

## Physiological response of eggplant (*Solanum melongena* L.) on biostimulant application

Rufino O. Arcega II\*<sup>1</sup>, Prof. Lucila V. Rocha<sup>2</sup>

<sup>1, 2</sup> Isabela State University, Echague, Isabela, Philippines

\*Corresponding Author e-mail: [bastearcega@gmail.com](mailto:bastearcega@gmail.com)

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### Abstract

**Aim:** This study aimed to evaluate the physiological growth and yield response of eggplant (*Solanum melongena* L.) to reduced rates of inorganic fertilizer supplemented with different biostimulants, and to determine whether biostimulant application can sustain crop productivity while minimizing inorganic fertilizer inputs.

**Methodology:** A field experiment was conducted using a randomized complete block design with treatments consisting of varying levels of inorganic fertilizer combined with different biostimulants, including AMO foliar fertilizer. Growth parameters such as plant height, leaf area, and number of lateral branches were measured at 30, 60, and 90 days after transplanting (DAT). Yield components, marketable fruit weight, projected yield per 1,000 m<sup>2</sup>, and cost and return analysis were also evaluated. Data were subjected to appropriate statistical analysis to determine significant treatment effects.

**Key Results:** Plant height at 30 and 60 DAT showed no significant differences among treatments; however, at 90 DAT, plants receiving half of the recommended inorganic fertilizer rate combined with biostimulant application exhibited significantly improved growth compared with the fully fertilized control. Leaf area and number of lateral branches were significantly enhanced in AMO-treated plants (Treatment 7). Although fruit length and diameter were not significantly affected by treatments, Treatment 7 produced the highest number of fruits and the greatest marketable fruit weight per plant and per sampling area. The computed yield per 1,000 m<sup>2</sup> increased by 32.32% in plants applied with half of the recommended inorganic fertilizer supplemented with AMO foliar fertilizer.

**Conclusion:** The study demonstrated that the application of half of the recommended inorganic fertilizer rate combined with AMO foliar biostimulant is an effective and sustainable strategy for improving eggplant growth, yield, and economic returns while reducing inorganic fertilizer input.

**Keywords:** *Biostimulants; eggplant; inorganic fertilizer reduction; AMO foliar fertilizer; sustainable crop production*

### INTRODUCTION

Eggplant (*Solanum melongena* L.) is one of the most widely cultivated vegetable crops globally and serves as an important component of human diets due to its high content of dietary fiber, vitamins, minerals, and bioactive secondary metabolites. These phytochemicals contribute not only to nutritional quality but also to pharmaceutical and medicinal applications, as many modern and traditional remedies depend on plant-derived compounds (Sevindik, 2019). Despite its economic and nutritional importance, eggplant production remains highly vulnerable to abiotic stresses such as drought, salinity, and extreme temperature fluctuations, which significantly constrain crop growth, yield, and quality.

Among these stressors, drought represents one of the most critical challenges affecting agricultural productivity, particularly in regions with limited water resources. Abiotic stresses disrupt plant physiological and biochemical processes, including photosynthesis, nutrient uptake, enzyme activity, and cellular metabolism, ultimately resulting in reduced yield and poor crop performance. With increasing pressure to enhance agricultural productivity under constrained land and water resources, there is a growing need for sustainable strategies that can improve crop resilience while minimizing environmental degradation.

In recent years, biostimulants have gained increasing attention as sustainable agricultural inputs capable of enhancing plant growth, nutrient use efficiency, and tolerance to environmental stresses. Biostimulants, including



humic substances, seaweed extracts, amino acids, and beneficial microorganisms, function by modulating plant metabolism, promoting root development, and strengthening antioxidant defense mechanisms (Ma et al., 2023). These mechanisms enhance the plant's capacity to withstand and recover from abiotic stress conditions, offering an alternative to excessive reliance on synthetic fertilizers.

The application of biostimulants aligns with global sustainability initiatives, particularly the United Nations Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). These goals emphasize the importance of sustainable food production systems, efficient resource use, and climate-resilient agricultural practices. In the Philippine agricultural context, where vegetable production is often challenged by erratic climatic conditions and rising input costs, the adoption of biostimulant-based nutrient management strategies offers significant potential for improving productivity while reducing environmental impacts.

Although numerous studies have documented the beneficial effects of biostimulants on various crops, existing literature remains fragmented with respect to their combined application with reduced inorganic fertilizer rates, particularly under field conditions and in tropical environments. Moreover, limited empirical evidence is available on the physiological and yield responses of eggplant to specific biostimulant formulations under stress-prone conditions. Previous studies have largely focused on single biostimulant components or controlled environments, leaving a research gap concerning integrated nutrient management strategies that combine biostimulants with reduced fertilizer inputs.

Addressing this gap, the present study investigated the physiological growth and yield performance of eggplant under varying levels of inorganic fertilizer supplemented with different biostimulants. Unlike previous studies, this research evaluated the combined effects of reduced inorganic fertilizer rates and biostimulant application under actual field conditions, with emphasis on crop performance, yield components, and economic returns. The findings aim to contribute to sustainable crop management practices by providing scientific evidence on the potential of biostimulants to optimize eggplant production while minimizing fertilizer dependency and environmental impact.

## Review of Related Literature and Studies

Biostimulants have been increasingly recognized as sustainable agricultural inputs capable of enhancing crop growth, productivity, and resilience to abiotic stresses. Abiotic stresses such as drought, salinity, and temperature extremes disrupt essential physiological processes in plants, including photosynthesis, nutrient uptake, enzyme activity, and cellular metabolism, ultimately leading to yield reduction. In response, biostimulants have been promoted as eco-friendly alternatives that enhance plant tolerance to these adverse conditions while reducing dependency on synthetic fertilizers.

Several studies have demonstrated that biostimulants such as humic substances, seaweed extracts, amino acids, and microbial inoculants positively influence plant growth and yield by improving root development, nutrient absorption, and water-use efficiency (Du Jardin, 2012; Ma et al., 2023). These substances function by regulating plant hormonal balance, stimulating antioxidant defense systems, and enhancing soil microbial activity, which collectively improve plant physiological performance under stress conditions.

The application of *Trichoderma* spp. has been widely documented for its role in promoting plant growth and suppressing soil-borne pathogens. *Trichoderma* colonizes the rhizosphere and root surfaces, enhancing nutrient uptake and inducing systemic resistance in plants (Harman et al., 2004; da Silva et al., 2016). Studies have shown that *Trichoderma* spp. improve plant vigor, root biomass, and yield in various vegetable crops, particularly under abiotic stress environments (Asgar & Kataoka, 2021; Das et al., 2022).

Seaweed extracts, particularly those derived from brown algae such as *Ascophyllum nodosum*, have also been extensively studied for their biostimulant properties. These extracts contain bioactive compounds including phytohormones, polysaccharides, amino acids, and vitamins that promote plant growth, enhance chlorophyll synthesis, and improve stress tolerance (Calvo et al., 2014; Santaniello et al., 2017). Foliar application of seaweed extracts has been reported to improve yield components and mitigate drought stress in several crops (Begum et al., 2018).

Effective Microorganisms (EM) consist of mixed cultures of beneficial microorganisms such as photosynthetic bacteria, lactic acid bacteria, and yeasts that improve soil fertility and plant growth. EM application has been shown to enhance nutrient cycling, accelerate organic matter decomposition, and increase crop yield when applied as soil amendments or foliar sprays (Yadav, 2012). However, despite extensive research on individual biostimulant components, limited studies have examined their combined application with reduced inorganic fertilizer rates under field conditions, particularly for eggplant production.

Overall, existing literature supports the potential of biostimulants to improve crop growth and yield; however, there remains a research gap regarding their integrated use with reduced inorganic fertilizers and their specific physiological effects on eggplant under stress-prone environments. This gap justified the conduct of the present study.

## Theoretical Framework

This study was anchored on the Plant Stress Physiology Theory and Sustainable Nutrient Management Theory.

Plant Stress Physiology Theory explains that plants exposed to abiotic stresses such as drought and nutrient limitation experience disruptions in physiological and biochemical processes, including reduced photosynthetic efficiency, impaired nutrient uptake, oxidative stress, and altered hormonal balance. According to this theory, plant adaptation and tolerance to stress depend on physiological adjustments such as enhanced root development, improved antioxidant defense, and osmotic regulation. Biostimulants support these adaptive mechanisms by modulating metabolic pathways, improving root architecture, and enhancing stress-responsive biochemical processes.

Sustainable Nutrient Management Theory emphasizes optimizing nutrient inputs to achieve maximum crop productivity while minimizing environmental impact. This theory supports the reduction of synthetic fertilizer use through alternative nutrient-enhancing inputs that improve nutrient-use efficiency and soil health. Biostimulants and beneficial microorganisms play a critical role in this framework by enhancing nutrient availability, stimulating soil biological activity, and improving plant nutrient uptake efficiency.

In this study, the application of biostimulants combined with reduced inorganic fertilizer rates was theoretically expected to improve eggplant physiological performance and yield by enhancing stress tolerance mechanisms and nutrient-use efficiency, thereby supporting sustainable crop production.

## Conceptual Framework

The conceptual framework illustrates the relationship between **nutrient management strategies** and **eggplant growth and yield performance** under field conditions.

The **independent variables** consisted of:

- Levels of inorganic fertilizer application (full and reduced rates)
- Application of biostimulants (including AMO foliar fertilizer and other biostimulant components)

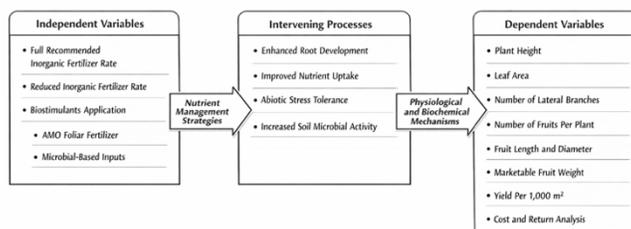
The **intervening variables** included:

- Improved nutrient uptake efficiency
- Enhanced root development
- Increased physiological stress tolerance
- Improved soil microbial activity

The **dependent variables** were the growth and yield parameters of eggplant, namely:

- Plant height
- Leaf area
- Number of lateral branches
- Number of fruits per plant
- Fruit length and diameter
- Weight of fruits per plant and per sampling area
- Computed yield per 1,000 m<sup>2</sup>
- Cost and return analysis

The framework assumed that the combined application of biostimulants with reduced inorganic fertilizer rates would positively influence the intervening physiological processes, leading to improved growth, yield, and economic performance of eggplant.



## Statement of the Problem

Eggplant (*Solanum melongena* L.) is an important vegetable crop valued for its nutritional and economic significance. However, its productivity is often constrained by abiotic stresses such as drought, nutrient limitation, and fluctuating environmental conditions, which negatively affect plant growth, yield, and profitability. Conventional farming practices rely heavily on inorganic fertilizers to enhance crop performance; however, excessive fertilizer use has been associated with declining soil health, increased production costs, and adverse environmental impacts.

Recent agricultural trends emphasize the use of biostimulants as sustainable inputs that can enhance plant physiological performance, improve nutrient-use efficiency, and increase tolerance to stress conditions. While numerous studies have documented the benefits of biostimulants in various crops, limited empirical evidence exists on their combined application with reduced inorganic fertilizer rates, particularly under field conditions and in eggplant production systems. Moreover, there is insufficient information regarding the economic viability of integrating biostimulants into nutrient management strategies for eggplant.

Given the increasing need for sustainable, cost-effective, and environmentally sound agricultural practices, it is essential to investigate whether biostimulant application, in combination with reduced inorganic fertilizer rates, can sustain or improve eggplant growth, yield, and profitability. Addressing this gap is crucial for developing nutrient management strategies that enhance crop performance while minimizing input costs and environmental risks.

## Objectives of the Study

### General Objective

To evaluate the physiological responses, yield performance, and economic viability of eggplant (*Solanum melongena* L.) as affected by the application of different biostimulants in combination with varying rates of inorganic fertilizer.

### Specific Objectives

Specifically, the study aimed to:

1. To determine the effects of biostimulant application on the growth and yield parameters of eggplant.
2. To identify the appropriate combination and rate of inorganic fertilizer and biostimulant that enhances eggplant growth and yield under stress conditions.
3. To determine the most economical treatment in terms of cost and return analysis.

### Research Questions

The study sought to answer the following questions:

1. What are the effects of biostimulant application on the growth and yield parameters of eggplant?
2. Which combination and rate of inorganic fertilizer and biostimulant produce the highest growth and yield performance of eggplant under stress conditions?
3. Which treatment provides the highest economic return based on cost and return analysis?

### Hypotheses

1. There is no significant difference in the growth and yield parameters of eggplant as affected by biostimulant application.
2. There is no significant difference in eggplant growth and yield when inorganic fertilizer rates are reduced and supplemented with biostimulants.
3. There is no significant difference in economic returns among the different fertilizer and biostimulant treatments.

## METHODS

### Research Design

The study employed a quantitative experimental research design using a Randomized Complete Block Design (RCBD) to evaluate the physiological growth and yield responses of eggplant (*Solanum melongena* L.) to different biostimulant applications combined with varying rates of inorganic fertilizer. RCBD was considered appropriate for this study because it effectively controlled field variability by grouping experimental units into homogeneous blocks, thereby increasing the accuracy and reliability of treatment comparisons under field conditions.

Seven treatments were evaluated and replicated three times, resulting in a total of twenty-one experimental plots. Each treatment was randomly assigned within each block to minimize experimental bias.

## Experimental Site

The study was conducted at the City Nursery of the Department of Agriculture located in San Fermin, City of Cauayan, Isabela. The area was previously planted with vegetables and was suitable for upland crop production. The experiment was conducted from March 13 to July 8, 2025.

## Systematic Selection of Representative Plants

The experimental population consisted of eggplant plants established in twenty-one plots arranged according to the RCBD layout. Each plot measured 4 m × 4 m. Ten representative plants per plot were selected through systematic selection of representative plants to serve as sample plants for data collection. This sampling size was deemed sufficient to represent plant performance within each treatment and replication.

## Treatments and Fertilizer Application

The treatments consisted of one full recommended rate of inorganic fertilizer and six reduced-rate inorganic fertilizer treatments supplemented with different biostimulants, as follows:

- T1 – 80-50-90 kg NPK ha<sup>-1</sup> (Recommended Rate)
- T2 – 40-25-45 kg NPK ha<sup>-1</sup> + Seaweed Extract
- T3 – 40-25-45 kg NPK ha<sup>-1</sup> + Effective Microorganisms (EM)
- T4 – 40-25-45 kg NPK ha<sup>-1</sup> + Humic Acid
- T5 – 40-25-45 kg NPK ha<sup>-1</sup> + *Trichoderma*
- T6 – 40-25-45 kg NPK ha<sup>-1</sup> + *Rhizobium*
- T7 – 40-25-45 kg NPK ha<sup>-1</sup> + AMO Foliar Fertilizer

The recommended rate of inorganic fertilizer was applied basally based on soil analysis. Biostimulants were applied as foliar spray at 30 and 45 days after transplanting at a rate of 3 L ha<sup>-1</sup>, except *Rhizobium*, which was applied basally using the slurry method.

## Instruments

Standard and calibrated measuring instruments were used in the study. Plant height was measured using a meter stick, leaf dimensions were measured using a ruler, fruit diameter was measured using a vernier caliper, and fruit weight was measured using a weighing balance. These instruments are commonly used in agronomic field experiments and ensured accuracy and consistency of measurements.

## Data Collection Procedures

Data were collected from the ten representative plants per plot throughout the cropping period. Plant height was measured at 30, 60, and 90 days after transplanting. Leaf area was measured at harvest using the formula: Leaf Area =  $L \times W \times k$ , where  $L$  represents leaf length (cm),  $W$  represents maximum leaf width (cm), and  $k$  is the correction factor (0.75).

Other data collected included number of lateral branches, number of marketable fruits per plant, fruit length, fruit diameter, weight of fruits per plant, and weight of fruits per sampling area. Harvesting was conducted at marketable maturity, and fruits were collected and recorded separately for each treatment to avoid intermixing.

## Treatment of Data and Statistical Analysis

All data gathered were collated, tabulated, and statistically analyzed using Analysis of Variance (ANOVA) appropriate for a Randomized Complete Block Design. When significant differences among treatments were detected, Tukey's Honestly Significant Difference (HSD) test was used to compare treatment means at a 5% level of significance. Yield per sampling area was projected to 1,000 m<sup>2</sup> to estimate productivity per unit area.

## Ethical Considerations

The study adhered to ethical research standards applicable to agricultural field experiments. No human or animal subjects were involved. Environmentally responsible practices were observed throughout the study, including proper handling of fertilizers, biostimulants, and pesticides in accordance with recommended agricultural guidelines to prevent environmental harm.

## RESULTS and DISCUSSION

This section presents and discusses the results of the study in direct alignment with the research questions. Findings are interpreted using relevant literature to explain observed trends and mechanisms.

### Research Question 1

#### What are the effects of biostimulant application on the growth parameters of eggplant?

##### General Crop Stand and Vigor

Field observations indicated that eggplant plants across all treatments exhibited good establishment and vigorous growth. Plants treated with biostimulants displayed fully developed leaves, thick and upright main stems, well-formed lateral branches, and healthy foliage characterized by green to slightly purple coloration without visible lesions or structural deformities. Flowering occurred normally, with no evidence of flower abortion or malformed fruits.

These observations suggested that biostimulant application supported physiological stability and plant vigor, particularly under the prevailing climatic stress conditions during the study period. Biostimulants are known to enhance stress tolerance by improving metabolic activity, antioxidant defense, and nutrient uptake efficiency, thereby supporting sustained vegetative growth under suboptimal environmental conditions (Du Jardin, 2015).

##### Plant Height

Table 1. Plant at 30, 60 and 90 days after transplanting (cm) as affected by biostimulant and inorganic fertilizer

TREATMENT	MEAN		
	30 DAT	60 DAT	90 DAT
T <sub>1</sub> – 80-50-90 kg NPK ha <sup>-1</sup> (RR)	28.84	69.45	105.67b
T <sub>2</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Seaweed Extract	30.14	65.41	98.43bcd
T <sub>3</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Effective Microorganisms	28.43	65.61	94.45cd
T <sub>4</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Humic Acid	30.00	65.50	98.32bcd
T <sub>5</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Trichoderma	30.21	61.30	96.82bcd
T <sub>6</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Rhizobium	32.25	66.19	99.92bc
T <sub>7</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + AMO Foliar Fertilizer	30.37	69.85	110.75a
F-RESULT	ns	ns	**
CV (%)	4.48	4.60	2.39

Note: Means within a column represented by common letters are not significant using HSD.

Plant height measured at 30 and 60 days after transplanting (DAT) showed no significant differences among treatments (Table 1). Mean values ranged from 28.84 to 32.25 cm at 30 DAT and from 61.30 to 69.85 cm at 60 DAT, indicating comparable early vegetative growth regardless of fertilizer rate or biostimulant application.

The lack of significant differences during early growth stages suggested that nutrient absorption and physiological responses to biostimulants required sufficient time to manifest. This observation was consistent with the findings of Masinde et al. (2009), who reported that enhanced growth responses in eggplant became evident only after nutrients were sufficiently assimilated and metabolized.

At 90 DAT, significant differences were observed. Plants treated with half the recommended inorganic fertilizer rate combined with AMO foliar fertilizer (T7) recorded the tallest mean height (110.75 cm), representing a 4.81% increase over the fully fertilized control (105.67 cm). This result demonstrated that the combined application of reduced inorganic fertilizer and biostimulant not only sustained growth but further enhanced plant height.

The improved growth performance in T7 may be attributed to the synergistic effects of biostimulants, which enhance root activity, nutrient mobilization, and stress tolerance. Similar synergistic interactions between biostimulants and inorganic fertilizers have been reported by Nikolajsen et al. (2020) and Di Sario et al. (2025), who emphasized improved nutrient efficiency and root development as key mechanisms.

## Leaf Area

Table 2. Leaf area (cm<sup>2</sup>) as affected by biostimulant and inorganic fertilizer

TREATMENT	MEAN
T <sub>1</sub> – 80-50-90 kg NPK ha <sup>-1</sup> (RR)	17.25b
T <sub>2</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Seaweed Extract	16.92b
T <sub>3</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Effective Microorganisms	16.92b
T <sub>4</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Humic Acid	16.93b
T <sub>5</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Trichoderma	16.88b
T <sub>6</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Rhizobium	16.93b
T <sub>7</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + AMO Foliar Fertilizer	20.67a
F-RESULT	*
CV (%)	6.61
HSD	2.64

Note: Means within a column represented by common letters are not significant at 5% level using HSD.

Leaf area was significantly affected by biostimulant application (Table 2). Treatment 7 (40-25-45 kg NPK ha<sup>-1</sup> + AMO foliar fertilizer) produced the largest leaf area (20.67 cm<sup>2</sup>), which was significantly higher than all other treatments and the control.

Larger leaf area enhanced photosynthetic surface capacity, enabling greater light interception and improved assimilation of water and nutrients. The observed increase was consistent with Yusuf et al. (2012), who reported that foliar biostimulants stimulate leaf expansion through improved hormonal balance and cellular activity.

Additionally, the results aligned with the findings of Liang et al. (2003) and Gofii et al. (2018), who demonstrated that biostimulants improve water relations and osmolyte accumulation, protecting chlorophyll integrity under stress. Enhanced leaf area thus contributed to sustained growth and improved physiological performance under elevated temperature conditions during the study period.

## Number of Lateral Branches

Table 3. Number of lateral branches as affected by biostimulant and inorganic fertilizer

TREATMENT	MEAN
T <sub>1</sub> – 80-50-90 kg NPK ha <sup>-1</sup> (RR)	8.33ab
T <sub>2</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Seaweed Extract	7.33b
T <sub>3</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Effective Microorganisms	7.67b
T <sub>4</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Humic Acid	7.33b
T <sub>5</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Trichoderma	7.67b
T <sub>6</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Rhizobium	7.33b
T <sub>7</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + AMO Foliar Fertilizer	9.00a
F-RESULT	*
CV (%)	6.75
HSD	1.50

Note: Means within a column represented by common letters are not significant at 1% level using HSD.

The number of lateral branches per plant was significantly influenced by treatment (Table 3). Plants treated with AMO foliar fertilizer (T7) produced the highest number of branches (9.00), which was statistically comparable to the control but significantly higher than the other reduced-rate treatments.

Increased branching was likely associated with enhanced stem elongation and node development, providing more sites for branch initiation. The biostimulant properties of AMO, including its content of enzymes, proteins, and vitamins, may have promoted cellular division and metabolic efficiency (Gupta & Abu-Ghannam, 2011), thereby supporting greater vegetative architecture.

## Research Question 2

**Which combination of inorganic fertilizer rate and biostimulant enhances eggplant yield performance under stress conditions?**

### *Number of Fruits per Plant*

Table 4. Number of fruits per plant as affected by biostimulant and inorganic fertilizer

TREATMENT	MEAN
T <sub>1</sub> – 80-50-90 kg NPK ha <sup>-1</sup> (RR)	15.00b
T <sub>2</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Seaweed Extract	14.67b
T <sub>3</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Effective Microorganisms	14.33b
T <sub>4</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Humic Acid	14.33b
T <sub>5</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Trichoderma	14.67b
T <sub>6</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Rhizobium	15.33b
T <sub>7</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + AMO Foliar Fertilizer	19.00a
F-RESULT	**
CV (%)	
HSD	

Note: Means within a column represented by common letters are not significant at 1% level using HSD.

Significant differences were observed in the number of fruits per plant (Table 4). Treatment 7 produced the highest fruit count (19.00 fruits per plant), representing a 26.67% increase over the fully fertilized control (15.00 fruits).

The increased fruit production in T7 may be attributed to improved flower retention, enhanced nutrient translocation, and balanced hormonal activity induced by AMO foliar fertilizer. Biostimulants have been shown to improve photosynthetic efficiency and reproductive development, leading to increased fruit set (Halpern et al., 2015; Debska et al., 2022).

Furthermore, increased lateral branching observed in T7 provided additional reproductive sites, which likely contributed to the higher fruit number.

### *Fruit Length and Diameter*

Table 5. Length of fruits per plant (cm) as affected by biostimulant and inorganic fertilizer

TREATMENT	MEAN
T <sub>1</sub> – 80-50-90 kg NPK ha <sup>-1</sup> (RR)	21.38
T <sub>2</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Seaweed Extract	20.51
T <sub>3</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Effective Microorganisms	21.10
T <sub>4</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Humic Acid	20.60
T <sub>5</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Trichoderma	21.30
T <sub>6</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Rhizobium	20.76
T <sub>7</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + AMO Foliar Fertilizer	22.30
F-RESULT	ns
CV (%)	4.65

Table 6. Diameter of fruits per plant (cm) as affected by biostimulant and inorganic fertilizer

TREATMENT	MEAN
T <sub>1</sub> – 80-50-90 kg NPK ha <sup>-1</sup> (RR)	3.44
T <sub>2</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Seaweed Extract	3.19
T <sub>3</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Effective Microorganisms	3.33
T <sub>4</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Humic Acid	3.11
T <sub>5</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Trichoderma	3.37
T <sub>6</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Rhizobium	3.41
T <sub>7</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + AMO Foliar Fertilizer	3.78
F-RESULT	ns
CV (%)	9.45

Fruit length and diameter were not significantly affected by fertilizer rate or biostimulant application (Tables 5 and 6). Mean fruit length ranged from 20.51 to 22.30 cm, while fruit diameter ranged from 3.11 to 3.78 cm across treatments.

These results suggested that fruit size was largely governed by genetic characteristics of the eggplant cultivar rather than nutrient input levels. Similar findings were reported by Parađiković et al. (2013) and Cakmakçi et al. (2006), who emphasized that once optimal nutritional requirements are met, further increases in fertilizer input do not necessarily enhance fruit dimensions.

### **Weight of Marketable Fruits per Plant**

Table 7. Weight of fruits per plant (g) as affected by biostimulant and inorganic fertilizer

TREATMENT	MEAN
T <sub>1</sub> – 80-50-90 kg NPK ha <sup>-1</sup> (RR)	1549.95b
T <sub>2</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Seaweed Extract	1538.40b
T <sub>3</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Effective Microorganisms	1551.84b
T <sub>4</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Humic Acid	1549.94b
T <sub>5</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Trichoderma	1600.05b
T <sub>6</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Rhizobium	1548.60b
T <sub>7</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + AMO Foliar Fertilizer	2136.55a
F-RESULT	**
CV (%)	5.44

Note: Means within a column represented by common letters are not significant at 1% level using HSD.

A highly significant difference was observed in the weight of marketable fruits per plant (Table 7). Treatment 7 recorded the highest mean value (2,136.55 g per plant), which substantially exceeded the control and all other treatments.

This result demonstrated that reduced inorganic fertilizer input, when combined with AMO foliar fertilizer, enhanced assimilate production and allocation to fruits. The improved yield efficiency reflected enhanced physiological processes, nutrient uptake, and stress mitigation provided by the biostimulant.

**Weight of Fruits per Sampling Area and Computed Yield**Table 8. Weight of fruits per sampling area (kg/3.60 m<sup>2</sup>) as affected by biostimulant and inorganic fertilizer

TREATMENT	MEAN
T <sub>1</sub> – 80-50-90 kg NPK ha <sup>-1</sup> (RR)	18.98b
T <sub>2</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Seaweed Extract	18.07b
T <sub>3</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Effective Microorganisms	17.81b
T <sub>4</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Humic Acid	18.12b
T <sub>5</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Trichoderma	18.28b
T <sub>6</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Rhizobium	18.59b
T <sub>7</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + AMO Foliar Fertilizer	24.75a
F-RESULT	**
CV (%)	
LSD	

Note: Means within a column represented by common letters are not significant at 1% level using HSD. <sup>□</sup>

Table 9. Projected yield per 1000 Square Meters (kg)

TREATMENT	MEAN
T <sub>1</sub> – 80-50-90 kg NPK ha <sup>-1</sup> (RR)	1186.25
T <sub>2</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Seaweed Extract	1129.37
T <sub>3</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Effective Microorganisms	1113.31
T <sub>4</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Humic Acid	1132.50
T <sub>5</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Trichoderma	1142.50
T <sub>6</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + Rhizobium	1161.87
T <sub>7</sub> – 40-25-45 kg NPK ha <sup>-1</sup> + AMO Foliar Fertilizer	1546.87

Consistent with per-plant results, T<sub>7</sub> produced the highest fruit weight per sampling area (24.75 kg per 3.60 m<sup>2</sup>) and the highest projected yield per 1,000 m<sup>2</sup> (1,546.87 kg), representing a 32.32% increase over the fully fertilized control (Tables 8-9).

These findings indicated that biostimulant application effectively compensated for reduced fertilizer input while enhancing yield performance. Similar improvements in yield efficiency associated with foliar biostimulants were reported by Riad et al. (2008) and Soppelsa et al. (2019), who highlighted improved nutrient use efficiency and fruit development.

**Research Question 3****Which treatment provides the highest economic return?****Cost and Return Analysis**

Table 10. Cost and return analysis

	T1	T2	T3	T4	T5	T6	T7
<b>TOTAL COST OF PRODN.</b>	11078.5	10001.75	10701.75	11051.75	10351.75	9956.75	10806.75
<b>GROSS INCOME</b>	47450	45174.8	44532.4	45300	45700	46474.8	61874.8
<b>NET INCOME</b>	35185.25	34043.73	32717.39	33115.8	34205.8	35356.23	49521.23
<b>ROI (%)</b>	317.6	340.38	305.72	299.64	330.43	355.1	458.24

The cost and return analysis revealed that Treatment 7 achieved the highest net income (₱49,521.23) and return on investment (ROI) of 458.24% (Table 10), despite not having the lowest production cost.

The results demonstrated that slightly higher input investment in AMO foliar fertilizer generated substantially greater economic returns through increased yield. This finding confirmed that productivity gains, rather than minimal input cost alone, were the primary drivers of profitability.



### Synthesis of Findings

Overall, the results demonstrated that reducing inorganic fertilizer application to half of the recommended rate and supplementing it with AMO foliar fertilizer effectively enhanced eggplant growth, yield, and economic performance under stress conditions. Biostimulant application improved vegetative development, fruit production, and nutrient efficiency without compromising fruit quality. These outcomes supported the role of biostimulants as sustainable inputs capable of optimizing crop performance while reducing dependency on synthetic fertilizers.

### Conclusions

The study demonstrated that the application of half of the recommended inorganic fertilizer rate in combination with AMO foliar fertilizer was an effective biostimulant-based nutrient management strategy for eggplant production. Although plant height at 30 and 60 days after transplanting was not significantly affected by fertilizer rate or biostimulant application, plants treated with biostimulants exhibited comparable and, in some parameters, improved growth performance relative to the fully fertilized control. At 90 days after transplanting, significant enhancement in plant height, leaf area, and number of lateral branches was observed, particularly in plants receiving AMO foliar fertilizer (Treatment 7).

Yield-related parameters further confirmed the advantage of the combined treatment. While fruit length and diameter were not significantly influenced by fertilizer rate or biostimulant application, the number of fruits per plant and the weight of marketable fruits were significantly higher in Treatment 7. Consequently, the computed fruit yield per 1,000 m<sup>2</sup> increased by 32.32% compared with the control treatment that received the full recommended rate of inorganic fertilizer. These findings indicated that the integration of AMO foliar fertilizer with reduced inorganic fertilizer input enhanced yield efficiency and economic returns without compromising fruit quality.

Overall, the results affirmed that the combined use of biostimulants, particularly AMO foliar fertilizer, and reduced inorganic fertilizer rates constituted a sustainable and efficient approach to optimizing eggplant growth, yield, and profitability under stress conditions while minimizing dependence on chemical fertilizers.

### Recommendations

Based on the findings of the study, eggplant growers may consider reducing inorganic fertilizer application to half of the standard recommended rate and supplementing it with AMO foliar fertilizer as a nutrient management strategy. This approach may help maintain plant vigor, enhance vegetative growth, increase fruit number and marketable yield, and improve economic returns.

Further studies may be conducted to evaluate the long-term effects of this fertilizer–biostimulant combination on soil health, nutrient-use efficiency, and crop sustainability under different agro-climatic conditions and across other eggplant cultivars. Additional research may also explore the performance of AMO foliar fertilizer in combination with reduced inorganic fertilizer rates in other vegetable crops to broaden its application in sustainable agriculture.

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