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INFLUENCE OF VERMITEA (VT) AND FISH AMINO ACIDS (FAA) SUPPLEMENTED WITH SNAP SOLUTION ON THE GROWTH PERFORMANCE OF LETTUCE (*Lactuca sativa*) IN A NON-CIRCULATING HYDROPONIC SYSTEM

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ABSTRACT

Hydroponic is a practice of farming without soil. Different materials can be used as growth mediums if such meets the required essential nutrient requirements of the plants. This method offers several benefits, especially in urban areas with limited space and regions with poor quality of soil that is prone to drought and flood. However, challenges such as nutritional management continue to pose significant barriers to widespread adoption of hydroponics. To address these concerns, this study investigated the use of vermitea (VT) and fish amino acids (FAA) in conjunction with a Simple Nutrient Addition Program (SNAP) solution in a non-circulating hydroponic system for lettuce (*Lactuca sativa*) production. The study sought to test the growth response of lettuce to varied nutrient levels, establish the best solution for maximum yield, and assess the economic viability of the treatments. The study, conducted in Brgy. Camoning, Asuncion, Davao del Norte, used a Completely Randomized Design (CRD) with five treatments and three replications. Results indicated that the treatment with 10ml VT, 10ml FAA, and 2.5ml SNAP per liter (T2) significantly outperformed others in terms of plant height, number of leaves, leaf dimensions, fresh weight, yield, and return on production cost. In contrast, lower nutrient levels, as seen in treatment T5 (VT + FAA), resulted in stunted growth and poor plant development. Based on the findings, the study recommends T2 as the most effective solution for improving lettuce growth and enhancing profitability in non-circulating hydroponic systems.

Keywords: fish amino acids (FAA), lettuce, non-circulating, Simple Nutrient Addition Program (SNAP), vermitea (VT)

INTRODUCTION

Lettuce (*Lactuca sativa*), part of the aster family (Asteraceae), has diverse leaf shapes that are either smooth or curled and come with different colors such as red or green. Its short-stemmed plant grows 30-100 cm. tall and is harvested annually. It is commonly used fresh in salads. It also exhibits a range of leaf arrangements, from a thick head to a loose rosette (Rana, 2017). Additionally, dietary fibers, vitamins A, B9, and C, carotenoids, and phenolic compounds are part of the nutrients that can be consumed from lettuce, which is frequently consumed fresh to maintain its crispness and nutritional richness.

The average lettuce productivity in the Philippines is 8.74 tons/ha., while the global average is 22.14 tons/ha. (Food and Agriculture Organization of the United Nations, 2019); Philippine Statistics Authority, 2020a, 2020b). The population in the Philippines is increasing and because of limited land availability, hydroponic cultivation is a potential solution for future challenges. Hydroponics is a hydroculture unit where the plants are cultivated soilless, and alternative mineral nutrient solutions are employed within a water solvent (Higgins, 2015).

The nutrient solution used in hydroponic systems is based on chemical fertilizers, making the hydroponic culture capable of providing higher quality produce and yield. In recent years, organic hydroponics has gained popularity as the demand for organic food keeps expanding (Ezziddine et al., 2021). Reducing the usage of traditional nitrate-based fertilizer sources may also lower nitrate levels in human food crops, which is another factor contributing to the growing interest in employing organic nutrient sources in hydroponics (Williams & Nelson, 2016). With these challenges faced in lettuce production today, incorporating vermitea (VT) and fish amino acids (FAA) as additives to nutrient solutions has the potential to significantly reduce dependence on high concentrations of inorganic nutrients. Investigating organic solutions is essential since the improper use of inorganic fertilizers is raising concerns about both the environment and human health.

This work promotes sustainable agriculture and contributes to the accomplishment of many Sustainable Development Goals (SDGs) by using hydroponics to boost lettuce yield. It increases food security as specified in SDG No. 2, water efficiency as stated in SDG No. 6, sustainable farming practices as provided in SDG No. 12, and climate action as pointed out in SDG No. 13 by limiting the consumption of resources and the environmental footprint. It gives communities and small-scale farmers the chance to transition to more sustainable farming methods by reducing production costs and the usage of potentially harmful pesticides. VT and FAA are organic nutrition solutions that promote plant growth by supplying essential nutrients and advantageous microbes. VT is a liquid concentration derived from the extraction of vermicompost (organic compost that comes from earthworms), while FAA is a liquid fertilizer derived from fish waste through fermentation.

Despite the improvement of hydroponics, there is less information on nutrient solutions using organic available resources. This study addresses this gap by comparing the effectiveness of organic solutions like VT, and FAA with Simple Nutrient Addition Program (SNAP) solution incorporated as nutrient source on the hydroponics production of lettuce.

Research Objectives

1. To determine the growth response of lettuce under a non-circulating hydroponic system at varying levels of vermitea (VT) and fish amino acids (FAA) plus Simple Nutrient Addition Program (SNAP) solution;
2. To identify which solution rates give optimum yield of lettuce grown under non-circulating system hydroponic; and

3. To evaluate the economic profitability of hydroponic lettuce applied with various rates of VT and FAA plus SNAP solution under non-circulating hydroponic system.

METHODS

The study was conducted in an open area in Purok Madasigon, Barangay Camoning, Asuncion in the first district of the Province of Davao Del Norte, which is situated in the Davao region of Mindanao, Philippines. The study has a duration of two months, spanning from February 2024 to March 2024.

The materials that were used in the study were the following: hammer, nails, wood saw, UV Plastic sheet/film, round timber or lumber, bamboo sticks, black fish net, steel tape, shovel, plastic grapes crates, 5 mm ordinary plywood, carton, Snap A and B nutrient solution, plastic container, tissue, untreated water, Styrofoam cups, ruler, tape measure, foam, VT, FAA, knife, seedling tray, garbage bag, masking tape, loose-leaf lettuce seeds, plastic drum, bucket, chisel, hinges, padlock, hygro-thermometer, boiler pot, stove, knapsack sprayer, chlorine, ballpoint pen, and record book.

The study employed quantitative experimental research design. The research was conducted following a quantitative experimental approach. It involves the use of varying rates of VT and FAA plus SNAP solution under non-circulating hydroponic system. The experimental design utilized was Completely Randomized Design (CRD), with a total of five treatments and three replications. The treatments used in the study were as follows: T1- 2.5 ml SNAP solution per liter of water; T2- 10 ml VT and 10 ml FAA plus 2.5 ml SNAP per liter of water; T3- 20 ml VT and 20 ml FAA plus 2.5 ml SNAP per liter of water; T4- 30 ml VT and 30 ml. FAA plus 2.5 ml SNAP per liter of water; and T5- 10 ml VT and 10 ml FAA per liter of water.

A water sample from different treatments was gathered from the vicinity and this was carefully transferred into a clean container with a volume of 1 L. The water sample collected was sent to the Department of Agriculture Soils Laboratory located in Agdao, Davao City.

The land area has a total of 2.5 m by 6 m. A greenhouse structure was constructed for the hydroponic system using various materials including a hammer, saw, nails, bamboo sticks, UV plastic sheet/film, round timber or lumber, fish net, padlock, shovel, and hinges. These materials were utilized to ensure the proper construction and functionality of the greenhouse for the hydroponic system.

A total of 375 experimental plants were included in this study. The plant population was divided into seven treatments, with each treatment having three replications. The seedlings were placed in wooden crates. These crates were specifically chosen for their compatibility with the non-circulating method of hydroponics. Using sterilized cocopeat in seedling trays was done for direct sowing of lettuce seeds.

In the non-circulating hydroponic method, a standard plant spacing of 13-18 cm apart was utilized. To facilitate this spacing, 1 in. of Styrofoam was used to create holes that were appropriate in size for the Styrofoam cups (8 oz) and grape crates. These holes securely held the Styrofoam cups, elevating them above the nutrient solution. The lettuce seedlings were carefully transplanted into the Styrofoam cups filled with the sterilized cocopeat after 2 weeks. Before being placed in the grape crates with the hydroponic nutrient solution, the seedlings underwent the hardening process first.

The hydroponic solution in this study was made by mixing SNAP A and B with untreated water following the recommended guidelines. VT was prepared by mixing 1 kg of vermicompost and 1 kg of molasses in 10 L aerated water, covering the pail to keep insects away, and fermenting it for 18 to 24 hr with occasional stirring. FAA was extracted using fresh fish heads or entrails, which were crushed, mixed with 1 kg of molasses, and blended thoroughly. The mixture was placed in a covered pail, allowing airflow for fermentation. It was stored until ready for use.

Line grape crates with cut cartons and cellophane were used to create a waterproof barrier for nutrient-rich water. Holes were drilled in Styrofoam to hold Styrofoam cups, which served as lettuce containers. Cups were filled with a growing medium to plant lettuce seedlings. The hydroponic solution was prepared by mixing 2.5 ml of SNAP A per 1 L of water, followed by 2.5 ml of SNAP B, ensuring thorough mixing throughout the process. The solution was poured into hydroponic boxes based on the required liter-per-box ratio. Then, FAA and VT were added according to treatment rates. Before setup, the greenhouse was disinfected with a chlorine solution, and a footbath was installed for biosecurity.

Pest management in the study involved the use of physical control methods, such as manually removing pests from lettuce plants, primarily in the early morning when they were more visible and easier to identify. Additionally, organic pesticides such as Oriental Herbal Nutrient were employed to complement these efforts.

The harvesting was done 40-45 days after sowing the seeds. The postharvest handling of lettuce was applied to reduce postharvest losses. The process of harvesting lettuce was done manually at exactly 5:00 AM and ended at exactly 7:00 AM in the morning. For efficient postharvest management care of hydroponic lettuce, sharp and clean tools were used to cut the leaves at the base without damaging the plant. All heads of lettuce were handled with care to avoid bruising or physical damage. The heads of lettuce were quickly rinsed to eliminate residues and conduct a thorough quality check.

Data Gathered

Plant Height. This data was gathered by measuring the height of 10 leaves from random sample plants per box using a ruler, focusing on the distance from the base to the tip of the main leaves of 10 random sample plants per box. This was done every week with the use of a ruler or tape measure.

Number of Leaves. Starting from the week of seedling transplantation, the number of leaves of 10 random sample experimental plants per box was counted. It involved the process of closely inspecting and tallying the functional leaves on the main stem every week, ensuring accurate data collection.

Leaf Width. This data was gathered by measuring the middle portion of the longest leaf of the fourth leaf of the 10 random sample plants per box using a ruler or tape measure on a weekly basis. Data on plant leaf width was collected weekly, beginning from the week of seedling transplantation into the hydroponic system.

Leaf Length. The length of each lettuce plant leaf was measured by determining the distance from the base to the tip of the fourth leaf of 10 random sample plants per box, employing a ruler for accurate and precise measurements.

Root Length. The data for the plant root length was collected upon harvesting the lettuce plants. The focus of root length measurement was specifically on the taproot. The length of each taproot was carefully measured using a tape measure, ensuring accurate and precise data collection.

Fresh Weight (g). To gather the fresh weight of plants in a hydroponic system after harvesting, plants were removed from the nutrient solution, gently shaking off any excess water, and these were promptly placed on a digital weighing scale. The fresh weight of 10 random sample plants per box was recorded using a digital weighing scale.

Fresh Yield (g). This data was obtained by weighing all the harvested plants per box using a digital weighing scale. Then, this data was converted to a grams per area basis.

All the data were subjected to statistical analysis using the analysis of variance (ANOVA) in a completely randomized design (CRD). The significant treatment means were tested using the Tukey's Honest Significant Difference (HSD) at a 5% level of significance.

The return of production cost of hydroponic lettuce was calculated per box. It was based using the amount incurred on all expenses. This data was determined by using the formula for return of production cost (%) which is equal to net income over total expenses times one hundred.

RESULTS

Plant Height (cm)

Table 1 shows the plant height (cm) of hydroponic lettuce as affected by the different levels of the VT, FAA, and SNAP mixture under a non-circulating hydroponic system.

Table 1

Plant Height (cm) of Hydroponic Lettuce as Affected by the Different Levels of the VT, FAA Plus SNAP Mixture under a Non-Circulating Hydroponic System

Treatment	Height		
	Week 1	Week 2	Week 3
T1- 2.5 ml SNAP/L	17.02[a]	27.31[a]	36.48[b]
T2- 10 ml VT + 10ml FAA + 2.5ml SNAP	17.88[a]	28.02[a]	39.62[a]
T3- 20 ml VT + 20ml FAA + 2.5ml SNAP	13.86[b]	20.06[b]	25.30[c]
T4- 30 ml VT + 30 ml FAA + 2.5ml SNAP	13.51[b]	19.42[b]	22.49[d]
T5- 10ml VT + 10ml FAA/L	11.41[c]	15.60[c]	18.96[e]
CV. (%):	3.16	4.01	2.27
F-test:	**	**	**

Note: Means having the same letter are not significantly different at 5% level of significance using HSD

The results show that treatment no. 2 or T2 (10 ml VT + 10 ml FAA + 2.5 ml SNAP) produced the tallest plants, gauged as significantly higher than all the other treatments. It suggests that the mixture of VT, FAA, and SNAP in the said treatment promotes lettuce plant growth, improving nutrient uptake. Meanwhile, treatment no. 5 or T5 (10 ml VT + 10 ml FAA/L) had the shortest recorded plant height among the treatments in three successive weeks, with average height measuring 11.41 cm, 15.60 cm, and 18.96 cm, respectively. The differences in plant height among the treatments were significant, confirming the effect of the treatments on plant growth in terms of height. The study shows that the best growth in hydroponic lettuce in terms of plant height was achieved with the combination of VT, FAA, and SNAP in T2.

Number of Leaves

Table 2 shows the number of leaves of hydroponic lettuce as affected by the different levels of the VT, FAA, and SNAP mixture under a non-circulating hydroponic system.

Table 2

Number of Leaves of Hydroponic Lettuce as Affected by the Different Levels of the VT, FAA Plus SNAP Mixture under a Non-Circulating Hydroponic System

Treatment	Number of Leaves		
	Week 1	**Week 2**	**Week 3**
T1- 2.5 ml SNAP/L	6.07^{a}	8.03^{a}	9.23^{b}
T2- 10 ml VT + 10 ml FAA + 2.5 ml SNAP	6.37^{a}	8.37^{a}	9.90^{a}
T3- 20 ml VT + 20 ml FAA + 2.5 ml SNAP	5.53^{b}	6.53^{b}	8.33^{c}
T4- 30 ml VT + 30 ml FAA + 2.5 ml SNAP	5.67^{b}	6.63^{b}	7.73^{d}
T5- 10 ml VT + 10 ml FAA/L	4.90^{c}	5.73^{c}	6.73^{e}
C.V. (%):	3.36	3.84	2.89
F-test:	**	**	**

Note: Means having the same letter are not significantly different at 5% level of significance using HSD

ANOVA results showed significant differences between treatments, with T2 (10ml VT + 10ml FAA + 2.5ml SNAP) having the highest average leaf count. It recorded the greatest average number of leaves in all weeks: 6.37 in Week 1, 8.37 in Week 2, and 9.90 in Week 3. T1 (2.5ml SNAP/L) also performed well, with 6.07 leaves in Week 1, 8.03 in Week 2, and 9.23 in Week 3, but was outperformed by T2 in Week 3. T3 (20 ml VT + 20 ml FAA + 2.5 ml SNAP) and T4 (30 ml VT + 30 ml FAA + 2.5 ml SNAP) had lower leaf counts, particularly in Week 3. T5 (10 ml VT + 10 ml FAA/L) had the fewest leaves among the treatments in three successive weeks.

Leaf Width (cm)

Table 3 shows the leaf width of hydroponic lettuce as affected by the different levels of the VT, FAA, and SNAP mixture under a non-circulating hydroponic system.

Table 3

Leaf Width of Hydroponic Lettuce as Affected by the Different Levels of the VT, FAA Plus SNAP Mixture under a Non-Circulating Hydroponic System

Treatment	Leaf Width		
	Week 1	Week 2	Week 3
T1- 2.5 ml SNAP/L	5.84[a]	9.21[a]	10.92[a]
T2- 10 ml VT + 10 ml FAA + 2.5 ml SNAP	6.38[b]	9.60[a]	11.03[a]
T3- 20 ml VT + 20 ml FAA + 2.5 ml SNAP	4.56[c]	5.94[b]	8.88[b]
T4- 30 ml VT + 30 ml FAA + 2.5 ml SNAP	4.56[c]	5.67[b]	8.05[b]
T5- 10 ml VT + 10 ml FAA/L	4.05[d]	4.52[c]	6.85[c]
CV. (%):	4.75	6.17	6.65
F-test:	**	**	**

Note: Means having the same letter are not significantly different at 5% level of significance using HSD

ANOVA results revealed statistically significant differences among the treatments. T2 (10 ml VT and 10 ml FAA, plus 2.5 ml SNAP per liter of water) exhibited the widest average leaf width which is comparable to other treatments. The small gap in average mean of leaf width between T2 and T1 was notable, suggesting comparable effectiveness despite differences in treatment composition. VT plus FAA had a lower average in terms of leaf width which is comparable to treatment with SNAP solution alone.

Leaf Length (cm)

Table 4 shows the leaf length of hydroponic lettuce as affected by the different levels of the VT, FAA, and SNAP mixture under a non-circulating hydroponic system.

Table 4

Leaf Length of Hydroponic Lettuce as Affected by the Different Levels of the VT, FAA Plus SNAP Mixture under a Non-Circulating Hydroponic System

Treatment	Length		
	Week 1	Week 2	Week 3
T1- 2.5 ml SNAP/L	10.70[b]	16.18[b]	18.22[b]
T2- 10 ml VT + 10 ml FAA + 2.5 ml SNAP	11.55[a]	17.43[a]	21.03[a]
T3- 20 ml VT + 20 ml FAA + 2.5 ml SNAP	7.99[c]	11.02[c]	14.63[c]
T4- 30 ml VT + 30 ml FAA + 2.5 ml SNAP	7.75[c]	10.55[c]	13.67[d]
T5- 10ml VT + 10 ml FAA/L	6.48[d]	8.22[d]	13.49[d]
CV. (%):	2.77	3.95	1.40
F-test:	**	**	**

Note: Means having the same letter are not significantly different at 5% level of significance using HSD.

The study found that T2 (10 ml VT + 10 ml FAA + 2.5 ml SNAP) produced the longest leaves, reaching an average of 11.55 cm in Week 1, 17.43 cm in Week 2, and 21.03 cm in Week 3. T1 (2.5 ml SNAP/L) also showed good results, with average leaf lengths of 10.70 cm in Week 1, 16.18 cm in Week 2, and 18.22 cm in Week 3, but was shorter than T2. T3 (20 ml VT + 20 ml FAA + 2.5 ml SNAP) and T4 (30 ml VT + 30 ml FAA + 2.5 ml SNAP) had lower leaf lengths, with T3 and T4 showing consistent growth but not exceeding the average length of 14.63 cm and 13.67 cm by Week 3, respectively. T5 (10 ml VT + 10 ml FAA/L) had the shortest leaves, with an average of 6.48 cm in Week 1, 8.22 cm in Week 2, and 13.49 cm in Week 3. Overall, T2 was the most effective, while T5 had the least growth.

Root length (cm)

Table 5 shows the root length of hydroponic lettuce as affected by the different levels of the VT, FAA, and SNAP mixture under a non-circulating hydroponic system.

Table 5

Root Length of Hydroponic Lettuce as Affected by the Different Levels of the VT, FAA Plus SNAP Mixture under a Non-Circulating Hydroponic System

Treatment	Replication			Mean
	I	II	III	
T1 – 2.5 ml SNAP/L	32.11	32.28	32.00	32.13[a]
T2 – 10 ml VT + 10 ml FAA 2.5 ml SNAP/L	23.19	23.95	24.94	23.79[b]
T3 – 20 ml VT + 20 ml FAA + 2.5 ml SNAP/L	15.72	13.46	14.22	14.46[d]
T4 – 30 ml VT + 30 ml FAA+ 2.5 ml SNAP/L	15.56	16.33	15.53	15.80[c]
T5 – 10 ml VT + 10 ml FAA/L	8.13	7.23	8.21	7.85
C. V. = 3.48%				
F – Test = **highly significant				

Note: Means having the same letter are not significantly different at 5% level of significance using HSD

The study showed that T1 (2.5 ml SNAP/L) had the longest root length, with an average of 32.13 cm, outperforming all other treatments. T2 (10 ml VT + 10 ml FAA + 2.5 ml SNAP/L) followed with an average of 23.79 cm. T3 (20 ml VT + 20 ml FAA + 2.5 ml SNAP/L) had the shortest average length of 14.46 cm. T5 (10 ml VT + 10 ml FAA/L) had the smallest root length, with an average of 7.85 cm. Overall, T1 showed the best root growth, while T5 had the lowest.

Fresh Weight (g)

Table 6 shows the fresh weight of hydroponic lettuce as affected by the different levels of the VT, FAA, and SNAP mixture under a non-circulating hydroponic system.

Table 6
Fresh Weight of Hydroponic Lettuce as Affected by the Different Levels of the VT, FAA Plus SNAP Mixture under a Non-Circulating Hydroponic System

Treatment	Replication			Mean
	I	II	III	
T1 – 2.5 ml SNAP/L	77.60	81.00	78.20	78.93[a]
T2 – 10 ml VT + 10 ml FAA 2.5 ml SNAP/L	74.50	85.00	78.20	79.23[a]
T3 – 20 ml VT + 20 ml FAA + 2.5 ml SNAP/L	34.00	37.20	39.00	36.73[b]
T4 – 30 ml VT + 30 ml FAA+ 2.5 ml SNAP/L	34.00	30.00	31.00	31.66[b]
T5 – 10 ml VT + 10 ml FAA/L	25.50	26.50	27.50	26.50[c]
C. V. = 5.82%				
F – Test = **highly significant				

Note: Means having the same letter are not significantly different at 5% level of significance using HSD

The ANOVA conducted on these treatments revealed statistically significant differences among all treatment groups. Notably, the plants treated with T2 (10 ml VT and 10 ml FAA, plus 2.5 ml SNAP per liter of water), exhibited the highest average fresh weight of 79.23 g, which is comparable to other treatments. This result is followed by T1 (2.5 ml per liter of water) with an average fresh weight of 78.93 g, T3 with 36.73 g, T4 with 31.66 g, and T5, which obtained the lowest average fresh weight among all the treatments used with an average mean of 26.50 g.

Fresh Yield (g/area)

Table 8 shows the fresh yield of hydroponic lettuce as affected by the different levels of the VT, FAA, and SNAP mixture under a non-circulating hydroponic system.

Table 8
Fresh Yield of Hydroponic Lettuce as Affected by the Different Levels of the VT, FAA Plus SNAP Mixture under a Non-Circulating Hydroponic System

Treatment	Replication			Mean
	I	II	III	
T1 – 2.5 ml SNAP/L	1,020.00	995.00	970.00	995.00[a]
T2 – 10 ml VT + 10 ml FAA 2.5 ml SNAP/L	870.00	1,200.00	1,020.00	1,030.00[a]
T3 – 20 ml VT + 20 ml FAA + 2.5 ml SNAP/L	525.00	485.00	515.00	512.00[b]
T4 – 30 ml VT + 30 ml FAA+ 2.5 ml SNAP/L	485.00	455.00	435.00	458.00[b]
T5 – 10 ml VT + 10 ml FAA/L	385.00	415.00	425.00	408.00[c]
C. V. = 11.28%				
F-Test = **highly significant				

Note: Means having the same letter are not significantly different at 5% level of significance using HSD

The ANOVA conducted on these treatments revealed statistically significant differences among all treatment groups. Notably, the plants treated with T2 (10 ml VT and 10 ml FAA, plus 2.5 ml SNAP per liter of water), exhibited the highest fresh yield with an average of 1,030.00 g, which is comparable to other treatments. This result is followed by T1 (2.5 ml per liter of water) with an average fresh yield of 955.00 g, T3 with 512 g, T4 with 458.00 g and T5, which obtained the lowest average fresh yield among all the treatments used with an average mean of 408.00 g.

Economic Analysis

Table 9 shows the economic analysis of hydroponic lettuce as affected by the different levels of the VT, FAA, and SNAP mixture under a non-circulating hydroponic system.

Table 9

Economic Analysis of Hydroponic Lettuce as Affected by the Different Levels of the VT, FAA Plus SNAP Mixture under a Non-Circulating Hydroponic System

Treatment	Gross Income	Total Expenses	Net Income	Rpc (%)
T1 – SNAP/L	₱110,245	₱26,605	₱83,640	314.30
T2 – 10 ml VT + 10 ml FAA 2.5 ml SNAP/L	₱131,075	₱29,445	₱101,630	345.20
T3 – 20 ml VT + 20 ml FAA + 2.5 ml SNAP/L	₱92,545	₱33,845	₱58,700	173.40
T4 – 30 ml VT + 30 ml FAA+ 2.5 ml SNAP/L	₱90,865	₱38,995	₱51,870	133.10
T5 – 10 ml VT + 10 ml FAA/L	₱40,982	₱17,945	₱23,037	128.30

The economic analysis showed that T2 (10 ml VT + 10 ml FAA + 2.5 ml SNAP/L) had the highest net income of ₱101,630 and the best return per cost (RPC) at 345.20%. T1 (2.5ml SNAP/L) also performed well with a net income of ₱83,640 and an RPC of 314.30%. T3 (20ml VT + 20ml FAA + 2.5ml SNAP/L) had a net income of ₱58,700 and an RPC of 173.40%. T4 (30ml VT + 30ml FAA + 2.5ml SNAP/L) produced a net income of ₱51,870 and an RPC of 133.10%. T5 (10ml VT + 10ml FAA/L) had the lowest net income of ₱23,037 and the lowest RPC at 128.30%. Overall, T2 was the most profitable, while T5 had the weakest economic performance.

DISCUSSION

Plant Height

ANOVA results revealed significant differences among the treatment means. It was noted that treatment 2, with 10 ml VT and 10 ml FAA supplemented by 2.5 ml SNAP solution, had a highest height, and it is comparable to treatment nos. 3, 4, and 5 throughout the observation period. In connection, Simeon and Bugawisan (2022) observed that combining 100 ml of VT per 10 liters of water with 25ml of SNAP per 10 liters of water enhances lettuce hydroponic plant development, attributing this effect to the organic compounds in VT that augment the provision of essential nutrients to the crop, resulting in increased plant height, metabolic activities, and overall yield. Moreover, the addition of SNAP to the solution further enriched the nutrients, leading to improved plant growth in terms of lettuce height (Borres, 2022). Furthermore, Tangpos (2022) reported in his study that FAA resulted in higher lettuce plant height compared to other organic treatments. It indicates that FAA has potential as a beneficial supplement for promoting plant growth in hydroponic systems.

The combination of VT and FAA, along with the suggested SNAP rate of 2.5 ml per liter of water, provides and increases the necessary nutrients for plants from transplantation to harvesting, promoting the growth of the tallest plants. This combination is attributed to the optimal concentration of SNAP solution tailored to meet plant requirements, particularly for leafy greens such as lettuce cultivated through hydroponic methods. Thus, it ensures the provision of all vital nutrients in balanced proportions, along with favorable external conditions (Resh, 2012).

Number of Leaves

It was observed that treatment 2, with 10 ml VT and 10 ml FAA supplemented by 2.5ml SNAP solution, got the highest leaf number among the treatments, which is significantly different from treatment nos. 3, 4, and 5. In consonance, Dhananjani and Pakeerathan (2023) noted a significant increase in the number of leaves per plant when treated with FAA compared to other organic nutrient solutions. In addition, Resh (2012) emphasized the crucial role of nitrogen (N) in enhancing leaf production and expanding leaf area in plants such as lettuce. Further, the arrangement or order of FAA application had a significant influence on leaf development, both in the early stages and as the lettuce reached maturity. Such results emphasize the importance of considering the hierarchical application of FAA in optimizing leaf production in lettuce cultivation (Tangpos, 2022).

Leaf Width

Results revealed significant differences, wherein treatment no. 2 with 10 ml VT and 10 ml FAA supplemented by 2.5 ml SNAP solution, got the highest mean while treatment no. 5 got the lowest among the treatments. This observation prompts comparison with the findings of Simeon and Bugawisan (2022) who investigated the impact of SNAP solution alone and in combination with VT on lettuce leaf width. They found that while SNAP solution alone resulted in certain leaf width measurements, combining it with VT yielded different outcomes. This result implies that the combination of SNAP with VT have essential combined effects on leaf development. It suggests that this combination might provide a well-rounded nutrient composition, fulfilling the plant's requirements and promoting its growth.

Furthermore, Borres (2022) also highlighted the efficacy of combining VT with SNAP solution, showing a superior response in terms of lettuce leaf width compared to other treatments. This result emphasizes the importance of this combination in enhancing plant development. The positive impacts of termites on eco-morphological traits, like leaf dimensions, are clear. Vermicompost tea not only delivers balanced nutrients to plant roots but also encourages growth and enriches compost with organic matter, including humic substances that aid in nutrient retention and boost root growth in tomato (Arancon et al., 2019).

Lastly, according to Dhananjani and Pakeerathan (2022), FAA serves as a beneficial source of nutrients for crop fertilization. It comprises both organic and inorganic substances that promote plant growth, although these nutrient levels are often unbalanced, especially regarding micronutrients. Their investigation revealed that FAA, containing nitrogen (N), phosphorus (P), and potassium (K) in balanced and readily available forms, significantly increased plant height, the number of leaves per plant, and the leaf area or width. Notably, the impact of FAA on leaf area or width was particularly significant.

Leaf Length

The study found that T2 (10ml VT + 10ml FAA + 2.5ml SNAP) was the most effective treatment, producing the longest lettuce leaves over three weeks. This suggests that the combination of VT, FAA, and SNAP provided a good balance of nutrients that promoted better growth. T2 appears to be the best option for maximizing leaf development, making it a promising choice for hydroponic or organic farming.

In the study also of Borres (2022), VT with SNAP were observed to obtain the highest mean score among other treatments, followed by SNAP alone. The findings suggested that lettuce treated with VT had a better response among plants. This difference may be attributed to the characteristics of biofertilizer extracts, particularly that manures undergo decomposition before application. Tangpos (2022) reported in his study that organic concoctions have the potential to be used as fertilizers in the absence of inorganic nutrient solutions. Among all organic concoctions, FAA showed higher lettuce heights and leaves.

Root Length

The ANOVA results showed highly significant differences among the treatments. The study suggests that using 2.5 ml/L of SNAP solution alone (T1) is the most effective for root growth, producing the longest roots. This indicates that SNAP alone provides the best nutrient balance for root development, while excessive organic additives may hinder growth. The distinct compositions of SNAP A and SNAP B, as discussed by Enrico (2022), underscore their potential to evoke varied responses in plant growth and yield. SNAP A, with its elevated levels of nitrogen, potassium, and calcium, may foster robust root development in lettuce plants. These macronutrients play pivotal roles in root elongation, branching, and overall biomass accumulation. Conversely, SNAP B's higher concentrations of micronutrients such as magnesium, iron, boron, and manganese may contribute to enhanced root architecture and functionality. These micronutrients are essential for processes like enzyme activation, cell division, and nutrient transport, crucial for optimal root growth and function.

In addition, Frayco et al. (2022) demonstrated that lettuce plants grown with SNAP nutrient solutions exhibited significantly increased root length, branching, and overall root biomass compared to those grown in organic concoctions. The balanced nutrient profile provided by SNAP appears to promote vigorous root growth, leading to enhanced nutrient uptake and improved plant performance.

Fresh Weight

The ANOVA results showed highly significant differences among the treatments. Treatment 1 is concluded to be significantly different to 3, 4, and 5, but not comparable to treatment 2. The findings regarding lettuce weight revealed that T2 and T1 exhibited significant improvement in comparison to the remaining treatments. This could be attributed to the ideal nutrient composition of SNAP and the distinctive qualities of vermicompost tea, as opposed to other treatments, as indicated by treatments subjected to fermentation processes (Borres, 2022). Yildirim et al. (2016) reported that utilizing fish emulsion or FAA liquid solution in hydroponic lettuce resulted in enhanced plant growth and productivity by stimulating the synthesis of plant hormones and bolstering biological activity within the plant. This leads to a more sufficient supply of micro and macronutrients to the leaves, promoting increased chlorophyll production. Elevated chlorophyll levels in leaves are indicative of enhanced photosynthetic efficiency, facilitating optimal plant growth. It is emphasized that the application of FAA or fish emulsion can significantly boost fresh weight.

Moreover, Santiago (2019) observed in his research that plants cultivated in SNAP solution consistently developed the longest roots and exhibited the highest lettuce fresh weight per plant. A crucial aspect of nutrient solutions lies in their ability to contain ions in forms readily absorbable by plants. Fundamental nutrient solutions primarily encompass nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur, with additional supplementation of micronutrients. Notably, the emphasis lies on the considerable weight gain observed in plants treated with SNAP solution.

Fresh Yield

The study shows that combining the VT, FAA, and SNAP mixture such as in T2 results in the highest fresh yield, while SNAP alone such as in T1 also produces good yields. Treatments with less or zero traces of SNAP, such as in T3, T4, and T5, resulted in lower yields, emphasizing the importance of SNAP for optimal plant growth and productivity. ANOVA results revealed a significant difference. T2 (10ml VT + 10ml FAA + 2.5ml SNAP) got the highest fresh yield, which is comparable to T3, T4, and T5. Lettuce treated with 10ml VT and 10ml FAA plus SNAP exhibited superior responses compared to other treatments, likely due to the unique characteristics and nutrient content of these solutions (Borres, 2022). In addition, SNAP is tailored to provide a balanced array of essential nutrients, fostering optimal plant growth and development in hydoponic lettuce (Frayco et al., 2022). Furthermore, this could be attributed to the provision of macro and micronutrients, as well as growth hormones in FAA, which enhanced growth parameters such as lettuce plant height, leaf count, and chlorophyll content, consequently amplifying green leafy yield (Ramesh et al., 2020).

Economic Analysis

The result shows that the higher percentage of return of production cost (RPC) was obtained by T2 with an RPC value of 345.2% followed by T1 with 314.3%, T3 with 173.4% and T4 with 133.1% and T4, which obtained the lowest RPC value of 128.3%. The study evaluated different treatments in hydroponic lettuce production and measured their return of production cost (RPC). Among the treatments, T2 (10ml VT and 10ml FAA, plus 2.5ml SNAP per liter of water) demonstrated the highest RPC at 345.2%, closely followed by T1 (2.5ml per liter of water) at 314.3%, T3 RPC% of 173.4%, T4 RPC% of 133.1%. However, T5 (10ml VT and 10ml FAA) yielded a significantly lower RPC of 128.3%. This decrease in RPC can be attributed to the low production of lettuce due to insufficient nutrient concentrations, particularly nitrogen, in the solution. The lack of nutritional content in VT hindered plant growth, resulting in slow development, yellowing, and leaf death. Similar inhibitory effects may occur with FAA, as indicated by previous studies. Factors contributing to FAA's negative impact on plant growth need further investigation (Simeon & Bugawisan, 2022; Frayco et al., 2022).

Summary of Findings

The present study assessed the effects of various blends of the VT, FAA, and SNAP mixture on hydroponic lettuce growth. On one hand, the findings revealed that T2, with 10 ml of VT, 10 ml of FAA plus 2.5 ml of SNAP, recorded the best general growth, tallest plant height, highest leaf number, longest leaves, and the largest fresh weight and yield. On the other hand, T1, with 2.5 ml of

SNAP/L, yielded the longest roots, while T5, with 10ml of VT and 10ml of FAA/L, yielded the poorest growth and yield. The economic analysis also backed the results and indicated that T2 was the most profitable treatment with the maximum possible net income and return per cost. Borres et al. (2022) found a significant effect on plant height and the number of leaves of lettuce, with a highly significant impact on yield. The SNAP solution proved to be highly effective in lettuce production, influencing plant height, leaf count, yield, and water consumption. Moreover, in the same study, it was discussed that the combination of SNAP and VT as well as SNAP and FAA resulted in the highest yield compared to FPJ and FFJ with SNAP in terms of yield production. This suggests that the combination of SNAP solutions with either VT or FAA offer a more effective approach for enhancing plant growth and achieving higher yields in hydroponic systems.

Conclusion

The experiment pinpoints the mixture of VT, FAA, and SNAP in T2 as the most efficient treatment to optimize hydroponic lettuce growth in terms of plant size, leaf yield, and total output. T1 is also the most efficient if maximum root growth is a priority, whereas T5 would not be a priority because of its poor results in terms of growth as well as profitability.

Recommendation

Based on the results, it is evident that the combination of 10 ml of VT, 10 ml of FAA, and 2.5 ml of SNAP per liter of water, as specified in T2, produced the most favorable outcomes across various parameters, such as plant height, number of leaves, leaf dimensions, fresh weight, fresh yield, and return on production costs. The researcher suggested that applying this specific combination would be highly recommended, as it provides optimal nutrient support for plant growth and development, as well as a higher return on production costs in a non-circulating hydroponic system. Further investigation into its postharvest and physicochemical analysis is also suggested.

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