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Agronomic traits determinants of superior varieties and millable cane productivity of sugarcane (S*accharum officinarum* L.) on dryland, Indonesia

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Abstract. Indonesia is one of the sugar-producing countries in the world, with most of the planting area shifted to dryland, sub-optimal. During the development of production, it is necessary to select varieties that are suitable for dryland. This study aimed to determine the adaptation of superior sugarcane varieties on dryland. This study used a split-plot under repeated Randomized Complete Block Design (RCBD). Six superior sugarcane varieties used in this research were *Saccharum* 'CMG Agribun ', *Saccharum* 'AAS Agribun', *Saccharum* 'ASA Agribun', *Saccharum* 'AMS Agribun', *Saccharum* 'PS864' and *Saccharum* 'Bululawang'. The variables observed were plant height, stem diameter, number of segments, and number of tillers at the age of 13, 15, and 17 WAP (weeks after planting). The results showed that growth parameters, namely plant height at 13 and 15 WAP, number of tillers at 15 and 17 WAP, and stem diameter at 13 and 15 WAP, showed better growth, indicating superior agronomic properties of a sugarcane variety on dryland. *Saccharum* 'AMS Agribun' and *Saccharum* 'Bululawang' varieties, stem diameter, increased with spacing treatment at the early growth of 17 weeks after planting. The *Saccharum* 'PS864' was the best, having the highest average of agronomic values compared to other varieties. The *Saccharum* 'PS864' had the highest plant height and number of internodes. The highest number of tillers was obtained in the *Saccharum* 'AAS Agribun' varieties.

Key words: adaptation, dryland, sugarcane, superior varieties.

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is a widely grown plant species. The species has been cultivated by millions of farmers in Indonesia to produce sugar as a source of livelihood, which helps the national economy (Indonesian Sugar Cane Statistic, 2020). Besides being used as a processed product, it is also a commodity as raw material for industrial foods or beverages. Sugarcane is also a potential source of energy from bagasse biomass (Brunerova et al., 2018). The demand for sugar is increasing following the increasing population. However, there is still a gap between the demand and production of domestic sugar.

Southeast Sulawesi is a potential area for planting sugar cane. Southeast Sulawesi can be used as a sugarcane development area by considering various problems or obstacles in the dryland planting area. One of the constraints is most planting areas in Southeast Sulawesi are dominated by Ultisol or Podzolik Red Yellow (PRY). This type of soil with low soil fertility due to high acidity, low organic matter content, macronutrient deficiency, high Al saturation, and very high Fe content (Sujana & Pura, 2015). In addition, the limited water availability on dryland is another important inhibiting factor in using agricultural land to support optimal production.

The success of each planting is dependent on the availability of quality seeds. Unfortunately, most farmers still use poor-quality seeds with genetic (Mulyono, 2011). This is one of the factors causing the low productivity of national sugarcane. The use of quality seeds includes the use of superior varieties. One example of a superior variety of sugarcane is PS864. The best yields of the ridges and furrows planting systems were PS864 compared to Bululawang, PSJT 941, VMC, PS 881, and Kidang Kencana varieties (Rokhman et al., 2014). The superior varieties of sugarcane released by the Center for Plantation Research and Development in 2017 were *Saccharum* 'CMG Agribun ', *Saccharum* 'AAS Agribun', *Saccharum* 'ASA Agribun', *Saccharum* 'AMS Agribun'. These varieties produced millable cane, sucrose content, and sugar in the range of 120–200 tons ha^{-1}, 10–11%, and 12–20 tons ha^{-1}, respectively (Center plantation research and development, 2018).

Superior sugarcane varieties adapted to drought stress, especially on dryland in Southeast Sulawesi. According to Hemaprabha (2014), new sugarcane varieties are released for specific purposes, e.g., sugarcane is rated as a drought-tolerant variety. This is in line with the report of Zhao et al. (2022) that there are variations in agronomic characteristics among sugarcane varieties, such as single-stem weight, height, stem diameter, and millable cane could be under certain climatic conditions. Therefore, the use of high-yielding varieties in this study is expected to provide results on the adaptation of high-yielding sugarcane varieties on dryland in Southeast Sulawesi.

MATERIALS AND METHODS

The research was conducted on the dryland of the Onembute Experimental Garden in Anggondara Village, Palangga District, South Konawe Regency, Southeast Sulawesi. The experiment was located at an altitude of 93 m. According to Koppen's classification, it belongs to a tropical monsoon climate (S: 4°21'07" and E: 122°20'15"). In 2018, the monthly precipitation of January, February, March, April, May, June, July, August, September, October, November, and December were 227.0; 210.0; 231.0; 139.0; 275.5; 386.5; 290.5; 0; 77.0; 2.5; 202.5; 150.09 mm per month. In 2018, the monthly average temperature was 26.69 °C (maximum: 28.0 °C, minimum: 25.2 °C). Monthly sunshine duration (%) in 2018 of January, February, March, April, May, June, July, August, September, October, November, and December were 51, 57, 50, 53, 30, 32, 37, 62, 72, 87, 61, 52.

The experimental design was a split-plot under repeated Randomized Complete Block Design (RCBD). The main plot was the row spacing of planting systems, namely (1) the row spacing was 100 cm (40×100 cm) and (2) the row spacing was 125 cm (40×125 cm). The subplot treatments consisted of 6 varieties, namely (1) *Saccharum* 'CMG Agribun ', (2) *Saccharum* 'AAS Agribun', (3) *Saccharum* 'ASA Agribun', (4) *Saccharum* 'AMS Agribun', (5) *Saccharum* 'PS864' and (6) *Saccharum* 'Bululawang'. The treatment layout was performed by randomizing the subplots (varieties) on the main plot (row spacing). Variables observed were plant height (cm), stem diameter (cm), number of internodes, and number of tillers at 13, 15, and 17 WAP. Plant height was measured from the top of the ground where the sugarcane grew to the tip of the leaf buds/young leaves of the plant. The stem diameter was measured on the second section of the plant from the ground surface using a caliper. The number of internodes was observed by counting the number of internodes that had been formed. The number of tillers was observed by counting the number of tillers that had grown and formed plants.

Statistical analysis

The data were analyzed according to the intervals of observation with analysis of variance (ANOVA) of a split-plot design under RCBD using the SAS 9 program for Windows. If there was an interaction between factors, the interaction effects were compared. Then, the treatment effects were compared based on Duncan's Multiple Range Test at $p \leq 0.05$. A Principal Component Analysis (PCA) Biplot was also carried out on agronomic observation parameters to find out the agronomic traits determinant of superior varieties of sugarcane growth.

Land cultivating

The land used for the experiment was previously planted with corn. Soil tillage was carried out in two stages: primary tillage and secondary tillage. Primary tillage was carried with a rotary plow to uproot the previous crop stubbles and break the soil into clods. Secondary tillage was carried with a harrow to break the soil clods to bring it to a fine tilth and leveling to create ridges and furrows. Ridges and furrows were formed in a field final preparation using a tractor. The depth of the furrows should be around 25 cm. The area of sugarcane planting area was 5 hectares. The physical and chemical properties of soil were texture clay with sand:dust:clay composition 30%:26%:44%, pH 4.5, bulk density 1.33 g cm^{-1}, soil moisture capacity/254 pf = 45.99%, C organic 2.3%, cation exchange capacity (cmol kg^{-1}) 31.65%, available P-content (mg P_2O_5 $100g^{-1}$) 33.77, potential K (mg K_2O 100 g^{-1}) 23,77 (Mulyaningsih et al., 2015).

Planting

Sugarcane seeds used in this experiment was six months old. Sugarcane seeds were planted directly without giving any treatment by stem cutting of sugarcane stalks having two buds. The planting system used was 'single-row planting' with the spacing adapting to the treatment of the main plots, namely (1) row spacing of 125 cm and (2) row spacing of 100 cm.

Plant maintenance

Provision of inorganic fertilizer was in the form of urea 300 kg ha^{-1} and NPK phonska 500 kg ha^{-1} with three application times, at 0, 1.5, and 3 months after planting. Applying organic fertilizer, i.e., cow manure, was done only once, at the beginning of planting during tillage. Soiling, weeding, and fertilizing inorganic fertilizers were carried out simultaneously. Control of plant-disturbing organisms used Nordox 56 WP (containing 56% Copper oxide active ingredient or equivalent to 50% Cu). Watering was done by using a 3-inch hose. During dry season, watering was done every three days; during rainy season, watering was unnecessary. However, when the sugarcane reached 2.5 months old, watering was done less frequently, every five days.

RESULTS AND DISCUSSION

Plant height

The variety significantly affected the height of sugarcane at the ages of 13, 15, and 17 WAP. In addition, the variety interacted with the row spacing and increased the plant height significantly at the age of 15 WAP (Table 1).

Table 1. The result of ANOVA of plant height at the age of 13, 15, and 17 WAP

Source	df	Pr > F Plant height (cm) at different ages		
		13 WAP	15 WAP	17 WAP
Repitation	4	0.9239	0.0709	0.9274
Variety (V)	5	0.0004	<.0001	0.0030
Repitation *V	20	0.7778	0.0231	0.8807
Row spacing (R)	1	0.8964	0.1509	0.9671
V*R	5	0.4778	0.0402	0.2516
CV (%)		13.08	9.25	13.94

Table 2. The effect of varieties on sugarcane plant height

Varieties	Plant height (cm) at different ages	
	13 WAP	17 WAP
CMG Agribun	56.75^{c}	175^{c}
AAS Agribun	63.5^{bc}	205.5^{b}
ASA Agribun	57.3^{c}	187.5^{bc}
AMS Agribun	61.8^{bc}	192.9^{bc}
PS 864	75.15^{a}	232.1^{a}
Bululawang (BL)	67.95^{b}	205.3^{b}

Numbers followed by the same letters in the same columns did not differ significantly at $p < 0.05$ according to Duncan's multiple range test.

Saccharum 'PS864' is a sugarcane variety with the highest plant height compared to other varieties, at ages 13 and 17 WAP (Table 2). The performance of plant height at the age of 13 WAP is shown in Fig. 1.

These findings are in line with Ahmed et al. (2010) that the plant height is influenced by the variety or genotype of each plant. Sugarcane genotypes differ in stem height, whereas the sugarcane stem is the economical part. Sugarcane produces relatively large biomass and high storage of photosynthate in the form of sucrose in the stem (Verma et al., 2013).

At the age of 15 WAP, the *Saccharum* 'PS864' with a row spacing of 40×100 cm produces the highest plant height growth,

Figure 1. Plant performance in the experimental field at the age of 13 WAP.

significantly different than all other treatment combinations, except for the same variety at a denser spacing (40×100 cm) and the *Saccharum* 'Bululawang' at a wider spacing (40×125 cm). Among the varieties, it seems that only the *Saccharum* 'Bululawang' interacts significantly with the row spacing, determining plant height. Saccharum 'Bululawang' has the highest plant height at wide spacing (40×125 cm), which is significantly different from the narrow spacing (40×100 cm) (Table 3).

Plant height is an important parameter that shows the growth process, determined by shoot and root growth parameters (Sulistiono, 2017). Sugarcane plants, with better agronomic characteristics of stem are supported by having better root properties: root length, root surface area, and root diameter at a certain age (Table 4). According to Sulistiono et al. (2018), better root growth properties inoculated by mycorrhizae, i.e., root length, root surface area, and secondary roots, are required to support the growth of the shoots in sugarcane at the early growth.

Table 3. The effect of interaction on sugarcane plant height at the age of 15 WAP

Varieties	Row spacing (cm)	Plant height (cm)
Saccharum 'CMG Agribun'	40×100	157.80 d
Saccharum 'CMG Agribun'	40×125	162.60 d
Saccharum 'AAS Agribun'	40×100	176.80 b–d
Saccharum 'AAS Agribun'	40×125	2,174.60 b–d
Saccharum 'ASA Agribun'	40×100	162.00 d
Saccharum 'ASA Agribun'	40×125	169.40 cd
Saccharum 'AMS Agribun'	40×100	174.60 b–d
Saccharum 'AMS Agribun'	40×125	158.60 d
Saccharum 'PS864'	40×100	201.00ab
Saccharum 'PS864'	40×125	206.20 a
Saccharum 'Bululawang'	40×100	195.60 a–c
Saccharum 'Bululawang'	40×125	159.20 d

Numbers followed by the same letters in the same columns did not differ significantly at $p < 0.05$ according to Duncan's multiple range test.

Table 4. Root properties that promoted increased growth of sugarcane plant height

Root properties	Parameter Estimate	Standard Error	Type II SS	Percentage of influence	*P*–Value
Total root length at the age of 8 WAP	0.342	0.03287	40,693.0	40.33	<.0001
Root surface area at the age of 5 WAP	-0.05	0.00666	20,299.0	20.12	<.0001
Root diameter at the age of 8 WAP	1,377.48	133.872	39,887.0	39.53	<.0001
Sum of Residuals	33.71	First Order Autocorrelation			0.4318
Sum of Squared Residuals	18,522.88	Durbin-Watson D			1.1290
Sum of Squared Residuals - Error SS	-0.000	R^2			0.98

Sulistiono (2017).

In shoot growth, plant height is determined by several growth characteristics. The physiological characteristics of sugarcane shoots that determine plant height are net assimilation rate (NAR), relative growth rate (RGR), and leaf area (LA) at a certain plant age, as shown in Table 5 (Sulistiono, 2017).

The results of this study indicate that at a certain age, the height of sugarcane plants is determined by the interaction between varieties and row spacing. This finding is consistent with the report of Sulistiono (2017) that at a certain age, the interaction effect of variety and row spacing appears to determine sugarcane growth. The leaf area index is significantly determined by the interaction of row spacing and variety at the age of 2 and 9 months after transplanting (Sulistiono, 2017). This is due to plant growth factors among varieties. Varieties with higher plant heights will place leaves to form LA and leaf area index (LAI), as well as chlorophyll content, which is more optimal in absorbing sunlight. According to Aboagye (2003), optimal LAI is immediately achieved at narrow spacing. Sugarcane plants that have optimal LAI lead to optimal absorption of sunlight by leaf area to be optimal for photosynthesis (Helal & Mengel, 1981). Optimal LAI in sugarcane is achieved at the age of 4 months with a value of 3.08–5.52 (Sulistiono, 2017).

Table 5. Physiological characteristics that promote increased growth of sugarcane plant height

Growth characteristics	Parameter Estimate	Standard Error	Type II SS	Percentage of influence	P-Value
NAR at the age of 5 WAP	2,818.508	306.28	33,543.0	44.89	<.0001
RGR at the age of 8 WAP	1,690.822	191.03	31,031.0	41.52	<.0001
LA at the age of 5 WAP	0.076	0.016	81,59.62	10.92	<.0001
LA at the age of 8 WAP	0.0069	0.003	19,93.44	2.67	0.0289
Sum of Residuals	45.482	First Order Autocorrelation			0.453
Sum of Squared Residuals	20,513.28	Durbin-Watson D			1.06
Sum of Squared Residuals-Error SS	-0.000	R^2			0.97

Sulistiono (2017).

Varieties with higher plant heights have an impact on increasing plant fresh biomass weight. Varieties determine the fresh biomass of sugarcane plants (Pereira et al., 2013; Schultz et al., 2017). In addition, differences in varieties also determine the ability to form leaf chlorophyll and adaptive capacity in the planting area, such as saline conditions (Willadino et al., 2011). Knowing the adaptive ability of suitable varieties at the planting location based on the parameters of plant height becomes is important for the selection of varieties.

The optimal sugarcane growth with the best plant height is also influenced by better root properties, such as total root length, root surface area, and root diameter (Table 4). The optimal root properties are important in the growth of sugarcane. Roots are essential for different functions for plant growth, including plant anchorage (Rebouillat et al., 2009), water and mineral nutrient uptake, and synthesis of various essential compounds and plant shoot biomass (Hishi et al., 2015; Nagakura et al., 2015; Sulistiono et al., 2018) and improve the physical conditions of the soil (Cai et al., 2021). Thus, the results of this study show that sugarcane varieties with better plant height agronomic properties indicate having better root properties.

Stem diameter

Variety had a very significant effect on the sugarcane stem diameter at the ages of 13, 15 and 17 WAP. At the age of 17 WAP, there was a significant interaction ($p < 0.05$) between variety and row spacing treatments in affecting the stem diameter (Table 6).

Table 6. The result of ANOVA of stem diameter at the age of 13, 15, and 17 WAP

Source	df	Pr > F steam diameter (cm) at different ages		
		13 WAP	15 WAP	17 WAP
Repitation	4	0.4113	0.2998	0.1687
Variety (V)	5	0.0047	0.0080	0.0013
Repitation *V	20	0.8052	0.6297	0.6094
Row spacing (R)	1	0.9964	0.0745	0.0600
V*R	5	0.5838	0.1812	0.0381
CV (%)		10.59	7.66	7.59

The *Saccharum* ‘CMG Agribun’, *Saccharum* ‘ASA Agribun‘, and *Saccharum* ‘AMS Agribun‘ provided larger stem diameters at the age of 13 WAP compared to other varieties. At the age of 15 WAP *Saccharum* 'CMG Agribun', *Saccharum* 'ASA Agribun', *Saccharum* 'AMS Agribun' and *Saccharum* 'PS864' provided the largest stem diameters (Table 7).

At the age of 17 WAP, the stem diameter of several varieties increases significantly with differences in row spacing. *Saccharum* 'AMS Agribun' produces the best stem diameter, significantly at denser spacing. Conversely, *Saccharum* 'Bululawang' produces significantly higher stem diameter at looser row spacing (40× 125 cm) (Table 8). This result is in line with the report by Gomathi et al. (2013) and Ahmed et al. (2013) that differences in varieties affect the diameter of the stems produced. In addition, the results are consistent with the report by Sulistiono et al. (2020) that wide inter-rows spacing (75 cm) in the planting material for bud chips results in significantly larger diameters than the dense inter-rows spacing of 45 cm or 30 cm (Sulistiono et al., 2020).

Table 7. The effect of varieties on sugarcane stem diameter

Varieties	Stem diameter (cm) at different ages	
	13 WAP	15 WAP
Saccharum 'CMG Agribun'	2.79[ab]	2.71[a]
Saccharum 'AAS Agribun'	2.51[cd]	2.47[b]
Saccharum 'ASA Agribun'	2.97[a]	2.74[a]
Saccharum 'AMS Agribun'	2.79[ab]	2.68a
Saccharum 'PS864'	2.69[bc]	2.63[ab]
Saccharum 'Bululawang'	2.45[d]	2.44[b]

Numbers followed by the same letters in the same columns did not differ significantly at $p < 0.05$ according to Duncan's multiple range test.

Table 8. The effect of interaction on stem diameter at the age of 17 WAP

Varieties	Row spacing (cm)	Stem diameter (cm)
Saccharum 'CMG Agribun'	40×100	2.76 b
Saccharum 'CMG Agribun'	40×125	2.90 ab
Saccharum 'AAS Agribun'	40×100	2.43 cd
Saccharum 'AAS Agribun'	40×125	2.65 bc
Saccharum 'ASA Agribun'	40×100	2.75 b
Saccharum 'ASA Agribun'	40×125	2.94ab
Saccharum 'AMS Agribun'	40×100	3.04 a
Saccharum 'AMS Agribun'	40×125	2.75 b
Saccharum 'PS864'	40×100	2.66 bc
Saccharum 'PS864'	40×125	2.69 bc
Saccharum 'Bululawang'	40×100	2.37 d
Saccharum 'Bululawang'	40×125	2.71 bc

Numbers followed by the same letters in the same columns did not differ significantly at $p < 0.05$ according to Duncan's multiple range test.

Diameter is an important agronomic characteristic because it determines the weight of sugarcane stalks and the volume of sucrose storage. The weight of millable canes is important for estimating productivity (millable canes). Estimated productivity is known from (1) the number of millable canes per clump, (2) the number of clumps in the planting row, (3) the weight of millable cane per stem, and (4) plant height (Taryono & Sulistiono, 2022). Sugarcane stem weight positively correlates with cane yields (productivity) and determines the productivity of 80.13% (Sulistiono, 2017). According to Jane et al. (2020), an appropriate model should be developed to determine the diameter of the cane stem. It can be used to model the initial growth and production of sugarcane varieties. Varieties with larger diameters will determine the ability of the source steam phloem to accumulate photosynthate (sucrose) in sugarcane stalks in conjunction with the photosynthesis sink process (Chandra et al., 2011; Wang et al., 2013).

Number of internodes

Varieties had a significant effect ($p < 0.05$) on the number of sugarcene internodes at the ages of 13 and 15 WAP, as well as having a very significant effect ($p < 0.01$) at the age of 17 WAP (Table 9).

The *Saccharum* 'CMG Agribun', *Saccharum* 'PS864' and *Saccharum* 'Bululawang' provide the highest numbers of internodes that differ significantly from other varieties at the ages of 13 and 15 WAP. Meanwhile, at 17 WAP, the highest number of internodes is obtained at *Saccharum* 'CMG Agribun' and *Saccharum* 'PS864' (Table 10). These results are in line with Santoso et al. (2015) and Ahmed et al. (2013) that different varieties produce differences in the number of internodes per stem. According to Sulistiono et al. (2020), several sugarcane varieties (*Saccharum* 'Kidang Kencana', *Saccharum* 'Bululawang' and *Saccharum* 'PS881') provide a high number of internodes at a wide inter-rows spacing of 60–75×100 cm. On the other hand, *Saccharum* 'PS864' provide a high number of internodes at a narrow inter-rows spacing of 45×100 cm. These results indicate that in certain varieties, the number of internodes can be increased by selecting adaptive variety or row-spacing treatment.

Table 9. The result of ANOVA of the number of internodes per stalk at the age of 13, 15, and 17 WAP

Source	df	Pr > F number of internodes per stalk at different ages		
		13 WAP	15 WAP	17 WAP
Repitation	4	0.8954	0.6827	0.2593
Variety (V)	5	0.0491	0.0268	0.0082
Repitation *V	20	0.6373	0.5130	0.8183
Row spacing (R)	1	0.7575	0.1179	0.3858
V*R	5	0.4203	0.9180	0.5933
CV (%)		21.19	19.97	18.17

Table 10. The effect of different varieties on the number of internodes per stalk

Varieties	Number of internodes at different ages		
	13 WAP	15 WAP	17 WAP
Saccharum 'CMG	4.3^{a}	5.3^{a}	7.2^{ab}
Saccharum 'AAS	3.7^{ab}	4.2^{b}	6.2^{bc}
Saccharum 'ASA	3.3^{b}	4.2^{b}	6.2^{bc}
Saccharum 'AMS	3.4^{b}	4^{b}	5.8^{c}
Saccharum 'PS864'	4a^{b}	4.6^{ab}	7.5^{a}
Saccharum 'Bululawang'	4a^{b}	4.7^{ab}	5.7^{c}

Numbers followed by the same letters in the same columns did not differ significantly at $p < 0.05$ according to Duncan's multiple range test.

Sugarcane varieties with more internodes have the potential to increase the organ storing more sugar. According to McCormick et al. (2006), the sucrose content in internodes number 7–12 from the bottom of the stem is about ten times higher than the internodes at the top. Thus, the number of stem internodes becomes an agronomic trait of the superior sugarcane. In general, the results are in line with those reported by Silva et al. (2012), that the number of internodes is one of the determinants of the agronomic superiority of sugarcane.

Number of tillers

Variety had a very significant different ($p < 0.01$) on the number of sugarcane tillers at the ages of 13 and 15 WAP. However, at the age of 17 WAP, both the variety and row spacing treatments do not significantly different on the number of tillers (Table 11).

The *Saccharum* 'AAS Agribun' has the highest number of tillers which is significantly different from other varieties at the age of 13 and 15 WAP (Table 12). This result shows that the number of tillers is a genotype factor and the time of tillering phase is different among varieties. These results align with the reports of Ahmed et al. (2013) that the varieties significantly influence the number of sugarcane tillers.

Table 11. The result of ANOVA of the number of tillers at the age of 13, 15, and 17 WAP

Source	df	Pr > F number of tillers a different ages		
		13 WAP	15 WAP	17 WAP
Repitation	4	0.6496	0.253	0.6686
Variety (V)	5	0.0020	0.021	0.1366
Repitation *V	20	0.8981	0.6064	0.8206
Row spacing (R)	1	0.4165	0.6594	0.6000
V*R	5	0.7132	0.5286	0.3113
CV (%)		32.06	31.55	32.50

Saccharum 'AAS Agribun' is a variety that has an ability to produce more tillers, significantly different than other varieties (Table 12). According to Pramuhadi (2010), the emergence of tillers is induced by the success of germination, which is largely determined by the inherent factors, namely varieties (genotype). Furthermore, tillering is determined by the germination process, and the growth of the sprouts itself on the sugarcane stalks underground to become new plants.

Table 12. The effect of varieties on the number of tillers

Varieties	Number of tillers at different ages	
	13 WAP	15 WAP
Saccharum 'CMG Agribun'	4.1[b]	4.3[b]
Saccharum 'AAS Agribun'	6.7[a]	6.7[a]
Saccharum 'ASA Agribun'	3.8[b]	3.8[b]
Saccharum 'AMS Agribun'	3.9[b]	4[b]
Saccharum 'PS864'	3.5[b]	3.9[b]
Saccharum 'Bululawang'	3.8[b]	4.7[b]

Numbers followed by the same letters in the same columns did not differ significantly at $p < 0.05$ according to Duncan's multiple range test.

Generally, the most important parameter of the number of tillers is the effective tiller. This is because effective tillers will be millable canes for productivity. According to Sulistiono (2017), effective tillers or the number of millable canes per clump are determined by physiological characteristics, namely RGR, LA, and NAR, and specific leaf weight (SLW) at a certain age (Table 13).

Table 13. Physiological characteristics that promoted the amount of millable cane per clump

Physiological characteristics	Parameter Estimate	Standard Error	Type II SS	Percentage of influence	*P*-Value
RGR at the age of 8 WAP	97.563	14.914	46.506	35.80	<.0001
LA at the age of 5 WAP	0.0069	0.0010	43.877	33.78	<.0001
NAR at the age of 5 WAP	80.177	16.891	24.486	18.85	<.0001
SLW at the age of 8 WAP	-84.779	34.781	6.457	4.97	0.0181
LA at the age of 11 WAP	0.00080	0.00038	4.925	3.79	0.037
LA at teh age of 8 WAP	-0.0018	0.00098	3.651	2.81	0.0723
Sum of Residuals	1.508	First Order Autocorrelation			0.148
Sum of Squared Residuals	54.340	Durbin-Watson D			1.659
Sum of Squared Residuals - Error SS	-0.000	R^2			0.96

The *Saccharum* 'PS864' has the highest plant height compared to other varieties, but has the lowest number of tillers. This result complements the report from Rosyady et al. (2017) that the higher the growth of sugarcane stems, the smaller the number of tillers. Sulistiono et al. (2019) reported that the variety and row spacing determine the number of tillers. The wide inter-rows spacing (75 cm) determines the number of tillers significantly different from the dense spacing (60–30 cm) (Sulistiono et al., 2020).

The number of effective tillers is an important agronomic parameter for superior high-yield sugarcane varieties. The number of effective tillers produced by the ability of plant growth is shown in the role of several growth parameters such as RGR, LA, NAR, and SLW at a certain age. The ability of a variety to have a high number of effective tillers indicates its optimal growth ability (Simoes et al., 2018). The number of tillers is the main parameter of superior traits of sugarcane varieties rather than plant height and diameter and to predict cane yield per hectare, which is a superior trait of agro-industrial characters in sugarcane (Grego et al., 2010; Silva et al., 2018).

Tillering depends on climate as a supporting environment factor. According to Samui et al. (2003), climatic elements that affect the tillering phase are minimum temperature, humidity, and high rainfall. The optimal temperature for germination and early growth-formation of tillers is 26–33 °C (Mayer & Clowers, 2011). On the other hand, the critical temperature for sugarcane in non-irrigated land is 19–20 °C (Bacchi, 1977). Meanwhile, the average temperature of the study site was 26.69 °C, with the highest rainfall compared to other months, which was 290.5–365.5 mm per month. This data shows that the climate element is still in the optimal range for the early growth of sugarcane.

Based on the PCA-Biplot, it shows that agronomic traits that show a high contribution to growth are characterized by orange color, namely: Plant Hight at the age of 13 WAP (PH13), Plant Hight at the age of 15 WAP (PH15), Number of tillers at the age of 15 WAP (NT15), Number of tillers at the age of 17 WAP (NT17), Stem Diameter at the age of 13 WAP (SD13) and Stem Diameter at the age of 15 WAP (SD15). On the other hand, the variables showing a medium contribution to growth are shown in yellow, namely: Plant Hight at the age of 17 WAP (PH17), Number of tillers at the age of 13 WAP (NT13), Number of Internodes at the age of 13 WAP (NI13) and Number of Internodes at the age of 17 WAP (NI17), while the lowest contribution is Number of Internodes at the age of 15 WAP (NI15) (Fig. 2).

Fig. 2 shows varieties with agronomic traits, such as higher plant height growth at 13–15 WAP of age, the ability to produce more tillers at 15–17 WAP of age, and higher diameter development at 13–15 WAP of age. These are superior agronomic traits of a variety of sugarcane to be able to grow better on dryland conditions. These growth parameters are superior agronomic traits obtained from the results of this study.

The agronomic properties of the number of tillers, the number of internodes, and the diameter of the stems are not hampered by the climatic conditions on dryland during growth. The agronomic properties that experienced growth pressure are plant height. Sulistiono (2017) reported that plant heights of *Saccharum* 'PS864' and *Saccharum* 'Bululawang' reach 1.95 m and 1.96 m on dryland with clay texture with a ratio of silt:dust:sand of 65.25%: 18.24%: 16.51%, pH 5, 78 and 5.1% organic matter during the rainy season. Meanwhile, the results of this study show that the plant height of *Saccharum* 'PS864' and *Saccharum* 'Bululawang' are 2.32 m and 2.05 m, respectively.

Therefore, the *Saccharum* 'PS864' and *Saccharum* 'Bululawang' do not decrease in plant height.

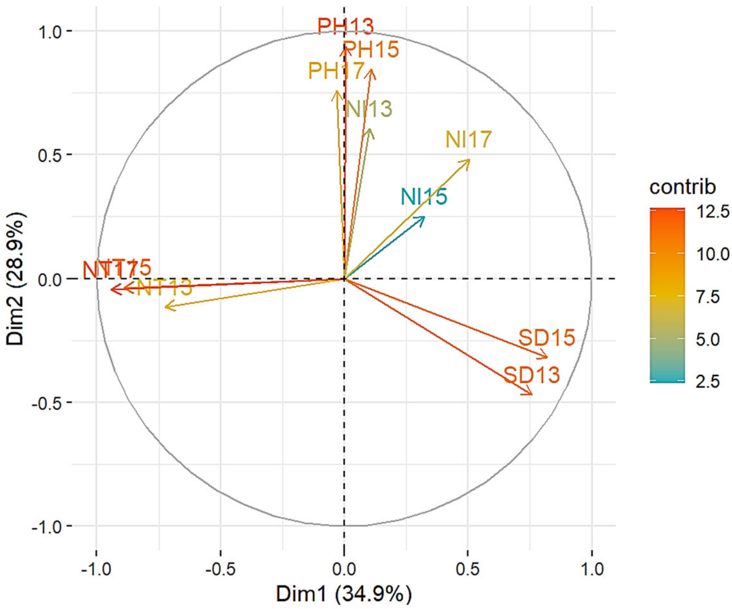

Figure 2. PCA_Biplot: Superior agronomic characteristics determine plant growth.
Caption: High contribution to growth = orange; Medium contribution to growth = yellow; Low contribution to growth = blue.

Saccharum 'CMG Agribun''s height is 14.6% lower than the optimal growth of *Saccharum* 'AAS Agribun'. Zhao et al. (2010) reported that the effect of drought on sugarcane causes a decrease in the growth of stem length, number of internodes, and shoot formation by 19%, 18%, and 45%, respectively. Taryono & Sulistiono (2022) stated that plant height is a grand growth phase susceptible to soil moisture stress. Therefore, low rainfall and the delay of rainy season or insufficient rain for the rapid grand growth phase causes inadequate stem elongation. This impacts the number of effective tillers (millable canes) and lower sugarcane weight (Taryono & Sulistiono, 2022). Rainfall data during the tillering phase is optimal for the 90-day tiller phase. However, the absence of rain in the 3rd month is thought to cause disturbed stem elongation in the CMG Agribun variety.

CONCLUSION

1. The plant height, stem diameter, number of internodes, and number of tillers are strongly influenced by variety. Whereas, on *Saccharum* 'AMS Agribun' and *Saccharum* 'Bululawang', the stem diameter increases affected by the rows spacing treatment at the early growth of 17 WAP. These growth parameters are the determinants of the productivity of millable canes.

2. Growth parameters, namely plant height at 13 and 15 WAP, number of tillers at 15 and 17 WAP, and stem diameter at 13 and 15 WAP, with better growth, indicating superior agronomic properties of a sugarcane variety on dryland.

3. The *Saccharum* 'PS864' has the highest plant height and number of internodes. The highest number of tillers is obtained in the *Saccharum* 'AAS Agribun'.

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