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Assessing Opportunities and Difficulties in Hydroponic Farming

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ABSTRACT

Background: Hydroponics or water-culture-based agricultural systems are devoted to a reasonable prospect for future farming agriculture production. Especially in that region where the fertility of agricultural land is continuously going to there is a decline in groundwater level for irrigation. Hydroponics-based agriculture system realizes an admiring action towards an eco-friendly system and innovative technique to overcome challenges concerning food safety. Hydroponics is an advanced agriculture technique in which the plants grow without soil and without any pesticide use. It is used to grow plants, vegetables and shrubs on vertical as well as horizontal basis in the series and parallel. It could be applied *via* glass pots, clay pots, PVC pipes and useless plastic buckets and bottles.

Methods: In the present study vegetables, flowering plants and shrubs were grown successfully by the use of mainly three techniques of hydroponics namely Kratky, Wick and DFT methods. This study was continued for two and half years (4th July 2020 to 21st March 2021 and December 2019 to April 2020) with controlled pH and TDS of the nutrient solution and conducted at different Indian climatic, weather and seasonal conditions at Markanda National College,Shahabad Markanda and at the researcher's home.Several vegetables and plants were grown from Kratky, Wick and DFT hydroponics methods under continuous monitoring of pH and TDS of nutrient solutions.

Result: During the conduction of this study of the growth of mustard, ladyfinger, spinach, marigold, daisy basil (Tulsi), cucumber, cauliflower, broccoli, tomatoes, peas, peppermint, coriander leaves plants in different sessions; some challenges and opportunities were discussed. The main objective of this research study is to spread awareness about novel types of advanced future agricultural techniques or farming among the farmers and masses, who have an interest in agriculture but cannot fulfill their ambitions towards agriculture farming due to scarcity of agricultural land. The results obtained from the growth of vegetable and plant through hydroponics methods province us to follow an idea to use of such agricultural techniques. We have grown several below said crops/vegetables two or three times and face several problems. It is an opportunity to overcome the world's food scarcity at a large scale, if adopted by a large population all over the world.

Key words: Eco-friendly, Hydroponics, Potential of hydrogen (pH), TDS, Temperature, Water conservation.

INTRODUCTION

India is having the second largest population in the world. As the population increased, rapid urbanization and industrialization significantly decreased per capita land availability for cultivation, reduction in underground water level resources or poor water quality for irrigation (polluted water)(Tom *et al*., 2021) (Igwegbe *et al*., 2021) (Some *et al*., 2021), decline in the fertile level of agricultural land due to use of fertilizers/pesticides and insecticides. Hence, these factors demand critical thinking for new ways and means to grow plants and vegetables in India. Therefore, Hydroponics-a water culture technique will prove to be useful in Indian circumstances (Sengupta and Banerjee, 2012) (Upadhyay, *et al*. 2019) (Sardare and Admane, 2013) (Sharma *et al*., 2018). Therefore, our farmers have to need to think about new techniques and focus on aquaculture agricultural techniques (Tom *et al*., 2021) (Sardare and Admane, 2013) *i.e*., aeroponics and hydroponics methods. Hydroponics techniques have gained popularity in recent years due to the benefits of water based techniques to both man and the environment (Ogunfowora *et al*., 2021). It is based on pure or distilled water with very low TDS approximately 10-100 ppm (Some *et al*., 2021). Vertical farming, such as hydroponics or aeroponics, allows us to grow higher quantities of produce in previously inaccessible areas.

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Rooftops, indoors and in old warehouses: one can grow plants and stack them on top of each other to farm a consistent crop that produces year-round and quickly, uses less water and energy, is more pest resistant and can help alleviate some of the logistical hassles associated with transporting produce to and from farms to cities everywhere.

Hydroponics and aeroponics are gaining momentum now among commercial farmers and others as they have various benefits, the most important of which being their water consumption efficiency, with some studies claiming that hydroponics and aeroponics use up to 70% and 95% less water, respectively.

Hydroponics allows us to grow crops in greenhouses, in multistory buildings, in roofs and yards of the houses which will dedicate to agriculture. It provides a power of control of the plants with an elemental environment (Khan, 2018).

The major goal of this research project is to raise awareness about these advanced techniques. This research work will contribute for the adoption of hydroponics techniques to grow vegetables, medicinal plants, shrubs and other plants on the roof or vacant space in the house.

History

William Frederick Gericke of the University of California at Berkeley publicly promoted that the solution culture is used for agriculture crop production (dos Santos *et al*., 2013), named as first in 1929, he grew tomato vines of 7.6 m high in his backyard in a nutrient solution rather than soil, (dos Santos *et al*., 2013) (Sharma *et al*., 2018). He introduced the term hydroponics or water culture in 1937 and proposed to him by W.A. Setchel, a phycologist with extensive education in Classics (AlShrouf, 2017). Hydroponics is derived from the Greek word 'hydro' means 'water' and 'ponics' means 'culture'. In 1960, Allen Cooper of England developed the NFT (Nutrient Film Technique) system (Suryaningprang *et al*., 2021). In recent decades NASA has done extensive hydroponic research for its controlled ecological life support system (CELSS).

MATERIALS AND METHODS

Different systems

There are various methods of hydroponics namely Kratky (Kratky, 2002), Wick, DFT, NFT, DWC, Ebb and Flow, Drip system, Aeroponics. In this study, the researchers applied three methods - Kratky, Wick and DFT to grow ladyfinger, spinach, marigold, daisy, basil (tulsi), cucumber, cauliflower, broccoli, tomatoes, peas, paper mint, Coriander leaves plants during the study period. Moreover, these methods of hydroponics technique are helpful in water conservation, no use of pesticide; requires less space and it proved to be eco-friendly (Sardare and Admane, 2013).

Kratky method

The Kratky method of growing plants suspended above a reservoir of nutrient-rich water is a passive hydroponic approach. Because it is a non-circulating approach, no extra water or nutrient inputs are required after the initial application and there is no requirement for energy, pumps, or water and oxygen circulation systems. The Kratky method can be used for commercial food production as well as a small-scale, low-maintenance strategy for home gardeners. It has been called "the most basic hydroponic system."

In Kratky (Kratky, 2003), mustard, spinach, cucumber, lady finger, peas, cauliflower, broccoli and tomato's plants of vegetables were grown in useless plastic bottles by tailor-made method. Each point size was 16 cm long $\times$ 8 cm wide. Each pot was prepared by cutting 1/5th of upper part of the bottle and a hole is drilled in the lid of the bottle; which was mounted into the remaining part of the bottle with inverted neck. The selected plants were transferred to plastic beakers containing one liter nutrient solution. The plants were also grown in 4 inches PVC pipes with a 2 inch diameter hole at equal distance. The plants were supported with the help of sandstone and coco peat, were then placed on each point with 3 cm height in upper cut plastic bottles placed at the roof of researcher's home in an open area with full sunlight (in open environment of North Indian climate from December 2019 to April 2020). The researcher used Kratky method at home from 4th July, 2020 to 31st March 2021 and had grown lady finger, spinach, coriander leaves, marigold, daisy, basil, cucumber, cauliflower, broccoli, tomato, peas, pepper mint leaves.

Wick method

The procedure of Wick method is same as Kratky method. But there is an addition to the procedure in which a cotton cloth was hanged as a wick. As a precaution to keep the nutrient safe in summer season from UV radiation, the plastic bottles were wrapped with a metal foil or a black polythene. However, the researcher didn't observe any direct intervention of Ultraviolet radiation on the nutrient solution.

DFT technique

Plants are supplied with nutrients through ponds using DFT, a hydroponic technique that uses water as the medium. Plants are grown in drainage channels filled with a nutritional solution that runs continuously and is roughly 4-6 cm deep, keeping the roots of the plants immersed at all times.

Wick and DFT Systems (Suryawanshi, 2021) were used for growing vegetables and basils. The handling of systems is discussed in detail (Sardare and Admane, 2013). It is also known as the Liquid Hydroponics method. Plants grown in solution culture have their roots suspended directly in a nutrient solution (Sardare and Admane, 2013),(Raviv *et al*., 1998) (AL-Mehadee and Sarheed, 2021).

Solutions used in the present study

Researcher purchased these hydroponics nutrient solutions from Dhakad Hi-tech Nursery (Agriculture farm) situated at a village of district-Ratlam, Madhya Pardesh, India by Arvind Dhakad.They were named as Solution "A", Solution "B" and Solution "C". These nutrients contains the exact ratio of primary nutrients such as N:P:K (19:19:19), secondary nutrients contains magnesium, calcium, sulphur *etc*. and micronutrients(trace elements) contains boron, cobalt, zinc, chelated iron, molybdenum, copper and manganese.

Using a liter of water, these nutrients were diluted to form a 1:1 mixture of each nutrient with the water (Took 1 ml of each dilute solution of nutrients separately in one liter of low TDS water with maintained pH and required TDS for plants and adjusted with an increase in the amount of dilute nutrients solutions with the required TDS water). These nutrients used in rainy season for the growth of lady finger, basils, spinach, peppermint leaves and cucumber in all techniques. In winter the solutions were used to grow peas, Marigold, daisy, mustard, tomatoes, coriander leaves, broccoli and cauliflower.

The researchers separately added 1 ml of each solution in 1 liter water and checked the pH and TDS of whole nutrient solution. The pH Metre (brand name: LAPHM001, Microseal) measured the pH of the solution, which was based on a true range for growth of a plant (5.5-6.5); the pH of the solution was balanced using pH Up and Down reagents purchased online from Maxigrow brand used in winter season up to April 2020. The TDS meter of range 9999 ppm (brand name: Nexqua Dew Digital LCD Meter) was used to measure the accurate TDS of the solution. The oxygen level in the root of the plants was maintained with the help of a supply of 1% hydrogen peroxide solution in a regular period (Burke *et al*., 2020).

Experimental hydroponics methods/techniques

Kratky, Wick and DFT methods were used to grow vegetables and flowers.
It can further be classified into-

i) Non-Circulating methods (closed system)

ii) Continuous flow solution culture

Experimental set up

Three systems of Hydroponics technique - Kratky method (Kratky, 2005), Wick system and Deep Flow Techniques were used in the present study to grow plants and vegetables in two years. The set up arrangement and working of hydroponics system were looks like similar to Fig 1 (a), (b) and (c). The nutrient solution (Kratky, 1993) was added on a requirement basis without replacing the used solution. The nutrients were rich in ions and salts necessary for plant growth and purchase from Dhakad Hi-tech Nursery (Agriculture farm) situated at a village of district - Ratlam, Madhya Pardesh, India by Arvind Dhakad.

Initially, seeds of Indian mustard (Brassica) of variety *Pusa-31* were germinated in soil soaked with water at 8-16°C in December 2019 for 15 days and Eight plants of tomatoes were taken from a plant nursery and 3 plants of basil, broccoli and cauliflower, collected from a nursery, were planted and recorded the study from 4th July 2020 to 21st March 2021 within temperature range from 10-36°C to be used randomly in both techniques, While spinach, coriander leaves, cucumber,10 plants of Ladyfinger, 5 plants of Marigold, pot marigold and daisy and 10 pea plants were grown in a seed tray containing coco peat (Arancon *et al*., 2015). These plants were germinated separately in a coco peat shell and get replaced in the flowing water holes with the help of a mesh cup.

In DFT system, the stored nutrient solution is regulated with the help of a tool pump or through air pump in 4 inch PVC pipes type of pot used. The water is supplemented with nutrient solution and the plant absorbs the same through their roots passing from the mesh cup fixed on the PVC pipe equipment or all containers used. This technique is regulated under environmental and climatic temperature conditions (less than 35°C) and with pH (5.5-6.5) balance of the nutrient solution.

The experiment was conducted at two different locations - Laboratory of Department of Chemistry, Markanda National College, Shahabad Markanda, District Kurukshetra, Haryana (India) and at the Principal researcher's house at Kurukshetra. The experiment was constructed on a tailor method basis. The period of study was from December 2019 to April 2020 with different temperature variations (5°C to 35°C) according to Climate of Northern India and 4th July 2020 to 21st March 2021 with a temperature range from 10-36°C. The reliability of the hydroponics technique was assessed by growing plants and vegetables during the study period with variable temperatures. The researcher planted the plants with equal spacing of 4-6 inches are shown in Fig 2(a), (b), (c) and Fig 3 (a) (b).

The plants were also grown in 4 inches PVC pipes with a 2-inch diameter hole at an equal distance. The plants were supported with the help of sandstone and coco peat were then placed on each point with 3 cm height in uppercut plastic bottles placed at the roof of the researcher's home in an open area with full sunlight (in an open environment of North Indian climate from December 2019 to April 2020).In the rainy season, the researcher used the Kratky method at home from 4th July 2020 to 31st March 2021 and had

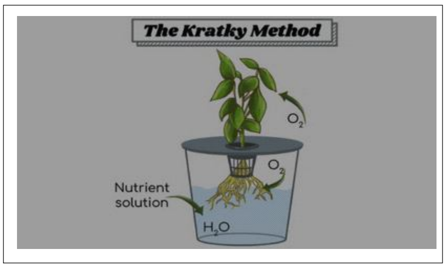

Fig 1(a): Kratky method.

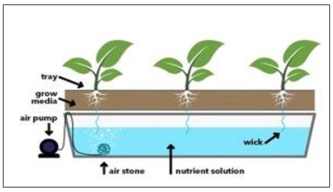

Fig 1(b): Wick system.

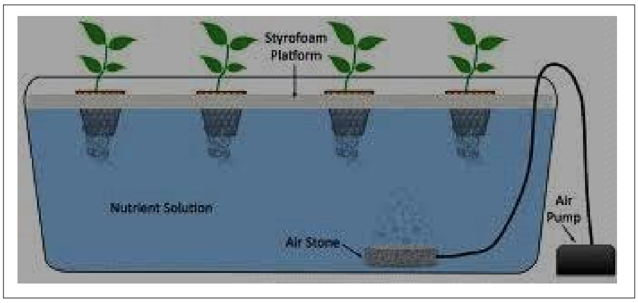

Fig 1(c): Deep flow technique (DFT) (Kenneth, 2021).

grown ladyfinger, spinach, marigold, Pot marigold, daisy, basil, cucumber, cauliflower, broccoli, tomato, peas, paper mint are shown in Fig 2(b), (c) and 3(a), (b), (c).

In the Wick method, the procedure is the same as the Kratky method, but there is an addition to the procedure in which a cotton cloth was hanged as a wick. As a precaution to keep the nutrient safe in the summer season from UV radiation, the plastic bottles were wrapped with metal foil or black polythene. However, the researcher didn't observe any direct intervention of Ultraviolet radiation on the nutrient solution (AlShrouf, 2017) (Asao, 2012) are shown in Fig 2(b) and 3 (a), (b).

In DFT system was operated in the open lobby with proper sunlight from 4th July 2020 to 21st March 2021. Sixteen points were prepared in the 4-inch plastic PVC pipes; each point was prepared by cutting a 3-inch hole of the size 10.16 cm wide $\times$ 7.16 cm long on the upper part of the pipe. The selected plants were transferred to the spot point with a 3-inch mesh cup filled with coco peat on the running nutrient solution in the pipes are shown in Fig 2(a) and (c). The nutrient solution was made to stir continuously for at least 10 h a day through the water pump; to maintain the level of conductivity of nutrients in the pipe, time to time, PH value and TDS of the nutrient solution were monitored (Håkansson and Lund, 2019) (Despommier, 2017).

RESULTS AND DISCUSSION

The use of the parameters of the pH and TDS from Table 1, the researchers obtained better results in all hydroponics techniques especially in DFT method. The yield was satisfactory in all techniques proved to be promising and resulted to be fruitful in the study (Maurya *et al*., 2017). The results and findings of the study are reported in Table 1.

Effect of high TDS water on plants growth

The suitability of water had been studied using four types of water-rain, ground water with high TDS, Distilled water and ground water with TDS less than 250 ppm. The best results were obtained in distilled water and low value of TDS to make nutrient solutions for plants. The pH level and TDS were maintained by adjusting the quantity of nutrients to make the solutions. The growth of plants was greatly affected in high value TDS of nutrient solution at different stages (Hakim, 2019). Therefore, use of high TDS water to make nutrient solution and feed to the plants, the plants almost dead.

The following points were discussed during the study:

An extended growing season

The working person attains an extended growing season due to controlled environment. These vegetables and plants can be grown hydroponically under controlled conditions of temperature, light and nutrition supply, obtained best results of different vegetables throughout a year.

Higher plant density

The hydroponic systems to deliver more nutrient charged solution to the roots of the plants. Therefore, the plants can be grown faster with competing for root space.

(a) Using DFT

(b) Using kratky and wick method

(c) Using DFT and kratcky

Fig 2: (a-c) DFT, Kratky and wick methods of Hydroponics.

Plants can grow anywhere

It is easily incorporated in outdoor as well as indoor because it can be possible on the roof of houses, verandahs, balconies and free space available at home/office or anywhere.

Less water consumption in the hydroponics systems

More than 80 to 90% water saved when using hydroponics agriculture farming. Therefore, it helps in water conservation.

Use of low TDS drinking water, distilled water and rainwater

These type of water qualities have great effect on the growth of plants hydroponically. Because water is the primary carrier of nutrients, it is critical that it be free of pollutants. Plants may suffer from stunted growth, nutrient deficits, bacterial contamination and other issues as a result of poor water quality. Unfortunately, drinking water, distilled water and rainwater are frequently treated with chemicals to make it safe for human use.

Use of waste plastic bottles and containers

In Kratky and wick systems, we can use waste plastic bottles and containers.

No use of pesticides

Absolutely, it is a great technique to try growing plants at minimum vacant space of the home/verandahs/anywhere hydroponically. Just remember, to observe the nutrition management according to the growth of the plants like pH and TDS of the nutrition solution, temperature *etc*. Therefore, requires constant monitoring and nutrition management, maintenance of the growing environment, vigilant about pH and TDS and refill the nutrition solution in pipes or containers after a regular interval of time. In the view of the demand of more consumers, the selection of hydroponic techniques to grow healthy and nutritious plants and get safe food from hydroponic plant is increased day by day because it is free from pesticide residues.

Hydroponic farms provide a way to a more sustainable food ethic that focuses the health of our food, bodies and environment while limiting the use of dangerous chemicals. Hydroponic farming is far from a pipe dream; it is currently being actively integrated into present food networks. Hydroponic farming had not yet been established at the time of the revolution. Only 20 years later, the industry has gained traction and is already influencing agricultural methods and the future of our food industry.

Suggestions and challenges

1. Flowing solution culture systems can provide a consistent nutrient environment for roots (Viljoen *et al*., 2021).
2. Rapid plant desiccation happens if the flow of the solution stops or the efficiency of the solution is affected for any reason. Thus, frequent attention is required.
3. Controlled temperature, TDS and pH range of the nutrient solutions need to be maintained. In this technique, the right temperature range, PH and proper TDS with growth must lie up to ~30°C. After 30°C, many plants did not grow and got damaged, but some vegetables and plants like capsicum, tomato, daisy, marigold grew at more than 30°C temperature (Meric *et al*., 2011).
4. The plants grown through hydroponics are eco-friendly because no waste product was produced.
5. Only plants and vegetables grew no extra weeds were grown, hence, no use of pesticide was observed. If any species of insect is grown, an organic compound pesticide was used. But in traditional farming more weeds grow with the crops and more use of pesticides and insecticides is inevitable (Muda *et al*., 2020).
6. This technique is very helpful in water conservation because the same quantity of water is recycled for the crops and vegetables *i.e.* Water conservation. Hence, keeping in view the future, hydroponics will be the biggest necessity.
7. This technique can use waste plastic bottles, tubs, glass and glass pots so that it helps in green chemistry (Sharma *et al*., 2018).
8. Initially, the cost is involved to set up, however, once launched only the cost of seeds or nutrients for the plants will be a recurring cost.
9. It demands technical expertise; hence competency can be enhanced through training only.
10. The water will be changed after 20-25 days otherwise the growth of microorganisms and algae would affect the growth and production of the crops (Sardare and Admane, 2013).

Challenges

Challenges related to temperature, nutrient flow in setup, High intensity of sunlight and rain were faced in Kratky and Wick method (Suryaningprang *et al*., 2021). The experiments proved to be successful in all techniques. Mustard plant and other plants (Tomatoes, Ladyfinger, basil, peas, Cauliflower, broccoli, paper mint, spinach, cucumber and marigold) were grown successfully by all techniques. So when these initial costs are met, more challenges must be solved in order to make sure a profitable and secure hydroponic farm.

Fig 3 a and b: Using DFT, Kratky and Wick method.

Table 1: Growth of Plants in Kratky from July 2020 to March 2021 with variation of temperature from 10°C to 36°C.

	Growth (in cms) Oct. 2019 to April 2020 Oct. 2020 to March 2021							Growth (in cms) July and Oct. 2020 to March 2021						PH value	TDS (ppm)
Days→ Vegetable name↓	15	25	35	50	60	70-90		15	25	35	50	60	70-100	5.6-6.9	100-2500
			Kratky and DFT methods							**Kratky, Wick and DFT methods**					
Lady finger	5-10 cm	22 cm	29 cm	38 cm Blooming and bud with two branches	50 cm Blooming, bud and fruiting	Ripening and harvested	Mustard	5-10 cm	22 cm	29 cm	38 cm Blooming and bud with two branches	50 cm Blooming, bud and fruiting	Ripening and harvested	5.7-6.9	250-1850
Basil plants (Tulsi)	7 cm	18 cm with four branches	26 cm with six branches	38 cm with eight branches	First flowering	Ripening	Tomato	7 cm	18 cm with four branches	26 cm with six branches	38 cm with eight branches	First flowering	Ripening	5.6-6.8	280-2000
Tomato plants/ Cherry tomato Cauliflower and Broccoli Marigold	16 cm- 22 cm 10 cm 10 cm 8 cm	20-28 cm 18-20 cm 16 cm 13 cm	30-36 cm 24-27cm Fruiting starts 30 cm	40-44 cm Flowering and fruiting 36 cm with blossom	50-5 cm Harvested	Flowering ripening and harvested	Spinach coriander leaves	10 cm	20-28 cm	30 -36 cm Blossom stars	40-44 cm with blossom and more branches	50-60 cm	Flowering ripening and harvested	5.6-6.8	350-1950
Cauliflower								10 cm	18-20 cm	Fruiting starts	Grow in size	Harvested	Harvested	5.6-6.5	360-1700
Broccoli								10 cm	16 cm Blossoms start	24-27 cm Harvested	Harvested and new more branches start	Harvested	-	5.6-6.8	300-1500
Marigold								8 cm 7 cm 6 cm	13 cm 15 cm 13 cm	New branches grow at 20 cm	Buds flowering starts at 36 cm with more blossom	Plucked and repining of flowers to prepare seeds	Plucked and repining of flowers to prepare seeds	5.6-6.25	200-1200
								3-6 cm	20-27 cm	Harvested	Second and third times harvested	Ripping		5.6-7.0	200-1000
Cucumber								4-6 cm with three leaves	20-32 cm	Buds flowered started	Grow in fruits	harvested		5.6-6.8	200-1200
Peas									10 cm	16 cm Blossoms msstart	24-27cm Harvested	Harvested and new more branches start	Harvested	5.6-6.8	300-1800
Spinach, coriander leaves, mint	3-5 cm	20-25 cm	Harvested	Second and third times harvested	Ripping									5.6-6.9	250-1350
Marigold daisy Pot Marigold								8 cm 7 cm 6 cm	13 cm 15 cm 13 cm	New branches grow at 20 cm	Buds flowering starts at 36 cm with more blossom	Plucked and repining of flowers to prepare seeds	Plucked and repining of flowers to prepare seeds		200-1300

There are some challenges (Raviv *et al*., 1998) for adopting hydroponic as an advanced agricultural technique due to the following reasons:

a) Less interest of farmers because of the uncertainty of yield (Sisodia *et al*., 2020).
b) It demands a high initial cost, but once a setup builds up, no more infrastructure is required, only demand of nutrient solution will be required.
c) Initial training is compulsory for setting up an infrastructure and must feel the experience of hydroponic growing crops (Suryaningprang *et al*., 2021).
d) The crops grown by hydroponics methods should be considered organics if follow the USDA guidelines.

Disadvantages of hydroponics

Hydroponics has some disadvantages also. Technical training at the initial stage is very compulsory. The high-cost setup requires a skilled and trained farmer with great care of plant health control and then only a high yield can be obtained. Otherwise, the hydroponics system fails. Finally, courage, moderation and determination inputs are necessary to run the system (Khan, 2018), (Sisodia *et al*., 2020), (Sayara *et al*., 2016), (Cifuentes Torres *et al*., 2021).

Advantages of water culture

There are many advantages of growing plants in water culture over traditional soil-based culture (Raviv *et al*., 1998). Hydroponics farming produces the healthiest crops with more yields over traditional soil-based culture. These are considered reliable because this farming is safe for the environment and wants 3-5 hours in a day for the work, so it is very easy farming with very little effort (Silberbush and Ben-Asher, 2001). The nutrients are supplied through the roots of the plants as a result plants grow faster than traditional farming. Water should be changed only with the supply of nutrient solution, no more water be used again and again like traditional farming. It can be started from a small area and then exceed in scale. It requires a small area as compared to traditional soil-based farming (Silberbush and Ben-Asher, 2001). It is also very effective for the regions of the World that has a range of human and climatic factors including degradation, climate change, soil constraints, urban encroachment and unequal land distribution and low water level, high pH value of soil or fertile land for agriculture (Cifuentes Torres *et al*., 2021), (Asao, 2012).

Opportunity

Several studies of hydroponics suggested that it is the best agriculture technique for crops and vegetable production as well as fit into environmental scenarios (Sharma *et al*., 2018), (Pandey *et al*., 2009), (Upadhyay *et al*., 2019).

In 2007, Euro fresh farmers grew more than 200 million pounds of tomatoes by hydroponics system (Allaby *et al*., 2020). In India, Hydroponics was introduced in the year 1946 by an English scientist, W.J. Shalto Duglas and he established a laboratory in the Kalimpong area, West Bengal. He collated his work in the form of a book named 'Hydroponics: The Bengal System'. During the 1980s, many automated and computerized hydroponics farms were established around the world. Home hydroponics kits for the kitchen and yard became very popular during the 1990s. As in 2017, the Government of Canada acquired a land on large scale for hydroponic greenhouses system and producing peppers, tomatoes and cucumbers (Upadhyay *et al*., 2019), (Meric *et al*., 2011).

Due to a decrease in land proportion with the increase in population, the food security and management system requires new ways and means of production (Pandey *et al*., 2009) (Yeole, 2016) (Sharma *et al*., 2018). Therefore, this technique will be highly helpful in the future. Especially, in a country like India, where the urban and industrial sector is growing each day, there is no option but to adopt a water culture to help improve the yield and quality of the product so that the food security of the country can be ensured (Khan, 2018) (Cifuentes Torres *et al*., 2021). The establishment of the new market for hydroponics crops and vegetables in India is a great challenge as the market demand is driven by traditional or terrestrial farming (Cifuentes Torres *et al*., 2021) (Muda *et al*., 2020). Therefore, the main aim of the researchers is to be spread the knowledge and its scientific attitude of different agricultural techniques such as hydroponics methods, which will be very helpful in solving the food scarcity (Tom *et al*., 2021) in our country and also helpful in water conservation in an eco-friendly way.

CONCLUSION

This study was an attempt to grow some mustard plants, tomato plants, basil, broccoli, spinach, cauliflower, cucumber, peas, meant leaves, ladyfinger and some flowers through the different methods of hydroponic. We significantly gained success through the techniques. These vegetables were grown in a natural, open and uncontrolled environment by using Kratky, Wick and DFT methods. Some challenges faced by the authors *i.e.* training, controlled TDS and pH of the nutrient solution, supply oxygen to the roots, change and cleanliness of supporting media (hygienic conditions) and controlled temperature. Another focus of the research was to spark interest in a future and sophisticated hydroponic farming technique in India among students and farmers from the neighbouring institute and home. The food security and management system necessitates new ways and means of production due to a decline in land proportion with the increase in population. Therefore, this technique will be highly helpful in the future. Especially, in a country like India, where the urban and industrial sector is growing each day, there is no option but to adopt a water culture to help improve the yield and quality of the product so that the food security of the country can be ensured.

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