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PERFORMANCE OF
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BANANA (*Musa paradisiaca* var.
sapientum L) SEEDLINGS
CULTIVATED ON PEATLANDS

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THE GROWTH PERFORMANCE OF MICROPROPAGATED TALAS BANANA (*Musa paradisiaca* var. *sapientum* L) SEEDLINGS CULTIVATED ON PEATLANDS

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ABSTRACT

Talas banana (*Musa paradisiaca* var. *sapientum* L.) has a high economic value. However, because of slowly breeding, a quick way of propagation: i.e. in vitro is required. Peatlands in South Kalimantan are quite large and has potential to be used for planting area of Talas banana. The acclimatization of seedlings planted on the peats requires more fertilizers, considering the low nutrient content of the peats. This study aimed to determine the amounts of chicken manure and nitrogen-phosphor-potassium (NPK) fertilizer on the growth of Talas banana acclimatized in peatlands. This study applied a randomized block design (RBD) with two factors, namely: (1) the amount of chicken manure (K): $k_1 = 5 \text{ t ha}^{-1}$; $k_2 = 10 \text{ t ha}^{-1}$; $k_3 = 15 \text{ t ha}^{-1}$; $k_4 = 20 \text{ t ha}^{-1}$, and (2) the amount of NPK fertilizers (P): $p_1 = 200 \text{ kg ha}^{-1}$; $p_2 = 250 \text{ kg ha}^{-1}$; $p_3 = 300 \text{ kg ha}^{-1}$. All treatments had 3 replicates; therefore, there were 36 unit of experiment. The results of the experiment showed that all variables observed in this study were affected by the amounts of chicken manure and NPK fertilizer. However, no interaction of the amounts of chicken manure and NPK fertilizer were observed for all variables. The amount of chicken manure 5 t ha^{-1} resulted in the highest increment of plant height observed at 2nd, 4th, 6th, 8th, 10th and 12th week after planting, increment of stem diameter, addition of leaf number, width and length of leaves. The results of experiment also revealed that the best increment of plant height observed at 8th week after planting and stem diameter observed at 4th week after planting was obtained by 250 kg ha^{-1} of NPK fertilizer application.

Keywords: Propagation, in vitro, peatlands, chicken manure, Talas banana

INTRODUCTION

Talas banana (*Musa paradisiaca* var. *sapientum* L.), an indigenous commodity in the South Kalimantan Province, has a high economical value. However, conventional propagation of Talas banana is relatively slow, which only produce 5-7 suckers per year (Aspariah, 2007). Therefore, other technique such as *in vitro* is required to enhance production of banana seeds. Pierick (1990) reported that micropropagation provide an efficient method to produce clonal populations of diverse species of banana in a short time and is relatively free of banana disease. Therefore, free mass propagation of a wide range of banana species is feasible (Elisama *et al.*, 2013).

Talas banana are currently cultivated on the Production Centre in dry land of the Halong District, Balangan Regency, South Kalimantan Province. Extensification of Talas banana cultivation across the South Kalimantan Province is essential to improve the production of the banana. The South Kalimantan Province covered wide areas of wetlands, including peatlands which is potentially used as cultivation area for Talas banana.

Cultivation of Talas banana seedlings obtained through acclimatization process in peatlands requires greater amounts of fertilizer. This is attributed to relatively low nutrient contents of peatlands. Although tropical peatlands containing high amount of organic matter, availability of nitrogen and phosphor for plants is relatively low (Sjögersten *et al.*, 2011). Therefore, macro and micro fertilizer application need to be

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done to increase nutrient availability for plant cultivation in peatlands. Sunarjono (1999) reported that 10 kg manure per banana plant or 650-900 kg NPK fertilizer $\text{ha}^{-1} \text{year}^{-1}$ need to be applied for banana cultivation. Relatively high amount of fertilizer applied for banana cultivation may relate to low efficiency of fertilization. Prasertsak *et al.* (2001) showed that most of the urea applied for banana cultivation was hydrolyzed within 4 days irrespective of whether the urea was applied onto dry or wet soil and losses by leaching and denitrification combined amounted to 5% of the applied N.

Study on the effects of fertilizers on the growth and production of banana have been reported in several studies (Fontaine *et al.*, 1989; Prasertsak *et al.*, 2001; Nyombi *et al.*, 2010; Mia *et al.*, 2010; Gurav and Jadhav, 2013). However, none of these studies examine the combination effect of organic and inorganic fertilizer on banana yield. Little information is available on the interaction effect of both organic and inorganic fertilizers on the growth and production of banana. In this study, the interaction effects of organic and inorganic fertilizers on the growth of banana were studied in a field experiment. The aim of this study was to investigate the application of chicken manure and NPK fertilizers at different rates and their interaction on the growth performance of Talas banana cultivated on the

MATERIALS AND METHODS

Materials and Experimental Site

Seedlings of Talas banana were obtained from the Green House of the Laboratory of Tissue Culture, Faculty of Agriculture, Lambung Mangkurat University. Cultivation of banana was carried out in peatland area of the Banjar District, South Kalimantan Province. Peatlands used for banana cultivation was classified as a sapric peat based on the rubbed fibre content and the von Post index (McKinzie 1974; Parent and Caron 1993).

Experimental Design

The experimental design was completely randomized block design with two factors. First factor was the amount of chicken manure (K): $k_1 = 5 \text{ t ha}^{-1}$; $k_2 = 10 \text{ t ha}^{-1}$; $k_3 = 15 \text{ t ha}^{-1}$; $k_4 = 20 \text{ t ha}^{-1}$ and the second factor was the amount of NPK fertilizer (P): $p_1 = 200 \text{ kg ha}^{-1}$; $p_2 = 250 \text{ kg ha}^{-1}$; $p_3 = 300 \text{ kg ha}^{-1}$. Each treatment had 3 replicates; therefore, there were 36 unit of experiment.

Banana Plantation

Plant holes with dimension of 50 x 50 x 50 cm (length x width x depth) were prepared on the seedbed to avoid flooding in the rainy season. Dolomite in equal amount to 2 t ha^{-1} and chicken manure in accordance to the treatments were added to each hole, mixed thoroughly, and then left for two weeks before planting. The 12 weeks old seedlings after acclimatization were carefully removed from the polybags and then plantation was carried out with spacing 2 x 5 m between two plants. The NPK fertilizer in accordance with the treatments was applied in three stages, i.e. 1/3 when planting, 1/3 at 20 days after planting and the remaining at 40 days after planting. Regular plant practices were conducted by daily watering, weeding as well as pest and disease control by using pesticides if necessary.

Data Analysis

Data collected from cultivated banana consisted of plant height, leaves number, stem diameter, foliar length and foliar width. The plant height, leaves number, stem diameter variables were observed every two weeks starting at 2 weeks after planting until 12 weeks after planting. The length and width of foliar were observed only at 12 weeks after plantation. Analysis of variance (ANOVA) procedure of SAS was used to determine the effects of treatments on the observed variables. In the case of significance in ANOVAs, means were compared by the Duncan Multiple Range Test (DMRT) at $P < 0.05$.

RESULT AND DISCUSSION

14 Analysis of variance showed that the amounts of chicken manure and NPK fertilizer influenced significantly increment of plant height, number of leaves, diameter of stem, length and width of foliar. However, the interaction between chicken manure and NPK fertilizer did not affect all observed variables.

14 Table 1. Effect of chicken manure dosage on the increment of plant height observed from 2nd to 12nd week after planting

Amount of chicken manure	Increment of Plant height (cm)					
	2	4	6	8	10	12
5 t ha ⁻¹	18,656 a	10,600 a	12,222 a	11,667 a	12,956 a	16,111
10 t ha ⁻¹	13,311 b	8,256 a	8,222 b	11,222 a	7,133 b	13,222
15 t ha ⁻¹	7,811 c	3,922 b	5,633 bc	6,489 b	6,422 b	10,056
20 t ha ⁻¹	7,567 c	3,567 b	4,156 c	3,856 b	5,911 b	8,756

2 Similar letters in each column indicate no statistical difference between the treatments based on the Duncan' Multiple Range Test at P<0.05.

Average increment of plant height with different amounts of NPK fertilizers observed from 2 to 12 weeks after planting is presented in Figure 1. Treatment of NPK fertilizer at the amount of 250 kg ha⁻¹ resulted in the largest increment plant height increment at 8th week (10.94 cm). Average increment of plant height with different amount of NPK fertilizer

The Increment of Plant Height

15 Application of 5 tons of chicken manure ha⁻¹ resulted in the highest increment of plant height. The increment of plant height at the application of 5 tons of chicken manure ha⁻¹ observed from 2 to 12 weeks after plantation were 18.66 cm, 10.60 cm, 12.22 cm, 11.67 cm, 12.96 cm and 16.11 cm, respectively (Table 1).

observed at 2 week after planting ranged from 9.96 to 13.65 cm, 5.82 to 7.83 cm at 4 week after planting, 6.44 to 8.78 cm at 6 week after planting, 6.38 to 9.83 cm at 8 week after planting, 6.26 to 9.83 cm at 10 week after planting, and 11.36 to 13.61 cm at 12 week after planting (Figure 1).

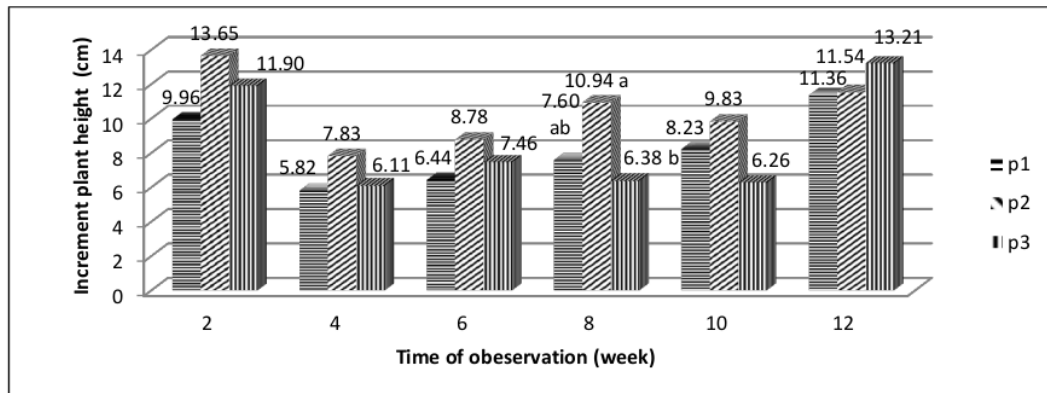


Figure 1. Average increment of plant height at the different amount of NPK fertilizer observed from 2 to 12 weeks after planting

According to Limin *et al.* (2000), peat soil is suitable for plant growth when viewed from the number of pores relating to the exchange of oxygen for root growth. High water holding capacity than mineral soils causing plants could be developed more quickly. However, with the presence of the other inherent properties such as high acidity, low base saturation and poor nutrients cause the peat soil is classified as marginal soils. In order to cope with that problem, the addition of organic and inorganic fertilizers such as chicken manure and NPK fertilizer to peat soils is required for plant cultivation.

Chicken manure contains macro and micro nutrients in large numbers with high alkaline saturation and but low cation exchange capacity. Chicken manure released nutrients to soils gradually. Previous experiment showed that application of chicken manure improved soil physical and chemical properties of peats (Limin *et al.*, 2000). Soil analysis of peats in the study sites showed that this soil contained 1.35% of N (very high), 626.89 mg P₂O₅/100 g (very high), 49.75 mg K₂O/100 g (very high) and had pH of 3.98 (very acidic). Nevertheless, a very high nutrient content does not guarantee nutrient availability to plants due to high soil acidity. In addition, anaerobic conditions slow the peat decomposition; thereby result in low availability of nutrients.

Chicken manure application of 5 t ha⁻¹ on peatlands for the growth of Talas banana provided the largest plant height compared to higher amount of chicken manure application. Macro nutrients such as nitrogen N contained in chicken manure could be available for the growth of the Talas banana. Nitrogen element functions to stimulate plant growth.

Chicken manure also provides phosphor for growing Talas banana. It is well known that phosphor function to transport energy resulted from plant metabolism, stimulates root growth, stimulate cell division and increase plant cell tissue. The smoother transportation of metabolism in plants led to better root growth. Therefore, the nutrients contained in the chicken manure and peat soils uptaken by roots, and finally resulted in better growth of the Talas banana. Chicken

manure also contained K, in which this element function in the process of photosynthesis, transportation of assimilation, enzymes and minerals including water and enhance plant immunity to disease. Fertilizing chicken manure of 5 t ha⁻¹ produced the largest increment plant height. It is likely that the chicken manure is able to improve soil physical and chemical properties of peat.

The increments of banana plant height become steady with increasing the amount of chicken manure application to 10 and 20 t ha⁻¹. It is thought to be due to two possibilities. The first is due to incomplete chicken manure decomposition that resulted in an increase in anaerobic conditions and peat soil acidification. Anaerobic environment and soil acidification can reduce the ability of manure in suppressing the solubility of toxic elements. The second possibility is caused by the microorganisms were only able to decompose lignin into aromatic groups (phenolic). High and raised acidification aromatic groups damage the root system of banana and poisoning aromatic group, and causing disruption of plant growth. Chemical characteristics of peat soils are very diverse and are determined by the mineral content, thickness, type of plant constituent of peat, mineral species on the substratum (at the base of peat) and peat decomposition rate. Hadi and Subushi (2000) suggested that peat soils in Kalimantan are generally dominated by woody material. Therefore, the composition most of the organic material is lignin, which generally exceeds 60% of the dry matter, while the content of other components such as cellulose, hemicellulose, and protein generally does not exceed 11%.

Figure 1 shows that increasing the amount of NPK fertilizer to 300 kg ha⁻¹ resulted in smaller accretion of plant height. NPK fertilizer was applied in three stages: first stage was applied at the time of planting as much as 1/3 of the total amount, then the second stage was applied at 20 day after planting at 1/3 of the total amount and the remaining was applied at 40 day after planting. Gradual fertilizer application increases the amount of available N uptake by plants and reduces the loss of N in the soil.

This is evident that the effect of NPK fertilizer on plant height of Talas banana was observed at 8th week after planting.

It is well established that nitrogen influence the increment of plant height. Sutedjo (2008) stated that vegetative and generative growth of plants require nutrients, especially N, P and K. Nitrogen required by plants for the formation of carbohydrates, protein, fat and other organic compounds that eventually stimulate meristem cells. Gardner *et al.* (1991) reported that the tip meristem produces new cells tip that finally improve plant height. Results of this study is in agreement with Prihatini (2012) who reported that banana plants with fertilizing of ZA 200 g + SP-36 200 g + KCl 100 g/plant/application observed at 1, 2 and 3 months gained increasing plant height of 27.08 cm, 66.10 cm and 41.90 cm, respectively. However, these results are in contrast to those of Prasetya (2014), where the height of tomato plants at the age of 40 and 60 day after planting showed the real effect in the presence of increasing doses of NPK Mutiara at the amount of 150 kg ha⁻¹, 300 kg ha⁻¹ and

450 kg ha⁻¹. Increasing the dose of fertilizer led to increment of plant height growth. It is due to that plants are growing up, the root systems are well developed and completed; therefore, plants are progressively able to uptake nutrients in the form of anions and cations (N, P and K) contained in the fertilizer of NPK Mutiara.

The Increment of Stem Diameter

Interaction between the amount of chicken manure and NPK fertilizer had no significant effect on the increase in diameter of the stem. However, treatment of chicken manure 5 t ha⁻¹ produced the highest stem diameter increase observed from 2nd to 12th week after planting (Table 2). The NPK fertilizer treatment resulted in the highest stem diameter increment only at 4 weeks after planting, namely 0.817 cm. The average increment stem diameter in response to the chicken manure application for all observations is presented in Table 2, while the increases in diameter stem due to NPK fertilizer treatment is depicted in Figure 2.

14

Table 2. Effect of chicken manure dosage on the increment of stem diameter observed from 2nd to 12nd week after planting

Amount of chicken manure	Observed at week					
	2	4	6	8	10	12
5 t ha ⁻¹	1.056 a	0.844 a	1.133 a	1.111 a	1.289 a	0.856
10 t ha ⁻¹	0.556 b	0.800 a	0.789 ab	0.867 a	1.000 a	0.744
15 t ha ⁻¹	0.600 b	0.378 b	0.500 b	0.433 b	0.589 b	0.667
20 t ha ⁻¹	0.489 b	0.400 b	0.411 b	0.433 b	0.456 b	0.633

Similar letters in each column indicate no statistical difference between the treatments based on the Duncan' Multiple Range Test at P<0.05.

Figure 2 demonstrates that the increases in stem diameter in the 2nd week of observation ranged from 0.60 cm to 0.73 cm, the 4th week ranged from 0.44 to 0.82 cm, the 6th week ranged from 0.67 to 0.80 cm, the 8th week ranged from 0.60 to 0.83 cm, the 10th week ranged from 0.66 to 1.05 cm, and the 12nd week ranged from 0.69 to 0.76 cm.

Plant growth is a quantitative change during the life cycle of plants that are

irreversible, increases in size or weight of the plant increases due to the addition of new structural elements. Increasing the size of the plant will not return as a result of cell division and enlargement such as increasing the diameter of the rod (Gardner *et al.*, 1991). Treatment of manure 5 t ha⁻¹ produced the largest stem diameter, due to mainly N nutrient is available for growth of the plants.

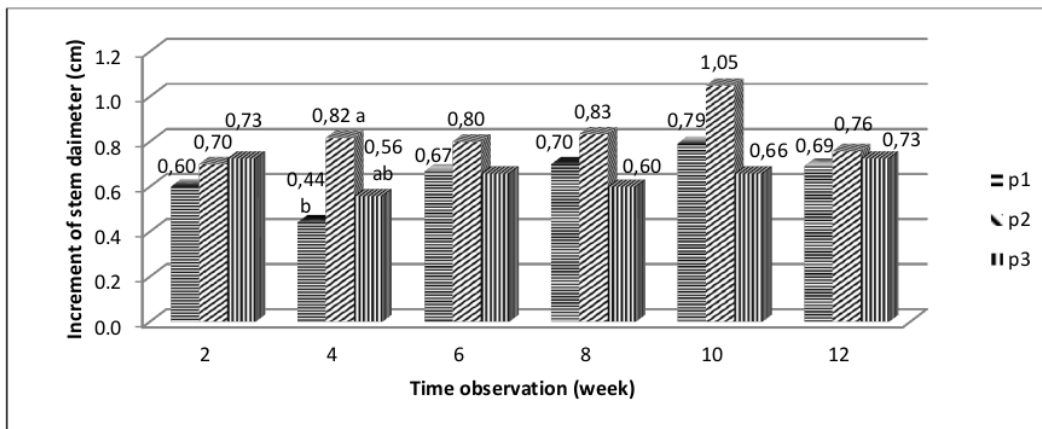


Figure 2. Average increment of stem diameter in response to NPK fertilizer observed at from 2nd to 12th week after plantation

Recommended fertilizer in Indonesia for a hectare was 250-350 kg of urea, 130-200 kg of SP-36, and the 150-550 kg of KCl. Should NPK fertilizer was used (15-15-15), the dose would be 650-900 kg/ha/year, depending on soil type and fertility. In this study, Talas banana cultivated in peatlands with NPK fertilizer of 250 kg ha⁻¹ could support increased stem diameter at the age of 1 month after planting.

The Increment of Leaf Number

Analysis of varian⁶ revealed that interaction the amounts of chicken manure

and NPK fertilizers did not affect the increment of the number of leaves. However, treatment of chicken manure 5 t ha⁻¹ provided the highest increment of leaf number observed at the 2nd and 6th week after planting. The effect of chicken manure application on the increment of stem diameter observed at week 2nd, 4th, 5th and 6th was not significantly different. Effect of treatment of chicken manure on the increment of leaf number is presented in Table 3, while the increases in the number of leaves due to NPK fertilizer treatment are described in Figure 3.

Table 3. Effect of chicken manure dosage on the increment of leaf number observed from 2nd to 12nd week after planting

Amount of chicken manure	Observed at week					
	2	4	6	8	10	12
5 t ha ⁻¹	3,778 ^a	0,889	1,133 ^a	1,222	1,333	2,000
10 t ha ⁻¹	2,444 ^b	0,778	0,789 ^{ab}	1,111	1,222	1,889
15 t ha ⁻¹	1,889 ^b	0,444	0,500 ^b	1,000	1,000	1,889
20 t ha ⁻¹	1,667 ^b	0,444	0,411 ^b	0,778	1,000	1,778

Similar letters in each column indicate no statistical difference between the treatments based on the Duncan's Multiple Range Test at P<0.05

Figure 3 shows the increases in the number of leaves observed at the 2nd week ranged from 2.33 to 2.58 cm, at the 4th week ranged from 0.58 to 0.75 cm, at the 6th week ranged from 0.75 to 1.17 cm, at the 8th ranged from 0.83 to 1.25 cm, at the 10th week ranged

from 0.92 to 1.33 cm, and at 12nd week ranged from 1.83 to 1.92 cm.

Peatlands are characterized by a high content of organic matter, high soil acidity and low availability of macro and micro nutrients (Gonggo *et al.*, 2004).

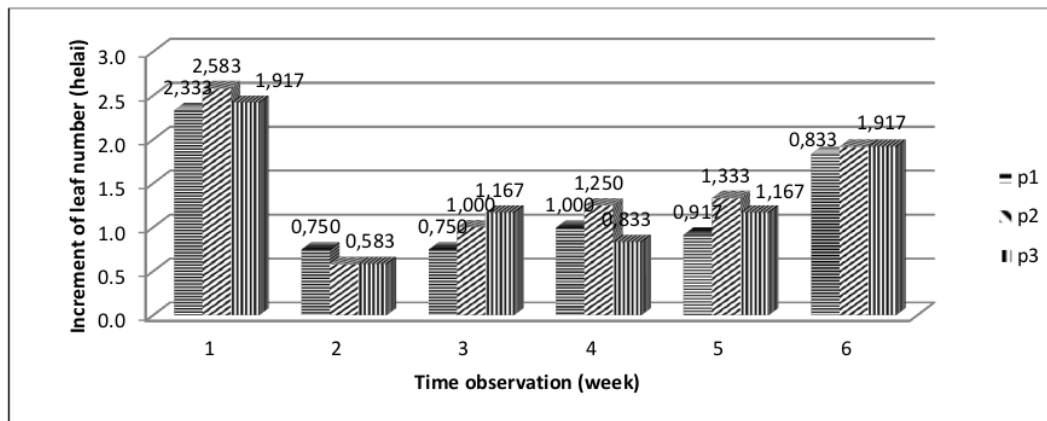


Figure 3. Average of increment of leaf number in response to NPK fertilizer application observed from 2nd to 12th week after planting.

Results of soil analyses showed that peatlands used in this study contained 1.35% of total N (very high), 626.89 mg P₂O₅/100 g (very high), K₂O 49.75 mg/100 g (very high) and had a pH of 3.98 (very acidic). As the contents of macro nutrients such as nitrogen, phosphorus and potassium are very high in peatlands, the application of 5 t ha⁻¹ chicken manure is sufficient to produce the highest increases in the number of leaves. This result indicates that 5 t ha⁻¹ of chicken manure was sufficiently able to supply elements of N, P and K for the growth of leaves. The results of this study is consistent with the research of Kausar (2014) who reported that chicken manure fertilizer

treatment of 5 t ha⁻¹ resulted in the highest number of leaves on the plant, namely 20.33 strands of scallion. This is due to the content of N in the chicken manure is higher than that in other animal manure.

The Increment of Length and Width Leaves

Similar to the number of leaves, the interaction of chicken manure and NPK fertilizer had no significant effect on the length and width of leaves. However, the amount of chicken manure of 5 t ha⁻¹ provided the highest leaf length and width of Talas banana (Table 4).

Table 4. Effect of chicken manure dosage on the increment of length and width leaves observed at 12nd week after planting

Amount of chicken manure	Width of Leaves	Length of Leaves
5 t ha ⁻¹	39.422 a	84.170 a
10 t ha ⁻¹	31.622 a	69.180 ab
15 t ha ⁻¹	19.300 b	46.130 bc
20 t ha ⁻¹	18.389 b	37.340 c

Similar letters in each column indicate no statistical difference between the treatments based on the Duncan's Multiple Range Test at P<0.05.

Gardner *et al.* (1991) reported that the length, width and area of leaves increased gradually according to the ontogeny through to a specific point; therefore, the biggest leaves lied close to the central plant. This is

evident in the growth of Talas banana in where the bottom leaf had smaller length and width of leaf compared to the top leaf that had longer and wider of leaf area. These results also showed that the highest length and width

of leaves was observed at the treatment of chicken manure application¹³ at the amount of 5 t ha⁻¹. This is due to the width and length of the leaves is affected by the high N contained in the fertilizer (1.43%). This result is in agreement to Gardner *et al.* (1991) who stated that N fertilization had a significant effect on the expansion of the leaves, especially on the width and leaf area.

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CONCLUSION

1. Interaction of the amount of chicken manure and NPK fertilizer had¹¹ no significant effect on the increment of plant height, stem diameter, number of leaves and the width and length of leaves.
2. The amount of chicken manure 5 t ha⁻¹¹³ resulted in larger increment of plant height, stem diameter, number of leaves, and width and length of leaves compared to other treatments.
3. The amount of NPK 250 kg ha⁻¹ is significantly better than other treatments and resulted in the highest increment of plant height observed at 8th week after planting and increment in stem diameter at 4th week after planting.

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