Module
Hydroponic Technology

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CHAPTER I
INTRODUCTION

1.1. History of hydroponics

Hydroponics is a widely and frequently used technique for growing plants without soil, providing for a considerable degree of control of the elemental environment surrounding the root. The technique has an interesting history of development and use dating back into the mid 18th-century, although the growing of plants in nutrient rich water may have dated back into the early history of man. The Hanging Gardens of Babylon, one of the seven wonders of the ancient world, is often considered the first use of hydroponics. The Hanging Gardens were supposedly built along the Euphrates River about 50 miles south of modern Baghdad, Iraq, by King Nebuchadnezzar (604-562 BC). There is no evidence of hydroponics in the Hanging Gardens. Nutrient solutions were unknown at that time, and the only written descriptions of the gardens are secondhand accounts that say the gardens were similar to multilevel roof gardens with plants growing in deep layers of soil. English physician John Woodward (1699) is usually remembered as the first person to grow plants in water culture because he published a scientific article about his experiments to test Helmont's theory that plant matter is formed entirely from water. However, Woodward noted that Robert Boyle had also conducted water culture experiments. Woodward grew spearmint and other plants in spring water, rain water, Thames River water, and Hyde Park conduit water and concluded that Helmont was incorrect because plants in purer water did not grow as well as plants grown in water containing dissolved substances. The latest discovery in 1860 by a German scientist named Julius von Sachs he managed to publish nine important elements needed by plants and became the forerunner of "nutriculture". In 1861, Wilhelm Knop received the title 'The Father of Water Culture'. The activity of cultivating land without soil was written in the book Sylva Sylvarum by Francis Bacon created in 1627, printed a year after his death. Aquaculture techniques in water became popular research after that. The term hydroponics itself was first introduced by Dr. William Frederick Gericke of the University of California at Berkeley in 1936 (although he confirmed that this term was first suggested by WA Setchell, from the University of California) for the cultivation of plants in the water. Hydroponics began to enter Indonesia around the 1970s, in that year hydroponics became material for lectures and practicum at Universitas Gadjah Mada. Then in the 1980s hydroponics began to develop commercially in Indonesia until now.

1.2. Hydroponic Terminology

Hydroponics is the cultivation of planting using water without using soil by emphasizing meeting the nutritional needs of plants. The need for water in hydroponics is less than the need for water in cultivation with soil. Hydroponics uses water more efficiently, so it is suitable to be applied in areas that have a limited water supply

Most hydroponic growing systems are not easy to manage by the inexperienced and unskilled. Soil growing is more forgiving of errors made by the grower than are most hydroponic growing systems, particularly those that are purely hydroponic

Hydroponics comes from the Greek word ‘hydro’ which means water and ‘ponos’ which means work or farming. Hydroponics is also known as soilless culture or plant cultivation without soil. So, hydroponics is the cultivation of plants that use water without using soil as a planting medium or soilless.

Hydroponics is currently considered as the agriculture of the future. Hydroponics has been widely applied to support large agricultural production systems, and provides high environmental, economic and social significance. Hydroponics is proven to be able to be applied in a variety of different conditions and does not depend on the availability of large areas. Hydroponics has various advantages, including:

- Crop production can be higher than using land

- More guaranteed freedom of plants from pests and diseases, especially soil-borne diseases.
- Plants grow faster and use less water and fertilizers.
- If a plant dies, it can be replaced with a new plant easily.
- Plants will give continuous results.
- Standardized working methods, make work easier and do not require manual labor.
- The quality of leaves, fruit or flowers is more perfect and not dirty.
- Several types of crops can be grown out of season, this results in higher prices in the market.
- Plants can grow in places that are not suitable for those plants.
- There is no risk of flooding, erosion, drought or other dependence on natural conditions.
- The work efficiency of hydroponic gardens causes less costly maintenance and equipment

Hydroponics also has several drawbacks:

- Application on a commercial scale requires a good knowledge and understanding of the principles of plant physiology and organic chemistry
- Requires high investment costs, especially on a commercial scale
- Requires intensive care on the equipment used
- Water supply must be constant
- Some systems also require a constant supply of electricity

There are a lot of supporting arguments for hydroponics;

As we know, for particular reasons hydroponics techniques are more economical and profitable than plants grown in the ground. There are several advantages to using hydroponic techniques as follows: More product per unit surface and better quality in shorter time, which means greater productivity. Hydroponic products are cleaner and fresher than traditional products, this allows to get a better price. Products can be produced at any time, so we can increase production when there is insufficient supply or when there is a bigger demand with the best price and quality. Hydroponic products are healthier because the farmers are rare using pesticides, since mostly pests and diseases resulting from direct contact with the soil. Hydroponic nutrient makes the plant grow stronger and makes the plant more resistant to disease. In addition, hydroponic farmers prefer to use nature or biological control to prevent or dealing with pest and disease problems. Hydroponics can be recreation for everyone. It is fun to plant crops and see the results of your own efforts and it can be done in a small space at your own home. Hydroponics is not full time cultivation technique, although must pay attention for both plant and the system, taking care of hydroponics plants is easy and entertaining.

Figure 1. NASA (*National Aeronautics and Space Administration*) researcher checking hydroponics leeks and lettuce

NASA is also making use of hydroponics in its space program. Ray Wheeler, a plant physiologist at the Space Center Space Life Science Laboratory, Kennedy, believes that hydroponics will contribute to making progress in space travel. He calls it a bioregenerative life support system.

CHAPTER II
VARIOUS TYPE OF HYDROPONIC SYSTEM

2.1. *Static Solution Culture* (SSC) and Wick System

In a static solution culture (for hydroponics), the plants are grown in containers filled with nutrient solution. This technique allowed the roots of the plant are continuously immersed in the nutrient solution. In Indonesia, Static Solution Culture is familiar as floating technique (or floating raft) and wick system. It is one of the simplest systems of all types of hydroponic systems.

The size of the solution container can be different depend on the use and size of the plant. On a small scale (household scale or small-scale hobby), hydroponics can be made with a container that is usually used in the household such as a glass, jar, bucket, or water tub. Clear containers can be wrapped in aluminum foil, black plastic, paint, or other opaque material to prevent moss from growing.

The lid of the water container is perforated and filled with plants. In the wick system, each netpot is filled with planting media and pieces of cloth that stick down which function to absorb the solution through the capillary hole of the cloth. While in the floating raft technique, we can use a sheet of cork that is perforated and filled with small pots for plants whose roots are submerged directly in the water container.

In order for the nutrient solution to circulate evenly, it is necessary to mix it with an air bubbling machine or an aerator (small aerators can be found in aquarium shops) or by using a water pump commonly used in aquariums. on a commercial scale can use a medium powered pump (which is commonly used for pool and garden showers).

Nutritional solutions can be changed according to schedule or according to the procedures. Every time the solution is reduced below the standard level, it is necessary to add water or fresh nutrient solution according to the needs of each plant which can be determined through the measurement of the required TDS (Total Solid Dissolved) or PPM (part per million) unit.

The problem with the wick system is the decreasing level of the nutrient solution lower than the root level or the wick. To prevent the height of the nutrient solution from dropping below the root or axis, use the water tap to maintain the level of the solution. In the wick system, the plant is placed in a gap on a sheet of cork / stereofoam that floats on the surface of the nutrient solution. While in the floating technique, the height of the solution should maintain not to drop below the roots and the roots are always immersed in nutrient solution.

Figure 2. Wick System/*Static Solution Culture*

Figure 3. Application of wick system

2.2. Aeroponics

Aeroponics comes from the word aero which means air and ponus which means power. Aeroponics is a technique of growing plant where the roots are hanging in the air, while nutrient solution is delivered to them in the form of a fine mist. There is no medium that supports plant roots in an aeroponic system. Aeroponics is different from other hydroponics system in general. Aeroponics is an evolution from hydroponics that is more efficient and can overcome the shortcomings of the hydroponic system. Aeroponic systems offer faster growing plants and less use of water and fertilizers than other hydroponic systems. Perfect aeration is the main advantage of aeroponics.

Aeroponic techniques have proven commercially successful for seed germination, potato seed production, tomato production and deciduous crops. Since the inventor, Richard Stoner commercialized aeroponic technology in 1983, Aeroponics has been implemented as an alternative to intensive hydroponic irrigation systems worldwide. Another advantage of aeroponics that differs from hydroponics is that any type of plant can grow (in a correct aeroponic system), because the microenvironment of aeroponics is completely controllable. The advantage of aeroponics is that aeroponic plants that are paused from wetting will be able to receive 100% of the available oxygen and carbon dioxide in the roots, stems and leaves, thereby accelerating biomass growth and reducing rooting time.

NASA research on aeroponic techniques, shows that plants can experience an 80% increase in dry mass compared to plants grown on other hydroponics system. Aeroponics uses 65% of the hydroponic water needs. NASA also concluded that aeroponically grown plants require ¼ of the nutrients used compared to other hydroponics.

Aeroponics farming makes farmers gain an ability to reduce the spread of disease and pathogens. Aeroponics is also widely used in laboratory research of plant physiology and plant pathology. Aeroponic techniques have received particular attention by NASA because fog is easier to handle than handling liquids in places without gravity.

There are two types of aeroponic systems, namely low pressure aeroponics (LPA) and high pressure aeroponics (HPA). What distinguishes these two aeroponic systems is the particle size of the water spraying and the spraying technique. Low pressure aeroponics (LPA) is the system that is usually the most widely used. This kind of aeroponic system is often introduced in hydroponic trainings and in agro-hydroponic tours is a low pressure aeroponic system (LPA).

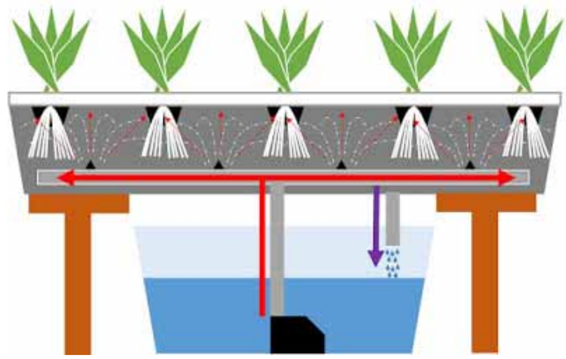

Figure 4. Low Pressure Aeroponics (LPA)

The low pressure aeroponic system (LPA) is inexpensive and very easy to manufacture. All it takes is a sprinkle / sprayer and a pump with a high flowrate. And the way it works is simple, from the reservoir, the pump sprays the hanging plant roots through the sprinkle / sprayer. Then the roots receive a spray of nutrient solution and the droplets return to the reservoir.

Plants can grow very well with this aeroponic system. However, the low pressure aeroponic system (LPA) is very inefficient. The spray produced on a low pressure aeroponic system (LPA) cannot form a fine mist because the aquarium pumps that are commonly used do not have high pressure. Therefore this system is called low pressure aeroponics (LPA). Low pressure makes the sprinkle / sprayer only as long as it is sprayed, unable to produce a fine spray.

Besides that, the use of energy in this system is very inefficient. Since one pump is only able to serve a few plants, of course this will be very wasteful of electricity. This system is more suitable for introductory aeroponic demonstration installations and installations for home hobbies.

Around the 2010s, HPA aeroponics can now be made for home to business scale with more affordable manufacturing costs and lower operating costs. However, for ordinary people, it is rather difficult to understand the working principle of the high pressure aeroponic system

(HPA). Aeroponic systems are not suitable for the novice hydroponics farmer.

This system requires high pressure water of around 60-80 PSI. With very high pressure, water can form a fine mist when sprayed through the mist sprayer nozzle. The fine mist spray makes nutrients and water easier to absorb and the roots can take up oxygen to the maximum. In addition, with high pressure the spray range can be wider and more effective than the low pressure aeroponic system (LPA). Therefore the use of water and nutrients is more efficient in this aeroponic system (HPA).

Even with high pressure, it does not mean that the electric power consumed is also high. Spraying only takes place alternating spraying for about 2-3 seconds and stops for about 3-5 minutes. Each mist spray can produce about 1.5 ml / second of spray.

A reverse osmosis pump with a discharge of 0.5 liter / minute with a power of about 30-50 watts can be used with high pressure aeroponic systems. Combined with a pressurized tank, the pump can serve the spraying of hundreds of plants and the pump does not need to run continuously so it saves more electricity.

In the HPA aeroponic system, the roots are sprayed by a mist sprayer which has a maximum output hole of 0.8 mm. When water is sprayed with a mist sprayer nozzle at a pressure of 60-80 PSI, the water will form a fine spray. The size of the water particles in the spray is 30-50 microns in size and with a discharge of 1.5 ml / sec on the spray. This is based on research conducted by NASA, roots are easier to absorb nutrients and water at a size of 30-50 microns and this spraying conditions cannot be carried out without high pressure.

If the water spray particle size is too large, there is less oxygen in the spray. And if the particle size of the spray is too fine (like the smog produced by ultrasonic misters), only root hairs grow while root branches are not formed.

The HPA aeroponic system includes a recirculation system, meaning that the nutrient solution is used repeatedly. The difference from the recirculation system from the hydroponic system lies in the pumping system. The nutrient solution from the reservoir / reservoir is pumped into the pressure tank by a booster pump. This booster pump is connected to a high pressure switch which functions as an automatic switch based on pressure. With a high pressure switch, the pump only turns on until the pressure in the pressure tank reaches 80 PSI. This pressure tank functions as a pressure collector that is released by the pump. The pressure tank output hose is installed with a solenoid valve to regulate the flow out of the pressure tank. This solenoid valve is connected to a cycle timer to regulate the frequency of spraying on plant roots. Usually spraying is carried out for 2-3 seconds and then off for 3-5 minutes.

Due to the very high pressure in the pressure tank, water will push out into the mist sprayer nozzle when the solenoid valve is opened. Due to the nature of water that presses in all directions, the water pressure experienced on all mist sprayers is the same as the same flow rate. That is about 1.5 ml / second per mist sprayer nozzle. One mist sprayer nozzle can cover an area range of 40x40 cm to 60x60 cm, meaning that one mist sprayer can serve about 9-16 mature lettuce vegetables.

Spraying carried out by the pressure tank continues until the pressure in the tank drops to 60 PSI. When the pressure in the pressure tank drops to 60 PSI, the high pressure switch will turn on the booster pump to refill the pressure tank to 80 PSI. The spray that is not absorbed by the roots will return to the reservoir / reservoir. And the cycle continues. Since the spraying rate of each 1.5 ml / second mist sprayer nozzle only lasts a few seconds and turns off a few minutes, the spray discharge count in one minute is very small, only a few milliliters.

For example, spraying is carried out 2 seconds on 5 minutes off, then automatically the volume of water released by each mist sprayer nozzle is only 2 x 1.5 / 5 ml / minute = 0.6 ml per minute. If there are 40 mist sprayers in the system, the total spray output discharge is only 40 x 0.6 = 24 ml / minute. That is, the rate of reducing the volume of water in the pressure tank is also 24 ml / minute. Therefore, even though the output of the booster pump is small, about 0.5 - 1 liter per minute, the pump is still able to serve tens to hundreds of mist sprayer nozzles with the help of a pressure tank.

Because the speed of the pump per minute to fill a pressure tank of 0.5-1 liter per minute is still greater than the speed of water output in the spray per minute of 24 ml / minute. This means that the time it takes for the pump to refill the pressure tank from 60 PSI to 80 PSI is still faster than the time it takes for the spray to make the pressure tank drop from 80 PSI to 60 PSI.

This is provided that the total output discharge of all mist sprayers (number of mist sprayer nozzles x duration of spraying seconds x 1.5 ml / duration of minutes of off) does not exceed the pump discharge (0.5-1 liter / minute).

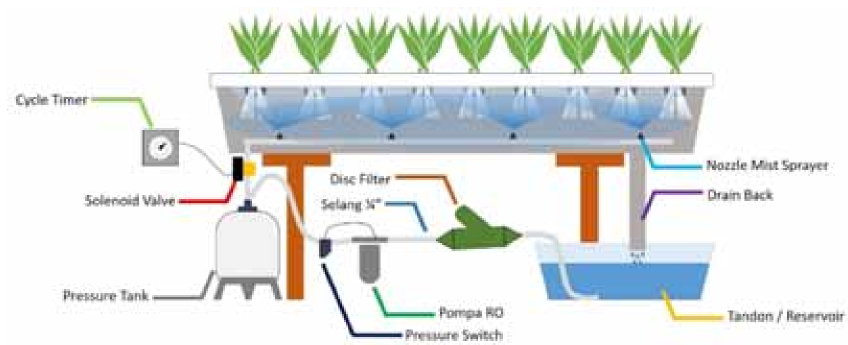

Figure 5. High Pressure Aeroponic (HPA)

Figure 6. Propagation of Potato Seeds using Aeroponic Hydroponics System

The components needed in the hydroponic aeroponic system are as follows :

1) Closed container for planting: can be made from a floating raft pool or tarpaulin
2) RO Booster Pump: to fill water and pressure on the persure tank can be found at the Reverse Osmosis shop
3) Pressure Tank (Membrane Tank): to collect pressure generated by RO pumps and spray plants can be found at home pump equipment stores or RO shops
4) High Pressure Switch: adjusts when the pump starts and stops based on the pressure you can get at the Reverse Osmosis shop 4) High Pressure Switch: regulates when the pump starts and stops based on the pressure you can get at the Reverse Osmosis shop
5) Cycle Timer: to adjust the frequency of spraying can be found in electrical supply stores
6) RO hose 1/4 ": irrigation network can be found at the Reverse Osmosis shop
7) Nozzle Mist Sprayer (Mist Jet Sprinkle): for a nutrient mist maker with a spray can be found at greenhouse supply stores
8) Solenoid Valve 1/4 ": adjust the frequency of spraying can be found at the Reverse Osmosis shop
9) Disc Filter 3/4 ": as a filter so that the system does not clog up, it can be found in greenhouse supply stores
10) Reservoir Containers: as a place for nutrient solution
11) 3/4 "to 1/4" Hose Adapter: hose coupling to a disc filter can be found at greenhouse supply stores
12) Standing Table for plant holder
13) EC / TDS meter: To control the concentration of nutrient solutions
14) pH meter: To check the acidity of the solution
15) Humidity meter: to measure the humidity in the root chamber

2.3. *Nutrient Film Technique* (NFT)

NFT system continuously flows nutrients without using a timer for the pump. These nutrients flow into the gully through the plant roots and then return to the water reservoir.

Plants are cultivated in a channel drained with a solution of +/- 2 mm with the roots of the plant always submerged in a thin film thickness in a nutrient solution and these nutrients are collected back into the reservoir. For a household scale, you can use gutters as a planting medium, polyfom for growing plants and a bucket as a tub.

The basic concept of NFT hydroponics system is a method of cultivating plants with plant roots growing in a shallow and circulating hydroponic nutrient layer so that plants can get enough water, nutrients and oxygen. Plants grow in a polyethylene layer with plant roots submerged in water containing a nutrient solution that is circulated continuously with a pump. The root area in the nutrient solution can develop and grow in a shallow nutrient solution so that the top of the plant roots is on the surface between the nutrient solution and Styrofoam, the presence of the roots in this air allows oxygen to be fulfilled and sufficient for normal growth.

The advantages of NFT System Hydroponics are:

1) Less use of nutrient solutions
2) The need for oxygen in the root area of plants can be fulfilled properly.
3) less dirt deposition in the root area
4) Easier installation maintenance.

Meanwhile, the weakness of hydroponics of the NFT system is that it is expensive to invest and maintenance costs, it is very dependent on electrical energy and diseases that infect plants will quickly spread to other plants.

In hydroponics, NFT systems that must be fulfilled are: Bed (gutters), storage tanks and pumps. NFT beds in several developed countries have been mass produced and provided by several greenhouse and agricultural supplier companies, in Japan it is made of Styrofoam, but in Indonesia it has not been produced so many Indonesian farmers use household gutters

(13-17 cm wide and 4 meters long) . The storage tank can use a water container or reservoir.

The pump functions to drain the nutrient solution from the storage tank to the NFT bed with the help of a network or distribution hose. Some things that need to be considered in the NFT are: the slope of the gutter (1-5%) for the flow of the nutrient solution, the inlet flow rate should not be too fast (can be adjusted by the opening of the faucet in the range of 0.3-0.75 L / min) and the width of the gutter is sufficient to avoid damming of the nutrient solution

The water and nutrients provided will not be wasted because the flow of water will enter the reservoir underneath after which it is pumped back up and flowed back to the plant roots. Hydroponics This NFT system can be applied on a small scale so you can try it at home.

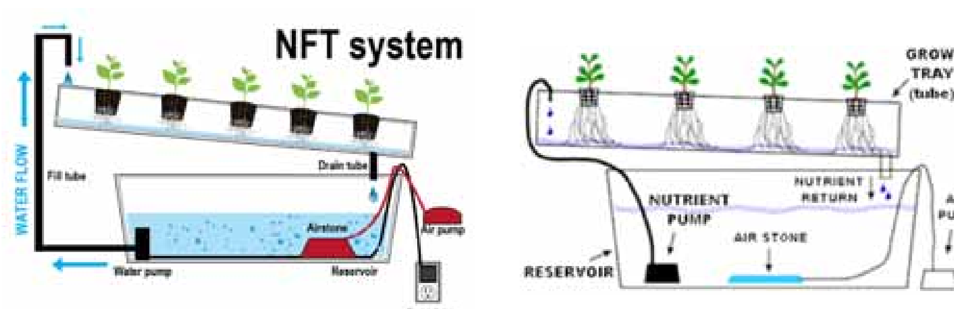

Figure 7. NFT System

Figure 8. Vegetable cultivation using NFT System

2.4. Deep Flow Technique (DFT)

Deep Flow Technique (DFT) is a hydroponic planting system that uses puddles in the installation and uses slow flow circulation. This system uses electricity as a pump drive so that it can easily circulate nutrition to all plant roots.

DFT is almost the same as the NFT system, which is circulating, however, in this system the installation used does not use a slope. The shape of the installation on the DFT is flat so that it can retain nutrient water to stagnate. The height of the nutrient water that stagnates in the installation is about 4 - 6 cm. The high nutrient water can also use the size of the pipe used.

The advantages of this DFT system are:

1. The DFT system does not have to circulate nutrients 24 hours.
2. When the electricity goes out, nutrients are still available to plants, because of a pool of nutrients.
3. Easier plant maintenance.
4. Growth and yields are more uniform.

The drawbacks of the DFT system are:

1. Plants can lack dissolved oxygen so that plant growth is disrupted.
2. Risk of root rot, because plant roots are always inundated during growth.
3. Plants that are exposed to viruses, fungi, bacteria, pests and diseases will spread quickly.
4. Requires more nutrition and water because of a puddle in the pipe pipe.
5. Determination of EC / PPM nutrition in water reservoirs is more complicated, because there is a pool of nutrient solution in the pipe that cannot be measured.

2.5. *Drip Irrigation System*

Drip Irrigation is the most efficient water and nutrient delivery system for growing crops. It delivers water and nutrients directly to the plant's root zone, in the right amounts, at the right time, so each plant gets exactly what it needs, when it needs it, to grow optimally. It enables farmers to produce higher yields while saving on water as well as fertilizers, energy and even crop protection products.

Drip irrigation is a type of micro-irrigation system that has the potential to save water and nutrients. Drip irrigation systems distribute water through a network of valves, pipes, tubing, and emitters. Depending on how well designed, installed, maintained, and operated it is, a drip irrigation system can be more efficient than other types of irrigation systems, such as surface irrigation or sprinkler irrigation

Like other irrigation systems, this drip irrigation also has advantages and disadvantages. The main advantage of the drip irrigation system is that the water provided is close to equilibrium with the water needs of the plants, minimizes runoff, and is percolated. A narrow wetting area can minimize weed growth and save water. There are facts that show that in general drip irrigation systems produce a higher yield to area ratio as well as yield to water volume than surface or sprinkle irrigation systems.

There are many reasons that indicate the high efficiency level of this system. First, the continuous provision of water around the root area causes the moisture content of the soil in the root area to be high. Lack of water that causes stress plants can be minimized. Second, limited soil surface that is exposed to water can reduce weed growth, so that competition for core plants for water and nutrients is low.

The drip irrigation system is quick and easy to assemble. The main component is a paralon pipe of two different sizes. The larger diameter one is used as the main pipe, while the smaller one is used as the drip pipe. The main pipe functions as a water divider to each drip pipe. The drip pipe is given holes to drop water into each plant at a distance according to the distance between the plants. To drain water from the source a water pump is required, also equipped with a faucet and a water filter to the main pipe, not forgetting the connector pipe for the connection.

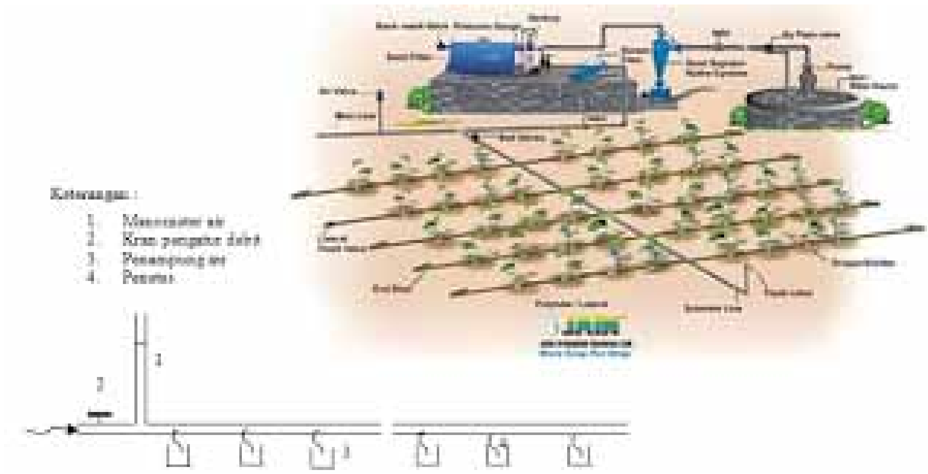

Figure 9. *Drip Irrigation* system

Figure 10. Tomato cultivation using Drip irigation

2.6. *Ebb and Flow System* or *Flood and Drain Sub-Irrigation*

Ebb and Flow System or also known as Flood and Drain System or Tidal System is a hydroponic system with a fairly unique working principle. In the ebb and flow hydroponic system, plants get water, oxygen, and nutrients through pumping from a reservoir which is pumped into the media which will then wet the roots (pairs). After some time the water along with the nutrients will fall back down to the reservoir (receding). The tide and low tide can be set using a timer according to the needs of the plants so that the plants will not be inundated or lack water.

The hydroponics of ebb and flow systems like this is generally carried out with a water pump immersed in a nutrient solution (submerged pump) connected to a timer (timer). When the timer starts the pump, the hydroponic nutrient solution will be pumped into the grow tray (basket / container / plant pot). When the timer turns off the water pump, the nutrient solution will flow back into the reservoir. The timer is set to start several times a day, depending on the size and type of plant, temperature, humidity, and the type of growth medium used. The ebb and flow hydroponic system can be used for several hydroponic growing media. Media that can store water is good enough for this hydroponic system such as rockwool, vermiculite, coconut fiber.

The advantages of the hydroponics of the Ebb and Flow / Flood and Drain / tidal system:

- Plants receive periodic supplies of water, oxygen and nutrients
- Better oxygen supply because of the tide and low tide
- Simplify maintenance because there is no need for watering

The drawbacks of the hydroponics of the Ebb and Flow / Flood and Drain system:

- Manufacturing costs are quite expensive
- Depends on electricity
- The quality of nutrition that has been pumped many times is not as good as the beginning

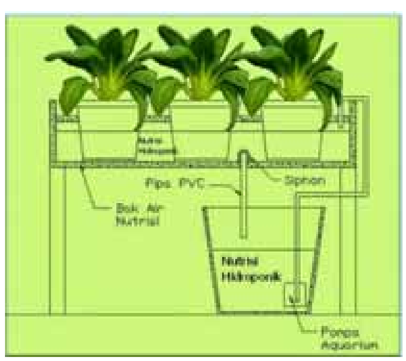

Figure 11. *Ebb and Flow system*

Figure 12. The application of *Ebb and Flow system*

2.6. ***Deep Water Culture***

One hydroponic method that is easy to apply is called Deep Water Culture (DWC) or a Floating Raft because the plants are made to float on a raft (generally made from styrofoam) that has been perforated the size of a planting pot. The term Deep Water Culture method is the plant roots are always submerged in water.

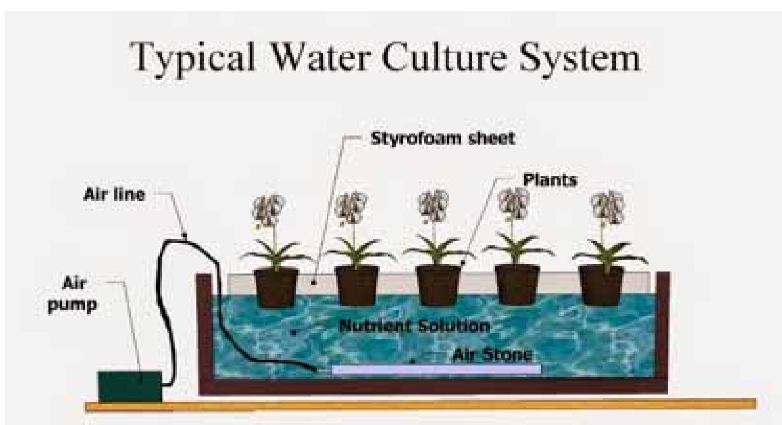

Figure 13. Deep Water Culture System

Figure 14. Cultivation of Plants using Deep Water Culture System

In this system, plant roots are allowed to soak in a water solution that is rich in oxygen and nutrients. Since plant roots are continuously immersed in water, the availability of dissolved oxygen in water is also absolutely necessary because basically plant roots also need to breathe and for that it requires sufficient oxygen availability.

The nutrients used are easily soluble in water, making it easier for plant roots to absorb them. Dissolved oxygen sufficiency can be created by using an air pump commonly used for aquariums which is connected to the "air stone" through an air pipe/hose. Air bubbles that come out continuously through this air stone will create conditions for water that contains nutrients to become rich in oxygen. To start farming with this floating raft culture, the seeds of the plants are sown in rockwool that has been moistened beforehand and placed in a shady place. It would be great if it was covered with plastic to create a temperature that was warm and moist enough so that the seeds germinate quickly. The use of root growth stimulating hormones can also be mixed in the water used to wet the rockwool during the nursery.

After the plant starts to germinate by produce a few leaves (usually within 2 weeks), then placed it in a special pot known as a net pot which is installed to the styrofoam raft holes. Furthermore, the raft is placed on the water that has been prepared in a container. Plants that are commonly cultivated using this method are vegetable crops, especially lettuce so that there are also those who call this floating raft culture is the lettuce culture.

Another variation of a typical water culture system is the reverse circulation water culture system. The circulatory system works like a flood and drain system but never runs out. Many alternative growing containers (water culture reservoirs) are connected to one central reservoir. Each grow container has its own fill line, as well as an overflow tube that flows back to the central reservoir.

Some growers will use buckets instead of wide shallow containers. Use a fountain to pump the nutrient solution into the respective buckets. When the water fills the bucket, excess water spills into the tube overflows and flows back into the reservoir, then recirculates through the system.

Most farmers who recirculate a nutrient solution like this, use only the air pump in the central reservoir, not in each individual box (mainly to save money). They let the water pump run all the time.

CHAPTER III
NURSERY, PLANTING, AND MAINTENANCE

3.1. Nursery

Some knowledge that needs to be learned before carrying out a seed nursery in hydroponic cultivation are : seed requirements, seed treatment, hydroponic growing media, nursery houses, sterilization of planting media, and seeding techniques.

Before sowing seeds, it is important to pay attention to the quality of the seeds. Seed quality can be identified from the seed quality standard. The components of the seed quality standard can be seen based on the physical, physiological, and genetic characteristics of the seed. The components of physical quality are the physical conditions of the seeds such as color, shape, size, weight, surface texture, level of physical damage, cleanliness, and uniformity. The physiological quality component is related to the viability of the seeds when grown (germinated), both in favorable (optimum) and less favorable (suboptimum) conditions. Genetic quality components are matters relating to the truth of the seed variety, both phenotypically (physically) and genetically. In simple terms, the requirements for quality seeds can be found in seed products with certified seed labels that have not expired.

Seed treatment is one of the stages in a seed nursery that needs attention. Seed treatment is carried out if the seeds have not obtained treatment from the seed producer. Seed treatment aims to anticipate pests, fungi and bacteria during the nursery. Treatment of seeds can use pesticides, insecticides, fungicides and bactericides. Pesticide application can be done in 2 ways : 1) dry method : mixing seeds with pesticides in the form of powder, 2) wet method : mixing seeds with pesticides that have been dissolved with water. The dosage or concentration of pesticides used for seed treatment is in accordance with the recommendations listed on the product packaging. Besides aiming to anticipate pest and disease attacks, seed treatment can also be done to breaking dormancy. Treatment of seeds to break dormancy can be done by soaking with hot water, certain chemical treatments, certain temperature treatments, and light treatment.

Another component that needs to be considered in a hydroponic seed nursery is the criteria for hydroponic growing media. A good hydroponic growing media must meet the following requirements : not containing nutrients, clean and aseptic, good porosity, good water storage ability, does not contain tree sap, does not contain oil, does not contain stain, and does not contain hazardous and toxic substances. Some alternative hydroponic growing media that can be used include : rockwool, cocopeat, husk charcoal, hydrotone, and hydrogell.

Environmental conditions during the seed nursery process need to be maintained so that seed growt normaly and healthy. The nursery house is a solution for a seed nursery environment that aims to maintain temperature, humidity, light intensity, rainfall, and pests and diseases. Nursery houses can be made of materials with a bamboo, wood, mild steel or pvc frame. Ideally, the roof and walls of the nursery are made of ultra violet plastic. Inside the nursery houses are arranged seeding racks, which are placed at a certain height so that they are not in direct contact with the soil which may become a source of pests of microorganisms. In addition, it also aims to facilitate the process of maintaining seeds during the nursery. Seeding racks can be made of bamboo, wood, mild steel, pvc or a combination of these materials.

If the seed nursery uses planting media, the planting medium also requires treatment to anticipate pest and disease attacks. The treatment of planting media can be done using chemicals or by means of steaming. Chemicals as materials for sterilizing planting media can use fungicides or bactericides according to the recommended dosage. While the sterilization of planting media by steaming can be done at a temperature of $150^{o}C$ for 1 hour.

The final step in a seed nursery is the seeding technique. Here are the steps for sowing seeds:

1. Prepare a good seedling location (temperature, humidity, light intensity and controlled rainfall).
2. Prepare media on a seedling container.
3. Prepare the seedling media that has been selected and sterilized.
4. Flush the seedling medium with clean water and make sure all the media for the seedlings are wet.
5. Make the planting hole according to the size of the seed not too wide and too deep.
6. Plant the seeds into the hole in the media and make sure that each seeding hole contains only one plant seed.
7. Cover the planting hole (if the media not using Rockwool).
8. Do the watering again and make sure the planting medium is not too wet.
9. While in the nursery, make sure the condition of the planting media is wet (enough water).

3.2. Planting

The next stage, after the seeds are sown, is the planting process. Before the planting process is carried out, it is confirmed that the seeds to be planted have met several physical characteristics. Make sure that the seeds of leaf vegetable plants have grown 2-3 pairs of leaves, while the seeds of fruit vegetable plants have grown 3-5 pairs of leaves. Make a selection of seeds before planting, choose seeds that grow normally and healthy.

Before the planting process, check the hydroponic installation, make sure the installation is running normally and smoothly. Planting seeds is done in the morning or evening, or when the weather is not hot. Planting is carried out in a position that the plant is not too submerged or too raised on the surface of the netpot or other planting media, make sure the position of the plant is upright and there are no parts of the plants organs contact with pvc, gully, or other installations.

3.3. Maintenance

Plant maintenance is one of the stages in the cultivation of hydroponic system plants that should not be ignored. The components of hydroponic system plant maintenance include : 1) checking nutrient concentration, nutrient pH, temperature, humidity, and light intensity; 2) checking the cleanliness and feasibility of the installation; and 3) identification of pests and diseases. The facilities needed during the maintenance of hydroponic system plants include : EC / TDS Meter, pH Meter, Thermometer, Hygrometer, and Digital Lux Meter.

Checking the concentration of nutrients (total solids/number of dissolved ions) was carried out using an EC/TDS meter. Checking the pH of nutrients is done using a pH meter. Check the ambient temperature using a thermometer. Checking the humidity is done using a hygrometer. Checking the sunlight intensity using a digital lux meter. Ideally, checking is done every day, and then recording is done to evaluate the next planting season. This check aims to determine the nutritional conditions and environmental conditions in which the plants are grown, to ensure that the nutrients and environmental conditions are in accordance with the needs for plant growth and development. If the nutrient concentration is reduced, it is necessary to add it immediately to maintain a stable nutrient concentration during the process of plant growth and development. If temperature, humidity and sunlight intensity interfere with plant growth and development, one solution is to modify the screenhouse or greenhouse, for example by providing shade in the form of paranets or other materials.

Checking the cleanliness and feasibility of installing on a hydroponic system is a must. Checks are carried out for dirt clogging in the installation, and installation damage such as leaks or improper installation position so that the flow of nutrients is interrupted. This check aims to ensure that the nutrients to be absorbed by plants are evenly and maximally distributed. If there is blockage by dirt, it must be cleaned immediately, and if there is damage, it must be repaired immediately.

Identification of pests and diseases is carried out periodically, to anticipate the emergence of the initial attack of pests and diseases. It is important to control pests and diseases from an early age. The use of synthetic (chemical) pesticides is avoided as long as attack is not a cause for concern. Natural pest control, such as the use of yellow traps or vegetable pesticides is the first alternative before using synthetic (chemical) pesticides. The use of quality seeds, the correct seeding process, the correct planting process, and the correct maintenance of plants periodically is a form of anticipation against pests and diseases from an early age.

CHAPTER IV
HYDROPONIC NUTRIENTS

4.1. Hydroponic Nutrients

Hydroponic nutrition is a food source for plants consisting of macro and micro nutrients which are fundamental elements for plant growth and development. Nutrients can be utilized in hydroponic systems in a dissolved state in water. Nutrients must be completely water-soluble as plants cannot absorb solids. Plants can absorb in the form of circulated solutions or in static conditions in the hydroponic system.

In every plant cultivation activity, fertilizer is one of the important factors, fertilizer is a source of food for plants needed for growth and development. Of course there are other factors such as light, water and so on. In the market, we know single fertilizers that contain only one nutrient, for example urea which only contains nitrogen, and compound fertilizers that contain more than one nutrient, for example NPK 15-15-15 which contains elements N, P and K. There are approximately 12 nutrients needed by plants in order to grow and flower or leaf properly. These elements are N, P, K, S, Mg, Ca, Fe, Zn, Mn, Cu, Mo B and Si

The key to successful management of a fertilizer program is to ensure adequate concentrations of all nutrients throughout the life cycle of the crop. Inadequate or excessive amounts of any nutrient result in poor crop performance. Excessive amounts can be especially troublesome since they can damage the crop, waste money and fertilizer resources, and pollute the environment when fertilizer is released during flushing of the nutrient delivery system.

Classification of plant mineral nutrients according to biochemical function

Mineral Nutrient	Functions
Group 1	Nutrients that are part of carbon compounds
N	Constituent of amino acids, amides, proteins, nucleic acid, nucleotides, coenzyms, hexoamines, ect
S	Component of cystein, cyctine, methionine and proteins. Constituent of lipoic acid, coenzyme A, thiamine pyrophosphate, gluthatione, biotin, adenosine-5'-phosphosulfate, and 3-phosphoadenosine
Group 2	Nutrient that are important in energy storage or structural integrity
P	Component of sugar phosphate, nucleic acids, nucleotides, coenzymes, phospholipids, phytic acid, ect. Has key role in reactions that involve ATP
Si	Deposited as amorphous silica in cell walls. Contributes to cell wall mechanical properties, including rigidity and elasticity
B	Complexeswith mannitol, mannan, polymannuronic acid, and other constituent of cell walls. Involved in cell elongation and nucleic acid metabolism
Group 3	Nutrients that remain in ionic form
K	Required as cofactor for 40 enzymes. Principal cation in establishing cell turgor and maintaining cell electroneutrality
Ca	Constituent of the midle lamella of cell walls. Required as a cofactor by some enzymes involved in the hydrolysis of ATP and phospholipids. Act as a second messenger in metabolic regulation
Mg	Required by many enzymes involved in phosphate transfer. Constituent of the chlorophyll molecule

Cl	Required for the photosynthetic reactions involved in O_2 Evolution.
Mn	Required for activity of some dehydrogenases, decarboxylases, kinases, oxidases, and peroxidases. Involved with other cation-activated enzymes and photosynthethic O_2 evolution
Na	Involved with the generation of phosphoenolpyruvate in C_4 and CAM plants, Substitutes for potassium in some functions.
Group 4	Nutrients that are involved in redox reactions
Fe	Constituents of cytochorems and nonheme iron proteins involved in photosynthesis, N_2 Fixation and respiration
Zn	Constituent of alcohol dehydrogenase, glutamic dehydrogenase, carbonic anhydrase, ect.
Cu	Component of ascorbic acid oxidase, tyrosinase, monoamine oxidase, uricase, cytochrome oxidase, phenolase, laccase and plastocyanin
Ni	Constituent of urease. In N_2-fixing bacteria, constituent of hydrogenases
Mo	Constituent of nitrogenase, nitrate reductase, and xanthine dehydrogenase.

Taiz and Zeiger, 2010.

Deficiency symptom of plant nutrient

1. Nitrogen (N)

   Nitrogen is absorbed by plants in the form of NO_3^- (N-Nitrate) or NH_4^+ (N-Ammonium) or both. Plants that live with media that contain lots of water will prefer to absorb N in the form of NH_4^+, while plants that live on land media will grow better if N is available in the form of NO3-. It is recommended that N-Ammonium is not more than 30% of the total N given to plants.

The function of $NH_4{}^+$ on plant growth will cause plants to grow rapidly, enlarge cells, spread thin leaves, weak, wilt quickly, and are susceptible to disease attacks.

The function of NO_3^- on plant growth is that it can extend the life phase or the shelf life of flowers / fruit, tolerate lack of water, make green leaf grains better, reduce the falling flower

Deficiency Symptoms

- A nitrogen deficient plant may have light green upper leaves and yellow or tan lower leaves.
- Symptoms of deficiency are seen first on the lowest-positioned leaves (older leaves).
- Slow average growth speed.

2. **Phosphorus (P)**

Phosphorus / phosphorus is absorbed by plants in the form of H_2PO_4, and a small portion can be absorbed in the form of HPO_4- ions. Together with $NH_4{}^+$ it can stimulate the root growth. Phosphorus has residual character on the soil.

Deficiency symptom

- As in nitrogen deficiency, in some species may produce excess anthocyanin, giving the leaves a slight purple coloration
- Slender stems and the death of older leaves
- Maturation of the plant may also be delayed.

3. **Potassium (K)**

Potassium, present within plants as the cation K^+, plays an important role in the osmotic potential of plant cells. Potassium can be mobilized to the younger leaves.

Deficiency symptom

- Potassium deficiency is characterized by mottled or marginal chlorosis, which then develops into necrosis primarily in leaf tips, at the margins and between veins.

- The leaves may also crinkle and curl.
- Plants may be slender and weak, with abnormally short intermodal region.

4. Calcium (Ca)

Calcium is absorbed by plants in the form of Ca^{++}, the availability of Ca can actually affect other nutrient elements, especially Mg, if Ca is in deficiency, the absorption of Mg will be too large and can poisoning the plants. The addition or application of Ca together with element N will be beneficial for the development of stems and the formation of new shoots. Ca is found in old part of the plant and its immobile.

Deficiency symptom

- Necrosis of young meristematic regions, such as the tips of roots or young leaves.
- Deformed young leaves.
- Root system may appear brownish, short and highly branched.
- Severe stunting may result if the meristematic regions of the plant die prematurely.

5. Magnesium (Mg)

Plants absorb magnesium in the form of Mg^{++} ions, the availability of Mg should not be excessive because it can be poisoning the plants, so the Mg element must be in balance, especially with the nutrient Ca. Magnesium can be administered in soil and leaves with a magnesium salt such as MgSO4.

Deficiency symptom

- Chlorosis between the leaf veins occurring first in the older leaves.
- If the deficiency is extensive, the leaves may become yellow or white.
- Premature leaf abscission.

6. **Sulfur (S)**

Plants absorb sulfur through the roots in the form of SO^{4-} and can be absorbed through the leaves in the form of SO^{2-} ions, but at too high a level it can poison plants. S content in plants is 0.1-0.4% on average. The S element in plants can suppress excess nitrate so that the negative effects of too high nitrate buildup can be prevented. Sulfur is a mobile nutrient even though it is not easily remobilized to the younger leaves in most species.

Deficiency symptom

- Arises initially in mature and young leaves, rather than in old leaves as in nitrogen deficiency.
- Chlorosis may occur simultaneously in all leaves.

7. **Boron (B)**

Boron is absorbed as BO_3^{3-} or $B_4O_7^{2-}$. It is required for uptake and utilization of Ca^{2+}, membrane functioning, pollen germination, cell elongation, cell differentiation and carbohydrate translocation

Deficiency symptom

- the deficiency symptoms first appear on young leaves, including thick, curled, and brittle leaves with reduced leaf expansion.
- Black necrosis of the young leaves and terminal buds, occurs primarily at the base of the leaf blade.
- a short internodal distance, resulting in a bushy plant appearance.
-

8. **Iron (Fe)**

Plants absorb Iron in the form of Fe^{3+} ions, but more is absorbed in the form of Fe^{2+} ions. Iron can also be absorbed in the form of complex salts (chelate) and also absorbed by the leaves in the form of Fe sulfate. Fe is one of the immobilized elements. There is a lot of iron in the soil, only its availability in the soil is very low. In calcareous soils and high phosphate content, iron deficiency can arise, in this condition the iron is difficult to absorb.

Deficiency symptom

- Leaf intervenous chlorosis, appear initially on the younger leaves.
- Under condition of extreme deficiency, the veins may also become chlorotic, causing the whole leaf to turn white.

9. **Manganese (Mn)**

Manganese is absorbed by plants in the form of Mn^{2+} ions and also in the form of organic complexes. Excessive levels of Mn for plants can cause poisoning. The character of manganese is immobile

Deficiency symptom

- Intervenous chlorosis associated with the development of small necrotic spots.
- The chlorosis may occur on younger or older leaves.
- Stunted plant growth.

10. **Copper (Cu)**

Plants absorb Cu in the form of Cu^{2+} and can be absorbed through leaves and in the form of complex molecules.

Deficiency symptom

- The production of dark green leaves, which may contain the necrotic spots.
- The necrotic spots appear first at the tip of the young leaves and then extend towards the leaf base along the margin.
- The leaves may also be twisted or malformed.
- Under extreme deficiency, leaves may abscise prematurely.

11. **Zinc (Zn)**

Many enzymes require zinc ions (Zn^{2+}) for their activity and zinc may be required for chlorophyll biosynthesis in some plant.

Deficiency symptom

- Reduction in intermodal growth.

- malformed growth occurs at the root tip and shoots are delayed at the shoot due to incomplete division of meristem cells.
- The leaves are light green, yellow or white between the bones of the leaves, and the stems are shortened, the leaves become small, narrow and rather thick, then cause the leaves to fall.

12. Molybdenum (Mo)

Plants absorb Mo in the form of MoO_4^{2-} ion in small amounts. A little excess of Mo can cause poisoning of plants

Deficiency symptom

Mo deficiency can affect the synthesis of amino acids and proteins, so that it can affect the function of N in plants.

13. Chlorine (Cl)

This element is absorbed by plants in the form of Cl-. The Cl element is soluble and readily available in groundwater so that symptoms of deficiency in nature are actually rare.

Deficiency symptom

- Withered on the edge of the leaf.
- Chlorosis and necrosis of the leaves are sometimes change onto bronze in color.
- Growth is stunted, especially at the roots where near the tips are thickened.

4.2. Managing the Quality of Hydroponic Nutrition

Some of the important factors that must be considered when selecting nutrients and preparing hydroponic nutrient solutions are:

1) Water quality - salinity, concentration of harmful elements dissolved in water (such as sodium, chloride and boron);
2) The nutrients needed and their concentration in hydroponic nutrient solutions;
3) Nutritional balance;

4) The pH of the hydroponic nutrient solution and its effect on nutrient uptake by plants.

One thing that is often overlooked when it comes to nutrition is the temperature of the nutrient solution. Plant roots grow underground in nature and in order to imitate what they will receive in nature, it is very important to keep the root zone at a temperature of 68-72 degrees. That doesn't mean that if the nutrient temperature reaches 73 or 74, the plants will die, but it should be kept as close as possible to 68-72 degrees. Plants that are too high in nutrients can experience yellowing and falling flower problems, damaged fruit and a lack of new growth.

The pH scale is a way of measuring acids or bases in a nutrient solution. pH (Power of Hydrogen) is a unit of measure that describes the degree of acidity or alkalinity of a liquid solution. It is measured on a scale of 0 to 14. The acid is in the 0 to 7 range, with the lower number being the stronger acid. Alkali is in the 7 to 14 range, with higher numbers being stronger bases.

The pH of the nutrient solution is very important for plants because it will affect how well each element can pass through the root cell walls and affect plant growth. When the pH of the nutrient solution is not balanced, the plants cannot absorb the nutrients in the water, which causes the plants to starve, even though there is a lot of food available.

The pH requirements for plants are not the same for all plants and it is not allowed to grow plants with different pH requirements in the same nutrient solution. We recommend using nutrient pH averages for all types of plants.

Measuring and adjusting the pH of a nutrient solution is fairly easy to do, but it must be done daily to ensure a constant pH level. Testing can be carried out cheaply and accurately, using an electronic pH meter. When measuring pH, the nutrients are evenly mixed with water first to ensure the correct reading.

The pH and electro-conductivity (EC) values of the nutrients specified here are given over a wide range. It should be noted that the requirements of a particular crop will vary according to regional climatic conditions, and from season to season in the region. These values are intended only for hydroponic crops (plants grown in the soil will be different). Electro-Conductivity (EC) or Conductivity Factor (cF) can be expressed as milliSiemens (mS), cF, or parts per million (PPM). 1 mS = 10cF = 700ppm.

Plants	pH	cF	EC	PPM
Artichoke	6.5-7.5	8-18	0.8-1.8	560-1260
Asparagus	6.0-6.8	14-18	1.4-1.8	980-1260
Bean (Common)	6.0	20-40	2-4	1400-2800
Beetroot	6.0-6.5	8-50	0.8-5	1260-3500
Broad Bean	6.0-6.5	18-22	1.8-2.2	1260-1540
Broccoli	6.0-6.5	28-35	2.8-3.5	1960-2450
Brussell Sprout	6.5-7.5	25-30	2.5-3.0	1750-2100
Cabbage	6.5-7.0	25-30	2.5-3.0	1750-2100
Capsicum	6.0-6.5	18-22	1.8-2.2	1260-1540
Carrots	6.3	16-20	1.6-2.0	1120-1400
Cauliflower	6.0-7.0	5-20	0.5-2.0	1050-1400
Celery	6.5	18-24	1.8- 2.4	1260-1680
Cucumber	5.8-6.0	17-25	1.7-2.5	1190-1750
Eggplant	5.5-6.5	25-35	2.5-3.5	1750-2450
Endive	5.5	20-24	2.0-2.4	1400-1680
Fodder	6.0	18-20	1.8-2.0	1260-1400
Garlic	6.0	14-18	1.4-1.8	980-1260
Leek	6.5-7.0	14-18	1.4-1.8	980-1260
Lettuce	5.5-6.5	8-12	0.8-1.2	560-840
Okra	6.5	20-24	2.0-2.4	1400-1680
Onions	6.0-6.7	14-18	1.4-1.8	980-1260

Pak-choi	7.0	15-20	1.5-2.0	1050-1400
Parsnip	6.0	14-18	1.4-1.8	980-1260
Peppers	5.8-6.3	20-30	2.0-3.0	1400-2100
Bell peppers	6.0-6.5	20-25	2.0-2.5	1400-1750
Hot Peppers	6.0-6.5	30-35	3.0-3.5	2100-2450
Potato	5.0-6.0	20-25	2.0-2.5	1400-1750
Pumpkin	5.5-7.5	18-24	1.8-2.4	1260-1680
Radish	6.0-7.0	16-22	1.6-2.2	840-1540
Spinach	5.5-6.6	18-23	1.8-2.3	1260-1610
Sweet Corn	6.0	16-24	1.6-2.4	840-1680
Sweet Potato	5.5-6.0	20-25	2.0-2.5	1400-1750
Taro	5.0-5.5	25-30	2.5-3.0	1750-2100
Tomato	5.5-6.5	20-50	2.0-5.0	1400-3500
Zucchini	6.0	18-24	1.8-2.4	1260-1680

In general, plants require higher nutrition during cold months, and lower nutrient requirements during the warmest months. Therefore, a stronger nutrient solution should be maintained during the winter months, and a weaker nutrient solution during the summer when the plants take up and excrete more water than the nutrients.

4.3. Making Hydroponic nutrient formula

The hydroponic system does not use soil as a growing medium, but it is replaced by other media such as husk charcoal, coco peat or other materials other than soil. The planting medium does not contain sufficient nutrients, so we must provide fertilizer to plants to meet the needs of plants (in hydroponics this is known as nutrient solution provision). In providing nutrition, we need to carefully calculate the amount of each nutrient according to the needs of each plant. For those of you who like hydroponic cultivation systems both commercially and as a hobby, you don't need to bother calculating the amount of nutrients you provide to hydroponic plants because currently on the market there are many hydroponic nutrition packages from various brands that you can easily use. Generally, hydroponic fertilizers on the market contain complete nutrition for the growth of your plants

But for those of you who want to use hydroponics in research and testing nutritional formulas for your plants. Then you can make your own nutritional solution. There are many nutritional formulas that can become the standard for your nutrition, such as Hoagland I, Hoagland II, Sundstorm formulas and so on. The number of hydroponic fertilizers on the market makes it easier for hobbyists and hydroponic cultivators to provide and apply hydroponic fertilizers that are suitable for plants. To make hydroponic fertilizer yourself, a fairly high investment is required in the form of equipment and fertilizer-making materials needed. Currently purchasing some of the materials for hydroponic fertilizer is quite difficult and is only sold in large quantities.

The manufacture of hydroponic nutrition, for example, we can use the Hoagland II formula as a basis or standard for making nutrition, then it can be developed according to field needs. To make nutrients, you need several compounds that contain essential nutrient elements needed by plants. these compounds are:

1. Macro nutrients : $5Ca(NO_3)_2.NH_4.NO_3.10H_2O$, KNO_3, KH_2PO_4 dan $MgSO_4.7H_2O$
2. Micro nutrients : Fe EDTA, $MnSO_4.4H_2O$, H_2BO_3, $ZnSO_4.7H_2O$, $CuSO_4.5H_2O$, dan H_2MoO_4
3. Water as a solvent for chemical compounds

Some of the tools needed in the manufacture of hydroponic nutrition, among others :

1. Analytical balance for weighing the required compounds
2. Beaker glass as a place to dissolve and measure the volume needed.

3. Magnetic stirrer, which is a tool that is useful for stirring the solution so that the compound is easily dissolved
4. pH meter to measure the pH of the solution
5. The EC meter is a tool for measuring the electrical conductivity of the solution

What is important for us to know is the names and nutrient composition of the compounds that make hydroponic fertilizer, because there are some fertilizer-making products that sometimes contain different amounts so they can change the composition of the hydroponic nutritional formula and make it less optimal.

Hydroponic fertilizers use measurements in ppm (parts per million), or mg / L (milligrams per liter)

1 ppm = 1 mg/L = 1 g / 1000 L

Furthermore, we also have to understand about the atomic weight of each element, this is important for people who want to deepen the calculation and formulation of hydroponic nutrients.

The compound for making hydroponic fertilizer is then weighed according to the plant's needs for each nutrient. The calculation of the need for this plant is determined by many things, especially by what type of plant the plant is in the form of leaf vegetables, fruit, ornamental plants or tubers because the needs of each plant's nutrient elements are different.

Each compound that has been weighed according to its composition is dissolved in a 5-liter container and made into 2 stock solutions to prevent sedimentation. Precipitation can occur when Ca ion is combined with PO ions or SO4 ions, this causes the nutrients to not be absorbed by plants. So that even hydroponic nutrients that are available in the market are usually divided into two stocks A and B and are known as A B Mix.

The stock solution A contains several compounds:

$5Ca(NO_3)_2.NH_4.NO_3.10H_2O$, 50% KNO_3, dan Fe EDTA

The stock solution B contains several compounds :50% KNO_3, KH_2PO_4, $MgSO_4.7H_2O$, $MnSO_4.4H_2O$, H_2BO_3, $ZnSO_4$, $7H_2O$, $CuSO_4.5H_2O$ dan H_2MoO

The solution is made in the form of a stock solution in concentrated conditions. If we make a stock solution of 5 liters each, it can be dissolved into 1000 liters of ready-to-use solution.

The following is an example of calculating the amount of nutrients for lettuce plants, for the amount of nutrient solution 1000 L especially for the macro nutrient.

Example for Lettuce

Nutrient	Standard concetration (ppm)	Used concentration (ppm)
N	70 – 250	250
P	15 – 80	62
K	150 – 400	300
Ca	70 – 200	185
Mg	15 – 80	62
S	20 – 200	110
Fe	0,8 – 6	5
Mn	0,5 – 2	2
Cu	0,05 – 0,3	0,1
Zn	0,1 – 0,5	0,3
B	0,1 – 0,6	0,6
Mo	0,05 – 0,15	0,05
Si	0,05 – 0,15	0,05

Hydroponic Nutrient Making Compounds :

2. $5Ca(NO_3)2.NH_4.NO_3.10H_2O$ (calcium nitrate)
3. $MgSO_4.7H_2O$ (magnesium sulfate)
4. K_2SO_4 (Potassium sulfate)
5. KNO_3 (potassium nitrate)

6. $NH4.H_2.PO_4$ (Ammonium dihydrogen phosphate)
7. KH_2PO_4 (Potassium dihydrogen phosphat)
8. Complete micro compounds

1 ppm = 1 mg/L = 1g/1000 L

Example calculation

Finding the amount of each element in the compound

1. Finding the amount of each element in the compound

   $5Ca(NO_3)2.NH_4.NO_3.10H_2O$

   The mass percent (you need to find the atomic weight of each element, how many atoms of each element in the compound, so you can find the mass percent of element that you need)

   Ca = 18,5 %

   NO_3 = 14,2%

   NH_4 = 1,3%

   Ca → 185 ppm

   The amount of $5Ca(NO_3)2.NH_4.NO_3.10H_2O$

   ↓

   185 g/1000 L x 100/ 18,5 = 1000 g

   The total amount of needed $5Ca(NO_3)2.NH_4.NO_3.10H_2O$ = 1000 g / 1000 L

   The amount of NO_3 dan NH_4 is

   NO_3 = 14,2 % x 1000 = 142 g/ 1000 L

   NH_4 = 1,3 % x 1000 = 13 g / 1000 L

2. To find the amount of $MgSO_4.7H_2O$

   Mg = 9,7 %

   S = 13 %

   Mg → 62 ppm (lihat tabel)

   The amount of $MgSO_4.7H_2O$

   62 g / 1000 L x 100/ 9,7 = 639 g

The amount of $MgSO_4.7H_2O$ in the solution is 639 g / 1000 L

The amount of S = 13 % x 639 = 83 g / 1000 L

3. To find the amount of K_2SO_4

S = 18,4 %

K = 44,8 %

In the table listed for S is 110 ppm but from $MgSO_4.7H_2O$ its already 83 ppm hence the lack is 27 ppm

So the amount needed for K_2SO_4

27 g/1000 L x 100/18,4 = 147 g

The amount of K_2SO_4 = 147 g/1000 L

The amount of K is

K = 44,8% x 147 = 66 g / 1000 L

4. To find the amount of KNO_3

NO_3 = 14 %

K = 39 %

NO_3 → 80 ppm (lihat tabel)

In the table listed for N is 250 ppm , but the total N (NO_3 + NH_4) from the previous compound is already 155 ppm hence its lack of 95 ppm which will be fulfilled by KNO_3 and $NH_4.H_2.PO_4$, then divided into 80 ppm from KNO_3 and 15 ppm from $NH_4.H_2.PO_4$. Then the amount of KNO_3 is

80 g/1000 L x 100/14 = 571 g

So the amount of KNO_3 = 571 g/1000 L

While the amount of K is

K = 39% x 571 = 223g/1000 L

5. To find the amount of $NH_4.H_2.PO_4$

NH_4 = 12 %

P = 27 %

NH_4 → 15 ppm (check the table)

In the table listed for N is 250 ppm , theres already (155 + 80) ppm from the previous compound, hence its lack of 15 ppm.

The amount of $NH_4.H_2.PO_4$

15 g/1000 L x 100/12 = 125 g

So the amount of $NH_4.H_2.PO_4$ = 125 g/ 1000 L

So the amount of P is

P = 27% x 125 = 34 g/ 1000 L

6. Mencari jumlah KH_2PO_4

   P = 22,8 %

   K = 28,7 %

   P → in the table listed 62 ppm, there's already 34 ppm from the previous compound so its lack of 28 ppm

   So the amount of KH_2PO_4

   28 g/1000L x 100/22,8 = 123 g

   So the amount of KH_2PO_4 = 123 / 1000 L

   The amount of K is

   K = 28,7 % x 123 = 35 g/1000 L

Complete Micro Compounds

Fe : 1,3 ppm

Mn : 0,68 ppm

Cu : 0,68 ppm

Bo : 0,35 ppm

Zn : 0,28 ppm

Mo : 0,03 ppm

Hydroponic Nutritional Composition of Lettuce

Stock	Compound	The amount g/1000 L
A	$5Ca(NO_3)_2.NH_4.NO_3.10H_2O$	1000
B	$MgSO_4.7H_2O$	639
B	K_2SO_4	147
A atau B	KNO_3	571
B	$NH_4.H_2.PO_4$	125
B	KH_2PO_4	123
A	Complete Micro Compounds	40

Dissolved into 5 liters of solution per stock

Stock A for 5 L

Stock B for 5 L

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