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# Integrated Hydroponic Farming Combined with Aquaculture System

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**ABSTRACT:** Hydroponics and Aquaponics areinnovative horticultural techniques that offer efficient, sustainable alternatives to traditional soil-based agriculture. These methods leverage advanced technology to optimize plant growth, conserve resources, and increase crop yields. Hydroponics involves growing plants in a nutrient-rich water solution, eliminating the need for soil. Plants are supported by inert media such as rock wool or clay pellets, which provide stability and facilitate root development. This method allows precise control over nutrient delivery,waterusage, and environmental conditions, leading to faster growth rates and higher yields. Hydroponic systems can be implemented in various forms, including nutrient film technique (NFT), deep water culture (DWC) and drip systems.

Aquaponics are integrates hydroponics with aquaculture, creating a symbiotic environment where plants and fish coexist. Fish waste provides an organic nutrient source for the plants, while the plants filter and purify the water for the fish.

**KEYWORDS**: Hydroponics, Aquaponics, fish, biodiversity.

## I. INTRODUCTION

One of the significant issues endangering the development of crops worldwide is water scarcity. The World Health Organization (WHO) estimates that every year, 55 million people suffer from the effects of drought. Improving water and resource management techniques is necessary to meet the demands of food production over the next fifty years. As a result, numerous academics are looking at the difficulties caused by drought in agricultural production and creating methods to utilize less water and more efficiently (Sharma, Acharya, Kumar, Singh, & Chaurasia, 2018).A lot of new producers are switching to resource-efficient alternative growing systems from traditional agricultural systems that demand a lot of inputs. Furthermore, attention is being focused on circular systems, which save and minimize resources and inputs without sacrificing total production (Gruda, 2019).

Although greenhouse and controlled environment production technologies allow us to manage and optimize plant growth conditions, high-quality crop production still need fertilizer and water inputs. Therefore, it's critical to give priority to effective resource management techniques that increase crop yield and quality while reducing waste (Walters, Behe, Currey, & Lopez, 2020)

Soilless agriculture, including aquaponics and hydroponics, allows production of fresh vegetables close to cities and hospitality hubs, even on non-arable land. This supports national goals around food security, reduced import dependence, and smarter water use. When combined with renewable energy or efficient cooling, these systems can become important long-term components of a resilient food system.

## II. MATERIAL AND METHODOLOGY

### Collection of materials

Fish tank is most important material in our project it will help for aquaponic system collected by the local aquarium shop and fish collected from the fish market located near Rasipuram, Tamil Nadu. Tray will help to place the micro-grain. Fresh green gram and are brought from the seed store near Rasipuram.

### Biotic Stressors & Sustainable Solutions

Hydroponic crops are susceptible to fungal, bacterial, and insect infestations.

**ORGANIC SOLUTIONS INCLUDE:**

- Herbal-Based Pesticides – Natural pest repellents reduce chemical dependence.
- Beneficial Microbes – Mycorrhizal fungi and rhizobacteria improve plant immunity.
- UV Sterilization & Oxygenation prevent microbial growth without chemicals.

## III. MATERIALS

### 1. Fish tank

Fish tank is made up of glass, the exact dimensions of the fish tank is 35cm breath and 30 cm depth. These tanks are generally used for keeping freshwater or saltwater fish, aquatic plants or small aquatic creatures. They can also serve as breeding tank or quarantine setups for fish.

### 2. Selection of micro-grain

Green gram seed (Vignaradiata) was collected from the seed store near Rasipuram. The seeds were air-dried and kept at room temperature until needed. Green gram seeds were surface sterilized with 0.2% $HgCl_2$ for 2 minutes, then carefully rinsed with distilled water to eliminate any mercuric chloride. The seeds were then placed on sterilized Petri dishes (15 × 20 cms) at equal distance. Seeds treated with distilled water were kept as a control. (Dullav, Lakshmikanti, & Mishra, 2012).

### 3. WoodStand

**Hardware and Fasteners**

The hardware and fasteners you pick are as important as the wood. You'll need strong screws, brackets, and maybe metal straps to hold your aquarium's weight. Stainless steel or galvanized hardware helps avoid rust and corrosion.When picking fasteners, think about the wood you're using. Choose screws that match the wood's density. Hardwoods need special screws.

**Finishing Materials**

The finishing touches are what make your DIY fish tank cabinet stand out. You need a finish that protects the wood and makes it look good. Polyurethane, varnish, and stain are popular choices.

## IV. PLANNING YOUR DIY FISH TANK STAND

To make your DIY fish tank stand both useful and good-looking, start with a clear plan. Planning is key to success. Measure your tank right and make a detailed plan to avoid mistakes and make building easier.

**Measuring Your Aquarium Dimensions**

Getting your measurements right is essential for any DIY project. Use a tape measure to get the tank's length, width, and height. Remember to measure any parts like handles or filters that might change your design. Double-check your measurements to avoid mistakes.

**SIZE OF THE WOODEN HOLDER**

**Tray**

Plastic containers are containers built entirely or partially from plastic. Plastic containers are widespread, whether single-use or reusable/durable, and include plastic cups, plastic bottles, plastic bags, foam food containers, Tupperware, plastic tubes, clamshells, cosmetic containers, intermediate bulk containers, and many forms of corrugated plastic containers. In addition to paperboard and other materials, the entire packaging industry is primarily reliant on plastic containers or containers with some plastic content (for example, plastic coating or composite material).

### *A.* Maintaining the Integrity of the Specifications

It has been shown that greenhouse conditions may effectively employ water and fertilizers(Verdoliva, Gwyn-Jones, Detheridge, & Robson, 2021). In greenhouse production, drip irrigation, hydroponics, and aeroponics are some of the more popular methods(Niu & Masabni, 2018). Although drip irrigation techniques vary, they all generally distribute little amounts of water on a controlled schedule to suit a crop's water needs(Kozai, Niu, & Masabni, 2021). The process of growing plants suspended in a nutrient-rich water-based solution without the use of soil substrates is known as hydroponics. Water Quality Parameters management Water is the life blood of an aquaponic system. It is the medium through which the plants receive their nutrients and the fish receive their oxygen. It is very important to understand the

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water quality and basic water chemistry in order to properly manage aquaponics. The key factors for maintaining healthy bacteria are water temperature, ph, dissolved oxygen total nitrogen concentration and hardness and adequate surface area on which the bacteria grow. Water analysis will provide information on the balance of the system also. High ammonia or nitrite indicates insufficient biofilteration, low nitrate indicates too many plants or not enough fish, increasing nitrate is desirable and indicates adequate nutrients for the plants (Pantanella, 2012). Hence knowing the effects of each parameter on fish, plants and bacteria is crucial. Below is the tabular form exhibiting the range of parameters, their tolerance levels and the mean data recorded weekly during experimentation.

Nutrition and Feed Management Successful aquaponic systems are balanced. The feed rate ratio is the guideline to balance the amount of fish feed to plant growing area, which is measured in grams of daily feed per square meter of plant growing space. Plants have different nutritional requirements, for instance the leafy green vegetables require more nitrates than the fruiting plants. The feed rate ratio for leafy vegetables is 40-50/m2 /day and the fruiting vegetables require 50-80 g/m2 /day (Pantanella et al., 2012). Standard manufactured fish feed pellets are supplied as they are a whole feed containing the correct balance of proteins, carbohydrates, fats, vitamins and minerals. Protein is the most important component for building fish body mass. The omnivorous fish such as tilapia, common carp and Magur, Clariasbatrachus are fed with 32% protein feed. Carnivorous fish like snakeheads are fed with 40-42% protein feed. Neither under feeding nor over feeding is done. The left out /uneaten feed is removed after 30 minutes to reduce risks of ammonia or hydrogen sulphide toxicity.

**Nutrient Film Aquaponics System:**

This system can be generated anywhere in any part of India even in arid or infertile land also. Rainwater storage tanks with non-corrosive rainwater drainage pipes function as lungs of the system. Shrub type & leafy vegetables with divergent kinds of carps are preferable species for culture them in this type of farming system.

## V. PRINCIPLE IN WORKING PROCESS OF AQUAPONICS SYSTEM:

The integration of recirculatory system and hydroponicsin one production system works as mutual benefit for both systems, as the nutrients requirements is fulfilled by the disposing of nutrient rich fish waste from the Aquaculture unit (thus there is no need for nutrient media). The fish waste provides all nutrients solutions for plant growth and this nutrient rich effluent is used to irrigate hydroponic bed and fertilize its plant crops at the same time. The filteration of the water is done by the hydrophonic unit as the plants absorb the nutrients and filter the water through the sand filter so this media based hydrophonic system serves as an aerobic biofilter that is generally used in RAS systems, converting ammonia to nitrate. The ammonia is converted by denitrifying bacteria in the hydrophonic grow bed, into forms readily up taken by plants for energy and growth. Essentially the hydrophonic bed and its crops serve as a bio filter for the fish. Waste water is cleaned before it is returned back into the fish tank. Thus, the anaerobic (denitrification) filter used in RAS is largely replaced with a hydroponic plant production system. Out of the total nitrogen input used into the system as feed, upto 30% may be captured as fish flesh and 40% or more may be captured as plant biomass. The balance is lost as nitrogen gas or as solids, which may be used as fertilizer in a garden (Fox et al., 2013). Higher levels of nutrients capture may be possible with additional separate biofilteration (Christopher S et al., (2015), Surner, et al., (2015), Sharma, et al., 2018). Further, the complex mix of nitrifying bacteria, rhizobacteria, fungi and microplankton in the recirculated water appears to benefit the plants due to both positive interactions at root level, and the higher resilience of the system against some plants pathogens (Savidov, 2005).

- **Performance:** Both systems show high yields (e.g., >600g of strawberries per plant) and offer significantly faster growth rates than traditional soil-based agriculture.
- **Sustainability:** Aquaponics often has a lower environmental impact than hydroponics due to reduced nutrient waste (no need to dispose of nutrient solution). However, it requires a higher initial investment in technical expertise and equipment to manage fish health alongside plant needs.
- **Key Trends:** Increasing investment in IoT and smart technology for automated monitoring of nutrient levels and pH is enhancing system efficiency, according to recent Market Research reports.
- **Best Use Cases:** Aquaponics is ideal for producing leafy greens and herbs while producing fish protein (e.g., Tilapia). Hydroponics is often more straightforward to scale for large, specialized commercial vegetable operations (tomatoes, peppers).
- **Environmental Impact:** While both are highly efficient, studies (like this Sciencedirect report) note that energy consumption for heating and lighting remains a major environmental footprint factor, which can be mitigated by using renewable energy

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*B.* **EQUATION**

**MOISTURE CONTENT DETERMINATION**

The moisture content of the Organic compost was determined by the Association of Official Analytical Chemists method (AOAC, 1995). 10 g of sample was weight and placed in a hot air oven at 105º C for 3 h. Reading was taken until the constant weight attain. The moisture content of the sample was expressed as percentage (%) of the dry weight of sample.

Moisture content(% ) = $(W_1 – W_2 / W_1) \times 100$

$W_1$ =Initial weight

$W_2$ = Final weight

The ash content of each of organic compost was determined by muffle furnace at 550ºC according to AOAC (1995). The ash content is inorganic residue left, as a percentage of the total weight of powder incinerated. Result was expressed as percentage(%)of the product mass.

Ash Content (%) = $(W2– W_1/W_3–W_1) \times 100$

$W_1$ = Weight of Empty crucible

$W_2$ = Initial weight of sample + crucible

$W_3$= Final weight of sample + crucible

**DETERMINATION OF FAT BY GERBER METHOD**

The fat content was determined by gerber method; in a clean butyrometer add 10ml of sulphuric acid, 10.75 ml of sample and 1ml of amyl alcohol. Stopper the butyrometer with the help of lock stopper using regulating pin/guiding pin. The butyrometer are placed in the Gerber centrifuge at 1100 rpm for 4 minutes. Take out the butyrometer in an upright position with the stopper end downwards. Note the reading. Reading should be taken from bottom of the fat column to lower border of meniscus on the scale.

**ANALYSIS OF PROTEIN BY KJELDAHL METHOD**

Kjeldahl method was used for determine the protein content. 0.2 g of prepared sample was weighed and it is transferred to 800 ml Kjeldahl flask ensuring that no proportion of the sample was clinging to then eck of the flask.5g of copper sulphate,5g of potassium sulphate and 10 ml of concentrated sulphuric acid were added to the flask. Then the distillation process was carried out. The flask was connected to a distillation apparatus in corporating an efficient flash heat and condenser. To the condenser a delivery tube which dips just below the surface of the pipetted volume of standard acid contained in a conical flask received was fitted. The contents of the digestion flask were titrated against 0.1 N sodium hydroxide solution where methyl green is added as an indicator. A blank titration was also carried out.

Total nitrogen content = (14×0.1×Titre value×100) / Weight of sample ×1000) (3.5.3.1)

Proteincontent(%)=TotalNitrogenContent×6.25 (3.5.3.2)

**DETERMINATION OF FAT BY SOXHLET**

The soxhlet flask was weighed for two consecutive concordant weights. 5g of the moisture free sample was packed into an extraction thimble and placed in an extractor which was fixed into a soxhlet flask. Pour the sufficient amount of ether so as to permit siphon action. The thimble and contents were allowed to soak in the ether for 24 hrs. The entire set up was kept over an electric water bath and the extraction was connected to the condenser. The nozzle of the condenser was always plugged with moistened cotton. The temperature was maintained at $60^oC$. The steady stream of water in the condenser was maintained. The evaporated ether would rise up but owing to the condenser arrangement, it fall back into the extractor.The soxhlet flask was then disconnected and ether was evaporated in a water bath maintaining at $60^oC$. When ether in the flask was evaporated, the flask was weighed again to get concordant values. From the difference in weight, the fat content was calculated.

**RODENT WASTE**

Fill a 250 mL hooked-lipped beaker with 50 g of the sample. Stir the surface layer occasionally for 30 minutes after adding the chloroform within 1 cm of the top. Gently pour the floating tissue and chloroform into a Buchner funnel, being careful not to disturb the thick residue at the beaker's bottom. Make sure the floating layer isn't so compacted that it makes decanting challenging before proceeding. Add carbon tetrachloride in an amount equal to the remaining sample and chloroform in the beaker, allow it to settle once more, and then decant as previously. Until there is very little tissue left in the beaker, repeat the procedure using a mixture of equal parts carbon tetrachloride and chloroform. Any possible rodent excreta particles should not be decanted. Use a stream of carbon tetrachloride or chloroform to wash the residue in a beaker onto a 7 cm ruled piece of paper, then examine under a microscope. For analysis, save the decanted floating tissues.

**CRUDE FIBER**

Extracted 2g of ground material with ether or petroleum ether to remove fat (initial boiling temperature 35-38°C and final temperature 52°C). Extraction may be omitted, if fat content is below 1%. After the extraction process with ether, boiled 2g of dried material with 200ml of sulphuric acid for 30mins with bumping chips. Filtered through muslin cloth and washed with boiling water until washings is no longer acidic. Boiled with 200ml of sodium hydroxide solution for 30 mins. Filtered through muslin cloth again and washed with 25ml of boiling 1.25% $H_2SO_4$, three 50ml portions of water and 25ml alcohol. The residues are removed and transferred to ashing dish (preweighed dish $W_1$). Dried the residue for 2 hours at 130 $\pm$ 2°C. The dish was cooled in a desiccator and weighed ($W_2$). Ignited for 30 minutes at 600 $\pm$ 15°C. Cooled in a desiccator and reweighed ($W_3$).

Loss in weight on ignition in gram = $(W_2 – W_1) – (W_3 – W_1)$

% crude fibre = (loss in weight on ignition)/ (Weight of the sample in gram) × 100

**CARBOHYDRATE DETERMINATION**

Proximate parameter carbohydrate of custard powder was determined using Association of Official Analytical Chemists (AOAC, 2000) method. The carbohydrate content of a food can be determined by calculating the percentage remaining after all the other component has measured.

**DRY MATTER CONTENT (DM)**

The DM content was calculated using the following formula (Ashfaq et al., 2024)
DM = 100 – Moisture Content%

**BENEFITS OF HYDROPONICS:**

1. **Higher Yields & Faster Growth** – Direct nutrient access accelerates plant growth by 30–50%.
2. **Water Efficiency** – Recirculating systems cut water use by up to 90%, making hydroponics ideal for water-scarce regions.
3. **Land Conservation & Urban Farming** – Can be implemented in cities, deserts, and degraded lands.
4. **Reduced Chemical Use** – Controlled environments minimize pesticides and herbicides, resulting in cleaner produce.
5. **Year-round cultivation & Climate Resilience** – Climate-controlled systems ensure continuous food production.
6. **Precise Nutrient Management** – Optimized nutrient solutions improve plant health and nutritional quality.
7. **Renewable Energy Integration** – Solar and wind power can reduce reliance on fossil fuels.

**ADVANTAGES OF HYDROPONICS**

In recent years, hydroponic techniques have become increasingly popular due to their simplicity and purity. Here are several notable benefits of hydroponics:

1. **Eradication of Soil-Borne Disease Risks:**
   Hydroponics eliminates the risk of soil borne diseases and significantly reduces or eliminates the need for pesticides, lessening toxicity concerns.
2. **Faster Plant Maturation:**
   Hydroponically grown plants experience unrestricted root growth and have easy access to nutrients, leading to faster maturation compared to conventional field crops.
3. **Suitability in Harsh Environments**:
   This method is particularly useful in areas with environmental stresses such as intense heat, cold, or desert conditions.
4. **Year-Round Cultivation:**
   Hydroponic systems are less affected by climate change and can support year-round cultivation, even in the off-season.

**AGENCIES TO PROMOTE HYDROPONICS ARE**(Hasan et al., 2018)

1. National Horticultural Board (NHB)
2. National Horticultural Mission (NHM)
3. Horticulture Mission for North East & Himalayan States

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## VI. RESULT

To investigate the optimal conditions for growingmicrogreens, a hydroponic system was employed to cultivate burley, gram, wheatgrass, and green gram in a controlled environment within a greenhouse. Experiments were conducted to tort the growth of the plants under varying environmental conditions. The experiments aimed to study the impact of temperature and humidity on the growth of plants. The greenhouse was tested for varying temperature levels and it was found that the system could sustain the optimal temperature and humidity levels.Hydroponics presents a viable solution to the growing challenges of food security, offering significant benefits in productivity and resource efficiency. However, overcoming its high energy costs, infrastructure limitations, and system complexities is essential for long-term success.By integrating renewable energy, organic practices, and innovative technologies such as aquaponics, hydroponics can contribute to a more sustainable and resilient agricultural future.With continued research and investment, it has the potential to reshape food production, ensuring a reliable food supply in an increasingly uncertain global environment.

## VII. CONCLUSION

In conclusion, the hydroponic microgreen growing system in a greenhouse can be optimized using various environmental parameters such as temperature, humidity, light, and water. By varying these parameters, we were able to adjust the growing conditions to maintain the optimal growth of different microgreens. The mobile application provided an easy way for users to monitor and control the growing conditions remotely.

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