Effect of biostimulant and silica application on sugarcane 
(Saccharum officinarum L.) production

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Abstract. Low productivity of sugarcane occurs due to low soil fertility and insufficient availability of water on sugarcane plantations. In addition to ensuring the soil nutrient availability by applying fertilization technology, nutrient absorption efficiency also needs to be optimized by applying a biostimulant. The research objective was to study the effect of the biostimulant and silica application on the efficiency and effectiveness of sugarcane nutrient absorption based on vegetative growth parameters, sugarcane quality parameters, and sugar rendement. This study was taken place in one of East Java’s sugar plantations from October 2019 to August 2020. There are four different treatments (P1, P2, P3, and P4) besides the control (P0), each with four replications. Data obtained were then statistically tested using a one-way Analysis of Variance followed by Duncan’s Post-Hoc Multiple Range Test. All the treatments showed no significant effect on sugarcane growth parameters. Based on the value, P1 (addition of 200 kg/ha silica and 3 L/ha biostimulant) was the best treatment with Brix and Pol values of 21.60% and 19.46% (p>0.05). This treatment also showed the best increase in sugar rendement by 28.53% compared to control (P0), which was 12.30% (p>0.05).

Keywords: biostimulant, Saccharum officinarum L., silica, sugarcane

1. Introduction
Sugarcane (Saccharum officinarum L.) belongs to a tall perennial grass in the family of Poaceae that has a high sucrose content in its stem. High sucrose content in sugarcane makes it one of the strategic and major Commodities in the sugar processing industry sharing 80% of global sugar production. In addition to sugar production, sugarcane is also used to provide renewable energy sources such as biofuel production, fiber, fertilizer, and various eco-products [1]. However, the high demand for sugarcane for various purposes is not followed by its high production.

Sugar, as the main product of sugarcane processing, decreased its production by 8%, from 2.23 million tons (2018/2019) to 2.05 million tons (2019/2020) [2] from sugarcane cultivation that covers an area of 415,660 ha [3]. Meanwhile, the sugar consumption level has increased in line with the development of the food and beverage industry, especially in this COVID-19 pandemic era, from 7.05 million tons (2018/2019) to 7.15 million tons (2019/2020) with 13 kg of sugar consumed/capita/year. Sugar production that does not meet consumption needs to have imports from other countries. This unmet national sugar production was partly due to the relatively low productivity of national sugarcane. Indonesia’s sugarcane production in 2019/2020 was 27.7 million tons. This value was lower than average production over the last six years, which is 30.2 million tons. Nationally, sugarcane productivity does not reach 70 tons/ha [3, 4].

Low sugarcane productivity is influenced by decreased soil fertility and insufficient water for
irrigation in a sugarcane plantation. Continuous intake of nutrients by plants without being balanced with sufficient fertilizer applications results in nutrient deficiency. Nowadays, some fertilization technology has been developed, including nitrogen fertilization technology, nano-fertilizer, bio-nano-silica, and a combination of organic and biological fertilizers.

Innovations in fertilization technology are needed to increase sugarcane productivity. Various important elements such as N, P, K, and Si are required to support sugarcane growth, increase harvested sugarcane weight, and maximize its sucrose content. In general, sugarcane plantation in Java has relatively low Si content [5]. On the other hand, sugarcane absorbs Si in large quantities compared to other microelements, causing a decrease in the Si content that available in the soil if it is not replaced by fertilization or external nutrition administration. Although as a microelement, Si is very crucial for sucrose formation and storage in sugarcane.

In addition to fertilizer, adding micronutrients plus biostimulants along with fertilizer application can increase sugarcane quality and productivity. Biostimulant is an ingredient that contains substances, plant hormones, and microorganisms that have a positive effect on plant growth and has a 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 [6, 7]. In previous studies conducted by Raposo et al. [8], applying biostimulants and micronutrients with foliar fertilizers can increase sugar yield by 17% [7, 8]. This experiment was conducted to determine the influence of biostimulant and Si application along with basic fertilizers on the growth, productivity, quality, and yield of sugarcane.

2. Material and method

The experiment was conducted from October 2019 to August 2020 at one of the sugarcane plantations in East Java. The sugarcane used in this experiment was plant cane with HW variety. The various treatment of biostimulant and silica can be seen in Table 1.

The experiment was conducted using a Randomized Complete Block Design (RCBD) with four replications. The trial unit consists of 5 rows with 50 meters long each. Nitrogen (N) fertilizer (ZA) is given twice, each at a dose of 250 Kg/Ha. P fertilizer (TSP) and K fertilizer (KCl) are given once each at a dose of 350 Kg/Ha and 250 Kg/Ha, respectively. Silica (Si) as much as 200 Kg/Ha and 300 Kg/Ha are added during fertilization of N, P, and K fertilizer. Biostimulants at a dose of 3 L/Ha and 6 L/Ha are given single without simultaneously added along with chemical fertilizers. Sugarcane is harvested when it is ten months old.

This study analyzed the effect of biostimulant and silica application based on its vegetative growth, post-harvest quality, and sugar rendement parameters. Sugarcane growth observation was carried out in a vegetative period, consisting of the diameter of the stem, the number of stalks, and the stem length. Measurement of stem diameter was carried out at three months after planting (MAP) and at 6 MAP with an observation point of about 20 cm above the ground. Sugarcane quality is analyzed based on Brix (%), Pol(%), and purity (%) parameters. Data obtained from sugarcane growth analyses, sugarcane quality, and sugar rendement were then statistically tested using IBM SPSS software® 25.0 with a one-way Analysis of Variance (ANOVA) method followed by Duncan’s Post-Hoc Multiple Range Test (p < 0.05).
### Table 1. Application of doses of fertilizers, biostimulants, and silica.

| Treatments | Application (MAP)* | Doses ZA (N) kg/ha | TSP (P) kg/ha | KCl (K) kg/ha | Silica (kg/ha) | Biostimulant (L/ha) |
|------------|--------------------|-----------------|---------------|---------------|----------------|------------------|
| P0         | 0                  | 250             | 350           | -             | -              | -                |
|            | 1.5                | 250             | -             | 250           | -              | -                |
|            | 1                  | -               | -             | -             | -              | -                |
| P1         | 1.5                | 250             | -             | 250           | 100            | -                |
|            | 2                  | -               | -             | -             | -              | 1                |
|            | 3                  | -               | -             | -             | -              | 1                |
| P2         | 1.5                | 250             | -             | 250           | 100            | -                |
|            | 2                  | -               | -             | -             | -              | 2                |
|            | 3                  | -               | -             | -             | -              | 2                |
| P3         | 1.5                | 250             | -             | 250           | 150            | -                |
|            | 2                  | -               | -             | -             | -              | 1                |
|            | 3                  | -               | -             | -             | -              | 1                |
| P4         | 1.5                | 250             | -             | 250           | 150            | -                |
|            | 2                  | -               | -             | -             | -              | 2                |
|            | 3                  | -               | -             | -             | -              | 2                |

*MAP: months after planting

### 3. Results and discussions

Growth observation during the vegetative period quantitatively determined biostimulant and silica effectiveness in maximizing the sugarcane. Meanwhile, sugarcane quality was determined based on some parameters: Brix(%), polarity or Pol(%), and sugar purity from sugarcane that has been harvested based on the standards of the International Commission for Uniform Method of Sugar Analysis (ICUMSA) 2014. Finally, sugar content that can be crystallized from each milling cane stem (sugar rendement) was determined by sugar rendement value as a commercialization standard for sugarcane in sugar mills.

#### 3.1 Analysis of biostimulant and silica application effect on sugarcane growth parameters

Sugarcane growth parameters measured in the vegetative period were: stem diameter, number of stalks, and stem length. Biostimulant and silica application effect on sugarcane growth during the vegetative stage at 3 MAP and 6 MAP is shown in Figure 1. Treatment without biostimulant and silica (control, P0) show no significant difference in stem diameter compared with P1, P2, P3, and P4, which has incorporated biostimulant and silica along with fertilizer application that following the plantation’s operational standards. P0 has an average stem diameter of 27.82 mm, which is not significantly different from the treatment of biostimulants and silica additions with a value of P1 (28.75 mm); P2 (28.2 mm); P3 (30.1 mm); and P4 (28.06 mm) at 3 MAP. Similarly, all treatments experienced an increase in the stem diameter but did not differ statistically compared to P0 at 6 MAP.

The biostimulant and silica effect on the number of sugarcane stalks in various treatments is shown in Figure 2. On 1.5 MAP, the average number of sugarcane stalks had no significant difference between
all the treatments. The number of sugarcane stalks in all the treatments was decreased on the 3 MAP observations. The fertilization process or soil raising happens when the sugarcane grows higher, so the soil buries small sugarcane stalks. On 6 MAP, the number of sugarcane stalks was also decreased but did not differ significantly between all the treatments. According to Khuluq and Hamida [20], sugarcane plants have an apical dominance at the beginning of the vegetative phase (39 days old, about 1 month after planting) and affect the growth rate of shoots or newly growth stalks.

![Figure 1](image1.png)

**Figure 1.** The effect of biostimulant and silica addition to sugarcane stem diameter at 3 MAP and 6 MAP on various treatments.

![Figure 2](image2.png)

**Figure 2.** The effect of biostimulant and silica addition to the number of sugarcane stalks on various treatments.

Sugarcane stem length at the end of observation (before harvested) also reviewed biostimulant and silica effectiveness on sugarcane growth. On stem length observation, it was seen that either control (P0) and all the treatments (P1, P2, P3, P4) have a stem length that does not differ statistically (Figure 3). Nevertheless, fertilizer treatment with an addition of 200 kg/ha biostimulant and 3 L/ha silica (P1) and the treatment of 200 kg/ha biostimulant and 6 L/ha silica (P2) has the greatest value of stem length. They are 328 cm and 329 cm, respectively. Biostimulant and silica application along with fertilizer increased the growth of sugarcane that can be seen from the addition of the stem length compared to the control.
The relationship between biostimulant and silica addition to the sugarcane stem length on various treatments.

These results are in line with the research done by Putra et al. [5], which states that foliar spraying of chitosan-based biostimulant at 1 MAP can stimulate vegetative growth of sugarcane.

3.2 Analysis of biostimulant and silica application effect on post-harvest sugarcane quality parameters

The effect of biostimulant and silica applications on post-harvest sugarcane quality was analyzed using sugarcane juice quality parameters as an important parameter of sugarcane production and processing. Brix represents the total percentage of solids in sugarcane juice. Brix value plays an important role in determining the value of sugar recovery in sugarcane juice [9,10]. The results of Brix measurement on sugarcane stems harvested at 6 BST are presented in table 2. Brix measurements were done on four samples, they are top, middle, bottom, and whole stem. Based on Brix value analysis, the application of biostimulant and silica did not influence significantly (p>0.05) on the Brix value of top, bottom, and overall stem of sugarcane. However, the application of biostimulant and silica significantly influences the value of top stem Brix (p<0.05).

| Treatments | Brix (%) | Middle stem | Lower stem | A whole stem |
|------------|----------|-------------|------------|--------------|
|            | Upper stem |              |            |              |
| P0         | 19.80 ± 0.32 a | 20.45 ± 0.87 a | 20.43 ± 0.50 a | 20.27 ± 0.22 a |
| P1         | 21.14 ± 0.22 b | 21.60 ± 0.52 a | 20.65 ± 0.87 a | 21.06 ± 0.66 a |
| P2         | 20.61 ± 0.79 ab | 20.98 ± 0.99 a | 20.19 ± 0.96 a | 20.55 ± 0.86 a |
| P3         | 20.83 ± 0.27 ab | 21.19 ± 0.63 a | 20.71 ± 0.67 a | 20.92 ± 0.63 a |
| P4         | 20.52 ± 0.77 ab | 21.23 ± 0.82 a | 20.30 ± 1.07 a | 20.67 ± 1.06 a |

Note: Values are expressed in the average ± deviation standard. Values followed by the same letter notation in the same column do not show a significant difference (p>0.05) based on statistical tests (ANOVA "Duncan’s Multiple Range Test").

The Brix value is in the range of 19.80%–21.60%. Based on its value, the treatment of 200 kg/ha silica and 6 L/ha biostimulant (P1) with a value of 21.60% (middle stem) found the best treatment with the largest average of Brix value. In general, all treatments with the addition of biostimulant and silica (P1, P2, P3, and P4) have a higher Brix value when compared to treatments without the addition of biostimulant and silica (P0). Therefore, the application of biostimulant and silica can increase the total...
dissolved solids in cane juice, indicating the increase in sucrose’s potential content in sugarcane juice. Research conducted by Putra et al. [5] showed an increase in Brix value of sugarcane by 11.2% compared to control due to the addition of liquid biostimulants foliar. In addition, there is a close relationship between Brix value and sucrose content (expressed in Pol). The maturity of sugarcane is characterized by the greater the value of Brix and Pol. Sugarcane is considered mature and ready to be processed if it has a minimum Brix value of 18% [11; 12].

Polarity (Pol) value indicates estimated sucrose content in sugarcane stem. This sugar content value is one of the important parameters in determining the quality of sugarcane and affects the value of sugar purity in the production of sugar and other processed sugarcane products [9; 10]. Pol(%) measurement results on four sugarcane stem samples for each treatment are shown in table 3. Based on Pol(%) value analysis, the addition of biostimulant and silica does not have a significant influence (p>0.05) on the Pol value of middle, lower, or overall stem sugarcane samples. However, the biostimulant and silica addition significantly influence the Pol value of top stem sugarcane (p<0.05). The average value of sugarcane stem Pol in this study has a range of 16.56%–19.46%. The lowest Pol value was found in the top stem sample of control (P0 = 16.56%). Meanwhile, the best treatment that gives the highest Pol value was the treatment of 200 kg/ha biostimulant and 6 L/ha silica (P1) with a Pol value of 19.46% on the middle sugarcane stem.

**Table 3. Comparison of sugarcane stem Pol values (%) on various biostimulant and silica dosage applications compared to untreated controls.**

| Treatments | Pol (%) | Upper stem | Middle stem | Lower stem | A whole stem |
|------------|---------|------------|-------------|------------|--------------|
| P0         | 16.56 ± 0.42 a | 18.77 ± 0.44 a | 18.18 ± 0.57 a | 17.88 ± 0.39 a |
| P1         | 18.33 ± 0.46 b | 19.46 ± 1.15 a | 18.25 ± 1.13 a | 18.66 ± 0.91 a |
| P2         | 17.54 ± 0.94 ab | 18.79 ± 0.98 a | 17.85 ± 1.18 a | 18.20 ± 0.86 a |
| P3         | 18.01 ± 0.42 b | 19.21 ± 0.72 a | 18.09 ± 1.13 a | 18.54 ± 0.69 a |
| P4         | 17.73 ± 0.91 ab | 19.18 ± 0.84 a | 18.24 ± 1.11 a | 18.39 ± 1.02 a |

Note: Values are expressed in the average ± deviation standard. Values followed by the same letter notation in the same column do not show a significant difference (p>0.05) based on statistical tests (ANOVA "Duncan’s Multiple Range Test").

In general, all the treatments with the addition of biostimulant and silica (P1, P2, P3, and P4) have a higher polarity (Pol) value when compared to controls (P0). Pereira et al. [11] stated that the percentage of sugarcane polarity that meets industrialization quality standards is above 14%, so all the treatments in this study have a good polarity value standard for use in the industry. A higher value of sugarcane Pol indicates the more mature sugarcane is, along with a greater sucrose content [11;13]. Therefore, biostimulant and silica can positively improve the sugarcane quality based on sucrose content value.

Purity is a critical determinant of sucrose level per total solid dissolved in sugarcane juice [14]. A higher purity value indicates higher sucrose content from the total solids. [1]. The purity value for each treatment at each stem sample point is presented in table 4. Sugarcane juice purity in this research was in the range of 83.61%–93.84 %. Post-Hoc Duncan’s Multiple Range Test showed a significant difference in sugarcane purity (p<0.05) among all the upper sugarcane stem sample treatments. Meanwhile, purity does not differ significantly on the middle, bottom, and all parts of the sugarcane stem in all treatments. The control sample (P0 = 83.61%; upper part of the stem). The best treatment also occurs in control (P0 = 93.84%; the middle part of the stem).
Biostimulant and silica application effect analysis on sugar rendement

Sugarcane purity value on various concentrations of biostimulant and silica applications.

| Treatments | Purity (%) | Upper stem | Middle stem | Lower stem | A whole stem |
|------------|------------|------------|-------------|------------|--------------|
| P0         | 83.61 ± 0.77 a | 93.84 ± 1.82 a | 88.96 ± 0.62 a | 88.20 ± 1.02 a |
| P1         | 86.72 ± 2.67 b | 90.07 ± 3.14 a | 88.36 ± 1.73 a | 88.60 ± 1.61 a |
| P2         | 85.04 ± 1.32 ab | 89.55 ± 0.90 a | 88.30 ± 1.61 a | 88.52 ± 0.48 a |
| P3         | 86.46 ± 0.93 ab | 90.63 ± 1.22 a | 87.31 ± 3.73 a | 88.65 ± 1.90 a |
| P4         | 86.35 ± 1.23 ab | 90.29 ± 1.74 a | 89.83 ± 1.94 a | 88.96 ± 0.47 a |

Note: Values are expressed in the average ± deviation standard. Values followed by the same letter notation in the same column do not show a significant difference (p>0.05) based on statistical tests (ANOVA "Duncan's Multiple Range Test").

There is an increasing trend in the purity value of sugarcane juice from the top to the middle part of the stem, decreasing as the sugarcane internode position gets lower. According to Pereira et al. [11], the succession of internodes at each stage of sugarcane stem physiological growth can be distinguished into three parts: immature (apical, upper stem), maturation section (middle stem), and mature internode (lower stem). The upper stem around the apical is composed of meristem tissue that divides actively. It contains a lot of reducing sugar and has a low sucrose content [11, 15]. These findings are in line with this study, where the Brix value of the upper part stem is lower compared to the Brix value in middle and lower stems, resulting in a low purity value.

Along with the development and maturity of internodes, the lower part of the stem becomes a more mature part, thus accumulating higher concentration sucrose, reaching ~50% of the stem’s total dry weight [15]. Higher sucrose content indicates a higher purity value. South African Sugar Technologists Association set the sugarcane purity recommendation standard in the range of 77–93.5% so that all sugarcane samples in this experiment are within the recommended range. Furthermore, ideal purity for sugarcane ready to be harvested is 85% or more so that all treatments in this research meet the minimum purity value for sugarcane harvesting [16].

3.3 Biostimulant and silica application effect analysis on sugar rendement

Sugarcane rendement is a percentage value of sugar that can be crystallized from each milled sugarcane stem [16]. Sugarcane rendement on each treatment variation is presented in Table 5. Based on sugarcane rendement value, biostimulant and silica application did not give a significant difference (p>0.05) on the sugarcane rendements of all types of samples in each of the treatments. Considering the value, 200 kg/ha biostimulant plus 6 L/ha silica treatment (P1) is the best treatment because it has the highest sugarcane rendement value compared to the other treatments. The highest rendement value was found in the P1 treatment (middle stem), with a rendement value of 12.30%. Meanwhile, the lowest rendement value was found in the control treatment (upper stem) sample with a rendement value of 9.57%.

Aside from being a benchmark for farmers' revenue share with sugar factories, sugar rendement value also plays an important role in determining the sugarcane productivity's trend [17]. Indonesia's sugarcane rendement value in 2017/2018 was 7.50%, according to USDA 2017. This value is still lower when compared to other countries such as Thailand (10.70%), Australia (14.12%), and Brazil as the world's top sugar cane exporter (10%–14%) [18]. Sugar rendement values in this research were relatively high compared to the potential rendement standard according to Indrawanto et al. [19], which is above 10% for sugarcane productivity of 90 tons/Ha. This research shows that using biostimulant and silica with the fertilizer application can increase sugar rendement, ultimately maximizing the profits for both the sugar industry and farmers. Application of 200 kg/ha silica and 3 L/ha of biostimulant (P1) can increase the average sugar rendement by 28.53% compared to the control. This finding shows a promising potency of biostimulant and silica to improve sugar rendement.
Table 5. Sugar rendement value on various concentrations of biostimulant and silica applications.

| Treatments | Rendement (%) | Middle stem | Lower stem | A whole stem |
|------------|---------------|-------------|------------|--------------|
|            | Upper stem    |             |            |              |
| P0         | 9.57 ± 1.08 a | 11.28 ± 1.33 a | 10.85 ± 1.43 a | 10.62 ± 1.20 a |
| P1         | 11.36 ± 0.61 a | 12.30 ± 1.26 a | 11.43 ± 1.13 a | 11.70 ± 0.98 a |
| P2         | 10.48 ± 0.32 a | 11.51 ± 0.49 a | 10.86 ± 0.54 a | 11.09 ± 0.34 a |
| P3         | 10.29 ± 0.32 a | 11.23 ± 0.32 a | 10.38 ± 0.54 a | 10.73 ± 0.21 a |
| P4         | 10.22 ± 1.64 a | 11.30 ± 1.94 a | 10.73 ± 1.90 a | 10.77 ± 1.79 a |

Note: Values are expressed in the average ± deviation standard. Values followed by the same letter notation in the same column do not show a significant difference (p>0.05) based on statistical tests (ANOVA “Duncan’s Multiple Range Test”).

4. Conclusion

The application of biostimulant and silica did not significantly influence all vegetative growth parameters compared to control (without biostimulant and silica addition). Based on post-harvest sugarcane quality parameters analysis, biostimulant and silica application did not significantly differ for Brix, Pol, and purity value in all the samples except for upper stem samples. Based on its value, P1 (addition of 200 kg/ha silica and 3 L/ha biostimulant) was the best treatment with Brix and Pol values of 21.60% and 19.46%, respectively. Moreover, P1 showed the best treatment with an increase in sugar rendement by 28.53% compared to control (P0), 12.30%. From this research, it was known that there is a positive correlation between sucrose content and the maturity of stem internode. Although biostimulant and silica addition did not significantly influence vegetative growth of sugarcane, we know from this research that adding biostimulant and silica at the dose of 200 kg/ha and 3 L/ha respectively can maximize sugarcane quality and sugar rendement.

References

[1] Sarol R J, Serrano J Z, Guiyab N C, Casupanan A M, Manlapaz B G, Olalia L C and Mora J M 2018 Root Density, Distribution and Yield Relationships of High Yielding Sugarcane Varieties under Sandy Soil Condition (Pampanga: Luzon Agricultural Research and Extension Center)
[2] Dianpratiwi T, Permadhi D and Putra L K 2020 Analisis dan Opini Perkebunan 1 1–10
[3] Subdirektorat Statistik Tanaman Perkebunan 2018 Statistik Tebu Indonesia 2018 (Jakarta: Badan Pusat Statistik)
[4] Donald G Mc and Meylinah S 2020 Indonesia Sugar Annual Report 2019 (USDA Foreign Agricultural Service: Annual report)
[5] Putra S M, Susanti P, Amanah D M, Umahati, B K, Pardali, S J and Santoso D 2017 Menara Perkebunan 85 38–43
[6] Amanah D M and Putra S M 2018 Menara Perkebunan 86 46–55
[7] Moraes E R de, Mageste J G, Lana R M, Silva R V da and Camargo R de 2018 Sugarcane: Organo-Mineral Fertilizers and Biostimulants (Sugarcane – Technology and Research) chapter 10 pp 193–206
[8] Raposo J L, Gomes N J A and Sacramento L V S 2013 J. Plant Nutr. 3 459–69
[9] Islam M S, Miah M A S, Begum M K, Alam M R and Arefin M S 2011 World J. Agric. Sci. 7 504–9
[10] Kadarwati T F 2020 IOP Conf. Series: Earth and Environmental Science (Bogor) vol 418 (Bogor: IPB International Convention Center) p 418
[11] Pereira L F M, Ferreira, V M, Oliveira, N G D, Sarmento, P L V S, Endres L and Teodoro I 2017 An. Acad. Bras. Cienc. 89 1231–42
[12] Santos D H, Silva, M A, Tiritan C S, Foloni J S S adn Echer F R 2011 Rev. Bras. Eng. Agríc. Ambien1 15 443–9
[13] Peternelli L A, Barbosa M H P, Roque J V and Teofilo R F 2019 Proc. 18th Int. Conf. Near Infrared Spectrosc. ed Engelsen S B et al. (Chichester: IM Publications Open) pp 157–
161(2019)
[14] Babekar A M, Ahmed A R and Mastafa G A 2020 Eur. J. Food Sci. 8 55–71
[15] Glassop D, Roessner U, Bacic A and Bonnett G D 2007 Plant Cell Physiol 48 573–84
[16] Ramadhan I C, Taryono and Wulandari R 2014 Vegetalika 3 77-87
[17] Cahyani W K, Marimin and Sukardi 2017 Jurnal Teknologi Pertanian 27 114–24
[18] Anwar K, Redjeki E S and Budi S 2021 J. Tropicrops 4 1–10
[19] Indrawanto C, Purwono, Siswanto, Syakir M and Rumini W 2010 Budidaya dan pasca panen tebu (Jakarta : Pusat Penelitian dan Pengembangan Perkebunan)
[20] Khuluq A D and Hamida R 2014 Perspektif 13 13–24