*Eco. Env. & Cons. 30 (February Suppl. Issue) : 2024; pp. (S314-S324)*
*Copyright@ EM International*
*ISSN 0971–765X*

**DOI No.: http://doi.org/10.53550/EEC.2024.v30i02s.064**

# Hydroponics: A Review

**Aishwarya Digvijay Mohite*[1] and G.R. Pathade[2]**

***[1]Krishna Institute of Allied Sciences (KVVDU),***
***Krishna Institute of Allied Sciences (KVVDU) Karad, M.S., India***

(Received 2 July, 2023; Accepted 7 September, 2023)

**ABSTRACT**

It is extensively recognised that environmental problems such as soil declination affect numerous agrarian lands. These problems have been caused due to soil quality decline, crop yield reduction, profitable extremity, poverty, severance, and pastoral civic migration. In traditional husbandry, crops require a lot of space (growing area), consume a large amount of water, absorb a small amount of nutrients from the soil, and are fully dependent on meteorological conditions. Thus, growing crops in this way entails high costs and a high threat to invested finances. The nonstop stoked demand for food products is rising with the increase in world population. The traditional husbandry system won't be suitable to cover the world's imperative demand for food. One of the measures to reduce these factors is the use of hydroponics. Hydroponics is a system of growing plants in a water-grounded, nutrient-rich environment. Hydroponics will be a better way to produce different kinds of fruits, vegetables, and fodder, as well as meet the global nutrition demand in the future. The quality of yield, taste, and nutritional value of end products produced hydroponically are generally higher than those produced in natural soils. This civilization is cost-effective, complaint-free, eco-friendly, and gaining fashion ability all over the world, in both developed and developing countries. In the future, hydroponics could be a way of supplying food to the world's population.

***Key words:*** *Hydroponics, Soli, Food, Traditional.*

## Introduction

Hydroponics is a technique of growing plants in nutrient solutions (water containing fertilizers) with or without the use of an inert medium (sand, gravel, vermiculite, rock wool, perlite, peat moss, coco peat, pebbles) to provide mechanical support (Swain *et al.,* 2021). The term 'hydroponics' is derived from two Greek words i.e., "Hydro" and "Ponos" means water and labour respectively. The first ultramodern use of hydroponics was done by W.F. Gericke from the University of California during the 1930's. In India, Hydroponics was introduced in year 1946 by an English scientist, W.J. Shalto Duglas. He established a laboratory in Kalimpong area, West Bengal and had written a book on Hydroponics, named as 'Hydroponics- The Bengal System' (Pant *et al.,* 2018) It is a more rational use of water resources, to provide better opportunities for a sustainable food supply in different countries. It offers the ability to reuse and recycle water and nutrients, environmental variability control, higher production and successive yield prevention of soil-borne diseases as well as pests compare to soil farming.According to hydroponics user continuous production is possible only through hydroponic systems that is production round the year and in a short growing period, less space, and plants can be produced at any place, i.e., in smalls paces with a controlled growth environment. Hydroponics user often reply that hydroponics always allows them to have higher productivities and yields without constrains of climate and

([1]Research Scholar, [2]Dean)

weather conditions and disease free. Various commercial and special crops can be grown using hydroponics including leafy vegetables, spinach, broccoli, various fruits tomato, cucumber, pepper, strawberry, water melon, ornamental flowers and many more. Europe is considered the biggest market for hydroponics in which France, the Netherlands and Spain are the three top producers, followed by the United States of America and Asia-Pacific region (Prakash *et al*., 2020). Due to the population explosion, urbanization and industrialization, the cultivable land area is declining day by day. The conventional methods of farming are also facing several challenges due to abnormal climatic behaviours. So that, new and modern methods for growing sufficient food have to be evolved in order to feed the world's growing population sustainably. Change in growing medium and nutrients can be an alternative approach for hydroponic crop production and conservation of quick depleting land and available water resources. That's why this 'hydroponics' systems becoming increasingly spired over the world and according to the most recent report, it is expected to reach a world growth of 18.8% from 2017 to 2023, corresponding to a global hydroponic market USD 490.50 Million by 2023 (Jan *et al.,* 2020).

**Media used for hydroponics**

There are various types of organic and inorganic media in hydroponics systems which acts substrate for plants to hold the plants,good water holding capacity, source of nutrients and to supply gases to plant.

**Media**

**Cocopeat**

It is also known as coconut coir, coir dust. It is by product of coconut. Generally, cocopeat contains high K, Na, and EC but the concentrations vary with sources it is used in soil less farming to grow various vegetables crops as well as fruits without any harmful impact. The high water holding capacity provides moisture to the plant roots (Karne *et al*., 2023).

**Rockwool**

Rockwool is a sterile, porous, non-biodegradable material made mostly of granite or limestone heated to a high temperature, melted, and spun into tiny threads. Following this, rockwool is cut into blocks, sheets, cubes, slabs, or flocking. Because rockwool readily absorbs water, it is necessary to avoid letting it become saturated as this could suffocate the roots of your plants and cause stem and root rot. Before use, rockwool needs to be pH balanced (Karne *et al*., 2023).

**Perlite**

Perlite originates from a silicone mineral which forms in volcanos and is very light in weight. It holds more air and less water and it is a fusion of granite, obsidian, pumice and basalt (Macwan *et al*., 2020).

**Sand**

Sand is commonly used as growing media used in hydroponics. It is very useful like rock, just smaller in size. As the particle size is smaller and finer than regular rock so there is no chance of quick drainage of moisture. Sand is also commonly mixed with Vermiculite, perlite or coco coir. It helps retaining moisture as well as helps in aerating the mix for the roots (Swain A *et al.,* 2021).

**Vermiculite**

It is hydrated magnesium aluminium silicate. Vermiculite is a micaceous mineral produced by heating to approximately 745ºC the expanded, plate-like particles, which are formed, have a very high water holding capacity and aid in aeration and drainage. Vermiculite has good exchange and buffering capacities as well as good ability to supply not only potassium but also magnesium. Though vermiculite is considered as less capacity to hold moisture than sand and perlite, its chemical and physical properties are very desirable for container media (Swain *et al.,* 2021).

**Nutrients**

The basic principles for vegetable and fruit production, both in soil and in hydroponic systems, is to provide nutrients as per plant needs. Some chemical elements are essential for growth of plants. Plants are cultivated in highly oxygenated, nutrient enriched water and disease free without the use of soil. There can be a significant difference in the cost, purity, and solubility of the chemicals comprising a nutrient solution, depending on the grade (pure, technical, food, or fertilizer) used. Smaller operations often buy ready-mixed nutrient formulations to which only water need be added to prepare the nutrient solution. Larger facilities prepare their own solutions to standard or slightly modified formula. A complete description of nutrient solution formula, mixing, etc., is in an article published by Jensen and Collins in 1985. In all hydroponic systems nutrient elements are mixed in specific solutions and in the amounts and proportions required by various plants. Nutrients play a key role in the quality and productivity of vegetables and fruits. Thus, the balanced application of nutrients is vital in determining the quality of the product (Khan *et al.,* 2020).

**Hydroponic systems**

There are different types of hydroponics set up to grow different types of plants according to vegetables, leafy vegetables, gardening, fodder, fruits, flowers, medicinal plants as well as exotic species of crops. All of these systems have some common components (pump, frame, piping, etc.), regardless of the method used to feed the plants. Cultivation media can be any that can support plant growth and development, such as various fibres, minerals, solutions, and composites, but the soil is not considered a hydroponic culture medium.

**Nutrient film technique (NFT)**

Nutrient Film Technique (NFT) is a hydroponics system, where the plant roots are directly exposed to the thin film of (thickness 0.5 mm) nutrient solution flowing through the channel. The channel is made of flexible PVC or plastic sheet on the top of which seedlings with growing media inside tailor made pots are anchored properly. The growing media absorbs the nutrient solution though the porous root system of the plant. The length of channel varies from 5-10 meter kept at the slope of 1 in 50 to 1 in 70. The flow rate of nutrient solution is 2-3 litters per minute and its salt concentration is monitored at regular interval through the important indices like EC, pH and TDS (Hasan *et al.,* 2018).

**Advantages**

- Constant movement of the solution in the irrigation system prevents it from stopping;
- The only hydroponic system that is effective in forage growing;
- No parts that could clog;
- Low cost of nutrient solution (Grigas *et al*., 2019)

**Disadvantages**

- Due to the tilt angle of the growing tray, the germinated seeds flow downwards during irrigation;
- With the low irrigation flow rate, the top layer of germinated seeds may not be adequately wet.

**Deep flow technique (DFT)/pipe system**

In this technique, 2-3 cm deep nutrient solution flows through PVC pipes to which plastic net pots with plants are fitted. The plastic pots contain planting materials and their bottoms touch the nutrient solution that flows in the pipe. Pump, tanks, valves, timers and other accessories including nutrient monitoring system are placed over the floor of the protected structure. PVC pipes are arranged in single horizontal plain or in multiple zig-zag vertical plain (Hasan *et al.,* 2018). Other than these there are methods which are also used in hydroponics system like root dipping technique, floating technique and aeroponics techniques etc (Agrawal *et al.,* 2020).

**Advantages**

- Ideal for soaking-loving, short growth cycle plants;
- Allows the plant to grow a large root mass;
- Relatively fewer plants are grown but their yield is higher;
- Low system installation costs. (Grigas *et al.,* 2019)

**Disadvantages**

- Required growing medium
- With this system, plants are prone to root diseases;
- Root mass can grow so large that clog irrigation cavities;
- The system is completely inadequate for efficient feed production (Grigas *et al*., 2019)

**EBB and flow method**

This system works on the principle of flood and drain. In this system, the nutrient solution is pumped from a reservoir into the growing medium, flooding it with solution for a short period and then the nutrient solution is allowed to flow out of the rooting medium back into the reservoir. This outflow of nutrient solution from the growing medium draws air into the rooting bed, providing a source of $O_2$. From the moist rooting medium, plants are able to obtain water and nutrient elements. Again, in such a system of nutrient solution delivery, the roots experience a changing environment, which may not be ideal for best plant growth and development, although plant performance is usually satisfactory with this hydroponic technique. In this system, the problem of root rot, algae and mould is very common therefore, some modified system with filtration unit is required.*(Swain et al., 2021)*

**Advantages**

- Nutrient solution can be reused;
- Reduce the likelihood of the presence of pathogens in feed;
- Evenly germinating all spread seeds;
- Low production costs (Grigas *et al.,* 2019)

**Disadvantages**

- Salt and mineral deposits can easily form in the culture medium;
- Germinated seeds clog the overflow valve;
- Growing trays cannot be removed for more convenient washing (Grigas *et al*., 2019)

**Wick system**

In the Wick system, the root of the plant is fed by a strip of porous material that is immersed into a liquid that is capillary fed to a tray, jar or other absorbent medium. Typically, for efficiency purposes, such systems employ multiple irrigation strips to ensure sufficient water or nutrient supply to plants. The system itself is usually installed at a minimum distance above the feed solution tank. In this case, the solution does not need to be delivered very far to reach the plant (Semananda *et al.,* 2018). The irrigation strip ("wick") is the most important part of this system because without good water absorption, plants will not be able to get the right amount of moisture and nutrients. When manufacturing such systems, it is usually advisable to test several materials to determine which material strips are most effective to use.Selecting a tank for such a system is the easiest task. The efficiency of the system is not directly dependent on the nutrient solution reservoir, but it is important to keep in mind that the water level in the reservoir is always high enough for the nutrient solution to reach the growth medium and root area. It is also important to periodically replenish the tank with nutrients or completely replace the nutrient solution with a new one. This is usually done in order to prevent algae and / or microorganisms from growing on the water, especially if the tank is not exposed to direct sunlight. This system is not suitable for forage production due to less efficient seed feeding (Grigas *et al*., 2019).

**Advantages**

- The system requires little maintenance.

**Disadvantages**

- The system is not suitable for plants that require a lot of nutrient solution;
- High system installation costs;
- Difficult to apply to vertical cultivation;
- The system is not suitable for production due to less efficient seed feeding (Grigas *et al*., 2019)

**Aeroponics**

Growing plants by humidifying the air in the root area of the plant is called aeroponics or growing plants by spraying the roots with an aerosol of nutrient solution. This concept and idea of growing plants in the air by feeding them from the environment is not very old. For scientists, the idea came from observing plants growing on rocks near a waterfall. They observed that the plants had successfully grown in rocks near waterfalls, although their roots were hanging in the open air (Lakhiar *et al.*, 2018).

Instead of immersing the roots in water as in the ebb and flow system the roots are moistened at intervals by spraying the nutrient solution with high pressure nozzles. This type of irrigation and nourishment provides high levels of dissolved oxygen and nutrients to plant roots. Unused water and nutrients are easily returned to the nutrient solution tank, from which the nutrient solution is used for re-irrigation (Lakhiar *et al.,* 2018).

**Advantages**

- High oxygen content for plant roots.
- Faster plant growth.
- Reuses the nutrient solution.

**Disadvantages**

- High pH fluctuations.
- The system is completely structurally unsuitable for forage production;
- Common root diseases;
- Nozzles often clog;
- The root should be watered frequently, which means that there is arisk of root drying out (Grigas *et al*., 2019)

**Parameters need to be controlled in hydroponics**

The key factor of rick in hydroponics is controlled environment agriculture for growth and development of plant. The optimal plant growth depends on parameters which are temperature of water air, water quality, air quality, humidity, media, nutrient level, air flow, water flow, $co_2$ sunlight or light intensity, diseases of crops and controlling these parameters is the major challenge with hydroponics systems.

### Artificial Sunlight-Light Intensity (Light Emitting Diode (LED) Lights)

Light quality plays a noteworthy part in the appearance and yield of food plant species. Studies on indoor farming using LED as a light source for plant photosynthesis had turned out to be high because of the uncertainty of climate and pest mortality. In an indoor farming system compared to conventional sources of lights, LED lights have been proven to be the most efficient and one of the finest techniques to reduce power consumption. LED lighting appliances are more proficient compared to the lighting sources used in conventional lights generally in agriculture. This enables light spectrum and intensity modulations to improve the light utilizes effectiveness for plants (Cocetta *et al.,* 2017). By fluctuating the light radiating from the distinctive shading LEDs the temperature, as well as the spectrum of the light, can be controlled and optimized for plant growth.

### Total dissolved salts (TDS)

TDS is an essential parameter for maintain optimal plant growth and overall system health. TDS provide information about nutrient concentration and can help to maintain nutrient level. The conductivity of the nutrient solution in terms of parts per minute (ppm) was analysed using Total Dissolved Salts [TDS] sensor at a prototype-scale.

### EC and pH Level

The growth of plants is totally depends on EC and pH. The pH is a measure of acidity or alkalinity on a scale of 1 to 14. In a nutrient solution, pH determines the availability of essential plant elements. The optimum pH range for soilless culture nutrient solution is between 5.8 and 6.5. The further the pH of a nutrient solution from recommended pH range, the greater the odds against the success. Nutrient deficiencies will become apparent or toxicity symptoms will develop if the pH is higher or lower than the recommended range for individual crops (Prakash *et al.,* 2020).

EC (dS $m^{-1}$) value is accurately calculated based on the aggregate of Ion concentration which can be effectively measured using EC meters which is highly influenced by temperature. The plant growth was adequately tested across several EC treatments from lower to higher range which influenced the profound effect of photosynthesis effect on leaves and its biomass. The range between 1.8- 2.4 EC treatment has yielded with better quality crop (Srivani *et al.,* 2019).

### Temperature

Although the light dependent reactions of photosynthesis are not affected by changes in temperature, the light independent reactions of photosynthesis are dependent on temperature. They are reactions catalysed by enzymes (Kume *et al*., 2018). In greenhouse, apart from light, air temperature is also the main environmental component influencing vegetative growth, cluster development, fruit setting, fruit development, fruit ripening, and fruit quality. The average 24-hour temperature is believed to be responsible for the growth rate of the crop-the higher the average air temperature, the faster the growth. It is also believed that the larger the variation in day-night air temperature, the taller the plant and the smaller the leaf size. Although maximum growth is known to occur at a day and night temperature of approximately 25 $^{o}$C, in general maximum fruit production is achieved with a night temperature of 18$^{0}$C and a day temperature of 20 $^{o}$C. The difference (DIF) between day temperature (DT) and night temperature (NT) influences internode length, plant height, leaf orientation, shoot orientation, chlorophyll content, lateral branching and petiole and flower stalk (khan *et al.,* 2020). As the enzymes approach their optimum temperatures the overall rate increases. It approximately doubles for every 10$^{0}$C. increase in temperature. Above the optimum temperature the rate begins to decrease, as enzymes are denatured, until it stops in this way, temperature plays an important role on the vegetative, and photosynthetic activity of the plants. It affects the plant growth either by increasing or decreasing the rate of different plant process as photosynthesis, respiration, and transpiration. The maximum activity is obtained between 21-27$^{0}$C day temperatures under greenhouse for most of the vegetables (Kawasaki and Yoneda, 2019)

**Humidity**

There exist different variations in determining humidity which is relative, specific and absolute humidity. Generally, the plant growers consider relative humidity (RH) which measures the content of moisture in the air. One of the case studies carried out by Nebula and Sirius for growing cannabis in hydroponic culture demonstrates that the optimal relative humidity during clones rooting can be 70-80%. During the transition from germination to vegetative phase the RH values is 40-60% and during blossoming phase the RH 40-50% (Srivani *et al.*, 2019).

**Aeration for the Roots**

In order to absorb water and nutrients, the roots require a certain amount of oxygen. Plants do not grow well in water logged soil devoid of air space and most plants do not grow well in water culture unless provision is made to aerate the solution by circulating it or by bubbling air into it. The solubility of O2 in water is quite low (at 75° F about 0.004 per cent) and decreases significantly with increase in temperature (Pant *et al.*, 2018).

**Advantages of hydroponics**

Hydroponics is a crop system that makes plants grow in nutrient –rich water solution this latest trends in smart farming.

**Suitable Plant Species Cultivation**

A suitable environment for improved crop production is sheltered cultivation or hydroponic greenhouse cultivation. It is possible to grow cereals, vegetables, fruits, fodder crops, flowers, spices and medicinal plants in hydroponic greenhouses the quality of the hydroponic products, as well as their taste and nutrient composition, often were better than those in conventional soil-based cultivation. Various experimental findings show that leafy vegetables (lettuce, spinach, parsley, celery and Atriplex, etc.) can be grown comparatively easily and successfully using hydroponic systems (Sharma *et al.*, 2018).

**Choice of Growing Medium**

The choice of material to be used as substrate depends on the plant species to be grown. Therefore, the properties of growing media have to meet the requirements of plant production, which in turn, are determined by plant biology and the cultivation method. Of course, costs also play an important role (Fussy *et al.*, 2022).

**Control of Pathogens**

The application of pesticides is generally reduced in hydroponic systems. With fewer pest problems and the constant feeding of nutrients to the roots, productivity in hydroponics is high, despite the limited plant growth that could occur due to low levels of carbon dioxide in the atmosphere or limited light supply in closed and sub-optimally ventilated environments (Fussy *et al.*, 2022).

**Less space**

The limited space requirement increases the advantage of hydroponic because it can be installed in terraces, balconies and courtyards. Therefore, it gives a great opportunity for the production of fresh crops in urban areas too also as it also maximizes space saving so that it is possible to store in areas that are normally unusable (Devvrat *et al.*, 2018). Hydroponic gardens can produce the same yield as soil gardens in about 1/5 of the space. This is a major space savings which makes it possible for a civilization to produce more for people by using less space.

**Better growth rate**

If you give a plant exactly what it needs and when it needs, the plant is likely to grow as healthy as genetically possible. In hydroponics, this is exactly the case as it is very much possible to create an artificial environment with the addition of a light or air conditioning in an area enclosed between four walls. As the environment created will be suited best according to the different plant's needs, they will give better results in terms of turning out to be fresher, greener and tastier to eat (Qureshi *et al.*, 2017).

**Conservation of water**

It requires just 2- 3 litres of water to produce one kg of lush green fodder, as compared to 60-80 litres to conventional system of fodder production (Jan S *et al.*, 2020).

**More palatability**

Hydroponically grown fodder is more succulent, palatable and nutritious as compared to conventionally grown fodder and this results in more milk and meat production (Ramteke *et al.*, 2019).

**Reduced labour requirement**

Continuous intense labour for cultivation of fodder is required in conventional fodder production, but in hydroponics labour required is 2- 3 hours / day only (Jan *et al.,* 2020).

**Economics**

Operations in hydroponics are simpler than those required in traditional farming. In this sense, conventional practices require many effort preparations before sowing, costly fertilizer, including the cost of heavy machinery and specialized equipment, which eventually may come through a rental of the same. In other aspects, hydroponics may require more dedication, commonly needing a set of sensors and devices for a precise follow-up of the crop condition.

**Disadvantages**

- High initial cost. The initial investment in a hydroponic system is relatively high due to the cost of required raw materials and equipment for the operation.
- Highly trained labor. Large-scale hydroponic operations require personnel with deep knowledge of agriculture, plant physiology, chemistry, and sophisticated control and information systems.
- Environmental pollution. If the residual nutrient solution is not properly disposed of, the discharged solution, enriched with phosphorus and nitrates, can generate excessive growth of algae and other microorganisms in bodies of water and effluents, creating serious environmental problems (Velazquez-Gonzalez *et al.,* 2022).

**Challenges with Controlled Environmental Agriculture System**

The challenges with conventional agricultural practices are confronted by true indoor farming agricultural systems by being more efficient with time, resources, space, energy and being more ergonomic and conducive for easier and faster cultivation of plants. Due to urbanization and industrialization cultivational land is decreased. The major concerns include financial sustainability, production management, time management, water conservation and recycling, wastewater management, Energy and climate (Srivani *et al.,* 2019).

**Power Optimization**

For a hydroponics system power optimization is to be considered as a major challenge when the photosynthesis of plants is made possible in hydroponic system using artificial light without sunlight. life support system with controlled environmentfor hydroponic plant production. Reducing the consumption of power to maximize plant growth can be achieved using various methodologies in Artificial intelligence.

**Energy Saving**

It is one of the challenges that have to be considered with indoor Hydroponics. The countries which are deprived of natural sunlight, make use of numerous hydroponic solutions by utilizing artificial light as an alternative to grow at indoors and outdoors. The source of lightning is through LEDs. The LED light treatment influences the growth of plants and shortens the period of harvesting. The cost-effective LED lighting frameworks require an accurate design, implementation and management practices to acquire the best performances in the system (Cocetta *et al.,* 2017). In future studies with respect to smart lighting systems are required for hydroponic system. Energy saving with artificial lightning still remains a huge challenge for developers.

**Water recycling**

In this soil-less culture, the plants are more dependent on water and nutrient solution. A lot of studies have been done to increase the efficiency of water conservation and recycling in closed systems which is a top priority in the today's need. The researchers are studying the reuse of the Hydroponic waste solution to grow vegetables and fruits which can re-

**Table 1.** Comparative concentration ranges of macronutrients (mM) in soil and soilless crops (Khan *et al.,* 2020).

| Sr. No. | Nutrients | Soil (mM) | Hydroponics (mM) |
|---|---|---|---|
| 1 | N-$NO_3$ | 0.5-10 | 5-20 |
| 2 | N-NH4$^+$ | 0.02-0.05 | 0.5-2 |
| 3 | P($H_2PO_4$-) | 0.0005-0.05 | 0.5-2 |
| 4 | $K^+$ | 0.2-2 | 5-10 |
| 5 | $Ca^{2+}$ | 0.5-4 | 3-6 |
| 6 | $Mg^{2+}$ | 0.2-2 | 1-2 |
| 7 | S ($SO^{2-}$) | 0.1-2 | 1.5-4 |

Source: (reworked by Epstein 1972; Marschner 1996) duce the water consumption. The use of _wastewater for agricultural irrigation has more potential, especially when incorporating the reuse of nutrients like nitrogen and phosphorous, which are essential for crop production. Among the current treatment technologies applied in wastewater reuse for agriculture, hydroponic system is identified as one of the alternative technology that can be integrated with wastewater treatment. The integration of hydroponic system with municipal wastewater treatment has the advantage of reducing costs in terms of pollutants removal while reducing maintenance and energy costs required for conventional wastewater treatment. resulting to increased food security and environmental protection. Moreover, the suitability of hydroponic system for wastewater treatment is derived from its capacity to minimize associated health risks to farmers, harvested crop and consumers, that may arise through contact with wastewater (Magwaza *et al.*, 2020).

**Pest Management**

With conventional farming, the plants are exposed to air and soil-borne pathogens, disease and pests due to several environmental factors. However, in hydroponic, plant grow without soil pest management system has to be adopted. The use of organic pesticide and chemicals may help in effective pest management, which has a more enormous benefit to the health and quality of crops. Benefitis come out with hydroponic solutions to grow pesticide-free plants. Effective measures have to be considered to optimize the health of plants grown with hydroponics. The focus is on pesticide-free farming or minimal and safe use of pesticides. One of the challenges with hydroponic is that there is threatening for the feasibility of plants by pathogens that harm the plant growth food, and fungal infections, however, exist With the use of several beneficial bacteria that can control the Phyto-pathogens, quality and quantity can be improved (Srivani *et al.,* 2019).

**Conservation of Biodiversity**

One of benefit of hydroponics is that it makes a major contribution to balancing the ecosystem by maintaining biodiversity. In urban areas, human activities have disturbed the biological ecosystem, including the habitat of several flora and fauna species. It has changed ecological patterns, increased environmental pollution, and changed natural processes The reduction in biodiversityresults in decreased natural resources and disturbed nutrients and water cycling.

**Hydroponics *Vs* traditional farming**

Soil is generally the most available growing medium for crops. It provides harbourage, nutrients, air, water, etc. for successful factory growth still, soil does pose serious limitations for factory growth too, at times. Presence of complaint- causing organisms and nematodes, infelicitous soil response, unfavourable soil contraction, poor drainage, declination due to corrosion etc. are some of them. In addition, conventional crop growing in soil (Open Field Agriculture) is kindly delicate as it involves large space, lots of workers and water. also, some places like metropolitan areas, soil isn't available for crop growing at each, or in some areas, we find failureof rich cultivable pastoralist lands due to their unfavourable geographical or topographical conditions. Of late, another serious problem endured since is the difficulty to hire workers for conventional open field husbandry. Under similar circumstances, soilless culture can be introduced successfully. Hydroponic husbandry offers numerous advantages when compared to conventional husbandry. One of the main advantages is that crops can be grown in places with barren or polluted land. Hydroponically grown crops are also more resistant to water with a high swab content. Another advantage includes not having insects, creatures, and conditions similar as fungi formerly present in the growing medium. Workers needed less as compare

**Table 2.** Major elements and micronutrients needed also their concentration range in most nutrient solutions (Khan *et al.,* 2020).

| Sr. No | Elements | Ionic form | Concentration range mg/l or ppm |
|---|---|---|---|
| 1 | Nitrogen(N) | $NO_3^-$, $NH_4^+$ | 100–200 |
| 2 | Phosphorus (P) | $H_2PO_4^-$ | 30–15 |
| 3 | Potassium (K) | $K^+$ | 100–200 |
| 4 | Calcium (Ca) | $Ca^{2+}$ | 200–300 |
| 5 | Magnesium (Mg) | $Mg^{2+}$ | 30–80 |
| 6 | Sulfur (S) | $SO_4$ | 70–150 |
| | Micronutrients | | |
| 1 | Boron(B) | $BO_{3-}$ | 0.03 |
| 2 | Copper (Cu) | $Cu^{2+}$ | 0.01–0.10 |
| 3 | Iron (Fe) | $Fe^{2+,}$ $Fe^{3+}$ | 2–12 |
| 4 | Manganese (Mn) | $Mn^{2+}$ | 0.5–2.0 |
| 5 | Molybdenum (Mo) | $Mo^{2-}$ | 0.5 |
| 6 | Zinc (Zn) | $Zn2^+$ | 0.5–0.5 |

traditional husbandry to manage system. hydroponic husbandry, needs only 25 percent essential rudiments set up in soil grounded diseases. Since shops don't have to contend for girding soil space for nutrient reserves, further shops can be grown using lower space in a hydroponic system. Distance is limited only by the quantum of available light. shops also grow important faster and bigger in hydroponic systems. thus, hydroponic systems have advanced yields per unit area when compared to traditional husbandry (Khan *et al.,* 2020).

**Impact of COVID 19 on agriculture**

The outbreak of the global coronavirus (COVID-19) pandemic posed a significant threat to health with a ripple effect on various sectors impacting human life. The virus rapidly spread and affected economies thus bringing out inefficiencies in both the agriculture and industrial sector resulting in food insecurity (Jámbor *et al.*, 2020). With the ongoing COVID-19 pandemic, the agriculture sector is facing huge challenges in satisfying the increasing demands for food. Factors like health and nutrition-based foods, improving safety, poverty reduction, and environmental sustainability have been of vital importance since the disease outbreak (Christiaensen and Martin *et al.,* 2018; Chatterjee *et al.,* 2020).

The use of eco-friendly diseases and other natural druthers may enhance crop productivity and replace dangerous chemicals. still, these products are precious and take months to deliver to the request. In recent times, there has been a promising approach toward sustainable husbandry and husbandry to deliver better health and profitable issues. The study outlines the strengths, openings, pitfalls and implicit business pitfalls and provides an expansive summary of the influence of COVID- 19 on the global request situation. Hydroponics refers to an agrarian process, similar as a mineral nutrient and a water result, used to grow shops in a soil-free medium. In a particular climate, crops have historically been cultivated, but in hydroponics, they're cultivated in a controlled terrain. Hydroponics uses two styles, Due to advanced yields from hydroponics, hydroponics is gaining instigation in the global husbandry request. In addition, by furnishing controlled environmental conditions, the civilization of crops by hydroponics removes the effect of external environmental factors on crop development. The strain on natural coffers, similar as land and water, is also minimised by hydroponics because it needs little inner space and the water used in the nutrient result can be reclaimed and reused.

**Future Scope**

Although, hydroponics is new door of science but it can feed millions of peoples where land and water are insufficient. Some countries like Japan and Israel have already proactive approach in hydroponics. This technology can be used anywhere in all agro-climatic zones. Use of solar heating technology in hydroponics can reduce cost of hydroponics. Applications of Internet of Things also have a great scope in future for hydroponics. (Nirankar *et al.,* 2022).

## Conclusion

Agriculture is the developing industry of our country which is expected to grow rapidly in future as well. From the above study we can conclude that hydroponics is the alternative farming method which does not require soil or wide space. This review paper has highlighted the various aspects of hydroponics, including the growth mediums available, different techniques for growing plants using hydroponics with advantages and disadvantages, parameters which are important to control for better plant growth, challenges for hydroponics, advantages and disadvantages of hydroponics, hydroponics and traditional farming comparison, impact of covid 19 on agriculture, future scope. Out of the papers reviewed, Hydroponic cultivation of plants is better than traditional methods of cultivation. It can play a great role in cultivating plants especially in urban areas where very limited space is available.

There is a lot of opportunity to improve the agricultural sector using hydroponics and development in hydroponics. Future developments can focus on making food production using hydroponics popular with the correct infrastructure, training, and support. There is a need for better integration of technology with this system to increase control of parameters, with a hands-on extension to exotic varieties of plants. There is a need for cost-effective and efficient energy usage given hydroponics relies on artificial lighting heavily. With the help of this technique, the demand and supply gap can be filled providing fresh and better quality also consistency can be maintain

## Acknowledgements

We would like to express our heartfelt gratitude to our supervisor, Dr.G.R. Pathade, Dean, Krishna Institute of Allied Sciences (KVVDU) Karad for his unwavering support and guidance throughout the research process. Her expertise, insights, and encouragement were invaluable in helping us to complete this work.

We also want to thank Dr Sonal G Chondefor their helpful feedback and support. In particular and their valuable contributions to our research.

Finally, we would like to thank our family and friends for their love and support throughout the research process. Without their encouragement and support, we would not have been able to complete this research.

## References

Agrawal, R. K., Tripathi, M. P., Verma, A., Sharma, G. L., and Khalkho, D. 2020. Hydroponic systems for cultivation of horticultural crops: A review. *Journal of Pharmacognosy and Phytochemistry*. 9(6): 2083-2086.

Chatterjee, R. 2020. Indian agriculture and role of agricultural extension system to cope up with COVID-19 crisis. *Food and Scientific Reports*. 1(6).

Christiaensen, L. and Martin, W. 2018. Agriculture, structural transformation and poverty reduction: Eight new insights. *World Development*. 109: 413-416.

Cocetta, G., Casciani, D., Bulgari, R., Musante, F., Ko³ton, A., Rossi, M. and Ferrante, A. 2017. Light use efficiency for vegetables production in protected and indoor environments. *The European Physical Journal Plus*. 132: 1-15.

Fussy, A. and Papenbrock, J. 2022. An overview of soil and soilless cultivation techniques—chances, challenges and the neglected question of sustainability. *Plants*. 11(9): 1153.

Grigas, A., Kemzûraitë, A. and Steponavièius, D. 2019. November). Hydroponic devices for green fodder production: a review. In *Proceedings of the International Scientific Conference "Rural Development"* (pp. 21-27).

Hasan, M., Sabir, N., Singh, A. K., Singh, M. C., Patel, N., Khanna, M. and Pragnya, P. 2018. Hydroponics technology for horticultural crops. *Tech. Bull. TB-*ICN. 188(2018): 30.

Jámbor, A., Czine, P. and Balogh, P. 2020. The impact of the coronavirus on agriculture: first evidence based on global newspapers. *Sustainability*. 12(11): 4535.

Jan, S., Rashid, Z., Ahngar, T. A., Iqbal, S., Naikoo, M. A., Majeed, S. and Nazir, I. 2020. Hydroponics–A review. *Int. J. Curr. Microbiol. App. Sci*. 9(8): 1779-1787.

Karne, H., Iyer, V., Joshi, S., Diwan, S., Gole, M., Sunthankar, S. and Phansalkar, S. Hydroponics: A Review of Modern Growing Techniques.

Khan, S., Purohit, A. and Vadsaria, N. 2020. Hydroponics: Current and future state of the art in farming. *Journal of Plant Nutrition*. 44(10): 1515-1538.

Khare, R. and Singh, K. (Eds.). 2016. Proceedings of National Conference on Recent Advances in Chemical Sciences.

Kumari, S., Pradhan, P., Yadav, R. and Kumar, S. 2018. Hydroponic techniques: A soilless cultivation in agriculture. *Journal of pharmacognosy and phytochemistry*. 7(1S): 1886-1891.

Kume, A., Akitsu, T. and Nasahara, K. N. 2018. Why is chlorophyll b only used in light-harvesting systems?. *Journal of Plant Research*. 131: 961-972.

Lakhiar, I. A., Gao, J., Syed, T. N., Chandio, F. A. and Buttar, N. A. 2018. Modern plant cultivation technologies in agriculture under controlled environment: A review on aeroponics. *Journal of Plant Interactions*. 13(1): 338-352.

Macwan, J., Pandya, D., Pandya, H. and Mankad, A. 2020. Review on soilless method of cultivation: hydroponics. *Int. J. Recent Sci. Res*. 11: 37122-37127.

Magwaza, S. T., Magwaza, L. S., Odindo, A. O. and Mditshwa, A. 2020. Hydroponic technology as decentralised system for domestic wastewater treatment and vegetable production in urban agriculture: A review. *Science of the Total Environment*. 698: 134154.

Pant, T., Agarwal, A., Bhoj, A. S., Joshi, R. P., Prakash, O., and Dwivedi, S. K. 2018. Vegetable cultivation under hydroponics in Himalayas: Challenges and opportunities. *Def. Life Sci. J*. 3: 111-119.

Prakash, S., Singh, R., Kumari, A. R. and Srivastava, A. K. 2020. Role of hydroponics towards quality vegetable production: an overview. *Int J Curr Microbiol. Appl Sci*. 10: 252-259.

Qureshi, M. U. N. 2017. *Comparative study of Hydroponic and Geoponic Systems* (Doctoral dissertation, MSc thesis of MSc in. Civil Engineering programme, Capital University of Science and Technology, Islamabad, Pakistan. https://cust. edu. pk/ms_thesis/UploadedFiles/Muhammad% 20Umar% 20Nadeem% 20Qureshi-MCE153001. pdf)..

Ramteke, R., Doneria, R. and Gendley, M. K. 2019. Hydroponic techniques for fodder production. *Acta Scientific Nutritional Health*. 3(5): 127-132.

Semananda, N. P., Ward, J. D. and Myers, B. R. 2018. A semi-systematic review of capillary irrigation: The benefits, limitations, and opportunities. *Horticulturae*. 4(3): 23.

Sharma, N., Acharya, S., Kumar, K., Singh, N. and Chaurasia, O. P. 2018. Hydroponics as an advanced technique for vegetable production: An overview. *Journal of Soil and Water Conservation*. 17(4): 364-371.

Somerville, C., Cohen, M., Pantanella, E., Stankus, A. and Lovatelli, A. 2018. Small-scale aquaponic food production. *Food and Agriculture Organizations of the United States Rome.* 589: 83–98.

Sridhar, A., Balakrishnan, A., Jacob, M. M., Sillanpää, M., and Dayanandan, N. 2023. Global impact of COVID-19 on agriculture: role of sustainable agriculture and digital farming. *Environmental Science and Pollution Research*. 30(15): 42509-42525.

Srivani, P. and Manjula, S. H. 2019. A controlled environment agriculture with hydroponics: variants, parameters, methodologies and challenges for smart farming. In *2019 Fifteenth International Conference on Information Processing (ICINPRO)* (pp. 1-8). IEEE.

Swain, A., Chatterjee, S. and Vishwanath, M. 2021. Hydroponics in vegetable crops: A review. *The Pharma Innovation Journal*. 10(6): 629-634.

Swain, Aurosikha, Subhrajyoti Chatterjee, and M. Vishwanath. 2021. Hydroponics in vegetable crops: A review. *The Pharma Innovation Journal*. 10(6): 629-634.

Velazquez-Gonzalez, R. S., Garcia-Garcia, A. L., Ventura-Zapata, E., Barceinas-Sanchez, J. D. O. and Sosa-Savedra, J. C. 2022. A review on hydroponics and the technologies associated for medium-and small-scale operations. *Agriculture*. 12(5): 646.