

**PLANT BIOSTIMULANTS IN ENHANCING THE GROWTH AND YIELD
OF LETTUCE (*Lactuca sativa* L.)**

**College of Agriculture and Natural Resources
BOHOL ISLAND STATE UNIVERSITY
Zamora, Bilar, Bohol**

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June 2022

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LETTUCE (*Lactuca sativa* L.)

A Thesis
Presented to the Faculty of the
College of Agriculture and Natural Resources
BOHOL ISLAND STATE UNIVERSITY
Zamora, Bilar, Bohol

In Partial Fulfillment
of the Requirements for the Degree of
Bachelor of Science in Agriculture

ANGELEE MAE S. MANUALES

June 2022

APPROVAL SHEET

This study entitled, "PLANT BIOSTIMULANTS IN ENHANCING THE GROWTH AND YIELD OF LETTUCE (*Lactuca sativa* L.)" prepared and submitted by Angelee Mae S. Manuales in partial fulfilment of the requirements for the degree Bachelor of Science in Agriculture has been examined and recommended for acceptance and approval for oral defense.

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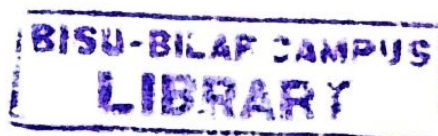

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ABSTRACT

Lettuce (*Lactuca sativa* L.) is an annual plant under the Asteraceae family, which is considered one of the most demanded salad crops. The deficiency of soil nutrients is now considered one of the significant constraints to successful upland crop production. The study was conducted at P6 Mahayag, San Miguel, Bohol, from March to May 2022. It was conducted to determine the effect of plant biostimulants on the growth and development of lettuce. The study was laid out in a single factorial in a Randomized Complete Block Design (RCBD) with four treatments and three replication per treatment. Analysis of Variance (ANOVA) was utilized to analyze the data gathered in the study. The results showed that the application of different levels of plant biostimulants has a significant effect on the yield and growth of lettuce. Application of commercial fertilizer significantly enhanced the plant height, number of leaves, leaf length, leaf width, root penetration depth, number and weight of marketable plants, weight per plant, and total yield, followed by the application of 30 mL FAA + 30 mL FSW (T3) every other day. Application of T2 (30 mL FAA + 30 mL FSW) and T3 (30 mL FAA + 30 mL FSW) produced smaller plants in terms of their horticultural characteristics and had lower yield since the plants were observed to have stunted growth. Applying fermented nutrient solution produced lower crop yield since it inhibited the growth performance of lettuce plants, resulting in small stunted plants with low yield performance. Thus, the null hypothesis was partially accepted.

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Chapter 1

THE PROBLEM AND ITS SCOPE

Rationale

Lettuce (*Lactuca sativa* L.) is an annual plant under the Asteraceae family which is considered one of the essential salad crops and also used as garnishing for other food preparations (USDA, 2018). It contains incredible amounts of essential nutrients with incredible benefits to health based on modern scientific research. It helps in proper digestion, promotes healthy liver, decreases the threat of heart diseases and stroke, lowers cholesterol levels, cancer control, protection of neurons, sleep induction, anxiety control, lowers inflammation, and provides ample antioxidants (Cervantes et al., 2017).

Lettuce production requires applying a large amount of chemical fertilizer to ensure high crop yield (Appendix Table 13). Due to the immediate results of using chemical fertilizers, traditional farmers trusted the short-term benefits of these inputs without looking forward to its adverse results. Several types of research found that chemical farm inputs cause severe environmental and soil-related crop production problems. Since man is a higher-order consumer, we are exposed to the harmful effects of fertilizer compounds. Hence, there is a need to look for sustainable horticultural practices to counteract chemical-based agribusiness. However, all these adverse effects of chemical fertilizers can be reversed by using different organic inputs that are locally available and can be produced by farmers. These inputs are a type of growth-promoting substance that could supply plant

nutrients and improve plant quality, ultimately boosting crop yield and commercial output.

To minimize chemical fertilizers, modern farmers are using organic plant bio-stimulants as an alternative. One of the known plant bio-stimulant is fish emulsion. It has been documented to promote seedling growth, fruiting, and microbe action in the soil. Fish Amino Acid (FAA) contains abundant nutrients like NPK with a ratio of 4:1:1 and various amino acids (Mel, 2015).

It helps improve the soil's microflora, thereby facilitating the assimilation of nutrients. It is an excellent source of nitrogen to improve growth and size. Furthermore, fermented seaweed (FSW) extracts are also used as fertilizer for plants to enhance nutrition efficiency, abiotic stress tolerance, and crop quality traits, regardless of their nutrient content (Du Jardin, 2015). Seaweed offers a wide range of exciting bioactive. With over 10,000 species globally, it is of great interest to be able to extract these compounds. It is used as nutrient supplements, biostimulants, or biofertilizers in agriculture and horticulture to increase plant growth and yield (Hernández-Herrera et al., 2014).

Thus, a study was conducted to determine the effects of plant biostimulants in enhancing the growth and yield performance of lettuce.

Literature Background

Botanical Characteristics and Importance of Lettuce

Lettuce (*Lactuca sativa* L.) is one of the most demanded salad crops in both fresh and ready-to-use global markets. It is an annual leaf vegetable of the aster family (Asteraceae). The lettuce plant can vary significantly in size, shape, and leaf

type, but generally, the plant's leaves form a dense head or loose rosette. The plant's stem is short, with larger leaves arranged at the bottom and progressively smaller further up to the stem.

It can grow to a height of 30-100 cm (12-40 in) in height and is typically grown annually, harvested after only one growing season. Four botanical varieties of lettuce are cultivated:

1. Celtuce, or asparagus lettuce, with narrow leaves and a thick, succulent, edible stem
2. Head, or cabbage with the leaves folded into a compact head
3. Leaf, or curled with a rosette of leaves that are curled, finely cut, smooth-edged, or oak-leaved in shape
4. Cos, or romaine with smooth leaves that form a tall, oblong, loose head

Wide leaf type varieties can be grown in low to high elevation sites, although yield and quality are better in cooler areas and seasons. It prefers a location with 5 to 6 hours of sun but can benefit from afternoon shade when temperatures soar. Soil should be loose, well-draining, and moist but not soggy.

Generally, lettuce is low in calories, fat, and sodium. It is a good source of minerals and various health-beneficial (anti-inflammatory, sedative, cholesterol-lowering, and anti-diabetic) bioactive compounds (Yakoot et al., 2011). It is among the most important crops that need to be grown organically.

It can be eaten cold and raw in some countries (in salads and hamburgers, among others) or cooked as typical in countries such as China. Although generally considered a poor source of nutrients, lettuce does provide many of the same

nutrients as other green vegetables, albeit mostly in smaller amounts (Katz & Weaver, 2003). Its low calories make it popular diet food. Some medicinal uses are also attributed to lettuce, including ingredients considered helpful as a sleep inducer and sedative.

Production Problems

The Food and Agriculture of the United Nations estimates that the total global lettuce production was 23.6 million metric tons in 2010. Moreover, the Crop Statistics of the Philippines (2017) reported that from 2011 to 2015, the production of lettuce and broccoli increased at an average annual rate of 2.2% and 0.3%. In 2015, the drop-in lettuce production by 6.2% was attributed to the lesser area harvested in Northern Mindanao (Bukidnon) due to a dry spell during the first semester. Low production during this period against sturdy demand from outside the province drove the average farm gate price of the majority of green leafy vegetables to ascend trend. Lettuce followed at 94.49% advancement, from Php 25.05 per kilogram last year to Php 48.72 per kilogram (PSA, 2021).

Commercial and conventional farming has been and is still relying on inorganic fertilizers for growing crops for they are easy to use, quickly absorbed, and utilized. However, these chemicals are believed to contribute substantially to human and animal food intoxication and environmental instability and degradation. Organic inputs can therefore be used to reduce the number of toxic compounds (such as nitrates) produced by conventional fertilizers in vegetables like lettuce,

hence, improving the quality of leafy vegetables and human health (Masarirambi et al., 2010).

Being a succulent vegetable, organic application in an appropriate dose is also a prerequisite for cultivating lettuce. The deficiency of soil nutrients is now considered one of the major constraints to successful upland crop production. As organic farming eliminates agrichemicals and reduces other external inputs to improve the environment and farm economics, it plays a vital role in the maximum profitable lettuce production with sustaining soil fertility (Islam et al., 2012). Chemical fertilizer overuse can contribute to soil acidification and crust, thereby reducing the content of organic matter, humus content, beneficial species, stunting plant growth, altering the pH of the soil, growing pests, and even leading to the release of greenhouse gases. Too much reliance on crop production on chemical fertilizers ultimately affects both environmental ecology and human health (Bisht & Chauhan, 2020). At the very least, food crops produced using chemical fertilizers may not be as nutritious as they should be because it trades fast growth for health in plants, resulting in crops that have less nutritional value. At worst, these chemicals may increase the risks of developing cancer in adults and children and adversely affect fetal brain development (Buckler, 2018).

Plant Biostimulants as an Alternative to Chemical Fertilizers

Plant biostimulants are one of the rising sources of organic plant inputs to sustain crop production without harming the environment, humans, and animals. One source of organic inputs is fish. It is rich in calcium and phosphorus and a great source of minerals, such as iron, zinc, iodine, magnesium, and potassium.

Fish emulsions have been documented to promote seedling growth, fruiting, and microbe action in the soil. FAA is a liquid made from fish known to be a cheap but effective organic liquid fertilizer. It has a great value to the growth of both plants and microorganisms because it contains abundant nutrients and various amino acids and constitutes a source of nitrogen (N) for plants. It is absorbed directly by the crops and stimulates the activity of microorganisms. It is a good fertilizer since it enhances the growth of crops during their vegetative growth when used with other natural farming materials (SARRA, 2015).

Sargassum spp. has the potential to be used as an input for crop production systems. Apart from improving crop productivity, *Sargassum* inputs have improved the resilience and resistance to harsh environmental conditions and pests, respectively (Aymen et al., 2014). Seaweed has long been used to help plant growth, especially before the advent of commercial fertilizer production. It provides many benefits to plants above and beyond conventional fertilizers to promote stronger, healthier plants. When plants are stronger and healthier, they are better able to withstand environmental stresses such as drought, salinity, insect pests, and diseases (Shiffler, 2021). It is free from weed seeds and other pathogenic fungi. It has recently gained importance as a foliar spray for many crops, including grasses, cereals, vegetables, fruit plants, and horticultural crops (Elansary et al., 2016).

Though seaweed extract biostimulants contain minimum leads of minerals that plants can readily assimilate, the main contribution of the extracts is their ability to stimulate various processes in the plant system, which would eventually

allow for enhanced growth and productivity of plants. It has been highly explored for possible use in crop production for improving biomass yield and product quality. These extracts have been shown to positively affect seed germination and plant growth at all stages up to harvest and even post-harvest (Ali et al., 2020).

Based on the study conducted by Rabina (2011), an amount of 10 tbsp/L of water gives the highest yield of carrots, 10 tbsp/L of water gets the lowest incidence of pests, 10 tbsp/L of water gets the lowest susceptibility to diseases, and 6 tbsp/L of water is the most profitable to use. Furthermore, a study by Mahmoud et al. (2019) showed that 3mL/L seaweed (*Sargassum vulgare*) extract enhanced red radish's growth, yield, and nutritional quality. In soybean, foliar applications of seaweed extract significantly enhanced yield parameters. The highest grain yield was recorded with 15% seaweed extract and 12.5% seaweed extract, resulting in 57% and 46% increases, respectively. Compared to the control, the maximum straw yield was also achieved with a 15% seaweed extract application; improved nutrient uptake (N, P, K, and S) was also observed with seaweed extract applications (Rathore et al., 2009).

Applying 100% *Sargassum sp.* seaweed extract to mustard greens plants showed enhancement effects on plant height at 7, 14, 21, and 28 DAP. In addition, the extract also increased the number of leaves, leaf area, shoot, root fresh weight, and shoot and root dry weight (Yusuf et al., 2021). A study by Gamage et al. (2021) suggests that 20% *Sargassum wightii* extract enhances the germination and growth of *Vigna unguiculata*. A 5% concentration of fermented brown algae extracts showed that it improved the growth of vegetative and generative phases

of corn in its plant height, stem circumference, cob length, cob diameter, and number of rows of seeds (Nurjannah et al., 2021). Furthermore, Sutsarhan et al. (2014) concluded that seaweed extract at a 20% concentration level could be used to enhance the growth, yield, and quality of *Lycopersicon esculentum* Mill.

According to Maghirang (2016), the applications of FAA (Fish Amino Acid) are used as 1-2 tbsp/ liter of water and applied as a soil drench or foliar spray weekly or depending on the vigor of the plants. A field experiment conducted by Faezah et al. (2021) concluded that kale applied with 30% FAA showed significantly higher plant height, number of leaves, number of branches, total leaf area, and plant biomass. Furthermore, according to the study conducted by Aganon and Duza (2021), pechay applied with 100 mL FAA (every five days) obtained the highest mean plant height, more extended leaf area, average fresh weight, and obtained the highest yield per hectare. In addition, a field experiment conducted by Ramesh et al. (2020) showed that amaranthus with 1% fish amino acid was comparable in plant height, number of leaves per plant, fresh weight, and dry weight of the whole plant. A study conducted by Ellyzatul et al. (2018) concluded that 20 mL fish waste extract was the best treatment for improving the growth, yield, and quality of cucumber.

THE PROBLEM

Statement of the Problem

The main objective of this study was to determine the effects of plant biostimulants on the growth and yield performance of lettuce (*Lactuca sativa* L.).

Specifically, the study aimed to answer the following questions:

1. What is the growth performance of lettuce applied with different concentrations of plant biostimulants in terms of:
 - 1.1 Plant height (cm);
 - 1.2 Number of leaves;
 - 1.3 Leaf length (cm);
 - 1.4 Leaf width (cm); and
 - 1.5 Root penetration depth (cm)?

2. What is the yield performance of lettuce applied with different concentrations of plant biostimulants in terms of:
 - 2.1 Number of marketable plants;
 - 2.2 Weight of marketable plants per plot (g);
 - 2.3 Weight per plant (g);
 - 2.4 Total yield (ton/ha);
 - 2.5 Total soluble solids; and
 - 2.6 Leaf pH?

3. What is the economic performance of lettuce applied with different levels of plant biostimulants?

Null Hypothesis

There is no significant difference among the different concentrations of plant biostimulants in the growth and yield of lettuce.

Significance of the study

The result of the study would be beneficial to the following concerns:

Academe. The result of the study would serve as a reference to the students who would conduct research related to this study. This would provide information to the people, especially the farmers, to sustain the fertility of their crop production.

Extension Workers. The results of this study would be beneficial to extension workers since this is helpful to them by promoting organic agriculture and serve as their basis for adopting another technique in raising lettuce production.

Government. This study would give the government additional knowledge on the benefits of seaweeds and fish amino acids to the people. It would give way to a strengthened policy for the protection of seaweeds and the provision of the enhancement of the seaweed industry.

Social Impact. The result of the study would be a better intervention in buying expensive fertilizers. Using natural plant biostimulants in influencing the performance of lettuce would help people in the community to understand how important, friendly and safe it would be to the consumer.

Environmental Impact. The result of the study would be helpful to the environment in reducing the toxicities yet sustaining the fertility of the soil.

RESEARCH METHODOLOGY

Design

The study was based on a single factorial experiment in a Randomized Complete Block Design (RCBD). Plant biostimulants were the sole factor for evaluation with three (3) levels. The area was divided into three blocks with four plots, measuring 1m×2m. A half-meter alleyways separated replication and treatment plots to facilitate farm operations, management, and data gathering. Ten (10) sample plants were used per plot with a planting distance of 30cm×30cm.

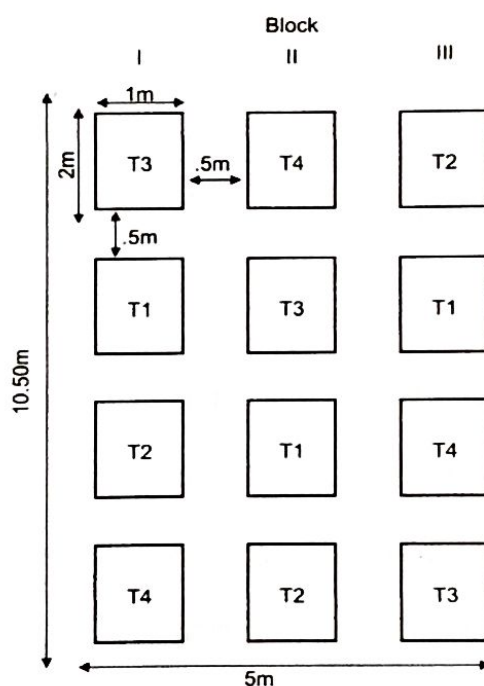


Figure 1. Experimental Field Layout Using Randomized Complete Block Design (RCBD)

Legend:

T₁ – commercial fertilizer (control)

T₂ – 20 mL FAA + 20 mL FSW /li. of water

T₃ – 30 mL FAA + 30 mL FSW /li. of water

T₄ – 40 mL FAA + 40 mL FSW /li. of water

Area: 10.50m × 5m = 52.50m²

Plot Size: 2m × 1m = 2.0m²

Environment

The study was conducted at Purok 6 Mahayag, San Miguel, Bohol, from March to May 2022. The site has a Ubay clay loam soil, alienable and disposable land, a slope of up to 3% (level to nearly level), Carmen formation (PPDO, 2022) with enough sunlight, and near a water supply.



Figure 2. The Entire View of the Research Area

Materials and Equipment

The study used the following materials; seaweed (*Sargassum vulgare*), pony fish, molasses, chemical fertilizer, empty gallons, leafy green Eton lettuce seeds, gardening tools (seedling tray, mattock, shovel, sprinkler, pail, and garden bolo), manila paper, 1-liter bottle, syringe, fine cloth, data sheets, ballpen, camera, straw, sharp knife, markers, meter stick, mortar & pestle, refractometer, pH meter, and digital weighing scale.

Procedure

Fermented Seaweeds (FSW) Production. Four kilograms of seaweeds (*Sargassum vulgare*) were gathered from a seashore in Garcia Hernandez, Bohol, and washed with seawater. The seaweeds were rewashed with tap water to

remove the dirt and sand. The seaweeds were chopped into pieces using a sharp bolo and mixed thoroughly with molasses at a 1:1 ratio. It was fermented in a large pail and covered with manila paper. The mixture was harvested after a month and stored in a clean empty bottle with a label.

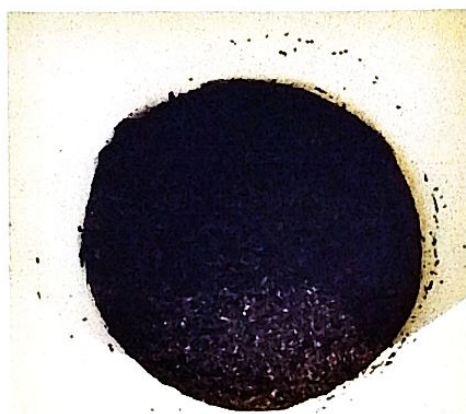


Figure 3. Production of Fermented Seaweed

Fish Amino Acid (FAA) Production. Four kilograms of pony fish were bought from Carmen public market. They were washed, and all parts were chopped using a sharp bolo. The chopped fish was mixed with molasses at a 1:1 ratio. Then, it was fermented for a month in a large covered container and harvested by separating the liquid using a fine cloth. It was placed in a clean empty bottle and provided with a label.



Figure 4. Preparation of Fish Amino Acid

Land Preparation. An area of 52.50 m² was cleared and plowed to pulverize the soil to make it suitable for sowing. After plowing, the removal of stones and seeds was done. Then lay-outing of the experimental plots was done. Each plot was prepared into raised beds. Twenty holes in each plot of about five cm depth were dug per plot with a distance of 30cm×50cm..

Seedling Production. Leafy green Eton variety of lettuce was used in the study as a test crop. The seeds were procured from an agrivet supply in Carmen, Bohol. The growing medium for the seedlings was a mixture of garden soil, carbonized rice hull (CRH), and vermicast in a 1:1:1 ratio in a seedling tray. The mixture was sterilized by heating to eliminate harmful microorganisms. One seed per cell was sown, covered with fine soil, and tightly pressed with fingers. The seedling trays were kept moist but not too wet to hasten germination. Two weeks after seedling emergence, it was hardened to acclimatize to the field condition. Seedlings were grown in the nursery to protect them from the extreme heat of the sun, and rain.

Transplanting. The lettuce seedlings were transplanted into the raised beds one week after hardening. Transplanting was done during the afternoon to reduce the stress of the experimental plants.

Application of Treatments. The plant biostimulants were applied late in the afternoon every other day, one week after transplanting. It was drenched in the soil following the lay-out of the experiment. From the first two weeks of application, 100 mL per plant on each plot was applied, and 200 mL per plant on each plot was

applied in the third week; then after, the application of treatments was stopped three days before harvesting.

Care and Management. Watering of plants was done once or twice a day - early morning and late afternoon, depending on the weather. Proper water management was observed during the study to promote better crop performance. Cultivation and weeding were done by using bolo to remove weeds and loosening the soil to optimize the retention and penetration of air, water, and nutrients. Controlling pests was done through handpicking.

Harvesting. Harvesting was done when lettuce reached its commercial maturity as a vegetable. It was done 26 days after transplanting before the lettuce showed signs of bolting. Harvesting was done early in the morning to protect the harvested plants against rain, sun, and mechanical damage.

Data Collection

Growth and Yield Parameters

1. **Plant Height (cm).** This was determined by measuring the height of the ten randomly selected plants from the base of the lowest leaf up to the tip of the terminal end at harvest.
2. **Number of Leaves.** This was determined by counting the number of leaves at harvest from ten randomly selected plants per plot.
3. **Leaf length (cm).** This was determined by measuring the longest big matured dark green leaves per plant from ten randomly selected plants per plot at harvest.

4. Leaf width (cm). This was determined by measuring the broadest part of big matured dark green leaves per plant from ten randomly selected plants per plot at harvest.

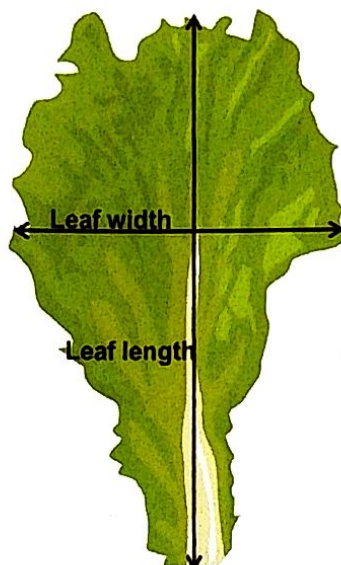


Figure 5. The Measurement of Length and Width of a Lettuce Leaf

5. Root penetration depth (cm). This was determined by measuring the longest root of the sample plants at the time of harvest. The plants were harvested carefully to avoid root damage. They were washed and measured after.
6. Number of marketable plants. This was determined by counting the marketable plants per plot in every treatment replication. Those marketable plants are those fresh, green, marketable size, free from discoloration, injuries, as well as pest and disease damage.
7. Weight of marketable plants per plot (g). This was determined by weighing all the good quality free from insect and disease damage at marketable size per plot at harvest.
8. Weight per Plant (g). This was determined by weighing the individual sample plant in every replication of the treatment at harvest.

9. Total Yield (tons/ha). This was determined by weighing all the harvested plant per treatment per plot in grams and convert it into tons/ha using the formula:

$$Y = \frac{W_H}{200}$$

Where:

Y = total yield, tons/ha

W_H = Weight of harvested product per plot (2m²), grams

10. Chemical characteristics

- a. Total soluble solids (TSS). The index of refraction determined the TSS content of the plant. One sample plant per plot was crushed using mortar & pestle to extract the juice needed for the analysis. This was done using a refractometer referred to as the degree Brix (Majidi et al., 2011).

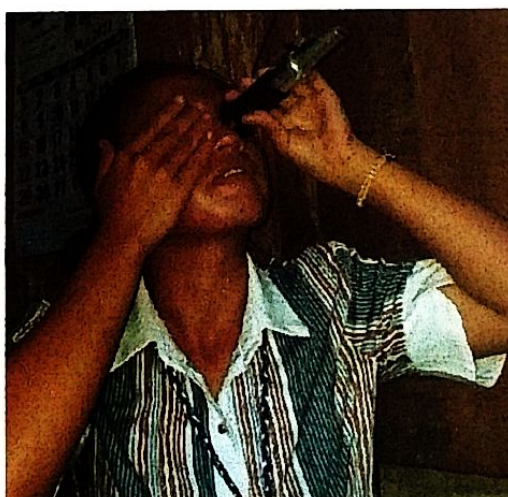


Figure 6. The Researcher Using Refractometer to Get TSS of Lettuce

- b. Leaf pH. This was determined by using a pH meter. One sample plant per plot was crushed using a mortar & pestle to extract juice which was needed for the analysis.



Figure 7. Leaf pH Extract That Was Analyzed Through pH Meter

Cost and Return Analysis

The cost and return of production were determined by recording all expenses incurred throughout the study, from land preparation up to the harvesting period. This included organic fertilizers, materials, and labor used in the field. The return of the investment was determined using the formula:

$$\text{Return on investment} = \frac{\text{Net Profit}}{\text{Total Production Cost}} \times 100$$

Data Analysis

All data gathered were tabulated and analyzed with the help of the statistician. A Statistical Package for Social Research (SPSS) was used for the

analysis of variance (ANOVA) of plant height, number of leaves, leaf length and width, root penetration depth, number and weight of marketable plants, weight per plant, total yield, total soluble solids, and leaf pH.

DEFINITION OF TERMS

Biostimulant. It refers to as treatments (Fermented Seaweed and Fish Amino Acid) in the study that was applied to lettuce to influence its plant growth and yield performance.

Fermentation. A process of chemical change that results in production of alcohol or acidic liquid.

Fermented Seaweeds. It refers to a liquid substance of seaweeds after the process of fermentation.

Fish Amino Acid. It refers to a liquid made from fish which contains abundant amount of nutrients and amino acids.

Lettuce. It refers to a green leafy vegetable that was used in the study which is most popular for salads and sandwiches.

Sargassum vulgare. Brown algae referred to as seaweeds in the study.

Seaweeds. It is the common name for countless species of marine plants and algae that grow in the ocean as well as in rivers, lakes, and other water bodies.

Synthetic. Substances or products made by chemical synthesis, as plastics or artificial fibers.

Treatment. It refers to a technique that is used in classifying and identifying the data.

Yield. It is the quantity and total amount of lettuce plants produced.

Chapter 2

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

This chapter deals with the presentation, statistical analysis, and interpretation of the gathered data on the application of plant biostimulants on the growth and yield performance of lettuce.

The data on the plant height (cm), number of leaves, leaf length (cm) and width (cm), root penetration depth (cm), number and weight of marketable plants (g), weight per plant (g), total yield (tons/ha), total soluble solids and leaf pH were collected, tabulated, analyzed, interpreted and presented as follows:

The researcher observed that there were sample plants that experienced necrosis. Due to the higher application rate, the plant biostimulants block the roots on its water potential, inhibiting water transport and slowing plant growth.

Growth Performance of Lettuce

Plant Height (cm). Table 1 shows the mean differences in plant height of lettuce as enhanced by plant biostimulants. Results revealed that commercial fertilizer (T1) has the highest mean of 13.50, followed by the application of 30 mL FAA + 30 mL FSW (T3) with a mean of 10.2. However, 20 mL FAA + 20 mL FSW (T2) with a mean of 8.91-, and 40-mL FAA + 40 mL FSW (T4) with a mean of 8.09. Organic plant biostimulants were said to have a lower amount of nutrients (Appendix Table 14), and some of these nutrients are not in the form the plants can readily absorb and utilize (Ali et al., 2020). Similar results were observed by Liu (2014) and his colleagues in their study on lettuce; plants applied with more

than 30 mL FAA have stunted growth. This is because fermented organic fertilizers have higher electric conductivity (EC) values, which could decrease the water potential of the soil and thus inhibit plant growth and development. Statistical analysis showed a significant difference among the treatments on the plant height of lettuce (Appendix Table 1a).

Number of Leaves. Application of commercial fertilizer (T1) has the highest mean of 17, followed by 30 mL FAA +30 mL FSW (T3) with a mean of 12 in terms of the number of leaves (Table 1). However, 20 mL FAA + 20 mL FSW (T2) with a mean of 11-, and 40-mL FAA + 40 mL FSW (T4) with a mean of 11. Pascual (2020) and his colleagues observed a contradicting result in their study of lettuce with 10mL/L of fermented seaweed had the highest growth rate, and a higher number of leaves were achieved. Statistical analysis showed that there was a significant difference among the treatments on the plant height of lettuce (Appendix Table 2a).

Leaf Length (cm). Table 1 indicates the highest number with a mean of 12.76, was achieved by the application of commercial fertilizer (T1) followed by the application of 30 mL FAA +30 mL FSW (T3) with a mean of 9.71 in terms of leaf length. However, 20 mL FAA + 20 mL FSW (T2) with a mean of 8.42-, and 40-mL FAA + 40 mL FSW (T4) with a mean of 7.97. Statistical analysis showed that there was a significant difference among the treatments on the plant height of lettuce (Appendix Table 3a).

Leaf Width (cm). Applying commercial fertilizer (T1) obtained the highest mean of 9.86, followed by 30 mL FAA +30 mL FSW (T3) with a mean of 7.60 on

leaf width. However, 20 mL FAA + 20 mL FSW (T2) with a mean of 6.40-, and 40-mL FAA + 40 mL FSW (T4) with a mean of 5.61. In contrast, a study on cucumber plants treated with 50 mL of fish waste extract produced the highest leaf area (Ellyzatul et al., 2018). Statistical analysis showed that there was a significant difference among the treatments on the plant height of lettuce (Appendix Table 4a).

Root Penetration Depth (cm). Regarding root penetration depth, commercial fertilizer (T1) gained the highest mean of 12.57, followed by 30 mL FAA +30 mL FSW (T3) with a mean of 9.51. However, 20 mL FAA + 20 mL FSW (T2) with a mean of 8.66-, and 40-mL FAA + 40 mL FSW (T4) with a mean of 8.14. Statistical analysis showed a significant difference among the treatments on the plant height of lettuce (Appendix Table 5a).

Table 1
Growth Performance of Lettuce Applied with Different Levels of
Plant Biostimulants

Treatment	Plant height (cm)*	No. of leaves*	Leaf length (cm)*	Leaf width (cm)*	Root penetration depth (cm)
T1	13.50 a	17 a	12.76 a	9.86 a	12.57 a
T2	8.91 c	11 b	8.42 bc	6.40 c	8.66 bc
T3	10.27 b	12 b	9.71 b	7.60 b	9.51 b
T4	8.09 c	11 b	7.97 c	5.61 c	8.14 c
CV (%)	6.36	9.03	6.80	6.63	5.01

*Means without letters are not significantly difference at 5% level of significance

Legend:

- T1 – commercial fertilizer
- T2 – 20 mL FAA + 20 mL FSW per L
- T3 – 30 mL FAA + 30 mL FSW per L
- T4 – 40 mL FAA + 40 mL FSW per L

Yield and Yield Components of Lettuce

Number of Marketable Plant. The highest number of marketable plants were obtained on crops by treatment 1 (commercial fertilizer) with a mean of 14, for it has a full and sufficient amount of macro and micronutrients readily available for plant utilization (see Appendix Table 14). Followed by treatment 3 (30 mL FAA + 30 mL FSW), which obtained the second-highest number of marketable plants with a mean of 9 (see Table 2). Statistical analysis showed that there was a significant difference among the treatments on the plant height of lettuce (Appendix Table 6a).

Weight of Marketable Plant per Plot (g). In Table 2, T1 (commercial fertilizer) has the highest weight of marketable plants with a mean of 393.60, followed by treatment 3 (30 mL FAA + 30 mL FSW) with a mean of 127.40. Statistical analysis showed a significant difference among the treatments on the plant height of lettuce (Appendix Table 7a).

Weight per Plant (g). In terms of weight per plant, the application of commercial fertilizer (T1) obtained the highest mean of 29.71, followed by 30 mL FAA +30 mL FSW (T3) with a mean of 12.14 (Table 2). Statistical analysis showed a significant difference among the treatments on the plant height of lettuce (Appendix Table 8a).

Total Yield (tons/ha). Table 2 indicates that the highest mean of total yield was obtained by the application of T1 (commercial fertilizer) with a mean of 2.18 compared to other treatments with three concentrations of plant biostimulants used, followed by 30 mL FAA + 30 mL FSW per liter of water with a mean of 0.99.

These results may be because commercial fertilizers contain a higher amount of macro and micronutrients readily available for plant absorption and utilization (see Appendix Table 14). Among the organic treatments, T3 is the optimum concentration that would result in a higher yield compared to the application of 20 mL FAA + 20 mL FSW (T2) and 40 mL FAA + 40 mL FSW (T4). However, a study conducted about cucumber concluded that 20 mL fish waste extract was the best treatment for improving its yield (Ellyzatul et al., 2018). Statistical analysis showed a significant difference among the treatments on the plant height of lettuce (Appendix Table 9a).

Table 2
Yield and Yield Components of Lettuce Applied with Different Levels of Plant Biostimulants

Treatment	No. of marketable plants (per plot)*	Wt. of marketable plants (g) (per plot)*	Wt. per plant (g)*	Total yield (tons/ha)*
T1	14 a	393.60 a	29.71 a	2.18 a
T2	3 c	27.30 c	7.27 c	0.50 c
T3	9 b	127.40 b	12.14 b	0.99 b
T4	2 c	19.33 c	5.76 c	0.39 c
CV (%)	27.84	29.76	10.98	20.42

*Means without letters are not significantly difference at 5% level of significance

Legend:

- T1 – commercial fertilizer
- T2 – 20 mL FAA + 20 mL FSW per L
- T3 – 30 mL FAA + 30 mL FSW per L
- T4 – 40 mL FAA + 40 mL FSW per L

Total Soluble Solids (TSS). Table 3 shows the results of the total soluble solids (TSS) of lettuce leaves at harvest. The analysis revealed that on TSS and pH, there was no significant difference in the effects of the treatments used in the study. Lettuce leaves grown and supplemented with different fertilizers obtained a TSS reading ranging from 2.33 – 3.00 °Brix. This shows that the treatments used

did not increase nor decrease the soluble solids content of the lettuce, this range in TSS is the appropriate range for lettuce because it has lower sugar contents than fruit crops (Fontana et al., 2018). However, a study on cucumber was observed (Ellyzatul et al., 2018) that 20mL/L of fish waste extract increased its leaf TSS content. Statistical analysis showed no significant difference among the treatments on the plant height of lettuce (Appendix Table 10a).

Leaf pH. In terms of the pH of lettuce leaves, Table 3 shows the mean differences of the lettuce applied with plant biostimulants. It indicates that lettuce leaves were nearly neutral in acidity regardless of the treatments applied to the plants. Statistical analysis showed no significant difference among the treatments on the plant height of lettuce (Appendix Table 11a).

Table 3
Chemical Characteristics of Lettuce Leaves Applied with Different Levels of Plant Biostimulants

Treatment	TSS	pH
T1 – commercial fertilizer	3.00	6.46
T2 – 20 mL FAA + 20 mL FSW per L	2.33	6.46
T3 – 30 mL FAA + 30 mL FSW per L	3.00	6.41
T4 – 40 mL FAA + 40 mL FSW per L	2.50	6.63
CV (%)	15.99	2.64

*Means without letters are not significantly difference at 5% level of significance

Cost and Return Analysis

Table 4 shows the cost and return analysis of lettuce production on the total yield applied with 30 mL FAA + 30 mL FSW per L. It implies that applying 30 mL FAA + 30 mL FSW per L expensed up to ₱16,833.75 as a grand total of the production cost of the farm labor and materials, then a gross income of ₱9,964.512 which harvested a 2,502 lettuce plants with a weight of 24.91128 kilograms.

Organic lettuce price starts at ₱400.00 per kg, as mentioned in a Facebook post of Bites and Things PH by Jeanne (posted on June 04, 2022) where they posted that their lettuce per pack that weighs 0.25 kg costs ₱100.00 per pack. With this, there was a Return on Investment of -40.8%. This is due to the cost of the fertilizer used that sum up to ₱12,000.00 and the low percentage of marketable plants harvested.

Table 4
Cost and Return Analysis of Lettuce Production

Items	Quantity	Unit	Unit Price (₱)	Total Cost (₱)
A. Production Cost				
A1. Farm Labor				
1. Land preparation				
- plowing (3 hours)	0.4	MAD	600	225.00
- weeding (5 hours for 3 times a month)	1.9	MD	300	112.50
- raising beds (2 days)	2	MD	300	600.00
2. Sowing (30 mins)	0.04	MD	300	18.75
3. Transplanting (3 hours)	0.4	MD	300	112.50
4. Watering (4 hours for 14 times)	7	MD	300	2,100.00
5. Nutrient Application (4 hours for 9 times)	4.5	MD	300	1,350.00
6. Harvesting (2 hours)	0.25	MD	300	75.00
Subtotal				4,593.75
A2. Materials				
1. Seeds (1.6g/pack)	4	pack	60	240.00
2. Fertilizer				
FAA	100	Li	60	6,000.00
FSW	100	Li	60	6,000.00
Subtotal				12,240.00
Grand Total				₱16,833.75
B. Revenue				
1. Lettuce	24.9	kg	400	9,964.51
Total				₱9,964.512
C. Return on Investment				
				(-40.8%)

Note: Using the application of 30 mL FAA + 30 mL FSW per L

Chapter 3

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions, and recommendations drawn from the findings.

Summary of Findings

In the growth performance of lettuce, there was a significant difference in plant height, number of leaves, leaf length, width, and root penetration depth. Plants applied with commercial fertilizer (T1) significantly produced better quality crops with taller, larger leaves, longer roots, and heavier, among others. Application of 30 mL FAA + 30 mL FSW ranks second in terms of the growth and yield parameters among the concentrations of plant biostimulants used. It produces better crops than other plant biostimulants concentrations (T2 and T4).

However, applying different fertilizers does not significantly affect the total soluble solids (TSS) and pH of the lettuce.

Conclusions

Based on the findings, commercial fertilizer can still produce better and higher yields in lettuce production. However, if one wants to produce organically grown lettuce, 30 mL FAA + 30 mL FSW could be used as a substitute for commercial fertilizer.

Recommendations

Anchored on the conclusions, the following recommendations were formulated:

1. Commercial fertilizer is the best fertilizer for large-scale production that does not require the organic production of lettuce.
2. For organic advocate farmers, it can be recommended to use 30 mL FAA + 30 mL FSW to enhance the organic production of lettuce.
3. Conduct soil analysis before applying plant biostimulants to know what nutrient is present in the soil to avoid over-application.
4. Conduct the same study using other leafy vegetables to verify the results of this research.

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APPENDICES

Appendix A-1
Plant Height (cm) of Lettuce as Affected by Application of
Plant Biostimulants

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	12.5476	14.224	13.716	40.4876	13.49587
T2 – 20 mL FAA + 20 mL FSW	8.5344	8.4328	9.7536	26.7208	8.906933
T3 – 30 mL FAA + 20 mL FSW	9.9822	10.16	10.668	30.8102	10.27007
T4 – 40 mL FAA + 20 mL FSW	8.509	7.239	8.509	24.257	8.085667

Appendix A-2
Analysis of Variance on the Plant Height of Lettuce as Affected by
Application of Plant Biostimulants

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	523.948 ^a	5	104.790	84.351	.000
Intercept	12459.435	1	12459.435	10029.322	.000
Block	13.659	2	6.830	5.498	.005
Trt	510.289	3	170.096	136.920	.000
Error	141.622	114	1.242		
Total	13125.006	120			
Corrected Total	665.571	119			

a. R Squared = .787 (Adjusted R Squared = .778)

Appendix B-1
Number of Leaves of Lettuce as Affected by Application of Plant
Biostimulants

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	14.1	18.4	17	49.5	16.5
T2 – 20 mL FAA + 20 mL FSW	9.6	10.7	12.9	33.2	11.07
T3 – 30 mL FAA + 20 mL FSW	11.6	11.5	13.3	36.4	12.13
T4 – 40 mL FAA + 20 mL FSW	10.5	10.5	11.7	32.7	10.9

Appendix B-2
Number of Leaves of Lettuce as Affected by Application of Plant Biostimulants

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	724.217 ^a	5	144.843	77.491	.000
Intercept	19202.700	1	19202.700	10273.482	.000
Block	104.450	2	52.225	27.940	.000
Trt	619.767	3	206.589	110.525	.000
Error	213.083	114	1.869		
Total	20140.000	120			
Corrected Total	937.300	119			

a. R Squared = .773 (Adjusted R Squared = .763)

Appendix C-1
Leaf Length (cm) of Lettuce as Affected by Application of
Plant Biostimulants

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	11.53	13.64	13.11	38.28	12.76
T2 – 20 mL FAA + 20 mL FSW	8.03	7.98	9.27	25.27	8.42
T3 – 30 mL FAA + 20 mL FSW	9.22	9.65	10.26	29.13	9.71
T4 – 40 mL FAA + 20 mL FSW	8.15	7.24	8.51	23.90	7.97

Appendix C-2
Analysis of Variance on Leaf Length (cm) of Lettuce as Affected by Application of
Plant Biostimulants

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	442.350 ^a	5	88.470	73.876	.000
Intercept	11326.913	1	11326.913	9458.443	.000
Block	22.697	2	11.348	9.476	.000
Trt	419.653	3	139.884	116.809	.000
Error	136.520	114	1.198		
Total	11905.783	120			
Corrected Total	578.870	119			

a. R Squared = .764 (Adjusted R Squared = .754)

Appendix D-1
Leaf Width (cm) of Lettuce as Affected by Application of Plant Biostimulants.

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	9.09	10.08	10.39	29.57	9.86
T2 – 20 mL FAA + 20 mL FSW	5.94	5.77	7.49	19.20	6.40
T3 – 30 mL FAA + 20 mL FSW	7.7	7.16	7.95	22.81	7.60
T4 – 40 mL FAA + 20 mL FSW	5.64	4.80	6.40	16.84	5.61

Appendix D-2
Analysis of Variance on Leaf Width (cm) of Lettuce as Affected by Application of Plant Biostimulants.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	442.350 ^a	5	88.470	73.876	.000
Intercept	11326.913	1	11326.913	9458.443	.000
Block	22.697	2	11.348	9.476	.000
Trt	419.653	3	139.884	116.809	.000
Error	136.520	114	1.198		
Total	11905.783	120			
Corrected Total	578.870	119			

a. R Squared = .764 (Adjusted R Squared = .754)

Appendix E-1
Root Penetration Depth (cm) of Lettuce as Affected by Application of Plant Biostimulants.

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	13.16	11.68	12.88	37.72	12.57
T2 – 20 mL FAA + 20 mL FSW	8.46	9.02	8.51	25.98	8.66
T3 – 30 mL FAA + 20 mL FSW	9.91	9.25	9.37	28.52	9.51
T4 – 40 mL FAA + 20 mL FSW	8.79	7.62	8.00	24.41	8.14

Appendix E-2
Analysis of Variance on Root Penetration Depth (cm) of Lettuce as Affected by Application of Plant Biostimulants.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	363.841 ^a	5	72.768	47.344	.000
Intercept	11336.786	1	11336.786	7375.830	.000
Block	9.459	2	4.730	3.077	.050
Trt	354.382	3	118.127	76.855	.000
Error	175.220	114	1.537		
Total	11875.847	120			
Corrected Total	539.061	119			

a. R Squared = .675 (Adjusted R Squared = .661)

Appendix F-1
Number of Marketable Plants of Lettuce as Affected by Application of Plant Biostimulants.

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	11	14	17	42	14
T2 – 20 mL FAA + 20 mL FSW	2	2	4	8	2.67
T3 – 30 mL FAA + 20 mL FSW	10	6	12	28	9.33
T4 – 40 mL FAA + 20 mL FSW	2	3	2	7	2.33

Appendix F-2
Analysis of Variance on Number of Marketable Plants of Lettuce as Affected by Application of Plant Biostimulants.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	301.583 ^a	5	60.317	15.510	.002
Intercept	602.083	1	602.083	154.821	.000
Block	16.667	2	8.333	2.143	.198
Trt	284.917	3	94.972	24.421	.001
Error	23.333	6	3.889		
Total	927.000	12			
Corrected Total	324.917	11			

a. R Squared = .928 (Adjusted R Squared = .868)

Appendix G-1
Weight of Marketable Plants (g) of Lettuce as Affected by Application of Plant Biostimulants.

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	301	415.1	464.7	1180.8	393.6
T2 – 20 mL FAA + 20 mL FSW	17.9	13.2	50.8	81.9	27.3
T3 – 30 mL FAA + 20 mL FSW	134.3	85	162.9	382.2	127.4
T4 – 40 mL FAA + 20 mL FSW	17.6	14.6	25.8	58	19.33

Appendix G-2
Analysis of Variance on the Weight of Marketable Plants (g) of Lettuce as Affected by Application of Plant Biostimulants.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	282558.134 ^a	5	56511.627	31.680	.000
Intercept	241655.701	1	241655.701	135.470	.000
Block	7401.472	2	3700.736	2.075	.207
Trt	275156.662	3	91718.887	51.417	.000
Error	10703.015	6	1783.836		
Total	534916.850	12			
Corrected Total	293261.149	11			

a. R Squared = .964 (Adjusted R Squared = .933)

Appendix H-1
Weight Per Plant of Lettuce (g) as Affected by Application of Plant Biostimulants.

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	27.23	31.08	30.83	89.14	29.71
T2 – 20 mL FAA + 20 mL FSW	6.18	5.36	10.28	21.82	7.27
T3 – 30 mL FAA + 20 mL FSW	11.71	11.47	13.24	36.42	12.14
T4 – 40 mL FAA + 20 mL FSW	6	3.86	7.41	17.27	5.76

Appendix H-2
Analysis of Variance on the Weight Per Plant (g) of Lettuce as Affected by
Application of Plant Biostimulants.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11075.579 ^a	5	2215.116	69.138	.000
Intercept	22591.352	1	22591.352	705.118	.000
Block	177.860	2	88.930	2.776	.067
Trt	10897.719	3	3632.573	113.379	.000
Error	3652.459	114	32.039		
Total	37319.390	120			
Corrected Total	14728.038	119			

a. R Squared = .752 (Adjusted R Squared = .741)

Appendix I-1
Total Yield (tons/ha) of Lettuce as Affected by Application of Plant Biostimulants.

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	1.73	2.42	2.38	6.53	2.18
T2 – 20 mL FAA + 20 mL FSW	0.4	0.38	0.71	1.49	0.5
T3 – 30 mL FAA + 20 mL FSW	1.02	0.88	1.08	2.98	0.99
T4 – 40 mL FAA + 20 mL FSW	0.4	0.31	0.45	1.16	0.39

Appendix I-2
Analysis of Variance on the Total Yield (tons/ha) of Lettuce as Affected by
Application of Plant Biostimulants.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.189 ^a	5	1.238	28.911	.000
Intercept	12.323	1	12.323	287.840	.000
Block	.143	2	.071	1.670	.265
Trt	6.046	3	2.015	47.072	.000
Error	.257	6	.043		
Total	18.769	12			
Corrected Total	6.446	11			

a. R Squared = .960 (Adjusted R Squared = .927)

Appendix J-1
Total Soluble Solids (TSS) of Lettuce as Affected by Application of Plant Biostimulants.

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	3	3	3	9	3
T2 – 20 mL FAA + 20 mL FSW	2	3	2	7	2.33
T3 – 30 mL FAA + 20 mL FSW	3	3	3	9	3
T4 – 40 mL FAA + 20 mL FSW	2.5	2	3	7.5	2.5

Appendix J-2
Analysis of Variance on the Total Soluble Solids (TSS) of Lettuce as Affected by Application of Plant Biostimulants.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.104 ^a	5	.221	1.178	.417
Intercept	88.021	1	88.021	469.444	.000
Block	.042	2	.021	.111	.897
Trt	1.063	3	.354	1.889	.232
Error	1.125	6	.188		
Total	90.250	12			
Corrected Total	2.229	11			

a. R Squared = .495 (Adjusted R Squared = .075)

Appendix K-1
Leaf pH of Lettuce as Affected by Application of Plant Biostimulants.

Treatment	Block			Total	Mean
	I	II	III		
T1 – commercial fertilizer	6.74	6.29	6.35	19.38	6.46
T2 – 20 mL FAA + 20 mL FSW	6.89	6.17	6.31	19.37	6.46
T3 – 30 mL FAA + 20 mL FSW	6.44	6.44	6.36	19.24	6.41
T4 – 40 mL FAA + 20 mL FSW	6.71	6.52	6.67	19.9	6.63

Appendix K-2
Analysis of Variance on the Leaf pH of Lettuce as Affected by
Application of Plant Biostimulants.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.345 ^a	5	.069	2.349	.164
Intercept	505.571	1	505.571	17237.008	.000
Block	.259	2	.130	4.419	.066
Trt	.085	3	.028	.969	.466
Error	.176	6	.029		
Total	506.092	12			
Corrected Total	.520	11			

a. R Squared = .662 (Adjusted R Squared = .380)

Appendix L
Recommended Nutrient Ranges for Lettuce.

Nutrient	Range	Target Level
Nitrogen	2.5-4%	3.5%
Phosphorus	0.4-0.6%	0.45%
Potassium	4.0-7.5%	5%
Calcium	0.9-2.0%	1.0%
Magnesium	0.3-0.7%	0.35%
Sulfur	0.1%-0.3%	0.1%
Iron	50-150 ppm	130 ppm
Zinc	25-50 ppm	40 ppm
Manganese	30-55 ppm	50 ppm
Copper	5-10 ppm	8 ppm
Boron	15-30 ppm	20 ppm
Molybdenum	0.1-2.0 ppm	0.6 ppm

Source: A & L Canada Laboratories. (2006). Molybdenm Ranges in Soils and Tissues. Ontario, Canada: A & L Canada Laboratories, Inc.
Valenzuela, H.R., Kratky, B.A. and Cho, J.J. (1996). Lettuce Production Guidelines for Hawaii. Manoa: CTAHR, College of Tropical Agriculture & Human Resources, University of Hawaii.

Appendix M
Nutrient Composition of Fish Amino Acid Fermented Seaweed, and Commercial Fertilizer.

Fish Amino Acid		Fermented Seaweed		Commercial	
Nutrients	Amount (%)	Nutrients	Amount	Nutrients	Amount (%)
Nitrogen	3.66±0.80	Nitrogen	0.18%	Nitrogen	14
Phosphorus	1.03±0.02	Phosphorus	0.48%	Phosphorus	14
Potassium	0.74±0.02	Potassium	1.89%	Potassium	14
Calcium	1.75±0.08	Calcium	0.11%		
Magnesium	0.19±0.03	Magnesium	0.01%		
Sodium	0.22±0.05	Sodium	0.13%		
Inorganic C	0.59±0.02	Iron	256.0 ppm		
Organic C	40.85±1.50	Zinc	11.87 ppm		
		Copper	15.62 ppm		
		Manganese	13.12 ppm		

Source: Yildirim, E., Kul, R., Turan, M. and Ekinci, M. (2016). Effect of Nitrogen and Fish Manure Fertilization on Growth and Chemical Composition of Lettuce. International Conference on Advances in Natural and Applied Sciences. DOI: 10.1063/1.4945847.

Source: Manimaran, P., Lakshmi, J. and Raja Sekar, P. (2018). Influence of Foliar Application of Seaweed Extract and Plant Regulators on Growth and Physiological Attributes of *Jasminum sambac*. Environment and Ecology. 36. 262-264.

Source: <https://whyfarmit.com/14-14-14-fertilizer/>