MANUSCRIPT Scientific Services...
www.manuscriptscientific.com

Journal of Agriculture and Forest Meteorology

Original Research Article

On-Farm Evaluation of Auxin-Treated Sugarcane Bud Chip for Enhanced Growth and Yield

Darwin M Cacal[1*], Janet P Pablo[2], Darwin A Basquial[2], Esther Josephine D Sagalla[2] and Leila Mary A Ayban[2]

[*1]*Isabela State University Cabagan Campus, Isabela 3328, The Philippines*

[2]*Benguet State University, La Trinidad Campus, Benguet 2601, The Philippines.*

Corresponding author: Darwin M Cacal, Isabela State University Cabagan Campus, Isabela 3328, The Philippines, E-mail: darwin.m.cacal@gmail.com

Abstract

Sugarcane, crop for sugar and bioethanol. Budchipan ideal technique to reduce cane seed usage while auxin hormone enhanced the productivity. This study determined the performance of sugarcane budchip-treated auxins under on-farm conditions. The experiment utilized a Randomized Complete Block Design with eleven treatment combinations: where T1- Non-budchip (farmers practice), T2- Budchip, no auxin applied, T3- 10 min soaking at 150 ppm, T4- 10 min soaking at 200 ppm, T5- 10 min soaking at 250 ppm, T6- 20 min soaking at 150 ppm, T7- 20 min soaking at 200 ppm, T8- 20 min soaking at 250 ppm, T9- 30 min soaking at 150 ppm, T10- 30 min soaking at 200 ppm and T11- 30 min soaking at 250 ppm. Analysis of variance (ANOVA) assessed the productivity of sugarcane budchip-treated with auxins in field conditions. Differences among treatment means were determined using the Duncan's Multiple Range Test (DMRT) test. The study employed hypothesis testing with P-values, presenting results as mean ± standard deviation (SD). The treatment 4 (10 min soaking at 200 ppm), T7 (20 min soaking at 200 ppm), and T10 (30 min soaking at 200 ppm) highly significant on plant height, number and length of nodes, tillers production, biomass yield, amount of juice extract, bagasse yield, and computed yield per hectare. T10 had highest return on investment (ROI) of 223.09 ± 38.90 %, significant to other treatments, however not significant difference to stalk diameter and sucrose/sugar content. Furthermore, during lodging caused by varying wind speeds, sugarcane budchips showed middle lodging at wind speeds of 89 to 117 km/h, while high lodging observed at wind speeds of 118 to 184 km/h. The control treatment remained erect across all levels of strong winds. Auxin-treated sugarcane budchip significantly improves sugarcane growth, yield, and economic viability.

Keywords: Sugarcane, Budchip, Auxin, Internodes, Bagasse yield

INTRODUCTION

The cultivation of sugarcane (*Saccharum officinarum*) is essential for the global sugar industry and plays a significant role in providing economic stability for farmers. In the data posted by Philippine Statistics Authority on July - September 2022, Cagayan Valley is 2nd top producer of sugarcane with a total share of 6.2% [1]. Sugarcane is planted by cutting of cane stalk known as setts. Setts is largely conventional, involving the use of sugarcane stems with 2-3 buds measuring 25-30 centimeters (cm).

According to Jain [2] that the conventional practice involves using setts/seed cane at a rate of 6-8 tons per hectare which comprises 32,000 stalks of planting material or constituting approximately 10% of the total production. The conventional technique presents challenges in terms of logistics during transportation, handling, and storage of seed cane. Loganandhan (2013) explained that the huge mass of planting material required poses difficulties and makes it susceptible to rapid deterioration, negatively impacting the viability of buds and subsequently hindering their sprouting. In addition, the tissue culture technique, once considered an alternative, is now losing in popularity due to its complexity and physical limitations, as reported by Nayak and Yadav [3]. Farmers are hesitant to adopt this method, preferring to choose their own planting materials, namely sugarcane cuttings. This preference is rooted in doubt regarding the practicality and suitability of tissue culture, further influencing farmers to stick with traditional practices.

In the pursuit of optimizing sugarcane production, directing attention towards the bud chip technique is proposed as the most favorable alternative for diminishing the quantity of seed cane and associated costs, ultimately augmenting net returns [4]. A bud chip comprises a small tissue portion with a root primordium, capable of sprouting into a viable sugarcane plant. This method, as indicated by Iqbal [5], is suitable for commercial planting and demonstrates commendable performance under favorable growing

Received: *January 07, 2025;* ***Revised:*** *January 27, 2025;* ***Accepted:*** *January 30, 2025*

Citation: Cacal DM, Pablo JP, Basquial DA, Sagalla EJD & Ayban LMA. (2025) On-Farm Evaluation of Auxin-Treated Sugarcane Bud Chip for Enhanced Growth and Yield. J Agric For Meterol Stud, 4(1): 1-15.

conditions. The bud chip technique offers economic advantages, featuring less bulky seeds that are easily transportable compared to conventional planting methods. Notably, a mere 300 kgs of bud chips suffice for planting one hectare, resulting in approximately 80% savings in terms of sugarcane weight [5].

On the other hand, the survival rate of matured sugarcane cuttings in conventional planting is notably lower, ranging around 35-40% [6], largely due to soil-borne diseases, susceptibility of the bud to drying, temperature fluctuations, and poor soil conditions, further reducing their survival rate. To mitigate the mortality of cuttings, one viable approach is the application of hormones such as auxin. The auxin such as NAA (Naphthaleneacetic Acid) has been identified as particularly effective in promoting adventitious root formation [7], thereby expediting the process of rooting in stem cuttings. Auxin exerts a significant influence on root development, thereby enhancing the rooting percentage of cuttings. The pre-sowing seed treatment of bud chips with growth regulators has demonstrated a substantial enhancement in seedling germination and vigor [8]. Bud chips treated with plant hormones exhibit an elevated concentration of reducing sugars, leading to improved water and nutrient use efficiency, along with enhanced resistance against pests [9].

In conclusion, with the increasing global demand for products derived from sugarcane, there is an urgent need to improve the productivity of sugarcane crops. One of the efforts is by using a bud chip technique (single eye segment) growing in nursery [10] or greenhouse condition applied with auxin to enhance the root and shoot development and also the growth and yield in the field experiment.

Despite the lengthy production time required for sugarcane, typically taking 10-12 months before harvest, integrating plant hormones into sugarcane management offers substantial benefits for farmers, researchers, and other stakeholders. It also contributes valuable insights to the field of sugarcane cultivation by thoroughly investigating the effects of naphthalene acetic acid (NAA) on sugarcane. The potential implications extend beyond local agriculture, encompassing global considerations related to the economy and sustainability.

MATERIALS AND METHODS

a. Materials needed in the study

The necessary materials for study encompass a range of items. Inorganic fertilizers, such as 16-20-0 and 46-0-0, along with straw lace, plastic sheets, tire wire, black polyethylene pots, meter sticks, and plastic nets, was procured from the Cabagan market. Bamboo pole pegs and wood for labeling purposes was sourced from the Farm Laboratory. Various tools, including a sieve, hole digger, shovel, rake, wheelbarrow, bolo, moisture meter, pail, hose, plastic container drum, beaker, cylinder, measuring cup, sprayer, and weighing scale, was borrowed from the Organic Laboratory of Isabela State University (ISU), Cabagan Campus. The sugarcane chipper was fabricated at the fabrication shop located in the City of Ilagan, Isabela. Naphthaleneacetic acid (NAA) was obtained from authorized seller. The variety of sugarcane is PHIL 2006-1899, an erect to recumbent and moderate grower with a yield potential of 148.29 tc/ha, this was resistant to smut, leaf scorch and downy mildew, it planting material is aged between 8 to 10 months, stalk was collected at ISU Cabagan.

b. Collection of Soil and Preparation of Bud chip

The soil was gathered from the sugarcane field using a wheelbarrow. Upon collection, it was strained through a sieve to remove large particles such as stubbles and hard soils. Sugarcane cuttings was gathered from the production site of Isabela State University (ISU), Cabagan, with a careful selection process focusing on obtaining healthy and disease-free cuttings. The part of the active bud was scooped using the fabricated manual sugarcane bud chipper. It was transplanted into 4" x 4" x 6" polyethylene bags the experiment was conducted in the Sugarcane Nursery Greenhouse of Isabela State University, Cabagan Campus, Cabagan, Isabela, Philippines. The experiment was conducted in the Sugarcane Production of Isabela State University, Cabagan Campus, Cabagan, Isabela Philippines. The geographical coordinates of the experimental are 17.4144° North latitude and 121.7670° East longitude. The study was carried out during the month of April to November in the year 2024.

c. Application of NAA

Before planting the sugarcane, bud chips were soaked in water with desired amount of auxin to encourage growth. The necessary quantities of these auxin per treatment are detailed in **Table 1**, considering a purity level of 98%. To ensure that the hormones reach 100% purity, a formula is: To prepare the stock solution, was started by thoroughly mixing the wettable powder form of NAA, which has 100% purity, with 10 ml of ethyl alcohol. This step aids in dissolution. Then, was add this mixture to 990 ml of water to achieve a total volume of 1000 ml. This concentration forms the basis for converting parts per million (ppm) to measure solvent concentrations in the solution, with the assumption that 1.0 mg/L of NAA equals 1 ppm. The dilution formula is $C1V1 = C2V2$ where in C1 denotes the concentration of the stock solution, V1 represents the volume of the stock solution required to prepare the new solution while C2 is the final concentration of the stock solution and the V2 is the final volume of the solution.

Table 1. Required amount of Naphthalene Acetic Acid (NAA) per treatment.

Amount of NAA	Number of bud chip per required ppm	Amount of plant hormones at 10 samples per treatment
0 ppm	250 bud chip	0 ppm
150 ppm	250 bud chip	6 ppm
200 ppm	250 bud chip	8 ppm
250 ppm	250 bud chip	10 ppm
300 ppm	250 bud chip	12 ppm

Note: ppm: parts per million

d. Land Preparation, Planting and Fertilization

The study was conducted at ISU Cabagan compound in sugarcane production area. The experimental area will undergo plowing, harrowing, and leveling, employing a riding-type tractor for efficient and thorough cultivation. It is imperative to ensure that the soil is properly pulverized before the planting process begins. Prior to commencing land preparation, a thorough soil sampling was carried out. The determination of fertilizer quantities applied will adhere to the specifications outlined in the soil analysis provided by the Soil Laboratory of the Department of Agriculture. The Auxin-treated bud chip sugarcane was planted in the field with a recommended spacing of 1.2 m between row x 0.5 m between hills.

e. Crop Maintenance and Harvesting

Proper watering scheduling was applied at critical growth phases, such as germination, tillering, and maturation. Hand weeding was done as the weeds grew to eliminate possible competition with nutrients, sunlight, space, and moisture and to minimize the host of insect pests and disease-causing organisms. The study conducted routine monitoring of sugarcane crops to promptly identify insect pests and diseases. The sugarcane was harvested manually by cutting down using bolo.

f. Observation and Collection of Data

The data collected on growth parameters included the Plant height (cm) was measured from the base to the dew lap of the sugarcane using a meter stick at 30 DAT, 60 DAT, and the final height during the harvesting stage. The number of nodes per sample plant was counted, and the internodal length (cm) in the middle portion of the sugarcane was measured using a meter stick. The number of tillers was observed at 30 and 60 and 160 DAT. Stalk diameter was measured using caliper at the middle portion. For biomass yield (g), the matured sugarcane was weighed using a digital scale, Sucrose/sugar content was determined using a handheld refractometer. It was gathered after extraction of the juice of sugarcane stalk and juice extract yield per stalk (ml) was obtained using a sugarcane juice extractor, with the amount measured using a graduated cylinder. Bagasse yield (g) was determined by weighing the freshly generated bagasse or residuals immediately after juice extraction using a digital scale. The computed yield per hectare (tc/ha) was derived by removing the leaves and roots, weighing only the sugarcane stalks, and determining the final yield based on the harvest from each 1-square-meter quadrant subjected to various treatments. The yield per hectare was calculated using the formula: Y = yield per 1 m^2 × 10,000 m^2. Cost and return analysis were conducted to determine the return on investment (%) for each treatment. Lodging score was assessed based on the lodging angle and graded as presented in **Table 2**.

Table 2. Treatments and Design of the Study.

Resistance Grade	Lodging Resistance Index	Lodging Level	Lodging Angle
Grade 1	1.00-1.60	High Lodging	0-30 degrees
Grade 2	1.61-2.30	Middle Lodging	31-60 degrees
Grade 3	2.31-3.00	Erect	> 60 degrees

Source: Li et al. (2012) and Xie [11] and Hao et al. (2008)

Treatments, Design and Data Analysis of the Study

The study was employed a Simple Randomized Complete Block Design across an expanse of 1,020.8 square meters as shown in **Figure 1**. This space was partitioned into three distinct blocks. Each block will encompass three (3) replications, hosting eleven (11) identical plots per replication shown in **Table 3** the treatment and its description, summing up thirty-nine (33) identical plots. Each plot will measure two point two (2.2) meters width by three (5.0) meters length, with two (2.0)-meter spacing between individual treatments and two (2.0) meters between replications. Quantitative data analysis was involved the use of Analysis of Variance (ANOVA). Significant differences

among treatment means was assessed through Duncan's Multiple Range Test (DMRT) at a significance level of 5%.

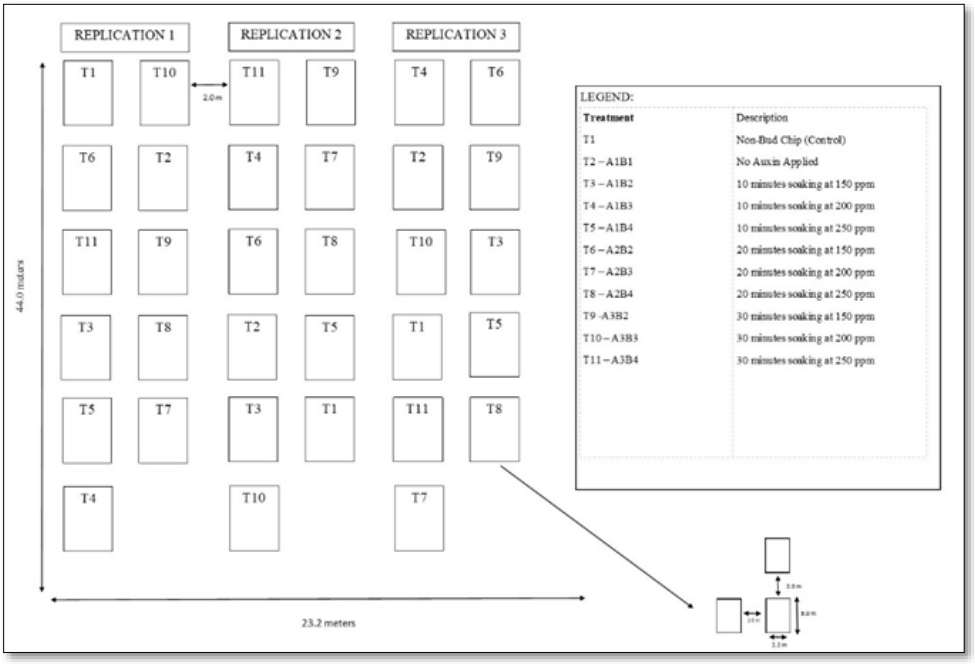

Figure 1. The experimental lay out of the study.

Table 3. Treatments and Design of the Study.

Treatment	Description
T1	Non- Bud Chip (Control)
T2	Budchip, No Auxin Applied
T3	10 min soaking at 150 ppm
T4	10 min soaking at 200 ppm
T5	10 min soaking at 250 ppm
T6	20 min soaking at 150 ppm
T7	20 min soaking at 200 ppm
T8	20 min soaking at 250 ppm
T9	30 min soaking at 150 ppm
T10	30 min soaking at 200 ppm
T11	30 min soaking at 250 ppm

RESULTS AND DISCUSSION

a. Plant height (cm)

The **Table 4** presented the response of sugarcane bud chip seedlings treated with NAA in terms of plant height under field conditions. Base on the result, ANOVA revealed highly significant differences in plant heights at 30 DAT, 60 DAT, and maturity. At 30 DAT, T4 exhibited the tallest plant height (4.35 ± 0.25 cm), which was significantly higher than all other treatments. It was followed closely by treatments T7, T10, T9, T11, T6, T5 and T2 which formed a statistically similar group with heights ranging from 4.08 ± 0.12 cm to 4.20 ± 0.16 cm however, highly significantly difference on T3, T8 and T1 as recorded the shortest height of 3.57 ± 0.17 cm. This early growth stimulation aligns with findings of El-Ghit [12] that NAA enhances cell elongation and division, promoting initial plant development. On the other hand, by 60 DAT, T7 achieved the greatest height with a mean of 36.22 ± 0.57 cm, followed closely by T4 (35.93 ± 0.82 cm). Both treatments significantly outperformed the control (19.03 ± 1.35 cm). This sustained growth suggests that 200 ppm NAA effectively promotes vegetative development over time [13]. Finally, at maturity, T4, T7, and T10 produced the tallest plants, with heights of 162.53 ± 5.06 cm, 162.33 ± 2.05 cm, and 161.29 ± 6.65 cm, respectively. These were significantly taller than the T1

(90.75 ± 8.18 cm). These results suggest that the application of 200 ppm NAA regardless of soaking durations may enhance the growth performance of sugarcane. Similar findings have been reported in previous studies, which indicate that the appropriate concentration and application of NAA can positively influence plant height by promoting cell elongation and division [14].

Table 4. The effect of plant height in sugarcane treated of naphthalene acetic acid (NAA) in budchip at field condition.

Treatment	Plant Height (cm)		
	30 DAT	60 DAT	Maturity
T1	3.57±0.17^{d}	19.03±1.35^{d}	90.75±8.18^{c}
T2	4.08±0.12^{ab}	27.29±3.04^{c}	136.27±19.80^{ab}
T3	3.90±0.37^{bc}	25.56±0.79^{c}	118.30±10.25^{bc}
T4	4.35±0.25^{a}	35.93±0.82^{a}	162.53±5.06^{a}
T5	4.08±0.12^{ab}	29.17±1.01^{bc}	122.67±26.82^{b}
T6	4.13±0.09^{ab}	25.73±0.88^{c}	137.80±15.46^{ab}
T7	4.20±0.16^{ab}	36.22±0.57^{a}	162.33±2.05^{a}
T8	3.77±0.21^{bc}	30.55±4.23^{abc}	142.53±17.82^{ab}
T9	4.17±0.06^{ab}	29.27±4.10^{bc}	118.73±21.58^{bc}
T10	4.20±0.16^{ab}	34.37±0.95^{ab}	161.29±6.65^{a}
T11	4.13±0.19^{ab}	30.64±0.51^{abc}	140.27±9.48^{ab}

Note: DAT: Days after Transplanting; cm: Centimeters, T1: Non- Bud Chip; T2: No Auxin Applied; T3: 10 min soaking at 150 ppm; T4: 10 min soaking at 200 ppm; T5: 10 min soaking at 250 ppm; T7: 20 min soaking at 150 ppm; T8: 20 min soaking at 200 ppm; T9: 20 min soaking at 250 ppm; T11: 30 min soaking at 150 ppm; T12: 30 min soaking at 200 ppm; T13: 30 min soaking at 250 ppm. The different superscript letters (e.g., a, b, c, d) used to denote significant differences at a 5% probability level by Duncan.

b. Number of nodes and internodal length

The **Table 5** presented the effects of naphthalene acetic acid (NAA) treatments on the number of nodes and internodal length in sugarcane bud chip seedlings under field conditions. Analysis of variance (ANOVA) indicated no significant differences in the number of nodes among treatments. Despite this, treatment T4 exhibited the highest mean number of nodes (10.47 ± 0.41), followed by the control treatment T1 recorded the lowest mean (9.20 ± 0.99). These findings suggest that NAA application may have a marginal effect on node formation, though not statistically significant. This observation aligns with previous research indicating that while NAA can influence vegetative growth parameters, its impact on node development may be limited [13].

Table 5. The effect of number of nodes and internodal length in sugarcane treated of naphthalene acetic acid (NAA) in budchip at field condition.

Treatment	Number of nodes	Internodal length (cm)
T1	9.20±0.99	7.43±0.60^{d}
T2	10.07±1.09	9.78±0.47^{abc}
T3	9.47±1.04	8.68±1.03^{cd}
T4	10.47±0.41	11.19±0.30^{a}
T5	9.53±3.07	9.03±0.12^{bc}
T6	9.60±2.83	9.79±0.63^{abc}
T7	10.10±0.29	10.83±0.47^{a}
T8	10.27±0.41	10.39±0.86^{ab}
T9	8.53±1.80	8.81±0.02^{bcd}
T10	9.53±0.98	10.40±0.28^{a}
T11	10.20±0.28	10.09±1.09^{abc}

Note: cm: centimeters; T1: Non-Bud Chip; T2: No Auxin Applied; T3: 10 min soaking at 150 ppm; T4: 10 min soaking at 200 ppm; T5: 10 min soaking at 250 ppm; T7: 20 min soaking at 150 ppm; T8: 20 min soaking at 200 ppm; T9: 20 min soaking at 250 ppm; T11: 30 min soaking at 150 ppm; T12: 30 min soaking at 200 ppm and T13: 30 min soaking at 250 ppm. The different superscript letters (e.g., a, b, c, d) used to denote significant differences at a 5% probability level by Duncan

In contrast, ANOVA revealed highly significant differences in internodal length among treatments. T4 achieved the longest mean internodal length of 11.19 ± 0.30 cm, followed by T7 (10.83 ± 0.47cm), T10 (10.40 ± 0.28 cm), and T8 (10.39 ± 0.86 cm). These treatments did not significantly differ from each other but showed highly significant differences compared to T9, T3 and T1 with a mean of 8.81 ± 0.02 cm, 8.68 ± 1.03 cm, and 7.43 ± 0.60 cm, respectively which exhibited the short internodal lengths. This suggests that NAA application, particularly in treatment T4, effectively promotes internodal elongation. Auxins like NAA are known to enhance cell elongation by modulating cell wall plasticity, leading to increased internodal length [15]. The differential response observed between the number of nodes and internodal length may be attributed to the specific role of NAA in plant growth regulation. While NAA primarily promotes cell elongation, leading to increased internodal length, its influence on node formation appears less pronounced. This distinction underscores the importance of targeted application of growth regulators to achieve desired morphological outcomes in sugarcane cultivation.

c. Number of tillers

The **Table 6** presents the effect of NAA treatments on the number of tillers at 30 DAT, 60 DAT, and the number of active tillers at elongation stage or 160 DAT in sugarcane under field conditions. ANOVA revealed highly significant differences in tiller numbers at 30 and 60 DAT, and significant differences at maturity. T8 recorded the highest mean tiller counts of 3.00, closely followed by T4 with 2.96 ± 0.22 counts. These were not significantly different from each other but were significantly higher than T5 (2.00 ± 0.16 counts), T3 (1.92 ± 0.12 counts), and T1 (1.47 ± 0.19 counts). This early stimulation of tiller growth may be attributed to NAA's role in enhancing cell division and elongation, promoting shoot proliferation. Surprisingly, NAA-treated sugarcane from T2 to T11 maintained a high number of active tillers, ranging from 7.93 ± 0.90 counts to 9.80 ± 0.16 counts, significantly higher than the control (T1) at 3.33 ± 0.47 counts.

Table 6. The effect of number of tillers in 30 DAT, 60 DAT and active tillers at 160 DAT or elongation stage and stalk diameter in sugarcane treated of naphthalene acetic acid (NAA) in budchip at field conditions.

Treatment	Number of tillers per hill		Number of active tillers per hill (160 DAT)	Stalk Diameter (cm)
	30 DAT	60 DAT		
T1	1.47±0.19^{d}	3.04±0.15^{d}	3.33±0.47^{b}	2.76±0.21
T2	2.40±0.43^{abc}	6.16±1.35^{abc}	8.67±1.64^{a}	3.12±0.19
T3	1.92±0.12^{cd}	4.95±0.91^{bc}	9.00±0.91^{a}	2.91±0.32
T4	2.96±0.22^{a}	8.00±0.72^{a}	9.80±0.16^{a}	2.69±0.70
T5	2.00±0.16^{bcd}	4.48±0.55^{cd}	7.93±0.90^{a}	2.95±0.47
T6	2.20±0.00^{bc}	4.92±0.82^{bc}	8.07±0.34^{a}	3.14±0.06
T7	2.65±0.49^{ab}	6.73±1.47^{ab}	9.40±2.37^{a}	3.18±0.26
T8	3.00±0.00^{a}	5.22±1.04^{bc}	7.93±1.57^{a}	3.18±0.23
T9	2.34±0.19^{abc}	5.03±0.45^{bc}	8.13±2.08^{a}	2.90±0.06
T10	2.60±0.28^{ab}	6.32±0.48^{abc}	9.07±1.09^{a}	3.16±0.12
T11	2.53±0.50^{abc}	5.73±0.34^{bc}	8.13±1.65^{a}	2.95±0.11

Note: cm: centimeters; DAT: Days after Transplanting; T1: Non- Bud Chip; T2: No Auxin Applied; T3: 10 min soaking at 150 ppm; T4: 10 min soaking at 200 ppm; T5: 10 min soaking at 250 ppm; T7: 20 min soaking at 150 ppm; T8: 20 min soaking at 200 ppm; T9: 20 min soaking at 250 ppm; T11: 30 min soaking at 150 ppm; T12: 30 min soaking at 200 ppm and T13- 30 min soaking at 250 ppm. The different superscript letters (e.g., a, b, c, d) used to denote significant differences at a 5% probability level by Duncan.

The T1, or the control (farmer's practice), did not show an increase in the number of tillers per hill from 60 to 160 DAT compared to other treatments. This can be attributed to the closer planting distance, which promoted stem elongation rather than tiller production. Additionally, the denser planting made the plants more susceptible to damage from insect pests such as fall armyworm (*Spodopterafrugiperda*) and stem borer (*Chiloterrenellus*), as illustrated in **Figure 2**. The closer spacing also increased vulnerability to diseases like red rot (*Glomerellatucumanensis*), as shown in **Figure 3**. However, treatments in budchip and treated NAA were observed to enhance tiller production during the period of 30 DAT to 60 DAT, contributing to improved yield potential. This aligns with findings by El-Ghit [12], who documented the role of NAA in promoting growth and yield in cereals and legumes.

Figure 2. The damage of Stem borer (*Chiloterrenellus*) as shown in left side of the picture and damage of fall armyworm (*Spodopterafrugiperda*) in shoot as presented in right side of the picture.

Figure 3. The Red Rot (*Glomerellatucumanensis*) of Sugarcane.

d. Stalk Diameter

The **Table 6** presents the effect of NAA treatments on the stalk diameter of sugarcane using the budchip method under field conditions. The ANOVA indicated no statistically significant differences among the treatments. However, treatments T7 and T8 recorded the highest mean stalk diameter of 3.18 ± 0.26 cm and 3.18 ± 0.23 cm, followed by T10 with a mean of 3.16 ± 0.12 cm, while T1 had the smallest mean diameter of 2.76 ± 0.21 cm.

The ANOVA results suggest that NAA did not significantly impact the improvement of stalk diameter. This finding aligns with the Sugar Regulatory Administration [16] report on the PHIL 2006-1899 variety, which notes a medium stalk diameter of 2.99 cm, closely matching the overall mean stalk diameter of 3.00 cm observed across the treatments. This consistency implies that the lack of significant differences may be attributed to the inherent morphological characteristics of the sugarcane variety rather than the effect of NAA.

In contrast, according to Singh [17] highlighted that NAA primarily promotes stalk elongation, which is crucial for secondary growth in sugarcane stalks furthermore he state that larger stalk is desirable because they are positively correlated with increased biomass and juice yield, essential for maximizing sugarcane productivity.

e. Biomass yield

The **Table 7** presented the effect of biomass yield per plant in sugarcane treated with naphthalene acetic acid (NAA) in budchip under field conditions. The results showed that T4 exhibited the highest biomass yield with a mean of 1060.00 ± 22.73 g, followed closely by T7 with a mean of 1031.67 ± 8.50 g. Similarly, T8, and T11 yielded means of and 1016.67 ± 59.70 g and 1013.67 ± 9.84 g respectively, which were not significantly different from each other. However, these treatments were highly significant compared to T5 (626.67 ± 174.77 g), T9 (576.00 ± 33.98 g), T3 (566.33 ± 71.60 g), and T1 (525.33 ± 68.63 g). The high biomass yield observed in T4 and T7 may be attributed to the role of NAA in promoting cell elongation, division, and nutrient translocation, as reported by Tolera [18], who emphasized the positive influence of plant growth regulators like NAA on sugarcane productivity. Moreover, similar findings by Xie [11] revealed that optimal concentrations of auxins, such as NAA, enhanced sugarcane growth by stimulating root and shoot development, which could explain the superior biomass yield in the higher-performing treatments. These results affirm the significant impact of NAA application on sugarcane yield, reinforcing its potential in enhancing productivity.

Table 7. The effect of biomass yield, amount of juice extract yield per stalk (ml), sucrose content and bagasse yield in sugarcane treated of naphthalene acetic acid (NAA) in budchip under field condition.

Treatment	Biomass yield per plant (g)	Sugar/sucrose content (% brix)	Amount of juice extract yield per stalk (ml)	Bagasse yield (g)
T1	525.33 ± 68.63^{d}	11.67 ± 0.47	80.00 ± 11.43^{d}	175.67 ± 32.29^{d}
T2	720.67 ± 21.31^{bc}	13.33 ± 1.25	185.00 ± 0.82^{b}	349.33 ± 22.23^{bc}
T3	566.33 ± 71.60^{cd}	13.00 ± 0.82	175.67 ± 3.40^{c}	195.00 ± 18.99^{d}
T4	1060.00 ± 22.73^{a}	12.67 ± 0.94	231.67 ± 12.47^{a}	685.00 ± 22.73^{a}
T5	626.67 ± 174.77^{cd}	12.67 ± 0.94	166.33 ± 5.44^{c}	251.67 ± 174.77^{cd}
T6	812.33 ± 23.04^{b}	14.00 ± 1.41	195.33 ± 2.49^{b}	437.33 ± 23.04^{b}
T7	1031.67 ± 8.50^{a}	12.67 ± 0.94	230.33 ± 3.86^{a}	656.67 ± 8.50^{a}
T8	1016.67 ± 59.70^{a}	14.00 ± 1.41	216.67 ± 1.25^{a}	641.67 ± 59.70^{a}
T9	576.00 ± 33.98^{cd}	13.33 ± 1.25	166.67 ± 1.25^{c}	201.00 ± 33.98^{d}
T10	1013.67 ± 9.84^{a}	11.67 ± 2.05	224.67 ± 9.39^{a}	638.67 ± 9.84^{a}
T11	957.33 ± 27.44^{a}	13.33 ± 1.25	209.33 ± 11.81^{b}	582.33 ± 27.44^{a}

Note: g: gram; ml: milliliter; %: percent; T1: Non-Bud Chip; T2: No Auxin Applied; T3: 10 min soaking at 150 ppm; T4: 10 min soaking at 200 ppm; T5: 10 min soaking at 250 ppm; T7: 20 min soaking at 150 ppm; T8: 20 min soaking at 200 ppm; T9: 20 min soaking at 250 ppm; T11: 30 min soaking at 150 ppm; T12: 30 min soaking at 200 ppm and T13: 30 min soaking at 250 ppm. The different superscript letters (e.g., a, b, c, d) used to denote significant differences at a 5% probability level by Duncan.

f. Sucrose/sugar content (% brix)

The study revealed the percent sucrose content in sugarcane treated with naphthalene acetic acid (NAA) in bud chip under field conditions shown in **Table 7**. The results showed that T6 and T8 had the highest sucrose content, with a mean of 14.00 ± 1.41 % Brix, followed by T2, T9, and T11, each with a mean of 13.33 ± 1.25% Brix. The lowest sucrose content was found in T1, with a mean of 11.67 ± 0.47 % Brix. However, ANOVA indicated that the percent Brix of sucrose among all the treatments did not differ significantly. The study also found that sugarcane bud chips treated with NAA yielded a sucrose content between 11.67 ± 0.47 % Brix and 14.00 ± 1.41 % Brix after only 5 months (160 days) of growth. This contrasts with the findings of Abu-Ellailn [19], who reported a sucrose content of 13.00% to 14.00% Brix across all varieties after 11 months of harvesting. According to Premachandran and Chandran [20], the percent Brix of sugarcane increases with age, with 5-month-old plants containing 10-12% Brix, 6-7 months having 14-16% Brix, 8-10 months accumulating 18-20% Brix, and 11-12 months reaching 20-24% Brix. Although there were no significant differences in sucrose content at 5 months in this study, it was observed that budchip treatments resulted in higher sucrose content compared to T1, which had only 11.67% Brix. Therefore, it is suggested that a separate study be conducted to collect data on sucrose content at different ages (from 8 months to 12 months) to better compare the NAA and control treatments and determine if significant differences exist.

g. Juice extract yield per stalk (ml)

Table 7 displays the volume of juice extract per stalk (ml) in sugarcane treated to NAA treatment in budchip under field condition. The treatment with the highest mean juice extract was T4 (231.67 ± 12.47 ml), followed by T7 (230.33 ± 3.86 ml), T10 (224.67 ± 9.39 ml), and T8 (216.67 ± 1.25 ml). The treatments, although not significantly different from each

other, demonstrated statistically significant differences when compared to T11 (209.33 ± 11.81 ml), T6 (195.33 ± 2.49 ml) and T2 (185.00 ± 0.82 ml), T1, with the lowest mean of 80.00 ± 11.43 ml, demonstrated a highly significant difference from all other treatments. The lower juice output in T1 is attributable to the shortened stalk height and internodal length, which constrain juice production. The findings indicate that stalk height and internodal length are key factors affecting juice extract output, with increased stalk height and longer internodes enhancing juice production. This outcome corresponds with the research conducted by Sugatha et al., 2018, which noted that the utilization of plant regulators such as NAA can markedly enhance internodal length, directly influencing stalk height. A further study, titled "Evaluation of 2, 4-Dichlorophenoxy Acetic Acid and Naphthalene Acetic Acid on Growth and Yield of Sugarcane (*Saccharum officinarum L.*) in Kenya," investigated the effects of NAA on morphological characteristics of sugarcane, including internode length. According to Wekesa [21], the results showed that applying NAA increased internode length, which may be related to increased juice production because of the greater stalk size.

h. Bagasse Yield

The study on the effect of NAA on sugarcane bagasse yield under field conditions, as presented in **Table 7**, reveals critical insights into the role of plant growth regulators in enhancing biomass production. Among the treatments, T4 achieved the highest bagasse yield with a mean value of 685.00 ± 22.73 g, followed closely by T7 (656.67 ± 8.50 g), T8 (641.67 ± 59.70 g), T10 (638.67 ± 9.84 g), and T11 (582.33 ± 27.44 g). Statistical analysis through ANOVA indicated no significant differences among these top-performing treatments. However, these treatments showed significant differences compared to lower-yielding treatments such as T6 (437.33 ± 23.04 g) and T2 (349.33 ± 22.23 g). Furthermore, the differences were highly significant when compared to treatments like, T5 (251.67 ± 174.77 g), T9 (201.00 ± 33.98 g), T3 (195.00 ± 18.99 g), and T1 (175.67 ± 32.29 g). These findings underscore the potential of specific NAA treatments to enhance bagasse yield, although the variability across treatments highlights the complexity of sugarcane's physiological response to NAA application in field conditions.

The higher bagasse yields and biomass yield consistently observed in T4, T7, and T10 that treated NAA at 200 ppm in bud chip, regardless of the soaking duration, may be that concentration of NAA promotes biomass accumulation in sugarcane during its growth stages. Bagasse, a byproduct of sugarcane processing, it is a substance with a high energy content that can assuage the impending energy crisis [22,23]. It serves as a renewable source for bioenergy, composting, and other agro-industrial applications. Increased bagasse yield signifies not only improved sugarcane productivity but also enhanced resource availability for various uses, contributing to environmental and economic sustainability [24-26]. Supporting this observation, the study by de Morais [27] emphasized the impact of plant growth regulators on sugarcane productivity. Their findings indicated a 7.7% increase in bagasse yield during the vegetative and maturation stages, attributed to improved photosynthetic and antioxidant activity.

i. Computed yield per hectare (tc/ha) and Percent Return on investment (ROI)

The **Table 8** illustrates the computed yield per hectare (tons of cane per hectare or tc/ha) in sugarcane treated with varying concentrations of naphthalene acetic acid (NAA) using the budchip method under field conditions. Results showed that T10 produced the highest mean yield of 164.71 ± 4.65 tc/ha. ANOVA revealed no significant differences between T10 and treatments T11 (148.99 ± 7.78 tc/ha), T8 (141.61 ± 4.62 tc/ha), T4 (139.59 ± 5.25 tc/ha), and T7 (135.77 ± 4.06 tc/ha). However, these treatments exhibited significantly higher yields compared to T5 (92.06 ± 29.28tc/ha), T3 (82.82 ± 5.71 tc/ha), T9 (76.18 ± 0.30 tc/ha), and T1 (28.35 ± 4.65tc/ha), which recorded the lowest yield.

Table 8. The effect of computed yield per hectare (tc/ha) and return on investment in sugarcane treated of naphthalene acetic acid (NAA) in budchip under field condition.

Treatment	Computed yield per hectare (tc/ha)	Return on investment (%)
T1	28.35 ± 4.65^{e}	36.72 ± 21.54^{e}
T2	102.49 ± 2.27^{cd}	113.76 ± 7.05^{cd}
T3	82.82 ± 5.71^{d}	$80.43d\pm 12.13^{e}$
T4	139.59 ± 5.25^{ab}	177.72 ± 22.70^{ab}
T5	92.06 ± 29.28^{d}	103.50 ± 60.07^{cd}
T6	121.35 ± 8.98^{bc}	145.41 ± 20.30^{bc}
T7	135.77 ± 4.06^{ab}	172.09 ± 23.86^{b}
T8	141.61 ± 4.62^{ab}	182.78 ± 28.49^{ab}
T9	76.18 ± 0.30^{d}	67.98 ± 6.10^{de}
T10	164.71 ± 4.65^{a}	223.09 ± 38.90^{a}
T11	148.99 ± 7.78^{ab}	193.16 ± 25.38^{ab}

Note: tc/ha: tons of cane/hectare; %: percent; T1: Non- Bud Chip; T2: No Auxin Applied; T3: 10 min soaking at 150 ppm; T4: 10 min soaking at 200 ppm; T5: 10 min soaking at 250 ppm; T7: 20 min soaking at 150 ppm; T8: 20 min soaking at 200 ppm; T9: 20 min soaking at 250 ppm; T11: 30 min soaking at 150 ppm; T12: 30 min soaking at 200 ppm and T13: 30 min soaking at 250 ppm. The different superscript letters (e.g., a, b, c, d) used to denote significant differences at a 5% probability level by Duncan.

A strong positive correlation was observed between computed yield and traits such as internodal length, plant height, bagasse weight per plant, biomass yield, and juice extract. Treatments T4, T7, and T10, where NAA treated with 200 ppm in budchip, demonstrated significantly higher yields, highlighting the efficacy of NAA in promoting sugarcane growth and development. This aligns with Praharaj [28], who reported that auxin application enhances biomass production and sucrose accumulation in sugarcane, thus increasing overall yield. Moreover, Sreelatha [29] showed that soaking sugarcane budchips to NAA improved tiller production during field performance which are important for maximizing cane yield. The superior performance of T10, T4, and T7 may also be due to their optimal NAA concentrations. Mehdi [30] noted that inappropriate auxin levels could disrupt hormonal balance, leading to inhibited growth. The findings of this study are consistent with Manzoor [31], who found that plant growth regulators, such as NAA, significantly improve sugarcane height and yield by promoting structural and physiological traits essential for cane productivity.

On the other hand, in the third column of the **Table 8** presented the percent return on investment (ROI) treatment in sugarcane treated of naphthalene acetic acid (NAA) in budchip under field conditions, it showed that T10 has the highest ROI with a total of 223.09 ± 38.90 % followed by T11, T8 and T4 with a percent mean of 193.16 ± 25.38 %, 182.78 ± 28.49 % and 177.72 ± 22.70 %, however ANOVA revealed that there is no significant differences among this them but significantly difference to T7 (172.09 ± 23.86 %) and T6 (145.41 ± 20.30 %) but highly significant to T3, T11 and T1 with a mean percent of 80.43 ± 12.13 %, 67.98 ± 6.10 % and 36.72 ± 21.54 %.

This study, based on computed yield and return on investment (ROI), demonstrates that the budchip method of sugarcane planting is effective in enhancing both production and income than traditional. These findings are consistent with the work of Narendranath [32], who reported that the budchip method of planting achieves significantly higher profits in sugarcane cultivation and is three times more cost-effective than conventional planting techniques. Mohanty [33] highlighted a notable increase in net returns, recording ₱84,000/ha under the Sustainable Sugarcane Initiative (SSI) using budchip technology, compared to only ₱59,000/ha with the conventional planting method while Wekesa [21] stated that the application of NAA to field crops, particularly sugarcane, was highly effective in improving yield, resulting in an enhanced benefit-cost ratio. The maximum yield was achieved with the application of NAA. Furthermore, Mishra (2019) observed higher gross returns, net returns, and benefit-cost ratios under farmer field conditions when using the budchip planting method compared to conventional methods. In spite of higher input costs, Sugeerthi [34] noted that the economic benefits of chip-budded were significantly greater, reporting the highest net income of ₱124,159/ha and a benefit-cost ratio of 2.63. Additionally, Patnaik [35] documented a 32.63% increase in net profit from sugarcane cultivation using budchip technology in Odisha compared to conventional methods. These studies collectively affirm that the budchip method of sugarcane planting is a viable approach for improving both yield and profitability, making it an economically advantageous alternative to traditional planting techniques.

j. Lodging Score

The study faced unexpected challenges due to a series of consecutive typhoons that struck from October to November 2024. These included Severe Tropical Storm Kristine (international name: Trami), which devastated Isabela on October 24, 2024, followed by Super Typhoon Leon (Kong-rey) on October 31, 2024. Tropical Depression Marce (Yinxing) hit on November 7, Typhoon Nika (Toraji) on November 11, Super Typhoon Ofel (Usagi) on November 14, and Super Typhoon Pepito (Manyi) on November 16. These typhoons brought strong winds ranging from 61 to 180 kilometers per hour (km/h) in northern Isabela, prompting PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) to issue wind signals ranging from Signal No. 1 to Signal No. 4 in the affected areas.

The results presented in **Table 9** demonstrate the effects of varying wind intensities on sugarcane treated with NAA in a budchip system under field conditions. During Tropical Depression (TD) conditions, corresponding to PAGASA's Wind Signal No. 1, the ANOVA analysis revealed no significant differences among treatments. This indicates that no lodging was observed, as the sugarcane plants remained erect. A similar result was observed under Tropical Storm (TS) conditions, where wind speeds were still insufficient to cause lodging. The lodging angle and scores in the lodging resistance index, as shown in **Table 5**, consistently supported the observation of erect plants during these lower wind intensity levels.

However, as showed in **Figure 4** under Severe Tropical Storm (STS) conditions (Wind Signal No. 3), lodging was observed in sugarcane plants treated with NAA (T2 to T11). The lodging was particularly pronounced in these treatments during typhoon conditions, except in T1. ANOVA revealed significant differences between T1 and other treatments, highlighting that T1 remained unaffected by lodging. This could be attributed to the significantly lower plant height, biomass, and tiller count in T1 compared to other treatments. Taller plants with higher biomass and more tillers were more prone to lodging due to the greater mechanical stress exerted by strong winds.

Table 9. The effect of different level of strong winds in sugarcane treated of naphthalene acetic acid (NAA) in budchip under field conditions.

Treatment	TD	LL	TS	LL	STS	LL	TY	LL
T1	3.00 ± 0.00	Erect	3.00 ± 0.00	Erect	2.67 ± 0.47^{a}	Erect	2.33 ±0.47^{a}	Erect
T2	3.00 ± 0.00	Erect	3.00 ± 0.00	Erect	2.00 ± 0.00^{ab}	Middle Lodging	1.33 ± 0.47^{b}	High Lodging
T3	2.67 ± 0.47	Erect	3.00 ± 0.00	Erect	1.67 ± 0.47^{b}	Middle Lodging	1.33 ± 0.47^{b}	High Lodging
T4	3.00 ± 0.00	Erect	3.00 ± 0.00	Erect	2.00 ± 0.00^{ab}	Middle Lodging	2.00 ± 0.00^{a}	High Lodging
T5	3.00 ± 0.00	Erect	2.33 ± 0.47	Erect	2.00 ± 0.00^{ab}	Middle Lodging	2.00 ± 0.00^{a}	High Lodging
T6	3.00 ± 0.00	Erect	2.67 ± 0.47	Erect	2.00 ± 0.00^{ab}	Middle Lodging	2.00 ± 0.00^{a}	High Lodging
T7	3.00 ± 0.00	Erect	2.67 ± 0.47	Erect	2.00 ± 0.00^{ab}	Middle Lodging	2.00 ± 0.00^{a}	High Lodging
T8	2.33 ± 0.47	Erect	2.33 ± 0.47	Erect	1.67 ± 0.47^{b}	High Lodging	1.33 ± 0.47^{b}	High Lodging
T9	3.00 ± 0.00	Erect	2.67 ± 0.47	Erect	2.00 ± 0.0.81^{ab}	Middle Lodging	2.00 ± 0.00^{a}	High Lodging
T10	2.67 ± 0.47	Erect	2.67 ± 0.47	Erect	2.00 ± 0.00^{ab}	Middle Lodging	2.00 ± 0.00^{a}	High Lodging
T11	2.33 ± 0.47	Erect	2.33 ± 0.47	Erect	1.67 ± 0.47^{b}	High Lodging	1.33 ± 0.47^{b}	High Lodging

Note: LL: Lodging level; TD: Tropical Depression or wind signal 1, with wind speeds up to 61 km/h; TS: Tropical Storm or wind signal 2, with wind speeds ranging from 62 to 88 km/h; STS or Severe Tropical Storm or wind signal 3, with wind speeds between 89 and 117 km/h; TY: Typhoon or wind signal 4, with wind speeds ranging from 118 to 184 km/h; T1: Non- Bud Chip; T2: No Auxin Applied; T3: 10 min soaking at 150 ppm; T4: 10 min soaking at 200 ppm; T5: 10 min soaking at 250 ppm; T7: 20 min soaking at 150 ppm; T8: 20 min soaking at 200 ppm; T9: 20 min soaking at 250 ppm; T11: 30 min soaking at 150 ppm; T12: 30 min soaking at 200 ppm and T13: 30 min soaking at 250 ppm. The different superscript letters (e.g., a, b, c, d) used to denote significant differences at a 5% probability level by Duncan.

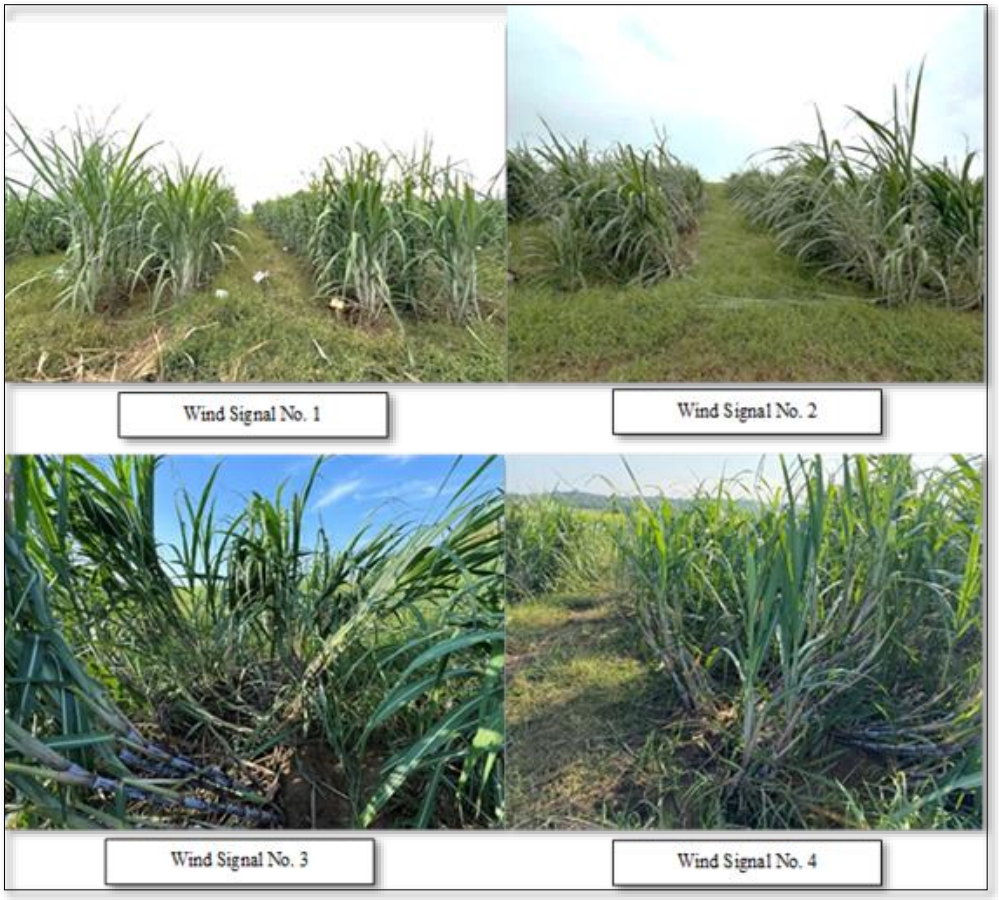

Figure 4. The effect of strong winds in sugarcane treated of naphthalene acetic acid (NAA) in budchip under field conditions.

Lodging susceptibility has been previously associated with plant height and biomass. Researchers observed that taller plants with higher above-ground biomass face increased leverage under wind pressure, making them more prone to lodging [36,37]. Additionally, Verma [38] noted that tiller density contributes to the overall biomass, further elevating the risk of structural failure during strong winds. NAA-treated sugarcane, known to enhance tillering and biomass production [39], may inadvertently increase the susceptibility to lodging during severe weather conditions.

Overall, even though the sugarcane experienced lodging, the plants exhibited a remarkable capability to recover over time. This self-recovery mechanism, known as phototropism, enables the stalks to gradually return to an upright position after being bent by strong winds as shown in **Figure 5**. However, the stress inflicted on the stalks during lodging was evident, as curvature was observed at the nodes where the plants experienced the most stress. This curvature indicates the point of mechanical failure or bending, which occurs when the force of the wind exceeds the stalk's structural capacity to remain erect. Such recovery behavior is consistent with findings by Singh and Dave [40], who highlighted that sugarcane stalks have flexible tissues that allow them to bend without completely breaking under moderate lodging conditions. However, prolonged stress at specific nodes may weaken the structural integrity of the stalk, leading to reduced efficiency in nutrient and water transport. Similarly, Singh [41] emphasized that while sugarcane plants can recover post-lodging, significant stress may compromise their overall growth and yield potential, especially when the curvature persists at critical points. This observation suggests that while sugarcane possesses adaptive characteristics to recover from lodging, excessive stress during severe weather events can negatively impact its physiological processes and yield.

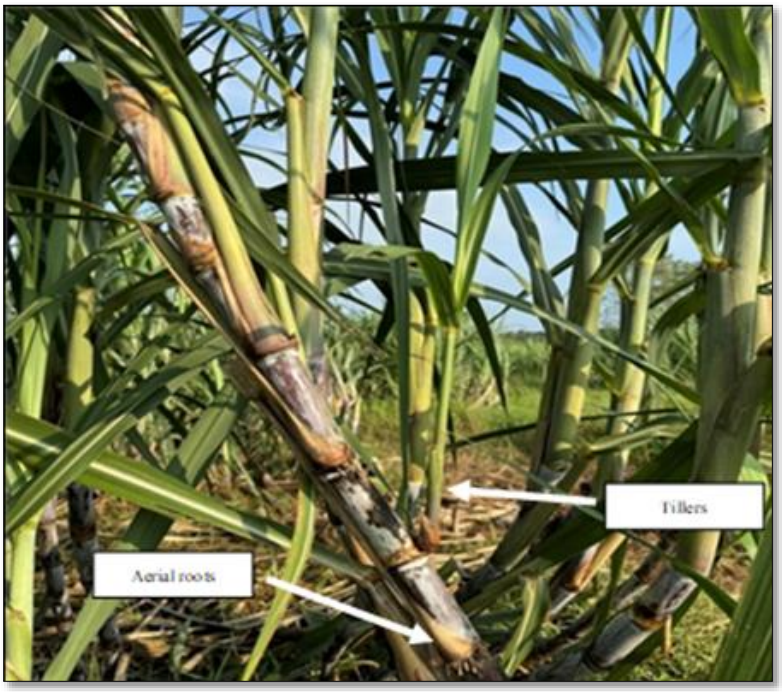

Figure 5. The release of aerial roots and tillers due to strong winds causing lodging in sugarcane treated of naphthalene acetic acid (NAA) in budchip under field conditions.

Furthermore, exposure to strong winds triggers a unique adaptive response in sugarcane: the release of aerial roots from the nodes as shown in **Figure 6**. This physiological adaptation serves a dual purpose-it stabilizes the plant against mechanical stress and promotes the germination of new tillers, thereby contributing to the plant's resilience and recovery after environmental stress. However, this adaptation may come at a cost to yield potential. The plant diverts its energy toward the production of tillers and root structures rather than allocating resources to stalk enlargement and sugar accumulation, which are critical for yield and quality. According to Gomathi [8], the release of adventitious roots and the subsequent formation of tillers under stress conditions is a survival strategy employed by sugarcane to overcome environmental challenges. While this mechanism ensures the continued growth and development of the plant, it can negatively impact productivity by shifting the plant’s focus away from optimal stalk development.

Figure 6. The self-recovery mechanism of known as phototropism due to strong winds causing lodging in sugarcane treated with naphthalene acetic acid (NAA) in budchip under field conditions.

CONCLUSIONS

The study demonstrated that the application of auxin on sugarcane bud chips significantly enhanced growth parameters, yield components, and economic returns under field conditions. The findings provide compelling evidence of the adaptability of the auxin treatment for improving sugarcane production. Auxin treatment significantly enhanced plant height, number of nodes, internodal length and stalk diameter collectively contributing to the overall biomass production. These results suggest that auxin application positively influences vegetative growth and uniform crop development. The increased number of tillers in treated sugarcane highlighted the treatment's role in stimulating lateral shoot production and early-stage vigor, which are critical for maximizing plant density and yield potential. In terms of yield components, auxin-treated sugarcane exhibited a substantial increase in sucrose content, biomass yield, juice extract yield and computed yield. These results have the potential of auxin in improving physiological processes, such as nutrient uptake and photosynthesis, which directly influence productivity. Bagasse recovery was also improved, further offers opportunities for by-product utilization, adding value to the crop. However, the treatment significantly increase lodging on auxin-treated sugarcane which can result in yield losses when neglected the management strategies after lodging. From an economic perspective, the cost and return analysis revealed that auxin treatment offers a favorable return on investment, making it a viable option for farmers aiming to maximize profitability while maintaining sustainable production practices. The combined improvements in growth, yield, and economic efficiency indicate that auxin treatment of sugarcane bud chips is an effective strategy for enhancing sugarcane production in on-farm conditions. Future studies could explore the long-term impacts of auxin treatment and its integration with other management practices to optimize its benefits across diverse agroecological conditions. It is recommended that farmers adopt the use of auxin-treated sugarcane bud chips as a cost-effective method to enhance growth, yield, and overall profitability. This practice holds significant potential for sustainable sugarcane production and efficient resource use. Future research should focus on optimizing the sugarcane seedling production from bud chips treated with auxin, specifically investigating the application of auxin at different sections of the sugarcane stalk.

ACKNOWLEDGEMENTS

We extend our heartfelt gratitude to the esteemed professors of the College of Agriculture at Benguet State University (BSU), La Trinidad, for their invaluable guidance and the opportunities they provided, which greatly contributed to the successful completion of this study. Our sincere thanks also go to the Department of Agriculture-Bureau of Agricultural Research (DA-BAR) for their financial support, making this study possible. Lastly, we are deeply grateful to Isabela State University (ISU), Cabagan Campus, for allowing us to conduct the study in their sugarcane production area.

FUNDING SOURCES

This work was supported by Department of Agriculture-Bureau of Agricultural Research (DA-BAR) in their scholarship specifically in Thesis/Dissertation Support Program (TDSP).

REFERENCES

1. PSA (Philippines Statistics Authority) (2022) Major Non-Food and Industrial Crops Quarterly Bulletin; ISSN-2094-6198. pp: 10.
2. Jain S, Singh R, Singh R (2010) Sustainable Sugarcane Initiative for Enhancing Water Productivity and Sustaining Farmers' Income. Sugar Tech 12(4): 355-359.
3. Nayak H, Yadav SP (2021) Importance of bud chip technique in sugarcane cultivation. Food Sci Rep 2(4): 30.
4. Mohanty M, Nayak K (2011) Economizing seed cane quantity by reducing sett size and bud number with sett treatment in sugarcane cultivation. Indian J Sugar Technol 26(2): 59-60.
5. Iqbal A, Ehsanullah K, Qbal K (2002) Biomass production and its portioning in sugarcane at different nitrogen and phosphorus application rates. Pak Sugar J 17(2): 4-17.
6. Singh P, Singh P, Singh J (2021) Sugarcane bagasse: a potential and economical source for raising sugarcane nursery in sub-tropical India. Sugar Tech 23(6): 1211-1217.
7. Rosier CL, Frampton J, Goldfarb B, Blazich FA Wise FC (2004) Growth stage, auxin type, and concentration influence rooting of stem cuttings of fraser fir. Hort Sci 39(6): 1397-1402.
8. Paul I, Savithri E (2003) Effect of biofertilizers vs perfected chemical fertilization for sesame grown in summer rice fallow. J Trop Agric 41: 47-49.
9. Wu L, Birch G (2007) Doubled sugar content in sugarcane plants modified to produce a sucrose isomer. Plant Biotechnol J 5(1): 109-117.
10. Meiriani A, Smith J, Johnson K, Lee S (2020) Advances in Sugarcane Cultivation. J Agric Sci 15(3): 102-115.
11. Xie Y, Duan H, Wang L, Zhang J, Dong K, et al. (2023) Phosphorus and naphthalene acetic acid increased the seed yield by regulating carbon and nitrogen assimilation of flax. Front Plant Sci 14: 1228755.
12. El-Ghit HMA (2015) Effect of naphthalene acetic acid (NAA) on growth and yield of rosemary (*Rosemarinus officinalis L.*) under salinity stress. Egypt J Bot 56(2): 303-317.
13. Sujatha P, Kumar BR, Naidu NV, Charumathi M, Beby P, et al. (2018) Plant growth promoters' effect on cane, quality and yield parameters in sugarcane (*Saccharum officinarum L.*). Int J Chem Stud 6(3): 737-743.
14. Hussain I, Ali M, Bakhsh I, Malik MWI (2021) Effect of different levels of naphthalene acetic acid at various phenological stages of hybrid sorghum to enhance fodder productivity. Pakistan J Agric Res 34(1): 121-127.
15. Mitchell J, Livingston G (1968) Agriculture handbook. Methods of studying plant hormones and growth-regulating substances. Agricultural Research Service: United States Department of Agriculture, pp: 1-131.
16. SRA. Sugarcane Regulatory Authority (2004) Sugarcane Varieties: PHIL 2006-1899.
17. Singh S, Tiwari DK (2009) Role of Plant Growth Promoters on Sugarcane Production Propagated Through Budchips in Semiarid Region of Pakistan. J Plant Environ 11(1): 34-38.
18. Tolera B (2016) Effects of Naphthalene Acetic Acid (NAA) and Indole -3- Butyric Acid (IBA) on *In Vitro* Rooting of Sugarcane (*Saccharum officinarum L.*) MicroShoots. J Biotechnol Biomater 6(1): 1-5.
19. Abu-Ellail FF, Gadallah AFI, El-Gamal ISH (2020) Genetic variance and performance of five sugarcane varieties for physiological, yield and quality traits influenced by various harvest age. J Plant Product 11(5): 429-438.
20. Premachandran MN, Chandran K (2013) Sugar accumulation pattern in tropical and subtropical sugarcane varieties of different maturity groups. J Sugar Res 3(1): 9-13.
21. Wekesa RK (2017) Evaluation Of 2, 4-Dichlorophenoxy Acetic Acid and Naphthalene Acetic Acid Concentration on Callogenesis, Somaclonal Variation and Sugarcane Mosaic Virus Elimination in Sugarcane (*Saccharum Officinarum L*) (Doctoral dissertation, IBR, JKUAT). Available online at: https://ir.jkuat.ac.ke/handle/123456789/2797
22. Yin CY (2011) Prediction of higher heating values of biomass from proximate and ultimate analyses. Fuel 90(3): 1128-1132.
23. Ajala EO, Olonade YO, Ajala MA, Akinpelu GS (2020) Lactic acid production from lignocellulose-A review of major challenges and selected solutions. Chem Bio Eng Rev 7(2): 38-49.
24. Pandey A, Soccol CR, Nigam P, Soccol VT (2000) Biotechnological potential of agro-industrial residues. I: Sugarcane bagasse. Bioresource Technol 74(1): 69-80.
25. Kumar A, Kumar V, Singh B (2021) Cellulosic and hemicellulosic fractions of sugarcane bagasse: Potential, challenges and future perspective. Int J Biol Macromol 169: 564-582.

26. Bezerra TL, Ragauskas AJ (2016) A review of sugarcane bagasse for second-generation bioethanol and biopower production. Biofpr 10(5): 634-647.
27. de Morais CH, de Almeida APPF, Momesso L, Jacomassi LM, Crusciol CAC (2024) Effects of Plant Growth Regulators on Sugarcane Productivity and Quality of the Art Through the Increase in Photosynthetic and Antioxidant Activity. J Plant Growth Regul 43: 4003-4017.
28. Praharaj S, Singh D, Guru SK, Meena BR (2017) Effect of plant growth regulators on tiller dynamics and yield of sugarcane (*Saccharum officinarum L.*). Int J Bio-resource Stress Manag 8(1): 75-78.
29. Sreelatha P, Umamahesh V, Subramanyam D, Sarala NV (2019) Effect of different chemical treatments on field performance of sugarcane planting materials. J Pharmacogn Phytochem 8(4): 2030-2036.
30. Mehdi F, Cao Z, Zhang S, Gan Y, Cai W, et al. (2024) Factors affecting the production of sugarcane yield and sucrose accumulation: Suggested potential biological solutions. Front Plant Sci 15: 1374228.
31. Manzoor M, Khan MZ, Ahmad S, Alqahtani MD, Shabaan M, et al. (2023) Optimizing Sugarcane Growth, Yield, and Quality in Different Ecological Zones and Irrigation Sources Amidst Environmental Stressors. Plants 12(20): 3526.
32. Narendranath M (1992) Cost-effectiveness of transplanting nursery raised sugarcane bud-chip plants on commercial sugar plantations. Proceed ISSCT Congress 21: 332-333.
33. Mohanty M, Das PP, Nanda SS (2015) Introducing SSI (Sustainable sugarcane initiative) technology for enhanced cane production and economic returns in real farming situations under east coast climatic conditions of India. Sugar Tech 17(2): 116-120.
34. Sugeerthi S, Jayachandran M, Chinnusamy C (2018) Effect of Planting Materials and Integrated Nutrient Management on Yield of Sugarcane Seed Crop. Madras Agric J 105(4-6): 141-146.
35. Patnaik J, Singh SN, Sarangi D, Nayak P (2017) Assessing Potentiality of Bud Chip Technology on Sugarcane Productivity, Profitability and Sustainability in Real Farming Situations Under South East Coastal Plain Zone of Odisha, India. Sugar Tech 19(4): 373-377.
36. Pieruschka R, Schurr U, Reynolds M, Pinto F, Acevedo L, et al. (2022) Advances in plant phenotyping for more sustainable crop production (Vol. 117). Burleigh Dodds Science Publishing.
37. Chauhan S, Darvishzadeh R, Boschetti M, Pepe M, Nelson A (2019) Remote sensing-based crop lodging assessment: Current status and perspectives. ISPRS J Photogramm Remote Sens 151: 124-140.
38. Verma KK, Song X-P, Singh M, de Mello RP, Wu J-M, et al. (2024) Sugarcane Cultivation and Management: Challenges and Opportunities.
39. Carvalho TLG, Rosman AC, Grativol C, Nogueira EDM, Baldani JI, et al. (2022) Sugarcane genotypes with contrasting biological nitrogen fixation efficiencies differentially modulate nitrogen metabolism, auxin signaling, and microorganism perception pathways. Plants 11(15): 1971.
40. Singh S, Dave AK (2024) Engineering Properties of Sugarcane for the Development of Efficient Sugarcane Machinery. Sugar Tech pp: 1-12.
41. Singh G, Chapman SC, Jackson PA, Lawn RJ (2002) Lodging reduces sucrose accumulation of sugarcane in the wet and dry tropics. Aust J Agric Res 53(11): 1183-1195.
42. Gomathi RPN, Chandran GRK, Selvi A (2015) Adaptive Responses of Sugarcane to Waterlogging Stress: An Over View. Sugar Tech 17: 325-338.