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Research Article

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Application of Simple Nutrient Plus Vermitea on High-Value Crops for NFT Hydroponics System under Controlled Climatic Conditions

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Abstract:

This study evaluates how a Simple Nutrient Addition Program (SNAP) combined with Vermitea affects the growth of plant in an NFT hydroponics system under controlled conditions. Specifically, it aimed to assess plant growth, system efficiency, and financial viability. An experiment was conducted using different SNAP and Vermitea concentrations on lettuce plants, measuring factors such as height, number of leaves, leaf length, weight per plant, and root growth. Results showed that higher concentrations (75%-100%) led to better plant growth compared to lower ones (25%-50%). The developed system also proved to be cost-effective, with a return on investment (ROI) as high as 120.3%, while using minimal amount of electricity. The automated greenhouse system improved climate control and nutrient management, making the system more efficient. These findings suggest hydroponics as a sustainable and productive alternative to traditional farming. To further improve this system, the study suggests improving nutrient combinations, integrating renewable energy sources, and disseminate hydroponics technology to farmers and entrepreneurs. Through support and policies, hydroponics can become a profitable and environmentally friendly solution, that may contribute to sustainable agriculture and food security.

1. Introduction

Greenhouses allow for greater control over the growing environment of plants. The key factors which may be controlled include temperature, levels of light and shade, irrigation, and fertilizer application, and atmospheric humidity, including pests and diseases. Hydroponics is a system of agriculture that utilizes nutrient-laden water rather than soil for plant nourishment [1]. Because it does not require natural precipitation or fertile land in order to be effective, it presents people who are living in arid regions with a means to grow food for themselves and for profit. The reuse of nutrient water supplies makes process-induced eutrophication (excessive plant growth due to overabundant nutrients) and general pollution of land and water unlikely since runoff in weather-independent facilities is not a concern. Aeroponic and hydroponic systems do not require pesticides, require less water and space than traditional agricultural systems, and may be stacked (if outfitted with led lighting) in order to limit space use vertical farming [2].

1.1 Organic Fertilizer for Hydroponic Systems

Modern agriculture produces sustenance for our people and animals, yet it has some environmental consequences. The release of nutrients into the environment can lead to many negative effects. Hydroponics is an efficient way of producing food with maximum efficiency of nutrient uptake by plants as the solution is completely controlled.
Generally, it sought to investigate the performance of greenhouse and their applications on selected high-value crops considering the climate conditions in Region 2. Specifically, investigates the applications of the hydroponics system on high-value plants under the shade and climate of the

developed greenhouse model and calculates financially using ROI analysis.

1.2 Scope and Delimitation

The study covers the planting of high-value crops, gathering information on their physical characteristics up to their harvest to evaluate if the performance of the model can able to supplement the needs of the crops throughout their growing and maturity stages. This model includes the financial viability to assess its cost and benefit ratio and return on investment to ascertain the real condition of putting up the technology.

It also involves collecting data from respondents through questionnaires and interviews to gather information on opinions, behaviors, or perceptions regarding the development of the greenhouse and hydroponics systems. In this way, the Likert Scale and open-ended questions were used. For the efficiency of the hydroponics system, the research design used is the experimental method. It also involves an independent variable, which is the application of nutrients to the roots of the high-value crops or plants are considered as the experimental group, while the controlled group was not treated with any nutrients. The dependent variables were the number, length, and width of the plants' leaves and the height and weight of the plants.

2. Review of Related Literature

2.1 Nutrient Solution

A nutrient solution for hydroponic systems is an aqueous solution containing mainly inorganics ions from soluble salts of essential elements for higher plants. Currently 17 elements are considered essential for most plants, these are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, copper, zinc, manganese, molybdenum, boron, chlorine and nickel [3]. With the exception of carbon (C) and oxygen (O), which are supplied from the atmosphere, the essential elements are obtained from the growth medium. Other elements such as sodium, silicon, vanadium, selenium, cobalt, aluminum and iodine among others, are considered beneficial because some of them can stimulate the growth, or can compensate the toxic effects of other elements, or may replace essential nutrients in a less specific role [4]. The most basic nutrient solutions consider in its composition only nitrogen, phosphorus, potassium, calcium, magnesium and sulfur; and they are supplemented with micronutrients. The nutrient composition determines electrical conductivity and osmotic potential of the solution.

2.2 Organic Fertilizer for Hydroponic System

Modern agriculture produces sustenance for our people and animals, yet it has some environmental consequences. Release of nutrients to the environment can lead to many negative effects. Hydroponics is an efficient way of producing food with maximum efficiency of nutrient uptake by plants as the solution is completely controlled. Compost tea has been used for centuries, evidence indicates that it has been used since the Roman Empire [5]. Vermicompost tea increases plant production and mineral nutrient content in pak choi (*Brassica rapa* cv. Bonsai Chinesis group [6].

Hydroponics is the art of growing plants in a soilless medium. Commercial organic hydroponic food production is still in its infancy. Natural sources of macro-nutrients need to be assessed and combined with natural sources of micro-nutrients at proper levels to produce a formulation that provides all the elements necessary to sustain acceptable commercial plant growth [7]. Adding one gallon of compost tea to every 50 gallons of hydroponic nutrient solution to prevent disease is also suggested [5].

Some of the advantages of aquaponics and hydroponics over conventional agriculture include: farming in a relatively small footprint, eliminating the need to lay crop land fallow (thus increasing turnover and yield in a given space), eliminating the need for large and expensive farming and harvesting equipment, elimination of effluent waste released into the environment containing excess fertilizers and other chemicals, increasing plant growth (sometimes as much as 18 times compared to ground control in the case of okra), and extremely low (about 2-4%) water use [8]. Production of multiple crops via the combination of aquaculture and hydroponic technologies synergizes the economic value of both enterprises [9]. Furthermore, being independent of the quality or even need for soil for producing crops this technology provides extraordinary freedom to farmers and gardeners alike as to where they may be able to grow their produce. Vermicompost has been shown to enhance plant growth, crop yield, and improve root structure and development in the field [10]. It is also suspected to have pH buffering capacities in soil. Vermicompost can be applied directly to soil, or seeped in water and made into a "worm tea." Vermicompost tea contains high levels of water-soluble mineral nutrients and microbial metabolites (i.e., organic acids, cytokinins, growth regulators, etc.) that act to enhance nutrient uptake [10].

Vermitea is a complex solution produced from worm castings. It contains microbes such as fungi, bacteria, protozoa, and other useful nematodes. The worm tea, which is in liquid form, can easily be absorbed by the plants, resulting to the increase in level of the plants' immunity (Benefit of vermin tea). The nutrients, vitamins and minerals needed by the plants are produced by these organisms present in vermitea. The microbes in vermi tea serve as the food in the food chain of other organisms found in the soil. Protozoa and nematodes are food for the bacteria and fungi. The worms eat bacteria-laden soil particles, thus, the life in the soil directly or indirectly merely depends on microbes. This research will focus on the use of compost tea in field of agriculture, and few studies have been conducted on its use in hydroponic, controlled environment crop production settings. Because of the positive results found in field studies, this experiment investigates the potential use of compost tea in a hydroponic lettuce production system.

Vermicast contains 40% more humus than compost, and humus is considered as the fundamental building block of soil. Likewise, humus holds and transfers water within the soil structure. Vermicast is one of the only certain ways you can fertilize without man-made chemicals, an all the Nitrogen, Potassium and Phosphorus that plants need in order to live is made by Mother Nature herself. Vermicompost is considered the organic fertilizer with better potential of utilization because it is easily produced in low costs. It reports that the utilization of organic fertilizers, as vermicompost, has very favorable signs in the production of hydroponics crops in Mexico [11]. It can be concluded that vermicast can be used as a nutritional source to lettuce cultivation in a hydroponics system [12].

3. Methodology

3.1 Research Design

For the present study, descriptive-experimental methods were used. For the descriptive, the survey design was used. It involves collecting data from respondents through questionnaires and interviews to gather information on opinions, behaviors, or perceptions regarding the development of the greenhouse, and hydroponics systems. In this way, Likert Scale, and open-ended questions were used. For the efficiency of the hydroponics system, the research design used is the experimental method. This design involves the manipulation of variables to determine cause-and-effect relationships. It involves an independent variable, which is the application of nutrients to the roots of the three types of plants that are considered as the experimental group while the control group will not be treated with any nutrients. The dependent variables were the number, length, and width of the plants' leaves, the height, and weight of the plants.

3.2 Research Instrument

The survey questionnaire contained the evaluation of the hydroponics system in terms of functionality, relevance, aesthetics, safety, and economic viability.

- Functionality refers to a system's ability to perform tasks effectively and efficiently. It encompasses features that support data collection and analysis in the context of descriptive research.
- Economic viability evaluates the financial sustainability of a system. It considers cost-effectiveness, return on investment, ensuring that the system offers positive economic outcomes and aligns with available resources.

These domains or features provided a comprehensive understanding of the system for descriptive research.

3.3 Data Gathering Procedure

Before distributing the survey to the target sample, researchers conducted a pilot test with a group to identify any issues with the questionnaire's wording, length, or clarity. Adjustments were made based on feedback from the pilot test. Upon validation and passing the reliability test, it was used for the evaluation of the whole system. The selected respondents consist of a group of experts in agriculture. The developed small-scale hydroponics system design was used in the project. The system comprises 4 spans and has 3 rows or parts: lower, middle, and upper parts. Each parts have 2 pairs of tubular gutters with 257 cm in length. Each pair has 12 holes with styro-cup where the seedlings of lettuce are transplanted at a space of 15 centimeters between plants. A mixture of SNAP solution was done in every plastic box. Each container has 50 liters of water mixed with different rate of nutrient solution (250 ml SNAP plus 10 ml vermitea in one liter of tap water): T_1 – 75 % of SNAP + Vermitea, T_2 – 100 % of SNAP + Vermitea, T_3 – 25 % of SNAP + Vermitea, T_4 – 50 % of SNAP + Vermitea represented as treatments used in the study. The solution was then recirculated back into the container. After a week, vermitea was sprayed in each treatment. 60 plants were planted per treatment following the Completely Randomized Design. Data on the use of hydroponics systems for different types of lettuce plants was gathered weekly, specifically height, number of leaves, leaf length, weight per plant, and length of roots.

3.4 Statistical Treatment of Data

The descriptive data was gathered and tabulated using the Statistical Package for Social Sciences (SPSS). Statistical tools such as frequency counts, percentages, and modes were used to evaluate the perceptions of the respondents on the development of the greenhouse structure and the installed hydroponics system. The efficiency of the hydroponics system with high-value crops, such as lettuce, was analyzed using Megastat. A completely randomized design was employed for the experimental part of this study. For the financial profitability and viability analysis of the study, a benefits and cost analysis was quantified, and a simple cost and return analysis was computed.

Scale	Descriptive Rating
5	Highly Acceptable
4	Acceptable
3	Undecided
2	Not Acceptable
1	Not Acceptable at all

4. Results and Discussions

4.1 Design and Construction of Hydroponics System

The mode, as the most frequently occurring value, provides insights into the most common perceptions of respondents regarding the hydroponics system's design, construction, and technical operation. For Table 1, the availability of parts in the market and the ease of constructing the system were both rated as Highly Acceptable (Mode = 5), suggesting that most respondents found these aspects to be highly satisfactory. However, the system’s weight, detachability, transferability, and functionality had a mode of 4, which means Acceptable, indicating that while respondents generally found these aspects favorable, there was slightly less agreement compared to availability and ease of construction. Likewise, the ability to withstand fair weather conditions also had a mode of 4, which means Acceptable. The overall mode for the design and construction is 4. This means that the general perception of the system’s design and construction is positive, with most respondents agreeing that it meets expectations but with some room for improvement.

4.1.1 Technical Operation

All aspects of technical operation, including ease of maintenance, faster plant growth, ease of harvesting, reduced labor requirements, and potential skill improvement, had a mode of 4 or Acceptable (Table 2). The overall mode for technical operation is 4, this indicates that while respondents generally found the system functional and efficient, there is still space for enhancements, especially in making the operation even more user-friendly and labor-efficient.

The mode values suggest that the hydroponics system is generally acceptable in both design/construction and technical operation. However, aspects such as weight, detachability, and weather resistance could be improved to achieve a "Highly Acceptable" rating.

Table 1. *Perception of respondents in the design and construction of the hydroponics system*

Design and Construction	Mode	Descriptive Rating
1. Parts are locally available in the market.	5	Highly Acceptable
2. The system and structure can be easily constructed.	5	Highly Acceptable
3. It is light weight, detachable, and transferable.	4	Acceptable
4. It has a functional hydroponics system.	4	Acceptable
5. It can withstand fair weather condition.	4	Acceptable
Overall	**4**	**Acceptable**

Table 2. *Perception of respondents in the technical operation of the hydroponics system.*

Technical Operation	Mode	Descriptive Rating
1. Hydroponics system is easily maintained.	4	Acceptable
2. Less time is needed for growing plants and vegetables.	4	Acceptable
3. It is easy to grow and harvest plants using this technology.	4	Acceptable
4. Operation of hydroponics does not require hard labor.	4	Acceptable
5. The technology may help improve farming skills and abilities.	4	Acceptable
Overall	**4**	**Acceptable**

4.2 Experimental Observation

Stand and Vigor of the Crop. The plants applied with 50 % solution of SNAP to 100 % + Vermitea had vigorous growth and good stand from emergence to maturity and the plants exhibited light green foliage.

Occurrence of Insect Pest and Diseases. No disease was observed throughout the duration of the study.

Plant Height. The effect of a simple nutrient addition program (SNAP) with vermitea on the height of lettuce at harvest is presented in Table 3. Results showed that the application of SNAP plus vermitea significantly affected the height of lettuce at 30 days after transplanting.

It was observed that the plants applied with 75 % SNAP + Vermitea (T_1), 100 % of SNAP + Vermitea (T_2), and SNAP + 50 % Vermitea (T_4) produced taller plants with comparable mean values of 27, 26.4, and 25.8 centimeters, respectively. However, shorter plants were observed in plants applied with 25 % of SNAP + Vermitea (T_3) with a mean value of 20.3 centimeters.

Number of Leaves. A significant result was obtained on the number of leaves of lettuce grown under SNAP with organic fertilizer Vermitea (column 2). Results showed that plants treated with 75 % SNAP + Vermitea (T_1), 100 % of SNAP + Vermitea (T_2), and SNAP + 50 % Vermitea (T_4) had a higher number of leaves with mean values of 5.3, 5.4, and 4.9 counts. However, the least number of leaves was found in plants applied with 25 % of SNAP + Vermitea (T_3) with a mean value of 3.7.

Leaf Length. The length of lettuce was significantly affected by the application of SNAP and organic fertilizer, as reflected in column 3. Data showed that the application of 75 % SNAP + Vermitea (T_1) had produced longer leaves comparable with 100 % of SNAP + Vermitea (T_2), and SNAP + 50 % Vermitea (T_4) with mean values of 12.5, 12.8, and 12.7 centimeters, respectively. Shorter leaves were observed in the application of 25 % of SNAP + Vermitea (T_3) with a mean value of 9.7 centimeters.

Weight per Plant. The effect of a simple nutrient addition program (SNAP) with vermitea on the weight per plant of hydroponics lettuce is shown in column 4. Significant differences were obtained on the weight of lettuce grown under SNAP with organic fertilizer Vermitea. The plants treated with 75 % SNAP + Vermitea (T_1) were comparable with 100 % of SNAP + Vermitea (T_2), which produced the heaviest with mean values of 188 and 120 grams, respectively. This is followed by the plants applied with SNAP + 50 % Vermitea (T_4) with mean values of 96 grams. Lightest weight was found in plants applied with 25 % of SNAP + Vermitea (T_3) with a mean of 60 grams. The result implies that vermitea and other organic solution contributed to the growth and development of the plants. Accordingly, vermitea contains trace elements and minerals for the speedy development of the plants [13].

Length of Roots. The length of roots of lettuce applied with SNAP with organic fertilizer varied significantly with each other (Table 4). Analysis of Variance revealed that application of the different treatments or percentage of SNAP + Vermitea had no significant differences with a mean ranging from 3.7 millimeters 25 % of SNAP + Vermitea (T_3) to 5.4 millimeters 75 % of SNAP + Vermitea (T_3).

4.3 Energy Consumption

The computed energy consumption presented below shows that every four hours of operation in a day of energy or electricity consumption is equivalent to 1.196 kilowatt hour multiplied by 30 days was only at a minimal cost amounting to Php 400 in one month.

4.3.1 Computed Electrical Energy Consumption

For our small scale hydroponic system, electricity was used for just 4 hours a day.

Power = Voltage x Current x cos Θ, assume a value for cos Θ = 1

Power =220 volts x 1.36 amperes x 1

= 299 watts

Energy = P x T (per day basis)

$$\text{Energy} = \frac{299 \text{ watts x 4hrs}}{1000} = \frac{1196 \text{ W-hr}}{1000}$$

Energy = 1.196 kwh/day

1 month (30 days)

Cost Consumption per month = Energy x No. of days x Rate per kilo-watt hour

= 1.196 kwh x 30 days x Php 11.14 per Kwh

Cost Consumption per month = Php 400

4.3.2 Cost and Return Analysis

Table 5 contains the cost and return analysis of Lettuce production under electricity consumption in a small-scale hydroponic system Hydroponics applied with Simple Nutrient Addition Program (SNAP) plus Vermitea was presented in Table 6. The cost and return of the different treatments is presented in descending order: T_2 – 100 % of SNAP + Vermitea = 120.3% had the highest ROI, T_1 – 75 % of SNAP + Vermitea = 65.5%, T_4 – 50 % of

SNAP + Vermitea = 36.9%. For T_3 – 25 % of SNAP + Vermitea = -7.0% (loss). It means that for every peso invested, it earned 1.20 pesos for the first year of operation for T2, etc. For the succeeding years, ROI may increase due to the decreased amount of total expenses. The result shows that our hydroponics is profitable, and there is a return on investment when it comes to the annual basis of computation. At first in setting up a hydroponic system was costly; however, in the long run, it will obtain additional income with fresh and high-value crops and with lower electricity consumption.

Table 5. *Cost and Return Analysis of Developed Small Scale Hydroponics with Lettuce Production*

YIELD	**T_1**	**T_2**	**T_3**	**T_4**
KILOGRAM	7.2	10	3.7	5.7
MATERIALS				
Hole saw	95	95	95	95
Convenience outlet	65	65	65	65
THHN wire	80	80	80	80
Duct tape	150	150	150	150
Tubular gutter 3"x2	2400	2400	2400	2400
Label hose	50	50	50	50
Submersible pump	1000	1000	1000	1000
PVC pipe, 1/2"	650	650	650	650
Fittings	2400	2400	2400	2400
Handy plastic box	220	220	220	220
Drill bit, 1/4	225	225	225	225
Anti UV plastic	225	225	225	225
Weighing scale	45	45	45	45
Solvent cement	115	115	115	115
Dry net	100	100	100	100
Labor	875	875	875	875
CONTINGENCY	2,000	2,000	2,000	2,000
SUB-TOTAL	10,695	10,695	10,695	10,695
EXPENSES				
Styro cup	130	130	130	130
Lettuce seeds	20	20	20	20
SNAP nutrients	225	300	75	150
Coco peat	25	25	25	25
Vermitea	40	40	40	40
Electricity	102.25	102.25	102.25	102.25
Water	10	10	10	10
SUB-TOTAL	552.25	627.25	402.25	477.25
For 1 year computation @ 9 cropping per year				
INVESTMENT	10,695	10,695	10,695	10,695
GROSS INCOME FOR 1 YR (9 CROPPING)	25,920	36,000	13,320	20,520
EXPENSES FOR 1 YR	4,970	5,645	3,620	4,295
ROI (%)	65.5	120.3	-7.0	36.9

5. Conclusion

1. This study successfully developed and tested an NFT hydroponics system using a combination of SNAP nutrients and Vermitea under controlled conditions.
2. The results showed that higher concentrations of SNAP and Vermitea (75%-100%) led to better plant growth, including taller plants, more leaves, longer leaf length, and heavier weight per plant.
3. The system proved to be cost-efficient, with a strong return on investment (ROI) as much as 120.3%. It also consumed minimal electricity, making it an energy-efficient alternative for growing crops.
4. The findings highlight the potential of hydroponics as a sustainable and innovative farming method that reduces the need for soil, minimizes environmental impact, and offers a profitable option for farmers and agribusinesses.

5.1 Recommendations

1. Farmers, entrepreneurs, and schools should explore hydroponics as a smart and sustainable way to grow crops. Expanding this system to

urban areas and public spaces could also help promote food security.
2. Future research should focus on optimizing the balance of SNAP and Vermitea to maximize plant growth while keeping costs low. Other organic solutions could also be tested for better results.
3. Integrating solar panels or other renewable energy sources could make the system even more cost-effective and environmentally friendly.
4. Workshops, training sessions, and seminars can help students, farmers, and aspiring agripreneurs understand and implement hydroponics successfully.
5. Further studies on different crops, pest control, and financial viability should be conducted. Government and private sector support through policies and funding can help make hydroponics more accessible and widely used.

Through these recommendations, hydroponics can become a mainstream farming method that supports sustainability, profitability, and food security for future generations.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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