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To cite this article: K Setiawan *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **824** 012002

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IOP Conf. Series: Earth and Environmental Science **824** (2021) 012002 doi:10.1088/1755-1315/824/1/012002

The effect of micro fertilizer on growth and yield of two cassava clones (*Manihot esculenta Crantz*) planting in early dry-season, South Lampung, Indonesia

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Abstract. Drought is one of the important climate changes that could affect the early planting of cassava to produce a high yield. Lampung province having a specific climate, wet tropical dry-season is the center of cassava production in Indonesia. Consequently, the objective was to evaluate the effect of micro fertilizers on the growth and yield of two cassava clones planting in the early dry season. This research was conducted on Ultisol soil of Tanjung Bintang District, South Lampung from May 2019 to April 2020. Treatment was arranged by factorial (2x2) in a Randomized Complete Block Design (RCBD) which 3 replications. The first factor was two applications of micro fertilizer, 0 and 40 kg ha^{-1}. The second factor was two cassava clones, UJ-5 and BW-1. Results showed that the leaf number of UJ-5 at 6 MAP and 9 MAP was increased by micro fertilizer. Yet, the leaf number of BW-1 at 6 MAP and 9 MAP was not increased by micro fertilizer. It seems that UJ-5 could be more tolerant to drought in early planting time. Consequently, the tuber fresh weight of UJ-5 was heavier due to micro fertilizer but lower starch content compared to BW-1. It could be concluded that UJ-5 when planted at early dry-season would show higher tuber fresh weight with lower starch content than BW-1.

1. Introduction

Indonesia was the fourth rank of cassava yield in the world after Brazil. Lampung province is one of the cassava production centers in Indonesia with a total area of around 160 thousand ha, and productivity of 23 ton ha^{-1} [1]. Additionally, Lampung is one of Sumatra provinces having a specific tropical climate, as dry-wet climate. Dry-season in Lampung could last more than 6 months and the rainy season frequently lasted only less than 5 months. Because of this, the main risk that affects cassava yield could be the planting date especially dry-season time. If there is climate change in Lampung, the dry season causes longer drought and leads to low cassava yield. Generally, in Lampung, the rainy season lasted 4.6 months, from November-March, and the dry season lasted 7.4 months from March-November [2]. There are two cassava clones frequently planted in Lampung, Indonesia namely UJ-5 and BW-1 to supply for tapioca industry. UJ-5 and BW-1 are originally selected from Kasetsart 50 and Rayong and are well adapted clones in Lampung, Indonesia. There are two main problems for developing cassava in Lampung, as drought in planting time and plant nutrient, especially micronutrient that is rarely used by both farmers and private sectors. In general, farmers and the private sector planted cassava in the early dry season to avoid drought in the growing stage. Unfortunately, it needs cassava clones to be well-adapted to cope with drought to be better vegetative growth.

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Cassava planted in the middle of the rainy season in Lampung (September 2017) and applied by micro fertilizer of Zn+Fe showed a low yield of tuber weight [3]. Moreover, high rainfall at the tuber formation period would reduce starch content [4]. Compare to other cassava clones, Kasetsart 50 was one of the genotypes showing high tuber dry weight at 360 DAP in the dry season. Yet Rayong showed better performances of tuber dry weight at 180 DAP (at rainy season) than at 270 and 360 DAP (late rainy-season and dry season) [5]. An experiment on micro fertilizer combined with macronutrient fertilizers to increase cassava starch was conducted by Panitnok et al. [6]. They showed that in Thailand, tuber weight and starch content would increase up to 30% and 29%, respectively when cassava is applied by Zn. The other researchers also reported that the application of a micronutrient (Zn+Mg) could improve starch content [7]. Moreover, in Indonesia, the application of micro fertilizer could increase tuber weight (yield increment of 0.47 kg) when harvested at 210 DAP Hadi M S [8] and Kurniawan et al. [9]. This means that low tuber yield and starch harvested at the early time could be improved by adding micro fertilizer. Consequently, the objective of this research was to evaluate the vegetative and tuber yield of two different cassava clones that were planted in the early dry season applied by micro fertilizer.

2. Material and methods

2.1 Experimental site

This research was conducted on Tanjung Bintang, South Lampung, Indonesia from May 2019-April 2020 early dry-season (Fig 1). Stem cutting of cassava was planted in May 2019 with soil characters as pH of 6.80; 0.06% N-Total; 14.42 ppm P-available; 0.15 me/100 g K-exchangeable; 36.25% sand; 36.83% loam; and 26.92% clay.

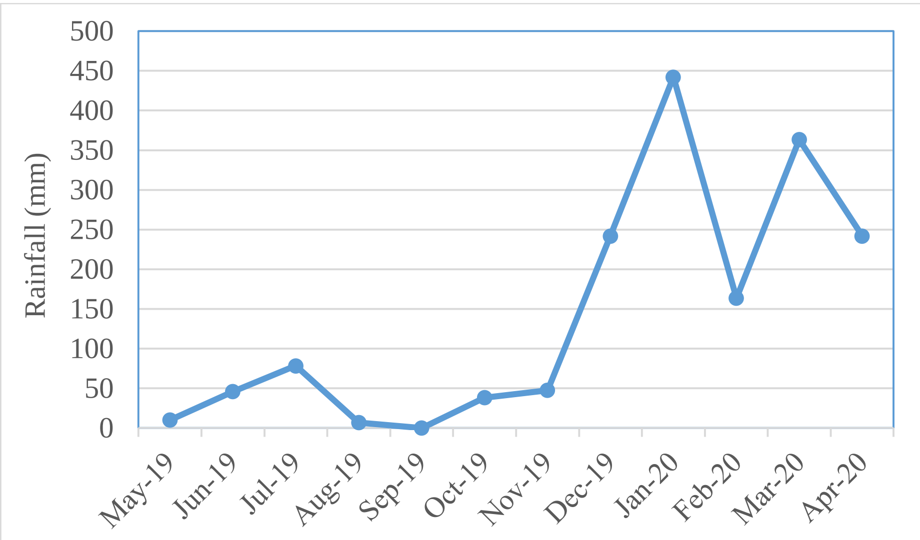

Figure 1. Rainfall in research location of south Lampung, Lampung Indonesia.

2.2 Experimental design and data analysis

Treatments were arranged by factorial (2x2) in CRBD with three reps used as block. The first factor was two cassava clones, BW-1 (originally from Rayong) and UJ-5 (originally from Kasetsart-50). The second factor was two dosages of micro fertilizer (5.880 ppm Fe+1.368 ppm Zn), as 0 and 40 kg ha^{-1}. Cassava was planted by using a 20-25 cm stem cutting length. Macro inorganic fertilizers in this research were urea (45% N), TSP (36% P_2O_5), and KCl (60% K_2O) with a dosage of 150 kg ha^{-1}, 50 kg ha^{-1} and 250 kg ha^{-1}, respectively. KCl was applied twice, the first was 75 kg ha^{-1} at one MAP together with 150 kg urea ha^{-1} and 50 kg TSP ha^{-1}. The application of micro fertilizer was together with the first application of macro fertilizer. The rest of 175 kg KCl ha^{-1} was applied at 5 MAP.

Variables observed were leaf number, plant height, leaf fresh weight, stem fresh weight, stem diameter, leaf dry weight, stem dry weight, root number, tuber number, tuber length, tuber diameter, tuber fresh weight, tuber dry weight, and starch content. Leaf number was recorded at 6, 9, and 11 MAP which was concomitant with early dry-season, dry-season, and rainy-season. Five cassava plants of each experimental unit were taken as samples. The others variables were observed at the harvested stage of 12 MAP. Starch content was analyzed by the method of *Thai Sang Metric co.Ltd*. Data were analyzed by Minitab 17 for analyses of variance and different treatment means were analyzed by least significant difference (LSD) with 5% α.

Table 1. Analysis of variance for variables.

Variable	Block	Micro fertilizer	Clone	Micro fertilizer x Clone	CV(%)
LN 6 MAP	210.72	58.59	1,200.79**	34.76	12.5
LN 9 MAP	118.69	153.07	935.49**	525.60*	21.3
LN 11 MAP	15.23	538.83**	390.58**	249.06*	16.6
SD	61.48	92.47**	340.269**	60.55**	10.9
PH	4,859.10	3,716.30	16,254**	215.80	12.2
SFW	3,713,928	4,069,010**	21,462,220**	1,116,570*	23.5
LFW	14,072.10	582.70	87,011.80**	67,678**	13.2
SDW	326,431	396,890**	2,195,129**	9521	20.3
LDW	445.40	2412*	7,312**	613.50	16.2
TD	30.23	90.76	244.16*	19.29	14.5
TL	30.43	26.83	12.81	24.50	16.9
RN	4.02	58.39	6.14	2.28	23.8
TN	22.11	1.23	56.11*	23.94	19.9
TFW	2,656,851	3,273,026*	797,858	10,278,197**	23.6
TDW	369,208	44,123	76,703	2175	13.6
SC	16.94	3.68	36.51*	33.14*	3.33

LN=leaf number, ST=stem diameter, PH=plant height, CV=coefficient variance, SFW=stem fresh weight, LFW=leaf fresh weight, SDW=stem dry weight, LDW=leaf dry weight, TD=tuber diameter, TL=tuber length, RN=root number, TN=tuber number, TFW=tuber fresh weight, TDW=tuber dry weight, SC=starch content, MAP=month after planting; *=significant difference at α=5%; **=significant difference at α=1%.

3. Result and discussion

3.1 Variation variables based on mean square values

The CV value was in the range of 3-24% (Table 1), which means that data variation of error is closed to the general average. The monthly rainfall data during research are presented in Fig 1. It is noticeable that rainfall was very low (May-November) during cassava growth and increased from November-April (at time of harvest). It was postulated by Williams and Ghazali [10] and later confirmed by Buxo [11] that planting at minimum rainfall would help to establish plants, although leaf production was at a minimum. With increased rainfall leaf production increased, therefore nutrient assimilation which coincided with tuber bulking increased, thereby increasing the tuber yield of cassava. There was no variation due to micro fertilizer for variables of LN at 6 and 9 MAP (Table 1). However, a significant variation of leaf appeared at 11 MAP, and this was followed by SD, SFW, SDW, LDW, and TFW. The explanation was the effect of micro fertilizer on leaves could be detected 4 months after application. There was no variation of RN either under micro fertilizer or clone. This probably means that BW-1 and UJ-5 have the same potential for RN. Dry-season during 6 months could influence vegetative growth led to TN variation. The established root swollen to be tuber was 3-4 MAP Carvalho et al. [12] and Chaweewan & Taylor [13] in which rainfall was extremely low during August-September 2019.

Tuber components in this research showed no significant variation. This means that two clones have the same response to drought when planted in the early dry season. Yet, the response of clones on vegetative parts was significantly different. This result was supported by Phoncharoen et al. [14] that stem and leaf growth rates of Kasetsart and Rayong clones were different. Interestingly, micro fertilizer showed synergized with clones to induce high variation in leaf character and tuber component. This probably means that response of clones on such variables would appear 4 months after the application of micro fertilizer. It could be addressed that a good response of clone to micro fertilizer in early dry-season planting was indicated by tuber yield. When planting in a short dry season with relatively well-distributed rainfall, tuber dry weight could be used as a good indicator for high yield due to its stable character [15].

3.2 Vegetative components

Response of clones to micro fertilizer appeared around 4 months after application, this was shown by LN of UJ-5 which consistently increased by 40 kg ha^{-1} at both 9 and 11 MAP (Table 2). Yet, the LN of BW-1 was no response to micro fertilizer. The same condition was followed by SD and SFW. The increase in LN of UJ-5 by 40 kg micro fertilizer ha^{-1} was followed by an LFW increment. This probably means that UJ-5 could be better adapted to drought. Yet, BW-1 seems sensitive to drought because there is a reduction in leaf water content.

Table 2. The effect of micro fertilizer and two different cassava clones.

Micro fertilizer	**Clone**	**LN 9 MAP**	**LN 11 MAP**	**SD**	**SFW**	**LFW**
		------ no. ------		**mm**	**------ g ------**	
Without	BW-1	45.2a	33.6a	23.8d	1,476d	634.2 a
	UJ-5	31.4b	24.5b	26.5b	2,399b	490.8c
40 kg ha^{-1}	BW-1	42.4a	35.6a	24.2cd	1,724cd	560.8b
	UJ-5	40.5a	34.5a	31.0a	3,193a	551.8b
$BNT_{(0.05)}$		6.24	3.9	2.11	379.7	54.2

LN=leaf number, SD=stem diameter, SFW=stem fresh weight, LFW=leaf fresh weight, MAP=month after planting; Mean values followed by the same letter in the same column showed no significant difference by LSD at 5% level/

The adapted UJ-5 to drought was shown by the increment of SD and SFW. Such character was supported by the increase in LFW of UJ-5 from 490.8 g to 551.8 g due to 40 kg micro fertilizer ha^{-1}. This result was concomitant with Phoncharoen et al. [14] who reported that the growth rate of Kasetsart was higher than that of Rayong at 10 MAP (planted in April) when the air temperature was around 30-31^{o}C. Better leaf growth would influence to photosynthesis rate lead to high photo-assimilate. This could be proven in UJ-5 that high photo-assimilate translocated from leaf part to stem.

3.3 Yield components

Without micro fertilizer, BW-1 had heavier TFW than UJ-5, yet TFW of BW-1 showed the same weight as applied by 40 kg ha^{-1} (Table 3). This means that BW-1 is not responsive to micro fertilizer for both TFW and SC. In contrast, micro fertilizer could significantly increase TFW of UJ-5. This proves that UJ-5 is highly responsive to micro fertilizer. However, SC of UJ-5 was significantly reduced due mainly to 40 kg micro fertilizer ha^{-1}. It seems that the heavier TFW would reflect the lower SC of UJ-5. High photo-assimilate of UJ-5 as indicated by LFW already translocated to sink part of tuber thru stem. The increase in TFW of UJ-5 could have resulted from photo-assimilate allocation from leaves to stem and root. This was supported by a highly positive correlation of TFW to LFW and LDW as 0.35** and 0.29** respectively (Table 4). The sink strength of UJ-5 was not followed by starch enhancement. Such conditions revealed that UJ-5 increased TFW by increasing tuber water content resulted in low SC. Two opinions for this, first, tuber fresh weight was negatively correlated with starch when planted in 2010 and 2011, as -0.27* and -0.35*, respectively Sraphet et al. [16] and Sagrilo et al. [17]. The second was starch did not correlate with TFW, r=-0.01 [18]. It seems that micro fertilizer (Zn+Fe) could stimulate better UJ-5 vegetative growth due to well-adapted to drought and led to high TFW. The other research showed that micro fertilizer (Fe+Zn) could increase tuber yield [19].

Table 3. The effect of micro fertilizer and two cassava clones on tuber and starch.

Micro fertilizer	Clone	TFW (g)	SC (%)
Without	BW-1	3,445.02b	23.8c
	UJ-5	2,847.88c	28.6a
40 kg ha^{-1}	BW-1	3,084.37bc	25.3bc
	UJ-5	4,142.77a	25.8b
$BNT_{(0,05)}$		585.3	1.87

TFW=tuber fresh weight, SC=starch content, MAP=month after planting; Mean values followed by the same letter in the same column showed no significant difference by LSD at 5% level.

Table 4. The correlation values among variables.

	LN	**SD**	**SFW**	**LFW**	**SDW**	**LDW**	**RN**	**TN**	**TFW**
LN		0.14	0.07	0.31**	-0.09	0.48**	-0.11	0.11	0.15
SD	0.30		0.86**	0.10	0.77**	0.02	0.14	0.54**	0.51**
SFW	0.62	0.00		-0.04	0.88**	-0.03	0.09	0.55**	0.51**
LFW	0.02	0.94	0.78		-0.06	0.65**	0.06	0.11	0.35**
SDW	0.50	0.00	0.00	0.62		-0.03	0.11	0.43**	0.36**
LDW	0.00	0.86	0.84	0.00	0.83		-0.07	-0.07	0.29**
RN	0.42	0.28	0.48	0.66	0.41	0.58		0.45**	0.04
TN	0.40	0.00	0.00	0.41	0.00	0.60	0.00		0.40**
TFW	0.25	0.00	0.00	0.01	0.00	0.03	0.74	0.00	

LN=leaf number, SD=stem diameter, SFW=stem fresh weight, LFW=leaf fresh weight, SDW=stem dry weight, LDW=leaf dry weight, RN=root number, TN=tuber number, TFW=tuber fresh weight; values above diagonal referred to correlation values and values below diagonal referred to probability, *=significant value at α<5% level and **=significant value at α<1% level.

Micronutrients (Zn+Fe) had a role in increasing wheat yield Hemantaranjan and Garg [20] by increasing chlorophyll and auxin. The facts showed that auxin signal would be inhibited by Zn-deficiency by decreasing Zn transporter-genes expression in rice roots [21] and under Fe-deficiency by blocking both root TaNAAT gene expression and phytosiderophores (PS) root release of wheat [22].

4. Conclusion

Better adapted UJ-5 to drought was reflected by high micro fertilizer response resulted in high LN, SD, SFW, and LFW lead to increase TFW of UJ-5. Yet, BW-1 showed sensitivity to drought in early planting lead to low photo-assimilate indicated by low SFW led to low TFW and tapioca yield. It is noteworthy that UJ-5 could be planted in the early dry season. This finding could be significant to farmers and the private sector for using UJ-5 when planting in the early dry season.

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