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Design and Development of Aeroponics System for Microgreens

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Abstract

The study focused on the design, fabrication, and evaluation of a compact aeroponics system developed for the cultivation of the four types of microgreens (corn, radish, mungbean and wheatgrass. The system consists of ten major components—fan, control, frame, grow lights, timer, pump set, water tank, cultivation bed, misters, and basin—designed to operate as a closed-loop unit that recirculates water and nutrient mist to optimize root exposure and growth efficiency. The setup integrates mobility and automation features, ensuring uniform misting and efficient resource utilization.

Performance evaluation of the system revealed high Water Use Efficiency (WUE) of 1,265.16 g/L, indicating minimal water consumption relative to fresh biomass yield. The germinative capacity of all four microgreens reached 100%, demonstrating that aeroponic cultivation effectively supports seed germination even without soil. Growth analysis showed a consistent upward trend in both shoot and root development across four species—corn, mungbean, wheatgrass, and radish—over a five-day period. Among these, mungbean and corn microgreens exhibited the greatest shoot elongation (75 mm and 65.75 mm, respectively), while wheatgrass displayed the longest root growth (110 mm). These findings align with earlier reports linking seed size and nutrient reserves to early growth performance.

Economic analysis demonstrated the system's viability and profitability. With an operating cost of ₱309.20 per 5-day cropping cycle and a yield of 1,398 g of corn microgreens, the production cost was estimated at ₱4 per gram. The projected annual gross income was ₱268,032, yielding a return on investment (ROI) of 685% and a payback period of approximately 1¾ months, confirming its strong economic feasibility for small-scale or urban producers.

An Information, Education, and Communication (IEC) material was developed to support technology transfer, detailing the system's operation, cultivation procedures, nutritional benefits, and economic indicators. Overall, the developed aeroponics system proved to be technically efficient, resource-conserving, and economically viable for sustainable corn microgreen production under controlled environments.

Keywords: Microgreens, Aeroponics, Sustainable Agriculture, Corn Microgreens, Radish Microgreens, Wheatgrass Microgreens, Mungbean Microgreens

1. Rationale

Global Sustainable Development Goal No. 2, established by the United Nations for 2030, urges all member nations to champion sustainable agriculture in food production as a remedy to issues linked with the expanding population, food security, and nutrition. This call, detailed by Rajan et al. (2019), becomes especially critical as the global population is anticipated to rise from 7.2 billion to 8.1 billion by 2025 and reach 9.6 billion by 2050.

Therefore, there is a continuing need to produce more food because of the growing world population. The sustainability of the globe is threatened by rising food production since it necessitates increased use of energy, water, and soil resources. Similarly, excessive land usage and intense farming methods can cause nutrient depletion, soil erosion, and a loss of soil fertility, all of which can eventually lower the land's productivity. (Winnerova, et.al, 2022). The Food and Agriculture Organization, FAO (2017) suggested using sustainable agriculture methods including aeroponics, hydroponics, and aquaponics to improve the problem.

These soilless methods leverage technology to increase food production efficiency without endangering the sustainability of the earth. (Garzon, et.al, 2023)

This surge in population, coupled with the escalating demand for agricultural products, highlights the need for innovative and sustainable approaches to address potential challenges such as the scarcity and cost of prime agricultural land (Kumari et al., 2019).

A pioneering technology emblematic of sustainable agriculture emerged in the 1920s but initially served primarily as a research tool in the 1940s. Known as aeroponics, this soilless agricultural technique nurtures plants by misting their roots with a nutrient-rich solution. A comprehensive review of 47 studies by Garzon et al. (2023) sheds light on the technological landscape in aeroponics, revealing prevalent use of sensing technology and Industry 4.0. While these technologies offer sustainability and time efficiency benefits, challenges persist, notably technical complexity and dependence on power (Garzon et al., 2023). Further innovation is explored in a Springer paper introducing a novel approach to aeroponic and hydroponic system monitoring, fault detection, and automation.

Aeroponics stands out as a promising soilless farming method compared to hydroponics technology due to its reduced water requirements. Positioned as a solution to future food crises, aeroponics offers a novel approach to plant cultivation marked by speed, cost-effectiveness, and sustainability (Kumari and Kumar, 2019). Particularly relevant in the face of challenges like soil degradation, resource scarcity, and climate change, aeroponics emerges as a leading technology for sustainable agriculture under SDGs No. 2, conserving resources for future generations. This technology boasts impressive reductions in water usage (98%), fertilizer usage (60%), and pesticide usage (100%), while simultaneously maximizing crop yields (Kumari and Kumar, 2019). NASA research supports these claims, indicating an 80% increase in dry weight biomass for aeroponically grown plants compared to hydroponically grown ones (Kumari et al., 2019). Aeroponics is not limited to specific plant species, as the micro-environment it provides can be finely controlled. However, studies emphasize its sustainability in microgreens cultivation, showcasing its potential to significantly reduce water usage, fertilizer consumption, and space requirements compared to traditional soil-based methods. The technology's global recognition is attributed to its ability to enhance nutrient absorption, resulting in high yields. The versatility and compatibility of aeroponics are further exemplified by its suitability for various microgreen varieties, including wheatgrass, lettuce, and herbs. For this study, four microgreens are planted-corn, radish, mungbean and wheatgrass.

Corn or *Zea mays* is one of the ancient crops consumed by mankind. This is the world's most productive and dominant crops, grown for food, livestock feed, biofuel, and industrial use. This consume as a whole grain, it can helps lower the risk of chronic illnesses like heart disease and type 2 diabetes. Corn is also a healthy source of fiber, vitamins, minerals, and antioxidants. It is used for animal feed, human consumption, ethanol, sweeteners, starch, and beverage/alcohol production. Because of the abovementioned benefits, it is best to consume corn as microgreens. Corn microgreens is a young greens are garnering attention for their concentrated nutrient content and potential health benefits. The early stage of growth intensifies their nutritional density, offering a concentrated source of goodness in just a small serving. They contain vitamins A, B, C, & E, iron, calcium and magnesium as well as other nutrients including calcium and magnesium. As with other microgreens, they pack a serious nutritional punch. (https://thistledownsfarm.com/the-secret-to-growing-sweet-corn-microgreens/). Corn Microgreens are the tender, immature shoots of the corn plant. They are harvested at an early growth stage, typically when the first leaves, also known as cotyledons, appear. Corn plants are famously fast growers, and it makes sense that corn microgreens are one of the quickest you can cultivate. In 4-10 days, you can transform a handful of hard corn kernels into an abundance of healthy, delicious microgreens. Corn microgreens are sweet and sugary. If processed, it can be a replacement for sugar like stevia plant. These microgreens are packed with more nutrients than their mature, green counterparts. Because corn microgreens are so young, the corn shoots receive all the necessary nutrients directly from the seed as they grow. The benefits of corn microgreens are even more impressive than many of the microgreens you may already be familiar with: It can: a)Boosts your immune system; b) Reduces hypertension; c) Prevents anemia; d) Improve your bone health; e) Rich in antioxidants; f) High amounts of vitamins; g) Packed with nutrients; h) Easy to grow; and

i) Can grow indoor or outdoor. (https://whyfarmit.com/corn-microgreens/). Corn microgreens is serve in salad, eaten with other raw vegetables or alone. It can also feed as fodder to poultry and livestock. (https://sustainablelivestocknutrition.com/microgreen-growing-fodder-with-diy-hydroponics-system/)

On the other hand, Radish (*Raphanus sativus*) microgreens, are highly valued for their peppery flavor and vibrant red-purple hue. They contain elevated levels of vitamins A, B, C, E, and K, alongside essential minerals such as calcium, iron, magnesium, and phosphorus. According to Xiao et al. (2012), radish microgreens possess significantly higher concentrations of vitamin E and beta-carotene than their mature counterparts. Research by Kyriacou et al. (2016) supports their antioxidant potential, highlighting their role in reducing oxidative stress and promoting cardiovascular health. Their rapid growth—typically within 5–7 days—makes them an ideal candidate for aeroponic cultivation due to their minimal resource requirements and high nutrient yield.

Mungbean (*Vigna radiata*) microgreens are another promising crop due to their exceptional protein content and digestibility. Studies by Li et al. (2020) and Singh et al. (2021) indicate that mungbean microgreens are rich in polyphenols, flavonoids, and ascorbic acid, making them potent natural antioxidants. They are also a rich source of amino acids, iron, and fiber, promoting improved gut health and metabolism. Mungbean microgreens grow efficiently under controlled aeroponic systems, requiring only 5–6 days from seed to harvest while producing high biomass yield and nutritional density. Moreover, their adaptability to low-light environments enhances their potential for indoor sustainable food systems (Ramesh et al., 2022).

In recent years, the health and wellness community has been buzzing about a tiny yet mighty nutritional dynamo – wheatgrass microgreens. Derived from the tender shoots of the *Triticum aestivum* plant, these young greens are garnering attention for their concentrated nutrient content and potential health benefits. Let's delve into the myriad advantages that make wheatgrass microgreens a potent addition to your daily diet. Wheatgrass microgreens pack a powerful punch of essential nutrients. These miniature greens are abundant in vitamins A, C, E, and K, as well as vital minerals like iron, magnesium, and calcium. The early stage of growth intensifies their nutritional density, offering a concentrated source of goodness in just a small serving. Wheatgrass microgreens are a nutrient-dense food that is easy to grow indoors. They are rich in vitamins, minerals, and antioxidants, making them an excellent addition to any diet. According to a study published in Medical News Today, wheatgrass contains high levels of chlorophyll, which gives it its bright green color (https://www.medicalnewstoday.com/articles/320210). It is also rich in vitamins A, C, E, and K, as well as calcium, magnesium, and iron (https://www.betterhealth.vic.gov.au/health/healthyliving/Vitamins-and-minerals).

The cultivation of microgreens in an aeroponics system is proposed as an ideal method to harness these benefits. Despite the acknowledged efficiency of aeroponics, challenges such as system failures, disease susceptibility, and the need for precise environmental control exist. Failures in nutrient supply may lead to crop loss, emphasizing the importance of automation and self-adaptation in aeroponic systems (Gnauer et al., 2019). Mitigation strategies, including automation, redundant system design, and disease prevention, are identified to address these challenges. Further, evaluation of the performance of aeroponics against other cultivation methods, such as hydroponics and traditional soil-based farming, are prevalent. These studies contribute valuable insights into the advantages and limitations of aeroponics in microgreen production.

Looking forward, that this literature highlights future directions and research gaps in aeroponic microgreen cultivation. Exploring additional plant varieties, optimizing nutrient formulations, and addressing the ecological footprint of aeroponic systems are identified as potential areas for further research. In conclusion, the literature on aeroponics for microgreens reflects a dynamic and evolving field, emphasizing sustainability, technological advancements, plant-specific considerations, and the need to overcome challenges.

The development of an aeroponics system for growing wheatgrass microgreens holds significant promise in addressing global challenges related to food security, safety, and resource optimization. As a sustainable cultivation approach aligned with SDGs No. 2, aeroponics emerges as a key player in advancing agricultural practices for a more sustainable and resilient future.

2. Objectives

1. Design and install the aeroponics system for corn microgreens;
2. Evaluate the performance of the designed aeroponics system in terms of Water Use Efficiency (WUE)
3. Evaluate the germinative energy of corn microgreens in an aeroponics system in terms of:(a) germinative capacity;(b) plant height; (c)root length; and (d) crop yield;
4. Assess the economic viability of the aeroponics system; and
5. Develop an Information Education materials for technology transfer of the aeroponics system and cultivation of corn microgreens.

3. Review of Literature

Aeroponics is a soil-less planting method wherein plants grow in the air with the assistance of artificial support (Osvald et al., 2001). This cultivation system, known as an air-water culture, involves suspending the plant roots inside a sealed container in darkness while being openly exposed to the air, receiving a nutrient-rich water spray through atomizers. The upper portion of the plant, including leaves and crown, extends above the wet zone. An artificially provided structure separates the roots and canopy of the plant. Under controlled conditions, the system utilizes nutrient-enriched spray in the air, facilitated by pressure nozzles or foggers, to sustain hyper growth (Nir, 1982; Engenhart, 1984; Zsoldos et al., 1987; Barak et al., 1996; Mbiyu et al., 2012).

The atomization spray delivers intermittent mists of nutrients to the plant roots at specific intervals for a defined duration rather than continuous misting. Klotz (1944) was the first researcher to discover vapor-misted citrus plants, conducting this work to support research studies on citrus and avocado root diseases. Vyvyan and Travell (1953) successfully grew apple plants in a misted environment. Went (1957) at the Earhart Laboratories in Pasadena, California, cultivated tomato and coffee plants in a water-tight container with a fine nutrient mist propelled by an atomization injector with pressure. He named the method 'Aeroponics plant growing system' (Stoner, 1983). Peterson and Krueger (1988) asserted that, in the present scenario, the aeroponics system stands out as the most efficient plant cultivation method, allowing plants to grow without soil interference compared to other soil-less techniques. This nutrient-mist system minimizes water usage and provides an optimal environment for plant growth (Buer et al., 1996).

Hessel et al. (1993) and Clawson et al. (2000) explored the utility of the aeroponics system for spaceflight and revealed its contributions to advancements in various areas of plant root studies. These studies encompassed root microorganisms (Hung and Sylvia, 1988; Sylvia and Jarstfer, 1992; Wagner and Wilkinson, 1992), root response to drought (Hubick et al., 1982), effects of oxygen concentrations on root growth (Shtrausberg and Rakitina, 1970; Soffer and Burger, 1988), legume-rhizobia interaction (Zobel et al., 1976), arbuscular mycorrhizal fungi production (Sylvia and Hubbel, 1986), and plant cultivar differences in root growth. The aeroponics system achieved impressive results, saving up to 99% of water, 50% of nutrients, and requiring 45% less time than soil-based cultivation (NASA, 2006). The adaptability of the system makes it appealing for application in spaceflight plant growth systems (Zobel, 1989; Mirza et al., 1998), allowing plant roots to quickly absorb available nutrients under controlled conditions. These controlled conditions include uniform nutrient concentration, electrical conductivity (EC) and pH values, temperature, humidity, light intensity, atomization frequency, atomization spray time, atomization interval time, and oxygen availability.

Despite the predominant use of modern plant growing technology for horticultural and ornamental cultivation, as well as the production of herb and root-based medicinal plants (Clayton and Lamberton, 1964; Cho et al., 1996; Park and Chiang, 1997; Burgess et al., 1998; Garrido et al., 1998a; Garrido et al., 1998b; Scoggins and Mills, 1998; Molitor et al., 1999; Kamies et al., 2010), aeroponics remains a versatile and efficient method with broad applications in diverse plant cultivation contexts.

4. Water Use Efficiency

Water use efficiency (WUE) is a critical metric in modern agriculture, reflecting the relationship between biomass production and the amount of water consumed. Aeroponic systems, by design, optimize WUE through precise and intermittent nutrient misting, minimizing water losses from evaporation and percolation. Studies by Barbosa et al. (2015) and Sharma et al. (2018) demonstrate that aeroponics can reduce water usage by 95–99% compared to conventional soil cultivation. According to Otazu

(2010), potato minituber production under aeroponic conditions showed a fourfold increase in WUE compared to hydroponic and soil systems. Similarly, Latif et al. (2021) found that leafy greens cultivated aeroponically maintained high productivity under reduced misting intervals, demonstrating that optimal spray timing enhances root aeration and nutrient absorption.

Tamon (2020) conducted a design and performance evaluation of an aeroponic system for lettuce production and found that lettuce grown aeroponically exhibited higher yield and greater water use efficiency compared to soil-grown lettuce. Desalisa (2020) further confirmed that aeroponics maintains an effective discharge coefficient and uniform nutrient distribution, ensuring water conservation without compromising plant health. These studies reinforce the system's role in sustainable food production and efficient water management under SDG No. 2.

5. Germinative Capacity and Germinative Energy

Germinative capacity refers to the percentage of viable seeds that successfully germinate, while germinative energy reflects the speed and vigor of germination under specific environmental conditions. In aeroponic microgreen cultivation, these parameters are essential indicators of system performance, particularly under controlled moisture and oxygen conditions.

According to Subedi and Chaudhary (2013), the controlled misting environment of aeroponics promotes rapid and uniform germination due to optimal humidity and oxygen availability around the seeds. Dinesh et al. (2019) reported that aeroponic-grown seeds of mungbean (*Vigna radiata*) and radish (*Raphanus sativus*) exhibited significantly higher germinative energy compared to those germinated in soil, attributed to efficient water and nutrient uptake through fine mist exposure. Moreover, Kaur and Singh (2020) observed that aeroponic seedling systems enhance root elongation rates and increase germinative capacity by up to 25% compared with hydroponic systems, primarily because of greater oxygen diffusion and lower pathogen interference.

In microgreens, particularly radish and mungbean, fast germination and early vigor are essential traits linked with nutrient accumulation and biomass yield. Studies by Sharma et al. (2021) and Poudel et al. (2020) indicated that the germinative capacity of mungbean microgreens exceeded 95% under intermittent misting conditions (5 seconds on, 10 minutes off) due to consistent moisture exposure. Similarly, radish microgreens demonstrated higher germinative energy and faster hypocotyl emergence in aeroponic environments compared to soil, as reported by Le et al. (2022), owing to the uniform distribution of atomized nutrient solutions.

Therefore, enhancing water use efficiency and optimizing germinative capacity and energy are critical factors in maximizing aeroponic productivity. When combined with precision misting and automated environmental control, these parameters ensure sustainable and high-yielding production of nutrient-rich microgreens such as wheatgrass, radish, mungbean, and corn.

Misting Frequency

The atomization spray time and interval time are crucial factors for the successful cultivation of plants in an aeroponic system. Potatoes have been cultivated under various atomization spray time and interval time conditions, including 20 seconds on and 5 minutes off, 3 minutes on and 5 minutes off, 3 seconds on and 10 minutes off, 30 seconds on and 5 minutes off, 10 seconds on and 20 minutes off, 15 minutes on and 15 minutes off during the daytime, and 15 minutes on and 1 hour off during the nighttime, as well as 10 seconds on and 3 minutes off during the daytime and 10 seconds on and 5 minutes off during the nighttime (Farran and Mingo-Castal, 2006; Ritter et al., 2001; Abdulla-teef et al., 2012; Chang et al., 2012; Mateus-Rodríguez et al., 2012; Tsoka et al., 2012; Rykaczewska, 2016).

Biddinger et al. (1998) and Osvald et al. (2001) successfully cultivated tomatoes under specific atomization spray time and interval time conditions, including 3 seconds on and 10 minutes off, and 60 seconds on and 5 minutes off, respectively. Furthermore, various studies have cultivated different plants using distinct atomization spray time and interval time settings, such as cucumber (7 seconds on and 10 minutes off) (Peterson and Krueger, 1988), lettuce (1.5 minutes on and 5 minutes off) (Lactuca sativa L.) (Kacjan-Marsic and Osvald, 2002), saffron (Crocus sativus L.) (1 minute on and 1 minute off) (Souret and Weathers, 2000), 96 Echinacea (Echinacea purpurea) and 30 burdocks (Arctium lappa) (30 seconds on and 60 seconds off) (Pagliarulo and Hayden, 2000), and Anthurium andreanum (15 seconds on and 15 minutes off) (Fascella and Zizzo, 2007).

Efficiency of the system

Aeroponics represents a significant advancement beyond traditional hydroponics (Kumari and Kumar, 2019). Many studies have been conducted to facilitate plant cultivation in space, emphasizing the advantages of aeroponic crop growth to supplement the dietary requirements and overall well-being of crew members during flights and on orbital platforms (Carillo et al., 2020). Carillo's study in 2020 aims to optimize water and nutrient delivery systems in microgravity to meet the needs of cultivated species. Additionally, the research involves experimentation with LEDs to maximize plant growth and quality, maintaining light intensity at a maximum around 300–400 µmol m−2 s−1.

In 2021, Halgamuge et al. investigated critical parameters for automating sustainable vertical gardening systems using the Internet of Things (IoT) concept in smart cities, contributing to smart living. The study involved collecting and reviewing data from 30 peer-reviewed publications published between 2004 and 2018, encompassing real-world vertical gardening implementations. Key criteria considered included crop/plant type, vertical gardening topology (size), sensing data, hardware used (sensors, actuators, etc.), power supplies, velocity or frequency of data collection, data storage methods, communication technologies, data analysis methods/algorithms, other strategies employed, and countries implementing vertical gardens. Analysis of the data revealed that 40% of studies used 6-20 tiers when implementing vertical gardens, with lettuce being the most popular crop (28.6%). Sensors were commonly connected to AC power and battery (44.4% each), while a smaller proportion utilized solar power (11.1%). Most IoT sensors measured room temperature (22.5%), light intensity (21.1%), humidity level (14%), and soil nutrition (7%). The frequency of data collection by these sensors ranged between 1 and 3 minutes (42.8%). Zigbee and Wi-Fi were the most frequently used data transmission technologies (42.8%) for collecting sensor data from vertical gardens. The study also found that using server databases, remote data management platforms, and cloud storage were the most popular data storage methods (each 25%). The most significant focus on automating vertical gardens incorporating IoT was observed in the USA (41.2%) and China (23.5%).

Tamon, 2020 study on the design, inatallation and performance evaluation of an aeronic system, planting lettuce. The result shows that lettuce grown in an aerophonics system has a greater yield in compare with the lettuce planted in soil. The study also shows that the aeroponics system uses less water in lettuce production that growing lettuce in soil condition.

Furthermore, Desalisa, 2020 study showed the performance of an aeroponic system that the actual discharge is higher than the designed discharge and implied an effective average coefficient of uniformity.

6. Methodology

Research Design

Descriptive and Evaluative research design were employed to provide an accurate and valid illustrations of the data gathered. The study started with the design and fabrication or development of the system. The following are the design considerations:1.)The average length of corn seeds varied from 11.335 mm to 12.45 mm (Tarighi, et.al.,2011); 2.)The average width varied from 7.93mm to 8.29 mm (Tarighi, et.al.,2011)1.) The average thickness varied from 4.49mm to 4.89 mm, (Tarighi, et.al.,2011) 3.) The Power requirement is ½ hp; 4.) the area of the cultivation bed is 5,974 square centimeter same with the area of the basin.

7. Materials and Procedure

Materials

The materials used are Tubular ½ x ½ , Aluminum Perforated Screen 1.2mm, GI Pipe S20, ¾ GI Pipe S20, Angle Bar 1x3/16 in, Pressurized tank w/electric motor, ½ hpPVC Pipe, blue ½ Mister, fogger Control Panel, 15cm x 16cm x 4cm Welding Rod Stainless Welding Rod, Bolt 1 ½ x ¼, PVC Elbow Blue, ½, PVC Tee, Blue ½ PVC Solvent, Convenient outlet, 15A, 240V, Circuit Breaker, 15A 240V, Basin, 95cm x 65cm, Tank, 100li.

The tools and equipment used are Calculator, Computer Aided with AutoCAD, Welding Machine, Cutting Tools. Testing equipment used are pH meter and TDS. Corn Microgreens and distilled water is used as testing materials.

Procedure

The aeroponics system will be composed of the following (a) Fan; (b) Control; (c) Frame; (d) Grow light;s (e) Timer; (f) Pumpset; (g) Nutrient Tank; (h) Cultivation Bed; (i) Misters; (j) Basin. The first to fabricate is the frame to put all the other components of the aeroponics system. The consideration for the design of the frame is the computed capacity of corn that will be planted in the cultivation bed which is two (2) kilogram of corn microgreens.

Next, the basin and the cultivation bed is fabricated and then attached to the frame.

Then, the water pipeline and the misters are put in the system. Also the grow lights, fan, timer and control are all placed in the system. The timer is set to the desired misting frequency.

Finally, pressurized tank and pump is assembled with the water tank and connect to the pipeline.

The research procedure of the whole study is shown in Figure 3 below

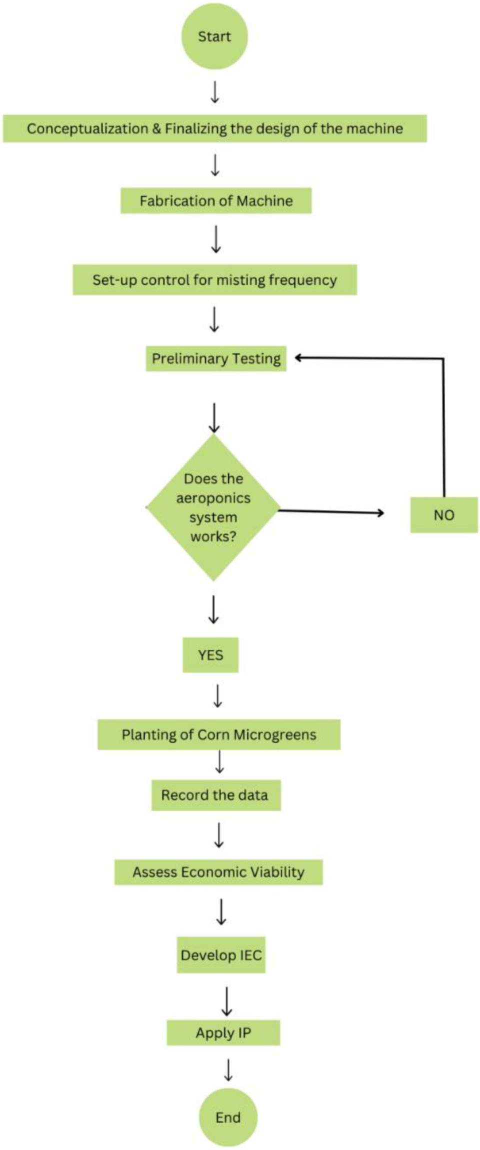


Figure 3. Process flow chart of the study.

After the installation of the aeroponics system, the system is tested without any crop planted to determine if all of its components functions.

The performance of the aeroponics system is assessed, focusing on Water Use Efficiency. The water applied in 10 seconds is measured to be 500 ml. The control is then set to mist every 3 hours. The water discharged after misting is also measured.The Water Use Efficiency will be calculated by measuring the volume of water applied in the aeroponics systems every 3 hours of misting for 10 secs and computed using the formula:

$$WUE = TFW/\Sigma W$$

Where:

WUE=Water Use Efficiency, g/li

TFW= Total Harvested Biomass

ΣW= Volume of water, li

Then, aeroponics systems will be installed inside the house, with normal conditions. Subsequently, corn microgreens will be planted on the installed aeroponic system. The germinative energy of corn microgreens in the aeroponics system will be evaluated in terms of (a) germinative capacity, (b) plant height, (c) root length; and (d) crop yield,

Also, the economic viability of the aeroponics system will be assessed. The cost is calculated to contextualize how much it costs to produce a unit of fresh corn microgreen biomass, Radish microgreens, mungbean microgreens and sunflower microgreens This is calculated by dividing the crop yield in grams of fresh weight with the operating costs (energy, water, seeds and nutrient solution).

$$\text{COST} = \frac{\text{Fresh Weight, grams}}{\text{Operating Costs}}$$

The Annual gross income will be computed by multiplying the cost and the crop yield in grams per planting per year.

ANNUAL GROSS INCOME =
Crop yield (grams) x Cost x times of planting

The economic viability is also computed using the following formula:

Return on investment (ROI) =

$$\frac{\text{Average net income}\quad\text{Average net income}}{\text{average total expenses}\,\text{average total expenses}}$$

Where:

ROI = Return on investment, %

Net Profit = Annual Gross Income – Operating Cost – Depreciation

Investment = cost of the machine

Payback period = $$\frac{\text{Average total expenses}}{\text{average net income}}$$

$$\frac{\text{Average total expenses}}{\text{average net income}}$$

Where:

PBP = Payback period, years

Investment = cost of the machine

Net Profit = Annual net return – Operating Cost – Depreciation

Finally, Information and Educational Campaign (IEC) materials for the technology transfer of the aeroponics system and corn microgreens cultivation will be developed. This is to educate farmers about this emerging technology in sustainable agriculture.

Data Gathering

The following data will be recorded during the conduct of the study:

Volume of water

Water sprayed in the cultivation box is collected every misting period.

Germinative Capacity

Numbers of seeds is counted before soaking and number of seeds germinated is counted before spreading in the cultivation bed.

Plant height

The height of the plant is measured twice a day (8:20 am and 8:20 pm) using a ruler.

Root Length

The root length of the plant is measured twice a day (8:20 am and 8:20 pm) using a ruler.

Crop yield

Weight of the harvested crop is measured and computed using the formula:

$$\text{Crop Yield} = \frac{\text{TFW (g)}}{\text{A}}$$

Where:

TFW = Total Fresh Weight, g

A = Area of the Cultivated Bed

Statistical Tools

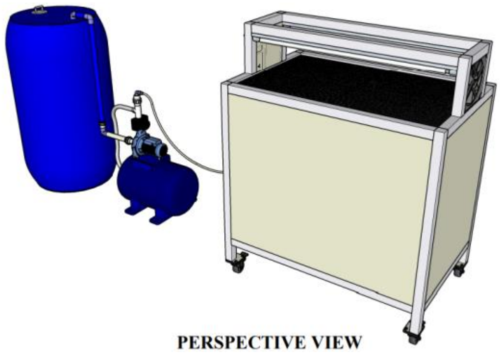
The gathered data is analyzed by computing for the mean or averaging. The analysis will be a descriptive analysis. It is presented in table and graph.

8. Results And Discussion

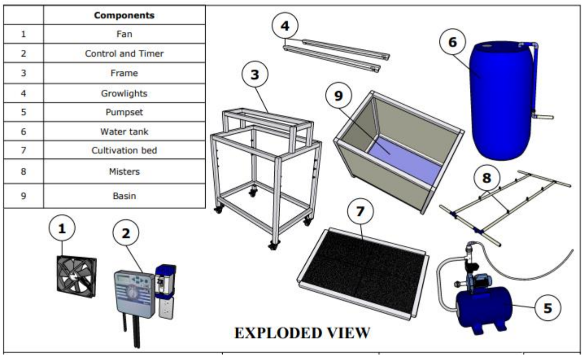
Design of the Aeroponics System

The aeroponics system developed is a compact and mobile setup designed for the cultivation of microgreens. As shown in the perspective view (a), the design features two main components: the water tank and pump system on the left, which supplies the nutrient solution under pressure, and the cultivation chamber on the right, where the microgreens are grown. The pump is connected to a mister system, ensuring that the nutrient-rich solution is sprayed directly onto the plant roots. This principle aligns with Stoner (1983), who emphasized that exposing roots to a fine mist environment enhances nutrient absorption efficiency.

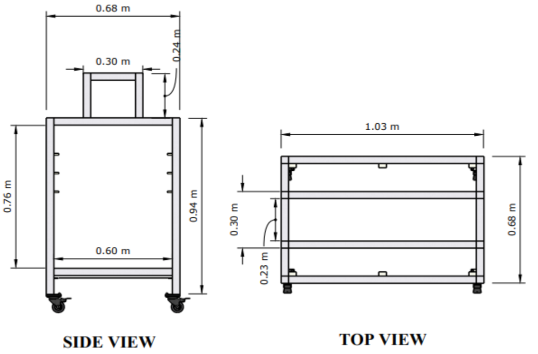
This aeroponics system functions as a closed-loop unit. The nutrient solution is stored in the tank, delivered under pressure by the pump, and sprayed through the misters directly onto the roots of the corn microgreens. Excess solution drains into the basin, where it is captured and recirculated. This efficient, space-saving, and water-conserving design supports sustainable and controlled-environment agriculture. Al-Kodmany (2018) stressed that aeroponics, along with other vertical farming technologies, represents a promising method for future urban food production, as it maximizes yields while minimizing land and water use.



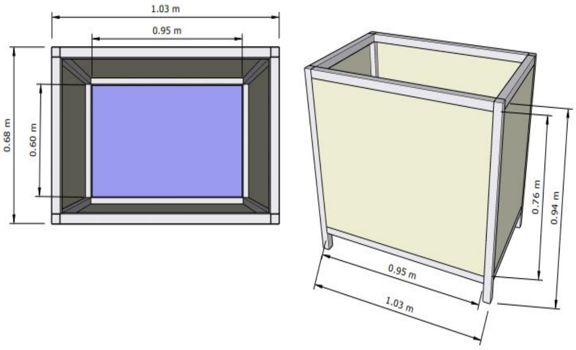
(a)



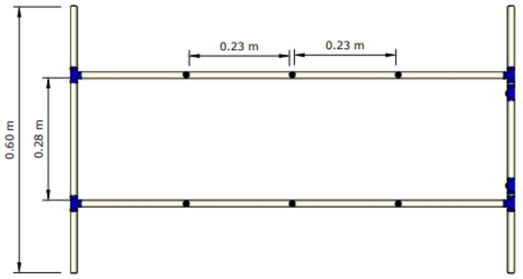
(b)



(c)



(d)



(e)

Figure 4. Aeroponics System for Corn Microgreens: (a) Perspective View; (b)Exploded View; (c) Frame; (d) Basin; and (e) Misters.

The frame of the system (c), measuring 0.94 m in height, 0.68 m in width, and 1.03 m in length, is equipped with vertical supports and wheels for mobility. This ensures both stability and ease of relocation, consistent with the modular and flexible design approaches highlighted by Shalaby et al. (2021), who argued that mobility and scalability are critical in advancing urban agriculture systems. The frame also provides specific allowances for mounting the basin and mister system, which ensures both functional efficiency and compact design.

The basin (d), with dimensions of 1.03 m by 0.68 m and an inner depth of 0.60 m, is lined with waterproof material to prevent leakage and acts as a housing for the mister system. It collects excess water for recirculation, creating a sustainable closed-loop system. Barbosa et al. (2015) demonstrated that such recirculating systems in controlled environment agriculture significantly reduce water consumption compared to soil-based farming, making them more resource-efficient. Misters (c), consisting of two 0.60 m long pipes connected by crossbars with nozzles spaced 0.23 m apart. This arrangement ensures uniform mist distribution, a vital aspect of aeroponic efficiency. Jensen (1999) emphasized that spray uniformity is essential in preventing root desiccation and ensuring balanced nutrient delivery.

Components of the Aeroponics System

The aeroponics system for corn microgreens is composed of; 1.)Fan; 2.)Control; 3.)Frame; 4.) Growlights;5.) Timer; 6.)Pumpset; 7.) Water Tank; 8.) Cultivation Bed; 9.) Misters; and 10. Basin.

1.Fan

In Zhang et.al. (2016), the exhaust fan was set to 3.1 m/s , based on the volumetric flow rate of the fan, and it optimization leading to improved resource use efficiency in indoor plant factory. According to the study the eshaust fan is used to control the control the growing environment and maintain the climate uniformity.

For this study, the fan is use to provide airflow and prevent moisture build up. The exhaust fan used is the commercial available fan in the market which is 58 CFM.

Figure 5. Exhaust Fan

Figure 6. Control

2.Control

Pinon (2024) study about the control of indoor microgreens used sensors and cultivators with control to microgreens planted inside a greenhouse. The control helps in the proper growth and maintenance of nutritional quality requirements like temperature, humidity ratio and lighting.

For this study, the control is used to automate the misting frequency. For this proposed design we use a misting frequency of 10 seconds every 3 hours.

Figure 7. Fabrication of the frame.

3.Frame

For the frame, this study uses, tubular ½ x ½ with full height of 116 centimeters, length of 103 centimeter and 57 centimeter.

The frame supports the different components of the machine especially the cultivation bed. It has wheels for the mobility.

Image Sources:https://shorturl.at/fbVyB

Figure 8. LED Growlights

4.Growlights

Zang et.al. (2020) stated that the anti oxidant capacity of microgreens can significantly increased by using LED light, in particular UV-B light and the accumulation of mineral is also increased during light exposure. LED lights is an efficient strategy on growing sprouts and microgreens with higher nutritional values. However, the effect of LED lights on the growth of microgreens is species dependent.

5.Timer

Figure 9. Timer

Di Gio (2019) uses a frequency of fertigation events of one or two minutes. It uses zinc and Iron agronomic bio fertigation on top of seeds using misting noozles.

But for this study, the timer is set only to open and close the exhaust fan and the growlights because the control already automates the misting frequency every 10 seconds every 3 hours.

6.Pumpset

Sreekuman (2020) use high pressure aeroponics systemto produce more yield at an affordable time. The highvvpressure aeroponics system use droplets sizes around 50 microns. It used to mounts the level of carbon dioxide, humidity lights intensity and solution levels

Figure 10. Pump set

For this study, Pump set is used to pump the water from the tank to the basin to mist the seeds under the cultivation bed. The pump set is composed of pressurized tank and electric motor. The pressurized tank used is available marklet size of 20 psi for 12 gal of water. It is powered by a ½ hp electric pump.

Figure 11. Water Tank

7.Water Tank

Kentegen, et.al. (2021) used distilled water for microgreens nutritional and sensory quality for two types of cress microgreens. Isik (2022) also used distilled water, no chlorinated water is used because microgreens need to be sprayed only with sterile distilled water.

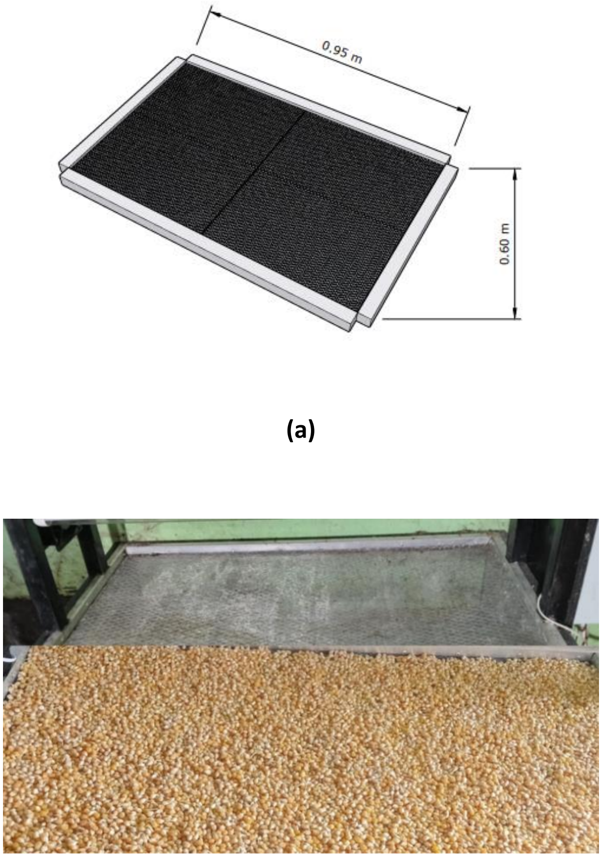
For this study, distilled water is also used to spray the corn microgreens. The water tank served as the reservoir for distilled water that will be used for the distribution of water by the pipeline and misters to the corn microgreens.100 li tank is used to contain the water.

8.Cultivation Bed

Sari et.al. (2022) plant microgreens is an smart box device to increase the growth of the microgreens. The box has a smart conditioning device for air temperature, soil moistuire, and light intenty detector.

The microgreens planted in the system has grown evenly, has wider leaves , taller stem and thefore have increase the crop yield.

For this study,The cultivation bed is made up of aluminum screen. This will serve as the support for the corn microgreens from germination to harvesting. The size of the cultivation bed is 0.60 m width and 0.95 m length.



(a)

(b)

Figure 12. a.) cultivation bed; b.) cultivatrion bed with corn sedds.

Image Source:https://shorturl.at/SpWrs

Figure 13. Misters

9.Misters

Pents, et.al. (2020) germinated microgreens directly in the greenhouse. They uses overhead mist. The misting system created an optimum condition for the germination of seeds. Saswati (2024) used 4 or 5 sprayer misters to distribute the mist evenly

For this study, Six misters to evenly distribute the mist on the cultivation bed.

10.Basin

Figure 14. Basin

The basin served as the catch basin for water droplets that will not be intake by the roots of the microgreens. The size of the cultivation bed is 50 cm width and 103 cm length.

Performance eroponics System in terms of Water Use Efficiency (WUE)

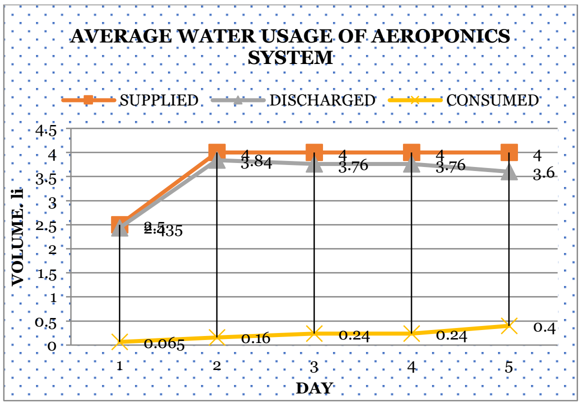


Figure 15. Average Water Usage of Aeroponics System

Figure 15 shows the volume of water applied, discharged and consumed for five days cultivating microgreens in an aeroponics system.

To get the water applied, the control and timer of the aeroponics system is set to a misting frequency of 10 seconds every 3 hours. During the preliminary testing, the volume of water every 3 hours is 0.5 liter per misting day. The total volume of water from day 1 to day is 18.5 liters.

During the conduct of the actual testing, after every misting the discharged water in the basin if measured. The total discharged water in five (5) day is 17.4 li.

To get how much is the consumed water, the total discharged water is subtracted from the total applied water. The total absorbed water is 1.105 li in five (5) days.

After five days, the corn microgreens Total Fresh Weight(TFW) 1,396 grams.

Using the formula:

$$WUE = TFW/\Sigma W$$

The Water Use Efficiency (WUE) of corn microgreens in an aeroponics system is 1,265.16 g/li.

Germinated Energy of corn microgreens in an aeroponics system

Germinative Capacity

Two (2) kilos of corn seeds are counted before soaking it with water. After soaking it with water, it is then set aside for 1 day. Before spreading it in the cultivation bed, the number of seeds germinated are counted. with soaking the corn microgreens the number of seeds germinated is counted.

Using the formula:

$$\text{Germinative Capacity(\%)} = \frac{\text{Number of Germinated Seeds}}{\text{Total Number of Seeds Planted}} \times 100$$

The germinative capacity of the corn seeds in the aeroponics system is one hundred percent (100%).Even without soil, all of the seeds germinated.

Plant height

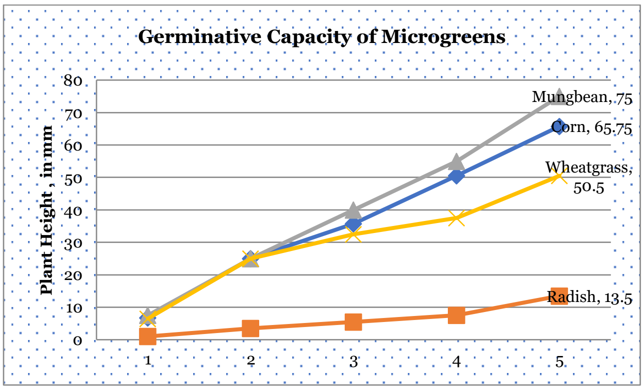


Figure 16. Corn Microgreens germinative energy in terms of plant height.

Figure 1 illustrates the average plant height of four microgreen species—corn, radish, mungbean, and wheatgrass—over a five-day period. The chart reveals a consistent upward trend in growth for all microgreens, indicating active germination and shoot elongation throughout the observation period.

Among the microgreens, mungbean exhibited the greatest growth performance, reaching approximately 75 mm by Day 5, followed by corn at 65.75 mm, wheatgrass at 50.5 mm, and radish at only 13.5 mm. The average growth line (dashed) shows a steady increase from 5.44 mm on Day 1 to 51.19 mm on Day 5, demonstrating that all species experienced significant height increases, particularly between Days 3 and 5.

The rapid growth of mungbean and corn microgreens can be attributed to their larger seed size and higher nutrient reserves, which provide stored energy essential for early growth and elongation. This finding is consistent with Kou et al. (2013), who noted that seed nutrient composition plays a vital role in determining the early growth rate of microgreens. Similarly, Xiao et al. (2012) reported that microgreens derived from larger-seeded species tend to exhibit faster and taller growth compared to small-seeded species.

In contrast, radish microgreens demonstrated a slower rate of elongation but tend to develop thicker stems and larger cotyledons—an observation supported by Kyriacou et al. (2016), who explained that species-specific morphology influences how growth energy is distributed between vertical and horizontal expansion. Wheatgrass, while showing moderate growth, displayed uniform and consistent elongation across all days, aligning with Pinto et al. (2015), who described wheatgrass as a slow but steady grower with a linear increase in height due to its efficient photosynthetic capacity.

The sharp increase in average height from Day 3 onward aligns with the typical growth stages of microgreens, where germination transitions into rapid vegetative growth as photosynthesis becomes fully active (Treadwell et al., 2010). According to Borges et al. (2020), environmental factors such as adequate moisture, temperature, and light exposure further accelerate this stage of development, allowing for faster cell elongation and tissue expansion.

Table 1. Average plant height of Microgreens per day.

MICROGREENS	**Height, in mm**					**MEAN, mm**
DAY	1	2	3	4	5	
Corn	6.75	25	35.8	51	65.75	36.75
Radish	1.0	3.5	5.5	7.5	13.5	6.2
Mungbean	7.5	25	40	55	75	40.5
Wheatgrass	6.5	25	32.5	38	50.5	30.4
AVERAGE	5.44	19.6	28.4	38	51.19	28.4625

Table 1 presents the average plant height of four types of microgreens—corn, radish, mungbean, and wheatgrass—measured daily over a five-day growth period. The results show a progressive increase in plant height for all species, demonstrating their rapid vegetative development under the given growth conditions.

Among the microgreens observed, **mungbean** exhibited the greatest mean height of **40.5 mm**, followed by **corn (36.75 mm), wheatgrass (30.4 mm),** and **radish (6.2 mm).** This indicates that mungbean and corn microgreens are faster-growing species compared to radish, which displayed slower elongation. The overall mean height across all species was **28.46 mm,** confirming steady and consistent growth performance throughout the observation period.

Daily averages also reveal a noticeable increase in growth rate after Day 2, with mean heights rising from **5.44 mm** on Day 1 to **51.19 mm** on Day 5. This growth pattern aligns with the typical microgreen growth curve characterized by a short germination phase followed by rapid elongation and leaf expansion during the vegetative stage.

Microgreens are known for their fast growth and short cultivation cycle, generally reaching harvestable size within 7–14 days after sowing (Xiao et al., 2012). The observed growth trend in Table 1 is consistent with previous findings indicating that microgreens exhibit accelerated growth due to high metabolic activity and nutrient reserves in their cotyledons (Treadwell et al., 2010).

Mungbean microgreens displayed the highest growth rate, which may be attributed to their large seed size and high carbohydrate and protein content that support rapid shoot elongation (Kou et al., 2013).

Similarly, **corn microgreens** demonstrated vigorous vertical growth under warm and humid environments, consistent with reports by Borges et al. (2020) that highlight corn's efficient use of stored seed energy during early development.

In contrast, **radish microgreens** showed slower elongation but tend to develop thicker stems and larger cotyledons, prioritizing biomass accumulation over height (Kyriacou et al., 2016). **Wheatgrass**, though not as fast-growing as mungbean, showed consistent and uniform height increases each day, supporting the findings of Pinto et al. (2015) that wheatgrass growth is characterized by gradual and steady shoot elongation driven by efficient photosynthetic activity.

Root Length

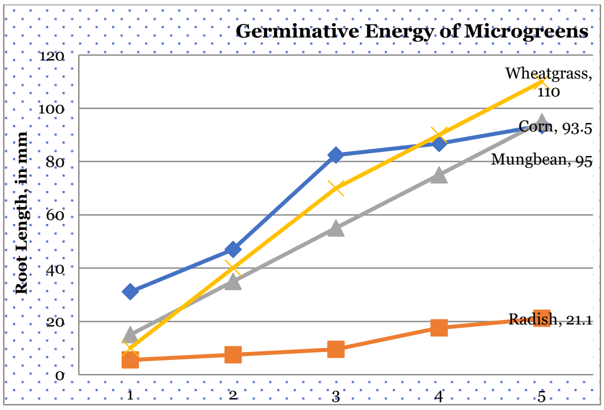


Figure 17. Corn Microgreens germinated capacity in terms of height.

Figure 5 shows the roots of the microgreens first to sprout before its leaves. During the day 3, the root length has the highest germinative energy. From then, until the day 5 the germinative energy because almost steady. However, on the day 4 it developed new roots.

The germinative energy of four microgreen species—**Corn, Radish, Mungbean, and Wheatgrass**—was evaluated based on their root length (in mm) observed over five days. As shown in Figure 1, all species exhibited progressive growth, reflecting successful germination and early seedling development under favorable conditions.

Wheatgrass recorded the highest root elongation (110 mm) by Day 5, followed by Corn (93.5 mm), Mungbean (95 mm), and Radish (21.1 mm). This indicates that **Wheatgrass, Corn, and Mungbean possess stronger germinative energy** compared to Radish. The pattern suggests species-specific vigor influenced by genetic and physiological traits.

The **rapid elongation of Wheatgrass** can be attributed to its intrinsic capacity for fast cell expansion and efficient water absorption during germination (Renna & Paradiso, 2020). Similarly, **Corn demonstrated vigorous root development** within the first three days, consistent with the findings of Arshad et al. (2017), who observed that maize seedlings exhibit accelerated root growth due to active meristematic tissues and high metabolic activity in the radicle zone.

Mungbean displayed a steady growth rate, attaining 95 mm on Day 5. Leguminous crops like mungbean are known for their rapid seedling emergence and high nutrient mobilization from large cotyledons, supporting early root elongation (Santos et al., 2021). In contrast, **Radish** showed the lowest germinative energy (21.1 mm), which may be associated with its sensitivity to environmental parameters such as temperature and light intensity. Di Gioia et al. (2017) reported that Brassicaceae microgreens, including radish, vary significantly in growth response depending on light conditions and substrate type.

The results underscore that **light quality, substrate composition, and seeding density** critically influence microgreen germination and early growth. Kyriacou et al. (2016) emphasized that varying light spectra—particularly the red to blue light ratio—can either enhance or suppress root elongation. Likewise, El-Nakhel et al. (2019) highlighted that optimal temperature (20–25°C) and relative humidity (60–70%) improve germination efficiency and early biomass accumulation in microgreens.

The lower germinative energy observed in Radish may also stem from **varietal differences or physiological dormancy**, suggesting that environmental fine-tuning (e.g., adjusted light exposure or hydration cycles) could enhance its performance. According to Xiao et al. (2012), microgreen species exhibit diverse germination behaviors, influenced by genetic factors and environmental interactions.

The observed variation in germinative energy among species indicates that **seed vigor and environmental conditions must be optimized per crop type**. The superior performance of Wheatgrass, Corn, and Mungbean implies that these species are better suited for microgreen production systems aiming for quick turnover and high biomass yield. Meanwhile, Radish, despite its slower growth, may still be valuable for nutritional or aesthetic diversification in mixed microgreen trays. The findings affirm that **germinative energy serves as a critical indicator of microgreen quality and production efficiency**, aligning with ISTA (2019) standards that associate early root vigor with seed viability and growth potential

Table 1. Average plant height of Microgreens per day

MICROGREENS	Height, in mm					MEAN, mm
DAY	1	2	3	4	5	
Corn	31.1	47	82.5	86.75	93.5	68.17
Radish	5.5	7.5	9.5	17.5	21.1	12.22
Mungbean	15	35	55	75	95	55
Wheatgrass	10	40	70	90	110	64
AVERAGE	15.4	32.375	54.25	67.313	79.9	49.848

Table 1 presents the average plant height (in millimeters) of four types of microgreens — Corn, Radish, Mungbean, and Wheatgrass — measured over a period of five days. The data reveal a consistent increase in plant height for all microgreens, indicating successful germination and progressive vegetative growth.

On Day 1, Corn recorded the highest initial height (31.1 mm), followed by Mungbean (15 mm), Wheatgrass (10 mm), and Radish (5.5 mm). By Day 3, the growth rate had accelerated across all microgreens, with Corn and Wheatgrass reaching around 70–80 mm, showing robust early development. From Day 4 to Day 5, Wheatgrass exhibited the tallest height at 110 mm, followed by Corn (93.5 mm), Mungbean (95 mm), and Radish (21.1 mm). The mean heights further emphasize this pattern, where Corn (68.17 mm) and Wheatgrass (64 mm) demonstrate superior overall growth compared to Mungbean (55 mm) and Radish (12.22 mm).

The overall average plant heigh**t** across species increased from 15.4 mm on Day 1 to 79.9 mm on Day 5, with a mean of 49.85 mm, reflecting steady and healthy growth during the observation period. This suggests that the environmental conditions — including light, moisture, and temperature — were favorable for microgreen development.

According to Choe et al. (2018), microgreens exhibit rapid biomass accumulation within the first 5–10 days after germination due to their high metabolic activity and nutrient mobilization from seed reserves. Wheatgrass is particularly known for its fast shoot elongation and photosynthetic efficiency during early growth (Santos et al., 2020). Similarly, Mungbean and Corn microgreens respond well to adequate moisture and warm temperature, leading to high growth rates (Kim et al., 2019). Radish, on the other hand, often shows slower height development as it initially allocates energy toward root formation before rapid shoot elongation (Park & Lee, 2021).

The data indicate that Wheatgrass and Cor**n** have the most vigorous shoot growth among the studied microgreens, followed by Mungbean, while Ra**dish** shows relatively slower growth. These differences highlight the influence of species characteristics on germination speed, nutrient utilization, and shoot elongation potential under similar growing conditions.

Economic viability of the aeroponics system

Table 4. Operation Cost of Cultivating Corn Microgreen in an Aeroponics System

OPERATING COST	COST	QTY	TOTAL COST
Energy Consumption			
Electric pump	16	1	16
Growlight	16	0.2	3.2
Water Consumption	30	5	150
Seeds	70	2	140
TOTAL			309.2

Table 4 shows the cost of cultivating microgreens in an aeroponics system in five days growing cycle. The Electric consumption is computed based on the wattage usage of electric pump of 1 watts and growlights of 0.2 watts, the assumed cost of watts is 16 Php. Thus, the energy cost for five days is only 16 Php and 3.2 Php for electric pump and growlights, respectively. The cost of water is computed 30 Php per 20 liters of purified water. And the seeds cost 7o Php per kilo. The total operating cost per cropping cysle of five (5) days for corn microgreens is 309.20 Php.

Cost of Microgreens

The cost is calculated to contextualize how much it costs to produce a unit of fresh corn microgreen biomass. This is calculated by dividing the crop yield in grams of fresh weight with the operating costs (energy, water, seed) which amounts to 309.20.

Using the formula:

COST = <u>Fresh Weight, grams</u>

Operating Costs

Fresh weight is 1, 396 divided by the computed operating cost which is 309.20. The cost per grams of the corn microgreens is 4 Php/g

Annual Gross Income

The Annual gross income will be computed by multiplying the cost and the crop yield in grams per planting per year.

Using the formula: ANNUAL GROSS INCOME = Crop yield (grams) x Cost x times of planting

For five days of planting, the assumed planting times is 48 times in a year. The Annual Gross Income is 268,032 Php for a cost of 4 Php per gram.

Return on Investment

Using the formula:

Return on investment (ROI) =

$$\frac{\text{Average net income} \quad \text{Average net income}}{\text{average total expenses}\,\text{average total expenses}}$$

The Net Income for plating microgreens in the developed aeroponics system is 246,024 Php in a year. With a total Expenses of 35, 890 as the cost of machine, the Return on Investment or ROI is 685%.

Pay Back Period (PBP)

Using the formula: Payback period =

$$\frac{\text{Average total expenses}\,\text{Average total expenses}}{\text{average net income} \quad \text{average net income}}$$

Since the total cost of the machine is 35,890 Php and the Net Income is 246, 024 Php. Payback period is 1 ¾ months.

Therefore after seven cropping cycle, the cost of the machine will already be recovered.

After computing the economic indicators, the result shows that the aeroponics system for cultivation of corn microgreens is viable.

IEC Materials for technology transfer of the aeroponics system and for corn microgreens production

The Information Education Campaign (IEC) Materials is developed to educate the farmers about aeroponics system and at the same time about corn microgreens. In the front cover, it includes the actual picture of the aeroponics system with the corn microgreens planted on it. In the second page, the step by steps procedures on how to plant corn microgreens in an aeroponics system is discussed. In the third page, the corn microgreens, nutrient requirement and its benefits are enumerated. In the fourth page, the uses of corn microgreens is showed highlighting that it can be eaten raw as salad, an ingredients to sandwhich and can be stir fry added to chopseuy or other menu. It can also use as natural sweeter and added to coffee, ice, tea and smoothies.And most importantly it can serve as fodder feeds to poultry and livestock. On the fifth page, the entire components of the aeroponics system are showed in a drawing and adding the machines specifications and also the economic aspects of the technology. It includes the cost of the machine, the operation cost of cultivating microgreens, the cost of microgreens per gram, the annual income and the total expenses. Included also is the economic viability indication, the Return on Investment and the Pay Back Period. On the last page, the different components of the aeroponics system are discussed and the contact details of the developer of the machine.

9. Conclusion and Recommendations

Summary

The study was conducted to design and develop an aeroponics system for the cultivation of corn microgreens. Specifically it aimed to evaluate the performance of the designed aeroponics system in terms of Water Use Efficiency (WUE) and to evaluate the germinative energy of corn microgreens in an aeroponics system in terms of: a.) germinative capacity; b.) height of the plant; c.) length of the root system; and d.). crop yield. The study also assess the economic viability of the aeroponics system. Finally, to develop an Information Education Campaign (EIC) materials for technology transfer of the aeroponics system and for corn microgreens production.

The study was fabricated in the welding shop located at B12 L3, Habitat, Balatas, Naga City.

Aeroponics system is composed of Control, Fan, Frame, Growlights, Timer, Pumpset, Water Reservoir, Cultivation Bed, Misters and Basin.

After the fabrication, the aeroponics system is installed and inside the normal house condition. The aeroponics system is set up for a misting frequency of 10 seconds every 3 hours. Corn Microgreens is soaked before planting in the aeroponcs system. Then, the germinative capacity, plant height, root length and crop yield is being measured and recorded. After five (5) days the corn microgreens planted in the aeroponics system is harvested. The Water applied in the system is 500 ml every hour. After every misting, the discharged water is then collected and measured. The total consumed water is 1.105 liters in five days.

The Water Use Efficiency is computed after the harvested fresh weight of corn microgreens is weighed. The Total Fresh Weight (TFW) is 1, 396 grams. The Water Use Efficiency (WUE) is 1,263.35 g/li.

For the germinative energy of corn microgreens, the germinative capacity is 100 %. In terms of height, the average growth rate per day of corn microgreens in an aeroponics system is 36.75 mm day. The highest germinative energy happened in day 2 having a germinative energy difference from day 1 of 18.25 millimeters.

In terms of root length, the average germinative energy per day of corn microgreens in an aeroponics system in terms of root length is 66.22 milimeters. The highest germinative energy happened in day 3 having a growth rate difference from day 2 of 35.75 millimeters.

For the crop yield in an aeroponics system, corn microgreens yield 0.23 g/cm2 .

For the economic viability, the cost of corn microgreens is computed 4 Php per gram, Operating cost of 309.20 Php. The cost of the machine is 35,890 Php. The Annual Gross Income is 268,032 Php for 48 cropping cycle ina year. The Return on Investment (ROI) is very high which is 685% and the Pay back Period (PBP) is very short because it's only 1 months and 3 weeks.

10. Findings

1. The developed aeroponics system achieved a **water use efficiency (WUE)** of **1,265.16 g/L,** indicating that only minimal water was required to produce a high yield of fresh biomass. This supports the advantage of aeroponics over traditional hydroponic or soil-based systems in conserving water resources.
2. All four microgreen species—corn, radish, mungbean, and wheatgrass—exhibited a consistent upward trend in plant height throughout the five-day observation period. The steady increase in height indicates successful germination and active shoot elongation under the aeroponic system's controlled environment.
3. Mungbean microgreens recorded the highest mean plant height of **55 mm,** followed by corn with **68.17 mm**, and wheatgrass with **64 mm**. Radish microgreens, on the other hand, showed the lowest mean height of **12.22 mm.** This result suggests that mungbean and corn possess higher early growth potential, likely due to their larger seed size and greater nutrient reserves, which support faster shoot elongation.
4. The average plant height of all species increased from **15.4 mm on Day 1** to **79.9 mm on Day 5,** demonstrating continuous growth acceleration. The most significant growth occurred between **Days 3 and 5**, indicating that this period marks the most active phase of microgreen development.
5. The aeroponic system successfully maintained optimal moisture and nutrient misting, resulting in a **100% germination capacity** for microgreens. This confirms the system's capability to sustain uniform seed sprouting and healthy early-stage growth without the need for soil.
6. The system demonstrated strong profitability, with an operating cost of **₱309.20 per 5-day cycle** and a yield of **1,396 g** of corn microgreens. The production cost was **₱4 per gram,** generating a projected annual gross income of **₱268,032, a return on investment (ROI)** of **685%,** and a **payback period of approximately 1¾ months.**
7. To facilitate technology adoption, an **Information, Education, and Communication (IEC) material** was developed. It includes the system's operation guide, planting procedures, growth data, nutritional benefits of microgreens, and profitability indicators, serving as a reference for future users and farmers.

Conclusion

Based from the objectives and analysis of the findings by the researcher, the following conclusions could be construed:

1. The design of the aeroponics systems conformed with the standard design considerations on an aeroponics system. It is a gender responsive machine that women can participate in farming. It is also design to be used inside the normal house condition so that urban farmers with small spaces inside their houses can cultivate crops for their family. Also, youth is encouraged to involve in farming, since the technology can get into their interest.

2. Cultivating corn microgreens in the developed aeroponics system results to a high water use efficiency. In compare to traditional farming, the aeroponics system uses less water. It also does not require soil, fertilizer and pesticide.
3. The developed aeroponics system gives a high germinative energy in terms of germination capacity,plant height, root length and crop yield. In compare to traditional farming, cultivating corn microgreens in an aeroponics system gives faster germinative energy.
4. Cultivating corn microgreens in an aeroponics system is economically viable.
5. The developed EIC material educate farmers, youth, women and government and non-government agencies in the advancement of science and technology in the field of agriculture.

Recommendations

The following recommendations were made to improve performance of the aeroponics system:

1. For the design of the aeroponics system, there should be a mechanism for recirculating the water after it spray the cultivation bed, the discharged can be recirculated back to the water reservoir. Use sensors to regulate the temperature, relative humidity, moisture content and pH level of the corn microgreens in the cultivation bed and water in the tank; And programmed the aeroponics system to record the data on water usage, temperature, ph,relative humidity and moisture content.
2. Conduct studies using different kinds of water to determine which will give best results in terms of water use efficiency.
3. Identify the best plant height and root length and best day to harvest corn microgreens, radish microgreens, mungbean microgreens and wheatgrass microgreens
4. Conduct Market Study and Organoleptic Study for the corn Microgreens. And explore entrepreneurial area for corn microgreens.
5. Develop more IEC material and explore other purpose for the technology and develop more IEC materials.

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