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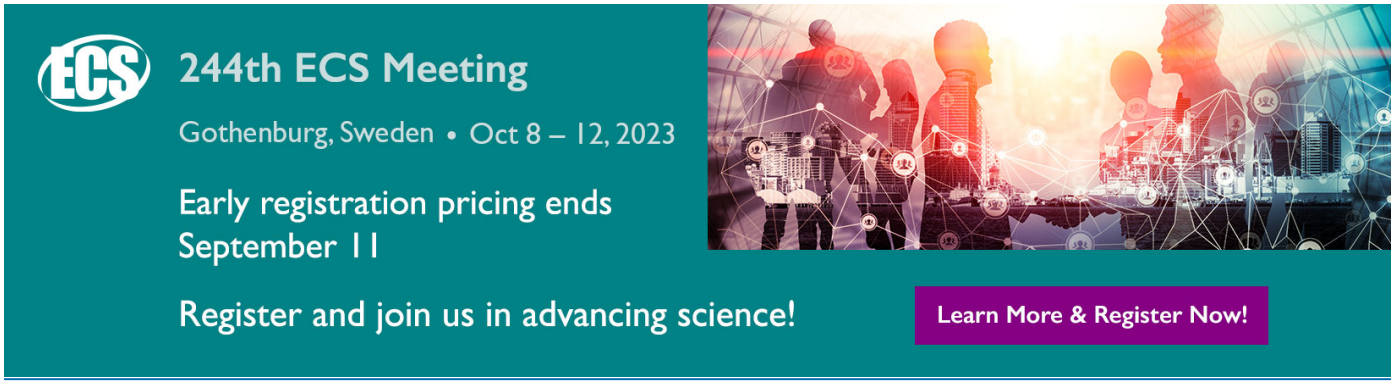

Detection of early harvest cassava clone through plant height development and starch content in dry land of Lampung

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Abstract. Lampung is one the biggest areas for planting cassava in Indonesia, approximately 119 thousand ha with a productivity of 26 tons/ha. Optimum harvest time for cassava high yield could be 10-12 months after planting (MAP). However, most farmers used to harvest cassava around 7 MAP leading to low yield. This condition needs to introduce early age of harvest cassava to achieve the alternative solution. The objective of this study were to evaluate the growth characteristics of early cassava harvest for high yield. Treatment were arranged by a single factor in a randomized complete block design (RCBD) with three replications. Factors were 12 cassava clones as CMR 51-61-1, CMR 51-48-17, CMR 51-48-16, UJ-3, UJ-5, Vamas, Adira, CMR 51-07-03, OMM 0806-57, CMR 51-06-16, MC 6.10.311, and Litbang UK2. In this study, the variables measured included plant height, root fresh weight, starch content, and starch yield. Result indicated that the Vamas clone had relatively low plant height. At 7 MAP, the Vamas clone showed high starch content compared to the UJ-3 clone. Low plant height and starch content could be used to detect early-harvest cassava clones at harvest of 7 MAP.

1. Introduction

Based on world cassava production, Indonesia is in the range five after Nigeria, the Republic of Congo, Thailand, and Ghana. Interestingly, Lampung is the most extensive harvested cassava area in Indonesia, approximately 250 thousand ha in 2019 [1]. Such areas consisted of > 85% belonging to the smallholder of farmers and the rest (around 15%) belonging to a private companies [1]. Potential cassava production could be 50-60 tons/ha, but cassava productivity in Lampung was still low, around 26 tons/ha. One of the main problems in Lampung why cassava productivity is the early age of harvested cassava in farmers, which is 6-7 MAP. Actually, the optimum age for cassava harvest would be 10 - 12 MAP. According to Apea-Bah *et al.* [2], the optimum starch content of cassava will be achieved at 10 or 12 months after planting (MAP) as 71-75%. It was well known that young cassava root could reduce both root fresh weight and starch content [3, 4], contain low protein [5], and also low amylose [2].

The other pineapple industry in Lampung is frequently used to plant cassava as a rotation crop after harvesting pineapple. Pineapple replanting program would be conducted around 6-7 months after

harvesting the pineapple. Time of cassava rotation crop would be short for optimum harvested cassava. Ideal alternative to solve such a problem for both farmers and the pineapple industry is early-age cassava clones that could be harvested around 6-7 MAP. Such a solution would help farmers to plant cassava as many as twice a year. Additionally, the rotation system in the pineapple industry could be applied by planting early-age cassava clones. Introduction of early-age cassava clones are still limited due mainly to planting material preparation either for farmers or the pineapple industry. Even private businesses use micronutrient fertilizers in the field little or never. The objective of this study were to evaluate the growth characteristics of early-cassava harvest for high yield.

2. Methods

This study was conducted in Lampung province of two Districts, Lampung Selatan (South Lampung) and Lampung Timur (East Lampung), from 2020 to 2022. Characteristic of soil for the planting area was sandy loam from 15-30%. There were 12 cassava clones as CMR 51-61-1 (C1), CMR 51-48-17 (C2), CMR 51-48-16 (C3), UJ 3 (C4), UJ 5 (C5), Vamas (C6), Adira (C7), CMR 51-07-13 (C8), OMM 0806-57 (C9), CMR 51-06-16 (C10), MC 6.10.311 (C11), and Litbang UK2 (C12) which also used by [6]. Clones of UJ-3 and UJ-5 were used as control. Population number was 12,500 cassava plants/ha or with a planting distance of 80 x 100 cm. In this study, the variables measured included plant height, root fresh weight, starch content, and starch yield. Fertilizer dosage to conduct this study was 100 kg urea/ha (45% N), 100 kg SP-36 (36% P_2O_5), and 150 kg KCl/ha (60% K_2O). Fertilizer of SP-36 was applied four weeks after planting (WAP), whereas urea and KCl were used twice as half dosage in 4 WAP or one month after planting (MAP), and the remnant was used in 8 WAP or 2 MAP.

Three repetitions of a randomized complete block design (RCBD) were used to arrange the treatment according to a single factor. Cassava plants were sampled three plants in each block, and the production of starch yield was calculated by multiplying starch content and root fresh weight per ha. Data were analyzed by analysis of variance and continued to least significant difference (LSD) with a 5% level of significant difference.

3. Result and discussion

The results showed that variations in plant shoot and root fresh weight (Table 1). It was demonstrated that the Vamas clone`s plant height of at the age of 7 MAP was the lowest in both places, South and East Lampung, as 247 and 208 cm, respectively. Interestingly, the UJ-5 clone was higher than the Vamas clone, and the height gap was 46 cm. it seems that the height growth of the Vamas clone in both places, South and East Lampung, was low. Moreover, the Vamas clone`s plant height was not significantly different from that of UJ-3. This result was concomitant with Anisya *et al.* [7], and Sholihin [8], who reported that the UJ-5 clone was higher than the UJ-3 clone. Average Vamas clone`s plant height (227 cm) was lower than that of all clones (249 cm) tested in this study.

The root fresh weight of the Vamas clone was not significantly different from that of UJ-5 in both places, South and East Lampung, at 7 MAP. However, the root fresh weight of the Vamas clone was significantly different from that of the UJ-3 clone at 7 MAP. Moreover, among 12 cassava clones tested in this study, the highest root fresh weight was Litbang UK2, especially in East Lampung at 7 MAP. According to Phoncharoen *et al.* [9], different planting locations would produce different amounts of cassava production. Genotypes differed significantly within and between locations for shoot and root characteristics [10]. Sundari and Yulifianti [11] reported that the interaction between genotype and planting location had a significant effect on the character of cassava production and observed cassava starch content. Genotype, harvest time, location, and their interactions were significantly different for root yield [12]. The root fresh weight average of the Vamas clone in South and East Lampung was higher than that of the UJ-3 clone, with a gap of > 10 tons/ha. However, the root fresh weight average of the Vamas clone in South and East Lampung was not significantly different from that of the UJ-5 clone. Noerwijati [13] reported that the potential root fresh weight of Vamas could be achieved by 41.1 tons/ha. At 7 MAP, the root fresh weight of the Vamas clone was

36.1 tons/ha, and this was relatively higher than the root fresh weight average of all clones tested as 31.2 tons/ha. According to Sundari and Yulifianti [11], early harvest clone could be elite high yielding clones if the root fresh weight of the early-harvest clones were similar to high yield potential. Moreover, the chemical and physical characteristics of the early-harvest cassava clone was close to the late-age harvest cassava clone, which was harvested at 10-12 MAP.

Observation of starch content at 7 MAP, Vamas clone planted in both places, South and East Lampung, showed not significantly different from UJ 5 clone (Table 2). However, the Vamas clone's starch content was greater than that of UJ-3 in East Lampung. Interestingly, the starch content average of the Vamas clone (20.4%) was relatively higher than that of all clones (19.4%) tested in this study. The lower starch content of 12 clones at 7 MAP was Litbang UK2 clone as 16.9%. Although the Litbang UK2 clone was able to produce higher root fresh weight, the starch yield was lower than the Vamas clone (approximately 7.4 tons/ha). The Vamas clone's starch content was higher than that of the UJ-3 clone yet not significantly different from that of the UJ-5 clone. It seems that the Vamas clone could be an elite early-harvest cassava clone. In support of this [3], who made that report the late-age cassava clone (harvested at 10-12 MAP) produced 19.2% starch content harvested at 8 MAP. When the late-age cassava clones were harvested at 4, 5, and 6 MAP, they would have the same starch content [14]. There was no statistically significant difference in the starch content according to genotype x environment. On the other hand, Chua *et al.* [15] reported that K fertilization of cassava allowed for better yields and starch content that could avoid progressive depletion of the soil K capital. It seems that K fertilizer could be applied to improve the starch content of early-harvest cassava clones. Additionally, applying balanced N, P, and K fertilizers could significantly increase the starch content of cassava clones [16].

The achievement of starch yield per hectare was close to the value of starch content and root fresh weight production per hectare. At 7 MAP, based on the accomplishment of starch yield per hectare, the Vamas clone could be an elite early-harvest cassava clone because late-age harvest cassava clones such as UJ-3 and UJ-5 produced starch yield of around 4.9 and 6.7 tons/ha, respectively. The lower starch yield of UJ-3 and UJ-5 was mainly due to harvest age (7 MAP). According to Baafi and Safo-Kantanka [4], the interaction between genotype, location, and age was significantly influenced cassava starch yield. Such a result was supported by Setiawan *et al.* [17], who made that report harvest age at 7 MAP could significantly decrease starch yield compared to that at 10 or 12 MAP.

Generally, farmers in Lampung planted UJ-3 and UJ-5 and frequently harvested at 6-7 months due mainly to their economic needs. Based on this study, UJ-3 and UJ-5 clones were not recommended to be harvested at 7 MAP. Fortunately, the Vamas clone could be recommended to be harvested at 7 MAP. Consequently, the Vamas clone could promisingly be used as an elite early cassava clone and harvested at 7 MAP. The other recommendation for early-harvest cassava clone of Vamas is applying balanced N, P, and K fertilizers to achieve maximum starch yield. This is because tapioca factories could receive cassava root yield from farmers when starch content is around 24%. Therefore, elite early-harvest cassava clones having high starch yield and content would be profitable for both farmers and tapioca industries.

4. Conclusion

The Vamas clone`s plant height was lower than that of the average plant height of 12 cassava clones. At 7 MAP, the Vamas clone relatively produced such competitive starch content and starch yield compared to 12 cassava clones tested in this study. It was recommended that the Vamas clone could elite early harvest cassava clone based on root fresh weight and starch content harvested at 7 MAP. The other recommendation is that Vamas early harvest cassava clone would produce high starch yield when soil contains balanced N, P, and K elements.

Acknowledgment

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Table 1. Performance of plant height and root fresh weight at 7 MAP of several cassava clones/varieties in South Lampung and East Lampung.

Clones/varieties	Plant height (cm)			Root fresh weight (t/ha)		
	South Lampung	East Lampung	Average	South Lampung	East Lampung	Average
C1	288 ab	219 bc	253 abc	33.90 ab	36.87 b	35.38 ab
C2	259 abc	282 a	271 a	23.20 def	29.90 bcd	26.55 cdef
C3	289 ab	235 bc	262 ab	18.07 f	25.23 cd	21.65 f
C4	270 abc	245 b	257 abc	26.07 cde	24.60 d	25.33 def
C5	293 a	231 bc	262 ab	33.80 ab	33.27 bcd	33.53 bc
C6	247 c	208 c	227 c	37.11 ab	35.13 b	36.12 ab
C7	263 abc	230 bc	246 abc	33.47 abc	33.93 bc	33.70 b
C8	267 abc	213 c	240 abc	38.13 a	35.20 b	36.67 ab
C9	263 abc	208 c	236 bc	30.10 bcd	31.23 bcd	30.67 bcde
C10	282 abc	236 bc	259 abc	20.00 ef	28.67 bcd	24.33 ef
C11	266 abc	219 bc	243 abc	34.37 ab	26.03 cd	30.20 bcde
C12	254 bc	220 bc	237 b	34.70 ab	46.80 a	40.75 a
Average	270	229	249	30.24	32.24	31.24
LSD 5 %	37.8	30	33.16	7.697	8.925	8.099

Table 2. Performance of yield of starch content and starch yield at 7 months of several cassava clones/varieties in South Lampung and East Lampung.

Clones/varieties	Starch content (%)			Starch yield (t/ha)		
	South Lampung	East Lampung	Average	South Lampung	East Lampung	Average
C1	18.20 ab	20.20 abc	19.20 ab	6.160 abc	7.500 abc	6.830 ab
C2	19.60 a	19.80 c	19.70 ab	4.577 cd	5.933 de	5.255 bc
C3	19.63 a	21.53 a	20.58 a	3.617 d	5.463 ab	4.540 c
C4	18.77 ab	19.73 c	19.25 ab	4.920 bcd	4.853 e	4.887 c
C5	19.77 a	19.90 bc	19.83 ab	6.747 a	6.637 abcde	6.692 ab
C6	19.70 a	21.43 ab	20.57 a	7.307 a	7.563 ab	7.435 a
C7	19.40 a	20.30 abc	19.85 ab	6.510 ab	6.857 abcd	6.683 ab
C8	19.33 a	19.80 c	19.57 ab	7.387 a	7.007 abcd	7.197 a
C9	19.23 a	20.93 abc	20.08 ab	5.863 abc	6.557 abcde	6.210 abc
C10	16.87 b	19.80 c	18.33 bc	3.460 d	5.687 cde	4.573 c
C11	18.10 ab	20.70 abc	19.40 ab	6.277 ab	5.397 de	5.837 abc
C12	16.90 b	16.80 d	16.85 c	5.900 abc	7.903 a	6.902 ab
Average	18.79	20.08	19.44	5.727	6.446	6.087
LSD 5 %	2.13	1.63	1.301	1.64	1.828	1.688

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