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PERFORMANCE OF CLONES OF THE 2018-CROSSBREED IN INCEPTISOL SOIL

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ABSTRACT
One way to increase sugarcane productivity is by improving the genetic potential through breeding by creating superior varieties with high sucrose content and quality. Improving the genetic potential can be done through hybridization followed by selection. The study took place in KP Karangploso, Malang, from January to December 2019. The study used 153 selected clones from the 2018 crossbreed (MLG-18). Each clone was planted on a plot consisting of 3 rows of 5 meters. The CTC (center-to-center) distance was 100 cm. Bud sets were grown in the nursery as seeds. Growing seeds aged 1.5 months were uniformly selected and planted in rows with a 50-cm planting distance; thus, each plot held 30 plants. Fertilizing was done with a dose of 160 kg N + 70 kg P2O5 + 60 kg K2O per ha. We observed the following parameters: number of stalks per clump, stalk length, stalk diameter, stalk weight per clump, sucrose content, and sugar sugar. This study aimed to produce sugarcane clones with high productivity and high quality. Our findings confirmed that: (1) 40 clones produce sugar of more than 0.65 kg per clump or equal to 10 tons per ha; (2) 72 clones have sucrose content of more than 10%; (3) 49 clones have minimum productivity of 6.05 kg per clump; (4) 59 clones have a minimum of 6.3 stalks per clump; (5) 38 clones have stalk weight of more than 1.0 kg per stalk; (6) 42 clones have a minimum stalk length of 150.0 cm; and (7) 1,749 clones have a minimum stalk diameter of 2.00 cm.

KEY WORDS
Performance, clone, sugarcane, crossbreeding, soil, inceptisol.

Sugarcane is one of Indonesia's strategic and important food commodities because sugarcane is the main source of sugar production. The total sugarcane plantation in 2021 was 443,501 ha, with a total production of 2,364,321 tons. The production of white sugar tends to fluctuate, mainly due to climate. The average production increase was 2.48% from 1970, but the production decreased by an average of 0.66% per year from 2015 to 2021 (Dirjenbun, 2020). The decline in production was caused by many factors, including low production and quality. Thus, it is necessary to increase the productivity and quality of sugarcane plants. One effort to do so is by improving the genetic potential through breeding programs, such as creating new superior varieties with high sucrose content and quality able to adapt to biotic and abiotic environmental pressures (Nels, J.R. 1981).

However, it is not easy to produce new superior varieties with high sucrose content and quality. Many factors affect the process of producing new superior varieties, including internal and external factors. External factors include biotic factors, such as pests and diseases, or abiotic factors, such as environmental stresses. One way to overcome these obstacles is by improving plant genetic traits, one of which is through crossbreeding. The success of a plant breeding program is largely determined by the availability of genetic diversity (Sumarno, 2002). Plant productivity can be increased by implementing environmental changes (amelioration) or utilizing plant genetic engineering. However, changing or improving the environment requires very high costs and may bring negative effects. Meanwhile, improvements by engineering plant genotypes are relatively cheaper and do not harm the environment (Lewis, 1982).

Since a long time ago, efforts have been made to get new high-sucrose contenting varieties in sugarcane; one of the efforts is through hybridization, followed by the selection of clones obtained from crosses. Bressiani et al. (2003) suggest that the first stage of selection

is generally based on Brix and stem height, while Chaudary (2000) suggests that in sugarcane, the selection can be based on parameters of weight per stalk and number of stalks that could be milled to obtain more sugar. The study aimed to identify clones from 2018 crossbreed in inceptisol soil.

MATERIALS AND METHODS OF RESEARCH

The study took place in KP Karangploso, Malang, from January to December 2019. The study used 30 combinations of 2018-crossbreed (2108 plants including parental varieties or clones and other varieties as a comparison), from which we selected 153 clones from the 2018 crossbreed (MLG-18). Each clone was planted on a plot consisting of 3 rows of 5 meters. The CTC (center-to-center) distance was 100 cm. Bud sets were grown in the nursery as seeds. Growing seeds aged 1.5 months were uniformly selected and planted in rows with a 50-cm planting distance; thus, each plot held 30 plants. The tools used include tape measures, scales, calipers, hand refractometers, and other additional tools.

Fertilizing was done with 160 kg N + 70 kg P2O5 + 60 kg K2O per ha or equal to 800 kg ZA + 200 kg SP36 + 100 kg KCl per ha. SP36 fertilizer was applied during tillage. ZA fertilizer was applied 2 times, the first at the age of 2 weeks after planting as much as 300 kg, and the second fertilization using 500 kg of ZA was applied 2 months after the first ZA fertilization. KCl fertilizer was given together with the second ZA fertilization. Other plant maintenance included weeding and controlling pests and diseases following the conditions in the field.

The MLG-18 population was carried out in two stages: (a) visually selecting individual plants through lodging, number of stalks per clump, and stalk diameter, and (b) choosing the selected individuals in the first stage based on the sugar they produced. The first selection was made by selecting plants without lodging, having a population of at least 4 stalks per clump, and having a stalk diameter of at least 1.50 cm. The selected clones were then observed for stalks per clump, stalk length, stalk diameter, stalk weight per clump, sucrose content, and sugar.

The data obtained were analyzed using descriptive statistics. A multiple linear analysis (Stepwise analysis) was carried out to trace the path of sugar improvement. The multiple linear analysis was done between the sugar and sucrose content and productivity, between sugarcane productivity and stalk number and stalk weight, and between stalk weight and stalk length and diameter.

RESULTS AND DISCUSSION

The first visual selection resulted in 117 clones, and those clones were observed for their sugar, sucrose content, productivity, the number of stalks per clump, stalk length, and stalk diameter. The observation results are presented in Figures 1 to 7.

The sugar of clones from the 2018-crossbreed varied. The sugar was from 0.073 to 1.462 kg per clump, with an average of 0.596 kg per clump (Figure 1). We found 40 clones that produced sugar of more than 0.65 kg per clump or equal to 10 tons per ha. Soomro et al. (2012) confirm that the different amount of sugar produced is due to different clones used.

Sugar represents the quantity of sucrose obtained per unit of land area (Gomathi et al., 2013). The sucrose content and sugarcane productivity are two main components that compile sugar productivity (Dashora, 2012; Junejo et al., 2010). In this study, the relationship between the sugar and sucrose content and sugarcane productivity was obtained by forming the following equation: sugar = 0.40085 of sucrose content + 0.93902 of sugarcane productivity - 0.32866 with a correlation coefficient (r) of 0.996*. These results mean that the sucrose content and productivity of sugarcane determined 99.6% of sugar produced. The influence of sucrose content and sugarcane productivity on sugar produced was 22.66% and 76.94%. Thus, the sugarcane improvement in the 2018-crossbreed occurred through productivity improvement.

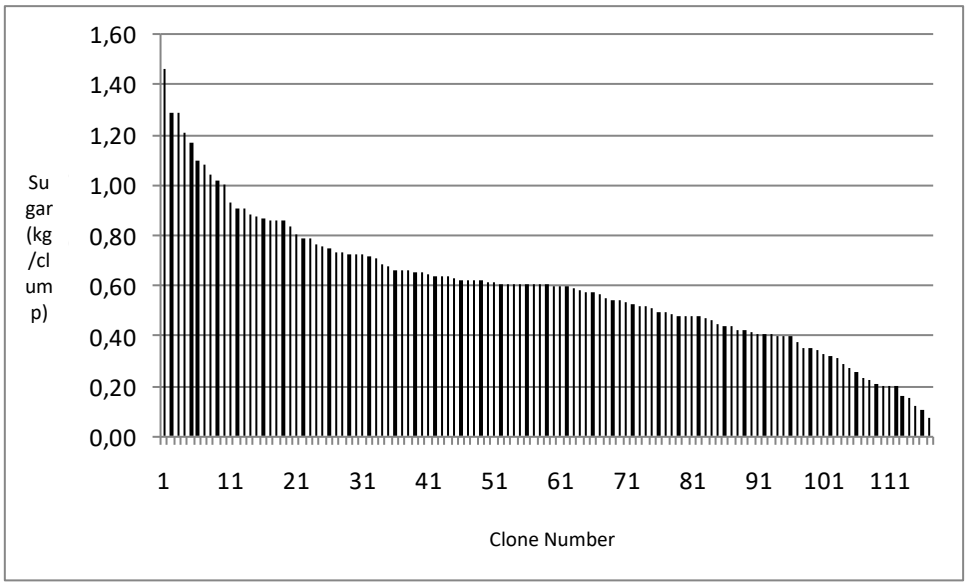

Figure 1 – Sugar of the Clones of the 2018-crossbreed

Sucrose content reflects the quantity of sucrose in the harvested sugarcane; the higher the sucrose content, the higher the sucrose content in the stalk (Inoue et al., 2009). Sucrose in sugarcane stalks at harvest results from the accumulation of carbohydrate deposits starting at the beginning of the generative phase (9 months after planting) until the plants are harvested. Carbohydrate deposits come from the remaining photosynthate after being used for respiration and maintenance. The length of the generative phase and the quantity of carbohydrate deposits of each plant genetic varies. Such conditions cause the sucrose content to vary from 7.57% to 12.08%, with an average of 10.24% (Figure 2). We found 72 clones producing sucrose contents of more than 10%, and the remaining 45 clones produced less than 10%. Schultz et al. (2017) show that the genetic differences in sugarcane cause the difference in sucrose content.

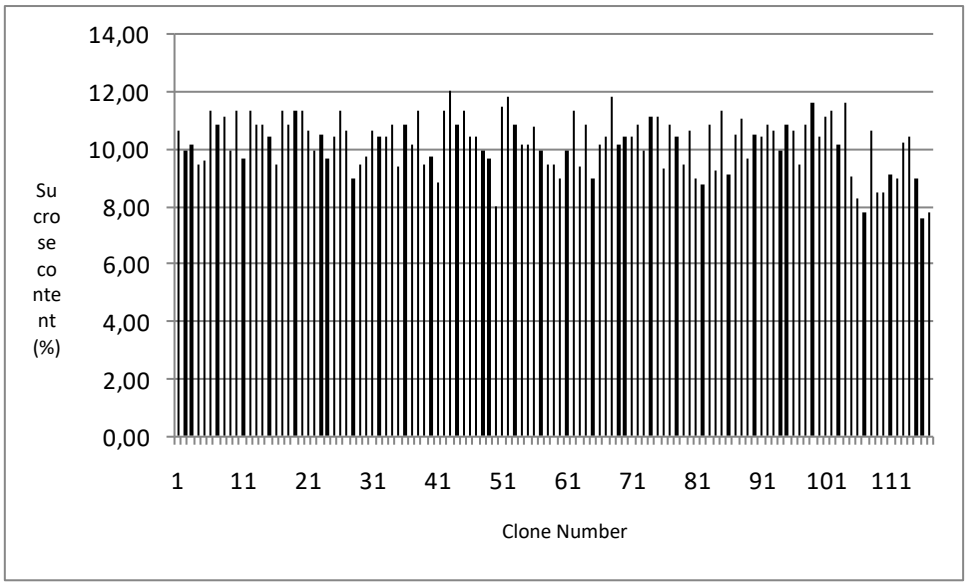

Figure 2 – Sucrose Content of the Clones of the 2018-crossbreed

The sugarcane productivity of the clones varied, from 0.93 to 13.73 kg per clump, with an average of 5.80 kg per clump (Figure 3). We found 49 clones with a productivity of more than 6.05 kg per clump, while other clones resulted in less than 6.05 kg per clump. Soomro et al. (2012) confirm that the genetic differences in sugarcane cause productivity differences.

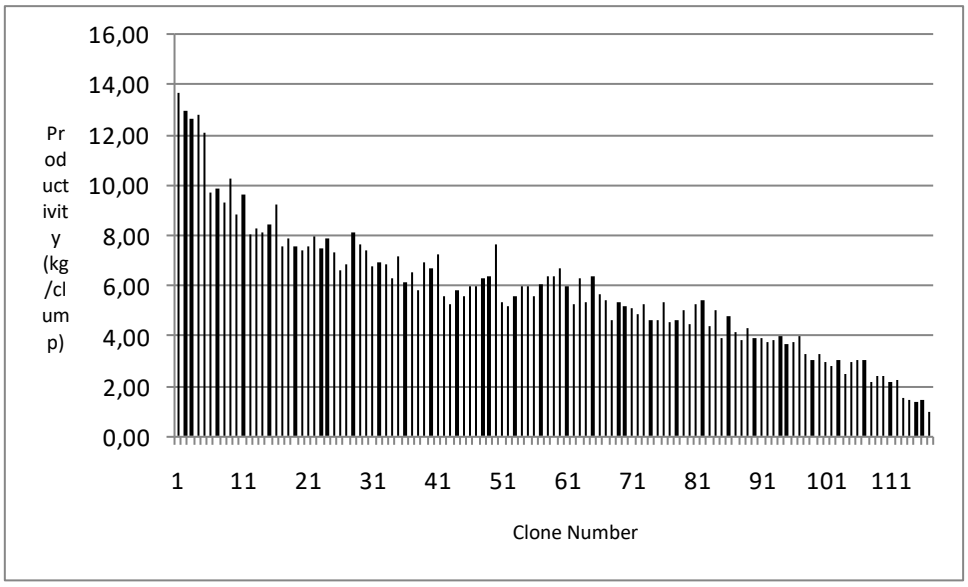

Figure 3 – Productivity of the Clones of the 2018-crossbreed

Sugarcane productivity represents the weight of sugarcane stalks. The weight and the number of stalks are the component of sugar cane productivity (Kumar et al., 2012; Patel et al., 2014). In this study, the relationship between sugarcane productivity and the number of harvested stalks and the weight of sugarcane stalks can be written using the following equation: sugarcane productivity = 0.79233 of the weight of sugarcane stalks + 0.86680 of the number of harvested stalks - 0.36744 with the correlation coefficient (r) of 0.970. The result means that 97.0% of sugarcane productivity is influenced by the number and weight of the stalks. The number of stalks influenced 72.1% of productivity, and the stalk weight per clump influenced 24.9% of productivity. Thus, the improvement of sugarcane productivity in the 2018-crossbreed occurred through the improvement of stalk weight.

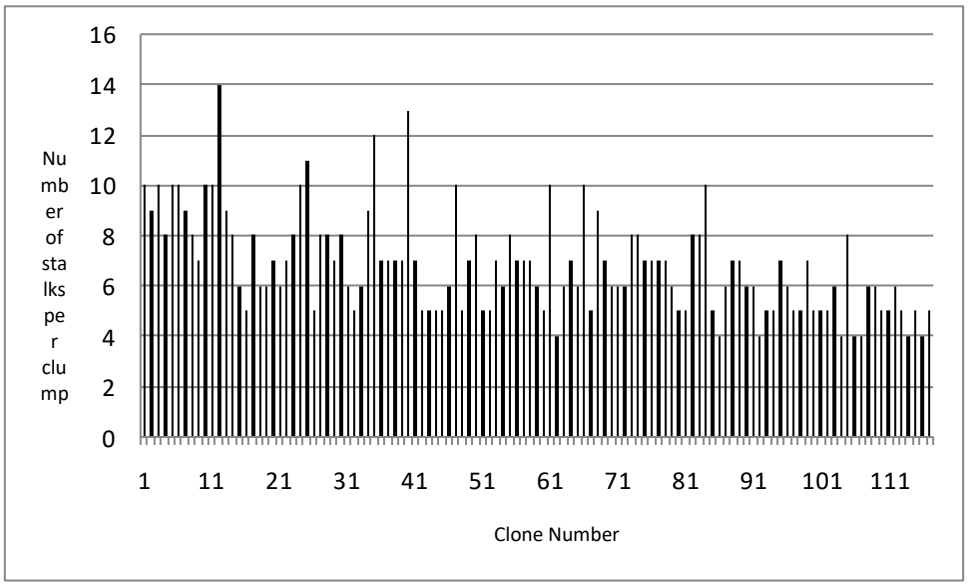

Figure 4 – Number of Stalks per Clump of the Clones of the 2018-crossbreed

The number of stalks per clump is one component of growth that determines sugarcane productivity (Soomro et al., 2012; Tyagi et al., 2013). The number of stalks per clump is determined by the ability of plants to produce young plants and provide food supplies to support the growth of the offspring (Wang et al., 2013). The ability of plants to produce young plants is influenced by plant genetics, while the ability to supply food is

determined by the quantity of carbohydrates available for growth. If carbohydrates for growth are limited, many young plants will die, so the number of harvested stalks per meter of the row will decrease. Within the same environmental condition, plant genetics also determines the quantity of carbohydrates for growth. Therefore, the clones of the 2018-crossbreed produce various numbers of stalks per clump, from 4.0 to 14.0 stalks per clump, with an average of 6.82 stalks per clump (Figure 4). If we assume that the number of stalks per clump of individual plants decreases by 40% compared to plants in the population, the conditions for the plant to be selected will change to 6.3 stalks per clump. Only 59 clones of the 2018-crossbreed produced a minimum of 6.3 stalks per clump. Shukla (2007) and Dashora (2012) show that the genetic differences of sugarcane plants cause differences in the number of stalks harvested.

Stalk weight represents the accumulated carbohydrates available for stalk growth during the vegetative phase and carbohydrate deposits during the generative phase (Yong et al., 2019). Plant genetics affects the carbohydrates available for growth and carbohydrate deposits. Thus, the clones of the 2018-crossbreed produce various stalk weights from 0.187 to 1.841 kg per stalk, with an average of 0.857 kg per stalk (Figure 5). We found 38 clones producing stalk weight of more than 1.0 kg per stalk. Chohan et al. (2014) show that the genetic differences of sugarcane plants cause differences in stalk weight.

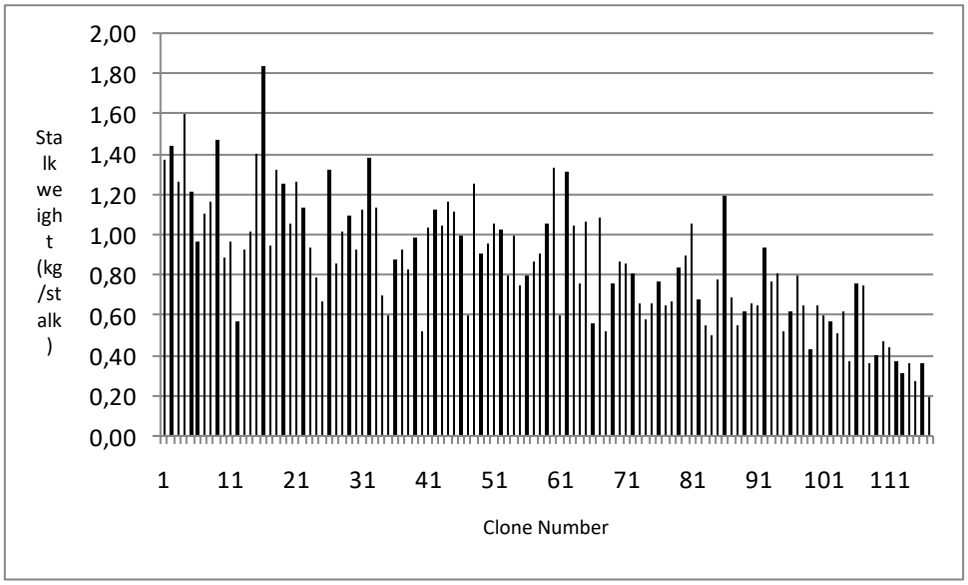

Figure 5 – Stalk Weight of the Clones of the 2018-crossbreed

Stalk length and diameter are the two components of growth that determine stalk weight (Chohan et al., 2014; Sajjad et al., 2014). We found the relationship between stalk weight with stalk length and diameter that can be written using the following equation: stalk weight = 0.56537 of stalk length + 1.2093 of stalk diameter – 0.86594 with a correlation coefficient (r) of 0.982. The result means that stalk length and diameter influence 98.2% of stalk weight—in which stalk length influences 42.5% of stalk weight and stalk diameter influences 55.7% of stalk weight. Thus, the improvement of sugarcane stalk weight in the 2018-crossbreed occurred through the improvement of stalk diameter.

Stalk length and diameter represent the accumulated carbohydrates available for growth from the beginning of growth to the harvest time (Streck et al., 2010). The more carbohydrates accumulated during those periods, the longer and bigger the sugarcane stalks will be (Silva et al., 2013). The accumulated carbohydrates available for growth are determined by the quantity of carbohydrates available for daily growth (Jones et al., 2011; Marin et al., 2011). The daily carbohydrates for daily growth result from photosynthesis minus respiration and maintenance (Streck et al., 2010). The photosynthesis rate is influenced by plant genetics and environmental growth conditions (Stirbert et al., 2014).

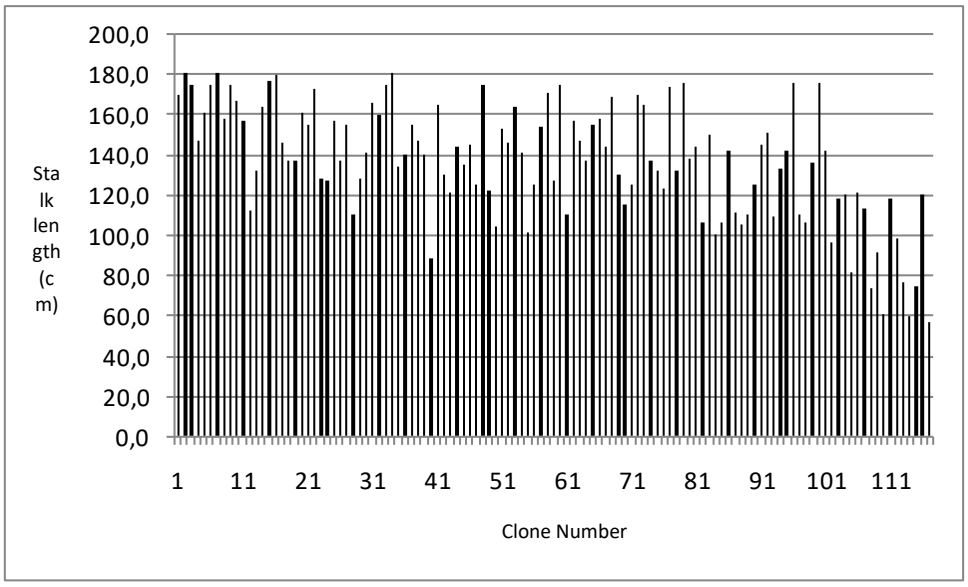

Figure 6 – Stalk Length of the Clones of the 2018-crossbreed

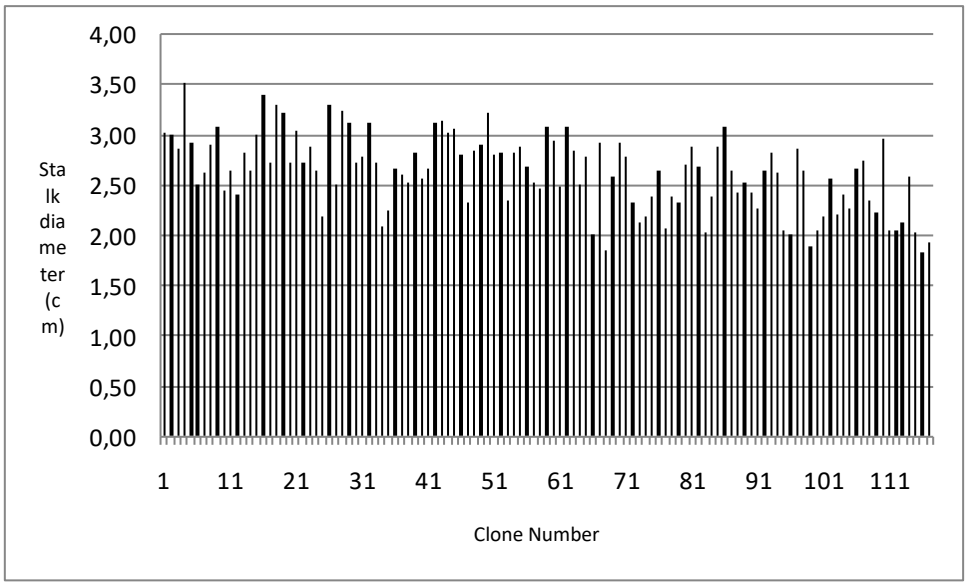

Figure 7 – Stalk Diameter of the Clones of the 2018-crossbreed

Plant genetics affects photosynthesis rates in homogeneous environmental growth conditions (Zhao et al., 2015). Therefore, the obtained stalk length of the clones varied from 56.5 to 181.0 cm, with an average of 136.92 cm, and the stem diameter varied from 1.83 to 3.52 cm, with an average of 2.63 cm (Figure 6 and 7). We found 42 clones producing a minimum stalk length of 150.0 cm. Almost all clones produced a minimum diameter of 2.00 cm except clones 18/58, 18/2/3, 18/21/10, and 18/59. Rahman et al. (2008) and Islam et al. (2011) show that the genetic differences in sugarcane cause the difference in stalk length and diameter.

CONCLUSION

From the identification of 153 clones, we present the following conclusions:

- As many as 40 clones produce sugar of more than 0.65 kg per clump or equal to 10 tons per ha;
- As many as 72 clones have more than 10% sucrose content;
- As many as 49 clones have minimum productivity of 6.05 kg per clump;

- As many as 59 clones have a minimum of 6.3 stalks per clump;
- As many as 38 clones have stalk weight of more than 1.0 kg per stalk;
- As many as 42 clones have a minimum stalk length of 150.0 cm;
- As many as 1,749 clones have a minimum stalk diameter of 2.00 cm.

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