Aeroponic Farming Technology

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"AEROPONIC FARMING TECHNOLOGY"

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CERTIFICATE

Certified that the Technical Seminar entitled **Aeroponic Farming Technology**, presented by **Mr. Katrahalli Sharat,** USN: **4NI20ME404**, a bonafide student of Department of Mechanical Engineering, is submitted in partial fulfillment for the award of Bachelor of Engineering Degree in Mechanical Engineering of The **National Institute of Engineering, Mysuru,** an autonomous institute under Visvesvaraya Technological University, Belagavi during the year 2022-23.

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ABSTRACT

Aeroponics is a promising soilless farming method for solving future food crisis and is relatively a new way of growing plants that is getting increasingly popular with many people because of the speed, cost and novelty. Aeroponic farming is a form of hydroponic technique and a type of vertical farming. The word aeroponic is derived from the Latin word ‘aero’ (air) and ‘ponic’ means labor (work). This farming system empowered the producer to precisely control root zone nutrients, water regimes, and environmental conditions and have complete access to the roots throughout the life of the crop. This aeroponic farming is superior in terms of excellent aeration, water use efficiency, less time and space requirement, seasonal independence, disease free plant propagation, and large-scale plant production etc. than the conventional methods of propagation. Aeroponic techniques have proven to be commercially successful for propagation, seed germination, seed potato production, tomato production, leaf crops, and micro-greens. Vegetable crops like potato, yams, tomato, lettuce and some of the leafy vegetables are being commercially cultivated in aeroponic system. Aeroponics appeared to be a highly feasible method for the production of both aerial parts and roots.

DECLARATION

I, **Katrahalli Sharat** bearing **USN: 4NI20ME404** student of 7Th semester of UG Programme, **Department of Mechanical Engineering**, **The National Institute of Engineering, Mysuru**, hereby declare that the Technical Seminar entitled **“Aeroponic Farming Technology”** has been presented by me under the guidance of **Dr. Sharath Chandra N,** Assistant Professor and Head – CTAT, Dept. of Mechanical Engineering. This Seminar Report is submitted to The National Institute of Engineering, Mysuru, (An Autonomous institute under VTU, Belagavi) in partial fulfillment of the course requirements for the award of Bachelor of Engineering degree in Mechanical Engineering of The **National Institute of Engineering, Mysuru,** during the **academic year 2022- 2023**. This written submission represents a record of original work and I have adequately cited and referenced the original Sources.

Further the matter embodied in this report has not been submitted to any other University or Institution for the award of any degree.

Place: Mysuru

Date: (Signature of the student)

CONTENTS

List of Notations/Abbreviations

1	N-NH4	Ammonium
2	N-NO3	Nitrate Nitrogen
3	P	Phosphorus
4	K	Potassium
5	Ca	Calcium
6	mg	magnesium
7	Na	Sodium
8	AM	Arbuscular Mycorrhiza
9	NFT	Nutrient Film Technique

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CHAPTER: 1

1.1 INTRODUCTION

Aeroponics is the process of growing plants in an air or mist environment without the use of soil or an aggregate medium. In other words, it is the whole plant, roots, and all, are suspended in mid-air. The word Aeroponics is derived from two Latin words "aero" (meaning air) and "ponos" (meaning labour). Aeroponics is an alternative for people with limited spaces to grow plants. An aeroponic system is defined as an enclosed air and water/nutrient ecosystem that fosters rapid plant growth with little water and direct sun and without soil or media. It is an effective and efficient way of growing plants for it requires little water (requires 95 per cent less water than traditional farming methods) and needs minimal space than even the most efficient system hydroponic system. Plant grown in these aeroponic system also been shown to uptake more minerals and vitamin, making the plants healthier and potentially more nutritious.

The suspended aeroponic plants receive 100 per cent of the available oxygen and carbon dioxide to the roots zone, stems, and leaves, thus accelerating biomass growth and reducing rooting times. The higher biomass yield of aerial parts from the aeroponic treatment indicated that this production technique should not be limited to root crops, but should be considered for other types of crops as well. Furthermore, using aeroponics, planting densities can be increased since plant-to-plant competition for nutrients and water is essentially eliminated. Any species of plants can be grown in a true aeroponic system because the micro-environment of an aeroponic can be finely controlled. Aeroponic systems for seed production have been established following increased demand for more efficient high quality seed production methods.

Aeroponic biopharming is used to grow pharmaceutical medicine inside the plants. Using aeroponics for cloning improves root growth, survival rate, growth rate and maturation time. Studies have shown that, the mean tuber yield under aeroponics is better than when the same material is left to produce tuber under conventional means. Some researcher reported that, the aeroponics system increased stomatal conductance of leaf, intercellular CO2 concentration, net photosynthetic rate and photochemical efficiency of leaf.

The basic principle of aeroponic growing is to grow plants suspended in a closed or semi-closed environment by spraying the plant's dangling roots and lower stem with an atomized or sprayed, nutrient-rich water solution. The leaves and crown, often called the canopy, extend above. The roots of the plant are separated by the plant support structure. Often, closed-cell foam is compressed around the lower stem and inserted into an opening in the aeroponic chamber, which decreases labour and expense; for larger plants, trellising is used to suspend the weight of vegetation and fruit. Ideally, the environment is kept free from pests and disease so that the plants may grow healthier and more quickly than plants grown in a medium.

However, since most aeroponic environments are not perfectly closed off to the outside, pests and disease may still cause a threat. Controlled environments advance plant development, health, growth, flowering and fruiting for any given plant species and cultivars. Due to the sensitivity of root systems, aeroponics is often combined with conventional hydroponics, which is used as an emergency "crop saver" – backup nutrition and water supply – if the aeroponic apparatus fails.

Hydroponic methods on a commercial scale. However, aeroponics has been increasingly used for growing numerous vegetable crops such as lettuce, cucumber, melon, tomato, herbs, potato, and floral crops, and especially for those crops where roots are harvested as the product. Seed potato production may be the most successful application of aeroponics on a commercial scale, done mostly in China, Korea, South America, and African countries in recent years.

Aeroponics is able to produce large numbers of minitowers in one generation that can be harvested sequentially, eliminating the need for field production, thereby reducing costs and saving time. Aeroponics was used to produce tree saplings (Acacia magnum) with arbuscular mycorrhiza (AM) fungi inoculation. The well-aerated root environment of aeroponics was beneficial for root initiation and subsequent root growth in woody (Ficus) and herbaceous (Chrysanthemum) cuttings.

1.2 NEEDS OF AEROPONIC FARMING

The current world population of 7.2 billion is projected to increase by almost one billion people within the next twelve years, reaching 8.1 billion in 2025 and 9.6 billion in 2050. With the increasing population growth, the demand for the more food and more land to grow food is ever increasing. As the world population continues to grow, the rising demand for agricultural production is significant. Prime agricultural land can be scarce and expensive.

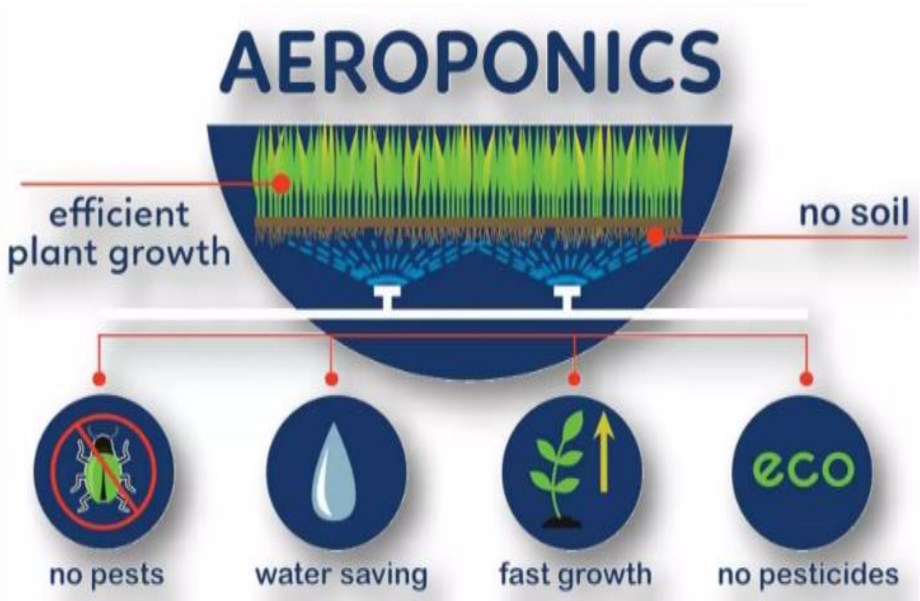

Fig 1: - Needs of Aeroponics Farming

Aeroponics is a technological leap forward from traditional hydroponics. Aeroponics-farming are also needed due to the many drawbacks of the traditional field farming system. Some of the drawbacks of the traditional farming system are 15 hours to harvest the crops, long time to harvest hence being sold for more expensive prices to earn back the time. Another factor is soil used in traditional system; decomposition of organic materials takes up long time. There is a high risk of getting soil disease. Pesticides are used, which is harmful for health. Whereas, in a developing country like India, it is very important to use resources like water, sunlight, soil and money very efficiently.

CHAPTER 2

2.1 LITERATURE SURVEY

Many studies have clearly shown that aeroponics promotes plant growth rates through optimization of root aeration because the plant is totally suspended in air, giving the plant stem and root systems access to 100% of the available oxygen in the air. Droplet size and frequency of exposure of the roots to the nutrient solution are the critical factors which may affect oxygen availability. Large droplets lead to less oxygen being available to the root system, while fine droplets produce excessive root hair without developing a lateral root system for sustained growth.

Three broad categories are generally used to classify droplet forming systems and droplet size: regular spray nozzles with droplet size >100 µm (spray), compressed gas atomizers with droplet size between 1 to 100 µm (fog), and ultrasonic systems with droplet size 1 to 35 µm (mist). The most common type is when the nutrient solution is compressed through nozzles by a high-pressure pump, forming a fine mist in the growth chambers. An ultrasonic misting system was adopted in a sterile aeroponics culture system for in vitro propagation.

In this study, air atomizing nozzles (1/4J Series) were employed for the aeroponics system. The air atomizing nozzles require a single air source for atomizing the air and to provide independent control of liquid, atomizing air, and fan air pressure for fine tuning of the flow rate, droplet size, spray distribution, and coverage. These air atomizing nozzles were equipped with clean-out needles to eliminate clogging and ensure optimum performance. The objectives of the present study were to compare shoot and root growth, root characteristics, and mineral contents of two lettuce cultivars grown in aeroponics, hydroponics (Nutrient Film Technique, NFT) and substrate culture.

Aeroponic research began in the 1920's and progressed steadily as a soilless growing method. In the early 1940s, the technology was largely used as a research tool rather than an economically feasible method of crop production. W. Carter in 1942 was the first researched air culture growing and described a method of using water vapor at the plants roots to deliver nutrients to facilitate examination of roots. In 1944, L.J. Klotz was the first to discover vapor misted citrus plants in facilitated research of his studies of diseases of citrus and avocado roots. In 1952, G.F. Trowel grew apple trees in a spray culture. The first commercial aeroponics setup was the Genesis Rooting System, commonly called the Genesis Machine, by GTi in 1983. The device was controlled by a microchip and simply connected to an electrical outlet and a water faucet. During the 1990s , NASA carried out a series of tests in space and on earth growing biomass with no soil and very little water and this method proved to be very productive. NASA research has shown that aeroponically grown plants have an 80 per cent increase in dry weight biomass (essential minerals) compared to hydroponically grown plants. Aeroponic techniques have been given special attention from NASA since a mist is easier to handle than a liquid in a zero-gravity environment.

Aeroponic biopharming is used to grow pharmaceutical medicine inside the plants. The technology allows for completed containment of remain inside a closed-loop facility. Reports show that the system is ten times more successful than conventional techniques, tissue culture and hydroponics, which take longer and are also more labour intensive. The system has the ability to conserve water and energy. Aeroponics system uses nutrient solution recirculation hence, a limited amount of water is used.

It comparatively offers lower water and energy inputs per unit growing area. Using aeroponics for cloning improves root growth, survival rate, growth rate and maturation time. Studies have shown that, the mean tuber yield under aeroponics is better than when the same material is left to produce tuber under conventional means. Such results clearly show that, aeroponics system can be effectively used for potato propagation.

The aeroponics system optimizes root aeration. This is true because the plant is totally suspended in air, giving the plant stem and root systems access to 100% of the available oxygen in the air which promotes root growth. Such environment also gives plants 100% access to the carbon dioxide concentrations ranging from 450 to 780 ppm for photosynthesis hence, plants in an aeroponics environment grow faster and absorb more nutrients than regular hydroponics plants. This is in line with Sun et al. (2004) who reported that, the aeroponics system increased stomatal conductance of leaf, intercellular CO_2 concentration, net photosynthetic rate and photochemical efficiency of leaf.

2.2 TYPES OF AEROPONICS

Low-pressure Units

In most of the low-pressure aeroponic gardens, roots of the plant are suspended above a reservoir of nutrient solution or a channel which is inside and is connected to a reservoir. The nutrient solution is delivered by a low-pressure pump through jets or by ultrasonic transducers, which drips or drains the nutrients back into the reservoir. When plants grow to maturity, then the units suffer from dry sections of the root systems and thus adequate nutrient uptake is avoided. These types of units lack features to purify the nutrient solution, removal of debris and unwanted pathogens because of cost. These units are usually suitable for bench top growing. And it is also used for the demonstration of principles of aeroponics.

High-pressure Devices

In high-pressure aeroponic devices, mist is created by high-pressure pump(s). And it is generally used in the cultivation of high value crops. This method includes technologies for air and water purification, nutrient sterilization, low-mass polymers and pressurized nutrient delivery systems.

Commercial System

The commercial system has high-pressure device hardware and biological systems. An enhancement for extended plant life and crop maturation is included in the biological systems matrix. Working: Aeroponic system is an endless process in a confined space and therefore it cuts down agricultural labour.

Aeroponics are based on the possibility of cultivating vegetables whose roots are not inserted in a substratum (the case with hydroponics) or soil, but in containers filled with flowing plant nutrition. The basic principle of aeroponic growing is to grow plants suspended in a closed or semi-closed environment by spraying the plant's dangling roots and lower stem with an atomized or sprayed, nutrient-rich water solution. The set up for aeroponic includes a proper monitoring and control system for water and nutrients distribution for utilizing the aeroponic cultivation at its best. A distribution system of pipes, spray nozzles, a pump and timer distribute the spray from a nutrient solution storage tank is required. It uses a small internal micro jet spray that sprays the roots with fine, high-pressure mist containing nutrient rich solutions from the nutrient reservoir as a fine mist in the rooting chamber. There is a programmable cyclic timer which is used to trigger the high-pressure aeroponic pump to go on. Nutrients are mixed in with water in a reservoir basin, this is than filtered and pumped into a pressurized holding tank that is intermittently misted on to the root system. Developed root hairs help in absorbing nutrients from the moisture. It is also easier to administer all sorts of nutrients to the plant, via the root system. Since the spray particles are small in size, there is negligible wastage of nutrient solution. And with an ample amount of oxygen supply, root rot is completely avoided.

The misting is usually done every few minutes around the hanged roots. The system normally turned on for only a few seconds every 2-3 minutes. Because the roots are exposed to the air, the roots will dry out rapidly if the misting cycles are interrupted. A timer controls the nutrient pump much like other types of hydroponic systems, except the aeroponics system needs a short cycle timer that runs the pump for a few seconds every couple of minutes. However, the chamber must be lightless materials from everywhere, so that the roots are in darkness functionally good also to inhibit algal growth that impedes the growing plants and pollute the system.

The droplet size of a nutrient mist is a crucial element in aeroponics. An oversized droplet may reduce the oxygen supply. An undersized droplet may stimulate root hair growth which prevents lateral root growth which influences the efficiency of an aeroponic system. The water droplets must be big enough to carry the nutrients to the roots in sufficient quantity, but small enough to not immediately precipitate out of the root mass. Unused solution drips down into the base of the unit is strained, filtered, and pumped back into the reservoir. Aeroponics system is that of easy monitoring of nutrients and pH. In aeroponics there is the minimal contact between the support structure and plant, due to which the unconstrained growth of the plant is possible.

CHAPTER 3

3.1 DIFFERENT COMPONENTS OF AEROPONICS

Nutrients used in Aeroponics

Carbon, oxygen, and hydrogen are present in air and water. Water may contain a variety of elements with primary nutrients such as nitrogen, phosphorus, potassium, and secondary nutrients viz., calcium, magnesium, and sulphur, micro-nutrients are iron, zinc molybdenum, manganese, boron, copper, cobalt, and chlorine. The optimal pH for plant growth is between 5.8 and 6.3. In aeroponic system where water and nutrients are recycled, it is important to measure the acid/base or pH measurement to allow plants to absorb nutrients. Aeroponic using spray to nourish roots use much less liquid resulting in easier management of nutrient concentration with greater pH stability. The main nutrients used in aeroponics are:

Nutrient	Concentration (g/L)
N-NH4	0.54
N-NO3	0.35
P	0.40
K	0.35
Ca	0.17
mg	0.08
Na	0.04

Table 1: - Main nutrients used in Aeroponics

Water used in Aeroponics

Water to be used in aeroponics should have a low EC, not exceeding one mS/cm. Water pH is also a useful indicator. Water sources with a pH of over eight are questionable for aeroponics. It is useful to have a water chemical analysis, even if EC and pH measures fall into acceptable levels. The other problem we may have to face is water biological contamination. Water from deep wells is usually not contaminated. Water from superficial wells, especially near urban areas, is likely to be contaminated with coli form bacteria, including Pectobacterium. Water from suspicious sources should have a microbiological analysis. Special filters can minimize this risk. If available, water should be filtered before going into the nutrient tank. Boiling is also another alternative if no other is available.

The plant material used in Aeroponics

Optimum plant material should be used for aeroponics. In vitro plants are preferred because of sanitary reasons. However, they need to be handled with proper care by experienced technicians. These plants should be the appropriate age and size and should go through a thorough acclimatization period before going into the greenhouse. Other plant materials, such as rooted cuttings and tuber sprouts, should be clean and disease free. The presence of any kind of symptom should be sufficient reason to discard the whole batch of plants. This should be noticeable when transplanting into the boxes. The underground part of the tissue coming from the sand trays should be completely clean and sand free. Before placing into aeroponics, plants should be managed in a clean greenhouse environment.

Spray misters

Atomization is achieved by pumping water through nozzles at high pressure. Nozzles come in different spray patterns and orifices. Larger nozzles and orifices reduce the chance of clogging but need pressure to operate and have high flow rates. Droplet size in a given spray may vary from sub microns to thousands of microns.

Misting Frequency and Nutrient Reservoir

Aeroponic systems may mist the root system continuously, or intermittently and both methods work well, since water logging and oxygen starvation are not a problem in aeroponics. The major advantage of intermittent aeroponics systems is the saving in running cost, since the pump is only on for a short period of time, but the roots are still contained within the nutrient, moisture and oxygen rich environment between misting's. As a rule, a misting cycle of 1 -2 minutes of misting followed by 5 minutes off will ensure the root system does not dry out under most conditions.

3.2 Aeroponics Growing System

The principles of aeroponics are based on the possibility of cultivating vegetables whose roots are not inserted in a substratum (the case with hydroponics) or soil, but in a container filled with flowing plant nutrition. In these containers root can be find the best condition regarding the best oxygenation and moisture. These conditions allow for the better plant nutrition assimilation in a more balanced way, with consequential faster development of the cultivated plant. The principles of Aeroponics are based on the possibility of cultivating vegetables whose roots are not inserted in a substratum (the case with hydroponics) or soil, but in containers filled with flowing plant nutrition.

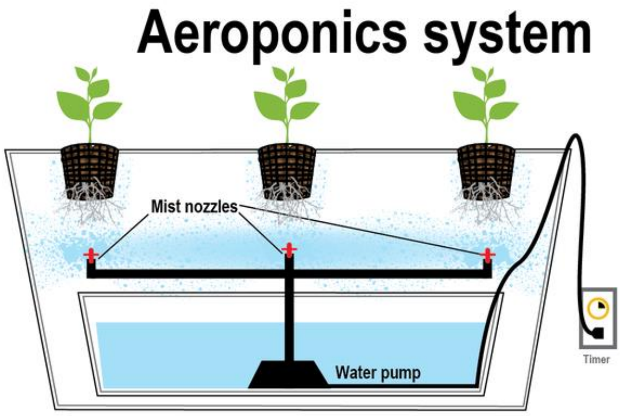

Fig 2: - Aeroponics Growing System

In these containers roots can find the best condition regarding oxygenation and moisture. These conditions allow for better plant nutrition assimilation in a more balanced way, with consequential faster development of the cultivated plants. Plant containers can be mounted on top of one another and because they are light and handy, they can be easily moved according to agricultural needs. Numerous plants are mounted in vertical columns within a greenhouse or shade house space. Nutrients are allowed to trickle down through the growth columns.

Most agricultural plants need a direct exposure to the sun during the first vegetative development. Afterwards this direct exposure is no longer relevant. Based on this observation, plant containers are periodically displaced. Young plants are placed at the highest level of the growth column. Afterwards they are progressively lowered utilizing a rotational mechanical system. With the rotation periodically repeated, this permits constant production without any interruption. The Aeroponic system is agriculture with a non-stop production cycle. Plant nutrition is supplied into a closed circuit. Consumption is consequently limited to only the quantities absorbed by the plants, allowing for substantial water savings. The aeroponic system is a continuous cycle in an enclosed space it reduces the agricultural labour into a series of mechanical routine operational tasks which are carried out daily and throughout the year. This enables workers to acquire considerable skill within a short period of time.

Some of the Commercial Designs of Aeroponic systems are shown below,

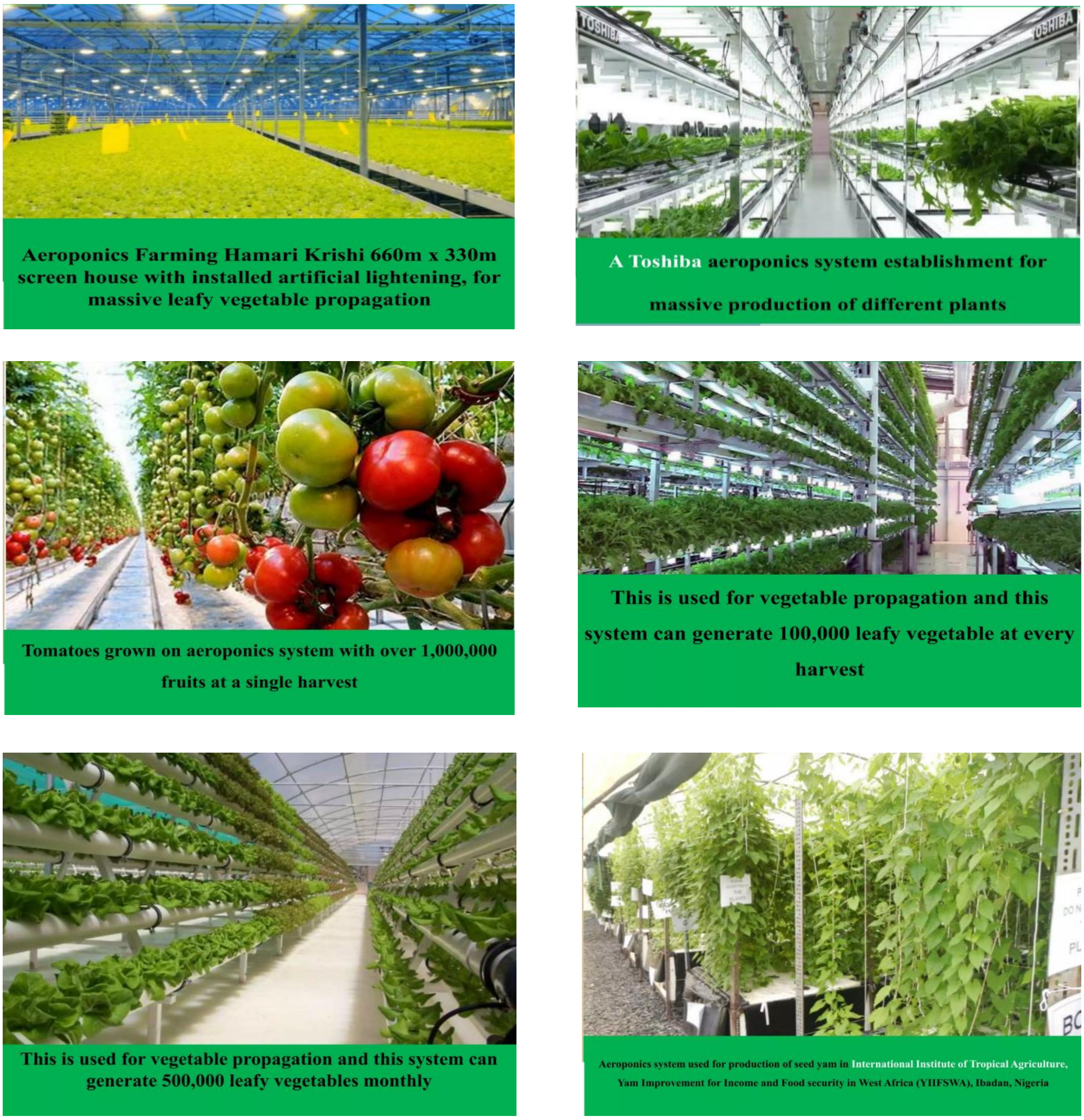

Fig 3: - Commercial Designs of Aeroponic

3.3 SOME OF THE KEY BENEFITS OF AEROPONICS

- **Round the year cultivation:** Since plants are grown in a controlled environment crops can be grown year-round without being dependent on the weather or atmosphere conditions outside.
- **Fast plant growth:** Plants grow fast because their roots have access to a lot of oxygen.
- **Easy system maintenance:** In aeroponics, all you need to maintain is the root chamber (the container housing the roots) which needs regular disinfecting, and periodically, the reservoir and irrigation channels.
- **Less need for nutrients and water:** Aeroponic plants need less nutrients and water on average because the nutrient absorption rate is higher, and plants usually respond to aeroponic systems by growing even more roots.
- **Mobility:** Plants, even whole nurseries, can be moved around without too much effort, as all that is required is moving the plants from one collar to another.
- **Requires little space and high yield:** Aeroponic systems can be stacked up in layers to build vertical farms that take up much less space than traditional farming methods.
- **Great educational value:** Plants and root growth study in laboratories is easier for students and researchers.
- **Proper root growth:** In this system, plant roots have proper space to grow well. So they don't stretch or wilt.
- **No transplantation shock:** Plants can be shifted to any growing media system without any transplantation shock after root development.
- **Easier fruit harvest:** Fruits produced from the system are easier to harvest.
- **Disease free produce:** Due to clean and sterile growing conditions, plant diseases and infections reduce up to a great extent.
- **Production at moon stations:** Using this technique, fruits can be grown at zero gravity i.e. at moon stations.
- Potentially healthier and nutritious plants can be grown at homes, indoors or at roof top.
- Nurseries can propagate seeds and cuttings into healthy, harvestable plants in a fraction of time of traditional methods.
- Aeroponics systems can reduce water usage by 98 per cent, fertilizer usage by 60 per cent, and pesticide usage by 100 per cent, all while maximizing crop yields.
- Power loss for a small period does not cause any damage to plants.

CHAPTER 4

4.1 Advantages

- **Less Fertilizer** - Since all the nutrients are contained, they don't end up in groundwater or sinking too deep into the soil to be of any help.
- **Less Water** - Very important for space travel and those in arid climates. Much of the water lost in traditional gardening is from water evaporating out of the soil. The rest of it just sinks past the roots and the plants never get a chance to drink it.
- **More Cost Effective** - Since less nutrient solution is needed as compared to hydroponics the costs to operate an aeroponic garden are less than to operate a hydroponic garden. There are also fewer moving parts and complicated systems involved.
- **Reduced Disease Damage** - Because the plants are separated from each other and not sharing the same soil, an infection in one plant has a much lower chance of spreading to the rest of your plants.
- Faster and healthier growth since it has enough oxygen (in the root region) Increased harvest rate is 45–70% faster than conventional agricultural techniques.
- Studies has shown that plants grown via the aeroponic system have an increase in flavonoids.

4.2 Disadvantages

- More expensive for long scale production.
- Ordinary farmers will struggle to manage all these sophisticated instruments.
- Mister spray heads may also tend to clog and not produce mist when needed.
- Many consumers believe that aeroponically grown plants are not as nutritious as other grown plants.
- Maintenance of an aeroponics farm is very expensive.

CHAPTER 5

5.1 CONCLUSION

Water plays an important role in the world economy. Approximately 70 per cent of the fresh water used by human goes to agriculture. Out of that 45 per cent is wasted due to gaudy irrigation techniques. By using aeroponic systems, we can save 98 per cent of total water because of recirculatory system. Fresh, clean, healthy, efficient and rapid food production can be obtained from aeroponic systems throughout the year. This soil less culture can overcome all the constraints that are present in soil culture production. Enhanced disease-free yield leads India to be at top growers and exporters in near future. Aeroponic system has the potential to produce enhanced vegetative growth without use of any artificial hormones, pesticides or insecticide. Aeroponics is still a good way to learn how to master plant growth and learn about their needs, within a controlled environment. For urban dwellers that live in apartments, sometimes aeroponics is the only practical way to garden. And on arid lands, aeroponics circumvents this problem, and provides the best means of growing plants effective.

5.2 FUTURE PROSPECTS

Soilless cultures consider as a new developed technique for agriculture development, but it is not simple technique. However, there is lack of technical background of the new technique among growers and horticulturists in many countries and well-trained employs are needed. Moreover, most substrates are internationally markets, so they are expensive. Therefore, it is better to look locally about not expensive good substrates. The growers can adept the soilless systems according to their needs, the place of the system and according to their potential cash. The system in any case need to take strong care and observation for the parameters needed for the good growth of the plants such as nutrient concentrations, light, oxygen around the plants root zone, water quality, pH, disinfection, temperature of the solution and more. Aeroponics helps conserve water, land and nutrients, so the aeroponics system is the way of the future, making cultivation of crops easier

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