# RELATIONSHIP OF GROWTH AND YIELD MINI TUBERS OF POTATO UNDER COCOPEAT MEDIA AND FREQUENCY OF FERTILIZER

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## ABSTRACT

The research aimed to determine the growth variable correlated to the mini tubers yield of potato and obtained the media thickness of cocopeat and frequency of fertilizer which was good for growth and yield of potato mini tubers. The research is arranged to use complete randomized block design with three replications. The main factor was the thickness of media cocopeat with three levels, which was 10 cm, 15 cm and 20 cm. The second factor was the frequency of nutrients with two levels, which was three days and six days. The results of the research showed that the number of mini tubers yield were influenced by frequency of fertilizer and were not the thickness of cocopeat media.The number of mini tubers yield were correlated with height plant, leaf area, root length, number of stolon, and stolon effectivity. The number mini tubers yield were most affected by number of stolon, and stolon effectivity with the regression model that was $\hat{Y} = -4.21588^{**} - 0.00338\, X_{PH}^{ns} + 0.00003\, X_{LA}^{ns} - 0.00377\, X_{RL}^{ns} + 0.52317\, X_{NST}^{**} + 0.08233\, X_{SE}^{**}$.

**Keywords:** cocopeat, media thickness, mini tubers, regression

## INTRODUCTION

Potato is one of the most important crops worldwide: ranking fourth in annual production behind the cereal species rice (*Oryza sativa*), wheat (*Triticumaestivum*), and barley (*Hordeumvulgare*)(Fernie *et al.*, 2001; Fatchullah, 2017). In the other hand, Potato (*Solanum tuberosum* L.) is one of mankind's most valuable food crops and mainstay in the diets of people in many parts of the world (Struik*et al.*, 1999). In Indonesia, potatoes become the supporting food diversification program due to its high protein content. Protein in potatoes is able to provide good nutrition for adults (Kenneth and Ornelas, 2012). This indicates that potatoes have good potential to support food diversification program in order to realize sustainable food security.

Potato productivity in Indonesia decreased until 3.37% in 2012-2013. Factors contributing to the decrease of potato productivity include: (1) the limited use of quality potato seeds, (2) potato seed is not available in the field at the time required by farmers, (3) most farmers use potato seed from harvests generation are deliberately set aside and stored for use as seed (Sayaka andHestina, 2011). The seeds produced by farmers have weaknesses, among others, easily contracting the disease and degradation results after the fifth generation. Soil born disease is one of the most important constraints limiting potato seed production with soil in Indonesia (Muriithi and Irungu, 2004).

The supply of potatoes seed must be based on a good seed system by fulfilling six precisely, ie the variety, quality, quantity, place, time, and price (Sayaka andHestina, 2011). Increased of potatoes needs will be followed by increased of potato seeds needs at both breeder level and farmer level. However, the increasing of potato seeds needs in Indonesia is not followed by the availability of potato seeds. In 2011, the total of potato seeds need 103.582 tonnes but it was only 15% available. This is because the production of seed potatoes in Indonesia is done with a network culture system required a large cost and just some peoples can do it.

High yield of potatoes can be obtained by using quality seeds in the process of cultivation. One of the efforts undertaken by the researchers is to provide microtuber seed (G0) is free from soil borne disease with various technologies. The technology that was developed was the cultivation of a screen system with sterile cocopeat media as an effort to exploit the potential of local resources as a medium for seeding of potato micro tubers(G0).Cocopeat is a planting media made from coconut fiber powder. Cocopeat has an easy absorbing and saving water. Cocopeat also has pores that facilitate the exchange of air, and the entry of sunlight. The content of Trichoderma molds (a type of enzyme from the fungus) can reduce the disease in the soil. Cocopeat also contains nutrients needed by plants, in the form of calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and phospor (P) (Kristijono, 2010).

The production of microtuber seeds is not only determined by the planting media, but the timing of nutrient giving also affects the production of potato micro tubers (Getie *et al.*, 2015). The time of fertilization application is very determining the growth and yield of crop production(Zamami *et al.*, 2016). Provision of nutrient solutions that are too frequent and high concentrations will cause toxicity to plants and inhibit plant growth (Wijayaniand Widodo, 2005), and if the frequent of nutrient solution is too rare caused nutrient deficiency in plants so that crop yield is low.This research aimed to determine the growth variable which has the correlation at the yield of potato mini tubers and achieved media thickness of cocopeat and frequency of fertilization.

## MATERIALS AND METHODS

The research was carried on the greenhouse with at altitude ± 1200 meters above sea level in Kaligoa,Brebes, Central Java, Indonesia ($7^0$15′42.8″S and $109^0$05′14.3″E) and soil/land resources laboratory, Agriculture Faculty, Universitas Jenderal Soedirman. This research started on October 2014 till January 2015. The data of cocopeat description in the experimental are shown in Table 1.

Plant Material Potato (*Solanumtuberosum L.*) plantlets of Tedjo MZ were produced in vitro from Indonesia Research Centers Vegetable Crops and cocopeat media. The fertilizers were prepared using macro and micro nutrient ($CO(NH_2)_2$ 0.37 g $L^{-1}$; $KH_2PO_4$ 0.36 g $L^{-1}$; $KNO_3$ 0.17 g $L^{-1}$; $Ca(NO_3)_2$ 0.51 g $L^{-1}$; $MgSO_4$-$7H_2O$ 1.13 g $L^{-1}$; Fe-EDTA 0.015 g $L^{-1}$; $MnSO_4$-H2O 0.0019 g $L^{-1}$; $CuSO_4$ 0.00014 g $L^{-1}$; $ZnSO_4$ 0.00029 g $L^{-1}$; $H_3BO_3$ 0.00318 g $L^{-1}$; $NaMoO_4$ 0.00004 g $L^{-1}$).

The concentration of fertilizers was 1 mS $cm^{-1}$ for the first one month and then increased to 2 mS $cm^{-1}$. The same concentration of fertilizer was used in all treatment. The nutrient solution was maintained at the pH range of 5.5–6.5. Potassium hydroxide was used to raise the pH of the nutrient solution if lower than the optimal pH range. And phosphoric acid was used for reducing pH of the nutrient solution if higher than the optimal pH range (Wahome *et al.*, 2011).

The tools utilized for this research are farming tools, drum (100 L), EC meter was used to measure a concentration of the fertilizer, a pH meter was used to measure pH of nutrient, and thermo-hygrometer.

The research is arranged to use complete randomized block design with three replication. The research used two factors, that was:

1. The main factors:
   a. The thickness of cocopeat media 10 cm (K1)
   b. The thickness of cocopeat media 15 cm (K2)
   c. The thickness of cocopeat media 20 cm (K3)
2. The second factors:
   a. The frequency of fertilizer once in 3 days (F1)
   b. The frequency of fertilizer once in 6 days (F2)

The data result of observation used ANOVA analysis and Duncan's New Multiple Range Test (DMRT) at 5% level with Ms. excel macro add-in (DSAASTAT version 1.101) (Onofri *et al*., 2014). The analysis used correlation analysis to determine between growth variable and mini tubers yield and the data result would also be analyzed to use correlation, regression analysis, and multiple regression analysis with Ms. excel macro add-in (DSAASTAT version 1.101) (Onofri *et al*., 2014).

## RESULTS AND DISCUSSION

### Weather condition in the experimental location

The data of humidity and temperature in the experimental location were shown in Figure 1. The measurement of humidity and temperature were initiated in October 2014 and ended in January 2015.Temperature and humidity during the research are supports during the growing period (Figure 1). Temperature and humidity are a big influence on the growth and tuber form of potato. Temperature and humidity ideal for the growth of the potato plant revolve around the daily average temperature of 18-24 °C and humidity of 70-90%, and need a night temperature of 10-15 °C and daytime temperatures of 20 °C for tuber form process (Otazu, 2010).

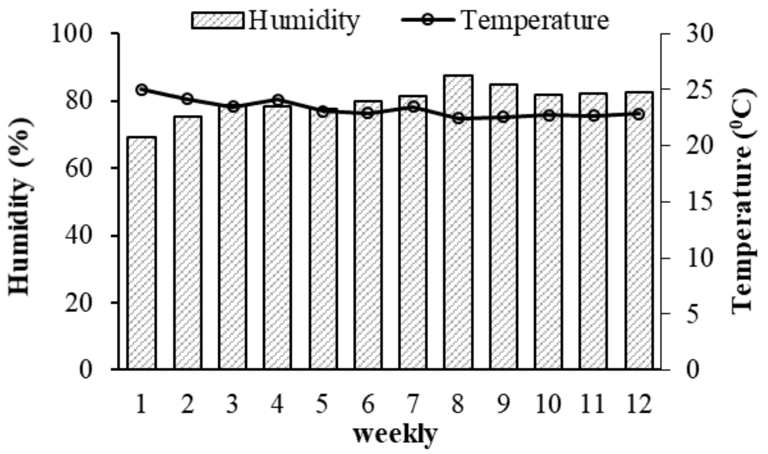


**Figure 1.** Average of weekly humidity and temperature in the period from October, 2014 to January, 2015.

**Table 1.** Physical and chemical properties of cocopeat

| Variable | Laboratory test result | Information |
|---|---|---|
| pH $H_2O$ | 5.3 | Acid |
| $P_2O_5$ available (ppm) | 644.102 | very high |
| Field capacity moisture content (%) | 86.99 | very high |
| CEC (me %) | 84.255 | very high |

Table 1 shows that the pH $H_2O$ of cocopeat media is acid. Cocopeat media have a cation exchange capacity (CEC), which is as high as 84.26 me %. The content of available $P_2O_5$cocopeat media isvery high at 644.10 ppm.

### Plant Height and Leaf Area of Potato

The result showed that the plant height and leaf area of potato were not significantly different (*$P \leq 0.05$*) with the cocopeat medium thickness. The growth of plant high and leaf area is affected by the frequency of fertilizer (Table 2). The frequency of fertilizer once in three days can show the growth of plant height and leaf area have better than the six days. The frequency of fertilizer once in three days to provide the availability of macro and micro nutrients were sufficient to be absorbed by the roots of potato.

**Table 2.** Plant height, leaf area, number of stolons and number of tubers

| Treatmens | Plant height (cm) | Leaf area ($cm^2$) | Number of stolons (stolon $plant^{-1}$) | Number of mini tubers (tubers $plant^{-1}$) |
|---|---|---|---|---|
| Media Thickness Treatments | | | | |
| 10 cm | 40.58 a | 3,180.59 a | 9.17 a | 4.63 a |
| 15 cm | 43.13 a | 3,739.41 a | 8.85 a | 3.81 a |
| 20 cm | 46.63 a | 5,265.21 a | 9.85 a | 5.04 a |
| Frequency of Fertilizer Treatments | | | | |
| 3 days | 47.20 a | 4,890.20 a | 10.02 a | 5.27 a |
| 6 days | 39.69 b | 3,233.27 b | 8.55 a | 3.71 b |
| interaction | (-) | (-) | (-) | (-) |
| CV (%) | 16.29 | 35.32 | 19.63 | 23.12 |

Description: The number followed by the same letter in the column and row are different according to DMRT α 0.05, (+) showing interaction between treatments.

The availability of adequate nutrients would be easily absorbed by roots and then used for metabolic processes that took place inside the plant body. These metabolic processes include the process of formation of dry matter (photosynthesis) used for the enlargement and division of plant cells(Chang *et al*., 2011). One of the appearance of the process of plant cell division and enlargement was the growth of plant height.

One of the essential macro nutrients present in Sundstrom nutrients is nitrogen. Nitrogen is needed by plants for vegetative growth such as the plant height and leaf area. Nitrogen is the main component in leaf chlorophyll, so that if nitrogen is fulfilled then the leaf growth will be better and photosynthesis process will be good process. The main function of the leaf is as an important organ in photosynthesis in which the greater the leaf the sun's capture and $C0_2$ fixation are higher, so that large photosynthesis will effect on large assimilate yields as well, and continuously processed in the formation of tubers (El-Latief *et al*., 2011).

Nitrogen is an essential macro nutrient important in the vegetative growth phase. The nitrogen derived from the nutrient solution is absorbed by the plant in the form of Nitrate ($NO_3^-$) and Ammonium ($NH_4^+$). Nitrogen is a macro nutrient plays an important role on the development of canopy and the accumulation of dry weight of plants(Dianawati*et al*., 2013).

**Number of Stolons and Number of Mini Tubers**

The result showed that the number of stolons and the number of mini tubers per plant were not significantly different ($P \le 0.05$) with the cocopeat medium thickness. Stolon formation was also not influenced by the frequency of nutrition, but the formation of mini tubers was influenced by the frequency of nutrients (Table 2). The frequency of fertilizer once in three days can form a larger number of tubers compared with the frequency of nutrients once in six days.

Macro and micro nutrient is the most important nutrient in the formation of energy in the process of photosynthesis that is mainly the formation of protein, leaf chlorophyll, and tubers (Chang *et al.*, 2011). Chlorophyll is formed from carbon, nitrogen and magnesium as the central atom of chlorophyll. Nitrogen and magnesium elements are available in the applied nutrient solution. Chlorophyll is a light harvesting organs in the process of light reactions inside thylakoid to form energy ATP and NADPH(Ramírez*et al.*, 2014). The more chlorophyll is formed then the process of energy formation will also be large and energy is used for the fixation of $CO_2$ which forms carbohydrates that is function for enlargement and formation of new organs such as the formation of stolon in potato plants. Potato tuber is a form of energy storage contained at the end of the stolon, so that at the end of the stolon will swell to form a potato tuber(Jackson, 1999).

**Root Lenght and Stolon Effectivity**

Figure 2 showed that the thickness cocopeat medium of 20 cm combined with the frequency of fertilizer once in three days stimulated root growth of potato and stolon effectivity. It affected by the cocopeat characteristic of porus so that the nutrient solution to be at the bottom of cocopeat medium. The medium thickness of cocopeat was 20 cm and frequency of fertilizer once in three daysraised the roots of potatoes by stimulating the roots of potatoes growing up to the bottom of the media to absorb water and nutrients that existed at the bottom of the cocopeat media.The root length variables are significantly influenced by the treatment of planting media. Planting media in general has two functions, namely as a place of grown and suppliers of nutrient for the growth of plants. In this study, treatment of medium thickness ofcocopeat 20 cm and the frequency of fertilizer once in three day could increase root length. The thickness of planting medium will increase the root length and weight of the root, the thickness of planting medium, the more nutrient storage capacity, therefore the management of water supply and good nutrient solution so that the plant growth will optimal(Ginting, 2009).Timing of nutrition needs to be considered for yield of mini tubers can be optimal. The timing of fertilizer is very influential in the availability of macro and micro nutrients. The effectiveness of stolon was influenced by media thickness and frequency of fertilizer. The best stolon effectiveness had been seen in the thickness treatment of medium 15 cm and 20 cm with the frequency of fertilizer once in three days. The point focus on the statement showed in the time of giving the fertilization.

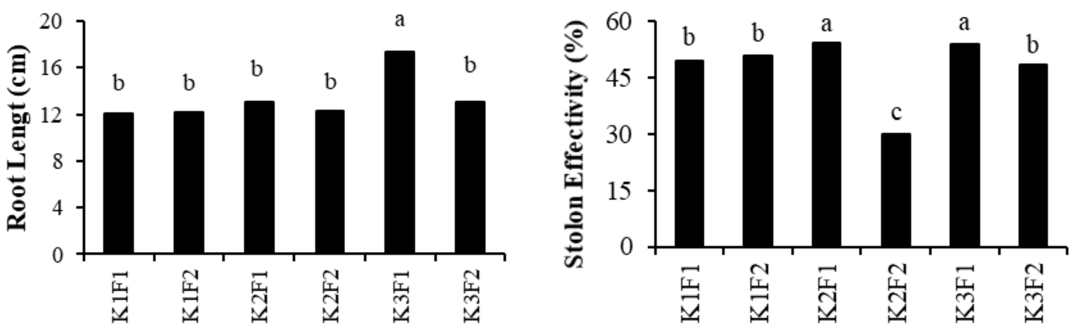


**Figure 2.** Root lenght and stolon effevtivity of potato (K1F1: Thickness media 10 cm with frequency of fertilizer once in 3 days, K1F2: Thickness media 10 cm with frequency of fertilizer once in 6 days, K2F1: Thickness media 15 cm with frequency of fertilizer once in 3 days, K2F2: Thickness media 15 cm with frequency of fertilizer once in 6 days, K3F1: Thickness media 20 cm with frequency of fertilizer once in 3 days, K3F2: Thickness media 20 cm with frequency of fertilizer once in 6 days). The Signifficant different according to DMRT α 0.05.

**Correlation and Regression**

Based on the results of the correlation test (Table 3), the number of mini tubers produced was positively correlated with the growth variable significantly. This was also demonstrated by simple linear regression tests showing that the number of mini tubers produced were influenced by growth variables such as plant height, leaf area, stolon number, and stolon effectiveness forming positive linear curves (Figure 3). However, the root length variable has not shown any real effect based on simple linear regression test.

**Table 3.** Correlation value between variable growth and mini tuber yield of potato

| Variable | PH | LA | RL | NST | SE | NTP |
|---|---|---|---|---|---|---|
| PH | 1 | | | | | |
| LA | $0.88^{**}$ | 1 | | | | |
| RL | $0.70^{**}$ | $0.89^{**}$ | 1 | | | |
| NST | $0.66^{**}$ | $0.61^{**}$ | $0.49^{*}$ | 1 | | |
| SE | $0.54^{**}$ | $0.46^{ns}$ | $0.36^{ns}$ | $0.36^{ns}$ | 1 | |
| NTP | $0.74^{**}$ | $0.66^{**}$ | $0.54^{*}$ | $0.86^{**}$ | $0.78^{**}$ | 1 |

Description: PH =Plant height; LA = Leaf area; RL = Root length; NST = Number of stolons; SE = Stolon effectivity; NTP = Number of mini tubers per plant, *, **=Significant different at level 5% and 1% (α = 0.05 and 0.01).

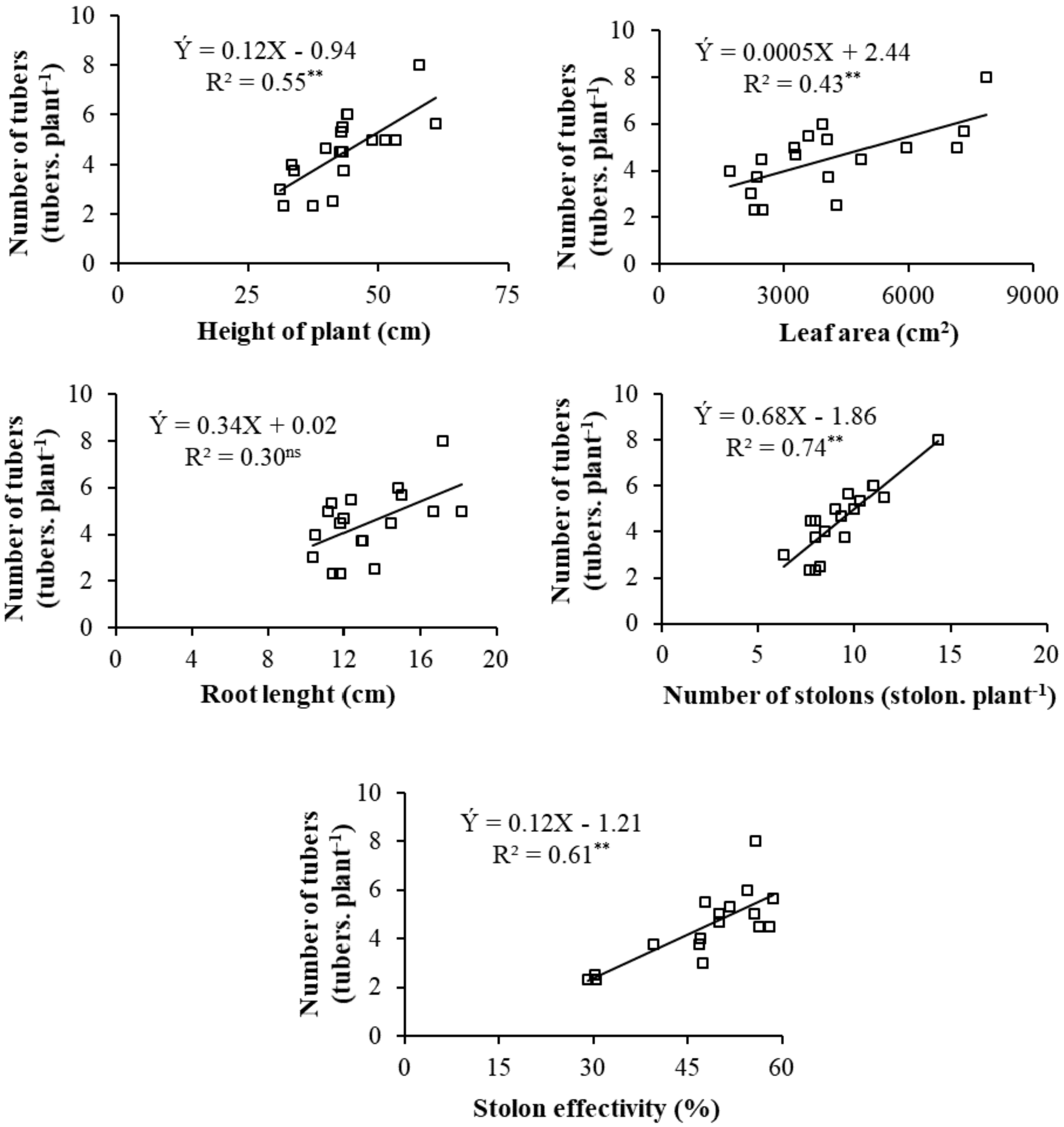


**Figure 3.** A = Regression graphic relation of plant height with number of mini tubers; B = Graphic relation of leaf area with number of mini tubers; C = Graphic relation of rootlength with number of mini tubers; D = Graphic relation of number of stolons with number of mini tubers; and E = Graphic relation of stolon effectivity with number of mini tubers.

Leaf area was known to have a positive relationship to the number of mini tubers were formed ($r = 0.66^{**}$). Leaf area is a source form on each plant, because it is the place where the process of energy generation through the process of photosynthesis. The wider the leaf of the plant then it can be ascertained the energy that is formed the greater. This was confirmed by the positive linear relationship between leaf area and the number of mini tubers formed ie $\hat{Y} = 0.0005 X_{LA} + 2.44$ ($R^2 = 0.43^{**}$).

The relationship between the number of stolons formed by the number of mini tubers produced has a very high correlation rate with $r = 0.86^{**}$. Then followed by stolon effectiveness with $r = 0.78^{**}$.This result was reinforced by a linear regression model between the number of stolons and the effectiveness of stolon with the number of mini tubers produced, $\hat{Y} = 0.68 X_{NST} + 1.86$ ($R^2 = 0.74^{**}$) and $\hat{Y} = 0.12 X_{SE} + 1.21$ ($R^2 = 0.61^{**}$).

### Multiple Regression Analysis

To know the model of relationship between variables of mini tubers with growth variable used multiple regression analysis. Based on the multiple regression result, the variabel with significant effect on the number of mini tubers are number of stolons and stolon effectivity (Table 4). Based on multiple regression test, it could be seen that the model of growth variables of potato plant with the number of mini tubers produced, $\hat{Y} = -4.21588^{**} - 0.00338 X_{PH}^{ns} + 0.00003 X_{LA}^{ns} - 0.00377 X_{RL}^{ns} + 0.52317 X_{NST}^{**} + 0.08233 X_{SE}^{**}$ ($R^2 = 0.99^{**}$).

**Table 4.** The affecting factors to the number of micro tuber per plant based on the multiple regression analysis

| Parameter | Estimate | Note |
|---|---|---|
| Intercept | -4.21588 | ** |
| Plant height | -0.00338 | ns |
| Leaf area | 0.00003 | ns |
| Root lenght | -0.00377 | ns |
| Number of stolon | 0.52317 | ** |
| Stolon effectivity | 0.08233 | ** |
| $R^2$ | 0.99 | ** |

Remarks: (ns) and (**) showed no significant and the significant difference of 1% ( α = 0.01).

## CONCLUSSION

The thickness of cocopeat did not affect the growth and the number of mini tubers that formed. The frequency of nutrients once in three days gives better the growth and number of mini tubers compared with the frequency of nutrients once in six days. The formed of mini tubers has correlation with plant height, leaf area, root lenght, number of stolon, and stolon effectivity.The model of regression between the number of mini tubers formed with growth variables is $\hat{Y} = -4.21588^{**} - 0.00338 X_{PH}^{ns} + 0.00003 X_{LA}^{ns} - 0.00377 X_{RL}^{ns} + 0.52317 X_{NST}^{**} + 0.08233 X_{SE}^{**}$ ($R^2 = 0.99^{**}$).

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