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Enhancing productivity of lettuce grown in vertical garden sprayed with various plant concoctions

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Abstract

This study focused on determining which plant concoction as foliar spray would significantly promote lettuce growth in terms of plant height, leaf length, width of leaves, number of leaves, and leaf color; identify the performance of lettuce grown in a vertical garden sprayed with different plant concoctions. This was laid out in a 2x5 factorial experiment arranged in a Complete Randomized Design with three replications. Factor A variety comprised two lettuce varieties such as A1 Lollo Bionda and A2 Black Simpson and factor B as Plant concoctions five treatments: B1-water only, B2-fermented plant juice (FPJ), B3-fermented fruit juice (FFJ), B4-calcium phosphate (Calphos), and B5-oriental herbal nutrient (OHN) affect variables like plant height, leaf length, leaf color, and weight of marketable. The findings showed that OHN is more effective than other concoctions, considerably increasing plant growth, leaf development, and financial returns. Regarding height, leaf size, and marketable weight, Lollo Bionda continuously outperformed Black Simpson, indicating that genetic heterogeneity across the lettuce types affecting how receptive they were to the mixtures. On the other hand, no significant interactions were observed between lettuce varieties and plant concoctions across all parameters. However, the result indicated that lettuce varieties responded similarly to plant concoctions. The findings suggest, that the best plant concoction to produce lettuce varieties grown in a greenhouse is Oriental Herbal Nutrient since it was observed that outshined across all parameters.

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IntroductionFood shortages are among the main issues confronting the world's growing population in the twenty-first century. Programs that increase the amount of food available for consumption are essential to the government's goal of reducing extreme poverty and hunger. This could enable the production of lettuce, the world's most important green vegetable crop, in terms of commerce.

Lettuce (*Lactuca sativa*), a widely consumed leafy vegetable, is vital in global agriculture due to its nutritional value and economic significance significance (Shatilov *et al*, 2019). On the international stage, lettuce production thrives in countries like the United States, Spain, and China, which dominate the global market with high-yield varieties, advanced cultivation techniques, and robust export industries (Shatilov et.al, 2019). Despite these advancements, climate variability, resource constraint, and pest management continue to affect yield and quality, emphasizing the need for innovative solutions (Heeb et.al, 2019).

In the Philippines, lettuce cultivation remains a niche but growing sector, primarily concentrated in highland regions like Benguet and Bukidnon, where cooler climates favor its growth. Moreover, scale farmers attempt to expand their agricultural base by promoting lettuce production among small-scale farmers. However, several issues hinder productivity and profitability, such as limited access to quality inputs, high cost of fertilizers, and climatic unsuitability (Cervantes, 2017). The study shows that lettuce is sensitive to high temperatures, which can lead to bolting, reduced yields, and poor quality (Khan, 2018). Further, studies highlight the critical role of access to resources like water and high-quality seeds in successful lettuce production (FAO, 2020).

Therefore, alternative ways to produce lettuce, such as using a vertical system, are needed. Vertical farming offers a transformative approach to addressing the challenges faced by small-scale lettuce farmers in lettuce production, especially in Datu Paglas and Maguindanao del Sur. By utilizing controlled-environment agriculture (CEA) in stacked layers, vertical farming optimizes space, conserves resources, and mitigates climate-related risks using good soil media and plant concoctions, minimizing chemical fertilizers and lessening expenses.

Furthermore, these systems enable efficient use of resources, including water and fertilizers, through hydroponics and aeroponics (Yuan, 2022). Also, studies have demonstrated that vertical farming can achieve yields up to 10 times higher per unit area than traditional farming (Van Gerrewey *et al*., 2022).

Meanwhile, plant concoctions are organic fertilizers that use organic materials that are more environmentally friendly than chemical fertilizers. They are fertilizers derived from living organisms, such as plants, and by-products that have undergone decomposition. Plant concoctions are applied to plants for growth and development.

With this information, it is crucial to examine the implications of vertical farming in areas with climatic constraints, using plant concoctions as alternative fertilizers. This study explored the feasibility of vertical farming as a climate-resilient solution to revitalize lettuce production in Datu Paglas and serve as a replicable model for other regions facing similar challenges. This study was aligned with the following SDGs: SDG 2 by increasing productivity and diversifying food sources in underserved areas (FAO, 2022); SDG 8 through the introduction of innovative farming practices that create jobs and improve livelihoods (UNEP, 2025) and encouraging resource efficiency, SDG 12 aims to promote responsible consumption and production (Ebesson et.al, 2022). Previous studies have demonstrated the effectiveness of organic fertilizers and plant based concoctions in enhancing crop yields and improving soil health in conventional farming systems. However limited research has been conducted on their application in non-traditional farming environments such as vertical farming particularly in areas with climatic constraints. Hence, the study determined the productivity of lettuce grown in a vertical garden

sprayed with different plant concoctions. It aimed to: determine which plant concoction as foliar spray would significantly promote lettuce growth in terms of plant height, leaf length, width of leaves, number of leaves, and leaf color; identify the speed performance of lettuce grown in a vertical garden sprayed with different plant concoctions; and calculate the cost and return of plant concoctions for lettuce production.

Materials and methods

Construction of Greenhouse for Vertical Garden

A Slunt roof greenhouse was constructed measuring 2.5m in width, 8m in length, and 2.70m in height using a tubular, polyethylene UV plastic, garden net, round tube, and PVC pipe. PVC was used as a standing point or foundation of a vertical garden. It was put with cement so that it would not collapse. After that, a butterfly stackable pot was established.

Establishment of a Vertical Garden and Preparation of Potting Media

A Vertical Garden was established using PVC pipe as the foundation, and round tube stackable pots were installed afterward, following the study's experimental layout (Frayco *et al.*,2023). The study used a 1:1:1 ratio of garden soil, carbonized rice hull, and vermicast to ensure good lettuce growth. Potting media were collected or purchased at the local market or nearby municipality (Frayco *et al.*, 2023).

Seeding Production

Seeds were sown directly into the pots after being soaked in water a day before sowing to permit fast germination. Each pot was planted with two seeds, and replanting was done to ensure germination. The seeds were irrigated thoroughly, and watering was regulated after germination (Frayco *et al.*, 2023).

Collection and Preparation of Concoctions

The preparation of Fermented Plant juice (FPJ), were the leaves of Kangkong were finely chopped until they weighed 1 kilograms, then mixed with 1/2 kilogram of molasses. After mixing, the mixture was placed in a clean container for fermentation, which took seven (7) days. The another concoction were the Fermented Fruit Juice (FFJ), were the ripe bananas were chopped up to 1 kilogram, placed inside a clean container, and mixed with 1 kilogram of molasses which was fermented (7) days. The third concoction was the Calcium Phosphate (Calphos), were one kilogram (kg) of crushed eggshell was fried until it turned brown and cooled. The cooked eggshell was placed in a container, and 9 liters of coconut vinegar were added. After the bubble subsided, the bottle was covered or sealed. The fermentation of eggshells was allowed for 30 days. The last one were the Oriental Herbal Nutrient (OHN) One kilo of each garlic and ginger was chopped into pieces. The herbs were placed in a plastic container, and 3 liters of coconut vinegar were added. The container was covered with manila paper and kept in a dark, cool place with no direct sunlight. Fermentation was done in 7 days. The next procedure was chili and molasses; another fermentation was done in 7 days.

Application of Plant Concoctions

Plant concoctions were applied 15 days after planting according to their designated treatments. The solution, prepared at a ratio of 20 ml per liter of water, was applied weekly until the study concluded. It was applied as a foliar spray to the lettuce leaves at seven-day intervals.

Watering and Weeding

Water is essential for plant growth and development. The plants were watered twice daily, in the morning and afternoon, ensuring sufficient water was provided to maintain soil moisture, support optimal lettuce growth, and facilitate nutrient breakdown in the soil. Additionally, weeding was conducted to eliminate unwanted vegetation that could compete for nutrients. Shallow cultivation was also utilized to manage and suppress weed growth effectively.

Control of Pests and Diseases

Insect pests and diseases, including lettuce, are common challenges that can lead to crop failure. In this study, potted lettuce was closely and routinely monitored for signs of insect infestations or disease. If insect pests were detected, they were managed

through hand-picking to prevent plant damage. Additionally, if any disease is identified, a chemical spray is promptly applied to eliminate it and protect the plants.

Harvesting

The crop was harvested 45 days after sowing, and essential data were collected to assess the growth performance of lettuce grown in a vertical garden sprayed with various plant concoctions.

Plant height (cm)

Plant height was measured in centimeters (cm) at the harvesting of lettuce by measuring the plants from the base to the highest leaf using a ruler. It was taken from the average of 10 sample plants per treatment (Frayco *et al.*, 2023).

Leaf length and width (cm)

Leaf length was determined by measuring the leaf from the base up to the tip of the leaf (average of 10 sample plants per treatment) at the end of the study. The leaf width (cm) was determined by measuring the widest portion of the leaf blade (an average of 10 sample plants per treatment) at the end of the study.

Weight of marketable plant (g)

The weight of the marketable plant (g**)** was determined by weighing the number of marketable plants using 10 plants as samples. It was done after classifying the plants that have marketable quality and are free from diseases and damage.

Number of leaves and leaf colour determination

The number of leaves was determined by counting the number per plant per treatment (an average of 10 sample plants per treatment) at the end of the study.

The leaf color was observed during the termination of data gathering for those Quantitative data (Measured Data); if there's a change in the leaf color caused by fertilizer application.

Statistical Analysis

Data gathered were statistically analyzed using the analysis of variance (ANOVA) in a Completely Randomized Design in a 2 x 5 factorial experiment. A P-value of ≤ 0.5 is considered insignificant, a P-value of ≥ 0.05 is considered significant, and a P-value of ≥ 0.005 is considered highly significant. A comparison of means was done using Tukey's Test to test its significance (Gomez *et al.*,1984).

Results and discussion

Plant Height (cm)

Results revealed highly significant effects on the plant height of lettuce varieties. Lollo Bionda significantly grows taller, with a mean of 27.32cm, compared to Black Simpson, with a mean of 25.34cm. The study's results imply that Lollo Bionda is more adaptable to foliar treatments due to its genetic makeup and efficient nutrient absorption. Damerum *et al.* (2021) supported that lettuce varieties showed varied growth responses due to differences in leaf morphology, root architecture, and water-use efficiency.

Table 1. Plant height (cm) of lettuce varieties grown in vertical garden sprayed with various plant concoctions. Poblacion, Datu Paglas, Maguindanao del Sur 2025.

Factor A	Factor B Mean					VarietyMean[1/]
variety	Concoction					
	Water only	FPJ	FFJ	Calphos	OHN	
A1 Lollo bionda	25.07	28.92	27.00	26.68	28.93	27.32[a]
A2 Black simpson	22.67	26.60	25.13	25	27.30	25.34[b]
Concoction Mean[2/]	23.87[b]	27.76[a]	26.07[ab]	25.84[ab]	28.12[a]	26.33

C.V. (%) = 5.71- [1/ & 2/] - Means with common letter superscripts are not significantly different at 5% level using Tukeys test.

Also, Lollo bionda may have better nutrient-use efficiency, leading to taller growth, which is crucial in vertical farming systems where space optimization is necessary, as asserted by Soufi *et al.* (2023). Also, Carrasco *et al.* (2024) found that leafy vegetables grown in vertical gardens exhibit varied responses to

organic foliar sprays, with certain cultivars showing superior biomass accumulation. Moreover, Javier and Sison (2023) confirm that varietal selection is key in organic and urban agriculture, as certain varieties yield higher economic returns due to better growth and resilience.

Meanwhile, statistical analysis revealed a highly significant effect on plant height in the various plant concoctions. The tallest plants were observed with those sprayed with OHN, with a mean of 28.12 cm, comparable to plants sprayed with FPJ and FFJ, with a mean of 27.76 and 26.07 cm, respectively. This was followed by calphos, significantly like FFJ, with a mean of 25.84 cm. The shortest plant was observed in the control, or water only, with a mean of 23.87.

The results imply that using different organic foliar sprays, such as FPJ, FFJ, and OHN, significantly enhances plant growth, making it sustainable for vertical gardening. OHN resulted in the tallest plants, indicating its effectiveness in improving plant metabolism and resistance to stress, as confirmed by Chang *et al.* (2014), who fermented herbs and spices with antimicrobial and enzymatic properties that boost plant immunity and nutrient absorption.

Table 2. Leaf length (cm) of lettuce varieties grown in vertical garden sprayed with various plant concoctions. Poblacion, Datu Paglas, Maguindanao del Sur 2025.

Factor A	Factor B Mean					VarietyMean[1/]
variety	Concoction					
	Water only	FPJ	FFJ	Calphos	OHN	
A1 Lollo bionda	16.93	19.40	18.77	18.48	20.67	18.85[a]
A2 Black simpson	15.50	17.53	16.10	17.00	19.10	17.05[b]
Concoction Mean[2/]	16.22[c]	18.47[ab]	17.44[bc]	17.74[bc]	19.89[a]	17.95

C.V. (%) = 5.65- [1/ & 2/] - Means with common letter superscripts are not significantly different at 5% level using Tukeys test.

Furthermore, FPJ contains growth-promoting hormones auxins, gibberellins, and beneficial microbes that enhance nutrient uptake and vegetative growth (Higa & Parr, 2018), which is parallel also to FFJ that is derived from fruit fermentation, which is rich in potassium and enzymes, which stimulate cell elongation and photosynthesis (Omar *et al.*, 2023). In contrast, calphos contains readily available calcium and phosphorus essential for root development (Lorio, 2021). However, its effect was not as pronounced as FPJ, since calcium alone does not strongly influence vegetative growth compared to hormone-rich treatments.

Moreover, no significant interactions were observed in the plant height between lettuce varieties and plant concoctions. The result implies that the effectiveness of plant concoctions is variety-dependent rather than uniform across all types. This is in line with research by Silva *et al.* (2017), who found that genetic variations among lettuce cultivars can affect how responsive they are to organic fertilizers, with certain genotypes needing higher nutrient supplementation to reach their full growth potential.

Statistical analysis revealed highly significant differences among treatments in the leaf length of lettuce varieties. Lollo Bionda has a significantly longer leaf length with a mean of 18.85, compared to Black Simpson with a mean of 17.95.

The result suggests that differences in leaf length can be attributed to genetic variation, which conforms with the study of Damerum *et al.* (2021), noting that leaf morphology, including elongation and expansion, varies among lettuce cultivars due to genetic differences in photosynthetic efficiency and nutrient allocation. Moreover, the results also suggest that larger leaves tend to have an increased photosynthetic rate, resulting in higher biomass accumulation. He *et*

al. (2021) found that leafy vegetables with broader and longer leaves have enhanced light interception and nutrient absorption, contributing to improved growth.

Leaf Length and width (cm)

Concurrently, results revealed highly significant differences among treatments on the leaf area of lettuce varieties sprayed with concoctions. Oriental Herbal Nutrient (OHN) revealed the longest leaf length with a mean of 19.89. Moreover, FPJ (B2) has moderate leaves with a mean of 18.47, while FFJ(B3) and Calphos (B4) have similar moderate growth in terms of leaves with a mean of 17.44 and 17.74, respectively. Control got the shortest leaves among treatments.

Table 3. Leaf width (cm) of lettuce varieties grown in vertical garden sprayed with various plant concoctions. Poblacion, Datu Paglas, Maguindanao del Sur, March 2025.

Factor A	Factor B Mean					VarietyMean[1/]
variety	Concoction					
	Water only	FPJ	FFJ	Calphos	OHN	
A1 Lollo bionda	9.83	12.00	11.63	11.93	13.60	11.80[a]
A2 Black simpson	7.90	11.03	10.60	10.87	12.67	10.61[b]
ConcoctionMean[2/]	8.87[c]	11.52[b]	11.12[b]	11.40[b]	13.14[a]	11.21

C.V. (%) = 7.14%- [1/ & 2/] - Means with common letter superscripts are not significantly different at 5% level using Tukeys test.

The result suggests that natural plant-based concoctions improve leaf growth by enhancing nutrient uptake, enzyme activity, and photosynthesis (Higa & Parr, 2018; Park *et al.*, 2021; Kim *et al.*, 2020). This may be due to OHN's ability to enhance plant resistance, boost nutrient absorption, and improve enzymatic activity, leading to better leaf elongation (Kim *et al.*, 2020). Also, He *et al.* (2021) reported that herbal extracts in organic farming increase leaf expansion by reducing oxidative stress and improving nitrogen assimilation.

Moreover, no significant interactions were observed in the leaf length between lettuce varieties and plant concoctions. The result implies that some plant-based treatments are better at encouraging the elongation of the leaves, particularly in lettuce cultivars. According to Wang and Lin (2022), who found that differences in photosynthetic capacity and nutrient uptake efficiency cause leafy vegetable cultivars to respond differently to organic inputs in terms of growth.

Results revealed highly significant differences in the leaf width of lettuce sprayed with various plant concoctions. Lollo bionda (A1) exhibits wider leaves with a mean of 11.80 compared to Black Simpson (A2) with a mean of 10.61. The results suggest that genetic potential influences leaf expansion. According to Singh *et al.* (2020), genetic variability and its association with yield attributes in lettuce. These findings suggest that leaf width is a valuable trait for improving lettuce yield and can be effectively selected for in breeding programs (Kumar *et al.*, 2016).

Moreover, Kumar *et al.* (2020) reported that lettuce varieties differ in leaf width due to genetic regulation of cell expansion and water retention capacity. Rodríguez *et al.* (2021) found that wider leaves enhance light interception, leading to better carbohydrate accumulation and plant vigor. Therefore, Lollo bionda captures sunlight more efficiently and produces biomass than "Black Simpson."

Whereas, highly significant differences in leaf area of lettuce treated with different plant concoctions were observed. OHN with a mean of 13.14 cm resulted in the widest leaves, followed by FPJ, FFJ, and Calphos, which have similar effects with moderate width leaves with a mean of 11.52 cm, 11.40, and 11.12,

respectively. While lettuce was sprayed with water, it only had a narrow leaf with a mean of 8.87 cm.

This suggests that organic foliar concoctions are crucial in maximizing leaf width (Kim *et al.*, 2020; Higa & Parr, 2018; Park *et al.*, 2021). According to the study conducted by Kim *et al.* (2020), herbal nutrient extracts enhance leaf size by promoting auxin biosynthesis and cell division. Also, Mambua *et al.* (2024 reported that fermented plant juices increase leaf size and biomass accumulation by improving plant metabolism.

Table 4. Weight of marketable (g) of lettuce varieties grown in vertical garden sprayed with various plant concoctions. Poblacion, Datu Paglas, Maguindanao del Sur, March 2025.

Factor A	Factor B Mean				Variety Mean1/	
variety	Concoction					
	Water only	FPJ	FFJ	Calphos	OHN	
A1 Lollo bionda	413.33	520.00	501.67	685.00	573.33	538.67^{a}
A2 Black simpson	323.33	463.33	411.67	468.33	548.33	443.00^{b}
Treatment Mean2/	368.33^{b}	491.67^{ab}	456.67^{ab}	576.67^{a}	560.83^{a}	490.84

C.V. (%) = 23.17-1/ & 2/ - Means with common letter superscripts are not significantly different at 5% level using Tukeys test.

Moreover, no significant interactions were observed in the plant height between lettuce varieties and plant concoctions. The result demonstrates that different lettuce cultivars respond uniquely to organic treatments.

The differential response between varieties indicates that genetic traits influence nutrient absorption and utilization, affecting leaf morphology. It also suggests that the impact of organic mixtures on leaf growth varies by variety, possibly because of variations in cell expansion processes, photosynthetic efficiency, and nutrient uptake. According to studies by Kumar *et al.* (2016), some lettuce cultivars respond better to organic fertilizers due to their superior leaf plasticity, which results in wider leaf plasticity.

Weight of marketable plant (g)

Results revealed significant differences in the weight of marketable plants sprayed with various plant concoctions. It was observed that Lollo bionda had a significantly higher marketable weight of 538.67 grams compared to Black Simpson with 443.84 grams. This suggests that genetic factors determine lettuce biomass and marketable yield (Singh *et al.*, 2020; Rodríguez *et al.*, 2021; Lee *et al.*, 2019).

Table 5. Number of leaves of lettuce varieties grown in vertical garden sprayed with various plant concoctions. Poblacion, Datu Paglas, Maguindanao del Sur 2025.

Factor A	Factor B Mean				VarietyMean1/	
Variety	Concoction					
	Water only	FPJ	FFJ	Calphos	OHN	
A1 Lollo bionda	7.03	9.93	9.43	10.20	11.60	9.64^{a}
A2 Black simpson	6.13	8.93	8.63	9.50	10.73	8.79^{b}
Treatment Mean2/	7.03^{c}	9.43^{b}	9.03^{b}	9.85^{b}	11.17^{a}	9.21

C.V.=8.33%- 1/ & 2/ - Means with common letter superscripts are not significantly different at 5% level using Tukeys test.

According to Singh *et al.* (2020), differences in lettuce biomass accumulation are strongly influenced by genetic makeup, with certain varieties having a higher capacity for leaf expansion and dry matter

accumulation. Also, the higher weight of Lollo Bionda suggests better water retention, nutrient uptake, and leaf area development. These results conform with Kumar *et al.* (2016), who reported that lettuce varieties with higher leaf area index (LAI) and leaf weight ratio (LWR) tend to have greater yield potential due to increased photosynthetic efficiency. Meanwhile, highly significant differences were also observed in the weight of marketable lettuce sprayed with plant concoctions under greenhouse conditions.

Table 6. Leaf color of lettuce varieties grown in vertical garden sprayed with various plant concoctions. Poblacion, Datu Paglas, Maguindanao del Sur 2025.

Factor A	Factor B Mean					VarietyMean[1/]
Variety	Concoction					
	Water only	FPJ	FFJ	Calphos	OHN	
A1 Lollo bionda	2.00	3.67	3.67	3.33	4.00	3.33[b]
A2 Black simpson	3.00	4.00	4.00	4.00	4.00	3.80[a]
Treatment Mean[2/]	2.50[b]	3.84[a]	3.84[a]	3.66[a]	4.00[a]	3.56

C.V. (%) = 8.7-[1/ & 2/] - Means with common letter superscripts are not significantly different at 5% level using Tukeys test.

Based on the result, Calphos and OHN had significantly higher marketable weights of 576.67 and 560.83, respectively. This was followed by FPJ and FFJ, with similar effects of 491.67 and 456.67, respectively. The lowest marketable weight was observed in the control, with a mean of 368.33. This highlights the importance of foliar nutrition in optimizing lettuce growth and yield (Frayco *et al.*, 2023). Calphos is rich in calcium and phosphorus, which enhance root development and cell wall strength, improving plant weight gain. According to Marschner (2012), calcium and phosphorus are essential for robust plant structure, improving leaf expansion and biomass accumulation.

Also, Afton *et al* (2020) found that consumers prefer heavier lettuce heads, as they indicate freshness, higher yield per unit area, and leaf proliferation.

Table 7. Cost and Return Analysis of Lettuce Varieties Grown in Vertical Garden Sprayed With Various Plant Concoctions. Poblacion, Datu, Paglas, Maguindanao del Sur 2025.

	Total cost of 60 heads	Survive lettuce for sale	Price per head	Gross return	Net return	ROI
B1 (water only)	1256.00	45	30	1350.00	94.00	7.48
B2 (FPJ)	1356.00	55	35	1925.00	569.00	41.96
B3 (FFJ)	1406.00	55	35	1925.00	519.00	36.91
B4 (Calphos)	1356.00	55	35	1925.00	569.00	41.96
B5 (OHN)	1456.00	60	35	2100.00	644.00	44.23

Moreover, no significant interactions were observed in the plant height between lettuce varieties and plant concoctions. The difference in response between varieties emphasizes how genetic factors influence growth potential and nutrient use efficiency. Kumar *et al.* (2016) corroborate this by showing that differences in photosynthetic efficiency and nutrient storage capacity cause some lettuce cultivars to respond better regarding yield to organic inputs.

Number of Leaves and leaf color

Results revealed highly significant differences in the number of leaves of lettuce sprayed with plant concoctions among lettuce varieties. Lollo Bionda (A1) had the highest number of leaves, with a mean of 9.64, compared to Black Simpson(A2), with a mean of 8.79. These results suggest that genetic factors play a major role in leaf development and proliferation. According to Singh *et al.* (2020), genetic differences

in lettuce varieties significantly influence leaf count, a critical determinant of biomass accumulation and marketable yield. Moreover, Kumar *et al.* (2016) reported that lettuce varieties with a higher leaf count tend to have better canopy structure, maximizing light interception and enhancing overall growth.

Fig. 1. Documentation of (A) Setup of the vertical garden (B) Potting Media Preparation composed of garden soil, carbonized rice hull and vermicast the ratio was 1:1:1. (C) Soaking two lettuce seeds in one day for fast germination (D) Sowing lettuce seed.

Meanwhile, significant differences were observed in the number of lettuce leaves sprayed with plant concoctions. Oriental herbal nutrient (OHN) produces the highest number of leaves with a mean of 11.17, followed by calphos with a mean of 9.85, similar to FPJ with a mean of 9.43 and FFJ with a mean of 9,03. The lowest was observed in control water, with a mean of 7.93.

This implies the essential role of organic fertilizer in leaf development. Plant concoctions may help with fast nutrient uptake, thus helping plants' shoot development. Park *et al.* (2021) demonstrated that lettuce treated with organic foliar applications consistently exhibits higher leaf counts and improved plant vigor. Also, according to Frayco *et al.* (2023), organic-based foliar sprays with microbial extracts enhance metabolic activity, increasing leaf proliferation.

Moreover, no significant interactions were observed in the number of leaves between lettuce varieties and plant concoctions. Lollo Bionda may have a better genetic capacity for leaf initiation and expansion under organic treatments, as evidenced by the different responses between varieties. This is supported by research by Singh *et al.* (2020), which shows that variations in lettuce cultivars affect how they react to organic fertilizers, especially regarding chlorophyll content and leaf area expansion.

Fig. 2. Documentation of (A) During preparation of Fermented Plant Juice (B) During preparation of Fermented Fruit Juice (C) During preparation of Calcium Phosphate (D) During preparation of Oriental Herbal Nutrient (E) Harvesting of Various Plant Concoctions (F) Application of Plant Concoctions as foliar spray 15 days after planting.

Results revealed highly significant differences in the leaf color of lettuce sprayed with plant concoctions among lettuce varieties. Results indicate a statistically significant difference. Black Simpson exhibited darker or more vibrant leaves with a mean of 3.80 than Lollo Bionda with a mean of 3.33. This highlights that genetic factors influence leaf pigmentation and photosynthetic efficiency (Shi *et al*., 2022; Huang *et al*., 2019; Gutiérrez *et al*., 2020). According to Shi *et al.* (2022), darker green lettuce varieties have higher chlorophyll and antioxidant content, enhancing their nutritional value. Moreover, Huang *et al.* (2019) found that lettuce varieties with higher chlorophyll content tend to be more resilient to fluctuating light and temperature conditions. Meanwhile, plant concoctions revealed highly significant differences in

the leaf color of lettuce varieties. Based on the result, Oriental herbal Nutrient (OHN) exhibits the darkest color with a mean of 4.00, followed by Calphos with comparable effects, then followed by Fermented Fruit Juice and Fermented Plant Juice with similar effects and a mean of 3.84, respectively. The lowest was observed in Water Only, with a mean of 2.50. This implies that using organic fertilizer as an organic spray in lettuce varieties improves chlorophyll production. Frayco *et al.* (2023) reported that organic plant extracts with bioactive compounds stimulate chlorophyll production, improving leaf color and photosynthetic efficiency. Moreover, Tanaka & Fujita (2020) found that FPJ and FFJ improve pigment biosynthesis, making plants more vibrant and visually appealing.

Fig. 3. Documentation of (A) During Data gathering on Plant Height of Lettuce (B) Data gathering on Leaf length of lettuce (C) Data gathering on Leaf Width of lettuce (D) During preparation of Oriental Herbal Nutrient (E) Data gathering on Weight of Marketable (F) Data gathering on Leaf color of lettuce.

Cost and return analysis

The Cost and return Analysis of lettuce from planting to harvesting, grown in a vertical garden sprayed with various plant concoctions, and two lettuce varieties grown in greenhouse conditions, is presented in Table 7.

The cost and return analysis of lettuce production in a vertical garden shows that the highest profitability was achieved by applying Oriental Herbal Nutrient (OHN), which had a mean return of 44.23. This was followed by Calphos, with a mean return of 41.96, demonstrating its effectiveness in enhancing yield and economic returns. Fermented Plant Juice (FPJ) and Fermented Fruit Juice (FFJ) generated moderate profits, with mean returns of 41.96, respectively, indicating their contribution to plant growth, but with slightly lower financial benefits than OHN and Calphos.

The water-only treatment had the lowest mean return of 7.48, reflecting the reduced yield and marketable quality due to the absence of supplemental nutrients. These results highlight that organic treatments, particularly OHN and Calphos, significantly improve lettuce production profitability. They offer a cost-effective and sustainable alternative to conventional inputs. The findings suggest that growers adopting organic concoctions can maximize returns while reducing dependency on synthetic fertilizers, aligning with sustainable agricultural practices.

The cost of lettuce production, local supply and demand, transportation, and market accessibility are some of the variables that affect lettuce pricing in the Philippines. The price of lettuce was justified based on the areas. In highland areas such as the Cordillera Administrative Region, where lettuce thrives due to the cooler climate, prices are typically more constant due to the consistent supply. Meanwhile, lettuce grown in areas where output is hampered by heat stress may affect prices. The price of lettuce was based on the current market price of 30-35 pesos, depending on the quality of lettuce per head rather than per kilo.

Conclusion and recommendations

In conclusion, the Oriental Herbal Nutrient is the best plant concoction for producing lettuce varieties grown in a greenhouse since it outperforms all other parameters. These plant concoctions facilitated the growth of healthy lettuce and provided a high yield. Furthermore, these materials are readily available and low cost, thus this study suggests the potential for plant concoctions as an organic foliar spray for lettuce production. Moreover, these results highlight those organic treatments, particularly OHN, and, significantly improve lettuce production profitability, offering a cost-effective and sustainable alternative to conventional inputs. Based on the findings and conclusion of the study the following recommendations are highly suggested: The use of Oriental Herbal Nutrient is highly recommended as plant concoctions as foliar spray for lettuce production and Lollo bionda as best lettuce variety for vertical garden and further study is recommended with emphasis on the other lettuce varieties.

Conflict of interest

The authors declare that they have no conflict of interest.

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