The Effect of Micro Boron Fertilizer Dosages on the Growth and Yield of UJ-5 Cassava (*Manihot esculenta* Crantz.) Clone

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Abstract. Cassava is one of the carbohydrate-producing food plants that is widely used by the community. Lampung Province is the number one largest cassava producing province in Indonesia. One way to increase the yield and growth of cassava plants used in this study is fertilization. In addition to macro elements. Cassava plants also need a balanced micro element. one of which is boron (B). In the dry land of Lampung, there is almost no data regarding the application of boron for increasing cassava yield. The purpose of this research was to evaluate vegetative growth and to determine the economic yield as applied by micro element of B. The results showed that the application of B fertilizer to cassava had a significant effect on vegetative growth as plant height. number of leaves. and economic yield as number of roots. root weight. but not starch content. It seems that dose of 0.63 kg B ha-1 could improve the vegetative growth and economic yield of UJ-5 especially at 10 MAP. The recommendation of B to produce the optimum root weight of UJ-5 was 0.63 kg B ha-1 as 1.98 kg root weight plant-1.

Keywords: Boron, cassava, dosage, fertilizer, UJ-5.

1 Introduction

Cassava is one of the food crops that is widely used by both farmers and the tapioca industries. According to researcher from the Indonesian Institute of Sciences or LIPI (2020) who conducted in cassava stated that the need for cassava flour to make various foods was also increasing in Indonesia [1]. It seems that the utilization of cassava is also diverse. namely as a food ingredient. animal feed. fuel. fertilizer. and industry packaging.

Indonesia was the fifth largest cassava or cassava producing country in the world after Nigeria, Congo, Thailand, and Ghana [2]. The amount produced per year by Nigeria is around 57 million tonnes. Followed by Thailand with around 30 million tons. then Brazil with around 23 million tons. Indonesia itself produces around 20-21 million

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tons of cassava per year [3]. Lampung Province is the number one largest cassava producing province in Indonesia. Based on data from [4] cassava production in Lampung in 2020 reached 5.4 million tons with a harvest area of 208.662 Ha. On the contrary, in 2018 the harvested area increased to 256,632 Ha, with a yield of 6.6 million tonnes. The data above shows that the national cassava crop area has been decreasing. Based on these data. the cassava productivity decreased from 2017 to 2018 by 0.17 ku ha^{-1}.

According to [5], the potential for cassava production, one of which is the UJ-5 clone. can reach 38 tons ha^{-1}. It seems that cassava production in Lampung province is still below the potential yield around 26 tons ha^{-1}. The production potential of cassava yield could reach 50-60 tons ha^{-1}. To get production results according to their potential. It is necessary to have a cultivation technology that can increase the production of cassava plants as application of micro nutrient especially B [6] and [7].

Increasing cassava production can be achieved in two ways. namely intensification and extensification. Intensification means a process to advance the agricultural sector by not adding more agricultural land but by using new methods and modern tools. Agricultural extensification is the expansion of agricultural areas into areas previously not utilized by humans. The target is forest land. steppe grasslands. peat-lands. or other forms of marginal land. It means that extensification program for increasing cassava yield is more difficult than the intensification one because there is increment of land for conversion and development program for other cereal crops as corn. Thus. one of the suitable intensification program to for improving cassava yield would be B application.

The nutrients needed by plants include macro and micro nutrients. So far, farmers fertilize cassava using only macro nutrients such as urea, KCl, and SP-36 and do not apply micro elements [8, 9, 10]. Thus. there is such deficiency of micro nutrients in the soil. In addition to macro elements, cassava plants also need a balanced micro element. one of which is B.

Micro nutrients are needed by plants in relatively small amounts but are important points for plant growth and yield. In several studies, the provision of B elements can increase growth and yield such as plant height and weight of roots. In the dry land of Lampung there is no data regarding the effect and the best boron dosage for cassava plants. Therefore, this research was conducted to determine the effect of boron on growth and yield and the best dosage for cassava.

2 Research methods

This research was conducted from January to December 2020 in Tanjung Bintang, South Lampung. The weighing Boron and soil samples were carried out at the Seed Laboratory and the Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, University of Lampung.

The tools used are analytical scales, hoes, tape measure, callipers, raffia rope, gutters, stationery, hammer, bamboo, scissors, labels, and Thai Sang Metric. The materials used were UJ-5 clone cassava, urea (45% N), KCl (60% K_2O), SP-36 (36% P_2O_5), and Boron. It was used boric acid which contained 45% boric hydroxides $B(OH)_3$.

The treatment design used was a single factor as 5 levels of B. the same as previously used [11], 0 (B0), 4 (B1), 8 (B2), 12 (B3), and 16 (B4) kg ha^{-1} (Table 1). The experimental design used was a completely randomized block design (CRBD) with 3 replications. The research data was tested for homogeneity of variance with the Bartlett and the additive data was tested by the Tukey procedure. If these assumptions were fulfilled, then continued to analyze the mean difference by using LSD at level of 5%.

Table 1. The conversion calculation of boric acid application to B dosage.

Application	Boric Acid (kg ha^{-1})	$B(OH)_3$ (kg ha^{-1})	Boron (B) (kg ha^{-1})
B0	0	0	0
B1	4	1.8	0.31
B2	8	3.6	0.63
B3	12	5.4	0.94
B4	16	7.2	1.26

Destructive samples were carried out twice, at 8 and 10 months after planting (MAP). As many as 3 plants from each treatment and replication were harvested. For the vegetative growth, plant height, leaf number, and stem diameter that was observed every month started at 2 until 10 MAP.

The variables in this study were observed in 2 components. namely vegetative growth and economic yield components. Vegetative growth was plant height, stem diameter, and leaf number. The economic yield was number of roots, number of swollen roots, number of economic roots, root length, root weight, and starch content.

3 Results and Discussion

3.1 Vegetative growth components

3.1.1 Plant height

The results showed that the application of B on cassava had a significant effect on plant height especially at 3-10 MAP, except at 2 MAP (Table 2).

Table 2. Variation of B application on plant height of UJ-5 cassava clone every month.

Time (MAP)	Average (cm)	MS	Error	CV
2	22.8	26.58ns	27.76	13.2
3	60.9	1676.9*	168.40	15.1
4	102.9	2944.5*	486.50	12.3
5	132.4	4617.2*	821.00	13.9
6	159.9	7811*	1538.00	15.7
7	175.0	9714*	1802.00	15.7
8	188.7	10479*	1955.00	15.2
9	204.0	11744*	2267.00	15.4
10	225.1	11589*	2348	14.2

MS=mean square. CV=coefficient variation.

* and ns indicated as significantly and not significantly different at the 5% level. respectively

The application of B on the plant height of the UJ-5 cassava clone showed that there were variations in every month. especially at 3-10 MAP (Table 3). The plant height variation was not occurred at 2 MAP. It means that B application do not have a significant effect yet on plant height at 2 MAP. However, at 3-10 MAP, it had a significant effect and plant height was increasing at plant age was increasing. Moreover, B2 application consistently affected plant height starting from 3 MAP until 9 MAP. It seems that the optimum dosage of B application for plant height was B2.

In general. plant height from 3 to 10 MAP varied in all treatments. The plant height due to B3 application showed decreasing then increasing again by B4 treatment. It probably means that the B3 application could have a negative effect on plant height. The interesting data showed that plant height due to B2 application was the same as that of B4 application. Consequently, the optimum dosage for plant height variable was B2.

Table 3. Effect of B application on plant height (cm).

Time (MAP)	Dosage of B (kg ha^{-1})					LSD 5%
	B0	B1	B2	B3	B4	
3	48.7d G	61.9bc G	66.5ab G	52.7cd F	74.9a G	10.6
4	90.8c F	97.5bc F	112.9ab F	87.9c E	119.9a F	18.0
5	121.3c E	127.6bc E	145.3ab E	110.3c D	153.3a E	23.4
6	149.7bc D	153.5bc D	174.7ab D	131.5c CD	190.1a D	32.0
7	163.5bc CD	169.9bc CD	191.7ab CD	142.1c C	207.7a CD	34.6
8	179.7bc BC	183.0bc BC	202.3ab BC	153.9c BC	224.6a BC	36.1
9	195.5bc AB	200.9b AB	218.3ab AB	165.1c AB	240.5a AB	38.9
10	223.3b A	218.5bc A	231.9ab A	183.3c A	260.6a A	39.5
LSD 5%	15.3	15.7	12.6	14.7	15.0	

The means followed by the same letter in the same row (lower case) for time and column (upper case) for B application showed no significant difference at the 5% level.

3.1.2 Number of leaves

The results showed that the application of B on cassava had a significant effect on leaf number especially at 3-7 MAP. except at 2, 8, and 9 MAP (Table 4). It means that B application does not have an effect at 2 MAP yet. Moreover, the high leaf number leaf fall occurred at 8 MAP, unfortunately the leaf fall was not variable.

Table 4. Variation of B application on the number of leaves of UJ-5 cassava clone in monthly observations.

Time (MAP)	Average (no.)	MS	Error	CV
2	25.8	58.89ns	35.13	13.2
3	40.8	399.6*	89.88	14.2
4	58.9	802.6*	202.30	14.2
5	63.7	1119.2*	288.10	16.0
6	50.7	1403.4*	339.00	22.1
7	44.1	1409.5*	403.70	14.1
8	53.4	4.933ns	181.28	13.7
9	48.2	5.61ns	3.01	13.7
10	57.8	6.34*	2.51	22.8

MS=mean square. CV=coefficient variation
* and ns indicated as significantly and not significantly different at the 5% level. respectively

In general. the B application had a significant effect at the age of 3-7 MAP and at 2 MAP did not show variations yet in the leaf number. The rapid increase in the leaf number was at 3 to 10 MAP was applied by B4. Yet, the increase of leaf number due to B2 application was the same as that due to B4 application (Table 5). This means that the optimum dosage for leaf number was B2 application.

Table 5. Effect of B application on leaf number (no.)

Time (MAP)	Dosage of B (kg ha^{-1})					LSD 5%
	B0	B1	B2	B3	B4	
3	35.0c BC	43.1ab E	47.6a D	36.3bc D	41.9c E	7.74
4	54.9bc AB	60.1ab AB	67.6a AB	48.7c AB	63.1ab BCD	11.6
5	64.0a A B C	62.4a A	71.5a A	50.0b A	70.6a BC	13.9
6	54.4a C	48.9a CDE	55.2a BC	34.9b BC	60.0a CDE	15.0
7	42.9ab C	38.5b DE	53.7a CD	31.5b BCD	53.7a E	16.4
10	53.3b A	54.9b A B C	53.5b AB	51.1b BCD	86.3a DE	38.4
LSD 5%	13.4	12.1	11.3	12.5	16.2	

The means followed by the same letter in the same row (lower case) and column (upper case) showed no significant difference at the 5% level

Based on data, the optimum B application for leaf number variable was 0.63 kg ha^{-1}. This means that B2 application could produce fresh green leaves which still attached to stem was better that other B application.

3.1.3 Stem diameter

The results of analysis of variance showed that the application of B on cassava had a significant effect on leaf number especially at 2-7 MAP, except at 8, 9, and 10 MAP (Table 6).

Table 6. Variation of B application on stem diameter of UJ-5 cassava clone on monthly observations

Time (MAP)	Average (mm)	MS	Error	CV
2	5.88	3.882*	1.38	22.2
3	9.85	23.72*	5.77	28.6
4	11.5	26.102*	6.08	24.2
5	12.7	22.52*	6.59	22.6
6	14.3	30.867*	8.42	22.5
7	15.3	31.357*	8.38	21.9
8	16.2	22.885ns	9.44	21.2
9	17.0	18.287ns	10.39	21.8
10	18.8	22.02ns	12.78	20.8

MS=mean square. CV=coefficient variation

* and ns indicated as significantly and not significantly different at the 5% level. respectively

Based on Table 7, there was a variation for stem diameter at 2-7 MAP. This means that the increase in stem diameter would accordant to the age. The increase in stem diameter at age of B2 application was the similar to that of B4 application. It seems that the optimum dosage of B application for stem diameter was 0.63 kg kg ha^{-1}

Table 7. Effect of B application on stem diameter (mm).

Time (MAP)	Dosage of B (kg ha^{-1})					
	B0	B1	B2	B3	B4	LSD 5%
2	6.05a F	6.20a E	5.99a E	4.98b G	6.17a F	0.95
3	9.13b DE	9.80ab D	11.0a D	8.17b F	11.2a E	1.96
4	10.9bc CD	11.3bc CD	12.5a b D	9.75c E	13.1a D	2.01
5	12.1bc E	12.6ab c CD	13.7a b D	11.2c DE	14.2a D	2.09
6	13.5bc C	14.4ab c BC	15.3a b C	12.4c CD	16.1a C	2.36
7	14.9ab BC	15.6a AB	16.2a BC	13.1ab BC	16.8a BC	2.36
LSD 5%	1.90	2.90	1.84	2.01	1.95	

The means followed by the same letter in the same row (lower case) for plant age and column (upper case) for B application showed no significant difference at the 5% level

It seems that B2 application could increase the vegetative growth including stem components as plant height and stem diameter and improve leaf condition specifically leaf number. The result from research conducted by [12. 13. 14] showed that B application tended to improve growth of stem and leaves.

3.2 Economic yield components

Table 8 showed that the B application had a significant effect on the components of the roots, the number of tubers, the weight and the diameter of cassava roots. However. this did not significantly affect on the number of root. length of root. and starch content.

Table 8. Variation of B application on the economic yield components of UJ-5 cassava clone.

Variable	Average	MS	Error	CV
Number of Roots (no.)	4.47	1.49*	0.53	22.3
Number of Economic Roots (no.)	1.43	0.03tn	0.02	40.1
Number of Swollen Root (no.)	2.48	0.96*	0.34	24.7
Root Weight (kg)	1.21	0.34*	0.09	15.4
Root Length (cm)	5.27	1.12tn	0.60	17.7
Root Diameter(mm)	55.3	279.70*	84.1	27.0
Starch Content (%)	23.4	7.82ns	3.96	10.1

MS=mean square. CV=coefficient variation
* and ns indicated as significantly and not significantly different at the 5% level. respectively

The B application showed that the component of economic yield as root number, swollen root number, root diameter, and root weight of B2 application was significantly different from the others. B2 application seems to have high economic value (Table 9) and B2 application was similar to B4 application. It means that B2 application is more liable than the others. This result was concomitant with [10] result who reported that the B application of 0.6 kg ha^{-1} was the optimum dosage for cassava yield improvement.

The previous result studied by [15, 16, 17, 18] reported that the micro nutrient did not improve the root weight of cassava. This result was strengthened by [11. 19] who showed that micro fertilizer would not increase the starch content but increase the starch granule size. It means that B application might be important for the future economic cassava market because B application could improve the starch quality. This future hope was supported by the result studied by [20. 21. 22].

Table 9. Effect of B application on economic cassava yield components.

Variable	Dosage of B (kg ha^{-1})					LSD 5%
	B0	B1	B2	B3	B4	
Number of roots (no.)	21.8a	22.0a	20.5ab	15.9b	22.9a	7.49
Swollen root number (no.)	5.53b	7.60a	7.67a	5.13b	6.67ab	0.48
Root weight (kg)	1.32bc	1.72ab	1.98a	1.09c	1.68ab	0.24
Root diameter (mm)	54.7abc	54.2bc	57.2ab	49.3c	61.1a	7.49

The means followed by the same letter in the same row indicated no significant difference at 5% level.

4 Conclusions

Based on the results and discussion that has been described. it can be concluded several things as follows:

1. The B application of 0.63 kg ha^{-1} resulted in a higher mean value for each growth component and yield of UJ-5 cassava clone aged 10 MAP compared to other treatments.
2. It could be recommended that B application of 0.63 kg ha^{-1} could produce optimum economic yield of UJ-5 cassava clone by 1.98 kg plant.

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