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Hydroponics Training Manual

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Oyo Hub

Hydroponics Training Manual

Foreword

This book aims to answer in basic form the following questions:
What is hydroponics?
Why should I consider hydroponics?
How should I farm using hydroponics?

TRAINING
Outline

MODULE

MODULE 1

INTRODUCTION

Aquiculture is the act of growing crops without soil, this is popularly called hydroponics which is just an aspect of aquiculture, the other aspect is aquaponics. Soilless farming has existed since but, the word 'Hydroponics' became popularized by the news media in the 1920s when a scientist named Dr William F. Gericke of the University of California put laboratory experiments in plant nutrition on a commercial scale. So, he termed these aquiculture systems HYDROPONICS.

Hydroponics is a method of producing crops without the use of soil, hence, any material that will be replacing a good soil must mimic its characteristics in structure, ability to retain sufficient air space, and ability to hold water. a Hydroponic system is needed to make this possible; this system may be as simple as a glass of water filled with pebbles and nutrient water or as complex as having a layered structure filled with the substrate in which the plants establish their roots and grow as represented in Plate A and Plate B.

Plate A: A glass of lettuce suspended in a jar water.

Plate A: A glass of lettuce suspended in a jar water.

HOW DOES HYDROPONICS WORK?

Experimentally, the idea of any hydroponic system is to stand your plants in a plastic container with their root system suspended by a Styrofoam or any substitute and let a nutrient solution trickle past their roots (with the help of gravity and a pump). The principle behind growing crops with any hydroponic system is no different from that of the conventional, however, the methodology of cultivation has evolved.

A hydroponicist makes use of processed coconut fibers commonly known as coco coir, rice hull, expanded clay, charcoal, perlite, Styrofoam, mesh cups and more-- these substrates can be a substitute of a good soil such as providing support to plants, water/nutrient retention and providing aeration to the roots of plants.

The Role of Water in Hydroponics

Water is essential to the development of every organism. In plants, it acts as the skeleton of the plant--providing turgor pressure to plant cell walls. In hydroponics, water does more than providing skeletal structure to plants. In it are dissolved the nutrients—in soluble form—needed for the survival of crops, hence, the breakdown of the word Hydroponics, *Hydro (water) + Ponics (Labor).*

The Role of Roots in Hydroponics

In hydroponics, the root matters a lot in the uptake of minerals, storage of manufactured materials, and providing physical support for the aerial part of the plants.

In hydroponics, plants can't absorb organic materials unless it is first broken down to pure elements. The absence of oxygen in hydroponics will lead to asphyxiation, which will lead to root rot. Once the root dies, the death of the entire plant is unavoidable.

HYDROPONIC MEDIUM

In choosing substrates in hydroponics, some determining factors are to be considered. The substrates must mimic the conventional substrate—a good soil, which possesses the following properties:

1. Holds an even ratio of air and water
2. Should be reusable and disposable
3. Should be affordable and easy to obtain
4. Should help to buffer pH changes over time.

HYDROPONIC SET-UP

A hydroponic set-up should provide plants with specific requirements to foster crop optimal growth. These requirements include:

1. Provide roots with a fresh, well-balanced supply of water and nutrients.
2. Must maintain a high level of gaseous exchange between nutrient solution and the roots of plants.
3. Protect against root dehydration and crop damage in case of pump failure or power outage.

Plate C. A stack of coco blocks and coconut husks.

Plate D. Squeezing soaked coco. coir

Plate E: Squeezed soaked coco.coir

TYPES OF HYDROPONIC SET-UP

Following are a few types of hydroponics systems:

NFT SYSTEM

Nutrient Film Technique (NFT) system: This type makes use of a pump and a reservoir combination situated below the channels and recycles the nutrient back through the system; roots grow down along the channel receiving oxygen directly from the trough, while receiving nutrient water from the tubings being carried along the channel by gravity.

Nutrient Film Technique (NFT) system

THE RAFT SYSTEM

This is an interesting system usually for growing lettuce and other short crops. In this system, plants are supported by baskets fitted into Styrofoam sheets and allowed to float on nutrient water.

A styrofoam sheets from the raft system holding the lettuce also showing the robust root growth

THE COCO COIR AND RICE HULL DRIP SYSTEM

The simplest and most common hydroponic method is using drip irrigation to deliver nutrient-enriched water to plants grown in coco coir and rice hull (tucked in grow bags).

Remember, when choosing a substrate for growing, consider must-have qualities such as good water holding capacity.

Cucumber plant in a grow bag

IMPORTANCE OF HYDROPONICS

Hydroponics makes it easier to evade some risks associated with conventional farming. These include:

1. Elimination of soil-borne diseases that easily occur in the soil.
2. Elimination of troublesome weeds.
3. Significant increase in yield.
4. Reduction of health risks and labor costs associated with pest management and soil maintenance, to look for good.

PLANT NUTRITION

To develop a concrete blueprint of any hydroponics nutrients, we must review the organic makeup and growth stage of the plants. Plants live in the earth's atmosphere which contains 78% nitrogen, 20% oxygen, and 2% of carbon. Thus, for a plant to develop properly, it must have access to these necessary elements.

These four elements (carbon, hydrogen, oxygen, and nitrogen) occur naturally. It should be emphasized that lack of any of these elements will lead to the ultimate death of the plants.

SELECTING A HYDROPONIC NUTRIENT

Most producers list the amount of NPK represented in percentages. For example, a 15:9:33 solution would contain 15% nitrogen, 9% of phosphorus, and 33% of potassium by weight. This adds up to 57%. The remaining percentage contain another nutrient, filler, or chelates. The percentage label on these fertilizers will help any potential grower make an informed decision on the type of NPK master-mix required per growth stage.

MAKING YOUR NUTRIENTS

In recent times, most people are now interested in growing their own food. Please consult the nutrient figure attached to each crop to calculate the

required nutrients per plants as specified by the producers. These formulas have been tested with a wide variety of plants in the same system. Your result will depend on the quality of your input and the accuracy of combining them.
Multiply the listed grams of each salt by the liters of water in your tank; ensure each salt dissolve before adding another.
Once all salts are dissolved, allow the solution to cool before diluting it for production in your reservoir/tanks.
PS: An EC (Electrical conductivity)/TDS (Total Dissolved Solids) meter is required to determine how much of the stock solution is needed to dilute into each tank of water.

Find following an example of fertigation schedule for a fruit vegetable.
Week 0: DAP (Fertigation: 4 g/plant).
Week 1: KNO3 (Fertigation: 2 g/plant).
Week 2: CAN (Fertigation: 2 g/plant) + Chelate Mix (Fertigation: 1 kg/ha).
Week 3: Magnesium Sulphate (Foliar: 2 kg/ha) + NPK 20:20:20 (Fertigation: 2 g/plant).
Week 4: KNO3 (Fertigation: 2 g/plant).
Week 5: CAN (Fertigation: 2 g/plant) + MOP (Fertigation: 2 g/plant).
Week 6: Magnesium Sulphate (Foliar: 2 kg/ha) + Chelate Mix (Fertigation: 1 kg/ha) + Maxi crop (Foliar: 200 ml/ha).
Week 7: DAP (Fertigation 3 g/plant) + MOP (Fertigation: 2 g/plant).
Week 8: CAN (Fertigation: 2 g/plant) + MOP (Fertigation: 2 g/plant).
Week 9: CALMAG (Foliar: 2.5 kg/ha) + Maxi crop (Foliar: 200 ml/ha) + NPK 20:20:20 (Fertigation: 2 g/pant).
Week 10: MOP (Fertigation: 2 g/plant) + Chelate Mix (Fertigation: 1 kg/ha).
Week 11: MKP (Foliar: 2.5 kg/ha) + NPK 20:20:20 (Fertigation: 2 g/plant).
Week 12: CAN (Fertigation: 2 g/plant).
Week 13: MOP (Fertigation: 2 g/plant).
Week 14: MKP (Foliar: 2.5 kg/ha).

Where:
- DAP - Di Ammonium Phosphate
- KNO3 - Potassium Nitrate
- CAN - Calcium Nitrate
- MOP - Muriate of Potash
- MKP - Mono Potassium Phosphate

Example of mitigation/fertigation schedule for a leafy vegetable
- NPK master mix of 15:9:33
- Calcium nitrate
- Magnesium sulphate

Fertilizers placed plastic containers

Nursery Schedule

This schedule should be applied only when the plants are about two weeks old in the nursery.

- NPK—100 grams in 16 liters of knapsack
- Calcium nitrate—100 grams
- Magnesium sulphate—80 grams

Supplementary foliar spray such as coco boost (8.3% N, 32% P, and 21% K) and boost extra (20% N, 20%, 20% P) can be applied twice a week.

Usually, most leafy vegetables spend two to three weeks in the nursery.

After Transplant Schedule

- NPK—2 kg in 2000 liter tank
- Calcium nitrate—2 kg in 2000 liter tank
- Magnesium sulphate—1 kg/tank. This schedule is slightly increased as the crops mature.

MODULE 2

NURSERY

A vegetable nursery is a place or an establishment for raising or handling young vegetable seedlings until they are ready for more permanent planting. This secluded place is commonly roofed with shaded nets or a UV nylon, or a mixture of both. In this area, plants are commonly cultivated from seeds or cuttings and often grow in bags, pots, and seed trays.

Nursery trays under placed under a roofed with shaded nets

Placing coco coir inside the nursery tray

Advantages of Nursery Raising in Vegetable Production

1. Eliminates the problem of difficult substrates, e.g., unbuffered coco coir.
2. It is possible to provide favorable growth conditions, i.e., germination as well as growth.
3. Easy weed control.
4. Reduced field management costs.
5. Improved crop uniformity.
6. More optimal use of hybrid seeds.
7. Shorter growing season and more efficient use of land.
8. More accurate prediction of harvest date.

Factors to be Considered for Raising a Nursery

1. Well exposed to the sun but protected against severe heat.
2. Well protected against animal damage, strong winds.

Nursery management

1. Hygiene has a vital role in the control of pests and diseases.
2. Use steam or chemical sterilization of the growing media, structures, tools, and trays.
3. Effective ventilation and air movement is also a sound disease prevention method.
4. Understand pests and diseases that could affect the growth of healthy seedlings.
5. Care must be taken with the use of pesticides within enclosed areas.
6. Note also that in a greenhouse, plants can be more sensitive to chemicals than in the open field.

MODULE 3

LETTUCE PRODUCTION

To start producing the lettuce plant, the seeds are sown in a germination area (nursery) where they germinate and grow for two weeks. On the first day after germination they should be shaded from full sun, but can then be exposed to full light.
Secondly, between days 12 and 14, the plants are transported to the greenhouse and transplanted into the hydroponic set-up (grow tower, NFT, and trough system) where they are grown and harvested on Day 35 or as desired by the market.

Matured lettuce plant

Nursery Stage
The nursery stage is scheduled for production from day(s) 0–11. This may occur in a growth chamber or nursery area in the greenhouse.

Day 0—Sowing
Production begins with the making of the germination media. Fill the nursery trays with a substrate (commonly buffered coco-coir). Place one lettuce seed into each cell of the tray.

Buffer the coco coir to be used to avoid lettuce die-back—moisten the substrate and check for high pH contaminants—maintain pH at 5 to 6.

Place the trays in the nursery which commonly contains tables. Sub-irrigate the trays on the table with water early in the morning or late at night and water only when dried.

For the initial 24 hours, set the temperature at 20 °C in the germination room. The seed trays may be covered with plastic humidity covers to ensure a high relative humidity, which prevents desiccation.

Maintain the Electrical Conductivity (EC) of the water at 1200 µS/cm above that of the source water. Adjust the pH of the solution to 5.8 with the possible addition of a base, potassium hydroxide (KOH), and nitric acid when it is too high.

Raise the temperature to 25°C. Maintain these environmental factors for the remainder of the crops' time in the nursery. Sub-irrigation continues until day 6.

Day 6

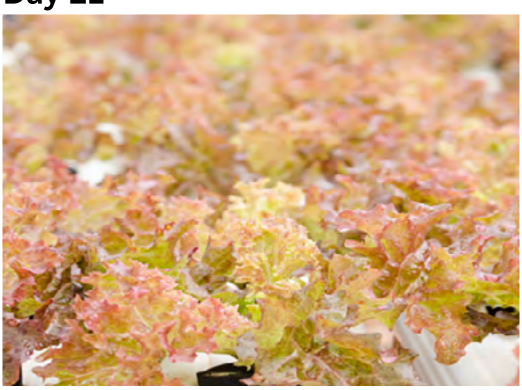
If hand-watering is used, the same watering frequency does not need to be used but care must be taken so that the media does not dry out.

At this time, the leaves are beginning to overlap and the roots of the seedlings have grown through the bottom of the cells. When transporting the trays to the grow area, avoid damaging these exposed roots.

Lettuce seedlings from Day 6 to Day 11

Lettuce progression from Day 6 to Day 11

Day 21



Lettuce progression from Day 6 to Day 21.

Day 30

Clusters of lettuce on Day 30

Elements	Deficiencies.
Nitrogen	Nitrogen deficiency slows down the growth and development of plants. Initially, the primary roots are fewer and longer. The plants appear stunted and are lighter green. With prolonged N deficiency, yellowing (chlorosis) of older or lower leaves occurs. This is followed by leaf tip death and leaf margins developing a brown discoloration (necrosis).
Phosphorus	Initially, plants appear darker green with reduced growth affecting the leaf size and stem thickness. Primary roots are longer with fewer secondary and tertiary roots than normal. As the deficiency continues, the older, lower leaves develop irregular spots of brown to dark brown dead tissue. In some instances, light purple pigmentation may appear on the surface of leaf margins, lower leaves, and stems. Eventually, leaf death of older leaves may occur
Potassium	Leaves appear small and dark green; they develop shorter nodes. These symptoms lead to the sudden development of necrotic patches on the leaves and the leaves appear curled downward.
Calcium	Unlike most other nutrients, lack of calcium generally affects the growing points (root and shoot tips) and young leaves of the plants. The growth is reduced with tiny black spots appearing around the mid-leaf area of young leaves and on the tips of very young leaves.

MODULE 4

CAPSICUM (PEPPER) PRODUCTION

The production of the Capsicum (pepper) is separated into two growing areas. Initially, the seeds are started in a germination area (nursery) where they germinate and grow for five weeks. They should be shaded from the full sun on the first day after germination, but can then be exposed to doses of light after two weeks for 10 to 15 min.
Secondarily, between days 35 and 37, transport the plants to the greenhouse and transplant them into the hydroponic set-up (usually into rice hull/coco coir filled bags) where they are grown and harvested between days 70 and 90, or as specified by the seed producer.

Post harvested peppers

Nursery Stage

The nursery stage in vegetable production takes places from day(s) 0–37 and may occur in the nursery area in the greenhouse.

Day 0—Sowing

Production begins with the making of the germination media. Fill the nursery trays with a substrate (commonly buffered coco-coir). Place only one seed into each cell of the tray.

Buffer the coco coir to be used to avoid die-back; moisten the substrate and check for high pH contaminants—pH should be maintained at 5 to 6.

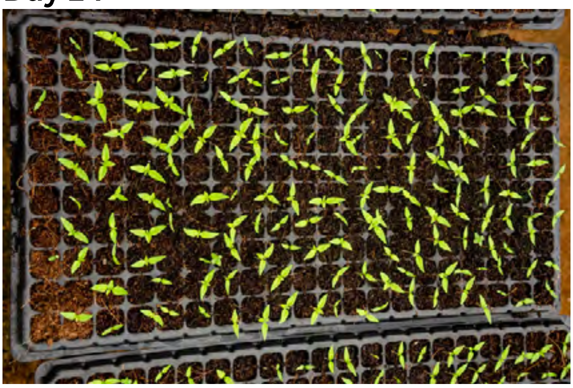
Place the trays in the nursey which usuallly contains tables. Trays on the table are sub-irrigated with water early in the morning or late at night—only water when dried.

For the initial 24 hours, set the temperature for 20 °C in the germination room. The seed trays may be covered with plastic humidity covers to ensure a high relative humidity which prevents desiccation.

Maintain the EC of the water at 1200 µS/cm above source water EC. Adjust the pH of the solution to 5.8 with the possible addition of a base, potassium hydroxide (KOH), and nitric acid when it is too high.

Raise the temperature to 25 °C. These environmental factors are maintained for the remainder of the crops' time in the nursery.

Day 14



Germinated peppers on Day 14: If hand-watering is used the same watering frequency does not need to be used but care must be taken so that the media does not dry out.

Day 21

Peppers on Day 21: At this time, the leaves are beginning to overlap. The roots of the seedlings have grown through the bottom of the cells.

Day 30

When transporting the trays to the grow area, avoid damaging these exposed roots.

Day 37

The seedlings are transported to the greenhouse and transplanted into the substrates. Prior to transplanting, the seedlings are thoroughly sub-irrigated. Transplanting can be scheduled to follow normal sub-irrigation periods to prevent desiccation during transfer.

Day 70

Flowering plants at Day 70

Day 90

Flower conversion at Day 90

Elements	Deficiencies.
Nitrogen	Growth is seriously affected. An early symptom is yellowing and premature death of lower foliage. Leaves are small and turn a pale yellow-green color throughout
Phosphorus	Fruit on P deficient plants are often shorter and narrower than normal
Potassium	Leaf blades show marginal and interveinal chlorosis with subsequent necrotic patches. Later on, these patches coalesce and the leaf becomes scorched.
Calcium	On fruits, large, sunken, and water-soaked spot develops near the distal end. The spot is soft at first, then hardens as it dries out. It eventually turns black and mold may develop. Several parts of the same fruit may be affected

MODULE 5

TOMATOES PRODUCTION

Harvested Tomatoes

Firstly, seeds are started in a germination area (nursery) where they germinate and grow for five weeks. They should be shaded from full sun on the first day after germination, but can then be exposed to doses of light after two weeks for 10 to 15 min.
Secondly, between days 35 and 37, the plants are transported to the greenhouse and transplanted into the hydroponic set-up (usually into rice hull/coco coir filled bags) where they are grown and harvested between days 70 and 90, or as specified by the seed producer.

Nursery Stage
The nursery stage is scheduled for production from days 0–37 and may occur in the nursery area in the greenhouse.

Day 0—Sowing
Production begins with the making of the germination media. Fill the nursery trays with a substrate (commonly buffered coco-coir). Place one seed into each cell of the tray.
Buffer the coco coir to be used to avoid die-back; moisten the substrate and

check for high pH contaminants—pH should be maintained at 5 to 6.
Place the trays in the nursery which commonly contains tables. Sub-irrigate the trays on the table with water early in the morning or late at night—only water when dried.
For the initial 24 hours, set the temperature at 20 °C in the germination room. The seed trays may be covered with plastic humidity covers to ensure a high relative humidity which prevents desiccation.
Maintain the EC of the water at 1200 µS/cm above source water EC. Adjust the pH of the solution to 5.8 with the possible addition of a base, potassium hydroxide (KOH), and nitric acid when it is too high.
Raise the temperature to 25 °C and maintain these environmental factors for the remainder of the crops' time in the nursery.

Day 14

If hand-watering is used the same watering frequency does not need to be used but care must be takes so that the media does not dry out.

Day 21


Picture showing germinated tomatoes. At this time, the leaves are beginning to overlap. The roots of the seedlings have grown through the bottom of the cells.

Day 21

Prior to transplanting, the seedlings are thoroughly sub-irrigated. Transplanting can be scheduled to follow normal sub-irrigation periods to prevent desiccation during transfer

Day 70

Flowering tomatoes on Day 70

Day 90

Fruit clusters on a tomato plant.

Elements	Deficiencies
Nitrogen	Leaves are smaller and uniformly pale green to yellow in color when nitrogen is deficient. Symptoms are first seen in the old leaves and gradually progress to new growth.
Phosphorus	Phosphorus deficiency causes small and rigid leaves, the plant habitus is very erect. Growth is sparse; thus, the plant shows a spindly appearance. Total height is almost normal. The bottom leaves show interveinal chloroses and necrotic leaflets.
Potassium	The older leaves become chlorotic, later necrotic, starting from the leaf edges. At severe deficiency, the intercostal areas of the leaves may become chlorotic, too. Whitish, necrotic dots develop within the chlorotic areas.
Calcium	Light case of Blossom End Rot (BER). More severely affected plants show a dark, sunken zone on the blossom end of the ripened fruit. This zone is sharply delimited against the fruit. The fruits ripen prematurely and are not marketable.

MODULE 6

CUCUMBER PRODUCTION

The production of the cucumber plants is separated into two growing areas. Firstly, seeds are started in a germination area (nursery) where they germinate and grow for three weeks. They should be shaded from full sun on the first day after germination, but can then be exposed to doses of light after two weeks for 10 to 15 min.
Secondly, between days 35 and 37, transport the plants to the greenhouse and transplant into the hydroponic set-up (usually into rice hull/coco coir filled bags) where they are grown and harvested between days 70 and 90, or as specified by the seed producer.

Nursery Stage

The nursery stage is can take place from days 0 to 37 and may occur in the nursery area in the greenhouse.

Day 0—Sowing

Production begins with the making of the germination media. Fill the nursery trays are filled with a substrate (commonly buffered coco-coir). Place one

seed into each cell of the tray.
Buffer the coco coir to be used to avoid die-back; moisten the substrate and check for high pH contaminants–pH should be maintained at 5 to 6.
Place the trays in the nursery which commonly contains tables. Sub-irrigate the trays on the table with water early in the morning or late at night—only water when dried.
For the initial 24 hours, set the temperature at for 20 °C in the germination room. The seed trays may be covered with plastic humidity covers to ensure a high relative humidity which prevents desiccation.
Maintain the EC of the water at 1200 S/cm above source water EC. Adjust the pH of the solution to 5.8 with the possible addition of a base, potassium hydroxide (KOH), and nitric acid when it is too high.
Raise the temperature to 25 °C. Maintain these environmental factors are maintained for the remainder of the crops' time in the nursery.

Day 14

If hand-watering is used the same watering frequency does not need to be used but care must be takes so that the media does not dry out.

Day 21

At this time, the leaves are beginning to overlap. The roots of the seedlings have grown through the bottom of the cells.

Day 30

Cucumber seedlings overlapping and ready for transplant

Seedlings transported to the greenhouse and transplanted into the substrates. Prior to transplanting, the seedlings are thoroughly sub-irrigated. Transplanting can be scheduled to follow normal sub-irrigation periods to prevent desiccation during transfer

Day 70

Fertilized flowers of cucumber

Day 90

Cucumber fruits ready for harvest

Elements	Deficiencies
Nitrogen	Nitrogen deficiency slows down the growth and development of plants. Initially, the primary roots are fewer and longer. The plants appear stunted and are lighter green. With prolonged N deficiency, yellowing (chlorosis) of older or lower leaves occur. This is followed by leaf tip death and leaf margins developing a brown discoloration (necrosis).
Phosphorus	Phosphorus deficiency causes small and rigid leaves, the plant habitus is very erect. Brown patches appear between the veins on mature leaves. These become scorched and spread until the leaf dies prematurely. Fruit set is reduced, so production is impaired until the deficiency is corrected.
Potassium	Symptoms of potassium deficiency first appear on older leaves. Typically, chlorosis first appears at the leaf margins, then, the interveinal area is affected. The symptoms progress from the base towards the apex of the plant. Yellowing and scorching of the older leaves begins at the edges and eventually spreads between the main veins towards the center of the leaf
Calcium	Deficiencies are found in the youngest leaves and growing points, which have low rates of transpiration. Emerging leaves appear scorched and distorted and may curl downwards because the leaf margins have failed to expand fully

MODULE 7

GOOD AGRICULTURAL PRACTICES (GAP) IN HYDROPONICS

The following are suggestions for maintaining a healthy greenhouse environment:

Keep the crop rapidly growing by providing adequate light, nutrients, and other environmental conditions at all times.

1. If root disease does occur, the substrate should be changed and the crop sacrificed. The trays should be cleaned with a 2% bleach solution.
2. It is possible the disease started in the nursery, and that area, including tables and solution tanks, should be cleaned, as well.
3. Wash trays, and other equipment with a 2% bleach solution. The equipment should be washed between each use, to prevent the spread of disease.

Keep meticulous records

It may not seem to have anything to do with safety and compliance in a greenhouse. Still, keeping records of everything you grow, harvest, clean, pack, and distribute can protect your business and keep your hydroponic greenhouse business accountable in case of outbreaks.

Do not bring other plant material or soil into the greenhouse:

1. This material may contain pests and pathogens likely to infect your crop.
2. Keep visitors to the greenhouse to a minimum or allow them to view the production area from the outside of the greenhouse only.

Keep the solution-tanks shaded in some manner

1. Algae flourish in wet, well-lit locations, and the solution tank is ideal for algal growth.
2. Shading the tanks, input and output pipes, and other “wet” equipment will inhibit algal growth.

The algae will not harm the crop directly, but may act to weaken the crop to potential disease.

Pests control mechanisms

Pests, especially in hydroponic cucumber production, can be a problem though they are not generally a major problem. Pests that may be found coupled with hydroponic capsicum production include thrips, whiteflies, and aphids. Fast plant growth rates make pest population establishment difficult. With continuous crop production, pest populations may have the opportunity to establish themselves. Precautions can be taken to exclude pests from the facility, such as screening potential entry points (ventilation inlets), Keeping the grass and weeds mowed outside the greenhouse or removing all vegetation entirely can reduce pest pressure inside the greenhouse. Few pesticides have been labeled for use on greenhouse vegetables. Biological insect control is a viable but less used alternative.

Treat, maintain, and flush irrigation lines regularly

Hydroponic irrigation pipes hold water often and consistently. It can also attract health-hazardous pathogens. These microbe-attracting environments thus need to be cleaned, sanitized, and sterilized routinely to keep these disease vectors from affecting your customers—and in many cases, even your hydroponic crops.

Test your water quality

Before testing your water source for growing hydroponically in a greenhouse, it should also be filtered, treated, screened, or potentially all three of these, to

ensure purity and cleanliness while growing. Even then, it's wise to actually test your water source directly for pathogens that could get people sick and the degree of solute in the water.

Packaging and postharvest storage

Packaging can be a significant cost depending on what materials customers demand. Often both a package for the product as well as a box to transport product in must be purchased.

Postharvest storage

After packaging, the lettuce should be stored at 4.4 °C
Keep equipment clean and sanitized.
All surfaces and equipment should be regularly cleaned including tables, pickers, buckets, and apparel.

Encourage handwashing sanitation

One of the first things one should include in a greenhouse is a handwashing station, usually at the entrance.

MODULE 8
SUMMARY

• Hydroponics system may be as simple as a glass of water filled with pebbles and nutrient water or as complex as having a layered structure filled with the substrate in which the plants establish their roots and grow.

• In hydroponics, plants cannot absolve organic materials unless they are first broken down to pure soluble elements. The absence of oxygen in hydroponics will lead to asphyxiation, which will lead to root rot; once the roots die, the death of the entire plant is unavoidable.

• In choosing substrates in hydroponics, some determining factors should be considered such substrates must mimic the conventional substrates—a good soil, which possesses the following properties:

- Holds an even ratio of air and water
- Should be reusable and disposable
- Should be inexpensive and easy to obtain
- Should help to buffer pH changes overtime

• Different plants require different fertigation schedules but can be broadly broken into two types, leafy and fruit vegetable.

• Good agriculture practices should always be ensured at all times as these increase our precision and limit uncontrollable risks of agriculture.

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IFAD AGRIHUB PROJECT TEAM
Oni Waheed – Agribusiness Hub Manager
Alfa Arome B – Assistant Agribusiness Hub Manager
Olaleye Kehinde – Vegetable Enterprise officer
Omobolanle Oladejo - Field Officer

CONSULTANT
Mr. Samson Ogbole – Team Lead Soilless farm lab

IITA YOUTH IN AGRIBUSINESS OFFICE
Adenmosun Adetola
Ibironke Ifedayo
Adesanya Omotomiwa
Adedeji Temiloluwa

PARTNERS

IITA Transforming African Agriculture

Songhaï L'AFRIQUE RELEVE LA TETE! AFRICA STANDS UP!

AFRICA PROJECTS DEVELOPMENT CENTRE