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HYDROPONICS : A STEP TOWARD FOOD SECURITY

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Water, energy and food systems are inter-linked via a nexus. In the basic sense, one joule of energy produced, inputs into one drop of water distributed, which grows one calorie of food. Similarly, a single drop of water inputs into a single joule of energy needed for one calorie of grain grown. Therefore, action on one system impacts the others.

This complexity is compounded by the fact that climatic conditions are deteriorating with time and a significant increase in global population is a major factor. Constant escalation in urbanisation and industrialization will require more water, energy and food resources in the future (Kiani, A.2019).

Althought, India has only about 4 per cent of the world's renewable water resources but is home to nearly 18 per cent of the world's population and to fulfil the demand of food for ever-increasing population where, the availability of arable land is decreasing due to urbanization and deforestation and water for irrigation purpose is decreasing day-by-day, there must be an alternative for tradition farming like hydroponics to overcome such challenges.

Hydroponics is a system of agriculture that utilizes nutrient-laden water rather than soil for plant nourishment (Bridgewood, 2003). Because it does not require natural precipitation or fertile land in order to be effective, it presents people who are living in arid regions with a means to grow food for themselves and for profit. The re-use of nutrient water supplies makes process-induced eutrophication (excessive plant growth due to overabundant nutrients) and general pollution of land and water unlikely, since runoff in weather-independent facilities is not a concern.

Aeroponic and hydroponic systems do not require pesticides, require less water and space than traditional agricultural systems, and may be stacked (if outfitted with led lighting) in order to limit space use (vertical farming) (Growing Power, 2011; Marginson, 2010). This makes them optimal for use in cities, where space is particularly limited and populations are high-self-sustaining city-based food systems mean a reduced strain on distant farms, the reduction of habitat intrusions, fewer food miles, and fewer carbon emissions.

How does it work?

In conventional agriculture, soil supports a plant's roots – helping it to remain upright – and provides it with the nutrients it needs to grow. In hydroponics, plants are artificially supported, and a solution of ionic compounds provides nutrients instead.

The thinking behind this is simple. Plant growth is often limited by environmental factors. By applying a nutrient solution directly to a plant's roots in a controlled environment, a farmer can ensure that the plant always has an optimal supply of water and nutrients. This nutritional efficiency makes the plant more productive.

The solution can be delivered in a number of ways. A plant may be:

- placed in an inert substance (such as the volcanic glass perlite or rock wool) and have its roots periodically flooded with solution
- placed in an inert substance and rained on by a solution dripper
- suspended with its roots in the air, with these then sprayed with solution mist
- placed on a slightly sloping film that allows solution to trickle over its roots

All of these systems are mechanised in one way or another, usually using either a pump or a mister to deliver the solution from a separate store. The solution is also usually aerated to ensure that the roots are supplied with adequate oxygen. Mineral absorption requires energy, and is powered by respiration.

Higher yield as compared to conventional agriculture practices

According to the FAO, due to the increasing population, food production is expected to rise by 70% before 2050. On the other hand, natural prerequisites of agriculture, *viz.*, arable land and water have been depleting, with rapid urbanization across the globe. To feed the increasing population, the productivity of food crops needs to be increased in the existing arable land, and also alternative farming techniques such as urban farming need to be encouraged.

Volume 2 – Issue 1
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Hydroponic systems or soil-less agriculture reduce the farmer’s consumption of resources, thereby enabling this farming technique to be adopted by a large number of stakeholders, ranging from home gardeners to professional growers, and supermarkets to restaurants. According to the UN reports on global population, plants grown in hydroponic systems have achieved 20%–25% higher yield than the traditional agriculture system, with its productivity being 2–5 times higher. Also, owing to controlled environmental conditions, the effect of climatic changes can be balanced with the help of these systems, thereby not affecting the annual crop production. CEH techniques directly affect the crop harvest cycle; hence, for hydroponic systems, crop harvest cycles are shorter in comparison to traditional farming techniques, thereby increasing the annual yield. Also, since climatic changes show a minimal effect on such systems, crops can be produced all year round, thereby again increasing the produce.

Hydroponic crops

Theoretically, hydroponics can be used to grow any crop. However, the technique is mostly used with plants that grow efficiently under hydroponic conditions, such as salad greens, cucumbers, peppers and herbs. Most commonly it is used to grow tomatoes.

Farmers tend to use hydroponics with tomato varieties that have had special characteristics bred into them, such as bearing larger fruit and growing indeterminately (meaning that they grow continually, repeatedly producing fruit along their stems).Disease-resistant varieties are also popular as they enable plants to live for longer and bear more produce. On the other hand, crops that are not genetically suited to hydroponics are avoided, such as wheat.

Volume 2 – Issue 1
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Hydroponic farming has been majorly adopted for vegetable production

The major factor for higher adoption of hydroponic farming in vegetable production is the yield obtained, which can be up to 10 times higher than traditional farming techniques. Since the capital cost involved in hydroponic setup is high, the crops produced are sold at premium rates, and according to industry experts, the price of the produce ranges at par with the organic produce prices. Vegetables that are grown using hydroponics are known to grow faster and stronger compared to traditional farming, as the right nutrients are delivered directly to the plants' roots.

Hydroponics Fodder for cattle rearing

The use of nutrient solution for the growth of the hydroponics fodder is not essential and only the tap water can be used. In India, maize grain should be the choice for production of hydroponics fodder. The hydroponics green fodder looks like a mat of 20-30 cm height consisting of roots, seeds and plants. To produce one kg of fresh hydroponics maize fodder (7-d), about 1.50-3.0 litres of water is required. Yields of 5-6 folds on fresh basis and DM content of 11-14% are common for hydroponics maize fodder, however, DM content up to 18% has also been observed. The hydroponics fodder is more palatable, digestible and nutritious while imparting other health benefits to the animals. The cost of seed contributes about 90% of the total cost of production of hydroponics maize fodder. It is recommended to supplement about 5-10 kg fresh hydroponics maize fodder per cow per day. However, sprouting a part of the maize of the concentrate mixture for hydroponics fodder production does not require extra maize. Feeding of hydroponics fodder increases the digestibility of the nutrients of the ration which could contribute towards increase in milk production (8-13%). In situations, where conventional green fodder cannot be grown successfully, hydroponics fodder can be produced by the farmers for feeding their dairy animals using low cost devices(Naik,2015).

Urban farming

The vast majority of plants are still grown using soil, but hydroponics is on the rise. In 2013, Thanet Earth – the UK's largest greenhouse complex, based in Kent – used controlled-environment agriculture to produce around 225 million tomatoes, 16m peppers and 13m cucumbers, which equated respectively to 12, 11 and 8 per cent of Britain's entire

Volume 2 – Issue 1
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annual production of these crops. It currently operates four greenhouses, and has plans to build another three.

Globally, it was estimated that the hydroponic farming industry was worth $21.4 billion in 2015, with its value projected to grow at 7 per cent per year. Slowly but steadily, farming appears to be changing.

But equally, there are big global changes on the horizon, and these could vastly accelerate the use of controlled-environment agriculture. By 2050, an extra 3bn people could be living on Earth, with over 80 per cent of the global population living in urban centres. We're already using the vast majority of land suitable for raising crops, so new growing areas – particularly in arid regions – need to be found.

One much-talked-about solution is vertical urban farming – creating stacked hydroponic farms inside buildings, including tall skyscrapers. This would solve the problem of running out of available farmland, and also place farms right at the heart of where crops are needed – our densely populated cities of the future. Vertical farms are already being built in Michigan and Singapore – and even in disused bomb shelters in south London. And, as it plans human space missions that will travel further and further from Earth, NASA is investigating whether hydroponics could be used to create space farms to feed astronauts. Working with the University of Arizona, it is seeing whether it can create a closed-loop system that feeds human waste and CO2 into a hydroponic farm to create food, oxygen and water.

Hydroponic systems are essential tools for plant production in indoor farming such as plant factories with artificial lighting (PFALs). Among various hydroponic systems, the deep flow technique (DFT), nutrient film technique (NFT), and aeroponic systems have been commercially used with recirculated nutrient solutions. To protect the plants in plant factories from disease, disinfection systems, such as ultraviolet (UV) systems, are required. The light intensity and exposure time of UV radiation are related to the disinfection ratio of pathogens. The hydroponic systems, sensors and controllers, nutrient management systems, ion-specific nutrient management, and nutrient sterilization systems required for plant production in plant factories.

Success stories in India

Future Farms based in Chennai, India has developed effective and accessible farming kits to facilitate hydroponics. The company develops indigenous systems and solutions, made from premium, food-grade materials that are efficient and affordable for Indian growers.

Junga FreshnGreen, an agri-tech start-up, is a joint venture with a leading Netherlands-based Agricultural technology company – Westlandse Project Combinatie BV (WPC). It is setting up high-technology farms in India. The company will create a hydroponics model that can cultivate farm fresh vegetables that have a predictable quality, having little or no pesticides, and unaffected by weather or soil conditions.

Limitations

1. Lack of government policy and tax breaks in developing countries

Hydroponic farming is seen as a key factor in improving food security in developing regions; however, while government support through tax cuts is present in developed countries, the same cannot be said for developing countries. The availability of the best equipment is fairly limited and often needs to be imported, which attracts taxes adding to the costs for hydroponic growers. The lack of tax cuts and incentives is also a key factor that hinders the growth of hydroponics in developing regions as the high set-up costs and running costs can often render operations unfeasible. The need for basic training and technical knowledge is necessary for operating hydroponic farms, which although is present in developing countries, does not add significantly to the value of hydroponic farms. The high costs of production often result in high costs of the final product, which in itself can draw consumers away in price-sensitive markets.

2. Spread of waterborne diseases and algae in closed systems

In a closed hydroponic system, the threat of waterborne diseases poses a major problem to growers. Considering that the nutrient-enriched water is recirculated throughout the system, any kind of waterborne disease that enters the nutrient reservoir often affects the whole crop as it has the capability to spread throughout. Growers often keep their plants spaced out to prevent crowding, which is often how pathogens enter the system.

The modulation of internal temperatures is also a crucial step as heat and moisture in an irrigation system if left untreated can result in the formation of molds and algae, which can draw nutrients from the water, thereby leaving little for plants, thereby affecting the crops in the process. To combat the instances of waterborne diseases, growers are

Volume 2 – Issue 1
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resorting to using screen or paper filters and additional filtration systems to curb the spread of waterborne diseases in the system. Other safety measures included in systems include a rapid flush system to drain the water from the crops and prevent the spread of any pathogens.

Conclusion

From the above discussion it is evident that in near future when there will be inadequacy of the cultivable land due to urbanization and deforestation for providing the shelter to outbreaking population, there will also be requirement of alternative of traditional farming and in that case, hydroponic may be a step toward food security. Today farmers are slowly increasing their use of hydroponics, and researchers are looking more closely at how it could solve future food problems. In the future, some of its applications could be out of this world. Hydroponics also give wings to the Urban farms and animal husbandry.

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