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A REVIEW ON HYDROPONICS: DEMAND OF FUTURE

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Abstract:

Increasing as the world population the demand and need for food production is also increasedbut food production is not much increase as required. The traditional farming method use soil system which does not have the capacity to fulfil the world's growing demand for food and day-by-day water availability also decreasing. So in the future this growing demand, there will be an expected food crisis in the coming years.To avoid food crisis issue in the future, other methods of farming and sources of food must be used. This paper studies describe about hydroponics and show the benefit of hydroponics. In hydroponics have different techniques which are used according to requirement and easy for handling. In this paper we gain the knowledge about different crops which are suitable for growing in hydroponics and the factor which are effect crop growth and its productivity.

Keywords: *hydroponics, growing media, hydroponic solution, advantage and disadvantage.*

Introduction:

According to United Nations Organization (UN) report world population reached 9.7 billion at the end of 2050. At the same time, it has been estimated that 50% of the arable land around the world will be unusable for farming [1].Consequently, it is need to 110% increase in food production from present production to meet the high demand of food grain in the future. United Nations news reports say that in present time many countries are facing food crisis and they do not able to full fill their requirement especially in Africa. The food crisis is expected to last to 2050 if the demand will not be covered [2]. Some major issues for this crisis that climate change, poverty, water, soil erosion and degradation. Due to climate change drought and flood is occurred more frequently in entire world. Second reason poverty, due to poverty of many countries they have not able to purchase best quality seed, fertilizer and irrigation facility these effect shows on food grain production and food

output become reduced. Southern Africa is such type of country [3]. The third reason is the water, due to high demand of water in crop and lack of irrigation management water crises will become increased. It is estimated that 80 per cent groundwater and surface water used in agriculture. Water will become a critical issue in the future when food production will need to increase [4]. Last reason is the soil erosion and degradation. It is happened due to traditionalmethodof farming and various factor of erosion. In India total geographical land 328.74 mha from this 187.80 mha land is degrade and only 141 mha areas is a net cultivated [5]. Soil is mainly required for providing various types nutrients and minerals for growth and development of plant.

Because of that, the world needs to develop various types of techniques and apply these techniques to improve and increase the productivity of farming systems. According to present time it is necessary to maximum use of per unit land and gets the maximum production. Today farming systems fundamentally based on soil, water and resilience to disasters. Hence, there is a need to some changes. Nowadays, the traditional farming systems not have a capacity to fulfil therequirement of the current and future demand of food. Therefore, there is a real need for adapting new techniques in farming system that stimulates plants to grow healthy and faster. This system should cover the fast-growing demand with less cost and minimum consumption of natural resources [3]. Hydroponic is a best solution of entire problem. It is considered a viable source to large scale food production.

Hydroponics is always a part of modern agriculture and can be the farming of the future with proven competitive points over soils - Space saver, effective use of plant nutrients, no weeds, fewer pests and plant diseases,stable and higher yields, control of the whole system, fewer fertilizers and insecticides used, easy to transplant, able to grow crops all year round etc. Hydroponics has great potential. According to available data of marketing value of hydroponics products it is expected that in the near future the market for Hydroponics is expand dramatically. It is valued at USD 23.94 billion (2018) and is forecast to account for a CAGR of 6.8% from 2019 – 2024 [6].

It is required for us that we can understand about hydroponics cultivation. Hydroponics area and grower will increase so fast in near future because day by day land availability for crop production is decrease and population is increase. Hydroponics has the capacity to meet out the demand of growing population. Due to various advantages it is popular in some countries like Canada but in India it is not popular till the date. Lack of knowledge and weak extension system is a main bottleneck behind it [7]. In our country for popularization of hydroponics is necessary to provide scientific knowledge and mass awareness between Gardner at National level. So its knowledge is necessary for our younger students who are deal with farmers in future and increase their capacity of crop production.

What is hydroponics?

Hydroponics is a process in which plants can be growing using water with the added mineral nutrient solution, without soil. It is the technique in which farmer grow plants more efficient manner and get high productivity with less labour and time requirement.

Figure 1:A view of hydroponic

In this technique plants not feel stress due to lack of water or nutrient because nutrients are directly fed at the root base. It is ideal for growing wide range of plant species, such as tomato, cucumber, leafy vegetables i.e. lettuce, herbs and flowering plants [7].

Need of hydroponics:

Soil is the best growing media for the plants. It provides all essential nutrients and water to the plants and anchorage the growth. Sometimes, soil has various limitations for desired growth of plants like unfavourable soil properties, harmful insects, pathogens etc. continuous cultivation of same crops in the same piece of land and erosion can reduced the soil fertility and make the soil unfits for crop production. In the metropolitan cities where land availability is low, high water scarcity and costly labour input, in these conditions plant hobbyists feel difficulties to grow ornamental plants, flowers, vegetables and other kind of plants. In this situation, hydroponics offers an opportunity for gardeners. It is unique system to successfully grow plant species with less water, less labour, small land and low investments [7].

Difference between Hydroponics and soil cultures:

Before the known hydroponics and its related technique it requires understanding the basic difference in hydroponic culture and soil cultivated crops or traditional culture. It provides a view that why we need to use it and which difference is good for hydroponics according to production and beneficial for farmers. The basic difference in hydroponics and soil culture is following-

Hydroponics	Soil culture
Soil is not required	Crop directly shown in soil
Automatic irrigation system, no water stress	To minimise water stress need to manually irrigation
Only water soluble fertilizers are used and nutrients are available at all times in balanced content	Nutrients must be added in soil for it required soil analysis report which is time taken and long process
Soil borne disease can be controlled	Soil borne disease occur due to soil
Production is not organic because artificial nutrients are used in production	Possible to produce organic production due to use of organic fertilizers
Slow-acting, low cost and ideal system	Expensive and troublesome
Advantages – space saving , high yield, low cost, fast growth, no weeding and digging	Required space, low yields, expensive, slow growth, requires weeding, digging and hard works

Source:[8]arc.agric.za

Types of hydroponic system:

Different types ofhydroponic techniques are available which is used for growing crops. Hydroponic systems have 6 basic types that is Wick Hydroponic, Deep Water Culture, Ebb and Flow system, DripHydroponic (recovery or non-recovery), Nutrient Film Technique (NFT) and Aeroponic. There are hundreds of variations on these basic types of systems, but all hydroponic methods are a variation or combination of these six.

1. Nutrient Film Technique (NFT) :- This technique was developed by Dr. Allen Cooper at England in 1970. He use this technique for the year-round production of greenhouse crops. It is widely adopted in Western Europe [15].

The NFT is an active recovery type hydroponic system in which we use submersible pump and reuse of nutrient solution. The NFT systems have a grow-tube in which plant roots suspended and nutrient solution can be flow. Pumping the nutrient solution from reservoir to grow-tube we are use a submersible pump. The grow-tube is slight downward angle so nutrient solution can be contact with plant root and then back into the reservoir. The nutrient solution flows over the roots up to 24 hours every day. In this method growing media is not required. Stop the light to reaching of the plants root this will prevent growth of the plant. For this plants can grow on light-proof plastic films placed over shallow, gently sloping channels. Air stones or capillary matting must be used in grow-tube because it is full filled the requirement of oxygen which is required in the grow-tube.

2. Deep Water Culture (DWC): The water culture system is the simplest of all active hydroponic systems. The plants root is suspended in the nutrient solution. An air pump supplies air to the air stone that bubbles the nutrient solution and supplies oxygen to the roots of the plants. Plants are suspended in nutrient solution and supplied unlimited oxygen, so they grow like crazy.

Leaf lettuce, which are fast growing and water loving plants, this characteristics make them an ideal choice for this type of hydroponic system. It is the best for growing under deep water culture. Very few plants other than lettuce will do well in this type of system.The biggest drawback of this kind of system is that it doesn't work well with large plants or with long-term plants.

3. Wick Hydroponic:- It is easy and inexpensive to grow and maintain. It is passive non-recovery type hydroponic system. In the system nutrient solution stored in the reservoir and moved into the root system by capillary action through candle or lantern wick. Wick systems often use sand or perlite, vermiculite mix, pro-mix, coconut fiber and a growing media.

4. Ebb and Flow System:- It is popular in home hydroponic gardening and ideal for growing a broad variety of crops. It is an active recovery type system. It is work on the simple flood and drain theory so it is also called Flood & Drain System. In this system a reservoir hold a submersible pump and plant can be grow in the upper tray.

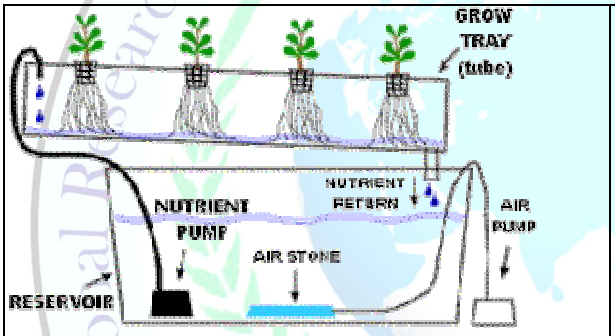

Figure 2: Nutrient Film Technique

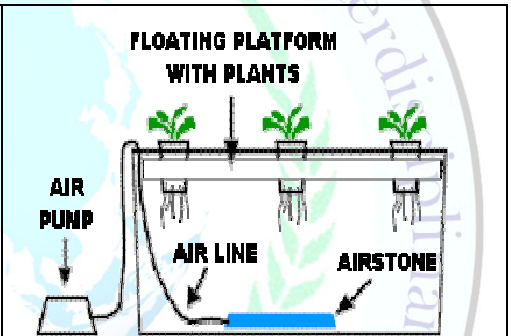

Figure 3: Deep Water Culture

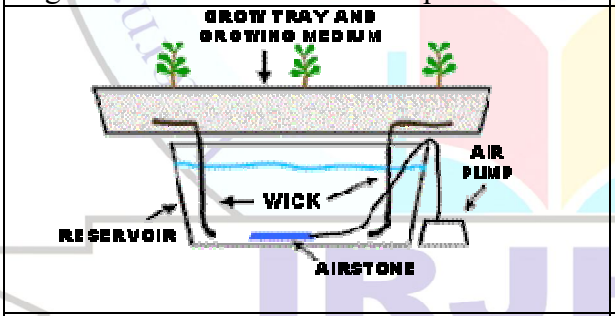

Figure 4: Wick system of Hydroponic

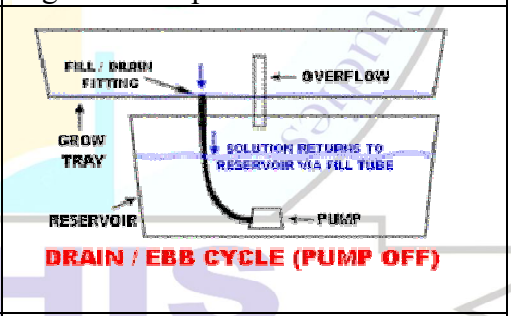

Figure 5: Ebb and Flow system

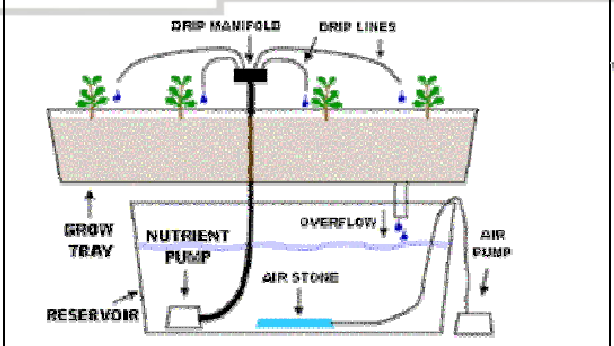

Figure 6: Drip system

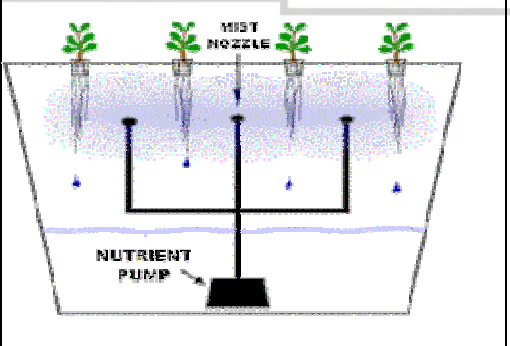

Figure 7: Aeroponics system

Nutrient solution stored in reservoir and when pump is tern on the nutrient solution can be pumped from reservoir and delivered to upper tray for reached to the root system of plants. Pump should be on for 20 – 30 minutes; this period is called flood cycle. When water level is reached a set level than overflow pipe is collected extra nutrient solution and put into reservoir. After the flood cycle the nutrient solution can be drains slowly-slowly from upper tray to reservoir through the pump. Moving nutrient solution pushed out the air which is low in oxygen from root system and when it is back in reservoir than oxygen rich air pulled into the growing media. In this system most commonly used growing mediums are Rockwool and grow rock.

5. Drip Hydroponics:- this system are easy to use and set up. It is use a submersible pump in a reservoir with supply line which is going to each plant. Supply lines have drip emitter for each plant. Gardener can be used this drip emitter for adjust the nutrient solution per plant. Under theeach row of plants have a drip tray which can send the solution back to reservoir. Any growing media can be used in this system but generally Rockwool is used.

6. Aeroponics:- Aeroponics is a new concept and a unique way of crop production but it is not easy and suitable for commercial crop production. Used for lab studies. In this method growing plants are hanged in air and nutrient solution is sprayed on the plant roots. Disadvantage of Aeroponics is regulating the consistency of the sprayers to assure constant flow[9 & 10].

Growing media for hydroponics:

Growing media is used to provide support plants and roots. Today various types growing media is available and it is used according to hydroponic system. The main aim of growing media is to aerate and support the root system of plants. The following media is generally used in hydroponic-

- Expanded clay- High performing media, capillary action very high, clay pebbles reusable.
- Rockwool- Extremely popular and widely used, produced from volcanic rock and lime stone, pH 7.8, inorganic, very high water and air holding capacity.
- Perlite- Hold more air, less water and no nutrient holding capacity, used with vermiculite or itself depend upon plant's need.
- Vermiculite - light, high water holding capacity than perlite.
- Coco coir- created from husks of coconuts, not used in India but due to low cost used in tropical countries.
- Oasis root cubes- Convenient propagation media, easy removal cube.
- Sand- 0.5 mm to 2.5 mm range of sand particles is most suitable.
- Coarse fir sawdust - Low in cost but not recommended, leached tannic acid into water.
- Crushed granite - Screen crushed granite with 2 mm particle size used, low water retention capacity.

- Scoria - Porous volcanic rock, mixture of fine and coarse scoria is used, provide good aeration [7].

Equipment which are used in hydroponics:

- Water pumps – Ordinary or submersible water pump necessary to operate hydroponic.
- Timer and controller- Timer used to set circulating time manually and controlled by controller.
- Oxygen detection sensor – Activate the pump when level of O_2 concentration of nutrient solution goes down.
- PVC pipes – used as channels, prefer UV resistant pipes
- pH meter – Used for checking and maintain the pH.
- Blower – It send airflow, so plants shake and pollens are distributed. Help in pollination.
- Pollinators – Electrical device, vibrate the individual plants when touch them, provide pollination facility.
- Nurtimeter– Measure the nutrient contents of solution.
- EC meter– Measure the Electrical Conductivity of the nutrient solution.
- TDS meter – Used for the determination of total dissolved solids (TDS) in nutrient solution [7].
- Water level sensor – used to measure water level i.e. high, medium and low.
- Water tank – used to store nutrient solution.
- Other – Thermometer, relative humidity measuring device, sensors etc.

Preparation of nutrient solution and its management:

Table -1 The average concentration of plant nutrient in plant solution (in ppm = parts per million)

Sr. No.	Nutrients	Concentration (PPM)
1.	Nitrogen (nitrate form)	70-300
2.	Nitrogen (ammonium form)	0-31
3.	Potassium	200-400
4.	Phosphorous	30-90
5.	Calcium	150-400
6.	Sulphur	60-330
7.	Magnesium	25-75
8.	Iron	5-5.0
9.	Boron	1-1.0
10.	Manganese	1-1.0
11.	Zinc	2-0.2
12.	Molybdenum	1-0.1
13.	Copper	2-0.2

Source:[7] Singh, D., 2013.

Farmer can prepare nutrient solution using completely water soluble nutrient salts. In present various formulations are available in market which is used by farmers. Table 1 show how much concentration is required of nutrients in nutrient solution where the table 2 show that which fertilizer is compatible with other. Table 3 show a nutrient formulation which is recommended by United States Department of Agriculture. In this mixture various fertilizer salts can mix in proposed manner and solution will be prepared.

Table -2 Compatibility chart for different fertilizers for hydroponics

Soluble fertilizers	AN	AS	CAN	MAP	SOP	MOP
Ammonium nitrate	-	C	C	C	C	C
Ammonium sulphate	C	-	L	C	C	C
Calcium ammonium nitrate	C	L	-	X	C	C
Mono ammonium phosphate	C	C	X	-	C	C
Potassium sulphate	C	C	L	C	-	C
Potassium chloride	C	C	X	C	C	-
Gypsum	X	X	X	X	C	C
Potassium nitrate	C	L	C	C	-	C

C = compatible (can be mixed), L = limited compatibility, (mix at the time of use or some precautions must be taken) X = incompatible (cannot be mixed)Source:[7] Singh, D., 2013.

Table -3 Nutrient formula recommended by the United States Department of Agriculture

Sr. No.	Fertiliser Salt	Gram (gm)	Quantity in Ounces	Nutrient Elements Supplied
1.	Ammonium sulphate	43	1½	Nitrogen, Sulphur
2.	Potassium nitrate	255	9	Nitrogen, Potassium
3.	Monocalcium phosphate	113	4	Phosphorus, Calcium
4.	Magnesium sulphate	170	6	Magnesium, Sulphur
5.	Calcium sulphate	198	7	Calcium, Sulphur
6.	Iron sulphate	Enough to cover the nail of your little finger		Iron

Source:[11] Jana, B.L., 2019.

Carefully manipulating the nutrient solution pH level, temperature and EC, when required to change nutrient solution than can be replace. Inappropriate management of nutrient solution can damage the plant and destroy them. The strict nutrient management programme can lead to a successful hydroponic garden.

Suitable crops for hydroponic culture:

T. Eastwood a scientist in the International Hydroponic Work in 1947. He recommended a list of vegetable and salad crops which is well suited for household soilless culture. The recommend

list is following-Tomatoes, Cucumbers, Green beans, Brinjal, Sweet pepper, Radish, Green onions, Lettuces, Chinese cabbage greens, Spinach, Mustard greens, Celery, Turnip greens [11].

But nowadays more crops can be growing in hydroponic. The other crops which are suitable for hydroponic that is Asparagus, Beetroot, Chicory, Leeks, Lettuce, Water melon, Musk melon, Bhindi, Onion, Peas, Potato, Yam, Sweet potato, flower etc.

Figure 8: Vertical model of Hydroponic

Figure 9: Pak-choi production in hydroponic

Figure 10: A frame model of Hydroponics

Figure 11: Horizontal hydroponic model and Tomato production

Figure 12: Lettuce cultivation under hydroponic

Figure 13: Cabbage production in hydroponic

Yield effecting factors:

Some factors play a major and important role in increasing yield in hydroponics. The factors are following-

1. Year–round production – it is most important factor. Due to controlled environment condition it provide facility to produce crop year-round intend field crops. Its result that crop yield increase per year by a factor of 2x to 8x.

2. Higher plant density – In hydroponics plants grow vertically, more closely and in layers so plant density increase by a factor of 4x to 16x and it directly related to yield.

3. Choose of crops – Crops and its variety influence hydroponics yield. In hydroponics leafy crops give better result than herbs. Watermelons and strawberries production more challenges, but some attention gives better result. Tomato, pepper and cucumber give high yield in hydroponics. Choosing crop and its variety, hydroponics can increase yield 2x – 4x over soil cultivation.

4. Proper lighting – Plant required light for photosynthesis. Blue light (around 430 nm) and red light (around 660 nm) responds photosynthesis. Good lighting increase yield 1x – 2x in hydroponics.

5. Water – it is most important factors which influencing crop yield. The water-weight of fruits is 86% and in vegetables is 90%. Hydroponics manages water more efficiently and increases in yield 1x – 2x.

6. Fertilizer efficiency – In hydroponics fertilizer mixed in water and prepared nutrient solution which is directly feed to the plant's root. In soil grown crop it is not possible. Proper and efficiently use of fertilizer increase yield by a factor of 1x to 2x in hydroponics.

7. Managed temperature and CO_2 – Most of plant species grow best in the temperature 75ºF to 85ºF and if more CO_2 present in air than plant grow faster than normal condition. Ideal levels of temperature and carbon dioxide enrichment both increase yield in hydroponics crops by a factors 1x – 2x.

8. Other factors – humidity, pollination, pest, disease, storms and bed weather influenced growth in open field but in hydroponics all factors is controlled and pest and disease can be eliminated. So all this factors increase yield by 1x – 2x in hydroponics.

When we are multiplied all the factors together than yield of hydroponics increase 100 times than open field cultivation [12]. It is show that how hydroponics is better than traditional cultivation system and give high yield.

Yield :

Hydroponics system provide all favourable condition for crop growth so crop grow fast and start production earlier than field crops. When crop mature earlier and come in market before coming of local cultivated crop production they get high price in market.Hydroponics have also high yield than normal cultivation so it increase farmers income. Hydroponics cultivated crop have good quality

and disease or pest freeso it increase self-life of vegetables and other crops. It provides high income than normal cultivated crops.Table 4 show that crop growing in hydroponics give very high yield compare to agricultural crops.

Table- 4 comparison of higher crop yield of hydroponics over soil cultivated yield per acre

Crop	Crop yield in soil per acre	Crop yield in hydroponics per acre
Soybean	600 lb	1,550 lb
Beans	5 tons	21 tons
Peas	1 ton	9 tons
Wheat	600 lb	4,100 lb
Maize	1,500 lb	7,000 lb
Rice	1,000 lb	5,000 lb
Oat	1,000 lb	2,500 lb
Beets	4 tons	12 tons
Potatoes	8 tons	70 tons
Cabbage	13,000 lb	18,000 lb
Lettuce	9,000 lb	21,000 lb
Tomatoes	5 – 10 tons	60 – 300 tons
Cucumbers	7,000 lb	28,000 lb

Source:[12]www.indianhydroponics.com

Advantage of hydroponics:

1. This technique is not need soils. We can grow crops easily where the land is limited or heavily contaminated.

2. Better use of space :- Generally plant's root expand and spread out in search of food and oxygen in the soil but in hydroponics roots are sunk in the tank of oxygenated nutrient solution and directly contact with vital minerals. So we can able to grow plants closer.

3. In hydroponic we have totally control climate like temperature, humidity, air composition, light intensification. So we can grow food entire year without season and have an opportunity to maximize our profits.

4. Plant can grow in hydroponic use only 10% water and save up to 90% water as compared to field grow crop. Plant take necessary water and extra run-off collected in reservoir and water can be recirculate.

5. In hydroponic fully control and need based plant nutrient can be provide to plant. Before planting we can able to calculate that which specific stage plant required in which amount nutrient. Nutrients are safely stored in the tank and not change or loss like soil.

6. All the plant nutrients and minerals are present in the water. That means we can more easily

adjust the pH of water as compared to soil.

7. In hydroponics plants have an ideal condition for growth. Plants not waste their energy on searching food and maintaining the balance with environment. It means plant's full focus on growing and production. So plants grow faster than normal plant.

8. Hydroponics crop have no problem of weed because mostly weeds are associated with soil.

9. Soil-borne disease and pest can be easily controlled. Indoors cultivation provide better opportunity of controlling disease and pest.

10. Hydroponics saves time and labour on various fields like tillage, weeding, irrigation, spraying [14].

Disadvantage of hydroponics:

1. Diseases and pests may spread quickly – in hydroponics plants grow in closed system using water. In the case of plant disease or pest they spread quickly on the same nutrient reservoir. Another risk is the water-based microorganisms.

2. Water and electricity both are used in hydroponics so beware to electricity in combination with water.

3. System failure threats – whole system is depended on electricity. So if power is cut than system stop his work and plants may be start dry out quickly and will die in several hours.

4. Experience and technical knowledge – proper manage of hydroponics required Experience and technical knowledge

5. Initial expenses – to setup hydroponics it required to purchasing various types equipment and it have high cost. Once you can setup the system than cost will be reduced because after than only nutrient solution and electricity expenses will be generated [14].

Conclusion:

The description made in chapter highlights the hydroponics and its components. It is describing the techniques of hydroponics and how to use it. Hydroponic is a young science and it having capacity to fulfil the demand of growing population because in hydroponics we are able to grow more crop per unit area than open field. Hydroponics give better yield compare to field crop and crop growth is faster than traditional method. Hydroponicscommercially use started before 40 years ego. It has some limitation but include much more benefit than limitation. It has a best source of income. Carefully maintenance, observation,experienceand technical knowledge is a main component of a successive hydroponics system. It is good business or source of income for innovator and young educated people who searched job.

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