Effect of organic manure fertilizer on the growth of Macaranga gigantea

by Dwi Susanto

NUSANTARA BIOSCIENCE
Vol. 11, No. 2, pp. 166-171
November 2019

ISSN: 2087-3948
E-ISSN: 2087-3956
DOI: 10.13057/nusbiosci/n110210

Effect of organic manure fertilizer on the growth of *Macaranga gigantea*

DWI SUSANTO[1,♥], AULIANA[1], RATNA KUSUMA[1], RUDIANTO AMIRTA[2]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Mulawarman. Jl. Barong Tongkok No. 4, Kampus Gunung Kelua, Samarinda 75123, East Kalimantan, Indonesia. Tel.: +62- 541-749140, ♥email: susantodwiki@yahoo.com

[2]Faculty of Forestry, Universitas Mulawarman. Jl. Ki Hajar Dewantara, Kampus Gunung Kelua, Samarinda 75123, East Kalimantan, Indonesia

Manuscript received: 12 September 2019. Revision accepted: 24 October 2019.

Abstract. *Susanto D, Auliana, Kusuma R, Amirta R. 2019. Effect of organic manure fertilizer on the growth of* Macaranga gigantea. *Nusantara Bioscience 11: 166-171.* *M. gigantea* planting research has been conducted in several habitats such as natural forest gaps, drained peatland and soil with highly degraded land for rehabilitation. This study investigated the effect of organic manure fertilization on soil, tissue chemical properties and growth performance of *Macaranga gigantea* planted at dense space of 2,5 m x 2,5 m. The experiment used a randomized block design with treatment of fertilization using goat manure with five gradual concentrations namely P0 (0 g), P1 (100 g), P2 (200 g), P3 (300 g) and P4 (400 g) in which each treatment consisted of three groups with 20 replications for each group, totaling 300 seedlings observed. The results showed that organic manure fertilization promoted stem height, stem diameter, leaf number and nutrient concentrations in the leaves of four-month-old *M. gigantea*. The best growth performance was gained from the treatment of P3 (300 g), followed by P2, P1, P4, and P0. The highest nutrient contained in leave tissue was potassium, followed by calcium, magnesium, nitrogen and available phosphorus.

Keywords: *Macaranga gigantea*, organic manure, planting pattern

INTRODUCTION

Macaranga is known as pioneer plant and commonly found in secondary forest and forest gap in Kalimantan (Indonesian Borneo) (Davies 1998; Slik et al. 2008; Susanto et al. 2016b; Susanto et al. 2017a; Susanto et al. 2017b). One species of the genus *Macaranga* is *Macaranga gigantea* which is potential as tree species used in land and forest rehabilitation (Suita and Nurhasyibi 2009), and restoration to maximize the outcomes for carbon and biodiversity in East Kalimantan, Indonesia (Budiharta et al. 2014) and is profitable to be used as pulp raw material (Mindawati et al. 2010) and ethanol source (Amirta et al. 2016a; Amirta et al. 2016b). Since it is native to Indonesia, the potential development of *Macaranga* for pulp and biomass plantation is promising as the productivity of exotic tree species for industrial forestry plantation continues to decline (Junaidi 2018).

Nonetheless, improvement of soil condition and fertilization are often required when conducting land rehabilitation and developing plantation especially when the soil is highly degraded. Reclamation using native trees to enhance growth performance of planted species (Lestari et al. 2019). Nussbaum et al. (1995) reported the growth of two species of Dipterocarpaceae (i.e. *Dryobalanops lanceolata* and *Shorea leprosula*) along with two species of *Macaranga* (i.e. *M. gigantea* and *M. hypoleuca*) on degraded land caused by log harvesting (former log pile or skid trail) following selective logging in Malaysia. Their study showed that fertilization rapidly increased the growth of *M. gigantea* six months after planting.

A study on forest gap of secondary forest at Botanical Garden of Mulawarman University indicated that NPK chemical fertilizer promoted the increase in stem height, stem diameter, leaf number and canopy diameter of *M. gigantea* in monoculture planting. Application of NPK fertilizer with 120 g for each plant promoted the best growth in stem height and stem diameter since this tree species accumulated potassium nutrient in high concentration (Susanto et al. 2017; Susanto et al. 2018). Junaidi (2018) reported that *M. gigantea* could grow better on drained peatland. While there are several studies on *M. gigantea* growth and planting treatment, information about the growth of *M. gigantea* on fallow land of local communities is limited. In this study, we aimed to investigate the effects of goat manure fertilization on the growth of *M. gigantea* on a fallow land.

MATERIALS AND METHODS

Study area and period

This study was conducted in Suka Damai village, Muara Badak Sub-district, Kutai Kartanegara District, East Kalimantan Province from April to November 2018. In this study, *M. gigantea* plants were planted at former fallow lands. Research plot was located in the coordinate of 00°17'18.2" and E 117°14'39.5".

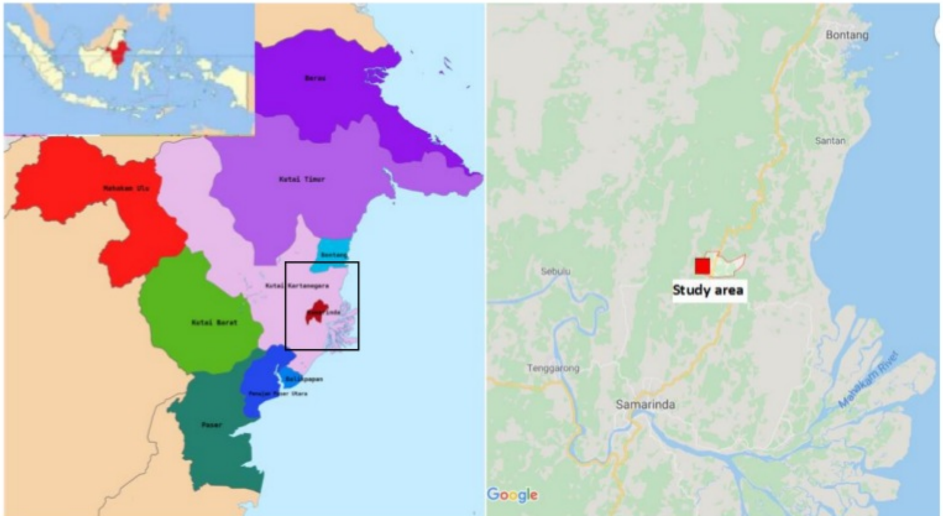

Figure 1. Map of research area in Suka Damai Village, Muara Badak Sub-district, Kutai Kartanegara District, East Kalimantan Province, Indonesia

Procedures

Seedling preparation

M. gigantea seedlings were collected from wildlings (wild seedlings) grew under host tree at Botanical Garden of Mulawarman University, Samarinda. Wildlings with similar size were collected and placed on wet newspapers, carried to nursery and transferred into polybags (Susanto et al. 2016a). These seedlings were covered for one month to maintain its moisture. Next, they were acclimatized gradually for two or three months until they were ready to be planted at the research site.

Land preparation

Research area was former local field with an extent of 7,000 m^2 in total that once was planted with sengon (*Paraserianthes falcataria*). Soil was prepared manually by clearing the grass, digging planting holes with space 2.5 m x 2.5 m for each sub-plot and separated 5 m for each plot. Prior to planting, soil samples were collected in a composite from five points, at soil depth of 0 - 30 cm, then nutrients concentration was analyzed at laboratory.

Experimental design

The experiment used randomized block design with treatment of adding organic manure at different levels as follows: P0 (0 g), P1 (100 g), P2 (200 g), P3 (300 g) and P4 (400 g) for each plant. Each treatment consisted of 20 replications and 3 groups, resulting in 300 seedlings in total. Fertilizer was applied 1 month after planting and plants were measured 6 months after the fertilization treatments.

Planting method

Seedling from each polybag was planted in the prepared holes. Seedling and its media were taken out from polybag carefully by tearing it with knife. They were placed in the holes and covered with soil. One month after transplanting, each plant was fertilized using organic manure as mentioned concentrations.

Plant growth measurement

Plant growth parameters were measured, including survival rate, stem height, stem diameter, leaf number, and leaf diameter. Leaf samples were collected in a composite from each treatment to analyze the chemical properties.

Soil and plant tissue analysis

Mixed soil samples, organic manure, and leaves were air-dried. Soil analysis consisted of pH, base saturation, cation exchange capacity, and organic matter content. Nutrient concentrations such as total N (using Kjeldahl method), available P (using Bray method) and available K, Ca and Mg (using spectrophotometrically) were measured at laboratory.

Figure 2. Seedling of *Macaranga gigantea*

A B C D E

Figure 3. *Macaranga gigantea* at planting plots (four months), with application organic manure: A. P0 (0 g), B. P1 (100 g), C. P2 (200 g), D. P3 (300 g), E. P4 (400 g) for each plant

Data analysis

Data were analyzed statistically using ANOVA to determine the significant difference between treatments and followed by Duncan's Multiple Range Test or DMRT (P = 0.1). All statistical tests used SPSS 22.0 (SPSS Inc. USA).

RESULTS AND DISCUSSION

Soil physical and chemical properties

Before planting, soil physical and chemical properties at research site were analyzed. The results of soil analysis are presented in Table 1. The results of soil analysis suggest that soil at the research sites was categorized as infertile, indicated by very low concentration of nitrogen and calcium, and low potassium and magnesium, although the available phosphorus was in a very high concentration.

Nutrient concentration inorganic (goat) manure

Based on Table 2, it can be concluded that the phosphorus content in goat manure was the highest, followed by nitrogen, calcium, potassium, and magnesium. Phosphorus is one of macronutrients and necessary for plant growth.

Effect of goat manure on the survival rate and growth of *M. gigantea*

The result of ANOVA (P= 0.1) suggests that fertilization had no effect on the survival rate of *M. gigantea* at four months after planting. The result of our study showed that the average survival rate of *M. gigantea* seedlings at research plot was rather high with survival rate of 75±2.89 - 80±5.77% (Figure 4). The plot (as referred to each group) had gentle slope, where subplot 1 was located over the slope, subplot 2 was in the middle and subplot 3 was further down the slope. Junaidi (2018) informed that *M. gigantea* and *Cratoxylum arborescens* planted on drained peatland at Lubuk Ogong village, Pelalawan, Riau had survival rate of 65.5 and 80%, respectively.

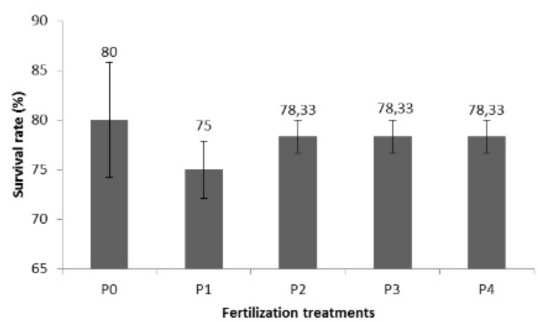

Figure 4. Effect of goat manure on survival rate of *M. gigantea* at four months after planting. Vertical bars represent standard error of the mean (n = 60).

Table 1. Soil physical and chemical properties at research site in Suka Damai village

Physical and Chemical Properties	Value	Status
pH (H_2O)	5.08	Acid
Cation exchange capacity (CEC)	4.20	Low
Base saturation	37.31	Low
Total N (%)	0.219	Very low
Available P (ppm)	45.92	Very high
Available K^+ (mg K kg^{-1})	172.6	Low
Ca^{2+} (ppm)	0.499	Very low
Mg^{2+} (ppm)	2.023	Low
Bulk density (BD)	1.57 gr cm^{-3}	-

Table 2. Nutrient concentration in goat manure

Nutrients	Concentration (%)
Total N	2.88
P	22.446
K^+	2.766
Ca^{2+}	2.88
Mg^{2+}	0.78

Table 3. Soil physical and chemical properties in each planting treatment

Treatments	Soil nutrient concentrations				
	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
P0	0.14 ± 0.02	36.60 ± 1.68	338.90±38.39	1.92 ± 0.34	2.03 ± 0.68
P1	0.10 ± 0.01	39.46 ± 1.94	229.63± 94.96	2.84 ± 0.36	3.49 ± 1.11
P2	0.12 ± 0.02	37.23 ± 0.95	333.97± 32.25	3.38 ± 1.14	3.22 ± 1.34
P3	0.12 ± 0.02	38.82 ± 4.28	355.10±144.6	2.27 ± 0.43	2.25 ± 0.82
P4	0.11 ± 0.02	43.60 ± 8.79	447.40± 94.74	3.24 ± 1.37	2.90 ± 1.18

ANOVA test (P = 0.1) indicated that organic manure application had no effect on soil nutrient concentration, yet on average there was an increase in following nutrient concentration: phosphorus, potassium, calcium, and magnesium (Table 3). After NPK chemical fertilizer was applied, soil nitrogen increased 0.10 - 0.13%, phosphorus 19.70 - 32.64%, potassium75.81 - 179.96% (Susanto et al. 2017). The concentration of nutrients measured on the planting sites was lower than that measured in goat manure.

Our study showed that fertilization using goat manure affected the growth of *M. gigantea* in terms of increase in stem height (P = 0.1) and this effect was significantly different among treatments (Figure 5). However, the fertilization had no effect on the growth in terms of stem diameter and leaf number.

Another study by Susanto et al. (2017) showed that *M. gigantea* fertilized with NPK chemical fertilizer, at six months after planting they had stem diameter of 1.55±0.16 - 2.31±0.61 cm, stem height of 65.1±8.3 - 84.7±16.7 cm and leaf number of 6.9±0.5 - 8.2±0.5. These results suggest that NPK chemical fertilizer produces better growth than goat manure on *M. gigantea*. Nutrient deficiency is an inhibitor factor in *M. gigantea* at six months after planting (Nussbaum 1995). Another study on *M. triloba* indicated that plant performance measures, such as growth rate and photosynthetic capacity, are not related to the improved nutrient allocation on any parts of plant immediately, due to certain limitations by the plant itself in regulating complicated cellular method (Heil et al. 2002). According to Yasir and Omon (2007), *Swietenia mahagoni* planted at degraded land with low pH firstly requires calcification treatment on the soil and followed by organic fertilization to increase soil pH. Mixed organic manure as suggested by Han et al. (2017) is still preferable, although the nitrogen, phosphorus, and potassium concentration contained are in small concentration. Their study showed that the yellow poplar (*Liriodendron tulipifera* Lin.) could grow as good when it is fertilized by chemical fertilizer in terms of improving soil quality, such as pH. The application of goat manure with a dose of 250 g. polybag^{-1} is sufficient to increase the growth of penage (*Calophyllum inophyllum* Linn.) and therefore recommended when planting its seedling (Wulandari et al. 2017). In another study, Ansoruddin et al. (2017) found that goat manure fertilization at a dosage of 1 kg per plant had significant effect in increasing leaf number of gaharu (*Aquilaria crassna*).

Our study also found that goat manure fertilization had no effect on leaf nutrient concentration (result of ANOVA test at P = 0.1). However, on average there was an increase of concentration in some nutrients, such as the highest nitrogen in treatment P2; phosphorus in treatments of P1, P2, P3 and P4; potassium in treatment of P4; and both calcium and magnesium in treatment P1 (Figure 6).

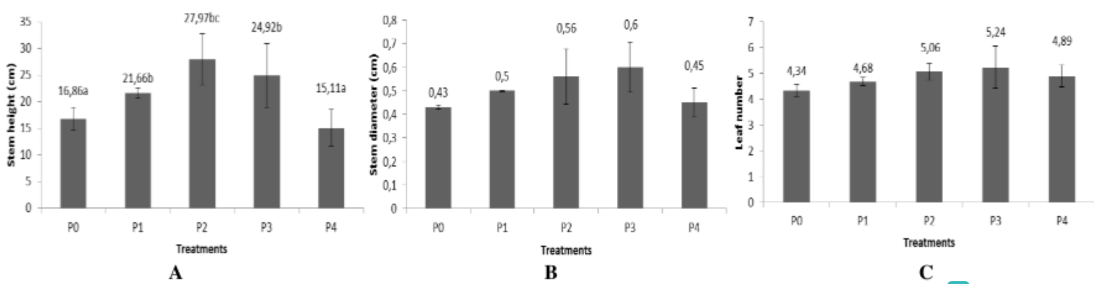

Figure 5. The effect of fertilization using goat manure on the growth of *M. gigantea* at four months after planting. A. Stem height, B. Stem diameter, C. Leaf number. Means with the same letter are not significantly different among treatments at P = 0.1. Vertical bars represent standard error of the mean (n = 20)

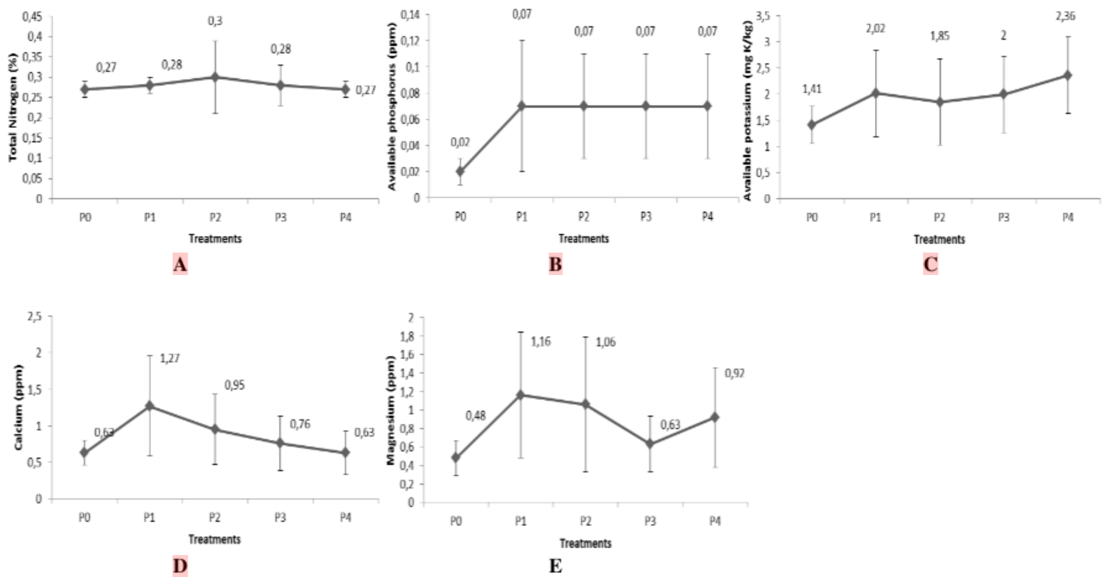

Figure 6. Effect of goat manure fertilization on leaf nutrient concentration of *M. gigantea* at four months after planting: A. Total nitrogen, B. Available phosphorus, C. Available potassium, D. Calcium, E. Magnesium. Vertical bars represent standard error of the mean (n = 20)

In another study, *M. gigantea* fertilized with NPK chemical fertilizer had nutrient concentration in the leaf vary, such as nitrogen 0.28-0.81%, phosphorus 0.65-0.73% and potassium 0.99-1.35% (Susanto et al. 2017b). If compared to the results of our study, leaf nitrogen concentration of *M. gigantea* fertilized with NPK chemical fertilizer by 160 g/plant is three times higher than that fertilized with goat manure by 400 g/plant. In addition, the phosphorus concentration in the leaf of *M. gigantea* fertilized with NPK chemical fertilizer is fourteen times higher than that by goat manure fertilizer. In contrast, the leaf potassium concentration fertilized by NPK is lower than that fertilized by goat manure. A study by Susanto et al. (2017) found that leaf nutrient concentration of *M. giganteag* row on shifting cultivation land in East Kalimantan at 6 months contained 2.0% of nitrogen, 0.18% of phosphorus and 0.61% of potassium. High nutrient productivity is influenced by long nutrient retention indicated with the high productivity for agriculture capacity, yet it only happened on fertile soil (Hiremath et al. 2002). Susanto et al (2019) reported that the accumulation of nutrients in the leaves of the tropical shrub plants varied widely, nitrogen 1.4-2.18%, phosporus 0.11-0.28%, potassium 0.44-2.98%.

In conclusion, our study revealed that fertilization using organic manure could promote the growth of *M. gigantea* in terms of stem height, stem diameter, leaf number as well as some nutrients required in plant tissues. The highest growth performance was obtained from treatment P3 with 300g of goat manure application, followed by P2 (200 g), P1 (100 g), P4 (400 g) and P0 (0 g), respectively. The highest nutrient contained in leave tissue was potassium, and followed by calcium, magnesium, nitrogen and available phosphorus.

ACKNOWLEDGEMENTS

We thank all technicians from Soil Science Laboratory, Mulawarman University, Samarinda, Indonesia for helping us analyzed soil and plant tissue. We also thank our students for their help with the fieldwork in research area.

REFERENCES

Amirta R, Nafitri SI, Wulandari R, Yuliansyah, Suwinarti W, Candra KP, Watanabe T. 2016a. Comparative characterization of *Macaranga* species collected from secondary forests in East Kalimantan for biorefinery of unutilized fast-growingg wood. Biodivers J Biol Divers 17 (1): 116-123.

Amirta R, Mukhdlor A, Mujiasih D, Septia E, Supriadi, Susanto D. 2016b. Suitability and availability analysis of tropical forest wood species for ethanol production: a case study in East Kalimantan. Biodivers J Biol Divers 17 (2): 544-552.

Ansoruddin, Purba DW, Kusuma D. 2017. Response of giving goat manure and pearl NPK fertilizer to the growth of agarwood (*Aquilaria crassna*) seedlings in polybags. Jurnal Penelitian Pertanian BERNAS 13 (1): 31-36. [Indonesian]

Budiharta S, Meijaard E, Erskine PD, Rondinini C, Pacific M, Wilson KA. 2014. Restoring degraded tropical forests for carbon and biodiversity. Environ Res Lett 9: 114020.

Davies SJ. 1998. Photosynthesis of Nine pioneer *Macaranga* species from Borneo in relation to life history. Ecology 79: 2292-2308.

Han SH, An JY, Hwang J, Kim SB, Park BB. 2016. The effects of organic manure and chemical fertilizer on the growth and nutrient concentrations of yellow poplar (*Liriodendron tulipifera* Lin.) in a nursery system. For Sci Technol 12 (3): 137-143.

Heil M, Hilpert A, Fiala B, Bin Hashim R, Strohm E, Zotz G, Linsenmair KE. 2002. Nutrient allocation of *Macaranga triloba* ant plants to growth, photosynthesis and indirect defence. Funct Ecol 16: 475-483.

Hiremath AJ, Ewel JJ, Cole TG. 2002. Nutrient use efficiency in three fast-growing tropical trees. For Sci 48 (4): 662-672.

Junaidi A. 2018. Growth performance of three native tree species for pulpwood plantation in drained peatland of Pelalawan District, Riau. Indon J For Res 5 (2): 119-132.

Lestari DA, Fiqa AP., Fauziah, F, Budiharta, S. 2019. Growth evaluation of native tree species planted on post-coal mining reclamation site in East Kalimantan, Indonesia. Biodivers J Biol Divers 20: 134-143

Mindawati N, Bogidarmanti R, Nuroniah HS, Kosassih AS, Suhartati, Rahmayanti S, Junaidi A, Rachmad E, Rochmayanto Y. 2010. Synthesis silviculture research of species alternatives for wood pulp production. Research and Development Center for Increasing Forest Productivity, Forest Research and Development Agency, Department of Forestry, Bogor, Indonesia. [Indonesian]

Nussbaum R, Anderson J and Spenser T. 1995. Factors limiting growth of indigenous tree seedlings planted on degraded rainforest soil in Sabah, Malaysia. For Ecol Manag 74: 149-159.

Slik FJW, Bernard CS, Van Beek M, Breman FC, Eichhorn KAO. 2008. Tree diversity, composition, forest structure, and aboveground biomass dynamics after single and repeated fire in a Bornean rain forest. Oecologia 158 (3): 579-588.

Suita E, Nurhasybi. 2009. Seed and plant propagation collection pioneers type *Macaranga* sp. for forest and land rehabilitation. Info Benih 13 (1): 170-175. [Indonesian]

Susanto D, Ruhiyat D, Sutisna M, Amirta R. 2016a. Flowering, fruiting, seed germination and seedling growth of Macaranga gigantea. Biodivers J Biol Divers 17 (1): 192-199.

Susanto D, Ruhiyat D, Sutisna M, Amirta R.2016b. Soil and leaf nutrient status on growth of *Macaranga gigantea* in secondary forest after shifting cultivation in East Kalimantan, Indonesia. Biodivers J Biol Divers 17 (2): 409-416.

Susanto D, Hayatudin, Setiawan A, Purnomo H, Ruhiyat D, Amirta R. 2017a. Characterizing nutrient status and growth of Macaranga gigantea in tropical rainforest gaps after selective logging in East Kalimantan, Indonesia. Biodivers J Biol Divers 18(3): 996-1003

Susanto D, Mulyati S, Purnomo H, Ruhiyat D, Amirta R. 2017b. Growth, biomass production and nutrient accumulation of *Macaranga gigantea* in response to NPK fertilizer application. Nusantara Biosci 9 (3): 330-337.

Susanto D, Kusuma R, Amirta R. 2018. Nutrient distribution on soil and aboveground biomass of *Macaranga gigantea* five years after planting. Asian J For 2 (1): 12-19.

Susanto D, Auliana A, Amirta R.2019. Growth evaluation of several types of energy crops from tropical shrubs species [version 1; peer review: awaiting peer review]. *F1000Research* 2019 **8**:329 (https://doi.org/10.12688/f1000research.18063.1)

Wulandari I, Muin A, Iskandar. 2017. Efficiency of goat manure fertilizer for penage (*Calophyllum inophyllum* Linn) nurseries. Jurnal Hutan Lestari 5 (3):814-823. [Indonesian]

Yasir I, Omon RM. 2007. Effects of organic fertilizer dosage on the growth of mahoni planted on alang-alang areas in Samboja - East Kalimantan. Jurnal Penelitian Hutan dan Konservasi Alam 4 (4): 377-384. [Indonesian]

Effect of organic manure fertilizer on the growth of Macaranga gigantea

ORIGINALITY REPORT

10%	10%	6%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	biosains.mipa.uns.ac.id Internet Source	4%
2	Submitted to Universitas Mulawarman Student Paper	2%
3	f1000research.com Internet Source	2%
4	Martel, Ashley B., and Mirwais M. Qaderi. "Does salicylic acid mitigate the adverse effects of temperature and ultraviolet-B radiation on pea (Pisum sativum) plants?", Environmental and Experimental Botany, 2016. Publication	1%
5	link.springer.com Internet Source	1%
6	Submitted to SUNY, Binghamton Student Paper	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		

Samarinda, 28 September 2020

Mengetahui,
Ketua Tim Validasi Artikel Ilmiah
FMIPA Unmul

Dr. Sri Wahyuningsih, M.Si
NIP. 19690413 200012 2 001