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Hydroponic— The Future of Farming

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Abstract— *Hydroponics is the modern solution for modern problems. Due to extensive traditional agriculture and various man made activities like deforestation. Fertile and arable land is decreasing day by day. While transporting the food we eat, so much of fossil fuels goes into transportation. The volume of water which is used in conventional farming is shocking. For the irrigation in these conventional farming, large volume of water is needed and water is one of the most crucial resource to be saved. Loads of chemical fertilizers and pesticides that are used in conventional farming flows into the water bodies and make them polluted. To tackle these problems hydroponics can be used as the effective method. In hydroponics plants are grown in a room without the use of any soil. Plants do not require soil for their growth all they need is water and various micro and macro nutrients that are present in soil. In hydroponics water and these nutrients are provided to the plants directly. With the effect of which plants do not have to spend their energy in the expansion of their root system for the search of water and minerals. The use this energy for the production of better food products. Hydroponics have numerous advantages over soil base farming. In this paper all the advantages, history, types and basic components of hydroponics has been explained.*

Keywords— Advantages, Drip system, DWC (Deep Water Culture), Ebb and Flow System, Grow Tray, History, Hydroponic farming, NFT (Nutrient Film Technique), Reservoir, RO (Reverse Osmosis), Wick System.

I. INTRODUCTION

In traditional agriculture, plants are grown in soil. But, plants do not need soil to grow, they need the nutrients that are present in the soil for their growth. Soil contains various micronutrients and macro-nutrients that are essential for the growth of plants. When water is added to the soil, it carries nutrients along with it to the plants. On traditional soil based farming and planting, plants have to spend lots of energy for the development of their huge root system as, roots has to search deep inside for water and minerals. In short, plants need water and minerals for their growth either from the soil or without soil. In soilless farming suggests hydroponic these micronutrients and macronutrients are delivered to the plants directly. The word hydroponics are delivered from two Greek words that are 'hydro' meaning water and 'ponics' meaning labour. In hydroponic farming various micro and macro nutrients that are required by plants are being directly given to them. These nutrients are premix in the water. By this method plants get everything they need at the right proportion and the right time so that plants can utilise it more efficiently. In soilless farming as plants need not to waste their energy for the growth of the complex root system the utilise that energy in food production and show its full genetic potential.

Hydroponics is a system of agriculture that utilizes nutrient rich water rather than using soil. This type of soil less farming have several advantages over traditional methods of farming. In traditional farming loads of chemical fertilizers, pesticides, Fungicides and herbicides are used. Lots of water is required for irrigation purpose. These things somehow disturb the ecological balance and deteriorate the environment. Hydroponics does not use any chemical based fertilizers and pesticides, but also reduces the use of water that helps with water conservation.

II. COMPONENTS OF HYDROPONICS

- **Temperature controller**

Plants require a specific range of temperature for their optimal growth. Temperature control of both, the environment in which hydroponic is done and the temperature of the nutrient solution is required. The best water temperature for hydroponic should be between 65° Fahrenheit and 80° Fahrenheit. The best grow room

temperature during vegetative stage is between 70° to 78° Fahrenheit, when the lights are on during the daytime, and it should not be more than 10° to 15° degree cooler during the night time, with the relative humidity of 45 to 55%.

The setup, which helps in the temperature control of the environment in which the hydroponic is performed have things like

1. Exhaust fan
2. Pad cooling system
3. Foggers
4. Sensor
5. Shade Cloth

1. Exhaust fan-

Exhaust fan facilitates proper ventilation inside the plantation room. They are mostly present on the roof of the grow room. These help in removal of hot air and oxygen rich air from the room. This helps in the proper circulation of air inside the grow room. Removal of hot and oxygen rich air facilitates the entry of Co2 rich air inside the room. Ventilation balances the humidity percentage and helps in heat management inside the room. It also helps in pest control, because stagnant and humid air has negative impact on the surface of growing room it encourages the entry and accelerate the reproduction of pest which damages the plants. Due to the stagnant and humid air the growth of fungi, mold and mildew also increase. Ventilation is very important for the optimal growth and protection of plants grown in hydroponics.

2. Pad cooling system-

It is also known as evaporative pad and fan system. It is the most common way of cooling down the grow room temperature. They are placed on the walls of grow room. Cooling pad has their separate water tank that is fitted outside the grow room. The water is performed by the pump or motor on the cooling pads which wet them completely. This water is then evaporated by using the heat present inside the grow room leaving the room cool. And this evaporated heat is dissipated outside the grow room through exhaust fans.

Cooling pads are made up of three types:-

- Wood
- Cellulose
- Plastic

Wood fibre is produced during shaving Aspen trees. They provide a cushion like structure with better air and water balance. It allows more air to travel through the air, which makes the air inside the room cooler. The would absorb just one part of the water and starts cooling it. They are less expensive, but have a short life. On the other hand cellulose pads are made with cellulose paper moulded with the honeycomb construction. As it is a thick material, it holds more water in it. This type of pad is used in the dry area where the water can the evaporated rapidly. Cellulose pads are more costly than wood. Plastic parts are not used commonly because they are not effective as compared to other type of pad material. Plastic is not a good absorbent of water. They are thinner and more cost effective, but they can only be used for shorter term.

3. Fogger-

Fogger adds water in the atmosphere by creating fog. They are fitted on the roof of the grow room. When the temperature is raised above the certain set point the fogger start creating fog which add tiny droplets in the environment, decreasing the temperature and maintaining the humidity of the grow room.

4. Sensor-

Sensors present in the grow room works on fuzzy logic. They record the room temperature and command temperature controllers accordingly in order to maintain room temperature. The sensors are connected with temperature controllers. Sensors are also present in temperature controllers which controls the temperature of nutrient rich water.

5. Shade cloth

Shade cloth is used to provide comfortable and environment friendly temperature for the plants. It provides protection from various pests and insects. Shade cloth also provides a greenhouse effect to the plants that are grown hydroponically. Shade cloth is made up of loosely woven polyester or even aluminium. They are of various densities degrees of shade ranging between 5% to 95%. There are two types of shade clothes-

a. Knitted shade cloth- knitted shade cloth is made up of light weighted polyethylene.
b. Woven shade cloth- woven shade cloth is made up of 100% polypropylene.

Type of Shade cloth is used according to the environment. Shade cloth also protects plants from harmful UV radiations of the sun.

- **Water coolant**

During hydroponics farming, one of the major problems that is faced is increased temperature of water. As the water keeps on circulating in a loop due to this water gets heated up. This increase in temperature of water decreases the amount of dissolved oxygen in it and make the water

oxygen deficient. So it is very important to keep the water temperature maintained.

To solve the problem of increased water temperature, a water coolant system should be connected to the water tank to maintain the desired temperature of the water.

For small scale hydroponics, a diy method can be used for lowering the water temperature.

Procedure

1. Take 2 litre water bottle
2. Fill it with water and add one tablespoon of common salt in it.
3. Keep the bottle in the freezer and convert it into ice.
4. Once, whole water gets converted into ice. Immerse frozen water bottle to the water tank.

Salt is added to the water before freezing at because salt increases the melting point of ice.

- **Water tank**

In hydroponic farming water tank is considered to be the heart of the system. Tank holds what plants need to live: nutrient rich water. All Hydroponic tanks are almost of same design. They hold water and nutrients that are to be delivered to plants. These water tanks are fitted with RO system so that any hardness that is present in water can be removed because this hardness can affect the growth of plants. Different type of hydroponic systems has slightly different tanks.

1. Ebb and flow

In this type of hydroponic system tank need not to be placed just below the Growing tray. Water is pumped using a water pump, into the growing tray till the water reaches to a certain level after the certain level is achieved water starts draining away from the growing tray. Many systems have a drainage line connected back to the water reservoir, i.e. nutrient-rich water flows in a loop system.

2. NFT

In this system tank can be placed away from the growing tray. In, nutrient film technique water reaches to the tray passing from the nutrient reservoir at a constant speed. Trays are placed slightly in slanted angle, therefore pump is needed to move water up to the growing tray.

3. DWC

In deep water culture hydroponic system, the plant's roots are suspended directly into the water reservoir, due to which water tank is placed just below the growing tray.

4. Drip

In drip hydroponic system, water tank is placed just below the growing tray. Tubes carry water to plants from the water reservoir, each plant receives water through the hole place in tubes. The tank is placed just below the growing tray as it helps to conserve any runoff water.

5. Wick

In wick hydroponic system, the tank is placed just below the growing tray as the growing tray has holes from which absorbent cord passes and connect from the tank. They absorb the nutrient solution from the tank and provided to plants in the growing tray.

- **Nutrient tank**

In hydroponic farming, a separate nutrient tank is required. This nutrient tank is attached to the water tank, it contains various nutrients that are required by plants for their growth. Both water reservoir and nutrient tanks are connected to an automatic machine which keeps on adding nutrients in the water tank as per the requirement. In nutrient and the TDS of the solution is measured by using TDS metre and pH buy pH metre. Maintenance of both TDS and pH is necessary for the optimal growth of plants.

Different types of plant required different TDS for example, nutrient solutions for cannabis require TDS of around 500 to 600 ppm for young clones and seedlings, whereas vegetative plants and flowering plants requires TDS from 800 to 900 ppm and 1000 to 1100 ppm respectively. TDS should be around 400 to 500 PPM when flushing the nutrient solution from the growing tray. The TDS keeps on decreasing as plants absorb nutrients from the solution. TDS helps track when you have to add fertilizers and nutrients or when you have to completely change your reservoir.

How pH of the nutrient solution is maintained?

The pH plays an important role in the growth of plants so it is very important to keep check on the pH of the nutrient solution and if the pH is fluctuating from the set range then it has to be maintained. The idle pH requirement for hydroponics rangers between 5.5 to 6.5 that is slightly alkaline. Hydroponic farming is performed under specialised personal so these things are easy to manage. There are two ways by which the pH of the nutrient solution can be balanced-

1. Phosphoric acid
2. Potassium hydroxide (Caustic Potash)

1. <u>Phosphoric acid</u>

Phosphoric acid has a pH 2.14, it means that it is highly acidic in nature. When the pH of of the nutrient solution becomes basic in nature and ranges between 8 to 9 then

this method can be used to maintain the required pH of the nutrient solution.

Procedure-

i. 1 litre hot water (60°-70°C) and 1 gram phosphoric acid.
ii. Mix both of them into a beaker.
iii. Slowly, Add this diluted phosphoric acid into the nutrient water.
iv. Left it for some time till the pH gets adjusted.
v. Check the pH of nutrient water after 35 to 40 minutes using a pH metre.
vi. Again add the leftover diluted phosphoric acid into the nutrient water
vii. Check the pH using pH metre
viii. Keep on repeating disturb unless the pH of nutrient water ranges between 5.5 to 6.5.

In the place of phosphoric acid, citric acid and white vinegar can also be used for the same.

2. Potassium hydroxide (Caustic potash)

Potassium hydroxide has the pH 10.98 that means it is alkaline in nature. When the pH of nutrient solution becomes acidic (around pH 4) potassium hydroxide can be added to maintain the pH level.

Procedure

i. Take 1 litre of lukewarm water and 1 gram of potassium hydroxide
ii. Mix both of them in a beaker
iii. Slowly add diluted potassium hydroxide mixture into the nutrient solution.
iv. Leave it for some time. (35-40 min)
v. After sometime measure the pH of nutrient solution using pH metre.
vi. Keep on repeating the step unless the pH of the nutrient solution reaches 5.5 to 6.5.

Note- do not mix potassium hydroxide and phosphoric acid together.

- **Seed growing medium**

Hydroponics is a soilless plantation method in which the plants are provided with all the essential micronutrients and macronutrients for their growth. These nutrients are provided to them with water because plants need only nutrients and water for their growth and survival.

Soil is not used in hydroponics therefore seed need to be germinated before transplanting them into hydroponic system. There are various seed growing medium in which seeds are germinated and grown to form a baby plant. Then this plant is transferred to the hydroponic system for the further growth.

Growing medium that is used commonly are-

a. Rockwool
b. Cocopeat
    a. **Rockwool-** We can use Rockwool for germinating seeds because Rockwool have high growing ratio as compared to other medium. Rockwool is a rock based mineral fibre that is made up of basalt rock and recycled slag. Basalt is an igneous rock and slag is the byproduct of steel and copper industry. These minerals are melted and spun together to form fibre. It is used because it is light weighted and more convenient. Rock wool has high germination ratio and a special feature due to which insect attack ratio is very low.
    b. **Cocopeat-** Cocopeat is also used for seed germination for hydroponics because it has high water holding capacity. It is made up of coconut husk. Due to its high water holding capacity, it is preferred for the germination of those which require constant and high moisture around it to germinate.

- **Thermometer**

Thermometer is used to measure or for mapping the temperature of the plants. Increase in temperature of plants helps us to know about stress. We have to check the temperature of individual plants regularly, if any, stress is found in a particular plant then that individual plant is removed from the grow tray and is planted in a suitable environment to reduce its stress level. When stress is recorded in a particular plant then that individual plant is removed from the grow tray, not the whole tray is removed from the system.

III. TYPES OF HYDROPONIC SYSTEM

There are six separate types of hydroponic system

a. Wick system
b. Water culture
c. Ebb and flow
d. Drip
e. N.F.T. (Nutrient film Technology)
f. Aeroponic system

- **Wick system**

Wick system is the most basic form of hydroponics and is the most easiest to set up. They are passive, it means that

they have no moving parts. Wick system is comparatively cheaper than other methods of hydroponics. It uses various wicks that are in contact with the roots of plants. One side of the wick is emerged in in the nutrient rich water where as other end surrounds the plant's root. The movement of nutrient rich water from the reservoir to the grow tray takes place by the capillary action.

This type of hydroponic system is only efficient with plants like rosemary which does not require a lot of water, but it does not work well with plants which require the large amount of water such as the bell peppers and tomatoes.

Four main components of wick system are explained below-

1. **The Grow Tray -** The grow tray in wick system does not require net pots to hold the growing medium. The seedlings are directly transplanted into the growing medium that fully covers the grow tray. The growing medium which does not drain the nutrient medium to fast and efficiently utilise the capillary action of the wicks are preferred like vermiculite and soilless mixes.
2. **The Reservoir-** The reservoir contains a nutrient rich solution. It is placed just below the grow tray and supplies nutrients to the plants.
3. **The Aeration System-** The aeration system consists of an airstone and a pump. The air stone is a porous stone which helps in the formation of bubbles when the air is pumped in it through the air pump. These bubbles ensure the supply of oxygen to the nutrient solution and nutrient solution does not get stagnant.
4. **The Wick**- the grow tray is connected to the reservoir with the help of two or more wicks. The easiest wick to use is cotton wick, but it has to be changed time to time as it got rot easily, so instead of the cotton wick nylon wick is also used because it does not rot easily. Nutrient solution travels from the reservoir to the grow tray through these wicks by capillary action. These wicks are inserted through the holes that are present in the grow tray and are immersed in nutrient solution present in the reservoir. Number of wicks that are to be used depends on the type of plants grown in the grow tray.

- **Water culture**

Water culture hydroponic system is another simple type of hydroponic system as it does not involve any complex setup. It is a very inexpensive type of system. Things that are required to build a water culture are-

a. Reservoir
b. Aeration system
c. Baskets, pots or cups
d. Some type of growing media
e. Grow tray

The Reservoir contains the nutrient rich solution that is placed just below the grow tray. Grow tray have holes with baskets or net cups, plants are placed in these baskets or cups. The grow tray is placed in such a way so that the plant's roots are fully immersed in the nutrient solution directly into the reservoir.

The aeration system ensures the proper amount of oxygen in the nutrient solution so that the roots can get oxygen rich nutrient solution. Airstone or soaker hose is placed on the floor of nutrient solution and it connects with the air pump that is present outside the nutrient solution tank with the help of an air line. Air pump supplies oxygen to the airstone which creates bubbles in the nutrient solution. Aeration is important as it provides oxygen to the nutrient solution and so to the roots, and does not allow the nutrient rich solution to become stagnant.

Deep water culture is just the variation of water culture system, the whole procedure is same the only difference between deep water culture and water culture is that in deep water culture water depth in the system is deeper than 8 to 10 inches whereas in water culture the depth is less than 8 inches.

- **Ebb and flow system-**

Ebb and flow system is also known as flood and drain hydroponic system. It has the intermediate difficulty level with relatively low cost to set up. Basic components of of the ebb and flow system are-

a. Plant tray
b. Reservoir
c. Submersible pump with timer
    a. Plant tray- plant tray is also called flood tray. It is large and shallow. It has perforated pots filled with growing medium such as perlite in which seedlings are transplanted. The pot in which the plants are grown should be

placed in such a way that they get fully emerged when the tray is flooded with nutrient solution. Water is pumped from the reservoir to the flood tray till roots get completely immersed in nutrient solution after sometime water get drained back to the reservoir, allowing the roots to dry and oxygenated before the nutrient rich solution again floods the tray.

b. Reservoir- reservoir is placed just below the flood tray. It is connected with the flood tray by two tubes- fill tube and a drain tube. The fill tube is attached to the immersible pump that is placed in the nutrient solution in the reservoir, it controls the flow of water up to the flood tray. This immersible pump is attached to the timer to regulate the nutrient rich solution flow to the flood tray. The drain pipe is connected between the flood tray and the reservoir, the flooded solution drains back to the reservoir by the action of gravity from flood tray.

- **Drip System-**

In drip hydroponic system, the nutrient rich solution is provided to plant by the process of drip irrigation. This type of hydroponic system is very water efficient as it does not flood the nutrient rich solution to the grow tray, but provide the nutrient rich solution to the base of each plant individually by slow drip.

In drip system, a pump is placed in the nutrient solution reservoir, it is accompanied by a timer which controls the irrigation schedule. The pump helps to flow the nutrient rich solution to the grow tray. The pipe that carries the nutrient rich solution to the plants have various drip emitters that deliver nutrient solution to the roots of each plant.

There are two types of drip system in hydroponics-

a. Recovery system
b. Non recovery system

a. Recovery systems

Recovery system is the system in which the nutrient solution is recovered and recycled again and again through the system.

Recovery system is basically used in vertical gardens in which the nutrient solution flows from top to bottom and drains back into the nutrient tank. The same nutrient solution is recirculated to the plant. This saves and recycle nutrients, the only thing that should be monitored carefully is pH and TDS of the nutrient solution. One needs to adjust the pH level and replace the nutrient solution with the fresh batch periodically.

b. Non recovery system

In non recovery system the nutrient solution is not recycled but is drained out of the system. It sounds counterintuitive, but this system is more resource efficient than recovery system. It is the most preferred technique for commercial hydroponic system. In non recovery system the drip cycle needs to be very precise, so that each plant receives the right amount of nutrient solution that is required by it. It is highly accurate with cycle time and irrigation time. Each drip emitter provides just the right amount of nutrient solution to the individual plant so that the growing medium around each plant can be moistened, and plant utilises water and nutrients completely and nothing goes unused.

As the nutrient solution is not being recycled then there is no need to monitor pH and TDS again and again, simply one have to refill the reservoir with fresh nutrient solution.

- **Nutrient Film Technique (NFT)**

Nutrient film technique is similar to that of the ebb and flow system as it has same components but they have a different configuration.

NFT is the active system of hydroponics because it have moving parts in its working. NFT is similar to that of ebb and flow system the only difference between both of them is that in the ebb and flow system, there is of a flood and drain mechanism whereas in NFT nutrient solution flows through the grow tray continuously.

Generally, in other hydroponic systems plants are grown in net pots filled with growing media, places in grow tray. Whereas, in NFT system a dense mat is used on which plants are grown. The roots of the plants grow into the mat in the channel. Pump is used to deliver water from the reservoir to the grow tray. The grow tray is placed at an angle due to which excess nutrient solution drains back to the reservoir using drain tube. The roots of the plants hang from the mat and touches the nutrient flowing below them. The roots and not fully emerged in the following nutrient solution, but get water without being entirely immersed. Due to this shallow flow of nutrient solution roots can have access to oxygen in the air directly. Plants like strawberries, which have a short root system and are light weighted, I prefer for this hydroponic system.

- **Aeroponic system**

In aeroponic system, plants receive nutrients in the form of mist. In this system root are held in a soilless growing medium like Coco coir on the grow tray, on these roots nutrient rich solution is being sprayed by using specially

designed misting devices. These misting devices are connected with the pump that flows nutrient rich solution from the reservoir to the misting devices. These pumps and devices are connected to a timer which insures spraying of nutrient rich solution periodically.

IV. ADVANTAGES OF HYDROPONICS

As in hydroponics there is no soil needed for the cultivation of crops, therefore plants in crops can be grown in places where the land is limited or is heavily contaminated. Hydroponics has been considered the 'farming of the future' by NASA, as crops can be grown in space where there is no soil for astronauts.

In hydroponics we can grow the number of plants in the small area. Traditional agriculture is done in soil and each plant it has to be planted at certain distances, so that they do not compete with each other for nutrients and water. Whereas in hydroponic each plant can be grown close to each other because they do not have to compete for nutrients and water as both are provided to them sufficiently. So we can plant, number of plants in the small area.

In hydroponic plantation the environment that provides for the growth of plants is manually controlled, whereas, traditional agriculture is completely relied on the natural environment and climate. Due to this the chances of crop failure are reduced. Various calamities like flood, drought, etc. Does not hamper the production. This increases the production and maximize the business profit.

As the climate is controlled artificially, seasonal fruits and vegetables can also be produced throughout the year. Without depending upon the seasons we can enjoy our favourite fruits and vegetables throughout the year.

In traditional agriculture irrigation requires large amounts of water. As the population increases water consumption is also increasing which is causing water scarcity all over the world. Plants grown in hydroponics uses 10% of water compared to the plants grown traditionally. In hydroponic water moves in a loop that means same water is recirculated. Water loss only occurs into form under hydroponic - evaporation and leaks from the system. In an efficient hydroponic system these leakages are minimized or stopped completely. Hydroponic require less amount of water and there is no water runoff or water wastage which also helps with water conservation.

In hydroponic, we have 100% control of the nutrients at plant needs. Before planting, plant growers can check about the requirements of particular crop and then can provide the plants with those specific nutrients in specific amount.

Since soil is not being used, so there are no chances of weeds. So there is no need of chemical fertilizers, weedicides, and pesticides. This helps in growing cleaner and healthier food.

V. HISTORY

Although hydroponic today involves tables, parts, pumps and high-tech lights for indoor gardens. It is nothing new. It is a technique that was used by the ancient Mayans and Babylonians.

In 600 BC, hydroponic principles were used in the creation of hanging gardens of Babylon. These gardens were built along the Euphrates River in Babylon. Since the climatic condition of Babylon was dry and rarely saw the rain, people believe that the ancient, people believe that the ancient Babylonian use a chain pull system for watering the plants. In this method the water was drawn from the river and cold on the top of the garden by using chain pull, water dropped to the steps or landing of the garden.

In 900- 1000 AD, there were floating gardens in the Aztecs. To fed their enormous population, the Aztecs indigenously built chinampas, or floating gardens, to convert the marshy wetlands of lake Texcoco into arable farmland. Each garden was 300 feet long by 30 feet wide. To make a garden, sticks were weaved together to form a giant raft, these rafts work covered with thick soil that was taken from the bottom of the lake. The layer of soil was of around 3 feet thick. These rectangular gardens were anchored to the lake by planting willow trees at each corner. Each garden was lined on all sides by canal to allow canoes so that work can easily reach each of the gardens. This network of gardens extended to 22,000 acres across the surface of the lake.

In late 1200s Marco Polo, the explorer noted in his writing that he saw floating gardens in China.

Around 1600 AD, Belgian Jan Van Helmont indicated with his experiment that plants can obtain nutrients from water, but somehow he failed to to explain that plants also need carbon dioxide and oxygen from air.

In 1699, John Woodward, a British scientist study the growth of plants using water culture. He found that plants can grow best in water with nutrients rather than in distilled water.

In 1930s, William Gerickle, a Berkeley scientist, demonstrate the benefits of soil less gardening. He was also credited for giving this a name 'Hydroponic'

In 1938, Two Berkeley scientists named Dennis Hoagland and Daniel Arnon, did an experiment and published "The Water Culture Method For Growing Plants Without Soil", this text is considered to be the most important text regarding hydroponics. They concluded in their research that the quality of crops grown in hydroponics I know better than the crops grown in quality soil. They developed three nutrient solutions that are still used today.

VI. CONCLUSION

Hydroponic farming has numerous advantages. Hydroponic is also considered as the future of farming. Products that are produced by hydroponics are full of nutrients as compared to the products that are produced by conventional farming. There are various types of hydroponic farming, which are adopted according to the plants that are grown. Hydroponics provides a nutrient solution directly to the roots of plants, plants don't have to spend their energy in the search of nutrient and water. Due to this, plants show their best genetic output. Fruits and vegetables that are produced in hydroponics high nutritive value and free from various chemical fertilizers and pesticides.

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