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Effects of aluminum stress on shoot growth, root growth and nutrient uptake of three pineapple smooth cayenne clone [*Ananas comosus* (L.) Merr.]

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SUMMARY

Aluminum (Al) is a biotoxic metal to most of plants which inhibits root growth, led to a series of influence metabolic abnornal and becomes the main limiting factor productivity in acid soils. In this experiment, effect of Al strees on plant growth, root growth, macronutrient uptake (N, P, K, Ca, Mg) and Al uptake in root and plant were studied. Three pineapple crown of smooth cayenne clones (GP1, GP3 and F180) was cultured from 0 to16 weeks in aquadest culture medium that contain 6 level of Al concentration treatment 0, 100, 200, 300, 400 and 500 µM $AlCl_3$. Experiments using a factorial randomized block design with 5 replications in a greenhouse growing environment. Results of this experiment showed that the three clones have a different response of tolerance to Al stress. GP3 clone showed the highest growth in the number of leaves, number of seminal roots, production of roots sugar, P leaf uptake and the lowest roots uptake of Al compared to other clones. GP1 clone produce the highest root length, percent of weight vertical root, and K leaf uptake. While F180 clone produces the highest water volume uptake of roots, weight of fresh roots, weight of plant, leaf uptake of N, Ca and Mg, and the lowest Al toxicity morphology than other clones. For the optimal balance proportion of plant and root growth, we can be said that F180 and GP3 clones have high levels to Al toxicity tolerance for that can growth well for acidic soils that have low pH.

INTRODUCTION

Pineapple [*Ananas comosus* (L.) Merr.] is one of the main plantation crop commodity in the world after bananas and oranges (Bartholomew et al., 2003). Generally, the pineapple is cultivated in the area 30 ° North latitude to 30º South latitude, with a temperature of 20-30 ºC, and variations in photo-periodism 10-12 hours. Pineapple is reported have adaptability at low pH soils containing high Al and Mn (Bartholomew, 2005).

The primary effect of Al toxicity is the inhibition of root growth; however, the mechanisms involved in this toxicity are far from clear (Matsumoto 2000).

Nutrient absorption and cell function will be impaired after exposure to high concentrations of Al. Root tip is the area where Al and interact root, root cell walls have a mechanisms to protect the entry of Al into the roots. Root cell walls are formed of a material that is negatively charged pectin that serves to attract cations. When the root tip saturated by Al, uptake of nutrients such as K^+, Ca^{2+}, Mg^{2+} and NO_3 will decline to enter the root cell walls. If the bond is excessive Al appeared between Al and the cell walls of root, root growth is inhibited (Lin and Chen, 2011).

Although aluminum toxicity can be ameliorated by surface application of lime, this is often not economically or physically feasible. Hence, combining the use of Al tolerant cultivars with liming is often the most effective strategy for improving crop production on acid soils. Several screening methods have been employed for this purpose, from genotype screening in the laboratory to soil bioassays and field evaluations (Hede et al, 2001). This study was conducted to examine the effects of six different Al concentration on plant growth, root growth and nutrient uptake of root and leave of three pineapple smooth cayenne clones [*Ananas comosus* (L.) Merrill] in strongly acid environment.

MATERIALS AND METHODS

Seed material used pineapple of three clones from smooth cayenne cultivar, namely GP1, GP3 and F180, which is derived from pineapple plantation location in PT Great Giant Pineapple, Terbanggi Besar, Central of Lampung, Lampung, Indonesia. Seedlings were selected

from crown seed which have fresh weight 200-350 gr (medium size seed for cultivation). After cleaning with deionized water, these seeds were cultivated in tin-coated plastic container (15 cm inner diameter and 10 cm height) which contain 500 ml of distilled water were treated with $AlCl_3.6H_2O$ appropriate level of Al toxicity (0, 100, 200, 300, 400 and 500 µM $AlCl_3$). Plants planted in a greenhouse environ-ment. $AlCl_3$ solution was added every 1 week to replace the water that is absorbed by the roots reaching back to 500 ml. Climate condition during the experiment was daylight temperature 31.4 – 33.9 °C, night temperature 21.6 – 23.2 °C, and relative humidity 85.0 – 91.3%.

Experimental design used randomized block design factorial (3x6) with 5 replications. Factor 1, pineapple smooth cayenne clones, consists of three clones : GP1, GP3 and F180. Factor 2, $AlCl_3$ concentration in the water culture solution, consists of 6 levels $AlCl_3$ concentration : 0, 100, 200, 300, 400 and 500 µM.

Shoot growth observation

Pineapple shoot growth parameters which measured were (1) plant height (2) length of D-leaf, (3) plant weight at 16 weeks after planting.

Root growth observation

Root growth parameters which measured were (1) the length of the (2) the amount of seminal roots, (3 the volume of water absorption by roots (4) fresh and dry plant weight (5) percentage of vertical root, (6) total sugar roots production

Observation of leaf and root nutrient uptake

The content of N, P, K, Ca, Mg and Al leaves were measured at 16 weeks after planting for composite samples of roots and leaves.

RESULTS AND DISCUSSION

Effect of $AlCl_3$ concentration on shoot growth

Figure 1 shows the effect of $AlCl_3$ concentration on the growth of plant height, length of D-leaf, number of leaves, and plant weight. Shoot growth tend decrease with increasing $AlCl_3$ concentration in the solution. F180 clone showed the highest of plant height (Figure 1), length of D- leaf (Figure 2), and plant weight (Figure 3) compared to the other clones. GP3 clone showed the best of number of leaves growth In addition, GP3 clone also did not show a decrease in plant weight at the higher $AlCl_3$ concentration in the solution.

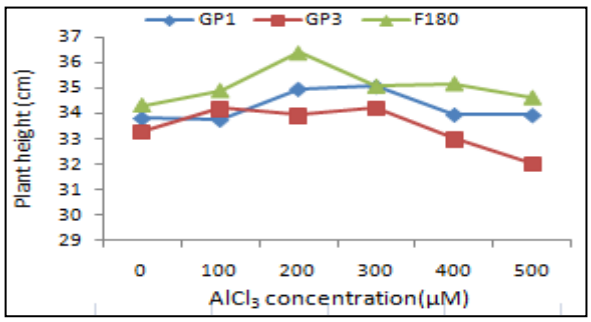

Fig.1. Effect of $AlCl_3$ on plant height

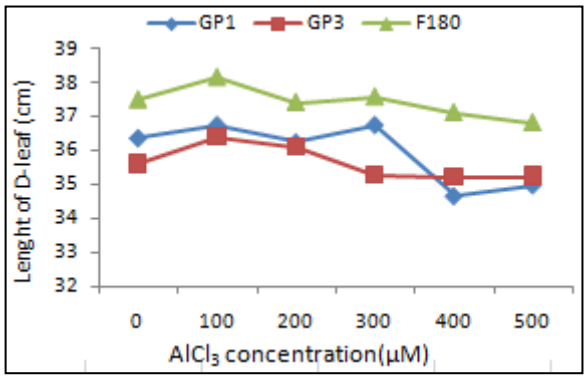

Fig.2. Effect of $AlCl_3$ on D-leaf length

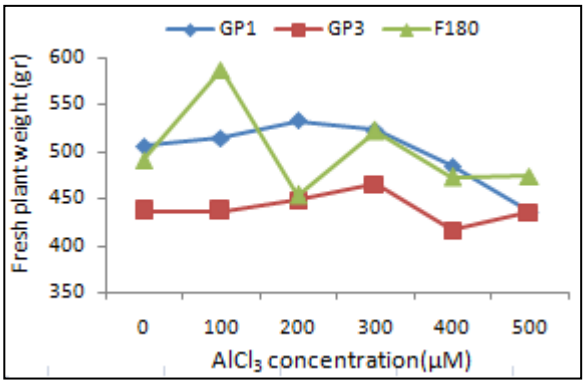

Fig.3. Effect of $AlCl_3$ on plant weight

Effect of $AlCl_3$ concentration on root growth

Root growth tend to decrease with increasing $AlCl_3$ concentration in the solution as seen in the root length (Figure 4), the number of seminal roots (Figure 5), fresh weight roots (Figure 6), percentage of vertical root weight (Figure 7).. Each clone showed a different root growth response to Al stress. GP1 clone shows the best growth of root length and percentage of vertical root weight especially in high Al stress (> 300 µM $AlCl_3$). While the best number of seminal root on Al stress at 500 µM $AlCl_3$

seen in GP3 clone (Figure 5) and F180 clone showed the highest fresh root weight in the Al highest stress

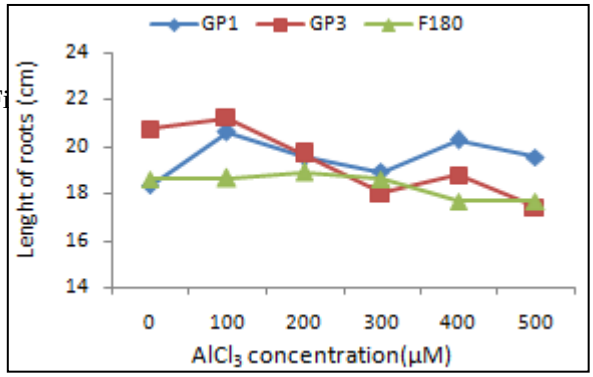

Fig. 5.Effect of AlCl3 on root length the root length

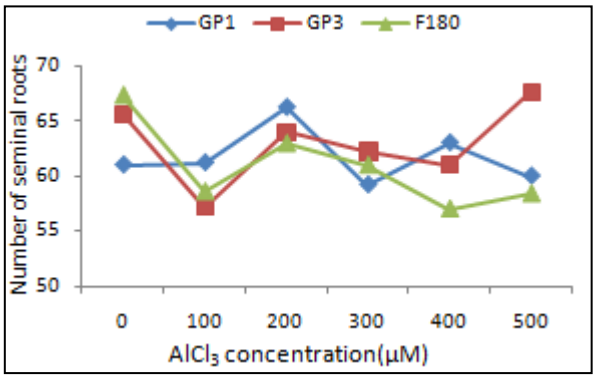

Fig. 6.Effect of AlCl3 on the number of seminal roots

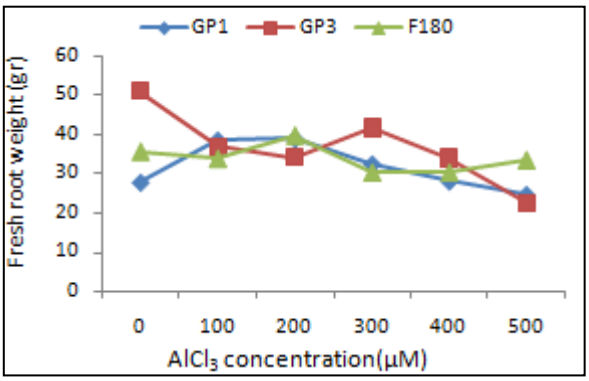

Fig. 7 .Effect of AlCl3 on fresh weight roots

Nutrient uptake by leaf

Ca and Mg leaf nutrient uptake nutrient uptake with the higher $AlCl_3$ concentration in the solution. concentration. This is similar to study Lin and Chen (2011) which states that the decreased uptake of Ca and Mg with increasing concentrations of $AlCl_3$. Increasing Ca and Mg uptake become an important indicator of the ability of the plant to reduce the toxicity of Al. Ca and Mg root uptake remain high in GP3 and F180 clones at high Al stress indicates that both these clones have a degree of tolerance to Al toxicity better than clone GP1.

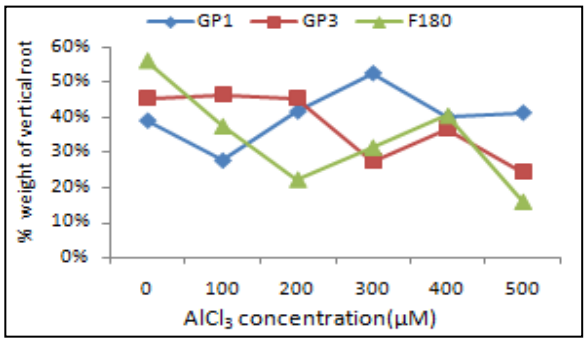

Fig. 8 .Effect of AlCl3 percentage of vertical root

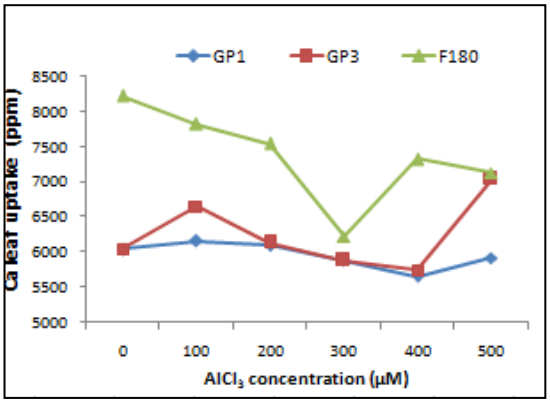

Fig. 9.Effect of AlCl3 on Ca upatke.

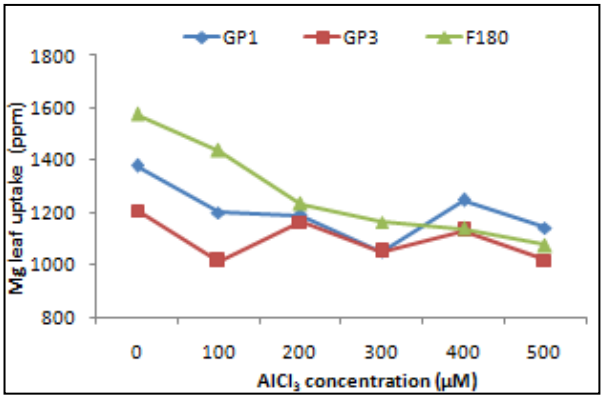

Fig. 10.Effect of AlCl3 on Mg uptake

CONCLUSION

In the Al high stress (500 µM $AlCl_3$), GP3 clone still show the best growth in the number of leaves, number of seminal roots, Tolerance of GP1 clone is shown in the best root length, percentage of weight vertical root. While F180 clone shown the best in root volume water

uptake, fresh weight root, fresh weight plant, leaf uptake of N, Ca and Mg. In other word, we can said that F180 and GP3 clones are clones that have good adaptability to grow well under conditions of stress Al.

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