chlorine (Cl)	❖ Chlorosis and wilting of young leaves occur. The chlorosis occurs on smooth flat depressions in the interveinal areas of the leaf blade. ❖ In more advanced cases, there often appears a characteristic bronzing on the upper side of mature leaves.	❖ Plants are generally tolerant of chloride though some species like grapevines are sensitive to chlorine and can show toxicity even at low chloride concentrations in the soil.

ACTIVITIES

Activity 1: Visit a Nearby Hydroponics Unit and Discuss with the Owner About Maintenance of Different Environmental Parameters

Material required:

Pen, pencil, notebook, environmental data sheet,

Procedure:

1. Identify and list parameters to be maintained in the hydroponics unit (e.g., temperature, humidity, light, CO_2 levels, and air circulation).

2. Interact with the owner/manager to understand their practices for monitoring and maintaining these parameters.

3. Observe the equipment used to measure and regulate the parameters.

4. Record observations and insights about how different parameters are managed.

Check Your Progress

D. Fill in the Blank:

1. Night temperature in a greenhouse should ideally be about _________ lower than daytime temperature
2. The range of light spectrum ideally required for plant growth in a greenhouse is between _______________ nm to _____________ nm.
3. EC stands is between _____________
4. Maintaining pH levels between ________ to _______________ is crucial for ensuring nutrient absorption in hydroponic systems.

E. Multiple Choice Question

1. What is the primary function of air stones in hydroponic systems?
   a. Providing structural support to plants
   b. Aerating nutrient solutions
   c. Filtering water
   d. Regulating temperature

2. What is the purpose of monitoring EC levels in hydroponic systems?

a. Assessing plant height
b. Testing water pH
c. Managing nutrient concentrations
d. Monitoring air humidity

3. What nutrient deficiency may cause yellowing of leaves in hydroponic plants?
   a. Potassium
   b. Sulphur
   c. Sodium
   d. Nitrogen

4. Which nutrient is essential for root development, *vis-à-vis* its function in hydroponic plants?
   a. Phosphorus
   b. Calcium
   c. Magnesium
   d. Sulphur

5. Which deficiency causes blossom-end rot in tomatoes?
   a. Potassium
   b. Calcium
   c. Magnesium
   d. Sulphur

Subjective Question:

1. How nutrient deficiency can be managed.
2. Write the common environmental factors responsible for hydroponic crops growth?

Session 2: Preparation and application of Nutrient Solution

Preparation of Nutrient Solution

Plants in hydroponic/soil-less cultivation must be nourished through a balanced nutrient solution containing all macro and micronutrients essential for plant growth. The following guidelines should be adopted for the preparation of nutrient solution:

- **Formulation of Nutrient Solutions:** For making nutrient solutions either growers can use commercially available nutrient solutions or they can prepare their own nutrient solution as per the requirement of nutrients based on plants to be grown in a hydroponic system. In any hydroponic system, additions of nutrients at appropriate concentrations in the correct form are essential for good plant growth. The various plant species may require nutrients of different concentrations, ratios or chemical forms for efficient absorption. Generally, the plant nutrient solution is prepared with a higher concentration than what plants would encounter in natural soil. The main advantage of a higher nutrient concentration is time-saving; as nutrient solutions need to be changed only once a week instead of daily. When selecting nutrients for the solution, it's essential to first study the plant's needs through available literature. A thorough understanding of the plant's nutritional requirements is crucial for designing the most effective nutrient solution.

- **Preparation of stock nutrient solution**

The preparation of nutrient solution is an important step to initiate hydroponics/soilless cultivation.

Plants uptake nutrients in the ionic forms. The requirement of different ions for optimum plant growth are mentioned in **Table 1.2.**

Table 1.2: Standard Major Nutrient Solution for Fertigation in Hydroponics

Major Nutrient	Conc. (mmol/L)	Conc.(ppm)
Nitrate	14	196
Dihydrogen Phosphate	1	97
Sulphate	2	192
Potassium	6	240
Ammonium	1	14
Calcium	4	160
Magnesium	2	48

A simple composition of nutrient elements based chemical compounds required for the preparation of hydroponics solution is mentioned in **table 1.3.** However, composition of nutrient may be changed as per the growing nature of plant.

Table 1.3: Chemicals needed to prepare 1000 L of nutrient solution for hydroponics fertigation (Dr Alan Cooper Formula)

Nutrient	**Weight in g**
Pot. dihydrogen phosphate	263
Pot. Nitrate	583
Calcium Nitrate	1003
Mag. Sulphate	513
EDTA Iron	79
Manganese Sulphate	6.1
Boric Acid	1.7
Copper Sulphate	0.39
Ammonium Molybdate	0.37
Zinc Sulphate	0.44

Note- Nutrient solutions are also available in the market.

pH Levels: The pH of the appropriate range should be maintained in the system. Generally, the pH of the system should range between 5.5 to 6.5

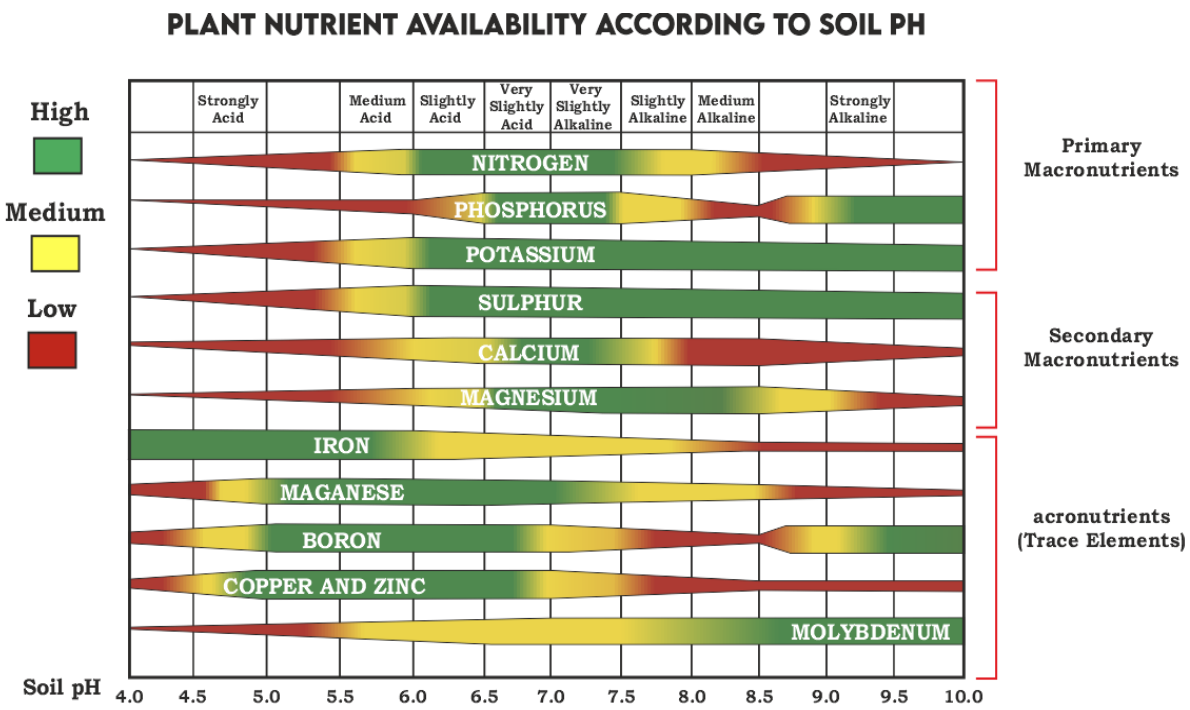

Fig. 3.2 Nutrient Availability varies by pH Level EC level

The EC of the system should be maintained within the desired range, typically between 0.5 to 2.5 dS/m.

Method and Timing for Application of Nutrient Solution

The change of water and nutrition addition is important for maintaining any hydroponic system. Before adding a nutrient solution or water change, growers should flush and clean the system properly so that no chemical residue is left in the reservoir otherwise it will cause an imbalance in nutrients, pH and EC levels. Flushing also removes organic matter such as dead plant material deposited in the reservoir and growing medium.

- **Filter Cleaning:** The water filtration system is an important component of the nutrient solution reservoir. It helps to remove organic matter and plant debris from the reservoir. The filter should also be cleaned regularly. The common filters are disc and screen filters used to clean the suspended impurities of water.

Addition/change of nutrient solution

The date and amount of water as 'topping off' or 'complete water change' should be recorded in the record book during each addition of water or nutrient solution in the system. Major water change is usually after two or three 'topping off' water changes. The concentration of nutrients level(ppm), pH and EC level should always be measured at the time of addition, remixing and cleaning of nutrients in the hydroponic system which should also be recorded in the record book.

The nutrient solution should be added at least once a week but only after analysis while water should be added daily as per requirement. Nutrient concentration in the solution of the hydroponic reservoir should be recorded regularly and be sure that it ranges from 800-1500 ppm. The concentration of dissolved nutrients gets higher with the evaporation of water from the nutrient solution. The solution is to be diluted by adding fresh water to the reservoir. As the water is absorbed by plants from the nutrient solution some of the water also gets evaporated from the reservoir which requires to be substituted. Further, the rate of water level also decreases at different rates depending on the size of the reservoir and temperature-cum-humidity of the grow room. Therefore, a grower should examine temperature and humidity regularly. Regular checking of nutrient level is necessary for adjustment to maintain optimal nutrient ratio and prevent any deficiency or toxicity of nutrients.

Process of Filtering and Sterilizing the Water and Nutrient Solution

- **Cleaning of System:** Clean and organized hydroponic systems are prerequisites for the success of this culture. For a well-organized hydroponic system, first, we must label all the components of the hydroponic setup such as the nutrient reservoir, grow tray, pump, tubes, pots, etc. This exercise ensures the proper integration of all components in the system for its successful operation. The growing surface of the hydroponic system should be sanitized between plant cycles using diluted hydrogen peroxide or another suitable disinfectant. This helps minimize the risk of pathogen infection. Additionally, the hydroponic reservoir should be cleaned at least once during a major water change, or it may be cleaned weekly to maintain optimal conditions.
- **Sterilizing:** The system should be sterilized after each harvest of the plant or when plants are affected by any pest or pathogens.

While cleaning the system, any component such as the pump, *etc.* attached to the reservoir should be unplugged first. After unplugging, the nutrient solution from the reservoir should be drained out, followed by a thorough cleaning with water or a mixture of water and vinegar (1:1) or water and hydrogen peroxide (1:2).

Precautions:

- It is always advisable to wear gloves at the time of cleaning of the reservoir.
- The inside of the reservoir should be cleaned by scrubbing the wall with a sponge.
- Scrubbing should start from the bottom upward. After scrubbing, any leftover solution should be drained, followed by thorough rinsing with water time and again.
- After completing the cleaning process, the system should be dried with a cloth to ensure that no fibres or particles are left behind.
- Avoid using chemicals or bleach to clean the reservoir.
- After thorough washing cum drying of the reservoir, it is filled with fresh nutrient solution having proper pH and nutrient concentration.

Frequency and Dose of Nutrient Solution: In a hydroponic system, nutrients are directly supplied to the plant root through the solution as per the requirement of the crop to be planted because different plants may have different requirements. However, leafy vegetables such as lettuce and spinach require higher nitrogen while fruiting plants such as tomatoes and peppers require more K and P. The size of the hydroponic system also impacts the amount of nutrients required. For example, a larger system with more plants requires a higher nutrient supply compared to a smaller one. Nutrient requirements can be calculated based on the number and size of the plants. The plant growth stages also affect the nutrient requirement as during the vegetative stage plants require a higher level of nitrogen for plant growth while during flowering-cum-fruiting stages, the requirement of potassium and phosphorus to support flowering and fruit development is increased. Some of the elements tend to deplete more quickly than others. Moreover, the fertilizer becomes more concentrated as the water evaporates so there becomes a risk of burning the plant roots.

Most hydroponic systems require nutrient replenishment every 1–2 weeks. Both over- and underfeeding can harm plants; however, an excessive supply of nutrients is especially detrimental.

Frequency

Growers should check the nutrient solution pH, and EC/TDS weekly. If nutrient concentration drops below the recommended PPM/EC, growers should change/substitute the nutrients accordingly. However, quickly nutrients deplete or change depends on factors such as plant growth, temperature, humidity and water purity (TDS). In general, the nutrient solutions are replenished every 1–2 weeks.

ACTIVITIES

Activity 1: Prepare a nutrient solution for the hydroponic crop.

Material required:

Pen, pencil, notebook, plant nutrients, glass container, pH meter, EC meter, TDS meter etc.

Procedure:

1. Identify and select plant nutrients
2. Prepare a stock solution of the desired concentration.

3. Maintain the pH of the solution.

4. Apply the prepared solution to a hydroponics plant.

5. Note down the observation periodically.

Check Your Progress

Fill in the Blank:

1. The concentration of nutrients in the nutrient solution is measured in ______.
2. For cleaning the hydroponic system, it is advisable to use a mixture of water and hydrogen peroxide in ratio of _______.
3. The EC of the hydroponic system should range between ______ to ______ dS/m.
4. In hydroponics, plants uptake nutrients in ______ forms.

A. Multiple Choice Question

1. What is the primary advantage of using a higher concentration of nutrients in a hydroponic system?
   a. Reduces water usage
   b. Prevents nutrient depletion
   c. Saves time by changing the solution less frequently
   d. Increases plant growth rate

2. Which of the following chemicals is used to prepare a hydroponic nutrient solution?
   a. Calcium Carbonate
   b. Potassium Nitrate
   c. Sodium Chloride
   d. Ammonium Sulfate

3. Which of the following is not a recommended practice when cleaning the hydroponic system?
   a. Use diluted hydrogen peroxide
   b. Scrub from the bottom upward
   c. Use bleach to clean the system
   d. Drain the nutrient solution completely

4. How often should the nutrient solution be replenished in a hydroponic system?

a. Quarterly
b. Weekly
c. Monthly
d. Annually

5. What is the most commonly used filter type in hydroponic systems?
    a. Carbon filter
    b. Disc filter
    c. HEPA filter
    d. Paper filter

Subjective Questions

1. Describe the process of preparation of the nutrient solution.
2. Write the process of sterilization and cleaning of the hydroponic system.

Glossary

Abiotic factors: Non-living factors such as temperature, humidity, light, and soil quality that can influence plant growth and development.

Aeration: The process of adding air to soil or growing media to improve oxygen levels for plant roots.

Arable land: Land suitable for growing crops, typically referring to land that is plowable and fertile.

Automation: The use of technology to perform tasks or control processes with minimal human intervention.

Biotic factors: Living organisms such as pests, diseases, and other organisms that can affect plant growth and health.

Cation Exchange Capacity (CEC): The soil's ability to hold and exchange positively charged ions (cations) such as calcium (Ca2+), magnesium (Mg2+), potassium (K+), and others. It's an important property of growing media as it affects nutrient availability to plants.

Contamination: The presence of unwanted or harmful substances, organisms, or particles.

Continuous harvest: A farming practice aimed at maintaining a steady supply of crops by planting and harvesting in succession, ensuring a constant flow of produce.

Cultural operations: Agricultural practices related to the care and management of crops, such as weeding, pruning, and fertilizing.

Damping Off: A fungal disease that causes seedlings to rot and die.

Diluted: Reduced in concentration or strength by mixing with another substance, typically water.

Drip Irrigation: A method of delivering water and nutrients to plants through a network of tubes and emitters, providing controlled and efficient watering.

E-commerce platform: An online marketplace or website where goods or services are bought and sold electronically.

EC (Electrical Conductivity): A measure of the water's ability to conduct electrical current, indicating the concentration of dissolved ions, including nutrients.

EC/TDS levels: Electrical Conductivity (EC) and Total Dissolved Solids (TDS) levels, which measure the concentration of dissolved salts and minerals in water, indicating their suitability for plant growth.

Evaporation: The process by which water changes from a liquid to a gas or vapour, typically due to heating or exposure to air.

Fertigation: The process of simultaneously applying fertilizers and irrigation water to crops through the irrigation system. It allows for precise control over nutrient delivery, promoting efficient plant uptake and minimizing nutrient loss.

Fungicide: A chemical substance or biological organism used to kill or inhibit the growth of fungi.

Germination: The process by which a seed develops into a new plant.

Greenhouse: A structure with transparent walls and a roof designed to trap heat and sunlight, creating a controlled environment for plant growth.

Growing mediums: Substances used to support plant roots and provide stability and nutrients in hydroponic systems, such as perlite, vermiculite, or coconut coir.

HEPA Filter: HEPA stands for High-Efficiency Particulate Air. HEPA filters are mechanical air filters capable of trapping extremely small particles such as pollen, dust mites, and even bacteria. They are commonly used in intake fans to improve air quality in indoor growing environments.

Heat Stress: A condition in which plants experience adverse effects due to high temperatures, impacting their growth and health.

Infestation: The presence and rapid reproduction of pests or harmful organisms that can damage crops.

Macronutrients: Essential elements required by plants in relatively large quantities for healthy growth. The primary macronutrients are nitrogen (N), phosphorus (P), and potassium (K), while secondary macronutrients include calcium (Ca), magnesium (Mg), and sulfur (S).

Microorganisms: Microscopic organisms like bacteria, fungi, and algae. In hydroponic systems, beneficial microorganisms can contribute to nutrient cycling, root health, and disease suppression, while harmful microorganisms can cause plant diseases and reduce crop yields.

Micronutrients (Trace Elements): Essential nutrients required by plants in small amounts for various physiological functions. Examples include iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), boron (B), molybdenum (Mo), and chlorine (Cl).

Nutrient Concentration: The amount or strength of nutrients present in a solution, often measured in parts per million (PPM) or electrical conductivity (EC).

Nutrient Deficiency: A condition in which a plant lacks one or more essential nutrients necessary for its growth and development, leading to characteristic symptoms.

Nutrient runoff: The movement of excess nutrients from the soil or growing medium into water sources, often leading to pollution and environmental degradation.

Nutrient Toxicity: A condition in which plants are exposed to excessive levels of certain nutrients, leading to adverse effects on growth and metabolism.

Ornamental plants: Plants grown for decorative purposes rather than for food or other practical uses.

Pathogens: Microorganisms, such as bacteria, viruses, and fungi, that can cause diseases in plants or animals.

Pest: Any organism that causes damage or poses a threat to plants, such as insects, mites, or rodents.

Pest infestations: The presence and proliferation of unwanted organisms, such as insects or rodents, that can damage crops or plants.

Pesticides: Chemical substances used to control or eliminate pests that can damage crops.

Photosynthesis: The process by which green plants and some other organisms use sunlight to synthesize foods with the help of chlorophyll.

Polytunnel: A type of tunnel structure made of polyethene typically used in agriculture to create a protected environment for crops.

PPM: Parts per million, a unit of measurement used to express the concentration of a substance in a solution.

Precision farming: Farming practices that utilize technology and data analysis to optimize inputs such as water, fertilizers, and pesticides, aiming to maximize efficiency and minimize environmental impact.

Runoff: The flow of water, especially excess rainwater, over the surface of the ground, which may carry pollutants and nutrients.

Sanitize: To clean or disinfect something, typically to reduce the risk of contamination by pathogens or other harmful substances.

Seed Treatment: The application of chemicals or other agents to seeds to improve their health and performance.

Sensors: Devices used to detect and measure changes in environmental parameters such as temperature, humidity, and nutrient levels.

Temperature tolerance: The range of temperatures within which a plant can grow and develop optimally.

Transplanting: The process of moving seedlings or young plants from one location to another, typically from a nursery to a field or garden.

Transpiration: The process by which moisture is carried through plants from roots to small pores on the underside of leaves, where it changes to vapour and is released into the atmosphere.

Vegetative Stage: The growth phase of a plant characterized by the development of leaves and stems, occurring before flowering.

Viability Test: A test to determine the ability of seeds to germinate and produce healthy seedlings.

Answer Key

Unit 1: Session 1

A. Fill in the Blanks

1. Soil
2. Soil
3. Nutrient
4. pH

B. Multiple Choice Questions

1-d, 2-b, 3-d

Unit 1: Session 2

A. Fill in the Blanks

1. Vegetative
2. Precision
3. wet

B. Multiple Choice Questions

1-b, 2-b, 3-d, 4-b

Unit 2: Session 1

A. Fill in the Blanks

1. Soil
2. Drain
3. Coconut
4. UV-Stabilized

B. Multiple Choice Questions

1-d, 2-c, 3-b, 4-b, 5-a

C. Match the column

1-b, 2-c,3-d, 4-a

Unit 2: Session 2

A. Fill in the Blanks

1. Compact
2. Seed testing
3. Seed treatment
4. aeration

B. Multiple Choice Questions

1-c, 2-c, 3-a, 4-a, 5-c

Unit 3: Session 1

A. Fill in the Blanks

1. 5°C
2. 400,700
3. Conductivity
4. 5.5, 6.5

B. Multiple Choice Questions

1-b, 2-c, 3-d, 4-a, 5-b

Unit 3: Session 2

A. Fill in the Blank

1. ppm (parts per million)
2. 1:2
3. 0.5, 2.5
4. Ionic

B. Multiple Choice Questions

1-C, 2-B, 3-C, 4-B, 5-B

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