Artikel 3.pdf

by

BIODIVERSITAS
Volume 17, Number 1, April 2016
Pages: 192-199

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d170128

Flowering, fruiting, seed germination and seedling growth of *Macaranga gigantea*

DWI SUSANTO[1,♥], DADDY RUCHIYAT[2], MAMAN SUTISNA[2], RUDIANTO AMIRTA[2]
[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Mulawarman University. Jl. Barong Tongkok No. 4, Gunung Kelua, Samarinda Ulu, Samarinda-75123, East Kalimantan, Indonesia. Tel./Fax.: +62-541-749140, 749152, 749153, ♥email: susantodwiki@yahoo.com
[2]Faculty of Forestry, Mulawarman University. Jl. Ki Hajar Dewantara, Kampus Gunung Kelua, Samarinda-75123, Indonesia

Manuscript received: 31 December 2015. Revision accepted: 3 March 2016.

Abstract. *Susanto D, Ruchiyat D, Sutisna M, Amirta R. Flowering, fruiting, seed germination and seedling growth of* Macaranga gigantea. *Biodiversitas 17: 192-199*. The stages of flower and fruit development of *Macaranga gigantea*, its seed germination behavior in nature and from fruit harvesting, as well as the process of raising its seedlings in the laboratory were studied to determine the potential for production of *M. gigantea* seedlings. Five reproductive trees of *M. gigantea* were chosen as sources of seed. To estimate natural germination rates, four sample plots of 1 x 1 m^2 in four cardinal directions below the crown of every tree were set up. In addition, dry and wet extraction processes were carried out to determine, which the more effective method for germination of *M. gigantea* seeds. The results showed that the time required from flower development to fruit ripening in *M. gigantea* flowers was 5-6 months. The flower buds initiated in the dry season (August 2011) and the fruits ripened in the rainy season (December 2011-January 2012). The seeds that fell under the parent tree germinated in approximately 24 days with an average seedling density of 75-267 per m^2. The germination in laboratory showed that the percentage and the rate of germination of the seeds extracted through the wet extraction process were higher than those extracted through the dry extraction process. The highest rate of germination (65%) is by the combination of seeds extracted through wet extraction process and grown on compost media. The relative growth rate of seedlings planted on mushroom spawn waste media was the highest rate (0.36 ±0.42%), followed by those planted on compost media (0.15±0.09%), top soil media (0.10±0.04%) and sand media (0.10±0.07%).

Keywords: Germination, *Macaranga gigantea*, pioneer species, seedling growth

INTRODUCTION

The giant mahang (*Macaranga gigantea*) has not been recognized as an important commodity with a high economic value. *M. gigantea* wood is light, soft and flimsy that it is not good for construction wood. However, Amirta (2010) reported that enzymatic hydrolysis process of *M. gigantea* wood produces the highest reducing sugar content (82.47% based on the weight of resultant pulp) compared to other types of fast growing woody species such as *Paraserianthes falcatria* and *Acacia mangium* and this plant has the potential to be used as raw material for bioethanol in the near future. Liquid bioethanol generated from wood is long lasting providing that the forest where it grows is preserved (sustainable) and it does not affect the production of food and the increasing price of food materials.

M. gigantea has not yet been cultivated and information about the stages of its flower and fruit development, seed germination in nature, as well as the process of raising its seedlings is still very limited. In order to have *M. gigantea* seedlings ready for cultivation, a source of seeds harvested from physiologically mature fruits is needed. Seed extraction is required to remove the seeds from other parts of the fruit (skin, flesh, wings, stalks), and if the seeds are not appropriately extracted, their germination viability will decrease.

In nature, *M. gigantea* plant is abundant in open mixed dipterocarp forests after extensive disturbances such as wood harvesting, forest fires, and shifting cultivation (Lawrence 2001; Silk et al. 2003; Lawrence 2005; Eichhorn 2006; Silk et al. 2008). After a great forest fire in East Kalimantan (1982-1983), *M. gigantea* and *M. triloba* simultaneously spread over and covered the canopy gaps of the destroyed forest, believed that seeds of *M. gigantea* and *M. triloba* might be buried in the soil before the forest fires and then they germinated immediately after the fires. However, Kiyono and Hastaniah (1997) reported that a careful observation indicated that *Austroeupatorium inulifolium* and some of wild bananas (*Musa* sp.) had been growing before the seedlings of *M. gigantea* and *M. triloba* grew and spread over the forest. They speculate that there were a considerable number of *M. gigantea* and *M. triloba* seed-trees that survived.

Seeds of *M. gigantea* were reported to have low water content of 8.23% and the seeds with low water content were commonly orthodox (Suita and Nurhasybi 2009). *M. gigantea* seeds resulting from dry extraction from mature fruits have low germination rates of 2-10%, but soaking the seeds into a solution of 0.2% potassium nitrate for 20 minutes before spreading on sand media can increase germination rates of seeds up to 20% (Mindawati et al. 2010).

It is necessary to conduct a study on the stages of flower and fruit development of *M. gigantea*, its seed germination behavior in nature, its seed germination rates from the fruit harvesting, as well as the process of raising its seedlings in the laboratory. From this reconstruction, it is expected that comprehensive information can be obtained so a way of preparing seeds and raising seedlings can be appropriately formulated in order to produce *M. gigantea* seedlings ready for cultivation.

MATERIALS AND METHODS

Study area

The research on flower and fruit development of *M. gigantea*, germination and seedlings growths in natural conditions was conducted in the Forest Education of Faculty of Forestry, Mulawarman University, East Kalimantan, Indonesia (inside Bukit Suharto Grand Forest Park, East Kalimantan). It was located between the coordinates of 0°25'10''-0° 25'24'' South and 117° 14'00''-117° 14'14'' East (Figure 1). The data obtained from 2003 to 2012 showed that the annual average rain fall was 2423 mm, and the highest annual rainfall was 2757.5 mm in 2008. The highest monthly rainfall was in April (288.3 mm) and the lowest was in August (115.3 mm). The wet season lasted for 9-12 months, while the dry season lasted for 0-3 months. The average monthly temperature was 27.5°C and the average moisture was 82% (Anon. 2012). The research on seed germination from fruit harvesting and the growth of *M. gigantea* seedlings was conducted in the Plant Physiology Laboratory at the Faculty of Mathematics and Natural Sciences, Mulawarman University, Samarinda, East Kalimantan, Indonesia. The research was conducted from July 2011 to March 2012.

Procedures

The developmental stages of M. gigantea *flowers and fruits*

Observations were conducted on five *M. gigantea* trees which were blooming and growing on the sides of a street. The trunk diameter and the height of the *M. gigantea* trees were measured and the litter under the tree crowns was cleared. The observation of flowers started from the time when the flower buds initiated, to the time when the flowers blossomed (anthesis), until they wilted and then the stages of the fruit development were observed until the fruits were fully ripe (Aminah and Muharam 2009).

Seed germination and M. gigantea *seedlings below their parent trees*

Observations on the germination of seeds fallen under the tree crowns were conducted in 4 sample plots of 1 x 1 m^2 in the four cardinal directions of every *M. gigantea* parent tree. The time when the seeds initiated germination was recorded and the number of seedlings in every plot was calculated.

Fruits and seeds of M. gigantea

M. gigantea fruits were collected in bulk (mixed from the different trees) in December-January 2012. The fruits were picked using a hooked pole and a large plastic sheet was extended under the tree to place the fallen fruits. The fruit samples weighing a total of 3 kg (1 kg from each tree were peeled and the seed yields for every kilogram of fruits were weighed. One hundred fruits and seeds of *M. gigantea* were randomly chosen and every fruit/seed was weighed and then their diameters and lengths were measured to find the average weight and the size of the fruits and seeds (Suita and Nurhasybi 2009).

Seed extraction process

Seed extraction is to remove the seed from other parts of the fruit (peel, flesh, wings, and stalk). Dry extraction was done by drying the fruits in an open place for 3-4 days until the fruits were broken and the seeds were easily removed from the fruit. Sieving was done to separate the seeds from the fruit rinds (Kumara et al. 2000; Schmidt 2007; Suita and Nurhasybi 2009). Wet extraction was done by brooding the fruits into a gunny sack for a week (the fruits in the sack were watered every day to make them moist) until the outer skin of the fruit became soft. Then they were dried in the wind until the fruit peels were broken and the seeds were easily removed from the fruits. Sieving was done to separate the seeds from the fruit skin.

Seed selection

Seed selection was carried out to choose large and heavy seeds by soaking them in the water. The floating and the sinking seeds were separated. The seeds that sank in the water were collected and put into a laboratory test sieve (number 8; the size of the hole was 2.36 mm) and they were rubbed by hand. The seeds with the diameter of less than 2.36 mm would pass through the sieve, while the seeds of larger sizes would remain in the sieve and were used as the materials to investigate germination.

Seed germination after harvesting

This research applied a randomized design with two treatments as follows: (i) the different techniques of fruit extraction: wet versus dry extractions, (ii) different germination media: sands, topsoil, compost, and mushroom prawn waste. Twenty seeds was sown evenly on each the germination media. This was repeated three times and each round was observed for 60 days. The observed parameters include the percentage of the germination (G), the germination rate (GR), mean germination time (MGT), the germinating time of the first seed (GTFS) and the germinating time of the last seed (GTLS) were calculated according to the following formulas (based on Fariman et al. 2011; Mendes-Rodrigues et al. 2011):

$$G\ (\%) = \frac{\text{Number of germination seed}}{\text{Number of viable seeds initiated}} \times 100\%$$

$$GR = \sum_{n=1}^{n} (\text{Number germination since} - 1)/n$$

Where, N is the days

$$MGT = \frac{\sum Ti\ Ni}{S}$$

Where Ti is number of days after beginning of experiment, Ni the number of seeds germinated on day i, and S the total number of seeds germinated.

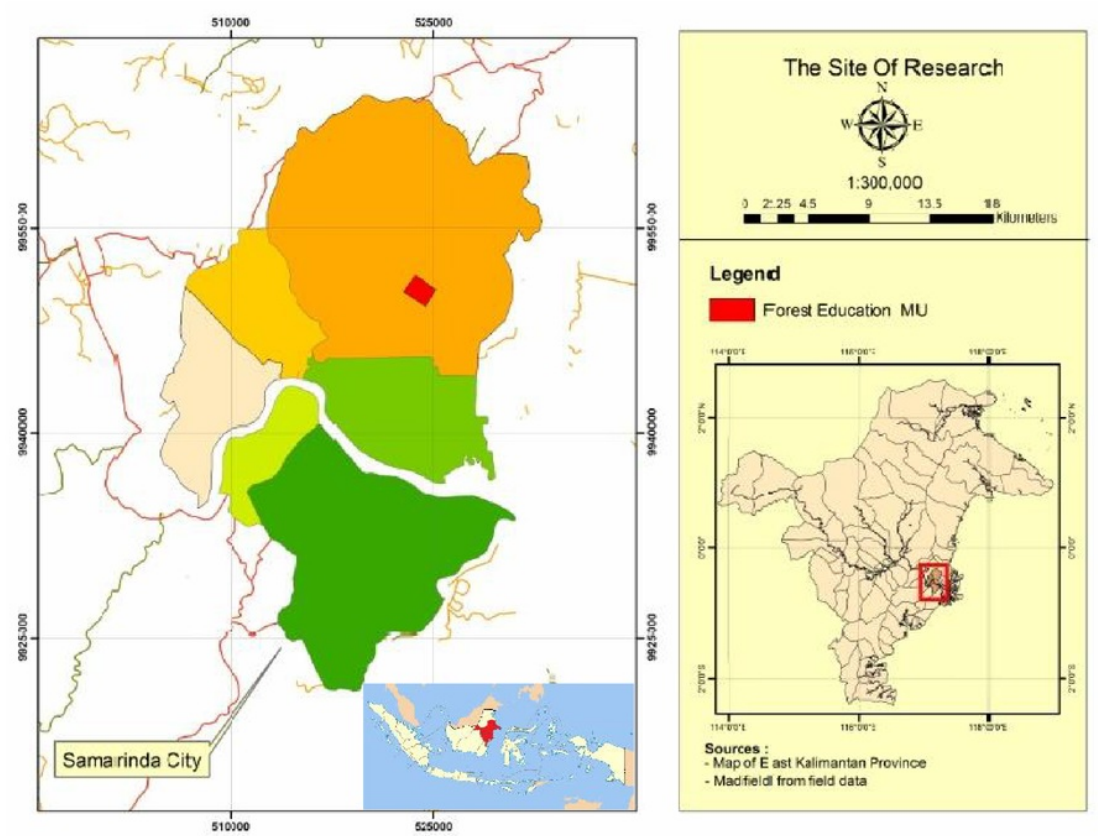

Figure 1. Map of study area in the Forest Education of Faculty of Forestry, Mulawarman University, East Kalimantan, Indonesia (inside Bukit Suharto Grand Forest Park, East Kalimantan)

The growth of M. gigantea *seedlings*

The seeds that germinated in the laboratory were put into polybags with a height of 30 cm and diameter of 15 cm. Each polybag was filled with different planting media: sands, topsoil, compost, and mushroom prawn waste media. The seedlings were kept in the green house and protected using a 50% shading net or paranet for a month. The height, number of leaves, wet mass, dry mass and the relative growth rate (RGR) were measured at the end of the experiment.

$$RGR = \frac{(\ln W2 - \ln W1)}{(T2 - T1)}$$

Where, W_1 and W_2 are plant dry weights at times t_1 and t_2.

Data analysis

The data obtained from the field observations were analyzed descriptively and correlation between diameters at breast height parent trees (X) with numbers of seedling in under the tree crowns (Y) was measured by simple linear correlation. The germination and seeding growth data from the laboratory experiments were analyzed using analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at 95% level of significance.

RESULTS AND DISCUSSION

Developmental stages of *M. gigantea* flowers and fruits

The time from the initial flower buds to the ripe fruits took 5-6 months. The flower buds were initiated in August 2011 when the rainfall was in its lowest level of 106.1 mm (i.e., during the dry season). The outer floral envelopes of the flowers and the male flowers fell in September 2011; the young fruits developed from October to November 2011; and the fruits started to ripen in December 2011 when the rainfall was high 247.2 mm and this occurred until January 2012 when rainfall was highest 327.1 mm; during the rainy season (Figure 2). The flower and fruit developmental stage of *M. gigantea* is presented in Figure 3, while morphology of ripe fruit and seed is presented in Figure 4.

The seed germination and seedlings under the trees of *M. gigantea*

Ripe fruit was noticed on November 25th 2011. Seed on the ground under the *M. gigantea* trees were observed on January 8th 2012 (Table 1). Eventually, the average number of *M. gigantea* seedlings (with 2-4 leaves) found below their parent trees was 75-267 seedlings per meter per m^{-1} (Tables 4) and this was highly correlated with the diameter of their parent stems (r=0.823). *M. gigantea* fruits and seeds were small with an average diameter of 0.784 cm and 0.415 respectively. One kilogram of fresh fruits (without stalks) yielded 86.15 gram of seeds and to obtain 1 kg of seeds required 11.61 kg of fruits (Tables 5).

Seed germination of *M. gigantea* from the ripe fruit harvesting

The techniques of seed extraction, the types of planting media and interaction between the techniques of seed extraction and the types of planting media had statistically significant effects (p-value≤0.005) on the percentage of seed germination. The percentage of germination of seeds extracted through the wet extraction process was higher than those extracted through the dry extraction process. The highest percentage of germination 65% was in the combination wet extraction and a compost medium, respectively (Figure 5). The germination rate (GR), mean germination time (MGT), the germination time of the first

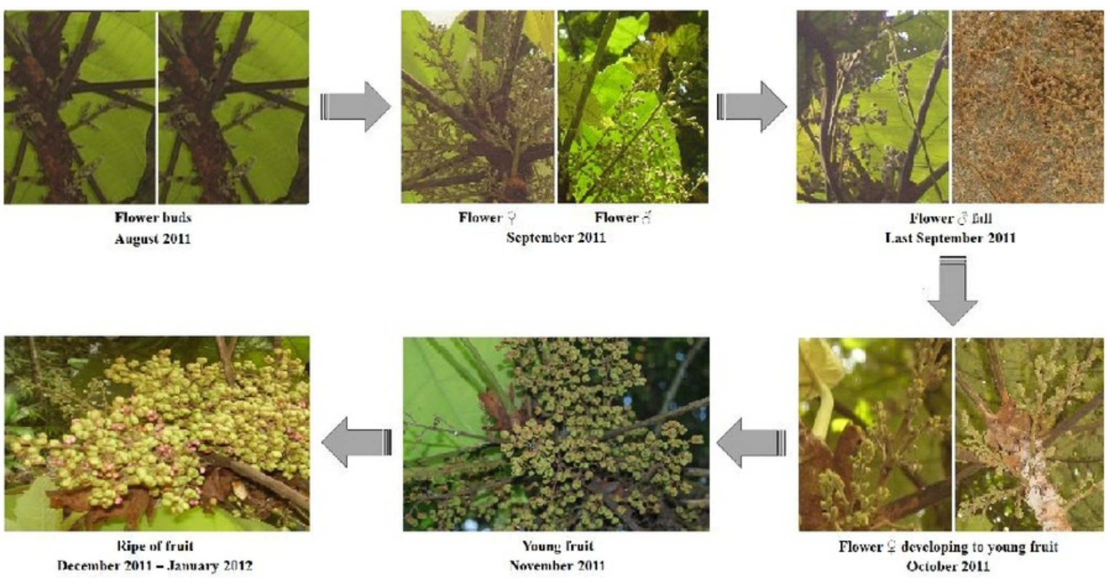

Figure 3. Developmental stages of *Macaranga gigantea* flowers and fruits

Figure 4. Morphology of fruits and seeds *Macaranga gigantea*: A. Ripe fruit, B. Seeds

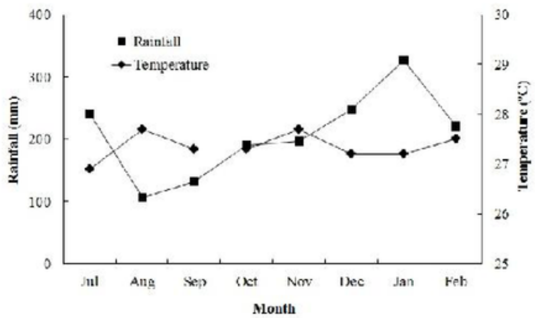

Figure 2. Mean temperature and rainfall in study region

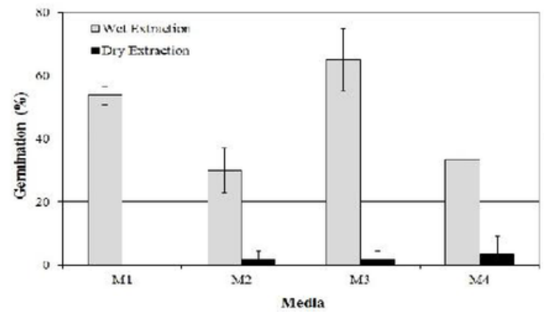

Figure 5. Effects of seed extraction method and media on seed germination (%) M1, sand media; M2, top soil media; M3, compost media; and M4, mushroom prawn waste media

Table 1. Time after fruits were fully ripe, seed germination and seedling growth under the mother trees

Germination stages	Date of obsevation								
	25-11-2011	5-12-2011	12-12-2011	19-12-2011	24-12-2011	02-01-2012	08-01-2012	15-01-2012	22-01-2012
Ripe fruit									
Seed germination									
Seedling (2-4 leaves)									

Table 2. Influence of seed extraction and germination media on mean seed germination measurement (±SD)

Measurement	Treatments							
	WM1	WM2	WM3	WM4	DM1	DM2	DM3	DM4
GR (days)	0.89 ± 0.18	0.77 ± 0.31	1.22 ± 0.27	0.67 ± 0.13	0.00 ± 0.00	0.07 ± 0.00	0.07 ± 0.00	0.11 ± 0.00
MGT (days)	13.67 ± 1.15	11.67 ± 1.10	11.97 ± 1.93	12.37 ± 1.52	15.00 ± 0.00	15.00 ± 0.00	15.00 ± 0.00	20.00 ± 0.00
GTFS (days)	7.67 ± 4.16	8.33 ± 1.15	7.67 ± 1.15	7.67 ± 2.31	0.00 ± 0.00	15 ± 0.00	15.00 ± 0.00	16.00 ± 0.00
GTLS (days)	19.00 ± 2.00	17.00 ± 2.65	17.33 ± 4.04	16.67 ± 1.53	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	20.00 ± 0.00

Note: WM1, wet extractions + sand media; WM2, wet extractions + top soil media; WM3, wet extractions + compost media; and WM4, wet extractions + mushroom prawn waste media. DM1, dry extractions + sand media; DM2, dry extractions + top soil media; DM3, dry extractions + compost media; and DM4, dry extractions + mushroom prawn waste media. GR, germination rate; MGT (days), mean germination time; GTFS (days), germination time of the first seed; GTLS (days), germination time of the last seed.

Table 3. Influence of seed extraction and media on seedling growth after 1 month (mean±SD)

Treatment	Parameters				
	Heigh (cm)	Leaves	Fresh wight (g)	Dry weight (g)	RGR (%)
M1	20.83±1.89	5.00±1.00	0.40±0.13	0.08±0.03	0.10±0.07
M2	18.66±2.95	6.33±0.58	0.64±0.06	0.12±0.012	0.10±0.04
M3	22.20±2.89	6.33±1.16	0.71±0.17	0.12±0.012	0.15±0.09
M4	23.35±3.08	6.67±1.53	0.86±0.38	0.16±0.05	0.36±0.42

Note: M1 = sand media; M2 = top soil media; M3 = compost media; and M4 = mushroom prawn waste media; RGR = Relative growth rate

Table 4. Mean seedling measurement (±SD) under mother trees

DBH	∑ Number seedling (per 1 m^2)				
Mother trees (cm)	I	II	III	IV	Mean ± SD
20.05	108	115	116	110	112.25 ± 3.86
49.34	258	272	264	275	267.25 ± 7.72
28.65	78	74	77	72	75.25 ± 2.76
25.15	139	123	126	128	129.0 ± 6.98
26.42	107	99	117	115	109.5 ± 8.23

Table 5. Mean fruit and seed measurements and seed yields (±SD)

Measurement	Fruit	Seed	Ratio seed/ fruit (g/kg)
Long (cm)	0.54 ± 0.06	0.31 ± 0.03	86.15 ± 13.11
Diameter (cm)	0.78 ± 0.10	0.42 ± 0.05	
Weight (g)	0.21 ± 0.05	0.02 ± 0.00	

Note: DBH, diameter at breast height; I, II, III, IV, plot replicates seed (GTFS), and the germination time of the last seed (GTLS) of the seeds extracted through the wet extraction process were faster than those extracted through the dry extraction process (Table 2).

The growth of *M. gigantea* seedlings

Planting media had statistically significant effects (p-value≤0.005) on the growth of *M. gigantea* seedlings. The highest relative growth rate (RGR) of *M. gigantea* seedlings was found in the mushroom spawn waste media at the end of one month with a average height of 23.35±3.08 cm, 6.67±1.53 leaves, a wet mass of 0.86±0.38 kg, dry mass of 0.16±0.05 kg, and a relative growth rate of 0.36±0.42%, followed by the other planting media, such as compost, topsoil, and sands respectively (Table 3).

Discussion

The flower buds developed in August 2011 when rainfall reached the lowest point during the dry season at the research location. When rainfall was low, light intensity was higher. Davies and Aston (1999) previously reported that the episode of *Macaranga* reproduction in 1992 occurred during a great dry season at Lambir Hills National Park, Sarawak, Malaysia. Some reproductive trees require more intense light, lower fecundity in lower light levels, and lower growth rates than non reproductive trees, reflecting resource-limited reproduction. Fleming et al. (1985) and Bentos et al. (2008) also reported that the flowering of pioneer trees occurred at the end of the dry season and fruiting occurred at the beginning of the wet season. In addition, the phenology of most tropical plants depends mostly on rainfall (Stevenson et al. 2008).

This research revealed that the fruits were mature in December 2011-January 2012 when the intensity of rainfall reached the highest level during the wet season. On the other hand, Suita and Nurhasybi (2009) reported that the fruits of *M. gigantea* were ripe in February-April 2008 in Samboja, East Kalimantan. This difference was caused by some factors including the unpredictable change of climate between the wet season and the dry season in the research location at Samboja. In fact, the time for *Macaranga* to flower and to bear fruits is determined by the local climate conditions. Birds are the main seed dispersers of pioneer trees in tropical Asia, including a considerable number of important pioneer trees that belong to *Macaranga* genus (Corlett and Hau 2000).

Macaranga gigantea seeds that fall below the crown would germinate in less than 24 days provided that the fruits are ripe and fall into canopy gaps, such as those alongside of forest paths. At the time when the fruits were fully mature (January), rainfall at the research location was at its highest level (annual peak), causing the forest floor to be wet and humid. Kiyono and Hastaniah (1997) had reported the seeds of *M. triloba* and *M. gigantean*, sown on wet argillaceous sandy soil and exposed to sunlight 5 hours a day, germinated in 21 days after sowing. If the seeds were planted 8 cm under the soil surface and watered, the seeds germinated 59 days after they were sown. Previous research conducted by Daws et al. (2008) in Panama similarly found that the small seeds from pioneer trees germinated only in humid microsites such as in small canopy gaps with decreased risks of death due to drought. A study conducted by Raich and Khoon (1990) in Pulau Penang, Malaysia showed that the seeds of pioneer trees (including *M. gigantea*) that were moved from the forest shade to canopy openings or to logged-over forest clearing would germinate because of the increase in light irradiation, and soil and air temperature. The photoblastic response of some types of tropical rain forest seeds seems to be adaptations to the change of light quality that occurs as a result of canopy loss (Vazquez-Yanes and Orozco-Segovia 1990). However, higher proportions of germination were found under bright conditions in tree canopy gaps and there was no correlation between the percentage of germination and temperature change (Valio and Scarpa 2001).

Macaranga gigantea seeds can be categorized as small seeds with an average weight of 0.018 grams. The previous study by Pearson et al. (2002) in Panama showed that small seeds (<2 mg) have higher germination percentage to light than under dark condition. Small seeds from tropical pioneer trees will germinate in canopy gaps if the seeds land on microsites that are suitable for seedlings to grow. Phytochrome B controls the germination of seeds in small canopy gaps (Sugahara and Takaki 2004). A study conducted by Van Ulft (2004) in Guyana showed that gap size increased the success of germination of small seeds and dramatically decreased the success of germination of large seeds. In addition, Aud and Ferraz (2012) found that a decrease in seed size was followed by a decrease in light requirement and tolerance to temperature change. Garcia et al. (2005) stated that light is essential for germination under all temperature regimes. According Vazquez-Yanes and Orozco-Segovia (1992) the germination of seeds of all species is either partially or totally hampered if the seeds are covered with leaf litter and if the growth of seedlings is constrained by the litter on the soil surface.

Understanding the ecology of germination and the growth of seedlings is important not only for the knowledge about plant community processes and succession that it provides but also developmental strategies for the conservation of biodiversity and restoration tropical rain forests (Khurana and Singh 2001). The understanding of the germination of *M. gigantea* in nature can be applied for the purposes of cultivation and industrial forest plantations.

Wet seed extraction brought about higher percentages and rates of germination compared with dry seed extraction. Natural seed germination suggested that the fruits of *M. gigantea* are fully ripe during the rainy season so that seeds that fall on the humid forest floor will germinate immediately. Germination peak in the wet season when the soil fertility is high (Marques and Oliveira 2008). Dry seed extraction might decrease the seed water content and kill the embryo. Our finding are in line with the previous report by Suita and Nurhasybi (2009) where, the germination proportion of *M. gigantea* seeds from dry extraction was 2-10%. In addition, germination proportion increased up to 20% when the seed was soaked into 0.2% potassium nitrate solution for 20 minutes and then sown on sand media (Mindawati et al. 2010). Furthermore, Sao (2004) also reported that initial treatment by soaking the seeds in 10 mg/l of GA_3 hormone solution produced the best seed germination rates of *M. gigantea* up to 65%.

In research, wet seed extraction was found to be able to increase the germination proportion of *M. gigantea* seeds up to 65%, similar to an initial treatment by soaking the seeds in 10 mg/l of GA_3 hormone solution. However, the cost required for wet extraction method was cheaper than soaking in hormone solution.

The highest growth rate of *M. gigantea* seedlings was found in mushroom prawn waste planting media and in compost media. This may be because compost is derived from the decomposition of organic materials, contains a lot of nutrients, and is fairly loose. According to Bramasto (2008), a loose, porous medium is easily penetrated by roots growing from the seed and this kind of media has enough pores for water and air. A medium which is too dense will make it too difficult for roots to penetrate and cause water stagnation so that the conditions become too humid and the seedlings become decayed. Moreover, seed mass has a correlation with the rate of growth. Small seeds have a relatively low rate of growth (Arunachalam et al. 2004).

In conclusion, the development of *M. gigantea* flowers and fruits took 5-6 months. The seeds that fell below the crowns would germinate in less than 24 days. The percentage and rate of germination of seeds extracted through the wet extraction process was higher than those extracted through the dry extraction process. The highest growth rate of *M. gigantea* seedlings was found in the mushroom prawn waste media, followed by compost, topsoil, and sand media.

ACKNOWLEDGEMENTS

The research supported by research stimulant fund through Kaltim-Cemerlang Program from East Kalimantan Government and we are grateful to our students Sri Mulyati, Mecka Lea Fasca, Winda Iswari, Maryanti and Heri Purnomo for help and contributions during field work.

REFERENCES

Aminah A, Muharam A. 2009. Flowers and fruit development stages Mindi (*Melia azedarach* L). Info Benih 13 (1): 7-13.

Amirta R. 2010. Potential utilization of tropical lignocellulosic biomass for biofuels-bioenergy production in East Kalimantan. JSPS Exchange Program for East Asian Young Researchers: "Fostering Program of Leading Young Scientists toward the Establishment of Humanosphere Science in East Asia", Shigaraki, Kyoto, Japan.

Anon. 2012. Meteorology, Climatology and Geophysics Station of Temindung Airport Samarinda, East Kalimantan. Indonesia.

Arunachalam A, Khan ML, Singh ND. 2003. Germination, growth and biomass accumulation as influenced by seed size in *Mesua ferrea* L. Turk J Bot 27: 343-348.

Aud FF, Ferraz IDK. 2012. Seed size influence on germination responses to light and temperature of seven pioneer tree species from the Central Amazon. Anais da Academia Brasileria de Ciencias. DOI: 10.1590/S0001-37652012000300018.

Bentos TV, Mesquita RCG, Williamson GB. 2008. Reproductive phenology of Central Amazon pioneer trees. J Trop Conserv Sci 1 (3): 186-203.

Bramasto Y. 2008. Techniques of forest plant seed treatment from harvesting fruits. Mitra Tanaman Hutan 3 (3): 131-140. [Indonesian]

Corlett RT, Hau BCH. 2000. Seed dispersal and forest restoration. In: Elliott S, Kerby J, Blakesley D, Hardwick K, Woods K, Anusamsuntom V (eds). Forest Restoration for Wildlife Conservation. International Tropical Timber Organization and The Forest Restoration Research, Chiang Mai University, Thailand.

Davies SJ, Ashton PS. 1999. Phenology and fecundity in 11 sympatric pioneer species of *Macaranga* (Euphorbiaceae) in Borneo. Amer J Bot 86 (12): 1786-1795.

Daws MI, Crabtree LM, Dalling JW, Mullins CE, Burslem DFRP. 2008. Germination responses to water potential in neotropical pioneer suggest large-seeded species take more risk. Ann Bot 102 (6): 945-951.

Eichhorn KAO. 2006. Plants diversity after rain-forest fires in Borneo. Blumea Suplement 18 Nationaal Herbarium Netherland, Universiteit Leiden branch, Leiden.

Fariman ZK, Azizi M, Noori S. 2011. Seed germination and dormancy breaking techniques for *Echinnacea purpurea* L. J Biol Environ Sci 5 (13): 7-10.

Fleming TH, Williams CF, Banaccorso FJ, Hernst LH. 1985. Phenology, seed dispersal, and colonization in *Muntingia calabora,* a neotropical pioneer tree. Amer J Bot 73 (3): 383-391.

Garcia X, Hong TD, Willis RH . 2005. Seed dormancy and germination of *Ficus lundellii* and tropical forest restoration. Tree Physiol 26: 81-85.

Khurana E, Singh JS. 2001. Ecology of tree seed an seedling: implications for tropical forest conservation and restoration. Curr Sci 6: 748-757.

Kiyono Y, Hastaniah. 1997. Slash and burn agriculture and succeeding vegetation in East Kalimantan. Appendix 1. PUSREHUT (The Tropical Rain Forest Research Center). Samarinda, Indonesia. Special Publication 6 : 125-129

Kumara AKKIU, Wickramasinghe U, Seneviratne R. 2000. Studies on dormancy and germination dynamics of *Macaranga peltalta* (Kanda), an early successional species. Proceeding of the Sixth Annual Forestry and Environment Symposium of the Department of Forestry and Environment, University of Sri Jayewardenepura, Peradeniya, 29-30 Desember 2000.

Lawrence D. 2001. Nitrogen and phosphorus enhances growth and luxury consumption of four secondary forest tree species in Borneo. Journal of Tropical Ecology 17: 859-869.

Lawrence D. 2005. Biomass accumulation after 10-200 years of shifting cultivation in Bornean rain forest. Ecology 86: 26-33.

Marques MCM, Oliveira PEAM. 2008. Seasonal rhythms of seed rain and seedling emergence in two tropical rain forest in Southern Brazil. Plant Biology 10: 596-603.

Mendes-Rodrigues C, Oliveira PE, Ranal MA. 2011. Seed germination and seedling growth of two *Pseudobombax* species (Malvaceae) with Contrasting Habitats from Brazilian Cerrado. Rev Biol Trop 59 (4): 1915-1925.

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.

Pearson TRH, Burslem DFRP, Mullins CE, Dalling JW. 2002. Germination ecology of neotropical pioneer : interacting effects of environmental conditions and seed size. Ecology 83 (10): 2798-2807.

Raich JW, Khoon GW. 1990. Effects of canopy openings on tree seed germination in a Malaysian dipterocarp forest. J Trop Ecol 6: 203-217.

Sao C. 2004. Germination and storage of *Dyera costulata* Hook. F. and *Macaranga gigantea* Mull.Agr seeds. [M.Sc.-Thesis]. Universiti Putra Malaysia, Selangor. [Malaysian].

Schmidt L. 2007. Tropical Forest Seed. Springer-Verlag, Berlin.

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: 579-588.

Slik FJW, Keßler PJA, Van Welzen C. 2003. *Macaranga* and *Mallotus* species (Euphorbiaceae) as indicators for disturbance in the mixed lowland dipterocarp forest of East Kalimantan (Indonesia). Ecol Indicat 2 (4): 311-324.

Stevenson PR, Castellanos ML, Cortes AI, Link A. 2008. Flowering patterns in seasonal tropical lowland forest in Western Amazonia. Biotropica 40: 559-567.
Sugahara VY, Takaki M. 2004. Effect of light and temperature on seed germination in Guajava (*Psidium guajava* L.-Myrtaceae). Seed Sci Technol 32: 759-764.
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]
Valio IFM, Scarpa FM. 2001. Germination of seeds of tropical pioneer under controlled and natural conditions. Rev Bras Bot 24 (1): 79-84.
Van Ulft LH. 2004. Effect of seed mass and gap size on seed fate of tropical rain forest tree species in Guyana. Plant Biol 6 (2): 214-221.
Vazquez-Yanes C, Orozco-Segovia A. 1990. Ecological significance of light controlled seed germination in two contrasting tropical habitats. Oecologia 83: 171-175.
Vazquez-Yanes C, Orozco-Segovia A. 1992. Effects of litter from a tropical rainforest on tree seed germination and establishment under controlled conditions. Tree Physiol 11: 391-400.

Artikel 3.pdf

ORIGINALITY REPORT

0%	2%	0%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

Exclude quotes	Off	Exclude matches	< 2%
Exclude bibliography	On		