Short Term Growth Responses of *Manihot esculenta* L. Crantz and *Ipomoea batatas* (L.) Lam. to Elevated CO_2

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***Abstract*—Recently an issue of global warming as a result of increase in CO_2 released to the atmosphere rise an awareness to the possibility of reduction in worldwide agricultural production. Cassava (*Manihot esculenta* L. Crantz) and sweet potato (*Ipomoea batatas* (L.) Lam.) are known as important daily food for Indonesian people. We investigated short term (14 days) growth responses of cassava and sweet potato to elevated CO_2 concentrations. The plants were five months old prior to exposure to elevated CO_2 concentration of 612 ppm, 777 ppm and 959 ppm, and 357 ppm (ambient CO_2 concentration). Exposure of CO_2 was conducted in a transparent plastic growth chamber for 14 days. After the exposure to elevated CO_2 concentrations of 612 and 777 ppm, cassava plants showed reduction in plant height, but at 959 ppm there was a significant increase. There was also an increase in chlorophyll content, HCN and proline concentration in cassava especially at 959 ppm. Sweet potato plants also showed significant increase in plant length at 959 ppm, whereas at 612 and 777 ppm showed reduction. There was also an increase in chlorophyll content of sweet potato leaves after the treatment. It can be concluded that high Elevated CO_2 concentration at 959 ppm seems to increase short term growth of cassava plants and sweet potato plants, whereas at 612 and 777 ppm plants reduced their growth.**

***Index Terms*—elevated CO_2, cassava, sweet potato**

I. Introduction

It has been two decades that climate change and global warming due to the increase of CO_2 level in the atmosphere has been widely discussed [1]. CO_2 level in the atmosphere was estimated to exceed 550 ppm in the year 2050, and could reach 800 ppm in the year 2100 [2]. If this is the case, this could severely affect agriculture sector [2].

Cassava (*Manihot esculenta* L. Crantz) and sweet potato ((*Ipomoea batatas* (L.) Lam.) are two important agriculture commodities that can play as alternatives for staple food after rice and corn, especially in tropical countries. Cassava ad sweet potato plants are also well known as plants that relatively easy to grow and produce their tuber even under stress conditions [3].

The increase of CO_2 concentrations in the atmosphere could affect the growth and yield of the plant. Some legumes, cereals, tuber plants at higher CO_2 concentrations were reported increased their photosynthetic rate, growth and biomass production [2], [4]-[8].

We investigated the growth, chlorophyll content, proline and HCN concentrations in cassava plant as its responses to elevated CO_2 concentrations, and compared the growth responses of sweet potato plant.

II. Materials and Methods

Cassava and sweet potato were planted in polybag in a green house. Daily condition of the green house is air temperature 31,4 ℃, light intensity 47.100 lux and air humidity 82,7%. Cuttings of cassava and sweet potato were grown in mixture of soil and compost (3:1). After 150 days, the plants were placed in a transparent plastic growth chamber for exposure to CO_2. Exposure to elevated CO_2 was given for 30 minutes each day.

Plant growth parameters measured weekly for cassava were plant height, plant length and leaf area. In addition, for sweet potato, tuber length and tuber diameter were also measured. Index of tolerance for growth parameter was calculated as follow:

$$Index\ of\ tolerance = \frac{|growth\ increased\ in\ treated\ plant|}{|growth\ increased\ in\ control\ plant|} \quad (1)$$

Chlorophyll content was measured using spad-meter. The leaves measured was the third leaf from the top to middle plants. Cyanide content in cassava was measured using picric method. Proline concentration in plant was measured using Bates Method (1973). Soil pH and humidity were measured regularly, as well as air temperature, humidity and light intensity within the chambers

Data were analyzed using ANOVA and post hoc Tukey using SPSS software.

III. Result and Discussion

A. Plant Height or Length

The result showed that elevated CO_2 612 ppm and 777 ppm reduced cassava plant height as index of tolerance

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less than 1, which means that treated plants showed lower plant height compared to control, this in line with result from Gleadow (2009), which showed that at high CO_2 concentrations (710 ppm), cassava as C3 plants, reduced their growth compared to normal conditions [9].

However at 959 ppm elevated CO_2, index of tolerance increased to 1.2, which means that the treatment gave better result to plant growth compared to control (Fig. 1).

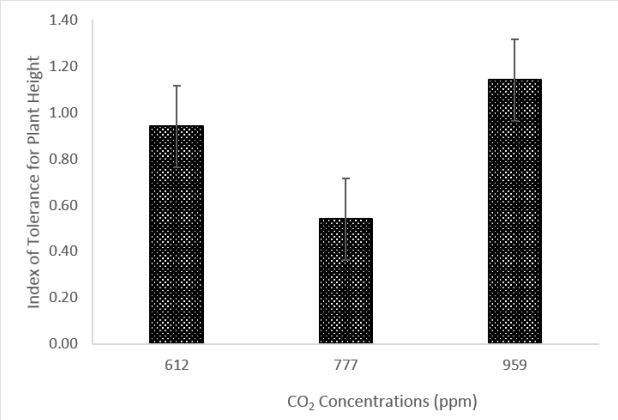

Figure 1. Index of tolerance based on plant height of cassava plant after 14 days exposure to elevated CO_2 concentrations. Bar chart indicates SE.

In sweet potato, elevated CO_2 to 959 ppm also increased plant length as its index of tolerance was 1,08 (Fig. 2)

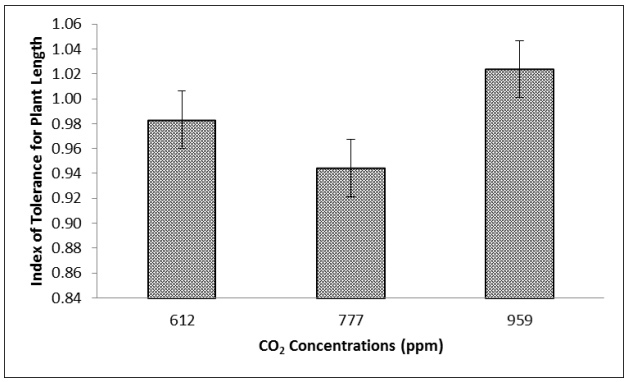

Figure 2. Index of tolerance based on plant length of sweet potato plant after 14 days exposure to elevated CO_2 concentrations. Bar chart indicates SE

Increasing concentration of CO_2 increased sweet potato growth. CO_2 as substrate for photosynthesis, induced more glucose and O_2 production. Photosynthesis product are used for growth and development, including hormones synthesis which include auxin and gibberellins which controls stem elongation. Auxin plays a role in tissue division and growth, especially in the shoot. Auxin synthesized in the meristem tissues, young leaves, fruit and growing seed. Gibberellins play a role in intercalary meristem which support the lengthening of inter-nodes [10], [11]. Based on Fig. 2, the length of the sweet potato increased after exposure by CO_2 during 14 days. Exposure of CO_2 at 959 ppm resulted plant height 49.4 cm in average. It is supported by the value of Index of tolerance of 1.14.

B. *Chlorophyll Content*

There is a tendency that elevated CO_2 increased chlorophyll content of cassava leaves. (Fig. 3).

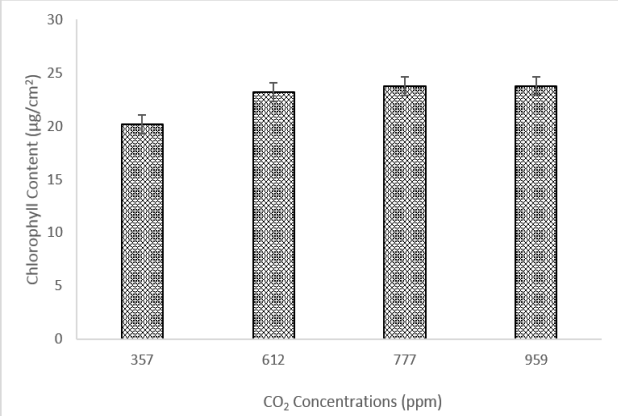

Figure 3. Chlorophyll content of cassava leaves after 14 days exposure to elevated CO_2 concentration. Bar chart indicates SE.

This data is not the same as found by Wilkins (1993) which showed that elevated CO_2 concentration could reduce chlorophyll content in plant leaves because elevated CO_2 concentration reduced ribulose-1,5-bisphosphate carboxylase-oxygenase (rubisco) enzyme which consequently reduced chlorophyll content in the plants [12].

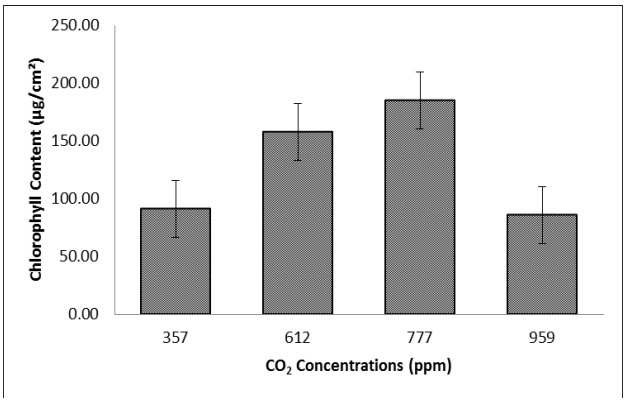

Figure 4. Chlorophyll content of sweet potato leaves after 14 days exposure to elevated CO_2 concentrations. Bar chart indicates SE.

The increase in chlorophyll content also found in leaves of sweet potato after exposure to at 612 and 777 ppm, but at 959 ppm there is no effect (Fig. 4). The increase in chlorophyll content could be related to Rubisco production [12].

C. *Tuber Size of Sweet Potato*

There is no significant different between treatment and control in tuber size of sweet potato for its length and diameter after 14 days of exposure (Fig. 5).

It is expected that Tuber production in sweet potato increased when exposed to CO_2 concentration above 750 ppm [7]. As the concentration of CO_2 in atmosphere increased, sweet potato plant could absorb more CO2 than in normal condition which result more photosynthetic production being store in tuber [8].

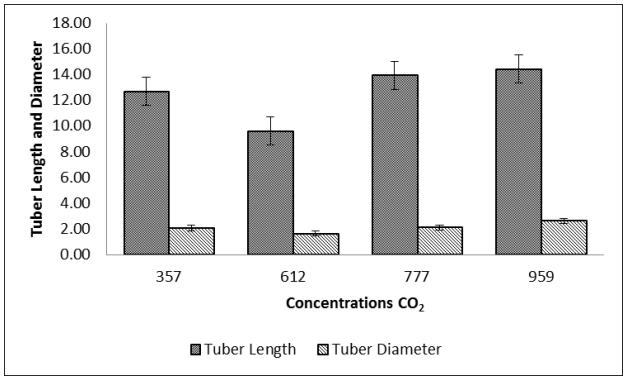

Figure 5. Tuber length and diameter after 14 days exposure to elevated CO_2 concentration. Bar chart indicates SE.

In term of its index of tolerance, elevated CO_2 to 959 ppm tends to increase plant length (Fig. 6).

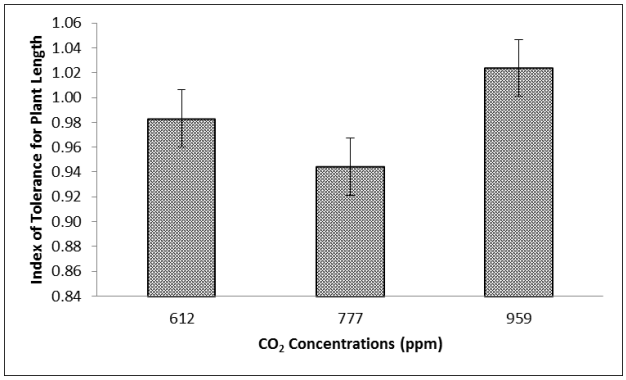

Figure 6. Index of tolerance on tuber length and diameter of sweet potato after 14 days exposure to elevated CO_2 concentrations Bar chart indicates SE..

D. HCN Concentration in Cassava Organs

There is a tendency that after 14 days exposure to CO_2, there is an increase in HCN concentration in root of cassava, but in stem there is no effect, except at 959 ppm of CO_2 where the increase of HCN concentration was significantly observed. In contrast, HCN concentration is seem to reduce gas CO_2 concentration increased (Fig. 7).

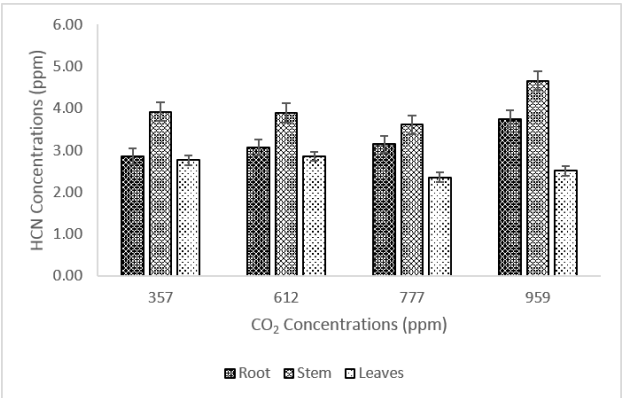

Figure 7. HCN concentrations in cassava organs after 14 days exposure to elevated CO_2 concentrations. Bar chart indicates SE.

Highest concentration of HCN in cassava was produced at CO_2 concentration 710 ppm [9]. Cyanogenic plants could produce HCN twice as much as the plants at CO_2 ambient. Cyanogenic glucoside could increase in plants as the results of environmental changes i.e. elevated CO_2 concentration in the atmosphere. According to WHO, maximum tolerable level cyanide in food is 10 ppm [9].

E. Proline Concentrations in Cassava Organs

In general, the concentration of proline in leaves was significantly higher than the concentration in root and stem (Fig. 8). At 959 ppm of CO_2, there was significant increase of proline concentration in leaves of cassava. Proline concentration in root and stem showed no significant different between treatment and control.

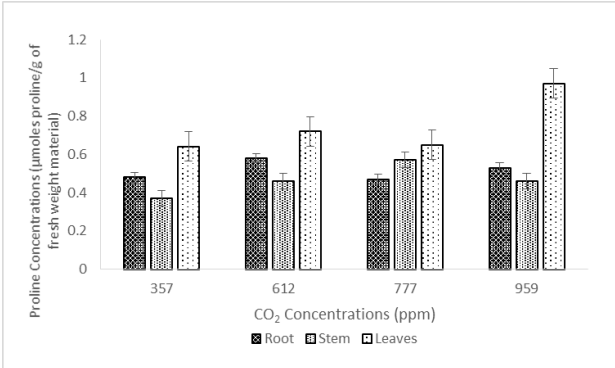

Figure 8. Proline concentration in cassava organs after 14 day exposure to elevated CO_2 concentrations. Bar chart indicates SE.

Proline concentration of safflower increased significantly in high carbon dioxide (700 ppm) with well irrigation [13]. Proline plays a role in plants exposed stress condition. A stressful environment effect an overproduction of proline in plants. Proline can maintain cell turgor or osmotic balance, stabilize membrane, and bring concentration of reactive oxygen species that make stress tolerance in plants [14].

IV. Conclusion

It can be concluded that high Elevated CO_2 concentration at 959 ppm seems to increase short term growth of cassava plants and sweet potato plants, whereas at 612 and 777 ppm plants reduced their growth. Sweet potato tuber increased its length and diameter after exposure to CO_2.

Acknowledgement

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