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Growth Response of Local Cassava to Cutting Models and the Number of Buds

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Abstract

Cassava is one of the local food sources that are widely available in almost every region. Cuttings are used to plant cassava, and these cuttings will produce a number of roots and buds. The main purpose of this study was to evaluate the effect of cuttings slices model and the number of buds on the growth of Tobelo local varieties of cassava. This study employed a factorial Randomized Block Design (RBD), with the cuttings slices model as the first factor, consisting of three levels, namely: flat slice, one-sided slice and two-sided slice. The second factor is the number of buds, which is divided into three levels, 1 bud, 2 buds and 3 buds. The observation parameters in this study include plant height, number of leaves, stem diameter and leaf area. The results have revealed that the model of two-sided sliced cuttings combined with the number of one bud is the most effective treatment in improving the growth of cassava plants of Tobelo local varieties. The models of one-sided and two-sided oblique cuttings slices yield the highest average value for the parameters of plant height, stem diameter and leaf area, while the treatment with one bud tends to give the best results for the growth parameters.

Keywords: cassava of Tobelo variety; cassava production; cuttings model; number of buds; staple food

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INTRODUCTION

The world is currently experiencing two major crises, the food crisis and the energy crisis. The energy crisis is triggered by the depletion of energy derived from fossil fuels, while the food crisis is caused by the phenomenon of global warming and unequal distribution of food. The increasing food crisis has compelled every country to further optimize the potential of existing local food sources, including Indonesia (Hardono, 2014). Cassava (*Manihot esculenta* Crantz) is a potential source of local food that is widely distributed (Adiele et al., 2020). Its wide agroecological adaptability makes cassava the third most important source of energy in the tropics (Hasibuan and Nazir, 2017; Neves et al., 2018). This plant has a great potential for development, providing an important source of calories and options for food security for the growing population (De Souza et al., 2017) based on local wisdom (Sulistiono et al., 2020). Cassava roots can be harvested all year, ensuring a continuous food supply for smallholder farmers and raw materials for related processing industries (Rahman and Awerije, 2016).

Cassava is a perennial woody shrub with edible roots, grown worldwide in tropical and subtropical climates (Oliveira and Miglioranza, 2014; Amarullah et al., 2017). Cassava has a strategic and promising role as food, feed and industry (Radjit and Prasetiaswati, 2011),

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with high biomass productivity so that feedstock bioindustry can be developed into bioenergy and biomass products, primarily for animal feed (Sundari, 2010; Simatupang, 2012; Nugraha et al., 2015). In Indonesia, cassava is the third most important staple food after rice and corn (Nurdjanah et al., 2012; Bantacut, 2014). The opportunities for developing cassava business are wide open because of the high demand for products made from cassava, such as tapioca, pellets, flour, syrup, textiles, paper and the livestock industry (Ariani et al., 2013).

The development of Indonesian cassava production since the last five years (2014 to 2018) has slowed down. In 2014 cassava production in Indonesia still reached 23,436,384 tons, but by 2018, the production dropped to 19,341,233 tons (Pusdatin, 2020). For this reason, efforts are required to increase the yield of cassava plants, given the promising prospects for the development of this food plant to be developed in support of local food availability. For North Maluku, the existence of local varieties of cassava is quite widely distributed in this area (Suwitono et al., 2017). Tobelo, North Halmahera, is home to one of the well-known local varieties. This area is a fairly high supplier of cassava for Ternate and the surrounding areas because cassava from this area is abundant and tastes good.

The growth and development of cassava plants can be identified through the formation of a number of roots and shoots. Shoots are a network that supplies assimilates, also known as sources. According to Taiz and Zeiger (2010), the source is an organ that produces and exports assimilates in plants. Gardner et al. (2017) added that this tissue is an active photosynthetic organ, green in color and chlorophyll, similar to leaves. Meanwhile, the roots or tubers in cassava are called sinks. Sinks are networks that accommodate or receive assimilation but are not actively photosynthesizing, such as fruits, seeds, tubers and old leaves (Taiz and Zeiger, 2010; Gardner et al., 2017).

Efforts to improve cassava yields necessitate a thorough understanding of the relationship between the source and sink (leaves and tubers). There is a relationship between leaf and tuber growth in cassava. It is suspected that the larger the tuber size, the production of buds and leaves will gradually stop and the leaves will experience age, resulting in a decrease in the total leaf area also. According to Amarullah et al. (2016), the success of root or tuber initiation is also influenced by the number of shoots on a cutting. Edmond et al. (1975) added the presence of shoots in cassava is very important for the root or tuber initiation process. Root or tuber growth will not occur if all shoots are removed or in a dormant state because the shoots provide auxin, which stimulates the formation of roots or tubers, especially when the shoots begin to growth.

In connection with the foregoing, efforts to improve the yields of cassava plants are required. Cassava yields can be increased substantially by improving plant formation, genotype, management (Adiele et al., 2020) and planting of high-yielding cassava stems (Ikuemonisana et al., 2020). Ceballos et al. (2010) mentioned that one of the cassava plant improvement programs is aimed at developing high-yielding varieties. The use of improved varieties in field trials in Nigeria yielded a fresh tuber weight of 40 ton ha^{-1} (Eke-Okoro and Njoku, 2012). Naturally, varieties of cassava have different characteristics depending on their genetic background, which can produce different responses to external factors (Neves et al., 2018).

There have been many studies on conventional cassava propagation related to the number of shoots in the cuttings to the rooting stage; however, only a few links explain plant growth and development with cuttings to be planted under field conditions. The purpose of this study was to examine the effect of cuttings and the number of buds on the growth of cassava plants. The novelty of this research is the use Tobelo local variety, which is high in production. Local cassava products are always in demand by the people of North Maluku as one of the staple foods and ingredients for making sago made from cassava as local food (Suwitono et al., 2017). This study is expected to encourage the development of Tobelo cassava plants for other areas to support the sustainable agricultural system in this region.

MATERIALS AND METHOD

This research was carried out from April to July 2019 in the farmers' land in Kalumata Sub-district of South Ternate Regency, North Ternate Province, Indonesia. This area is geographically located at N $00^0 45' 46''$ and E $127^0 21' 40''$. Laboratory analysis was carried out at the Soil Science Laboratory, Faculty of Agriculture, Universitas Khairun, Ternate and the Soil Science

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Laboratory, Faculty of Agriculture, Universitas Tanjungpura, West Kalimantan, Indonesia.

The materials used were local cassava varieties from Tobelo, chicken manure, urea, SP-36, potassium nitrate (KNO_3), Curacron pesticide and aqua destilata. This research was arranged in factorial Randomized Block Design (RBD). The first factor is manipulation at the bottom, including the cuttings model at the bottom (L) with three levels: L1 = flat slice, L2 = one-sided slice and L3 = two-sided slice (Figure 1). The second factor is manipulation at the source, the regulation of the number of planting buds (S), including S1 = 1 bud, S2 = 2 buds and S3 = 3 buds (Figure 2). Each treatment combination was repeated three times.

L1 L2 L3

Figure 1. Different treatments of sliced cut models,

S1 S2 S3

Figure 2. Different treatments of the number of buds

The type of soil in the research location is Inceptisols and soil processing is accomplished by plowing the soil, followed by piling. The soil was treated as deep as ± 50 cm. Cassava planting materials of main stem cuttings with 10 buds were sliced with based on the treatment: flat, one-sided slanted and two-sided slanted. Cassava cuttings were planted in an upright position with a spacing of 100 cm x 100 cm, as deep as 5 to 10 cm, with approximately one-third of the cuttings buried in the soil.

Watering was conducted in every morning and evening based on the soil water condition. In the first 1 to 3 days of planting, the cuttings were watered with sufficient water to avoid the dryness of cuttings. Starting from one week after planting, the treatment setting for the number of buds (1 bud, 2 buds and 3 buds) was by allowing the buds to grow according to the treatment. Manure was given as a base fertilizer at a dose of 15 ton ha^{-1} (BALITKABI, 2019), given two weeks before planting, together with the time of bed preparation. Inorganic fertilizer of 200 kg urea + 100 kg SP-36 + 100 kg KCl ha^{-1} (Sundari, 2010), as continued fertilizer, was provided in two stages, a half dose when

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the plant was 1 month and a half dose at 3 months. The fertilizers were spread evenly over the surface.

Weeding was performed manually at the age of 4, 6, 8 and 10 weeks after planting. Soil loosening was carried out three times particularly at the age of 1, 2 and 3 months, to improve soil aeration, and make room for roots to grow, develop and form tuber. Adjustment of the number of shoots was done by removing the shoots growing beyond the treatment.

Tetranychus urticae commonly attack young and old leaves, while *Phenacoccus* sp. Pests attack the leaves and shoots of plants and stems. These pests attack in the beginning of dry season, causing disruption of leaf growth and leaf loss of plants. The control of *Tetranychus urticae* was carried out by spraying water as often as possible on the affected plants, while the control of *Phenacoccus* sp. was completed using an insecticide solution made from active ingredients of organophosphate and dimethoate (BALITKABI, 2019), namely Curacron insecticide diluted with water then sprayed on the affected plant parts. Plants were observed by considering particular parameters, including the plant height, stem diameter, number of leaves and leaf area:

a. Plant height was measured from the base of the stem that bordered the soil surface to the point of growth, with observations carried out every two weeks.
b. Stem diameter measurement was done together with plant height measurement.
c. Number of leaves was measured by counting the leaves perfectly opening, excluding the buds, carried out together with measurements of plant height and stem diameter.
d. Leaf area was measured using the gravimetric method; the leaves were traced using paper, and then the tracing was cut and weighed. The results were compared with the weight and area of the whole paper. The area of the whole paper was previously weighed and calculated beforehand (Guritno and Sitompul, 1995). Leaf area was calculated based on the weight of the leaf replica and the total paper weight, with the following formula:

$$LA = \frac{Wr}{Wt} \times At$$

Note: LA = leaf area
Wr = net weight of leaf replica
Wt = total paper weight
At = total paper area

Observation data were examined with Analysis of Variance (ANOVA). The treatments having significant effect would be further tested using the Least Significant Difference (LSD) at a 5% significance level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The effect of cuttings model, number of buds and their interaction on the growth of cassava plants

The cuttings model does not significantly affect all the growth parameters of cassava, but when viewed from the results of the average value, each treatment provides the average value which varies and this condition can be seen in Figures 3, 4, 5 and 6. In Figure 3 and 4, it appears that the treatment of the L2 model gives the highest average value of the plant height and stem diameter parameters, followed by the treatment of L3 and then the treatment of L1. Likewise, in the leaf area parameter (Figure 5), the highest leaf area is found in the L3 treatment and the lowest is in the L1 treatment. However, the opposite condition occurs in the number of leaves; the L1 treatment contributes to the highest number of leaves, while the L3 treatment yields the lowest number of leaves (Figure 6).

The results have proven that in the sliced cuttings model, either 1 side or 2 sides, a number of callus on each side are formed, contributing to numerous formed roots or tubers. Many roots or tubers can absorb water and nutrients available in the soil, which then are allocated to all parts of the plant, so that the growth of upper plants related to the plant height, stem diameter, number of leaves and leaf area also increases.

This situation is in line with the results of several studies reporting that, in addition to nutrient status, different cutting surface areas cause varying number of callus formation which has implications for the growth of upper plants (Fermont et al., 2010; Okpara et al., 2010; Edet et al., 2013). In the case of cassava, the results are strongly related to tuber diameter, size and weight (Fermont et al., 2010; Agahiu et al., 2011). As more nutrients are absorbed by the roots, the nutrients transferred from the roots

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to all parts of the plant increase. This shows that the opportunity to grow and develop leaves and buds is improved (Zuraida, 2010). Roots absorb plant nutrients and play a role in storing carbohydrates produced in photosynthesis (Wild and Jones, 1988).

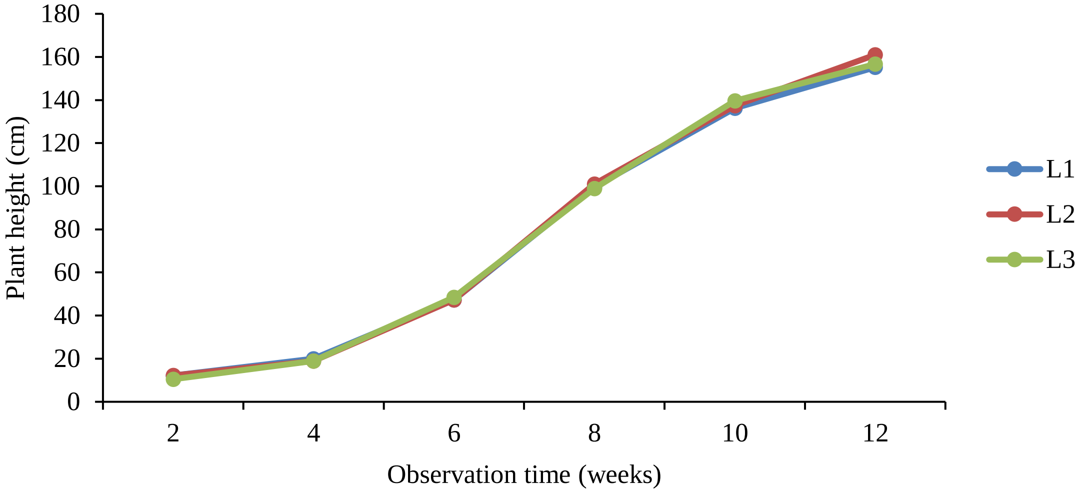

Figure 3. Growth of cassava height in the treatment of cuttings slice models

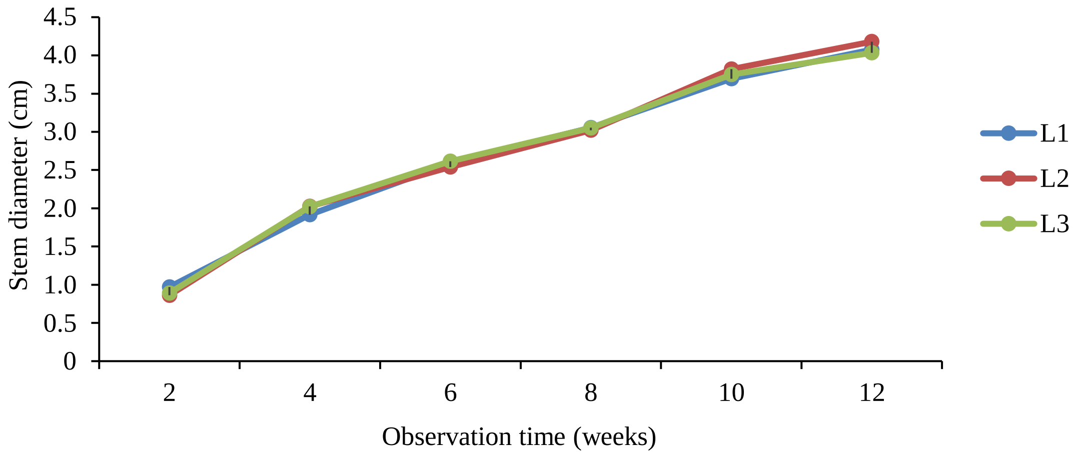

Figure 4. Growth of cassava stem diameter in the treatment of cuttings slices models

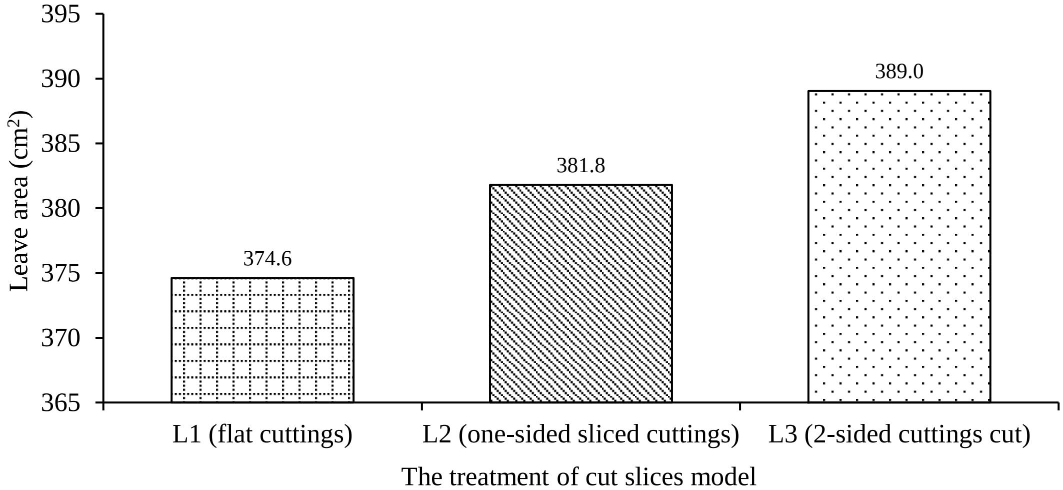

Figure 5. Leaf area of cassava in the treatment of cuttings slice models

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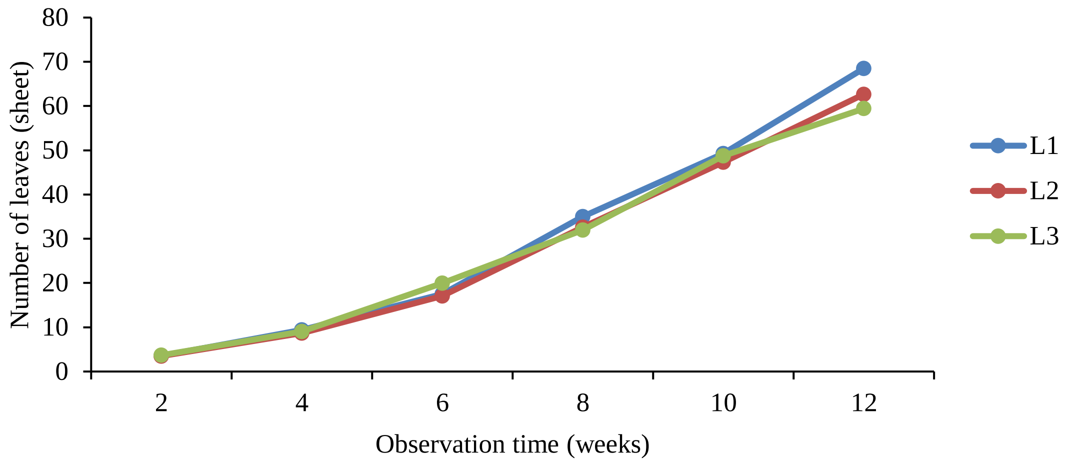

Figure 6. Growth of cassava leaf number in the cuttings slice model

Cassava is cultivated vegetatively using stem cuttings of varying lengths and calluses are formed at the base of the cuttings at the time after the cuttings are planted. The calluses formed at the base of the cassava cuttings differentiated into a large number of roots or tubers. Remison et al. (2015) pointed out that one method for increasing the availability of large-scale planting material in cassava crops is reducing the nodal units of the stake, i.e by decreasing the length of the cassava cuttings.

Sundari's (2010) states that in a vertical and inclined planting position with the base of cuttings in the soil, the callus will immediately develop at the base and a few days later, roots will appear. Arrangement of the cut model at the base of the cuttings allows for a different cross-sectional area and circumference of the cuttings, causing the appearance of potential roots or tubers to vary depending on the circumference area. Based on the results of the analysis of the soil properties, the study site is classified as sandy clay. The high sand fraction (59%) also facilitates the formation of a number of callus. According to Wijanarko (2014), the most suitable soil for cassava is one with a crumbly structure, is loose and is not too hard.

Setting the number of buds can affect the number of leaves (source). Leaves are plant organs that perform photosynthesis, which produces carbohydrates for plant (Gardner et al., 2017). The results of this study show that the treatment of the number of buds has a significant to very significant effect on plant height, stem diameter and number of leaves, while leaf area has no significant effect. The results of the average difference test of the treatment of the number of buds on cassava plant height are listed in Table 1.

Table 1. The effect of bud number treatment on plant height of Tobelo cassava local variety

Observation time (Week)	Average plant height (cm) in the bud number treatment		
	S1	S2	S3
2	13.77a	10.74a	10.36a
4	22.73b	18.84ab	16.22a
6	54.89b	49.16ab	38.95a
8	107.87b	102.19ab	89.79a
10	143.24a	141.84a	128.20a
12	169.50a	157.77a	145.55a

Note: Numbers followed by the same letter in the same line show no significant difference in LSD Test α = 0.05

Table 1 demonstrates that the effect of the treatment of the number of buds on cassava plant height begins to differ significantly between the 4th and 8th weeks, but not between the 10th and 12th weeks. From the 4th to the 8th week of observation, there is a period of rapid vegetative growth combined with the availability of sufficient water due to high rainfall, so the effect appears to be very real. Entering the 10th and 12th weeks of observation, the weather

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is different because it is entering summer. As a consequence, the growth is slightly hampered due to the lack of water intake although watering is performed. Moreover, the attack of *Tetranychus urticae* and *Phenacoccus* sp. causes plant stunting.

Santisopasri et al. (2001) and Tappiban et al. (2020) state that environmental conditions at the initial and final growth stages are very important for root growth. Stress due to the lack of water in initial plant growth will affect its productivity (Santisopasri et al., 2001; El-Sharkawi, 2006). Egesi et al. (2007) and Benesi et al. (2008) add that starch productivity will only increase if it is supported by environmental conditions; and therefore, the selection of locations for cassava planting must be done carefully. In the present study, the highest plant height is shown in treatment S1 because there is no competition in this treatment in taking nutrients or light. In contrast, in S2 and S3 treatments, the competition to obtain nutrients and light take place since those elements will be distributed into several branches.

Based on the observation results, it appears that all treatments contribute significantly to the stem diameter, except treatment given in week 6 (Table 2). S1 treatment causes the plant to have the largest stem diameter. Meanwhile, in S2 and S3 treatments, the stem diameter of the plants are smaller because more shoots develop (Figure 7). Bridgemohan and Bridgemohan (2014) evaluated the effect of the number of buds on yield and dry matter accumulation in cassava roots and concluded that the initial dry matter content (6 to 15 g) and the number of buds in the cassava (1 to 3) significantly influence the crop growth and development. The cassava stems are formed by nodal units composed of axillary buds, which are responsible for the development of new shoots (Ceballos and de la Cruz, 2002). The leaves of stems produce the carbohydrates necessary to maintain the nodal units and influence root growth (Cock, 2012).

Table 2. The effect of bud number treatment on the stem diameter of Tobelo cassava local variety

Observation time (Week)	Average stem diameter (cm) in the treatment		
	S1	S2	S3
2	1.02b	0.90ab	0.80a
4	2.14b	1.98ab	1.83a
6	2.76a	2.62a	2.36a
8	3.38c	3.09bc	2.66a
10	4.18c	3.74b	3.36a
12	4.54c	4.07b	3.68a

Note: Numbers followed by the same letter in the same line show no significant difference in LSD Test α = 0.05

S1 S2 S3

Figure 7. The relationship between stem diameter and the number of shoots

The treatment of the number of buds also has a strongly significant effect on the number of leaves at each observation, exce pt at the 6th week of observation. As presented in Table 3, it appears that if the number of buds increases, the number of leaves will

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decrease. This condition is seen in treatment S1, which shows the highest number of leaves compared to in other treatments. On the other hand, the number of buds does not demonstrate significant effect on the leaf area. However, when viewed from the average results, each treatment gives a different average value for leaf area (Figure 8).

Table 3. The effect of bud number treatment on the number of leaves of Tobelo cassava local variety

Observation time (Week)	Average number of leaves (strands) in the treatment		
	S1	S2	S3
2	4b	4ab	3a
4	10b	9ab	8a
6	20a	19a	15a
8	41b	30a	28a
10	59b	45a	40a
12	81b	61a	49a

Note: Numbers followed by the same letter in the same line show no significant difference in LSD Test α = 0.05

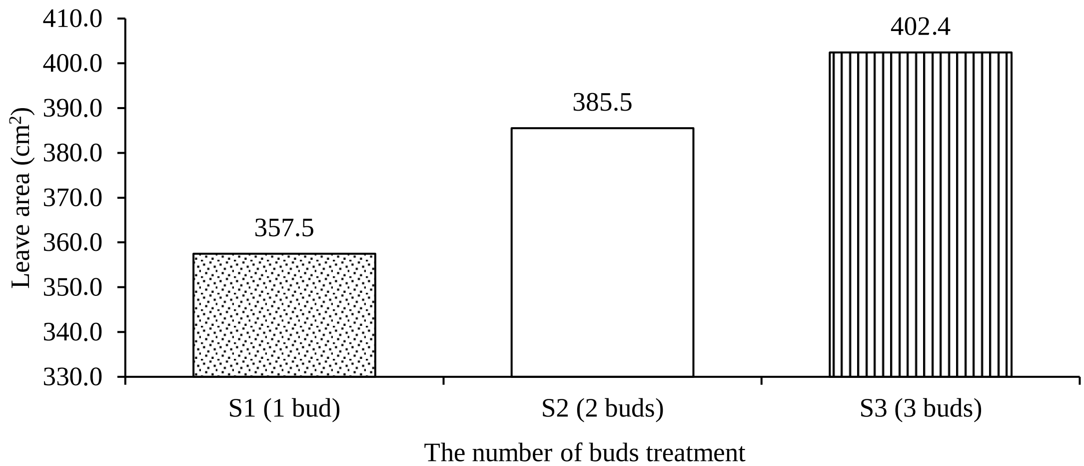

Figure 8. Cassava leaf area in the treatment on the number of buds

The results of this study have depicted that S1 treatment tends to give the best results on the cassava plant growth. However, treatments with more buds cause the plant growth to decrease. This is possible because as the number of buds increases, the nutrients produced from photosynthesis will be divided and distributed into many buds, resulting in the decreased plant growth and yield. This is in line with the results of the study by Enyi (1973) that the more shoots are, the slower the growth rates and yields of cassava plants are. According to Angga (2011), healthy shoots will be more resistant to the growing environment, resulting in faster growth.

Remison et al. (2015) pointed out that sprouting rate and vegetative growth are related to the number of buds in the cuttings. This condition was seen in the S3 treatment, where plant height, stem diameter and number of leaves were lower than that in the other two treatments. However, for leaf area parameter, the opposite occurred, where the more the number of buds, the leaf area increased. This condition proves that S3 treatment contributes to a slightly wide leaf shape of plant despite the small number of leaves.

Interaction gives a significant influence on the growth parameters, except for the leaf area. The different test of the effect of the cuttings, the number of shoots and their interactions on the parameters of plant growth are listed in Table 4. It appears that the treatment interaction gives the highest value on the combination of the model cuttings with a single cuttings (L1S1) for the stem diameter and number of leaves parameters, except for the plant height parameter. In terms of plant height parameters, the combination of the one-sided sliced cuttings with three buds (L2S3) model has the highest combination of plant height; however, this combination is not significantly different from L1S1 and the treatment of the flat sliced cuttings with two buds (L1S2).

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Table 4. The effect of cut slice model, number of buds and interaction on growth of cassava plants

Cut slice model	Number of buds			Average
	S1	S2	S3	
Plant height (cm)				
L1	244.83cd	248.17cd	176.42a	223.14
L2	218.33b	228.00bc	263.83d	236.72
L3	225.67bc	239.42bc	219.51b	228.20
Average	229.61b	238.53b	219.92a	229.35
Stem diameter (cm)				
L1	5.76g	5.11d	4.33a	5.07
L2	5.60fg	4.88cd	4.92cd	5.13
L3	5.70fg	5.46ef	4.79bc	5.31
Average	5.69c	5.15b	4.68a	5.17
Number of leaves (sheet)				
L1	252e	231de	152ab	212
L2	224e	180ab	189bc	198
L3	170ab	213cd	251e	211
Average	215b	208ab	197a	207

Note: Numbers followed by the same letters in the same column show no significant difference in LSD Test $\alpha = 0.05$

This condition is in line with the results of the study by Amarullah (2016) that the growth of plant height and stem diameter of cassava plants are related to the manipulation of sources with the arrangement of plant branches and cuttings model, resulting in significant differences in plant height, stem diameter, number of leaves and leaf area. According to Hidayat (2004) the developing canopy is a stronger sink, while the root is a weaker sink. However, once the leaves become the sources, the distribution of assimilates to other organs such as roots or tubers changes (Amarullah et al., 2016). El-Sharkawy (2014) also highlights that the shoot and root compete for photosynthetic assimilates due to cassava's unique simultaneous development of sinks organ; however, to achieve high yield, shoot and root growth must be well balanced.

CONCLUSIONS

This research concludes that the treatment of sliced cuttings model tends to provide the highest average value to the growth parameters of cassava plants, whereas in the treatment of the number of buds, the more number of buds, the average value of growth parameters tends to decrease, except for the leaf area parameters. The model of two-sided sliced cuttings combined with the number of one bud (L3S1) is the treatment that can improve the growth of Tobelo cassava local variety. Further research on crop yields is required to supplement the findings of this study.

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REFERENCES

Adiele, J. G., Schut, A. G. T., van den Beuken, R. P. M., Ezui, K. S., Pypers, P., Ano, A. O., Egesi, C. N., & Giller, K. E. (2020). Towards closing cassava yield gap in West Africa: agronomic efficiency and storage root yield responses to NPK fertilizers. *Field Crops Research*, *253*, 107820. https://doi.org/10.1016/j.fcr.2020.107820

Agahiu, A. E., Baiyeri, K. P., & Ogbuji, R. O. (2011). Correlation analysis of tuber yield and yield related characters in two cassava (*Manihot esculenta* Crantz) morphological-types grown under nine weed management systems in the Guinea savanna zone of Nigeria. *Journal of Applied Biosciences*, *48*, 3316–3321. Retrieved from http://www.m.elewa.org/JABS/2011/48/6.pdf

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Amarullah, Indradewa, D., Yudono, P., & Sunarminto, B. D. (2016). Effect of source-sink manipulation on yield and related yield components in cassava, Manihot esculenta Crantz. *International Journal of Agricultural Research, Innovation and Technology*, *6*(2), 69–76. https://doi.org/10.3329/ijarit.v6i2.31708

Amarullah, Indradewa, D., Yudono, P., & Sunarminto, B. H. (2017). Correlation of growth parameters with yield of two cassava varieties. *Ilmu Pertanian (Agricultural Science)*, *1*(3), 100–104. https://doi.org/10.22146/ipas.10706

Amarullah. (2016). *Manipulasi sumber dan lubuk dengan pengaturan jumlah cabang pertanaman dan model irisan stek untuk meningkatkan hasil ubikayu* (Doctoral Dissertasion). Tarakan, Indonesia: Universitas Borneo Tarakan. Retrieved from https://docplayer.info/87008724-I-pendahuluan-1-1-latar-belakang.html

Angga, W. (2011). *Pengaruh jumlah mata tunas stek terhadap pertumbuhan empat varietas ubi kayu (Manihot esculenta Crantz.)* [Undergraduate theses]. Bogor: Institut Pertanian Bogor. Retrieved from https://repository.ipb.ac.id/handle/123456789/51128

Ariani, M., Hermanto, Hardono, G. S., Sugiarto, & Wahyudi, T. S. (2013). Kajian strategi pengembangan diversifikasi pangan lokal. In *Laporan Kegiatan Kajian Isu-Isu Aktual Kebijakan Pembangunan Pertanian*. Bogor, Indonesia: Pusat Sosial Ekonomi dan Kebijakan Pertanian Badan Penelitian dan Pengembangan Pertanian. Retrieved from http://pse.litbang.pertanian.go.id/ind/pdffiles/anjak_2013_06.pdf

BALITKABI [Balai Penelitian Tanaman Aneka Kacang dan Umbi]. (2019). *Cara dan jenis pupuk untuk tanaman ubikayu/singkong*. Malang: BALITKABI. Retrieved from http://cybex.pertanian.go.id/mobile/artikel/78664/Cara-dan-Jenis-Pupuk-untuk-Tanaman-Ubi-Kayu---Singkong/

Bantacut, T. (2014). Indonesian staple food adaptations for sustainability in continuously changing climates. *Journal of Environment and Earth Science*, *4*(21), 202–215. Retrieved from https://www.iiste.org/Journals/index.php/JEES/article/view/17448

Benesi, I. R. M., Labuschagne, M. T., Herselman, L., Mahungu, N. M., & Saka, J. K. (2008). The effect of genotype, location and season on cassava starch extraction. *Euphytica*, *160*, 59–74. https://doi.org/10.1007/s10681-007-9589-x

Bridgemohan, P., & Bridgemohan, R. S. H. (2014). Effect of initial stem nodal cutting strength on dry matter production and accumulation in cassava (*Manihot esculenta* Crantz). *Journal of Plant Breeding and Crop Science*, *6*(6), 64–72. https://doi.org/10.5897/JPBCS2013.0452

Ceballos, H., & de la Cruz, G. A. (2002). Taxonomía y morfología de la yuca. In B. Ospina, H. Ceballos (Ed.), *La yuca en el tercer Milenio: Sistemas Modernos de producción, procesamiento, utilización y comercialización*, pp. 16–31. Cali, Colombia: CIAT (International Center for Tropical Agriculture). Retrieved from https://repository.agrosavia.co/handle/20.500.12324/18089

Ceballos, H., Okogbenin, E., Pérez, J. C., López-Valle, L. A. B., & Debouck, D. (2010). Cassava. In J. Bradshaw (Ed.), *Root and Tuber Crops*, pp. 53–96. New York: Springer. https://doi.org/10.1007/978-0-387-92765-7_2

Cock, J. H. (2012). Cassava : A basic energy source in the tropics. In R. H. Howeler (Ed.), *The cassava handbook: A reference manual based on the asian regional cassava training course, held in Thailand*, pp. 23–38. Bangkok, TH.: Centro Internacional de Agricultura Tropical (CIAT). Retrieved from http://ciat-library.ciat.cgiar.org/Articulos_ciat/biblioteca/The%20Cassava%20Handbook%202011.pdf#page=31

De Souza, A. P., Massenburg, L. N., Jaiswal, D., Cheng, S., Shekar, R., & Long, S. P. (2017). Rooting for cassava: insights into photosynthesis and associated physiology as a route to improve yield potential. *New Phytologist*, *213*(1), 50–65. https://doi.org/10.1111/nph.14255

Edet, M. A., Tijani-Eniola, H., & Okechukwu, R. U. (2013). Comparative evaluation of organomineral fertilizer and NPK151515 on

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growth and yield of cassava varieties in Ibadan, southwestern Nigeria. *African Journal of Root and Tuber Crops*, *10*(1), 9–14. Retrieved from https://hdl.handle.net/10568/76679

Edmond, J. B., Senn, T. L., Andrews, F. S., & Halfacre, R. G. (1975). *Fundamentals of horticulture* (4th ed.). New York, United States: McGraw-Hill, Inc.. Retrieved from https://scholar.google.co.id/scholar?cites=10560392343957292712&as_sdt=2005&sciodt=0,5&hl=id&authuser=3

Egesi, C. N., Ilona, P., Ogbe, F. O., Akoroda, M., & Dixon, A. (2007). Genetic variation and genotype × environment interaction for yield and other agronomic traits in cassava in Nigeria. *Agronomy Journal*, *99*(4), 1137–1142. https://doi.org/10.2134/agronj2006.0291

Eke-Okoro, O. N., & Njoku, D. N. (2012). A review of cassava development in Nigeria from 1940-2010. *ARPN Journal of Agricultural and Biological Science*, *7*(1), 59–65. Retrieved from http://www.arpnjournals.com/jabs/research_papers/rp_2012/jabs_0112_356.pdf

El-Sharkawi, M. A. (2006). International research on cassava photosynthesis, productivity, eco-physiology and responses to environmental stresses in the tropics. *Photosynthetica*, *44*(4), 481–512. https://doi.org/10.1007/s11099-006-0063-0

El-Sharkawy, M. A. (2014). Global warming: causes and impacts on agroecosystems productivity and food security with emphasis on cassava comparative advantage in the tropics/subtropics. *Photosynthetica*, *52*(2), 161–178. https://doi.org/10.1007/s11099-014-0028-7

Enyi, B. A. C. (1973). Growth rates of three cassava varieties (*Manihot esculenta* Crantz) under varying population densities. *The Journal of Agricultural Science*, *81*(1), 15–28. https://doi.org/10.1017/S0021859600058251

Fermont, A. M., Titonell, P. A., Baguma, Y., Ntawuruhunga, P., & Giller, K. E. (2010). Towards understanding factors that govern fertilizer response in cassava: lessons from East Africa. *Nutrient Cycling Agroecosystem*, *86*(1), 133–151. https://doi.org/10.1007/s10705-009-9278-3

Gardner, F. P., Pearce, R. B., & Mitchell, R. L. (2017). *Physiology of crop plants*. Jodhpur, India: Scientific publishers. Retrieved from https://scholar.google.co.id/scholar?cites=4067135385125625208&as_sdt=2005&sciodt=0,5&hl=id&authuser=3

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for Agricultural Research* (2nd ed.). New Jersey, United States: John Wiley & Sons. Retrieved from https://scholar.google.co.id/scholar?cites=14957946235125646981&as_sdt=2005&sciodt=0,5&hl=id&authuser=3

Guritno, B., & Sitompul, S. M. (1995). *Analisis pertumbuhan tanaman*. Yogyakarta: Gadjah Mada University Press. Retrieved from https://scholar.google.co.id/scholar?cluster=8192137574706130258&hl=id&as_sdt=2005&sciodt=0,5&authuser=3

Hardono, G. S. (2014). Strategi pengembangan diversifikasi pangan lokal. *Analisis Kebijakan Pertanian*, *12*(1), 1–17. http://dx.doi.org/10.21082/akp.v12n1.2014.1-17

Hasibuan, S., & Nazir, N. (2017). The development strategy of sustainable bioethanol industry on iconic Sumba island, Eastern Indonesia. *International Journal on Advanced Science, Engineering and Information Technology*, *7*(1), 276–283. Retrieved from https://core.ac.uk/download/pdf/296918917.pdf

Hidayat, R. (2004). Kajian pola translokasi asimilat pada beberapa umur tanaman manggis (*Garcinia Mangostana* L.) muda. *Agrosains*, *6*(1), 20–25. Retrieved from https://scholar.google.co.id/scholar?cites=9012011237802973815&as_sdt=2005&sciodt=0,5&hl=id&authuser=3

Ikuemonisana, E. S., Mafimisebib, T. E., Ajibefuna, I., & Adenegan, K. (2020). Cassava production in Nigeria: trends, instability and decomposition analysis (1970–2018). *Heliyon*, *6*(10), e05089. https://doi.org/10.1016/j.heliyon.2020.e05089

Neves, R. J., Diniz, R. P., & Oliveira, E. J. (2018). Productive potential of cassava plants (*Manihot esculenta* Crantz) propagated by leaf

Copyright © 2021 Universitas Sebelas Maret

buds. *Anais Da Academia Brasileira de Ciências*, *90*(2), 1733–1747. http://dx.doi.org/10.1590/0001-3765201820170867

Nugraha, H. D., Suryanto, A., & Nugroho, A. (2015). Kajian potensi produktivitas ubikayu (*Manihot esculenta* Crant.) di Kabupaten Pati. *Jurnal Produksi Tanaman*, *3*(8), 673–682. Retrieved from http://protan.studentjournal.ub.ac.id/index.php/protan/article/view/249

Nurdjanah, S., Susilawati, & Sabatini, M. R. (2012). Prediksi kadar pati ubi kayu (*Manihot esculenta*) pada berbagai umur panen menggunakan penetrometer. *Jurnal Teknologi & Industri Hasil Pertanian*, *12*(2), 65–73. Retrieved from http://jurnal.fp.unila.ac.id/index.php/JTHP/article/view/87

Okpara, D. A., Agoha, U. S., & Iroegbu, M. (2010). Response of cassava variety TMS 98/0505 to potassium fertilization and time of harvest in South Eastern Nigeria. *Nigeria Agricultural Journal*, *41*(1), 91–100. Retrieved from https://www.ajol.info/index.php/naj/article/view/90575

Oliveira, E. C., & Miglioranza, E. (2014). Stomatal density in six genotypes of cassava. *International Journal of Engineering Science and Innovative Technology (IJESIT)*, *3*(3), 205–208. Retrieved from http://www.ijesit.com/Volume%203/Issue%203/IJESIT201403_40.pdf

Pusdatin [Pusat Data dan Sistem Informasi Pertanian/Center for Agricultural Data and Information System]. (2018). *Agricultural Statistics 2018*. Jakarta: Center for Agricultural Data and Information System, Ministry of Agriculture Republic of Indonesia. Retrieved from https://polbangtanmalang.ac.id/wp-content/uploads/2019/07/Statistik-Pertanian-2018.pdf

Radjit, B. S., & Prasetiaswati, N. (2011). Potensi hasil umbi dan kadar pati pada beberapa varietas ubikayu dengan sistim sambung (Mukibat). *Buana Sains*, *11*(1), 35–44. Retrieved from https://jurnal.unitri.ac.id/index.php/buanasains/article/view/177

Rahman, S., & Awerije, B. O. (2016). Exploring the potential of cassava in promoting agricultural growth in Nigeria. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, *117*(1), 149–163. Retrieved from https://www.jarts.info/index.php/jarts/article/view/2016050350174

Remison, S. U., Omorodion, E., & Eifedyi, E. K. (2015). A re-examination of the effects of length of stem cuttings on the growth and yield of cassava (*Manihot esculenta* Crantz). *Nigerian Annals of Natural Sciences*, *15*(1), 9–13. Retrieved from https://www.researchgate.net/publication/297715769_A_RE-EXAMINATION_OF_THE_EFFECTS_OF_LENGTH_OF_STEM_CUTTINGS_ON_THE_GROWTH_AND_YIELD_OF_CASSAVA_Manihot_esculenta_CRANTZ

Santisopasri, V., Kurotjanawong, K., Chotineeranat, S., Piyachomkwan, K., Sriroth, K., & Oates, C. G. (2001). Impact of water stress on yield and quality of cassava starch. *Industrial Crops and Products*, *13*(2), 115–129. https://doi.org/10.1016/S0926-6690(00)00058-3

Simatupang, P. (2012). Meningkatkan daya saing ubikayu, kedelai dan kacang tanah untuk meningkatkan pendapatan petani, ketahanan pangan, nilai tambah, dan penerimaan devisa. *Prosiding Seminar Hasil Penelitian Tanaman Aneka Kacang dan Umbi*, 1–12. Retrieved from https://balitkabi.litbang.pertanian.go.id/wp-content/uploads/2013/08/01_Pancar-1.pdf

Sulistiono, W., Hartanto, S., & Brahmantiyo, B. (2020). Respons beberapa varietas ubi kayu terhadap pemupukan NPK pada tanah Latosol di Maluku Utara. *Buletin Palawija*, *18*(1), 43–51. http://dx.doi.org/10.21082/bulpa.v18n1.2020.p43-51

Sundari, T. (2010). *Petunjuk teknis: Pengenalan varietas unggul dan teknik budidaya ubi kayu (Materi pelatihan agribisnis bagi KMPH).* Palembang: Ministry of Forestry. Retrieved from http://www.forclime.org/merang/55-STE-FINAL.pdf

Suwitono, B., Hendaru, I. H., & Putri, P. H. (2017). Karakterisasi agronomis ubikayu lokal Maluku Utara. *Prosiding Seminar Hasil Penelitian Tanaman Aneka Kacang dan Umbi*, 510–517. Retrieved from https://balitkabi.litbang.pertanian.go.id/wp-content/uploads/2018/07/Prosiding-2017-52-bayu.pdf

Copyright © 2021 Universitas Sebelas Maret

Taiz, L., & Zeiger, E. (2010). *Plant Physiology* (5th ed.). Sunderland, Massachusetts, United States: Sinauer Associates, Inc. Retrieved from https://scholar.google.co.id/scholar?cluster=15354113465242236017&hl=id&as_sdt=2005&sciodt=0,5&authuser=3

Tappiban, P., Sraphet, S., Srisawad, N., Wu, P., Han, H., Smith, D. R., & Triwitayakorn, K. (2020). Effects of cassava variety and growth location on starch fine structure and physicochemical properties. *Food Hydrocolloids*, *108*, 106074. https://doi.org/10.1016/j.foodhyd.2020.106074

Wijanarko, A. (2014). *Peningkatan kesuburan dan kualitas tanah dengan pemberian biomassa tanaman legum dan non legum pada pola tumpangsari-tumpang gilir ubikayu di Typic Hapludult Lampung* [Doctoral Dissertation]. Yogyakarta, Indonesia: Universitas Gadjah Mada. Retrieved from http://etd.repository.ugm.ac.id/penelitian/detail/71090

Wild, A., & Jones, L. H. P. (1988). Mineral nutrition of crop plants. In A. Wild (Ed.), *Russell's soil conditions and plant growth* (11th ed.), pp. 69–112. Harlow, UK: Longman Scientific and Technical. Retrieved from https://scholar.google.co.id/scholar?cluster=16451850463393787335&hl=id&as_sdt=2005&sciodt=0,5

Zuraida, N. (2010). Karakterisasi beberapa sifat kualitatif dan kuantitatif plasma nutfah ubi kayu (*Manihot esculenta Crantz.*). *Buletin Plasma Nutfah*, *16*(1), 49–56. http://dx.doi.org/10.21082/blpn.v16n1.2010.p49-56

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