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Research Article

Enhancing The Growth and Yield of Bush Sitao Using Bio-Stimulants in the Philippines

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ABSTRACT

The study aims to determine the effects of different levels of concentrations of bio-stimulant solution (BSS) in enhancing the growth and yield of bush sitao plant. The study was conducted at Bacolod City, Philippines. It was laid-out in RCBD (Randomized Complete Block Design) with 4 treatments, and replicated 4 times. Statistical analysis revealed a highly significant differences among treatments in growth parameters such as the flower initiation, plant height, weight of stems and leaves, and biomass from plants applied with 15% BSS (ɑlpha = 0.01). Furthermore, results indicated highly significant differences with yield parameters as well, namely the number of pods per plant, pod weight per plant, number of seeds per pod, total weight of 100-seeds, and the yield in kg/ha (ɑlpha = 0.01). The weight of stems and leaves and biomass accumulation were strongly correlated with the plant height while weight of roots were correlated moderately (ɑlpha = 0.01). Relatively, the number of pods per plant, pod weight, as well as the number of seeds per pods were strongly correlated with the yield. Based on excellent results of the study, for bush sitao it is recommended to apply BSS with a concentration of 15% in order to enhance the growth and yield of the plant. Furthermore the result could contribute to organic farming and food sustainability program being aspired in the whole world.

Keywords: *Bio-stimulant, Legumes, Bush sitao, Organic farming, Soil microorganisms, Food sustainability, Biomass*

Introduction

Bush sitao *(Vigna sesquipedalis* and *Vigna unguiculata*), belongs to the Fabaceae family. Despite its potential, this crop remains relatively minor in the Philippines, primarily cultivated on a small scale in both backyard gardens and limited farming areas. It is often grown as an intercrop or in rotation with other upland crops.

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The decreasing supply of bush sitao, an important vegetable crop, necessitates the development of practical and cost-effective alternatives to expensive synthetic fertilizers. Replacing these costly fertilizers with readily available and more economical organic options found in farm environments offers a promising solution. Bio-stimulants promote flowering, plant development, fruit formation, crop productivity, and efficient nutrient utilization, representing a promising advancement (Rouphael et al, 2020).

However, it is important to acknowledge that beans thrive better under adequate fertility conditions. In the current economic downturn, the escalating costs of inorganic fertilizers and agricultural supplies pose a challenge for farmers struggling to afford essential inputs, especially commercial ones. The new bio-liquid fertilizers and plant enhancers are emerging as alternatives to traditional chemical fertilizers, aiming to boost plant growth (Allouzi et al., 2022; Dos Santos et al., 2020). It include the supply of growth regulators and essential minerals such as potassium, phosphorus, and Nitrogen (Yao et al, 2021).

Recently, Chemical Agriculture has proven to harm human health and the environment (Elbana et al., 2018; Yang et al., 2020).

Organic fertilization at appropriate times was essential to stabilize and ensure peanut production with high quality and yield, (Sanglap, et al, 2025). Bio-stimulants were versatile and could affect all aspects of a plant's life: e.g. nutrition and growth, plant processes and development.

Bio-stimulants affect the metabolic and enzymatic processes in plants, thus improving their yield and quality. They are microbial solutions consisting mainly of lactic acid bacteria, photosynthetic bacteria, and yeasts, and organic as they do not contain genetically modified microorganisms (Lobaton, et al 2025).

In the study of Caruso et al (2019), Biostimulants had seen to increase the yield and production of tomato plants in a conventional and organic vegetable system. Bio-stimulants, comprising organic compounds, active microorganisms, or extracts from other plants, had shown promising results in various crop productions.

Hellequin et al (2020) reported that these beneficial microorganisms present in the substance, function greatly in the plant and the root zone area in the soil. It encouraged effective biological processes for plants to better absorbed the needed nutrients, the consistent utilization of nutrients, and the adaptation of plants to environmental or external stresses. The most vital advantage that were mention are important in the growth and development of the crop to get the most benefit from it.

The effect of bio-stimulant were studied in other legumes, fewer studies are done on bush sitao in the Philippines.

Furthermore this study can contribute to a pool of knowledge in food sustainability, organic agriculture, studies on eco-friendly technologies.

Objectives of the Study

This study aimed to evaluate the effectiveness of the different levels of concentration of BSS on the growth and yield of bush sitao plants.

Specifically, it aims to:

1. determine the growth performance of bush sitao applied with different levels of concentrations of BSS.
2. determine the effective level of BSS in increasing the yield of the bush sitao plant.
3. identify variables that are correlated to growth and yield of bush sitao plants when applied with different concentrations of BSS.

Theoretical Framework and Related Literature

This study was related to the THEORY of MICRBIAL COEXISTENCE in promoting soil–plant ecosystem health.The theory states that soil microorganisms form a complex assembly and play an important role in agro ecosystems by regulating nutrient cycling, promoting plant growth, and alleviating biotic and abiotic stresses. Improving microbial coexistence may be an effective and practical solution for the promotion of soil–plant ecosystem health in the face of the impacts of anthropogenic activities and global climate change.(Zhang et al., 2021)

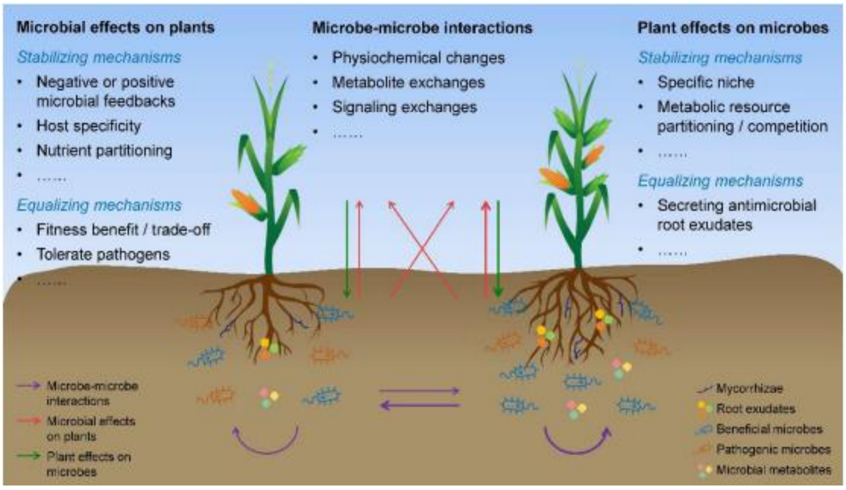

Fig 1. Theory of Microbial Coexistence (after Zhang et al, 2021)

Use of bio-stimulant in agriculture. Microbial (arbuscular mycorrhizal and plant growth-promoting rhizobacteria: Azotobacter, Azospirillum and Rizhobium spp.) and non-microbial (humic substances, silicon, animal and vegetal-based protein hydrolysate and macro and micro-algal extracts, bio-stimulants represent a sustainable and effective alternative or complement for their synthetic counterparts, bringing benefits to the environment, biodiversity, human health and economy.

Bio-Stimulant does not only improve the quality and yield of crops but also the restoration of the fertility of the land (Ali et al., 2023; Naqve et al., 2023). It delves into how these natural substances contribute to reducing the environmental footprint by promoting healthier plant growth, improved soil health, reduced chemical dependency, and enhanced crop resilience to abiotic and biotic stresses.

Bio-stimulants, is considered as nutrient-supplying substances that contain microorganisms, can enhance plant growth and well-being. They offer promising opportunities to revolutionize agricultural methods, potentially leading to sustainable and cost-effective solutions for boosting crop productivity. Many studies and phenotypic observations have proposed the functions of bio-Stimulant in improving plant processes. It aids in decreasing abiotic stresses, promotes plant growth and development, and improves the quality and the yield of the crops (Yuniati et al, 2023).

Bio-stimulant effects on legumes. Several studies have investigated the impact of Bio-stimulants on peanut growth. Research by Zheng et al (2023) proved that the application of plant bio-Stimulants derived from several plant extracts has influenced root development, leading to increase in nutrient uptake and improved plant productivity

The study of Sivakumar et al (2024) investigated a natural bio-stimulant derived from the green seaweed *Chaetomorpha aerea.* The bio-stimulant significantly improved peanut growth and yield in pot and field experiments.

Bio-stimulants, which consist of various organic substances or microorganisms, have garnered attention as potential enhancers of plant growth and productivity. (Xu Geelen, 2018; Oñal et al., 2024, 2023).

Components and functions of bio-stimulant. Microorganism components of the bio-stimulant such as bacteria, fungi, and yeasts can be utilize as bio-control agents to fight harmful plant pathogens in crops. (Joshi et al, 2021).

According to Yuniati et al, (2022), the application of moringa leaf extract as a plant bio-stimulant has demonstrated effects on improving physical attributes such as increased plant metabolism, enhanced yield parameters, including size, color, and uniformity of produce, as well as prolonged shelf life and reduced post-harvest losses that is relevant in the production of leaf crops.

Benefits of beneficial microorganisms. Organic waste is a valuable resource that can be transformed into bio-products through bio-conversion processes. Bio-conversion can recover nutrients from organic matter to create nutrient-rich supplements and generate useful energy (Huang et al, 2021). Dos Santos et al, (2020*)* highlighted the importance of diverse microorganisms residing in the rhizosphere, emphasizing their ability to thrive alongside plant roots, stimulate plant growth, and mitigate diseases.

One of the prominent bacteria in action is the rhizobia, rhizobium inoculation stimulates the proliferation of potentially beneficial microbes, strengthens connections within rhizobacterial networks, and improve the composition of hub microbes that produce a great amount of nitrogen for the plant (Zhong et al., 2019; Wang et al., 2021).

Del Canto et al, (2023) identified three highly effective indigenous rhizobium strains that not only improved cell wall elasticity, enhanced water use efficiency. The characteristics of the crop in physiology and biochemical, yield, and the development of antioxidant enzymes have significantly increased with the application of high-protein rhizobium in an organic bio-stimulant (Ajaykumar et al, 2023).

A review by Francesca et al, (2022) proved that the plant-derived protein hydrolysate tested in this study demonstrated bio-stimulant activity by enhancing hormone production for mung beans utilized as feed ration Oñal, et al (2023).

Contribution to research. Theories and related literature suggest that bio-stimulants has a notable effect on the peanut growth, root development, and increasing the yield. Optimal concentrations of bio-stimulants, such as seaweed extracts and humic substances, had shown positive effects on nutrient absorption, flowering, and overall yield parameters in peanuts. Further research was a requisite to determine the optimal concentrations and formulations of plant bio-stimulants for maximizing peanut productivity while ensuring sustainable agricultural management practices.

Limitation of the Study

The study was limited only to the growth and yield performance of bush sitao plants applied with the different level of concentrations of BSS. This research was conducted in a 100-square-meter area. It was laid out at the compound of the University of Negros Occidental-Recoletos, Inc. (UNO-R, Inc.), Philippines from February to April 2024. There were four treatments and replicated four times using the Randomized Complete Block Design (RCBD)

Methodology

This study focused on assessing the efficacy of BSS treatments in facilitating the growth and yield performance of bush sitao. Bio-stimulants, defined as substances or microorganisms applied to plants or the rhizosphere, were investigated for their potential to enhance natural processes, ultimately improving crop quality, stress resilience, nutrient absorption, and overall efficiency (Ganugi et al, 2021).

These bio-stimulants were found to play a crucial role in modulating plant hormonal processes, enabling plants to better withstand abiotic stresses such as salinity, drought, and high temperatures. This led to improved nutrient availability, underscoring the multifaceted benefits of bio-stimulant applications in bush sitao (Nyochlat et al, 2020).

Four (4) treatments with four (4) replications was design for this experiment. This study evaluated the growth and yield performance of bush sitao using the different levels of BSS following a Randomized Complete Block Design (RCBD).

Research Design and Treatments

Treatment	Description
T1	0% BSS)
T2	5% BSS
T3	10% BSS
T4	15% BSS

Cultural Management and Procedures

Site Selection and Gathering of Soil Sample

An open area at school campus with sufficient sunlight throughout the day was selected for the study. The selected experimental area was cleaned and leveled-off. Soil samples were gathered for analysis. The soil type in the area is sandy loam.

Preparation of Seeds

Good quality or viable seeds were selected seeds were soaked in water for 24 hours to promote germination. After the soaking process, the soaked seeds were spread out in a single layer of a clean, dry surface and air dried for 30 minutes to remove excess water.

Sowing and Thinning

Five (5) seeds were sown at a depth of 2-4 cm. Thinning was done 2 weeks after sowing. Sowing time was during summer with average temperature between 24-30ºC.

Water and Weed Management

Soil moisture was done regularly. Hand weeding was employed retard the growth of weeds

Pest and Disease Control

The area was monitored from time to time to check the presence of pests and diseases during the entire growth of plants. Proper control was employed.

Harvesting

Monitoring of flowering and pod development was closely monitored. Harvesting was done by priming by manually picking the mature pods early in the morning to avoid weight loss. All harvested pods were weighed immediately using a weighing scale equipment.

Preparation and Application of BSS

Diluting the self-formulated bio-stimulant to the desired concentration with water was done before the actual application. Preparation of individual solutions was done separately for each treatment before application. Application of BSS was done at 10 days after sowing the seeds (DAS), 25DAS, and 40DAS.

Data Gathered

1. Flower Initiation (in number of days).
2. Plant Height (cm) - was gathered at 15 days after sowing (DAS), 30 DAS and after harvest.
3. Data to be gathered after harvest:
   a. Pod number
   b. Pod weight per plant (gm)
   c. Number of seeds per pod
   d. Total weight of 100 seeds
   e. Weight of leaves and stems (gm)
4. Bean yield (kg/hectare)
5. Biomass (kg/hectare) - It was done by adding the weight of the roots and the upper portion of the plants including the weight of beans, pods, leaves, and stems.

   Formula: Bs=Wr+Wb+Wp+Wl+Ws

Statistical Tool and Analysis

All data gathered were computed statistically and were subjected to Analysis of Variance (ANOVA) in RCBD using STAR 2.0.1.

The Least Significant Differences (LSDs) was utilize to determine significant differences among treatments.

Pearson's Product Moment Correlation Coefficient or simply Pearson's Correlation Analysis was used to measure the strength of the linear correlation between two variables.

Results and Discussions

Flower Initiation

One of the most important data gathered on this study was the determination of initiations of flowering of bush sitao as indicated in Table 1. The results showed that plants applied with 15% BSS had the shortest period of flowering which was 32.80 days statistically earlier by 2.58 days from those plant not applied with BSS that had flowered at 35.48 days (αlpha = 0.01). It can be deduced from the results that higher concentrations of bio-stimulant solution (15%) can effectively shorten the flower initiation of bush sitao. Furthermore, the absence of application of bio-stimulant solution can delayed the flowering.

The findings of Malabataan et al (2023), support these results, demonstrating the effectiveness of irradiated carrageenan (IC) on flowering in cowpea and "bush sitao." Which shortened the flowering period by two to four days in cowpeas.

Table 1. The flowering period of bush sitao (in the number of days) applied with different levels of concentration of BSS.

Percent Concentration of BSS	Mean
0% BSS	35.38[a]
5% BSS	34.45[b]
10% BSS	33.45[c]
15% BSS	32.80[d]
Mean	**34.02**
Pr (>F)	0.0000**
CV (%)	0.6504

*Means followed by the same letter are not significantly different from each other, **=highly significant*

Height of Bush Sitao

The height of bush sitao at 15 DAS, 30 DAS, and at harvest as applied with different volume of bio-stimulant solutions is presented in Figure 2.

15 Days After Sowing

The average height of bush sitao (cm) at 15DAS applied with different levels of concentration of the BSS indicates that increasing the concentration of bio-stimulant solution positively hastens the growth of bush sitao plants. The results show that those plants applied with 15% BSS had the tallest height of 21.52 cm higher by 29.63% or 4.92cm from those with 0%BSS which had the shortest height at 16.60 cm only (αlpha = 0.01).

The results implied that greater increase in plant height can be achieved by applying a higher concentration of a bio-stimulant solution (15% BSS).

30 Days After Sowing

The data from Figure 2 also shows the average height of bush sitao at 30 DAS. The results show significant variation among treatments. Plants applied with 15% BSS statistically were the tallest with 45.66 cm much higher by 35.49% or 11.96cm as compared to those plants not applied with the BSS with 33.70 cm only (αlpha = 0.01).

It can be deduced from the results that the application of higher concentrations of BSS (15%) can greatly enhance the growth of bush sitao at 30 days. The absence of application of bio-stimulant solution (0%BSS) can stunt or slows down the growth of the plant in terms of stem height.

Height at Harvest

The average height of bush sitao (cm) at harvest applied with different levels of concentration of BSS is also shown also in Figure 2. In-detailed plants applied 15% BSS had an average height of 58.02cm, statistically higher by 24.77% or 11.52 cm from those with no BSS application with an average height of 46.50 cm only, a difference of 4.17 cm (αlpha = 0.01).

The results implied that highest concentration of BSS (15%) significantly boosted the height to 58.02 cm at harvest period, indicating a positive correlation between the BSS concentration and the growth of bush sitao.

The study of Johnson et al (2023), highlighted that bio-stimulants act as both hormonal and nutritional supplement and significantly enhanced the plant growth. Their research underscores the effectiveness of bio-stimulants in improving plant development under challenging conditions.

This correlates with the observations of the group of Di-Filippo-Herrera (2018), on seaweed extract which was used as a bio-stimulant that had the most significant impact on increasing mung bean height by almost 39%.

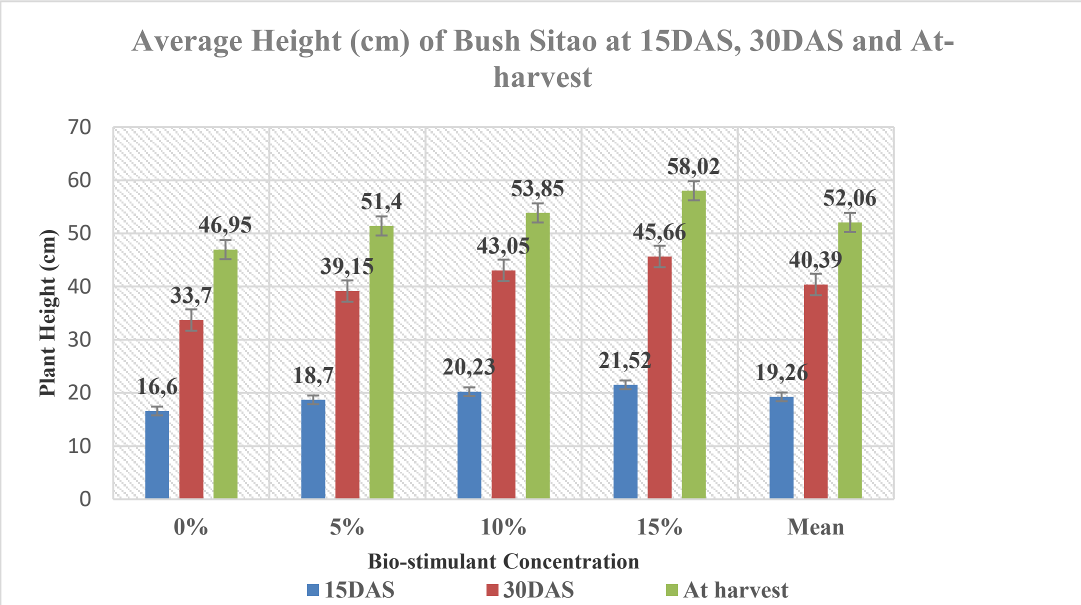

Fig 2. Average height of bush sitao (cm) applied with different concentrations of BSS at 15DAS, 30DAS and at harvest.

Weight of Stems & Leaves, Root Weight and Biomass

Weight of Stems and Leaves

The average weight of leaves and stem (gm) of bush sitao applied with different levels of concentration of the BSS is shown in Table 3. The results show that plants applied with 15% BSS produced the heaviest stems and leaves 223.75 gm significantly higher by 16.69% or 32.00 gm from plants not applied with BSS (alpha = 0.01). Plants with 0% BSS had the lightest weight of leaves and stems 191.75 gm only with a difference of 8.75 gm.

These results connotes a positive correlation between the concentration of the BSS and the average weight of bush sitao leaves and stem. Furthermore it indicates the potential benefits of BSS in enhancing plant growth and dry matter accumulation.

Weight of Roots

The data on the average weight of roots (gm) of bush sitao is also shown in Table 3. Comparable results are observed between plants applied with 15% BSS and those applied with 10% BSS with an average weight of 31.75 gm and 28.50 gm, respectively (αlpha = 0.01). The lowest root weight is shown by the bush sitao plant with no BSS with average weight of 22.75gm.

These findings implied a clear positive relationship between the concentration of the BSS and root weight of the plant, suggesting that higher levels of BSS at 15% and/or 10% promote root growth in bush sitao.

Biomass

The accumulation of biomass as indicated on the average weight (in gm) of bush sitao applied with different levels of concentration of a BSS is also shown in Table 4. The heaviest biomass accumulated are those plants applied with 15% BSS with 280.35 gm significantly higher by 20.27% or 47.35 gm from plants not applied with BSS with a biomass of 233.10 gm only (αlpha = 0.01).

These results implied that higher concentrations of BSS positively influence the biomass accumulation of bush sitao (gm). The maximum weight of accumulated biomass were those for bush sitao applied with a 15% BSS.

The investigations of the group of Tahiri in 2024 on the beneficial effects of bio-stimulants on the growth parameters of green beans (*Phaseolus vulgaris*) in Morocco. They measured the growth weight of leaves from 21, to as far as 49 days of cultivation. The results showed a 52.95% increase in the number of leaves in plants treated with bio-stimulants.

Additionally, there was an 83.45% improvement in foliar weight. These findings underscore the efficacy of bio-stimulants in enhancing vegetative growth in legume crops, e.g. bush sitao, promoting better plant structure and overall productivity.

Relatively, Loconsole et al (2024), has a research that focuses on the effects of bio-stimulants on root development in plants. Their study reveals that the application of bio-stimulants significantly enhances root growth, leading to longer and denser root systems. They observed that plants treated with bio-stimulants experienced improved nutrient uptake and greater resilience to environmental stress. Those mentioned factors had helped in the increased of root development which contributes to overall plant health and productivity. The findings underscore the efficacy of bio-stimulants in promoting robust root systems and enhancing plant growth.

In the study of Wang et al (2022), which was done in a greenhouse trial assessing bio-stimulants in hydroponic lettuce, the shoot biomass with bio-stimulant supplementation was significantly greater or comparable to that with full-strength nutrient solution. Treatments with seaweed extract (SE) and gamma polyglutamic acid (PGA) resulted in higher root biomass compared to the half-strength and full-strength nutrient solutions alone. The combination of a half-strength nutrient solution with fulvic acid (FA) produced the lowest root-to-shoot ratio. While FA and SE improved biomass production, PGA had a minimal impact. Overall, the study highlights that SE and FA are more effective than PGA for enhancing biomass production in hydroponic lettuce.

Table 3. The average weight of leaves and stems (gm), the weight of roots (gm), and biomass (gm) of bush sitao (cm) applied with different levels of concentration of BSS.

Percent Concentration of BSS	Other Growth Parameters		
	Weight of Leaves & Stems (gm)	Weight of Roots (gm)	Biomass (gm)
0% BSS	191.54^{d}	22.75^{c}	233.10^{d}
5% BSS	204.00^{c}	26.25^{b}	249.75^{c}
10% BSS	215.00^{b}	28.50^{ab}	265.85^{b}
15% BSS	223.75^{a}	31.75^{a}	280.35^{a}
Mean	**208.63**	**27.31**	**257.26**
Pr (>F)	0.0000**	0.0000**	0.0000**
CV (%)	1.63	7.86	1.86

Means followed by the same letter are not significantly different from each other,
***=highly significant*

Yield Parameters

Weight of Pods

Yield parameters as shown in Table 4 commenced by determining the average weight of pods (gm) of bush sitao as applied with different levels of concentration of the BSS. The weight of beans were statistically comparable between plants applied with 15% BSS and 10% BSS with an average weight of 24.85 gm and 22.35 gm, respectively (αlpha = 0.01).

These findings show a significant positive relationship between the concentration of the BSS and the weight of bush sitao pods, highlighting the potential effectiveness of BSS in enhancing crop yield. The application of 15% of BSS can also maximized the weight of the bush sitao pod.

Number of Pods per plant

The other important parameter determined in the yield of bush sitao was getting the average number of pods per plant as shown in Table 4. Specifically, the results revealed a positive correlation between the concentration of the BSS and pod production. Plants applied with 15% BSS have produced the highest number of pods with an average of 11.85 statistically higher by 53.90% or 4.15 pods with 0% BSS applied (αlpha = 0.01).

These findings suggest that the application of higher concentrations of BSS at 15% significantly enhances the pod yield of bush sitao.

Number of Seeds per Pod

Relatively getting the number of seeds per pod for yield is another factor of great importance for yield determination. Specifically, Table 4 shows the data on the average number of seeds per pod of bush sitao. Consistently, plants applied with15% BSS produced the highest number of seeds per pod with an average of 13.59 statistically higher by 51.51% or 4.62 seeds from plants with 0% BSS with average of 8.97 seeds per pod only (αlpha = 0.01).

This result aligns with the studies of the group of Oñal in 2024, on the mung bean crop, where the highest number of seeds per pod was observed in plants treated with 15% BSS, averaging 17 seeds per pod.

Weight of 100 Seeds

The weight of 100-seed is also a good indicator for yield determination. Hence, the average weight of 100-seed of bush sitao is also shown in Table 4. Plants with 15% BSS had the heaviest weight of 100-seed of 16.50 gm significantly higher by 42.29% or 4.50 gm for those plants with 0% BSS with an average of 11.35 gm only (alpha = 0.01).

The findings indicate that increasing concentrations of BSS can significantly enhance the weight of (100) seeds of bush sitao. It can also be deduced that bush sitao plants applied with BSS have heavier 100-seed as compared to plants with 0% BSS.

Yield

The data on the total yield of bush sitao applied with different levels of concentration of BSS at harvest is also shown in Table 4. The yield data indicates that plants with 15% BSS have the highest yield of 1,440 kg/ha statistically higher by 48.05% or 370 kg/ha with those bush sitao plants with 0% BSS applied with an average yield of 770 kg/ha only (αlpha = 0.01).

The results suggest that the application of higher concentrations of BSS at 15% is highly effective in boosting the total yield of bush sitao.

A meta-analysis of bio-stimulants' effects revealed that legumes, e.g. bush sitao, showed substantial yield increases compared to other crops, with soil treatments leading to the most significant improvements (Rouphael & Colla, 2020).

In a study of Kocira (2019), conducted over three growing seasons (2014-2016), the field experiment used Terra Sorb Complex bio-stimulant. Results showed that foliar application increased the number of pods, boosting soybean yield by 25% compared to the control.

Relatively, the study of Rymuza (2023) indicates that various factors, including climatic conditions, cultivar selection, and bio-stimulant application, affected soybean seed yields. Notably, the use of bio-stimulants significantly increased the 1000-seed weight compared to the control.

Sadoyan et al (2023) conducted a study in the Ararat Valley to test the effects of two bio-stimulants. The results showed significant yield improvements across all chickpea varieties.

Table 4. Yield parameters of bush applied with different levels of concentration of BSS at harvest.

Percent Concentration of BSS	Yield Parameters of Bush Sitao				
	Weight of Pods (gm)	Number of Pods per Plant	Number of Seeds per Pod	Weight of 100 seeds (gm)	Bean Yield (kg/ha)
0% BSS	17.80[c]	7.70[c]	8.97[d]	11.35[c]	770[d]
5% BSS	20.25[b]	8.50[c]	10.47[c]	13.25[b]	888[c]
10% BSS	22.35[ab]	10.15[b]	11.46[b]	13.65[b]	980[b]
15% BSS	24.85[a]	11.85[a]	13.59[a]	16.15[a]	1,140[a]
Mean	**21.31**	**9.55**	**11.12**	**13.60**	**945**
Pr (>F)	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
CV (%)	2.69	6.38	2.59	3.13	1.80

Means followed by the same letter are not significantly different from each other,
***=highly significant*

Correlation of Selected Characteristics

The competency of associating between characteristics provides the strength of a linear relationship between two parameters and helps identify the most important characteristic(s) to be considered in determining possible phenomena of the effect of bio-stimulant solution. In this novel study, it is important to obtain information on the relationship between yield and growth performance of bush sitao plants as subjected to different levels of concentration of bio-stimulant solution.

Growth Characteristics Correlated with Plant Height of Bush Sitao

Table 5 shows the characteristics that are correlated with the height of the bush sitao plant. Among the characteristics tested for correlation with the height of bush sitao plants, three characteristics are positively correlated. Among the positive correlations are, the weight of stems & leaves and biomass are strongly correlated with the height of bush sitao, with coefficient *r-values* of 0.89, and 0.90, respectively.

The weight or roots on the other hand have a moderate correlation with coefficient *r-values* of 0.77.

Furthermore, days to flower had a negative (strong) correlations with *r-values* of (-) 0.94, respectively.

Table 5. Growth characteristics of bush sitao plant that significantly correlated with plant height when applied with different levels of concentration of BSS.

Growth Characteristics of Bush Sitao Correlated with Plant Height	Correlation Coefficients *(r)*	P-value	Interpretation
Days to flower	-0.9415	0.0000**	Strong (-) linear correlation
Weight of stems & leaves	0.8990	0.0000**	Strong (+) linear correlation
Weight of Roots	0.7789	0.0004**	Moderate (+) linear correlation
Biomass	0.9037	0.0000**	Strong (+) linear correlation

***= highly significant at a 1% probability,*

Growth Characteristics Correlated with the Yield of Bush Sitao

Table 6 indicates the characteristics that correlate to the yield of bush sitao. Among the characteristics tested for correlation with the yield of bush sitao plants, three characteristics correlate positively. Among the positive correlations are, the number of pods per plant, number of seeds per pod, and total weight of pods are all strongly correlated with the bush sitao yield, with coefficient *r-values* of 0.94, 0.98, and 0.97 respectively.

Table 6. Growth characteristics of bush sitao plant that significantly correlated with the yield when applied with different levels of concentration of BSS.

Growth Characteristics of Bush Sitao Correlated with the Yield	Correlation Coefficients *(r)*	P-value	Interpretation
Number of pods/plant	0.9454	0.0000**	Strong (+) linear correlation
Number of seeds/pod	0.9824	0.0000**	Strong (+) linear correlation
Total weight of pods	0.9793	0.0000**	Strong (+) linear correlation

***= highly significant at a 1% probability*

Conclusion and Recommendation

The use of 15% BSS concentration significantly improves the growth and yield of bush sitao.

Based on the findings, this study recommends the application of 15% BSS concentration in improving the growth and higher yield of bush sitao plant production.

Further study is also suggested to explore the long-term effects and potential benefits of different bio-stimulant formulations and concentrations on bush sitao and other crops.

The use of different varieties, the season of planting, distance and even planting the crop at different elevations plus the bio-stimulant are some of the research gaps are hereby recommended for further study.

This study could be an eco-friendly alternative in lieu of using the synthetic fertilizers

Conflict of Interest

No other group is involved in this study

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Ethical Consideration and Data Privacy

The researchers take responsibility for the securing the sanctity and confidentiality of all the results generated on this study.

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