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Article *in* Current Journal of Applied Science and Technology · October 2023

DOI: 10.9734/CJAST/2023/v42i384247

Current Journal of Applied Science and Technology

Volume 42, Issue 38, Page 1-11, 2023; Article no.CJAST.107157
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Organic Hydroponics: The Future of Farming

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2023/v42i384247

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/107157

Review Article

Received: 05/08/2023
Accepted: 10/10/2023
Published: 20/10/2023

ABSTRACT

The review "Organic Hydroponics: The Future of Farming" offers a comprehensive analysis of the developing sphere of organic hydroponics, that integrates hydroponic technology with organic agriculture principles. The paper covers the ideas of hydroponics and organic farming while outlining their advantages and disadvantages in contemporary agriculture. It investigates how organic practices are aligned with hydroponic elements such as substrates, fertilizer solutions, pest and disease management. The paper explores ways to apply organic principles while taking into account economic factors, such as using organic sources of nutrients and bio-based pest control. In the study, organic and inorganic hydroponic systems are compared and discussed in terms of yield, quality, utilization of resources, and sustainability. Overall, the report emphasizes the potential advantages of combining hydroponic technology and organic farming methods, providing information for additional study and comprehension of sustainable crop production.

Keywords: Hydroponics; inorganic; organic; pest management; sustainability.

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1. INTRODUCTION

Hydroponics is an emerging agricultural production system that is ought to provide sustainability in agricultural production. The Greek words 'hydro' for water and 'ponos' for labour are the origin of the phrase "hydroponics". As the name implies, it is a water-based system that relies solely on fertilizer solutions and is completely free of soil. In hydroponics, plants are kept alive under controlled environment using nutrient-supplying media other than soil. With increasing population and rapid urbanization, conventional farming system based on soil will not be able to feed the world population. According to a research, the plants can grow 50% more quickly in a hydroponic system than in a soil-based one Agrawal et al. [1]. According to USDA, growing medium used in this method can include aggregate substrates like vermiculite, coconut coir, or perlite [2].

The relevance of hydroponics has increased in the contemporary era for a variety of reasons. The demand on conventional agricultural practices has never been higher due to factors including climate change, exponential increase in population urbanization, and a lack of arable land [3]. A more effective and ecological alternative to conventional farming is hydroponics. Given the growing global water shortage, it utilizes 70–90% less water than traditional farming. The fact that the nutrients are provided directly to the plants also means that less fertilizer is needed, lowering the likelihood of runoff and the subsequent water contamination Reddy et al. [4]. The fundamentals of hydroponics are relatively straightforward: a nutrient solution must be maintained oxygenated, at a manageable temperature, and with the nutrients the plants require. The main factor is actually oxygenation. The water in a successful hydroponic system must always be saturated with oxygen [5].

India is the birthplace of organic farming. The term 'Organic' refers to the plant or animal source [6]. Ancient Indian farmers were credited with developing environmentally friendly farming techniques like crop rotation, mixed farming, and mixed cropping. Organic farming includes farming methods that are cultivated using organic inputs like-cow dung and green manures Rajesh et al. [7].

To achieve the goal of sustainable agriculture one of the method is organic farming [8].Sustainable agriculture defined by the Food and Agriculture Organization (FAO) states as "the effective management of resources for agriculture to satisfy changing human needs while maintaining or improving the quality of environment and conserving natural resources". The United States Department of Agriculture (USDA) describes this system as "a system that is designed and maintained to produce agricultural products by the use of methods and substances which helps to maintain the integrity of organic agriculture produce till they reach the consumer" (Narayanan, 2005).

2. ANALYZING THE PLANT-FERTILIZER RELATIONSHIP IN HYDROPONICS

Creating a nutrient solution with the proper ion ratio, which is essential for plant growth and development, is a vital step in hydroponic farming techniques. Historically, the majority of the nutrient solutions used in hydroponic crop cultivation came from inorganic substances and they were delivered through different chemical mixtures (Williams and Nelson, 2014). A hydroponic fertilizer solution is a water-based mixture that includes specific organic ingredients like iron chelates along with inorganic ions derived from soluble salts of essential plant nutrients. For the majority of plant species, key nutrients like zinc, molybdenum, manganese, nitrogen, phosphorus, phosphoric acid, potassium, sulphur, iron, copper, chlorine, boron, and nickel are thought to be essential for optimum plant growth and development [9].

Hydroponic plant growth and development are highly dependent on the mineral concentrations in the chemical-based nutrition solution. Any one of these mineral deficiencies can result in less productive plants. Mineral nutrients are absorbed by plant roots as ions, and only some chemical components are permitted to pass through during this process. Exchangeable ions from a colloidal reservoir replace the ions that plants absorb through their roots. Plants can prioritize ions in a helpful ratio for their growth and development when they are given a sufficient flow of nutrient solution. Additionally, through creating relationships with plant roots, microbes, particularly mycorrhizal fungi, nutrient uptake is more efficient [10].

Conversely, a deficiency in critical components might cause nutritional issues that culminate in lack of particular traits. In hydroponic systems, deficiencies frequently correspond to a specific chemical element that is insufficient. Visual signs of nutritional shortage make deficiencies in macronutrients including nitrogen, potassium, phosphorus, magnesium, calcium, and sulfur obvious. These deficits have a detrimental effect on seedling development and nutrient concentration in plant tissues [10].

3. INCORPORATING ORGANICS IN HYDROPONICS

Organic farming is a sustainable method of farming that emphasizes the production of high-quality crops while protecting the environment and its natural resources. In contrast to conventional farming, it promotes environmentally benign practices by avoiding or minimizing the use of synthetic fertilizers, chemical pesticides, and other chemicals. Hence, liquid organic fertilizers made from organic waste and leftovers are receiving a lot of interest as a possible replacement for mineral fertilizers in hydroponic system. This non-traditional method of hydroponics is known as "organic hydroponics" or "bioponics" which is short for biological hydroponics. Organic hydroponics involves structuring a system rooted in the principles of organic agriculture. Various methods are employed to manage plant pathogens, encompassing physical, naturally-derived chemical, and biological controls, alongside the utilization of bio-fertilizers, bio-remediations, and integrated pest management techniques. Essential nutrients are meticulously provided in controlled quantities, extending to organic crops within this context. Building a system around the tenets of organic agriculture is the goal of organic hydroponics.

The standard hydroponic nutrients contain nitrogen, phosphorus, magnesium, calcium, sulphur, potassium, etc. The organic adaptation into hydroponics includes components like compost, manure, fish meal, etc. Hydroponic systems undertaking organic farming frequently employ liquid organic fertilizers, which are nutrient-rich solutions made from organic sources [11]. These solutions are made by injecting water-diluted organic-origin nutrients to the hydroponic setup. However, the organic molecules that make up organic materials are so tightly bound with critical nutrients that plant roots cannot directly access them. As a result, these nutrients must go through biochemical processes of mineralization and breakdown that are aided by a variety of microbes. Through this process, the nutrients are released in a mineral form that plants may easily absorb Calvet et al. [12]. As a result, "bio-ponics" or organic hydroponics, differs from conventional hydroponics in that it involves a live organic environment and as a result presents special obstacles.

3.1 Organic Substrates for Production

Substrate describes any substance or media used in hydroponics to maintain and stabilize the plant's root system while enabling the absorption of water, nutrients, and oxygen. The substrate acts as a structural and functional support system, making it easier for the plant to get the materials it needs. Commonly employed organic substrates in hydroponics are biochar, coconut coir dust, compost, peat, sawdust, etc [10]. Organic substrates have many advantages over inorganic and synthetic substrates [13]. Due to the fibre concentration in these substrates, which results in a moderate to high level of porosity that affects root aeration and gas exchange, they are known for their ability to retain water Maher et al. [14]. The fact that fewer substrate volumes are needed per plant to provide adequate water supply indicates that a significant percentage of stored water is readily accessible to plants [15]. According to research, organic substrates have an impact on how plants develop. These effects can be direct, like when humic substances are absorbed and improve nutrient uptake and enzymatic activities, or indirect, like when cation exchange capacity is increased and microbiological activity around plant roots is stimulated. The organic substrates have the potential to support advantageous microbial population. Numerous biological, chemical, and physical interactions occurring inside the growing substrates as well as the plant itself have an impact on the microorganisms that are present in the rhizosphere [10].

3.2 Nutrient Management in Organic Hydroponics

Increased agricultural productivity and environmental sustainability have both benefited considerably from the use of organic fertilizers [16]. These fertilizers are made from organic materials and include vital components that support plant growth and development. Animal-based organic fertilizers include things like blood meal, vermicompost, fish hydrolysates, animal manure and digested animal slurry. Plant-based organic fertilizers include things like plant biomass, extracts, and other by-products of plants. Mineral-based organic fertilizers include things like rock phosphate and Epsom salt. The principal sources of organic fertilizers, which might include urban trash like kitchen and market garbage as well as agricultural waste from plants and animals, have an impact on their quality Lim et al. [17]. Nutrient availability is also impacted by the processes used to make organic fertilizers, including fermentation, composting, vermicomposting, aerobic digestion, and anaerobic digestion [10].

3.2.1 Vermicompost

Vermicompost is created when organic waste decomposes through the action of earthworms and microorganisms into a nutrient-rich material that is ideal for plant growth [10]. Depending on the materials that were composted, it includes different vital elements. Vermicomposting improves plant development flowering, fruit production and germination when applied to soil or plant growth media. It can be combined with water and fermented to create vermicompost tea, which produces soluble nutrients. The tea is utilized as an addition to hydroponic systems, increasing plant yields and making better use of plant hormones for growth Adekiya et al. [18]. Even though it's effectiveness in comparison to inorganic solutions has produced mixed results, with some research revealing lower yields they do provide increased antioxidant content in plants. When pH-adjusted, the liquid by-product known as vermicompost leachate also functions as a nutrition source with comparable advantages Adekiya et al. [18].

3.2.2 Animal manure

Animal waste, such as faeces and urine, is known as animal manure. Sometimes it is combined with other materials, such as straw for bedding. Type of animal, diet, and management strategies all affect the nutritional content in different ways. An excellent source of organic nutrients, animal dung contains both macro- and micronutrients that are crucial for plant growth. When used as organic fertilizer, chicken dung improves soil qualities and contains plant growth hormones. Similar to aquaponics, successful results have been obtained using chicken dung as a nutrient supply in hydroponic systems. Its use can be impacted by varied hydroponic systems and concentration levels, though Gorenjak et al. [19]. According to a research, extracts from cow and turkey manure have also been effective in hydroponic farming, promoting the growth of vegetables like lettuce and kale.

3.2.3 Plant biomass and its by-products

Sugarcane waste like press mud, molasses and bagasse are examples of plant by products and biomass that have the potential to be used as organic fertilizers. The creation of liquid fertilizer for hydroponics using fermented sugarcane leaves, leftover molasses, and distillery slop was the subject of research. This liquid fertilizer performed admirably when compared to chemical solutions in promoting lettuce growth. Similar to this, a liquid fertilizer made from sunflower stem and leaf biomass showed promise as an organic feed for tomatoes and cucumbers growing in hydroponic systems [20]. These results imply that additional mineral-rich plant biomass and its by products may also be used as the main source of nutrients in hydroponic systems.

3.1.4 Biogas digestate

A nutrient-rich organic by-product of anaerobic fermentation in biogas facilities is called biogas digestate. According to research, these uses include soil fertilizer, hydroponic growth medium, and organic disease and pest management. Notably, it has been successfully used as the primary supply of nutrients in the hydroponic cultivation of vegetables Domínguez et al. [21].

4. COST ESTIMATION

4.1 Physical Components

The structural building phase carries the highest financial burden. It need at least one acre of room to build the greenhouse. As an alternative, it might reuse current buildings such as warehouses or other underused spaces. In addition, after building a structure that works, it will require a system for lightning and indoor farming. This pertains to the pump systems in charge of distributing nutrients as well as the seed towers or trays that desire to use [22].

4.1.1 Power supply

Indoor hydroponic agricultural systems heavily rely on the use of grow lights. However, using this strategy can be expensive. First, it requires spend money on the necessary lighting and the price can differ greatly based on the size of company. Later on, there will be recurring costs to keep these lights on throughout the entire year, day and night. The level of your cultivation will determine how much lights you need.

However, it's best to plan on using your lighting system for at least 6 to 8 hours every day.

4.1.2 Labour

Labor expenditures will probably be incurred unless operation is sufficiently small to operate it on your own. In fact, for hydroponic farms, this frequently represents the main continuous expense. Budget should be prepared for at least 25 to 30 full-time employees per acre (4046.85 m^2) of hydroponic farming operation. Consequently, it's important to take into account the current local labor costs and associated perks as you develop the budget for your hydroponic farming business.

4.1.3 Continuous supplies

In the end, money is required for farm's continuing expenses. It will include growing media, plant nutrients, seeds, and fertilizer, transportation and packing (if intended to package products on-site). Moreover, the costs associated with buying hydroponic farming equipment.

Table 1. Displays the nutrient content of organic fertilizer regularly used as a source of plant nutrients for organic hydroponic systems [10]

Organic Fertilizers	N	P	K	S	Ca	Mg
Vermicompost	2.915	0.341	1.377	-	2.975	0.562
Compost	2.249	0.337	1.124	-	2.660	0.497
Plant Biomass (fermented)	0.00485	0.000341	0.00045	0.0084	0.0008	0.01
Biogas digestate	0.021	0.0038	0.024	-	0.011	0.0023
Chicken manure	5.96	1.38	2.24	0.78	5.84	0.70
Aquaculture waste	0.01217	0.0058	0,01853	0.0013	0.0124	0.0017
Fish emulsion	2.38	2.08	0.554	-	0.391	0.072

Table 2. The one-time setup cost [23]

Material required	Cost (INR)
Polyhouse shelter	600000 INR
Tank (2000 Litres)	55000 INR
Plastic Tank (1000 Litres)	15000 INR
Stand platform (hold 32 pipes each)	100000 INR (40 Stands)
Water Pump (1 HP)	30000 INR
NFT System	
- Pipes (4 inches)	70000 INR
- Pipes (2 inches)	12000 INR
- Pipe connectors	120000 INR

Table 3. The categories of irrigation pumps [23]

Material Required	Cost (INR)
RO system	50000 INR
TDS meter	2000 INR
pH meter	1200 INR
Water cooler	60000 INR
Net cups	100000 INR (20000 Plus)
Water pump(0.5 HP)	10000 INR (2 pumps)
Labor cost	10000 INR

Total one time cost: 1887200 to 2000000 INR

Table 4. The cost per cycle

Material Required	Cost (INR)
Seeds	20000 INR/month
Fertilizers	20000 INR/month
Electricity	1500 INR/month
Maintenance	5000 INR/month
Labor	10000 INR/month

Per Cycle cost - 80000 INR

4.2 Hydroponic Farming Investment Per Square Foot (0.0929 m^2)

Total investment which includes one time and per cycle cost: 20,00,000 INR
Hence,

- One time investment per square foot will cost : 400 INR
- Per cycle investment for one square foot will cost : 16 INR [23]

4.3 Hydroponic Farming Profit Per Square Foot

Total profit margin on the area of 5000 square feet is 6,90,000 INR. Therefore, profit margin per square foot will be 138 INR/cycle [23].

5. PEST AND DISEASE MANAGEMENT IN ORGANIC HYDROPONICS

Managing diseases, weeds, and pests without the use of synthetic chemical herbicides or pesticides is known as organic pest and disease control. This eco-friendly method prevents environmental contamination and harm to the health of people and animals. While successfully eradicating pests and diseases, it protects beneficial insects and pollinators, aiding in the preservation of natural ecosystems. Furthermore, long-term cost savings may be possible due to sustainable practices that lessen the demand for overpriced synthetic chemicals.

5.1 Methods for Pest Control

Various pests in organic hydroponics are Whiteflies, Spider Mites, Aphids, Thrips, Fungus Gnat [24].

a) Garlic and clove extracts: The newest organic insecticides on the market often contain extracts from clove or garlic. Besides the power to kill insects instantly, these powerful herbs also work well as repellents. Both garlic and cloves force insects which come in touch with them to leave right away.

b) Rosemary extracts: They have special substances that block the octopamine receptors observed in different insect species. Because of this, when insects come into contact to a solution containing rosemary extract, they get paralyzed and eventually die. Importantly, since octopamine receptors are found only in insects, applying the solution near humans or birds won't have any unfavorable effects.

c) Organic tea: Put decomposed compost in a bucket, add water, and leave it to rest for 24 hours or until it turns dark brown. Placing a strainer over another bucket, strain using muslin cloth. In your hydroponic system, use this liquid in place of synthetic nutrients, replenishing it as often as weekly is necessary for plant health.

d) Organic oils

- Natural oils are an organic kind of pest management that come through plants, seeds, and nuts [25].
- Essential oils have insect-repelling and insecticidal properties include peppermint, rosemary, and thyme.
- *Horticulture Oils:* Pests such as spider mites, aphids, and whiteflies are suffocated by these oils.

e) Natural fertilizers

Natural fertilizers, like compost tea and worm castings, are organic substances or materials generated from nature that supply vital nutrients to plants, fostering their development and general health.

- **Compost tea**

  It is a nutrient-rich liquid that is produced by soaking compost in water. It is used as a plant food to feed plants and helps them withstand pests and disease.

- **Worm castings**

  These nutrient-rich byproducts of worms decomposing organic debris also promote healthy soil microorganisms that benefit plant growth [25].

f) Organic sprays

- **Neem oil spray**

  Made from the neem tree, this organic spray is an excellent insect repellant, insecticide, and fungicide.

- **Garlic spray**

  This versatile spray can repel and kill insects and is effective against mildew, rust, and fungus.

- **Cinnamon spray**

  This organic spray has antifungal properties and helps control fungus and mildew growth.

- **Hot pepper spray**

  Made from hot peppers, this organic spray repels insects by giving them a burning sensation.

g) Diatomaceous earth:

Diatomaceous earth, which comes from fossilized diatoms, is a safe and effective pest control solution for hydroponic gardening. Insects are killed when their exoskeletons come into touch with its sharp edges, which damage them. Using organic pest control methods ensures that a hydroponic garden is devoid of toxic substances, benefiting both the surroundings and human health. Additionally, using natural alternatives promotes biodiversity by drawing beneficial pollinators and prey species [25].

5.2 Methods for Disease Management

5.2.1 Root rot prevention

It is common and damaging disease in hydroponics, affecting plant roots causing yellowing, wilting, and ultimately plant death. Root rot is caused by the pathogenic fungi like *Phytophthora* and *Pythium* sustaining in excess moisture and high humidity. Prevention strategies are maintaining proper drainage, humidity levels, utilizing water from reliable sources and pre-treated water with Pythoff products [26].

5.2.2 Beneficial insects

Beneficial insects can provide an organic solution to pest control by acting as natural predators of garden pests. Some common beneficial insects include [25].

- **Ladybugs**

  They eat aphids, mites, whiteflies, and other soft-bodied pests.

- **Praying mantis**

  This predator can consume a variety of insects, including beetles, grasshoppers, and even other praying mantises.

- **Lacewings**

  They are known to consume pests like aphids, spider mites, and whiteflies.

5.2.3 Microbial pesticides

Microbial pesticides use natural microorganisms like fungi and bacteria that can control or kill pests. Here are some examples of microbial pesticides:

- **Bacillus thuringiensis (bt)**

  A type of bacteria that is toxic to certain insects like caterpillars, beetles, and fly larvae.

- **Beauveria bassiana**

  A fungus that can control pests like whiteflies, aphids, and mealybugs.

- **Trichoderma**

  A fungus that can protect plants from fungal diseases such as root rot.

6. COMPARING ORGANIC HYDROPOPNICS AND INORGANIC HYDROPONICS

Two well-known methods of hydroponics have come into existence: organic and inorganic hydroponic farming. These methods have different ideologies, sources of nutrients, and growth techniques, which has both advantages and downsides for producers. We will contrast the fundamental distinctions between inorganic and organic hydroponics in this comparison, illuminating their nutrition mechanisms, growing media, mechanisms for regulation, environmental effects, and more. Growers must be aware of these variations in order to choose hydroponic procedures that are compatible with their objectives, guiding principles, and the particular requirements of their crops.

7. ANALYZING THE FUTURE OF SOILLESS CULTIVATION

The most sophisticated production method now in use is hydroponic farming under protected cultivation. Ruthenberg classified hydroponics as a "high input-highoutput-high risk" farming technology in 1980 Pandey et al. [27]. In India, hydroponic farming is becoming more popular. India has a mostly traditional farming system. Therefore, there is a limited market for this form of farming in modern, global cities. India's farmers are steadily adopting this innovative and intense agricultural method nowadays [28].

Table 5. Comparing organic hydroponics and inorganic hydroponics systems

Parameters	Organic	Inorganic
Sources of Nutrients	Compost tea, animal manure, and various other natural sources based solutions are some examples of natural, organic nutrition sources used in organic hydroponics. These nutrients come from living things and usually release more slowly.	Inorganic hydroponics makes use of mineral-based nutrition solutions such water-soluble salts or artificial fertilizers. These chemically created nutrients offer an accurate mixture of necessary components for plant growth.
Growing Media	To support plants physically and hold moisture, organic hydroponics frequently uses natural growing media like peat moss or coconut coir. These media may degrade over time and affect the availability of nutrients.	Inert growing medium, such as perlite or hydroton, is frequently used in inorganic hydroponic systems and does not provide nutrients to the plants. This facilitate better nutrient delivery.
Nutrient Control	Due to the variety of organic fertilizer sources, it might be difficult to accurately control nutrient levels in organic hydroponics. Microbial activity within the system may potentially affect the availability of nutrients.	With the ability to precisely manipulate nutrient concentrations, inorganic hydroponics makes it simpler to adjust the nutrient solution to the particular requirements of the plants.
Pest and Disease Management	Organic hydroponic structures may rely on organic means of disease and pest management, such as helpful insects or microbial remedies without relying on chemical pesticides.	Chemical pesticides and fungicides are used in inorganic hydroponics that are synthetically produced.
Impact on Environment	Organic hydroponics generally adheres to more environmentally friendly and sustainable procedures. In addition to possibly using natural resources for nutrient solutions, it lessens the requirement for manufactured chemicals.	Due to the creation and usage of manufactured fertilizers and chemicals, inorganic hydroponics may have a greater negative influence on the environment. However, in terms of plant nutrient uptake, it may be more resource-effective.

7.1 Technological Developments and their Effects

As technology develops, so does its use in hydroponics farming system. In Indian hydroponics industry, automation and artificial intelligence have changed the game. Businesses like - CultYvate, a Bangalore based company, are creating automated hydroponic systems that aim to maximize plant growth while using less water.

7.2 Urban and Vertical Farming with Hydroponics

Urban and vertical farming using hydroponics is becoming more popular in India due to the country's growing urbanization and declining countryside. When paired with vertical farming, hydroponics, in particular, offers a workable method for growing food in an urban setting. An indoor or outdoor balcony, rooftop, or other small place can be used to put up a vertical hydroponics system because it takes up less room.

7.3 The Contribution of Hydroponics to Secure Food Supply and Sustainable Agriculture

India's food security faces a substantial problem as a result of growing population and the effects of climate change. The use of hydroponics can be extremely important in solving the problem. It produces higher yields, requires less soil and uses less water, all of which help to create a more sustainable agricultural system. Reddy et al. [4]

7.4 Securing Future Arable Land

Rapid population growth in India has led to a notable decrease in available arable land, posing difficulties in meeting the food needs of the expanding population. To combat this issue, farmers are turning to hydroponic systems to secure future arable land availability and potentially initiate a new green revolution.

7.5 Alleviating Substantial Loads on Farmer

Use of hydroponic farming system in India will lessen the burdens placed on farmers. Because hydroponic units require less land, less water, and a very high rate of plant growth. Without excess food, there is struggle with hunger.

7.6 Pest and Disease Management

The use of hydroponics will lessen weed growth and pest and disease attack. Using fewer insecticides and pesticides leads to less environmental contamination and lower agricultural costs.

7.7 Favoring Climatic Change

Unseasonal rain and hailstorms are two examples of how climate change is affecting India's weather and agriculture. However, by producing an artificial atmosphere in a hydroponic farming system, plants can grow under controlled conditions [28].

8. CONCLUSION

As a harmonious fusion of organic agriculture with hydroponic technology, organic hydroponics is an emerging field that this review paper illuminates. This research illustrates the complex interaction between these two fields by carefully examining the aspects of organic ideas and hydroponic procedures. It is convincingly demonstrated that hydroponic components, including substrates, fertilizer solutions, and pest and disease management which are adaptable to organic methods. This review's essential point is the comparison of organic and inorganic hydroponic systems, which captures the wider implications of adopting organic hydroponics. In terms of sustainable crop production, this paper's explanation of the possible advantages brought about by the merger of organic principles and hydroponic technology positions it at the forefront. The compiled knowledge invites academics, professionals, and decision-makers to investigate, develop new ideas, and add to the conversation on organic hydroponics. In doing so, the study promotes critical thinking, deepens understanding, and calls for additional research that has the potential to lead to a more resilient and environmentally harmonious agricultural future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/107157