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Research Article

Maximizing Productivity of Cucumber (*Cucumis sativa* L) Applied with Bio-Stimulant Solution

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ABSTRACT

The study sought to determine the effects of different levels of concentrations of bio-stimulant solution (BSS) in enhancing the growth and maximizing the yield of the cucumber plant. The study was conducted at UNO-R School of Agriculture, Philippines, last January 8, 2024, to March 18, 2024. The study was laid out in (CRD) with four treatments and replicated 4 times. The BSS solution was diluted in the water. It was applied at the base of the vine following the research protocol. Statistical analysis revealed highly significant differences among the treatments in growth and yield parameters such as length of vine and weight of marketable fruits, respectively. Likewise, results showed highly significant differences among treatments on flower initiation, number of leaves, number of fruits, circumference, and diameter of fruits, biomass, and root weight. For the longest vine, greater number of leaves, early flower initiation, great number of fruits, greater length and bigger circumference of fruits, heavier weight of fruits, heavier roots, and biomass accumulation were obtained from plants applied with 400ml BSS, followed by 300ml BSS, and 200ml BSS, respectively. While those who have no BSS had the lowest result in almost all of the parameters mentioned above. Four growth characteristics are strongly correlated with the length of vines, and three for the root weight, respectively. This study recommends the use of 400ml BSS in enhancing the growth and maximizing the yield of cucumber.

Keywords: *Flower initiation, Biomass, Productivity, Foliage, Vines, Marketable fruits, Bio-stimulant*

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Introduction

Cucumber (*Cucumis sativa L.*), is a member of the family Cucurbitaceae. It is regarded as an essential vegetable for fresh consumption crops worldwide. The fruit is a good source of vitamins, minerals, and antioxidants. Cucumber is a low-calorie food and contains 90% water, the reason why it provides superior hydration to humans. Its eminent texture and flavor are the main reasons for its use in salads in fresh form and pickles in processed form.

Its medicinal value is another distinguished property, which includes its antioxidant ability, ability to lower glycemic and antimicrobial activity, etc. Consuming fruits regularly can boost metabolism and improve immunity. Cucumber is said to be a native of India (Yang and Sagar, 2022).

Cucumber has a wide range of advantages for human beings (Lobine et al, 2022). Researchers indicated that cucumbers contain calories, vitamins, and minerals (Shooshtari et al, 2020). Furthermore, the crop has a high water content, approximately 96% (Elavarasan et al, 2022). The high water content can help to lose body weight in several ways, and this is an admirable solution for obese and overweight people, particularly in the developed world (Kim and Cho, 2022).

Jia and Wang (2020) stated that the worldwide area of cucumber cultivation in 2018 was 1.984 million hectares, which produced 75.2 million tons of cucumber. The total production of cucumber was 87,805,086 tons worldwide, and Asia was the largest producer accounting for 84.9% of the world's total production in 2019.

The cucumber is a creeping vine that roots in the ground and grows on support frames; the plant has large leaves that custom shade over the fruit, and the fruit also has a lengthened approximately cylindrical shape (Kumar et al, 2022). Cucumbers have a single taproot (the plant's main root) that can reach up to 120 cm underground, and the rest of the root system extends along the surface and is only approximately 60 cm deep (Sarkar et al, 2022).

Cucumber breeders reported that it has separate male and female flower organs on the same plant (Pandey and Kujur, 2022). Nevertheless, male flowers are eminent due to the lack of a small fruit behind them, and they produce the pollen required to form the fruit but not the fruit itself (Vignati et al, 2022). However, female flowers and male flowers appear to be on a thinner stem, and if there are no male or female flowers on the plant, the cucumber plant will flower but produce no fruits (Behera et al, 2022).

Most vine crops benefit from additional hives to promote pollination, and researchers reported that all vine crops depend on insects to transfer pollen from male to female flowers and that each female flower must be visited 15–20 times for proper pollination to take place (Rahimi et al, 2022).

The group of Drobek (2019) gives an overview of the importance and influence of different natural plant bio-stimulants on both the yield and quality of crops. Natural soil stimulants can induce the development of beneficial soil organisms that provide substrates for plant growth. The use of natural preparations that are not harmful to the environment is particularly important in connection with the progressive processes of soil degradation and atmospheric pollution.

Bio-stimulants are among the natural inputs prepared to improve the general health, vitality, and growth of plants and protect them against infections. They can be successfully used in both agri-and horticultural crops. The main active substances used in such preparations are humic and fulvic acids, protein hydrolysates, compounds containing nitrogen, seaweed extracts, beneficial fungi, and bacteria.

Bio-stimulant formulations may be single- or multi-component, but the synergic action of several different components has been observed. Many groups of bio-stimulants have been distinguished through their method of application (soil, foliar), the material from which they were produced (plant, animal), or the process by which they were created (hydrolysis, fermentation, extraction).

Objective of the Study

This study aimed to determine the effect of applying the different levels of concentration of bio-stimulant solution on the growth and yield of the cucumber plant.

Specifically, it aims to:

1. Determine the effect of applying the different levels of concentration of bio-stimulant solution on the growth of the cucumber plant.
2. Determine if there is a significant increase in the yield of cucumber plants applied with different concentrations of bio-stimulant solution.
3. Determine other characteristics of the cucumber plant that are directly correlated with the length of vines and root weight.

Research Design and Treatments

This study is laid out in Complete Randomize Design (CRD), the use of CRD is the standard design for agricultural experiments where similar experimental units are grouped into blocks. This study applies the different levels of concentrations of Bio-stimulant solution on cucumber plants. It is conducted at the University of Negros Occidental-Recoletos, School of Agriculture, Bacolod City, Philippines.

Treatments

T1- Control (no BSS)
T2- 100ml BSS
T3- 200ml BSS
T4- 300ml BSS

Cultural Management

Area Preparation and Lay-outing

The area was cleared and the layout was done by the research design.

Seed Selection and Planting of Seeds

Eighty (80) viable seeds were selected and were directly sown in the polyethylene bag.

Water Management

Soil moisture was maintained by watering as the need arose.

Weed Management

Cleanliness was done by removing the weeds.

Pests and Diseases Control

Monitoring for the presence of pests and diseases was done during the entire duration of the study.

Harvesting

Harvesting of cucumber fruits was done by priming starting forty-five (45) days after sowing. Fruits were carefully cut from the vines using a pruning knife.

Preparation and Application of Bio-stimulant Solution

a. Preparation of solutions was done at the onset of every application.
b. The required concentrations per treatment were diluted in water.
c. Application of solutions was done 15, 35, and 55 days after sowing the seeds. A plastic measuring cup was used to measure the solution for even distribution.
d. The mixture was applied at the base of the vines.
e. Application was done early in the morning or late in the afternoon.

Data Gathered

1. Length of the Plant Vine
2. Number of Leaves
3. Days of Flower Initiation
4. Circumference of Fruits
5. Length of Fruits
6. Weight of Fruits
7. Number of Fruits
8. Biomass
9. Yield

Statistical Analysis

All data gathered were computed statistically. It was subjected to Analysis of Variance (ANOVA) in CRD using STAR 2.0.1.

The Least Significant Differences (LSDs) were utilized to determine the significant differences among treatments.

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

Results and Discussions

Length of the Vines

The average height of cucumber was taken at 21DAS, 42DAS, 63DAS, and 70DAS as shown in Table 1. The results indicate that the height of cucumber in 21 days after sowing (DAS), 42DAS, 63DAS, and 70DAS is significantly

enhanced by applying the different concentrations of bio-stimulant solution. Furthermore, the result implied that as the concentration of BSS applied increases a corresponding increase in the growth of cucumber vine is also attained.

A relatively, significant result could also be employed that exposing the plant for a longer period, vine length will be tremendously enhanced as well as indicated on the result at 70 DAS period. The growth of cucumber plants with no BSS was almost stagnant as well.

Great significance is observed in the length of vines 21DAS. The cucumber plant applied with 400ml BSS has the longest vine 25.80cm longer by 5.6cm with the control which has an average vine length of 20.20cm only. In descending order, those with 300ml BSS have an average vine length of 23.65cm, followed by 200ml BSS with 22.55cm, and 20.20 only for the control, respectively.

Furthermore, a similar result is shown at 42DAS. The average vine length for those applied with 400ml BSS had further increased its length to 99.68cm comparable to those applied with 300 ml BSS with an average length of 80.5 cm.

A comparable mean is also observed between those applied with 300ml BSS and 200ml BSS with 80.35cm and 75.10cm, respectively. The control, on the other hand, has an average of 55.60cm only, which is the shortest among the four treatments.

The trend continues at 63DAS. The longest vine was shown by the cucumber plant applied with 400ml BSS with an average length of 161.53, way ahead of the control (no BSS) by 63.68cm. The control has the shortest vine length of 97.85cm only. Those applied with 300ml BSS follow with 147.08cm and the 200ml BSS is third with 123.66 ml, among others.

At the last priming of harvesting, which is 70DAS, those with the maximum application of 400ml BSS also maximize the length of cucumber vine at an average of 243.58cm statistically double those of the control with 118.88cm only. On the other hand, those plants applied with 300ml BSS had an average length of 149.08 cm while, the 200ml BSS had an average of 136.75cm, respectively.

Table 1. The average vine length (cm) of cucumber applied with different levels of concentration of Bio-stimulant solution 21DAS, 42DAS, 63DAS, and 70 DAS (last harvest).

Level of Bio-stimulant	Length of Cucumber Vines (cm)			
	21DAS	42DAS	63DAS	70DAS
T1 – Control (no BSS)	20.20^{d}	55.60^{c}	97.85^{d}	118.88^{d}
T2 – 200ml BSS	22.55^{c}	75.10^{bc}	123.66^{c}	136.75^{c}
T3 – 300ml BSS	23.65^{b}	80.35^{ab}	147.08^{b}	149.08^{b}
T4 – 400ml BSS	25.80^{a}	99.68^{a}	161.53^{a}	243.58^{a}
Mean	**23.05**	**77.68**	**132.53**	**162.08**
Pr (>F)	0.0000**	0.0043**	0.0000**	0.0000**
CV (%)	2.03	7.03	3.37	3.43

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

The use of bio-stimulant has significantly increased cucumber growth parameters; such as the plant height, stem diameter, leaf number, leaf area, shoot fresh weight, and roots fresh weight (Abdelgalil et al, 2021).

Number of Leaves

The number of leaves of cucumber was taken at 21DAS, 42DAS, 63DAS, and 70DAS (last priming day of harvesting) is shown in Table 2. The results show that the number of leaves of cucumber 21DAS, 42DAS, 63DAS, and 70DAS are statistically significant among treatments as applied with different levels of concentration of bio-stimulant solution.

It implied further that a higher number of leaves develops *viz-a-viz* with the levels of concentration of BSS solution as well as when

plants are subjected to a longer duration of growth.

As the concentration of BSS applied increases, a significant increase in the number of foliage (leaves) of the cucumber plant is also observed at 21DAS. At 21DAS, the cucumber plant applied with 400ml of BSS a great number of leaves can also be observed.

The concentration produces 7.70 leaves higher than 1.6 leaves with the control (no BSS) which has an average of 6.10 leaves only. A greater number is also observed for those applied with 300ml BSS with an average number of leaves of 7.25, while those with 300ml BSS have an average foliage of 6.45, respectively.

Relatively, the same results are indicated at 42DAS. Comparable statistical result is observed between those cucumber plants applied with 400ml BSS with 28.60 leaves and the 300ml BSS with 25.15 leaves, respectively. Similarly, comparable results could be observed between the 300ml BSS and 200ml BSS with 25.15 leaves (as mentioned) and 22.03 leaves, respectively. The lowest number of leaves is for those with no BSS at 17.80 only.

A tremendous increase of leaves is observed at 63DAS. The average number of leaves, for cucumber applied with 400ml BSS, is 58.65 higher by 17.20 from those plants with no BSS with 41.45 leaves only. On the other hand, those applied with 300ml BSS have an average foliage of 55.55 and 200ml BSS has 41.45 leaves, respectively. As mentioned, cucumber plants with no BSS have the lowest average of 41.45 leaves.

At 70DAS the same trend could be observed although there is a slowdown in the sprouting of leaves. Those plants applied with 400ml BSS still have the highest number of leaves with an average of 66.50 much statistically higher than 21.90 leaves for those plants with no BSS. Those plants applied with 300ml BSS had an average of 60.20 leaves while plants with 200ml BSS had 52.60 leaves only. Those with no BSS had the least leaves that sprouted with an average of 44.60.

Table 2. The average number of leaves of cucumber applied with different levels of concentration of Bio-stimulant solution 21DAS, 42DAS, 63DAS, and 70 DAS (last harvest).

Level of Bio-stimulant	Number of Cucumber Leaves			
	21DAS	42DAS	63DAS	70DAS
T1 – Control (no BSS)	6.10^{d}	17.80^{c}	41.45^{d}	44.60^{d}
T2 – 200ml BSS	6.45^{c}	22.03^{bc}	51.25^{c}	52.68^{c}
T3 – 300ml BSS	7.25^{b}	25.15^{ab}	55.55^{b}	60.20^{b}
T4 – 400ml BSS	7.70^{a}	28.60^{a}	58.65^{a}	66.50^{a}
Mean	**6.88**	**23.40**	**51.72**	**56.00**
Pr (>F)	0.0000**	0.0032**	0.0000**	0.0000**
CV (%)	2.59	13.69	2.07	4.22

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

The use of bio-stimulant significantly increases cucumber growth parameters; such as the plant height, stem diameter, leaves number, leaf area, shoot fresh weight, and roots fresh weight (Abdelgalil et al, 2021).

The group of Radhika (2024) commented in the book which they co-authored that the use of bio-stimulant that increases blooming, crop growth, fruit development, crop productivity, and nutrient usage efficiency is a promising and environmentally beneficial innovation to boost yield and ensure year-round productivity in whatever conditions of weather.

Days to Flower Initiation

Table 3 indicates the period of flower initiation of cucumber plants applied with different levels of concentration of bio-stimulant solution. The results implied that flower initiation of cucumber plants could be shortened by applying a higher concentration of BSS at a maximum of 400ml.

Results show that plants applied with 400ml BSS have shortened the flower initiation of cucumber plants at 26.00 days only way ahead by 6.50 days for those plants with no BSS. The cucumber plant applied with the minimum concentration of 300ml BSS flowered at 28.50 days two days ahead of those applied with the lowest concentration of 200ml BSS that flowered at 30.58. Plants with no BSS flowered longer at an average of 32.50 days.

Table 3. Average days of flower initiation of cucumber plants applied with different levels of concentration of bio-stimulant solution.

Level of Stimulant	Days of Flower Initiation
T1 – control (no BSS)	32.50[a]
T2 – 200ml BSS	30.58[b]
T3 – 300ml BSS	28.50[c]
T4 – 400ml BSS	26.00[d]
Mean	**29.40**
Pr (>F)	0.0000**
CV (%)	2.40

*Means followed by the same letter are not statistically different from its others, **=highly significance*

Cucumber breeders reported that it has separate male and female flower organs on the same plant (Pandey and Kujur, 2022). Nevertheless, male flowers are eminent due to the lack of a small fruit behind them, and they produce the pollen required to form the fruit but not the fruit itself (Vignati et al, 2022). However, female flowers do, and male flowers appear to be on a thinner stem, and if there are no male or female flowers on the plant, the cucumber plant will flower but produce no fruits (Behera et al, 2022).

Most vine crops benefit from additional hives to promote pollination, and researchers reported that all vine crops depend on insects to transfer pollen from male to female flowers and that each female flower must be visited 15–20 times for proper pollination to take place (Rahimi et al, 2022).

The group of Radhika (2024), commented in the book they co-authored that the use of bio-stimulants that increase blooming, crop growth, fruit development, crop productivity, and nutrient usage efficiency is a promising and environmentally beneficial innovation to boost yield and ensure year-round productivity in whatever conditions of weather.

Number, Length, and Circumference of Cucumber Fruits

Table 4 shows the result of the number of fruits, length of fruits, and circumference as influenced by the application of the different levels of concentration of bio-stimulant solution at 70 DAS. Those variables are very important in comparing the performance of applying the different levels of concentration of bio-stimulant solution *viz-a-viz* to the quantity and quality of cucumber plants

The results implied that good quality and higher quantity can be influenced by different concentrations of BSS solution. At 400ml BSS more fruits could be produced that are longer and bigger. Lower concentrations of solution applied or no solutions can lower the number, length, and size of the cucumber fruits.

Number of Fruits

The number of fruits is a key indicator for the yield performance of cucumber when subjected to the different levels of concentration of bio-stimulant solution. Although harvesting was done in three primings, Table 4 indicates the total fruits harvested. The results indicate that those cucumber plants applied with 400ml BSS have produced the greatest number of fruits at 36.00 tremendously higher than 16

fruits for plants with no BSS. Those applied with 300ml BSS followed by 26 fruits were statistically comparable with 300ml BSS with 24 fruits, respectively. Plants with no BSS have the least fruits of 20.

Length of the Fruits

Another important variable for the yield is the length of the fruits. Fruit length further explains the efficacy of subjecting the cucumber to the different levels of concentration of BSS solution. Data for the length of the fruits is shown also in Table 4. Relatively, cucumber plants applied with 400ml BSS have the longest fruits with an average of 24.71cm longer by 4.75 cm for plants with no BSS. On the other hand, plants applied with 300ml BSS have an average length of 22.97cm, and those with 200ml have 21.11 cm, respectively. Plants with no BSS have the shortest length of 19.93 cm only.

Circumference of the Fruits

For the yield, fruit circumference is an important quality that should be taken into consideration too. As indicated in the table plants with 400ml BSS have the largest fruits with an average circumference or girth of 16.50cm bigger by 1.97cm for those with no BSS. Plants applied with 300ml of BSS have an average of 15.52cm. Comparable results are observed for those applied with the lowest concentration of 200ml and no BSS with an average circumference of 14.82cm and 14.53cm, respectively.

Table 4. The number, length (cm), and circumference (cm) of cucumber applied with different levels of concentration of Bio-stimulant solution 70 DAS.

Level of Bio-stimulant	Number of Fruits	Fruit Length (cm)	Fruit Circumference (cm)
T1 – Control (no BSS)	20.00^{c}	19.93^{c}	14.53^{c}
T2 – 200ml BSS	24.00^{bc}	21.11^{c}	14.82^{c}
T3 – 300ml BSS	26.00^{b}	22.97^{b}	15.52^{b}
T4 – 400ml BSS	36.00^{a}	24.71^{a}	16.50^{a}
Mean	**26.50**	**22.18**	**15.59**
Pr (>F)	0.0004**	0.0000**	0.0025**
CV (%)	14.00	3.50	3.89

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

The cucumber is a creeping vine that roots in the ground and grows on support frames; the plant has large leaves that custom shade over the fruit, and the fruit are long and cylindrical (Kumar et al, 2022).

For other crops like snake gourd (*Trichosanthes cucumerina* L.), as studied by the group of Sariya (2023), they found out that application of bio-stimulant of 3ml/liter (seaweed extract) plus 5 tons/hectare of vermicompost had a significant results on some yield parameters. Maximum results on the yield were as follows: number of fruits per vine (20.32), fruit length (39.46 cm), fruit girth or diameter (15.21 cm), weight per fruit (490.26 gm) fruit yield per vine (9.94 kg), and fruit yield per hectare (24.82 tons).

Total Weight and Weight of Marketable Fruit

The total weight of cucumber and the weight of marketable fruits are two of the most important variables that directly affect the income in growing the cucumber plants. The results in Table 5 implied that applying a higher concentration of bio-stimulant solution to cucumber helps improve statistically the average weight of fruits as well as the number of fruits that could be marketed.

Total Weight of Fruits

The total weight of harvested fruits is of great importance with the number of fruits to evaluate the effect of applying the different concentrations of bio-stimulant solution to cucumber plants. Table 5 indicates that plants with 400ml BSS have the heaviest fruits with an

average of 7.04kg much higher by 3.75kg to plants with no BSS.

Plants with 300ml BSS produced 6.23kg while those with the lowest concentration of 200ml BSS produced the third heaviest production of 4.50kg. Those with no BSS on the other hand, produced the least with 3.29kg only

Weight of Marketable Fruit

The weight of marketable fruits is indicated in Table 5 as well. Statistically comparable is observed between those applied with 400ml BSS and 300ml BSS with 2.62kg and 2.45kg, respectively. The same results are observed between those applied with 200ml BSS and no BSS with 2.25kg and 1.40kg, respectively.

Table 5. The total weight of the harvested and marketable weight of cucumber applied with different levels of concentration of Bio-stimulant solution 70 DAS.

Level of Bio-stimulant	Total Weight of Harvested Fruits (kg)	Weight of Marketable Fruits (kg)
T1 – Control (no BSS)	3.29^{d}	1.40^{c}
T2 – 200ml BSS	4.50^{c}	2.25^{c}
T3 – 300ml BSS	6.23^{b}	2.45^{ab}
T4 – 400ml BSS	7.04^{a}	2.62^{a}
Mean	**5.26**	**2.18**
Pr (>F)	0.0004**	0.0000**
CV (%)	9.69	8.24

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

Lugowska, (2019), observes in her study that responses with bio-stimulant, fruit protein content of cucumber, and yield significantly increase relative to the control.

The yield is usually determined as the amount of fruit obtained from one plant or plot. The yield depends on the type of bio-stimulant used, the dose, the method of application, and the plant variety. Increased yield is often associated with improving the quality of vegetables or fruit. This is particularly important in organic farming, where artificial fertilizers cannot be used (Mallic et al, 2022)

Bio-stimulants' many advantageous characteristics are increased yields, improved plant development, better fruit quality, and defense against diseases, increased antioxidants, quick germination, and improved photosynthetic capacity. (Rodrigues et al, 2020)

The European Bio-stimulant Industry Council (EBIC) (2023) defines bio-stimulants as "products containing substances, and when applied to plants or the rhizosphere, microorganisms encourage natural processes that improve/benefit nutrient uptake, nutrient efficiency, abiotic stress tolerance, and crop quality. Bio-stimulants can be treated as an additive to fertilizers and support the uptake of nutrients, promote plant growth, and increase tolerance to abiotic stress. The popularity of bio-stimulants in agriculture is associated with the possibility of obtaining higher yields without the need to discontinue the production of ecological crops.

The group of Radhika (2024) commented in the book which they co-authored that the use of bio-stimulants increases blooming, crop growth, fruit development, crop productivity, and nutrient usage efficiency is a promising and environmentally beneficial innovation to boost yield and ensures year-round productivity in whatever conditions of weather.

For other crops like snake gourd (*Trichosanthes cucumerina* L.), as studied by the group of Sariya (2023), they found out that application of bio-stimulant of 3ml/liter (seaweed extract) plus 5 tons/hectare of vermicompost had a significant results on some yield parameters. Maximum results on the yield were as follows: number of fruits per vine (20.32), fruit length (39.46 cm), fruit girth or diameter (15.21 cm), weight per fruit (490.26 gm) fruit yield per vine (9.94 kg), and fruit yield per hectare (24.82 tons).

Root Weight and Biomass

The average weight of roots produced underground by cucumber plants as well as the accumulated biomass are indicators of good growth when applied with the different levels of concentration of bio-stimulant solution. The result implied in Table 6 that the higher the concentration of bio-stimulant solution of 400ml the higher the root volume it produced and the accumulation of biomass of cucumber plant.

Root Weight

The volume or weight of roots produced is indicated in Table 6. Cucumber plants applied with a maximum concentration of 400ml BSS statistically produced the heaviest roots with 7.04kg almost seven times heavier than plants with no BSS, which produced 0.07kg only. Plants with 300ml BSS produce 0.68kg while plants with 200ml BSS produce an average of 0.13kg, respectively. Cucumber plants with no BSS produced the least volume of roots with 0.07kg only.

Biomass

Biomass is the total volume of dry matter produced by any plant. Table 6 further indicates the biomass accumulated by the cucumber plants as applied with the different levels of concentration of bio-stimulant solution. The highest accumulated biomass of 2,149.00kg, is produced by plants applied with 400ml BSS almost double with those with no BSS with a difference of 1,049.50kg.

Biomass accumulated by plants with 300ml BSS is 1,815.25kg and the 200ml BSS has produced 1,490.75kg, respectively. As mentioned those with no BSS have accumulated the least biomass with 1,099.50kg.

Table 6. The total weight of roots (kg) and biomass accumulated (kg) of cucumber applied with different levels of concentration of Bio-stimulant solution 70 DAS.

Level of Bio-stimulant	Root Weight (kg)	Biomass (kg)
T1 – Control (no BSS)	0.07[d]	1,099.50[d]
T2 – 200ml BSS	0.13[c]	1.490.75[c]
T3 – 300ml BSS	0.68[b]	1,815.25[b]
T4 – 400ml BSS	7.04[a]	2,146.00[a]
Mean	**1.98**	**1,638.63**
Pr (>F)	0.0004**	0.0000**
CV (%)	6.58	7.39

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

The use of bio-stimulant significantly increases the cucumber growth parameters; such as the plant height, stem diameter, leaves number, leaf area, shoot fresh weight, and roots fresh weight (Abdelgalil et al, 2021).

Common forms in which bio-stimulants occur are ready-to-use extracts or powder to make an aqueous solution. Soil bio-stimulants often affect the structure of the root, increasing, among other factors, its ability to absorb nutrients. Foliar extracts protect the plant against biotic and abiotic stresses. The circadian rhythm of plants should be taken into consideration. Bio-stimulants should be applied in the morning when the stomata are open and the assimilation rate is at its peak.

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 cucumber plants as subjected to different levels of concentration of bio-stimulant solution.

Characteristics Correlated with the Length of Vines of Cucumber

Table 7 shows the characteristics that are correlated with the length of the vines of the cucumber plant. Among the characteristics tested for correlation with the length of cucumber plants, eight characteristics are positively correlated. Among the positive correlations are, the number of fruits, length of fruits, weight of fruits, and biomass are strongly correlated with the length of vines, with coefficient *r-values* of 0.83, 0.84, 0.80, and 0.82, respectively.

Moderately correlated characteristics are the number of leaves, circumference of fruits, and weight of marketable fruits with coefficient *r-values* of 0.82, 0.78, and 0.67, respectively.

On the other hand, days to flower have a negative (strong) correlation with *r-values* of (-) 0.88.

Table 7. Characteristics of cucumber plants that significantly correlated with the length of vines applied with different levels of concentration of bio-stimulant solution.

Characteristics Correlated with Length of Vines	Correlation Coefficient *(r)*	P-value	Interpretation
Number of leaves	0.8228	0.0001**	Moderate (+) linear correlation
Days to flower	-0.8838	0.0000**	Strong (-) linear correlation
Number of fruits	0.8369	0.0001**	Strong (+) linear correlation
Length of fruits	0.8412	0.0000**	Strong (+) linear correlation
Weight of fruits	0.8000	0.0002**	Strong (+) linear correlation
Circumference of fruits	0.7851	0.0003**	Moderate (+) linear correlation
Weight of marketable fruits	0.6709	0.0044**	Moderate (+) linear correlation
Biomass	0.8277	0.0001**	Strong (+) linear correlation

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

Characteristics Correlated with the Root Weight of Cucumber

Table 8 indicates the characteristics that are correlated with the root weight of cucumber. Among the characteristics tested for correlation with the root weight of cucumber plants, seven characteristics are positively correlated. Among the positive correlations are, the length of fruits, the weight of fruits, and biomass are all strongly correlated with the weight of roots, with a coefficient *r-values* of 0.91, 0.93, and 0.91, respectively.

Moderately correlated characteristics are the number of leaves, number of fruits, circumference of fruits, and weight of marketable fruits with coefficient *r-values* of 0.78, 0.79, and 0.76, respectively.

On the other hand, days to flower have a negative (strong) correlation with *r-values* of (-) 0.92.

Table 8. Characteristics of cucumber plants that significantly correlated with the weight of roots applied with different levels of concentration of bio-stimulant solution.

Characteristics Correlated with the Weight of Roots	Correlation Coefficient *(r)*	P-value	Interpretation
Number of leaves	0.9129	0.0000**	Moderate (+) linear correlation
Days to flower	-0.9263	0.0000**	Strong (-) linear correlation
Number of fruits	0.7852	0.0003**	Moderate (+) linear correlation
Length of fruits	0.9132	0.0000**	Strong (+) linear correlation
Weight of fruits	0.9381	0.0000**	Strong (+) linear correlation
Circumference of fruits	0.7922	0.0003**	Moderate (+) linear correlation
Weight of Marketable fruits	0.7682	0.0005**	Moderate (+) linear correlation
Biomass	0.9159	0.0000**	Strong (+) linear correlation

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

Conclusion and Recommendations

The different concentrations of bio-stimulant resulted in enhancing the growth and maximizing the yield of cucumber. The use of 400ml bio-stimulant solution has a highly significant influence on the length of vines, number of leaves, shortening of the initiation of flowers, number of fruits, length of fruits, size of fruits, weight of fruits, yield in terms of marketable fruits, weight of roots, and biomass accumulation of the cucumber plants

Based on the findings, this study recommends the use of a 400ml bio-stimulant solution to enhance the growth and maximize the yield of the cucumber.

For correlated traits with the length of vines, four characteristics are in strong positive linear correlation. Making it true that the number of fruits, length of fruits, weight of fruits, and biomass are directly correlated with the length of vines.

For correlated traits with the weight of roots, three characteristics are in strong positive linear correlation. Making it true that the length of fruits, weight of fruits, and biomass are directly correlated with the weight of roots.

The researchers suggest further study of the effects of different levels of concentration of bio-stimulant solution on the different variables in cucumber production, e.g. at different elevations, locations, seasons, and types of trellis, among others.

Conflict of Interest

No other group is involved in this study

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