INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY: APPLIED BUSINESS AND EDUCATION RESEARCH
2024, Vol. 5, No. 6, 2244 – 2257
http://dx.doi.org/10.11594/ijmaber.05.06.26

Research Article

Influence of Bio-Stimulant to Rooting and Biomass of Sugarcane Setts at Pre-Tillering Stage

Paulino A. Oñal, Jr.*, Jeff Gregorr A. Garcia, Amie E. de la Cruz, Jewel V. Pitallar

School of Agriculture, University of Negros Occidental-Recoletos, 6100 Bacolod City, Philippines

Article history:
Submission June 2024
Revised June 2024
Accepted June 2024

**Corresponding author:*
E-mail:
docpaulonal011260@gmail.com

ABSTRACT

Sugarcane is an important crop in the Philippines planted throughout the country but is most abundant in the Visayas and particularly on Negros Island. This study aims to determine the effect of the application of different concentrations of bio-stimulant on enhancing root and biomass accumulations at the pre-tillering stage of the sugarcane plant. The study was conducted at the University of Negros Occidental – Recoletos School of Agriculture, Philippines last December 6, 2023, to February 6, 2024. One hundred pieces of two-eyed cane points of RC-88 were used as planting materials. Soaking the cane points in water was done for 24 hours. Thereafter they were removed from water and air-dried for 30 minutes. The bio-stimulant was prepared before the application based on the study protocol. The bio-stimulant was diluted in distilled water and applied at the base of the plant using a measuring cup for even distribution. Regular monitoring for the presence of pests/diseases was done including watering. There were five (5) treatments, replicated four (4) times using Complete Randomized Design (CRD). Statistical analysis revealed that most of the characteristics of sugarcane plants significantly correlated with roots and biomass accumulation when applied with different levels of concentrations of bio-stimulant concentration at the pre-tillering stage of sugarcane. The use of 500ml Bio-stimulant significantly influenced the germination, tiller height, weight of tillers, weight of roots, length of roots, and biomass. This study recommends the use of 500ml bio-stimulant in enhancing the rooting and biomass accumulation of sugarcane setts at pre-tillering stage.

***Keywords**: Beneficial microorganism, Biomass, Bio-stimulant, Pre-tillering, Sugarcane rooting, Tropism*

Introduction

The giant tropical grass known as sugarcane (*Saccharum officinarum*), which belongs to the Graminaceae family, is unique in that its stalk can hold sucrose, a sugar that crystallizes. It is primarily utilized in the industrial

How to cite:
Oñal, Jr., P. A., Garcia, J. G. A., de la Cruz, A. E. & Pitallar, J. V. (2024). Influence of Bio-Stimulant to Rooting and Biomass of Sugarcane Setts at Pre-Tillering Stage. *International Journal of Multidisciplinary: Applied Business and Education Research. 5*(6), 2244 – 2257. doi: 10.11594/ijmaber.05.06.26

processing of stalks to produce rum. But the amazing plant mass it yields is also rich in molecules for the chemicals sector and can be turned into energy in the form of charcoal, biofuel, or combustible material. It comprises three sugar-bearing species (Cirad, 2023). The sugarcane root system generally comprises highly branched superficial roots, downward-oriented buttress roots, and deeply penetrating agglomerations of vertical roots known as rope roots (Madha et al, 2017).

Sugarcane originated in Papua New Guinea. A tuft of five to twenty upright stems, or "tillers," that is two to five meters tall and two to four centimeters in diameter is known as a sugarcane plant. Every stem consists of several internodes and nodes, with a band of root primordia and a bud at each node. Underneath the tough, waxy bark is the pith, which contains the sugar. Every five to ten years, cane fields are replanted using cuttings that are a few nodes long from the stems. The stems are also incredibly rich in cellulose and lignin, which are widely used as fuels, energy sources, materials, and other resources in the green chemicals field (Cirad, 2023).

The main parts of the sugarcane plant are the stalk, leaf, and root system. The stalk consists of segments called joints. Each joint is made up of a node and an internode. The node is where the leaf attaches to the stalk and where the buds and root primordia are found. The leaf of the sugarcane plant is divided into two parts: sheath and blade, separated by a blade joint. The mature sugarcane plant has an average total upper leaf surface of about 0.5 square meters, and the number of green leaves per stalk is around ten, depending on variety and growing conditions. The function of the root system is twofold: first, it enables the intake of water and nutrients from the soil; and second, it serves to anchor the plant. The root cap protects the tender tissues of the growing point as the root pushes through the soil. (Sandhu et al 2019).

In the Philippines, the amount of sugarcane production is at 5 in the crops (PSA, 2018). Therefore, sugarcane is one of the major crops for the Philippine agriculture sector. Moreover, the agriculture sector has a share of 24.3% of the country's total employment (PSA, 2019). The Philippine's sugarcane production from April to June 2023 was registered at 2.83 million metric tons, indicating a decrease of -11.3 percent from the 3.19 million metric tons output in the same quarter of 2022 (PSA, 2023). In addition, the Philippines Sugarcane Industry contributes no less than P70 Billion to our economy annually. Out of the total land area of about 30 million hectares, sugarcane is planted to about 422,500 hectares in the Philippines, with about 62,000 farmers. There are 29 operating raw mills with a combined crushing capacity of 185,000 metric tons of cane per day (SRA,2024).

Sugarcane is grown in seventeen (17) provinces in the country, distributed in eight regions from northern Luzon (Isabela, Cagayan) to Mindanao (Bukidnon, Cotabato, Davao). The largest producer is Western Visayas, contributing 1.44 million metric tons or 55% share of the total sugarcane production. Northern Mindanao and Central Visayas followed with shares of 14.9% and 13.4%, respectively. The main players in the sugar industry are the big landlords, millers, distillers, and refineries (Milling, 2019)

In 2022/2023, approximately 177.3 million metric tons of sugarcane were produced in total worldwide. Brazil was the leading sugar cane producer worldwide. In that year, the nation yielded approximately 715.66 million metric tons of sugar cane, accounting for more than 38 percent of the global sugar cane production (Statista, 2023).

Victorias Milling in Negros Occidental is the largest producer of sugar in the country and one of the largest sugar millers and refineries in Asia. It supplies about 30% of the county's daily need for refined sugar (Victoria Milling, 2019).

In terms of sugar yield, the Philippines has a lower sugar yield at 5.1 tons sugar/ha compared to other major producing countries such as Columbia with 2.38 times more sugar/ha; Australia with 2.15 times; Brazil with 1.88 times; Guatemala with 1.74 times; and Thailand, with 22% more. Like any other agricultural commodity, low productivity is one key issue that beset the sugar industry. Comparing the Philippines with other Southeast Asian countries such as Thailand (sugarcane production is 100 tons of cane per hectare), the country has low productivity which is estimated at 60 tons of cane per hectare.

This could be attributed to production issues such as a variety of planting materials, soil fertility, and irrigation. Also, the effects of climate change such as higher temperatures and drier conditions (WWF, 2019) contributed to low yield. These concerns can be addressed through improvements in the varieties of planting materials, the establishment of nurseries, improved fertilizer use and efficiency, and improved irrigation systems (Tobias, 2019).

The productivity of sugarcane is intricately linked to its root development and biomass accumulation, making these two aspects crucial factors for achieving high yields. However, the challenges posed by climate change, soil degradation, and the need for sustainable agricultural practices have necessitated innovative approaches to enhance sugarcane root growth and biomass production.

Bio-stimulants can be used to supplement and enhance existing agricultural practices and crop inputs. They enhance the uptake of nutrients, develop tolerance to abiotic stresses, and increase the vigor and yield of crops such as wheat, rice, and barley. Bio-stimulants have increasingly been considered valuable advanced farming techniques used in worldwide agricultural production. They enhance crop health, quality, and grower profitability and can effectively contribute to overcoming the challenges posed by the increasing demand for food by the world's population and continuous growth. The cost and time required for the development of new formulations maybe even less than that required for the development of new bio-stimulants (Hazra and Purkait, 2020).

In addition to fertilizer, adding micronutrients plus bio-stimulants along with fertilizer application can increase sugarcane quality and productivity. Bio-stimulants an ingredients that contain substances, plant hormones, and microorganisms that have a positive effect on plant growth and function as a stimulant of nutrient absorption naturally, streamline the use of nutrients, increase tolerance to abiotic and biotic stress, and maximize the productivity and quality of crops (Amana and Moraes et al, 2018).

This study on enhancing the rooting and biomass accumulation of sugarcane plants applied with different levels of concentrations of bio-stimulant aims to contribute to the limited sources of knowledge on the root physiology of the said crops at the pre-tillering stage (2 months).

It also aspires to identify some correlated traits or characteristics that could be a tool in selecting cane points as planting materials for propagation and establishment of a nursery.

Objectives of the study

The general objective of this study is to determine the effect of different concentrations of Bio-stimulant solution (BSS) on rooting capacity and biomass accumulation of sugarcane sett at the pre-tillering stage (60 days after planting).

Specifically, it aims to

1. Determine the effective levels of concentrations of bio-stimulant solutions that could affect the rooting capacity of sugarcane setts 60 days after planting.
2. Determine the effect of the application of the different levels of concentrations of Bio-stimulant on biomass production of sugarcane setts 60 days after planting.
3. Determine the effect of the applications of different levels of concentrations of Bio-stimulant solutions on the root development and weight of roots 60 days after planting of sugarcane setts.
4. Identify characteristics that could be correlated in enhancing the rooting and biomass accumulation of sugarcane plants applied with different levels of concentrations of bio-stimulant at its pre-tillering stage.

Materials and Methods

Materials

One hundred two-eyed sugarcane setts of VMC 88-354 were used as planting materials.

Research Design and Treatments

Methods

This study investigated some characteristics of sugarcane setts at the pre-tillering stage (60-day growing period), mainly on root enhancement and biomass accumulation applied with the different levels of concentrations of bio-stimulant. There were five (5) treatments and were replicated four (4) times. The study was laid out in a Completely Randomized Design (CRD).

Treatments

T1 - Control (No BSS)
T2 - 200 ml BSS
T3 - 300 ml BSS
T4 - 400 ml BSS
T5 - 500 ml BSS

Cultural Management

Preparations of Planting Area, Materials, and Poly-ethylene Bags

1. The experimental area of 100 square meters was cleaned and leveled off.
2. Around 100 polyethylene bags were filled with soils as planting mediums.
3. After filling up with soil, the bags were laid out per the treatment design.
4. Soil samples were taken from each P-bag for analysis before the actual planting of the cane points.

Soil Sampling Procedure

1. A handful of soil was gathered in every P-bag.
2. Soil samples were mixed using the hands and air-dried for 3 days.
3. One (1) kilo of soil sample per treatment was placed in a plastic bag and was properly labeled.
4. Samples were brought to the soil laboratory for analysis.

Soaking and Planting of Cane Setts

1. Around 100 pieces of 2–eyed VMC88-354 cane setts were utilized as planting materials.
2. The cane setts were soaked in water for 24 hours.
3. Soaked cane setts had undergone air-drying for at least 30 minutes before planting.
4. One cane sett was planted per P-bag.

Watering and Maintenance

1. Sugarcane requires consistent moisture, especially during its initial growth stages. The plants were regularly watered to keep the soil moist
2. The plants were monitored regularly and ensured that water penetrated the soil, to encourage the development of roots.
3. Holes at the bottom of the bags were made to drain out excess water.

Monitoring of the Presence of Pests or Diseases

Regular monitoring for the presence of pests or diseases was done throughout the study

Weeding

Hand weeding was regularly done.

Preparation and Application of Bio-stimulant

1. Preparation of solution was done separately per treatment before application.
2. Application of solution was done using a measuring cup and placed at the base of each growing setts.
3. Succeeding application of bio-stimulant solution was done at 15 and 45 days after planting.

Research Environment

The experiment was conducted at the UNO-R School of Agriculture Field, Bacolod City, Philippines last December 6, 2023, to January 6, 2024.

Data Gathered

1. Period of Germination.
2. Height of tillers.
3. Number of tillers.
4. Weight of tillers.
5. Weight of roots.
6. Length of roots.
7. Biomass.

Statistical Analysis

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

The Least Significant Differences (LSDs) were used 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

Period of Germinations

Table 1 indicates the germination period of sugar cane setts applied with different levels of concentrations of bio-stimulant. The results indicates that application of different level of bio-stimulant can significantly affect the germination period of sugarcane setts.

The results showed that there is a very high significant difference among treatments. 500ml BSS had the shortest days of germination at 4.50 only while control had the longest germination period at 6.93 days.

Relatively, 400ml BSS had germinated at 5.23 days, followed by 300ml BSS at 5.60 days, 200ml of BSS at 6.15 days, and control at 6.93 days, respectively.

Table 1. Period of germination (day) of sugarcane setts.

Level of Bio-stimulant	Mean
T1-Control (no BSS)	6.93^{a}
T2-200 ml BSS	6.15^{b}
T3-300 ml BSS	5.60^{c}
T4-400 ml BSS	5.23^{d}
T5-500 ml BSS	4.50^{e}
Mean	**5.68**
Pr (>f)	0.0000**
CV (%)	3.23

*Means with the same letters are not significantly different from each other, **=highly significant.*

Bio-stimulants can enhance the growth and performance of crops, increased attention has been seen recently in utilizing them in agricultural and horticultural applications and productions (Drobe et al, 2019). Reports on bio-stimulants have indicated their positive impact on crop performance in terms of significant increases in growth and metabolic processes, resulting in increased yield, nutrient- and water-use efficiencies, and tolerance to abiotic stresses (Jolayemi et al, 2022).

The germinating buds produce primary tillers, which are the oldest shoots. The secondary tillers grow from the primary and the tertiary from the secondary shoots. At full canopy, when full leaf ground cover is achieved, shading out of the smaller tillers occurs and they start dying.

Cultivar characteristics and as many as 350,000 tillers per hectare have been recorded in South Africa on ratoon NC0376 before full canopy. However, only about 155,000 tillers survive to harvest in NC0376, whereas other cultivars with higher sucrose tend to have a lower stalk population at harvest of 90,000 to 120,000.

Damage to the growing point (e.g. from hail, frost, or chemical ripeners) reduces apical dominance and increases the development of lower-order tillers and side shoots (PGB Sugar and Bio-Energy (Pty) Ltd).

Rapid stalk occurs when daily mean temperatures reach about 18.5 °C and will continue to grow rapidly under warmer conditions at between 1 to 2 cm/day, and then can almost cease when temperatures drop in the cool winter months. Any stress reduces growth rate and this is manifested in a decrease in the distance between successive nodes (reduced internode length). Under conditions of continuous growth, more than 30 nodes may be produced in a year, and stalk length can reach over 3.5 m (PGB Sugar and Bio-Energy (Pty) Ltd).

Tiller Height

The height of sugarcane tillers were taken at 30 and 60 days after planting as shown in Table 2 The results indicate that tiller height taken both in 30DAP and 60DAP were highly significant as applied by different levels of concentration of bio-stimulant.

Thirty (30) days after planting the T5 has the tallest average height of 59.78 cm, much longer by 15.50 cm with T1 which has the shortest tillers at 44.20 cm. T4 has an average height of 56.33 cm, T3 has 51.70 cm, and T2 has 48.18 cm, respectively.

Relatively, the same results are shown at 60DAP, T5 has increased its height to 105.88 cm. Moreover, T4 has an average height of 93.70 cm, followed by T3 at 91.43 cm, T2 at 87.13 cm, and T1 has the shortest height at 72.28 cm, respectively.

Table 2. Tiller height (cm) of sugarcane plants 30DAP and 60DAP.

Level of Bio-stimulant	Tiller Height (cm)	
	30DAP	60DAP
T1-Control (no BSS)	44.20^{e}	72.28^{e}
T2-200 ml BSS	48.13^{d}	87.13^{d}
T3-300 ml BSS	51.70^{c}	91.43^{c}
T4-400 ml BSS	56.33^{b}	93.70^{b}
T5-500 ml BSS	59.17^{a}	105.88^{a}
Mean	**51.91**	**90.08**
Pr (>f)	0.0000**	0.0000**
CV (%)	3.23	1.59

*Means with the same letters are not significantly different from each other, **=highly significant.*

Bio-stimulants application has demonstrated its efficacy in enhancing plant growth, traits, and productivity by improving soil health, structure, and properties (Berg et al. 2020; Colla et al, 2017; Nosheen et al, 2021).

Number of Tillers

The average number of sugarcane tillers as influenced by the application of different levels of concentrations of bio-stimulant at 30 and 60 days after planting (DAP) is shown in Table 3. The results indicates that application of different levels of concentrations of bio-stimulant significantly affect the production of tillers of sugarcane setts.

At 30 DAP the data indicates that there is a high significant differences among treatments. Treatment 5 has the highest number of tillers that sprouted with an average of 2.80 while T1 has the least number with 1.65 tillers. Specifically T4 has second most number of tillers with an average of 2.36 tillers, T3 with 2.08, and T2 has 1.85 tillers, respectively.

For 60 DAP the table shows great significant differences among treatments. T5 has the most number of tillers of 5.90, much higher by 2.77 tilers with that of the T1 with 3.13 tillers only. T4 on the hand is second with 4.68 tillers. Table 3 shows further that there is a comparable result between T3 and T2 with 4.13 tillers.

Table 3. Number of tillers of sugarcane plants 30DAP and 60DAP.

Level of Bio-stimulant	Number of Tillers	
	30DAP	60DAP
T1-Control (no BSS)	1.65^{e}	3.13^{d}
T2-200 ml BSS	1.85^{d}	4.13^{c}
T3-300 ml BSS	2.08^{c}	4.13^{c}
T4-400 ml BSS	2.36^{b}	5.68^{b}
T5-500 ml BSS	2.80^{a}	5.90^{a}
Mean	**2.15**	**4.59**
Pr (>f)	0.0000**	0.0000**
CV (%)	8.62	0.00

*Means with the same letters are not significantly different from each other, **=highly significant.*

The application of sucrosin to sugarcane cuttings significantly increased the early growth of sugarcane indicated by an increase in shoot height, shoot and tillers number, and the number of leaf chlorophyll. The variable value of sucrosin treatment was highly correlated with the control indicated by the highest correlation value in the leaf chlorophyll number (0.996) and the lowest in the shoot height increase (0.991).

This is because the growth hormone content in sucrosin plays a role in accelerating the emergence of shoots and increasing the initial growth of sugarcane as a result of vital processes and internal structures that affect plant growth through increasing tolerance to abiotic stress and improving the quality of seeds. The application of sucrosin to sugarcane can stimulate plant metabolic process thereby increasing the biomass and sugarcane content. (Kumalawati et al, 2021).

Weight of Tillers, Weight and Length of Roots

Table 4 show three variables taken which include the weight of tillers, weight of roots and the length of roots as influenced by the application of the different levels of concentrations of bio-stimulant at 60 DAP.

The application of bio-stimulant at different levels of concentration had a high influence on the weight of the tillers as well as on the weight and length of the roots at 60 DAP.

Weight of tillers

In detailed T5 has the heaviest tillers with 48.25 grams much heavier by 22.00 grams from T1 which has the lightest weight with 22.25 grams at 60 DAP. On the other hand, T4 has a total of 39.50 grams. The means of T3 has a comparable result with T2 with 32.40 grams and 28.50 grams, respectively.

Weight of roots

On the weight of roots at 60DAP, still T5 has the heaviest weight with 29.00 grams with a great difference of 23.12 grams as compared to T1, which has the lightest weight of 5.88 grams. Comparable results is shown between T3 and T2 with 9.24 grams and 8.63 grams, respectively.

In modern agriculture, additional techniques to obtain the maximum productivity of sugarcane are being used. Among them is the use of bio-stimulants, regulators of plants, or bio-regulators. They act to activate the metabolism of cells, assist and confer greater vigor to the immune system. It helps to enable physiological processes at different stages of development, stimulate root growth due to the higher rate of cell development and induce the formation of new shoots, resulting in the potentialization of the quality and quantity of production (Moraes et al, 2017).

Length of roots

On the third parameter, which is the length of sugarcane roots at 60 DAP, T5 has the longest roots with 48.73 cm longer by 27.10 cm with T1 which has the shortest average roots of 21.65 cm, respectively. Comparable result is observe on T4 and T3 with average root length of 36.40 cm and 32.18 cm. respectively. T2 on the other hand has the average root length of 27.18 cm.

By understanding the growth and distribution of sugarcane roots, yields can be optimized through improved strategic decisions. Sugarcane is a deep-rooted crop owing to its long growth cycle and longevity of the root system through multiple rotations compared to other crops. The root system reaches a depth of 1.5 meters and even 6 meters (Ball-Codho et al, 2018).

Table 4. Weight of tillers (gm), weight of roots (gm), and length of roots (cm) of sugarcane plants 60 days after planting

Level of Bio-stimulant	Weight of Tillers (gm)	Weight of Roots (gm)	Length of Roots (cm)
T1-Control (no BSS)	22.25^{d}	5.88^{d}	21.65^{d}
T2-200 ml BSS	28.50^{c}	8.63^{cd}	28.18^{c}
T3-300 ml BSS	32.40^{c}	9.25^{c}	32.98^{b}
T4-400 ml BSS	39.50^{b}	16.63^{b}	36.40^{b}
T5-500 ml BSS	48.25^{a}	29.00^{a}	48.73^{a}

Level of Bio-stimulant	Weight of Tillers (gm)	Weight of Roots (gm)	Length of Roots (cm)
Mean	**34.18**	**13.88**	**33.59**
Pr (>f)	0.0000**	0.0000**	0.0000**
CV (%)	9.55	13.82	7.45

*Means with the same letters are not significantly different from each other, **=highly significant.*

Biomass

The accumulated biomass of the sugarcane plant is influenced by the application of different concentrations of bio-stimulants is shown on Table 5. The results shows that application of different concentrations of bio-stimulants significantly affect the biomass accumulation of sugarcane accumulated computed in kilos/hectare

At 60 DAP results indicates that T5 has accumulated the highest volume of biomass with 3,193 kg/ha, much higher by 1,680 kg/ha with that of T1 which has the biomass of 1,513 kg/ha only. T4 has an accumulated biomass of 2,848 kg/ha, T3 2,097 kg/ha, and T2 has 1,891 kg/ha, respectively.

Table 5. Biomass (kg/hectare) of sugarcane plants 60 DAP.

Level of Bio-stimulant	Mean
T1-Control (no BSS)	1.513.00[e]
T2-200 ml BSS	1,891.00[d]
T3-300 ml BSS	2,097.00[c]
T4-400 ml BSS	2,848.00[b]
T5-500 ml BSS	3,193,00[a]
Mean	**2,308.40**
Pr (>f)	0.0000**
CV (%)	1.73

*Means with the same letters are not significantly different from each other, **=highly significant.*

Biomass is taken by weighing the dry weight of organic matter produced. It is the weight of living material contained above and below the unit ground surface area, at a given point in time (Roberts and Bealde, 1985).

By positively stabilizing the cellular redox balance of plants, the action of SWE increases biomass production, resulting in greater energy generation up to 10.5%. Thus, the SWE strategy is a tool for alleviating drought stress while enhancing sugarcane development, stalk yield, and sugar production, and improving plant physiological and enzymatic processes (Jacomassi, 2021).

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 ineffective characterization. In this simple study, it is important to obtain information on the relationship between rooting determinants and accelerating accumulation of biomass of sugarcane plants at its pre-tillering stage

As a backgrounder, the roots of sugarcane could serve as information on the genetic variability among sugarcane plants that can partially explain the acceleration of their formation including the tillers on the above ground. By understanding, the growth and formation of roots and tillers especially the factor that enhances their formation, the challenges in the production of selected planting materials (especially, if the number of materials is limited) for the establishment of a nursery will be well managed by the farm administrators and/or farmers.

Relatively, the roots serve as the primary factor in the survival, development, and performance of any plant including sugarcane. It is because the above-ground parts including the tillers, number of nodes, tiller weight, and numbers among others, depend on it for anchorage and absorption of water and nutrients including the bio-stimulant that was used in this study.

Correlated Characteristics of Sugarcane Plant with Length of Roots

Among the characteristics Among the characteristics tested for correlation with root length 4 are found to be positively correlated while 1 is negative as shown in Table 6. Among the positive correlation, the tiller height, number of tillers, tiller weight, and root weight are strongly correlated with root length, with coefficient with r-value of 0.97, 0.96, 0.95, and 0.94, respectively. On the other hand, days of germination have a negative correlation with r-value of (-) 0.93.

Table 6. Characteristics of sugarcane plants that significantly correlated with root length applied with different level of bio-stimulant.

Parameters	Correlation Coefficient *(r)*	P-value	Interpretation
Root weight	0.9472	0.0000**	Strong (+) linear correlation
Germination	-0.9352	0.0000**	Strong (-) linear correlation
Tiller height	0.9676	0.0000**	Strong (+) linear correlation
Tiller weight	0.9451	0.0000**	Strong (+) linear correlation
No. of tillers	0.9647	0.0000**	Strong (+) linear correlation

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

For further discussion of the data presented in the above-mentioned table (Table 6), the root length can be directly correlated with the above-ground parameters such as tiller height (r-value =0.97), tiller weight (r-value =0.94), and the number of tillers (r-value=0.96), respectively

Correlated Characteristics of Sugarcane Plants with Biomass Accumulation

Among the characteristics tested for correlation with the accumulation of biomass, 5 are found to be positively correlated while 1 is negative as shown in Table 7. Among the positive characteristics, the tiller weight, number of tillers, tiller height, root length, and root weight with r-value of 0.95, 0.95, 0.93, 0.93, and 0.92, respectively. On the other hand, days of germination have a negative correlation with r-value of (-) 0.94.

The data presented in Table 7, indicates that biomass characteristics can be correlated with almost all of the parameters of sugarcane plants as applied with different levels of concentrations of bio-stimulant.

Table 7. Characteristics of sugarcane plants that significantly correlated with the biomass accumulation applied with different level of bio-stimulant.

Parameters	Correlation Coefficient *(r)*	P-value	Interpretation
Root length	0.9311	0.0000**	Strong (+) linear correlation
Root weight	0.9196	0.0000**	Strong (+) linear correlation
Germination	-0.9429	0.0000**	Strong (-) linear correlation
Tiller height	0.9342	0.0000**	Strong (+) linear correlation
Tiller weight	0.9479	0.0000**	Strong (+) linear correlation
No. of tillers	0.9384	0.0000**	Strong (+) linear correlation

***=highly significant at 1% level of probability,* The expansion of sugarcane production areas is limited therefore, the improvement of yield components of sugarcane might be a strategy to enhance cane production. The group of Khonghintaisong (2020) studied to identify the relationship between roots in each tiller and their above-ground parts during the tillering phase. The results showed that there was a positive correlation between the sum of the roots in all tillers per hill and shoot dry weight. Furthermore, they observed that root traits of individual tillers, for almost all cultivars tested, root volume, root surface area, root length, and root numbers were positively correlated with biomass and stalk weight except for one cultivar. They concluded that the root characteristics can potentially be used as criteria to assess shoot performance. Relatively, in contrast, the root-to-shoot ratio may not be an appropriate characteristic to assess shoot growth, and dry weight varied among cultivars that they tested Khonghintaisong (2020).

Conclusions

The different concentrations of bio-stimulant resulted in enhancing the rooting and biomass accumulation of sugarcane plants at their pre-tillering stage. The use of 500ml Bio-stimulant significantly influenced the germination period, tiller height, weight of tillers, weight of roots, length of roots, and biomass. Based on the findings, this study recommends the use of 500ml bio-stimulant in enhancing the rooting and biomass accumulation of sugarcane plants.

For correlated traits, the root length is influenced strongly so many characteristics, the height of the tillers, number of tillers, weight of the roots, and weight of the tillers. Hence, this study recommends that in selecting planting materials for propagation or establishment of the nursery, the above-mentioned characteristics must be given great consideration.

For biomass accumulation, its strong correlated traits must be considered. Hence, the study recommends that the more bio-stimulant concentration applied to sugarcane plants the more accumulation of quantity of biomass produced.

The researchers suggest further study of the effects of different concentrations of bio-stimulant solution on the different parameters in sugarcane production. The researchers suggest also that they include the different varieties as well as the yield both in tonnage and sugar rendiment (Lkg).

Conflict of Interest

No other group is involved in this study

Acknowledgment

Our deepest gratitude to our fellow faculties, the school administrators, and the students involved in this study.

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