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Effect of Sugarcane Varieties and Milling Delay Time on Cane Sugar Yield

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ABSTRACT

The quality of sugarcane decreases after harvesting so that it affects the yield and sugar production. The objective of this study was to determine the decline in sugarcane production and sugar yield in different varieties and milling delay time. This study used a split plot design consisting of three varieties (PS 881; PSJK 922; Bululawang) as the main plot and delay time (0; 2; 4 days) as sub plots with three replications so that 27 experimental units need to be provided. The observation parameters consisted of initial stalk weight, stalk weight after delay time, initial yield per hectare, yield per hectare after delay time, °brix, %pol, purity, cane yield and sugar yield. Results show that variety and delay time had an effect on stalk weight loss, juice quality, cane and sugar yield. PS 881 and PSJK 922 varieties showed better juice quality and higher cane and sugar yield compared to Bululawang varieties. Sugarcane with a delay time of up to 4 days showed lower stalk weight, juice quality, cane and sugar yield as compared to no delay time. The loss of stalk weight and yield of sugarcane at 2 days delaying time can reach 9.2% and 12.3% at 4 days delay time.

1. INTRODUCTION

Sugarcane is one of the plantation crops that is used as the main source of raw material for producing crystal sugar. Crystal sugar is widely used by Indonesian people as a source of sweetener for both food and drinks. This is indicated by the high level of direct consumption of sugar. Nationally, sugar consumption reached 2.66 million tonnes in 2020, consisting of household consumption, industry, services and others (BPS, 2021). The level of domestic sugar consumption will continue to increase along with the increase in population and growth of the food and beverage industry, so that domestic sugar availability must be guaranteed to be sufficient to meet domestic demand (Andeva *et al*., 2018).

Every year Indonesia continues to import crystal sugar because it is unable to meet its sugar needs, both for consumption and industrial needs. Indonesia's sugar imports in 2021 reached 5.46 million tonnes or 1.53% lower than the previous year, but overall during the 2012 - 2021 period sugar imports increased by 9.35% per year (BPS, 2021). This was also influenced by low domestic sugar production which caused import volumes to increase to cover the resulting sugar deficit. Sugar production in Indonesia was only 2.55 million tons in 2013 and is estimated to decrease to 2.35 million tons in 2022 (Kementerian Pertanian, 2022). Apart from that, sugar consumption in Indonesia also continues to increase along with the increase in population and the development of the food and beverage industry. Overall, the national sugar need until 2021 will reach 3.9 million tons, including the need for imports of raw sugar (Jaelani *et al*., 2022).

In the process of making sugar, the quality of sugar cane is the main factor that must be considered because it is susceptible to degradation which can be caused by various factors such as temperature, humidity, delivery and processing time, as well as the maturity level of the sugar cane (Urgesa & Keyata, 2021). Post-harvest reduction in sugar cane quality affects the yield of sugar that can be crystallized. Improper handling after the sugar cane is cut can reduce the yield of cane sugar because the value of the sucrose which should be able to crystallize into sugar is reduced. The process from harvesting sugar cane to processing has the potential to experience sugar losses of up to 35% or more if not carried out properly (Prasetiyo *et al*., 2016). The efficiency of sugar cane processing in a sugar cane mill also influences the sugar extraction process that can be produced (Tando, 2017). Therefore, post-harvest handling needs to be paid attention to, especially the time after harvest until the sugar cane is milled at the sugar factory.

The decline in sugarcane quality, especially the reduction of sugar content in sugarcane, is a major problem in the sugar industry (Datir & Joshi, 2015). The sucrose content in sugar cane stalks will continue to decrease after being cut. Sucrose will undergo a degradation process shortly after being cut so it must be processed immediately to avoid further sucrose loss. Apart from that, sugar cane that is not immediately milled has the potential to lose weight and increase the reducing sugar content (Kurniawan & Purwono, 2018). Differences in varieties can also cause differences in the level of sucrose loss in sugarcane due to differences in genetic potential, thus affecting the characteristics of the sugarcane stalks (Misra *et al*., 2022). According to Kuspratomo *et al*. (2012), factors that have a big influence on sugarcane quality include the potential of the sugarcane variety and the length of delay in milling. The research results of Vajantha *et al*. (2019) showed that delaying milling for 5 days could reduce stem weight by up to 5.93% and sugar yield by 9.5%. The research results of Sohu *et al*. (2011) also stated that the reduction in sugar cane stalk weight could reach 7.64% if it was not immediately milled within 8 days of harvest. Furthermore, according to Mueangmontri *et al*. (2020) the sucrose content of sugar cane decreased by 5% per day of delay in milling.

Based on the description above, research is needed regarding the reduction in yield and sugar cane in different varieties and milling delay times. The aim of this research was to determine the reduction in yield and sugar cane in different varieties and different milling delay times.

2. RESEARCH METHOD

2.1. Location, Time, and Materials

This research was carried out in August 2022 at laboratory of PG. Kebon Agung, Pakisaji, Malang Regency, East Java. The materials used in this research were sugar cane of three varieties, namely PS 881, PSJK 922 and Bululawang obtained from the Sempalwadak Experimental Field, Malang Regency, East Java. The sugarcanes had reached harvest age, namely 10 months for the PS 881 variety, 11 months for the PSJK 922 variety and 12 months for the Bululawang variety. The amount of sugar cane used for each treatment was 3 sugar cane stalks.

2.2. Research Design and Observations

This research was structured using a Split Plot Design with varieties as the main plot and length of milling delay as a sub plot. The varieties as the main plot consisted of 3 types of varieties, namely the PS 881, PSJK 922 and Bululawang varieties. The PS 881 sugar cane variety is an early ripe variety, PSJK 922 is a middle ripe variety, and Bululawang is a late ripe variety. The length of milling delay time as a subplot consisted of 3 levels, namely 0, 2 and 4 days. The combination of these two factors resulted in 9 treatments and were replicated 3 times so that there were 27 experimental units. Each treatment was labeled and the sugar cane stalks were stored at room temperature ± 25 ºC and not exposed to direct sunlight.

The harvested sugarcane was then weighed to determine the initial weight and then stored in the Milling Laboratory of PG. Kebon Agung at room temperature (± 25 ºC) and treated according to the type of variety and length of delay time for milling. The sugar cane that has been stored according to the milling delay time was then weighed again to determine the final weight and juice analysis was carried out to determine the ºbrix, %pol, purity level, and yield. The juice analysis was carried out based on the procedures prepared by P3GI Pasuruan in the book of *Penuntun Pengawasan Gilingan* (Buletin 4). The sugarcane stalks were cut into 3 parts and then put into a mill to get sap. The juice obtained was then taken as much as 100 ml and put into a measuring flask. The remaining juice from the milling process was also observed using a refractometer to determine the ºbrix value. The sugarcane juice in a measuring flask was then mixed with 5 ml of form A and 5 ml of form B. The solution mixture was shaken until homogeneous and then filtered using modified straw paper to obtain pure juice. The pure juice was then inserted into a saccharomat polarimeter to obtain the ºbrix, %pol, purity value, sap value and yield.

Observations in this research were carried out to obtain quantitative data. Quantitative observations consisted of initial cane stem weight (kg/m^2), final cane stem weight (kg/m^2), stem weight reduction percentage (%), yield per hectare of initial cane (tons/ha), yield per hectare of final cane (ton/ha), ºbrix, %pol, purity, yield and crystal. Sugarcane harvest per hectare can be obtained using the formula:

$$\text{Harvest yield} = PB \times BB \times JJ \times JB \quad (1)$$

where *PB* is the length of the stem (m), *BB* is the weight of the stem per meter (kg/m), *JJ* is the number of row per hectare (833 rows), and *JB* is the ideal number of stems per row (90 stems).

2.3. Data analysis

The data obtained from the research results were analyzed using analysis of variance (ANOVA) based on the Divided Plot Design. Analysis of variance was carried out to determine whether there were significant differences in the single treatment factor or the interaction of the two factors. If the results of the analysis of variance show a real effect, a further test will be carried out using the Least Significant Difference (LSD) to determine the real differences between treatment levels.

3. RESULTS AND DISCUSSION

3.1. Weight Loss of Sugarcane Stems

The results showed that there was no real interaction between the type of sugarcane variety and the length of pre-milling time on the weight of the sugarcane stem. However, the influence of the single factor type of sugarcane variety and the length of delay for milling has an effect on the weight loss of sugarcane stalks per meter. The average reduction in stem weight per meter and the percentage of weight reduction can be seen in Table 1. It shows that the length of delay in milling sugar cane has a significant effect on the percentage of weight loss per meter of sugar cane. The longer the milling delay time or the longer the sugar cane is not immediately milled, it can cause greater weight loss of the sugar cane stalks. This is caused by loss of water in the cane stalks due to evaporation or chemical processes after harvesting. Loss of water can cause the weight of the sugarcane stalks to decrease so that less sap can be extracted from the sugarcane stalks. This is in accordance with the opinion of Vajantha *et al*. (2019) that most of the reduction in sugarcane stalk weight is caused by evaporation and respiration resulting in loss of water content in the sugarcane stalk. Apart from that, according to Misra *et al*. (2020) the rate of weight loss of sugar cane stalks can vary depending on temperature, humidity, wind speed, type of variety used, and storage conditions. Loss of stem weight also occurs more quickly, especially in

Table 1. Weight loss of sugarcane stems for different varieties and length of pre-milling time

Treatment	Cane Length (m)	Initial weight (kg/m)	Final weight (kg/m)
Variety			
PS 881	2.17	0.72 b	0.67 b
PSJK 922	2.30	0.74 b	0.69 b
Bululawang	2.33	0.50 a	0.47 a
LSD 5%	-	0.13	0.10
Delay Time			
0 day	2.16	0.68	0.68 b
2 day	2.28	0.66	0.61 a
4 day	2.36	0.62	0.54 a
LSD 5%	-	ns	0.07

Note: Numbers followed by the same letters in the same column indicate not significantly different based on the 5% LSD test; ns = not significant.

mechanically harvested sugar cane, causing the size of the sugar cane to become smaller, which has the potential to experience water loss more quickly due to the high surface area (Datir & Joshi, 2015).

3.2. Juice Quality and Sugar Cane Yield

The results of the research show that there is a significant interaction between the type of sugarcane variety and the length of milling delay on the ºbrix of sugarcane. In addition, the single factor type of sugarcane variety and length of milling delay showed a significant influence on other juice quality indicators such as %pol, juice purity, juice value (%), and juice yield. The results of the interaction between the type of sugarcane variety and the length of milling delay time on ºbrix can be seen in Table 2, while the influence of the single factor of sugarcane variety and the length of milling delay time on the juice quality and sugarcane juice yield can be seen in Table 3.

Table 2 shows that the interaction of sugarcane variety type and length of pre-milling time shows a decrease in ºbrix along with the length of delay in pre-milling time. The PS 881 and PSJK 922 varieties experienced a higher reduction in ºbrix, namely 17.86% and 15.88% respectively if they experienced a milling delay of up to 4 days compared to without a milling delay. Meanwhile, the Bululawang variety tends to experience a lower ºbrix reduction, namely 6.96% compared to without delay milling. This condition shows that each variety has a different ability to maintain the juice content in sugar cane. Sugarcane that is not processed immediately after harvest also affects the brix content of sugarcane juice. This is in accordance with the statement of Yesuf *et al*. (2016) that each variety has different genetic capabilities which influence the brix value produced by sugarcane. The brix percentage is also directly related to the moisture in the sugar cane stalk. The lower the humidity of the sugar cane stalk, the brix percentage will also decrease along with the weight of the stalk also decreasing (Ali *et al*., 2018).

Table 2. Effect of interaction between type of sugarcane variety and length of milling delay on ºbrix of sugarcane juice

Sugarcane Variety	ºbrix at different delay time (day)		
	0	2	4
PS 881	18.75 d	16.44 c	15.40 ab
PSJK 922	18.07 d	15.80 abc	15.20 a
Bululawang	16.08 bc	15.67 abc	14.96 a
BNT 5%	0.84		

Note: Numbers followed by the same letters in the same column indicate not significantly different based on the 5% LSD test; ns = not significant.

Table 3. Effect of single factor of sugarcane variety and milling delay time on the yield and juice quality

Treatment	°Brix	%Pol	Purity level (%)	Juice value (%)	Yield (%)
Variety					
PS 881	16.86 b	13.90 b	82.47 ab	12.72 b	6.36 b
PSJK 922	16.36 b	13.92 b	85.20 b	12.94 b	6.47 b
Bululawang	15.57 a	12.41 a	79.71 a	11.14 a	5.57 a
LSD 5%	0.78	0.70	4.30	0.87	0.43
Milling delay time					
0 day	17.63 b	14.70 c	83.39	13.53 b	6.76 b
2 day	15.97 a	13.21 b	82.83	12.11 a	6.05 a
4 day	15.19 a	12.32 a	81.15	11.17 a	5.58 a
LSD 5%	0.84	0.86	ns	1.08	0.54

Note: Numbers followed by the same letters in the same column indicate not significantly different based on the 5% LSD test; ns = not significant.

Table 3 shows that the type of sugarcane variety and the length of delay for milling affect the quality of the juice and the yield produced. The PS 881 and PSJK 922 varieties tend to have higher sap quality compared to the Bululawang variety. The different juice quality and yield between varieties shows that the varieties have different genetic abilities so that the quality of the juice and yield produced are also different. This is in accordance with the statement of Riajaya *et al*. (2022) that the yield produced by sugar cane is greatly influenced by plant genetics and optimal environmental conditions for plant growth. Apart from that, delaying milling for 2 days and 4 days reduces the quality of sap so that it has an impact on the yield obtained. This supports the research of Saxena *et al*. (2010) which shows that the highest rate of decrease in yield in sugar cane occurs 48 to 72 hours after harvest. Apart from that, the purity of sap also decreased with increasing milling delay time, even though this study did not show a real difference in purity parameters. This cannot be separated from bacterial activity which can reduce the purity of the juice. Bacterial activity can increase if the storage environmental conditions are suitable for the development of bacteria so that it can reduce the sucrose content in sugar cane stalks (Mueangmontri *et al*., 2020). The presence of bacteria in juice causes a fermentation process due to the amylase enzyme produced by bacteria, resulting in a process of changing sucrose into fructose and glucose which will then turn into alcohol and water (Ansar *et al*., 2019; Destriyani *et al*., 2014).

3.3. Yield and Crystal Loss in Sugarcane

The research results showed that there was no significant interaction between the type of sugarcane variety and the length of milling delay on the loss of sugarcane yield and sugar crystals produced. However, the single factor type of variety and length of milling delay have a significant effect on the loss of sugar cane and crystal sugar yields as shown in Table 4. It shows that variety and length of milling delay have a significant effect on harvest yield and sugar crystals per hectare. Each variety has different potential yields and yields so the amount of shrinkage experienced is also different. The increasing delay time for milling, up to 4 days, causes the crystal sugar obtained to be also lower. The decrease in crystal is caused by chemical reactions and microbial activity in the sugar cane stalks which causes the quality of the juice to decrease, thus disrupting the sugar extraction process and reducing the amount of sugar that can be crystallized. This is in accordance with the statement of Khan *et al*. (2020) that the decrease in sugar yield is due to the invertase enzyme reaction which increases with the length of the grinding time delay. The invertase enzyme causes sucrose to break down into glucose and fructose. Apart from that, delaying the milling time causes sugar cane to also produce dextran due to microbial activity. Dextran causes losses in the sugar extraction process because it interferes with the sugar separation and crystallization process as a result of increasing the viscosity of the juice so that the resulting sugar is lower (Baktir *et al*., 2010).

Table 4. Yield of sugar cane and sugar crystals per hectare for different varieties and milling delay times.

Treatment	Cane production at harvesting (ton/ha)	Cane production after delaying 4 days (ton/ha)	Crystal production (ton/ha)
Variety			
PS 881	115.3 b	108.0 b	7.67 b
PSJK 922	126.4 b	117.5 b	8.48 b
Bululawang	86.9 a	79.81 a	4.97 a
LSD 5%	15.1	13.1	1.29
Milling delay time			
0 day	107.0	107.0 b	8.15 b
2 day	112.5	102.6 ab	6.99 ab
4 day	109.2	95.7 a	5.98 a
LSD 5%	ns	9.43	1.24

Note: Numbers followed by the same letters in the same column indicate not significantly different based on the 5% LSD test; ns = not significant.

4. CONCLUSION

The PS 881 and PSJK 922 varieties have higher juice quality and yield than the Bululawang variety. The milling delay time of 2 days and 4 days reduces sugar cane weight, juice quality, yield per hectare, and sugar crystals per hectare. Sugar cane stalks experienced weight loss of 9.2% at a milling delay of 2 days and 12.3% at a milling delay of 4 days as compared to milling without delay. The sugar crystal obtained also decreased by 14.2% at a milling delay of 2 days and 26.6% at a milling delay time of 4 days as compared to that of processed directly without delaying.

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