GROWTH PERFORMANCE OF THREE NATIVE TREE SPECIES FOR PULPWOOD PLANTATION IN DRAINED PEATLAND OF PELALAWAN DISTRICT, RIAU

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GROWTH PERFORMANCE OF THREE NATIVE TREE SPECIES FOR PULPWOOD PLANTATION IN DRAINED PEATLAND OF PELALAWAN DISTRICT, RIAU. The productivity of exotic species developed in pulpwood plantations in Indonesia (HTI-pulp) has been continuously decreasing. On the other side, there is a possibility to develop several promising native tree species in peatland HTI-pulp plantations. However, less information is available on the performance of those native tree species for planting in peatland pulpwood plantation. This study evaluates the performances (survival rate, growth and yield) of three native trees [mahang (*Macaranga pruinosa)*, skubung (*Macaranga gigantea*) and geronggang (*Cratoxylum arborescens*)] in drained peatland, in terms of suitability for pulpwood plantation. An experiment plot was established by planting three native tree species and krasikarpa (*Acacia crassicarpa*) in drained peatland at Pelalawan District, Riau. Survival, growth and yield variables were monitored frequently until 5.5 years after planting (YAP) and then were analyzed. Geronggang (survival rate = 80.0%) and mahang (survival rate = 65.6%) showed good survival rates at 5.5 YAP which were significantly ($p<0.05$) higher than that of krassikarpa (22.4%). Geronggang and mahang are relatively promising growth and yield in which height, diameter and yield increment until 5.5 YAP were 1.96 m/year and 2.31 m/year; 2.08 cm/year and 2.59 cm/year; 13.1 m^3/ha/year and 21.4 m^3/ha/year, respectively. Yet, those growths and yields were still significantly ($p<0.05$) lower than those of krasikarpa, probably due to unequal seedling quality. These results indicated the potential of mahang and geronggang to be developed in peatland pulpwood plantations. However, tree improvement program is necessarily required for mahang and geronggang to initiate the development.

Keywords: Native tree species, pulpwood plantation, drained peatland, seedling quality

*PERTUMBUHAN TIGA JENIS POHON LOKAL UNTUK DIKEMBANGKAN PADA HTI-PULP LAHAN GAMBUT YANG DIKERINGKAN DI PELALAWAN, RIAU. Produktivitas jenis pohon eksotik yang dikembangkan di HTI-pulp di Indoneisa terus menurun. Sementara itu, beberapa jenis pohon lokal mempunyai potensi untuk dikembangkan sebagai tanaman HTI-pulp. Akan tetapi, informasi mengenai performa jenis pohon lokal tersebut belum tersedia dengan memadai jika secara khsusus akan dikembangkan di HTI-pulp. Penelitian ini dilakukan untuk mengevaluasi performa (kemampuan hidup, pertumbuhan dan hasil) tiga jenis pohon lokal lahan gambut [mahang (*Macaranga pruinosa*), skubung (*Macaranga gigantea*) dan geronggang (*Cratoxylum arborescens*)] yang berpotensi untuk dikembangkan di HTI-Pulp. Sebuah plot penelitian dibangun di lahan gambut yang dikeringkan di Pelalawan, Riau; dengan menanam ketiga pohon lokal tersebut dan ditambah jenis eksotik krasikarpa. Pengamatan dan analisis data dilakukan terhadap variabel kemampuan hidup, pertumbuhan, dan hasil dalam kaitannya untuk bahan baku pulp. Hasil penelitian menunjukkan bahwa geronggang (persen hidup 80%) dan mahang (persen hidup 65,6%) memiliki kemampuan hidup yang baik sampai pada umur 5,5 tahun dan secara nyata ($p<0,05$) lebih baik dibandingkan krasikarpa (persen hidup 22,4%). Pertumbuhan dan hasil kedua jenis ini pun sampai pada umur yang sama relatif baik, dengan riap tinggi 1,96 dan 2,31 m/tahun, diameter 2,08 dan 2,59 cm/tahun dan hasil 13,1 dan 21,4 m^3/ha/tahun. Akan tetapi, pertumbuhan dan hasil tersebut secara signifikan ($p<0,05$) masih lebih rendah dibandingkan pada krasikarpa, diduga karena adanya perbedaan kualitas bibit. Hal ini mengindikasikan bahwa mahang dan geronggang merupakan kandidat kuat untuk dikembangkan pada HTI-pulp di lahan gambut. Namun, untuk sampai pada tahap pengembangan, program pemuliaan terhadap kedua jenis pohon lokal tersebut harus dilakukan.*

Kata kunci: Jenis pohon lokal, bahan baku pulp, lahan gambut didrainase, kualitas bibit

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I. INTRODUCTION

Indonesia has large areas of industrial plantation forests (HTI) which have been dominated by pulpwood plantations (HTI-pulp). Until 2015, the total area of HTI was around 2.1 million ha and about 1.8 million ha (88%) was HTI-pulp (Ministry of Environment and Forestry, 2016). This HTI-pulp is the main supplier of the wood to pulp and paper industries, whereas Indonesia is one of the largest producer of pulp and paper in the world. The Ministry of Industry (2016) reported that the production of pulp and paper in Indonesia until 2013 was 4.55 million ton (number 9^{th} in the world) and 7.98 million ton (number 6^{th} of the world), respectively.

The Government of Indonesia has made various efforts to increase the production of pulp and paper. However, these efforts have been facing the declining trend in the productivity of HTI-pulp including ones that were established in peatland of Riau. It gets serious concern because Riau is one province in Indonesia with the largest area of HTI-pulp, i.e. approximately 800 thousand ha and over 50% of it is in peatland (Ministry of Environment and Forestry, 2016).

Krasikarpa (*Acacia crassicarpa*), one of an exotic tree, is the only species of acacia that grows well in peatland it had been developed in the peatland HTI-pulp over the years. However, the performance of this exotic species in HTI-pulp shows a declining trend as plant rotation is progressing. The survival rate and yield of krasikarpa in the second and upward rotations were relatively low i.e. below 30% and 140 m^3/ha at 5 years (Nurcan, Refdanil, Sribudiani, & Sudarmalik, 2014; Suhartati, Rahmayanto, & Daeng, 2014).

Diseases were suggested as one of the main causal factor in the declining performance of krasikarpa. The root disease by *Ganoderma* spp. and wilting caused by *Ceratocystis* spp. were suspected as the main diseases in krasikarpa (Rimbawanto, 2014; Tarigan, Roux, Wyk, Tjahjono & Wingfield, 2011). The efforts to overcome this decline in productivity of the exotic species showed no promising results; therefore it is required to explore other tree species to be developed in peatland HTI-pulp. Then, it is reasonable peatland to explore native tree species. These native trees must be already well adapted with the peatland conditions and surely could grow, The exotic species in several cases were even better than exotic species (Bare & Ashton, 2015; Farias et al., 2016; Nath, Schroth, & Burslem, 2016; Onefeli & Adesoye, 2014).

Yet, other studies showed opposite results and it was noted that tree performance of native species is than that of exotic species (Kawaletz et al., 2013; May, 2016; Junaedi, 2018). Nevertheless, there is little information on survival rate and growth of native tree species in regard to specific purpose for pulpwood plantation. Most studies on native tree species growth performance in peatland had focused on broader purposes, such as for reforestation, restoration or rehabilitation (Astiani, Burhanuddin, Curran, Mujiman, & Salim, 2017; Banjarbaru Research Institute, & Graham, 2014; Lampela, Jauhiainen, Sarkkola, & Vasander, 2017; Rotinsulu, Indrayanti, & Sampang, 2016; Tata & Pradjadinata, 2016). Therefore, it is necessary to study the survival rate and growth characteristics of some native species of peatland that will be promoted for pulpwood plantation.

This paper evaluates the performance (survival rate, growth and yield) of three native tree species namely mahang (*Macaranga pruinosa*), skubung (*Macaranga gigantea*) and geronggang (*Cratoxylum arborescens*), which will be promoted for pulpwood plantation in peatland. All of the three species have been naturally found in peat forest and also peatland around Riau area (Blackham, Webb, & Corlett, 2014; Lim, Lim, & Yule, 2014; Nurulita, Adetutu, Gunawan, Zul, & Ball, 2016; Suhartati, Rahmayanti, Junaedi, & Nurrohman, 2012). Those tree species were selected as they are pioneer species which are fast growing; and moreover, its fiber is good in relatively quality as pulp raw material (Aprianis, 2016). Krasikarpa as the exotic species has been included in the study for comparation.

II. MATERIAL AND METHOD

A. Site Description

The study was conducted in the Community Forest Lubuk Ogong Village, Pelalawan District, Riau Province (101°41'06"–101°41'10" E, 0°19'42"–0°19'48" N and 12 m asl), about 26 km from Pekanbaru, the capital of Riau Province. The soil type was is peat (histosol) with maturity dominated by fibric–hemic. Peatland in the location was drained to a water table level that was about 20–135 cm below surface depending on the season (rainy or dry) (Husnain et al., 2014). The climate was type A with a daily temperature range of 21°–32°C and annual precipitation of 2,500–3,000 mm (Husnain et al., 2017).

B. Plot Establishment

Three native tree species of peatland were selected for the experiment: mahang (*Macaranga pruinosa*), skubung (*Macaranga gigantea*) and geronggang (*Cratoxylum arborescens*). One exotic species krasikarpa (*Acacia crassicarpa*) was also included in this study. Seedlings of the selected native tree species were obtained from wildlings because there was still lack of technique on generative propagation of these species. Mahang wildlings were obtained from secondary peat forest in Siak District, Riau. Geronggang wildlings were obtained from secondary peat forest in Bengkalis District, Riau. However, skubung wildlings were obtained from community land, especially around rubber plantation because they could not be gathered from the peat forest. In contrast, seedlings of krasikarpa originated from the tree improvement program of PT. RAPP nursery (Papua New Guinea Provenance). All planting materials (wildling and seedling) were prepared in 2010.

A randomized block design was used as experimental plot design in approximately 1 ha of area. There were 5 blocks as replications and each block was divided into 4 rectangular sub-blocks to provide 4 tree species: 3 native that were mahang, skubung, geronggang and one exotic that was krasikarpa. Following the randomized block design, the four selected species were then planted onto each designed sub-block. Each sub-block consist of 7 rows x 7 columns thus each sub-block has 49 trees of one selected species. Therefore there were 245 seedlings of each species or totally 980 seedlings for all selected species.

Land preparation was conducted with machinery, subsequently similar silviculture treatments that is commonly used in PT. Riau Andalan Pulp and Paper (RAPP) were applied to all tree species, except for weed control. These treatments were: plant spacing of 2 x 3 m; fertilizing during planting and consisting of rock phosphate/$Ca_3(PO_4)_2CaF$ (250g/seedling), KCl (50 g/seedling), ertibor/ $Na_2B4O_7 \cdot 5H_2O$ (10 g/seedling) and zincop/ $ZnSO_4.H_2O$ & $CuSO_4.7H_2$ (10g/seedling); pruning was done six months after planting; monthly tree blanking until 1 year; while weed control (manual removal) was carried out three monthly until 2 years for native species and until 1 year for krasikarpa. Land preparation and subsequent plantation were conducted until the end of 2011 (October–November 2011).

C. Measurements

Variables that express the survival rate and growth performance were measured in this study. The number of alive individuals (n), height (Ht), base diameter (Db), diameter at breast height (DBH) and crown diameter (Crw). The n, Ht, Db and DBH were measured six monthly during 1–3.5 years after planting and then annually until 5.5 years after planting. The Ht was measured using measuring stick, while Db, DBH and Crw were measured by measuring tape.

The value of form factor (*f*) is required to quantify the wood volume (yield) of each species. In order to obtain the *f* value, tree diameter at 10 cm height from the soil surface up to the height where the diameter was 5 cm was measured in one meter intervals, in terms of pulpwood. This measurement was conducted on selected trees at 4.5 and 5.5 years after planting. The number of trees measured for each species at 4.5 years after planting were mahang (29 trees), skubung (29 trees), geronggang (29 trees) and krasikarpa (5 trees); while at 5.5 years after planting 3 trees for all native species and 1 tree for krasikarpa. These diameter sections data were used to quantify the actual yield (wood volume) for pulpwood for each species.

D. Data Analysis

The data on alive individual tree of each species were used to quantify the survival rate (Sv) of each species as a percentage of trees that were planted. Basal area and crown diameter were calculated based on Aisah, Yusop, Noguchi, and Rahman, (2012) as follows:

Basal area (m^2/ha) = $\pi .(DBH/2)^2$..................(1)

Crown area (m^2) = $\pi. (Crw/2)^2$..........................(2)

where: π = 3.146; *DBH* = diameter at breast height (m) and *Crw* = Crown diameter (m)

The yield or wood volume of each species for pulp raw material were calculated using the formula as mentioned by Masota, Malyango, Zahabu, Malimbwi & Eid, (2014):

Volume per tree (Vi, m^3/tree) = 0.25. $\pi.(DBH)^2.Ht.f$..(3)

where: π = 3.146; Ht = Total Height (m), f = form factor for pulpwood ($f = Va/Vs$, Va = actual yield for pulpwood that was calculated using Smalian Method, Vs = cylinder volume with surface area based on dbh and length based on *Ht*)

Volume per ha (V, m^3/ha) = $Vi. D_0 . Sv.$ ......(4)

where: D_0 = initial seedling density (n/ha) and Sv = Survival rate

One-way analyses of variance (ANOVA) were performed to test the difference among species in survival rate and growth. The Duncan test wasapplied to test those variables to determine the statistical difference of the mean of survival rate and growth. Prior these analyses data transformation was performed on several data that had not met ANOVA assumption (The normality and homogeneity of variance).

III. RESULT AND DISCUSSION

A. Survival Rate and Growth

The survival rate of tree species was significantly different ($p<0.05$). Overall, after 5.5 years planting, two native species (mahang and geronggang) showed noticeably high survival rates (Sv>60%) and were significantly ($p<0.05$) higher than the exotic tree (Sv of krasikarpa <30%). The survival rate of skubung was relatively similar ($p >0.05$) to that of krasikarpa (Figure 1).

The highest survival among native species until 5.5 YAP was presented by geronggang (Sv = 80.0 %), although it was not statistically different ($p>0.05$) from mahang (Sv = 65.6 %). Geronggang also showed a conspicuously stable survival rate, while the survival of mahang and skubung sharply declined 4.5 YAP. Earlier mortality and higher decline of survival was revealed in krasikarpa compared to those of the native species. Krasikarpa exhibited Sv >80% at 2 YAP, but subsequently continued to reduce and by the 3rd YAP, the survival declined to 22.4 %.

Overall, significantly different growth ($p<0.05$) was observed within the tested species. The growth of the exotic species krasikarpa was significantly ($p<0.05$) better than those of the native species and this trend continued to increase with increasing stand age. In general, the best growth performance among the native species was for mahang despite it was not significantly ($p>0.05$) different from geronggang (Figure 2).

The growth rate of krasikarpa was decreasing during 1.5–5.5 YAP that was shown by the decreasing height and DBH increment as the age was increasing (Figure 3). In contrast, the growth rates of the native tree species were relatively more stable. However, the growth rate

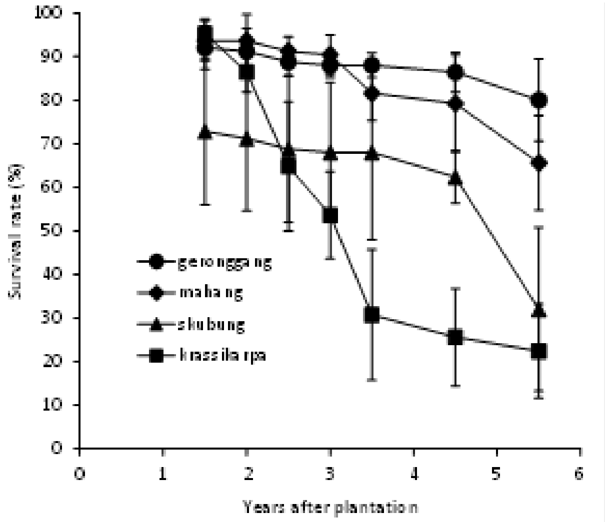

Figure 1. The survival rate of three native tree species and krasikarpa (exotic species) observed until 5.5 years after plantation (YAP) in drained peatland of Pelalawan, Riau (data = mean ± Sd, n = 5)

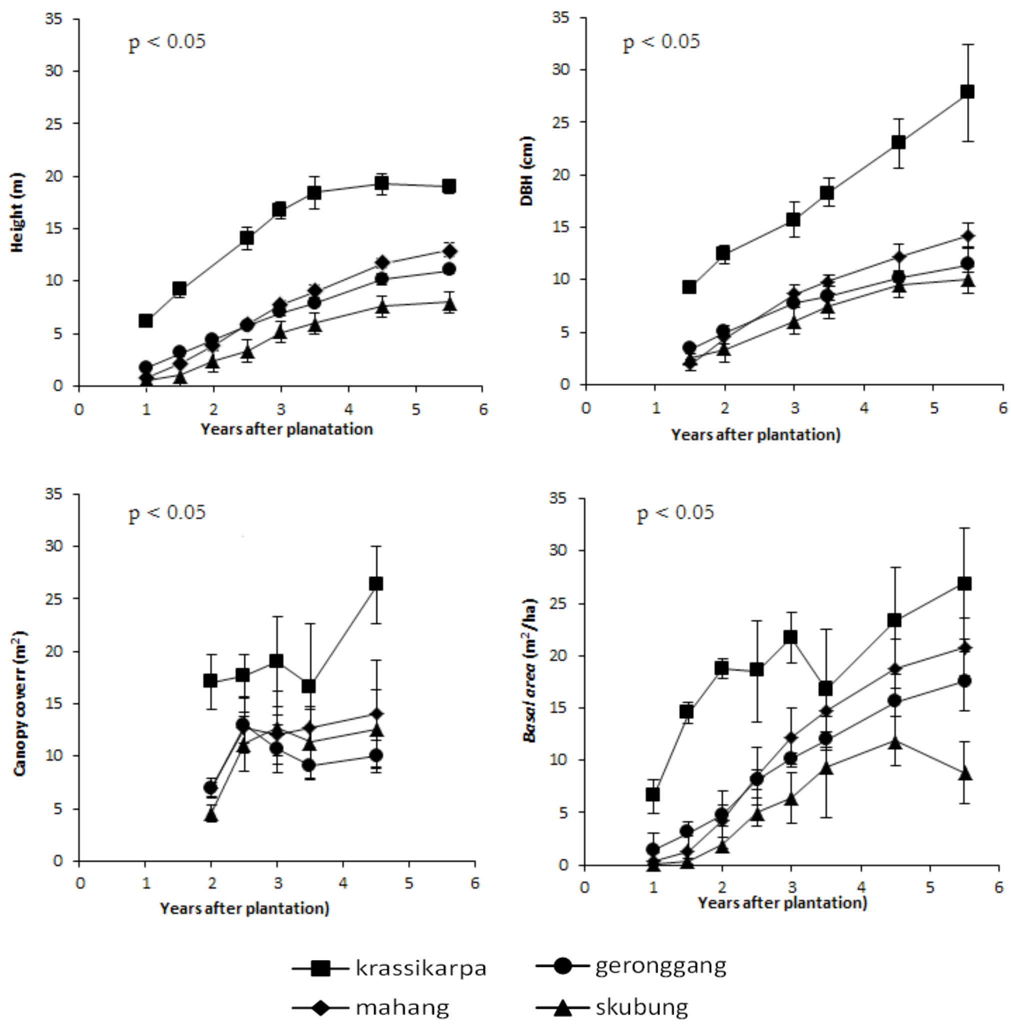

Figure 2. The growth of three native tree species and krasikarpa (exotic species) observed until 5.5 YAP in drained peatland of Pelalawan, Riau (data = mean ± Sd, n = 5)

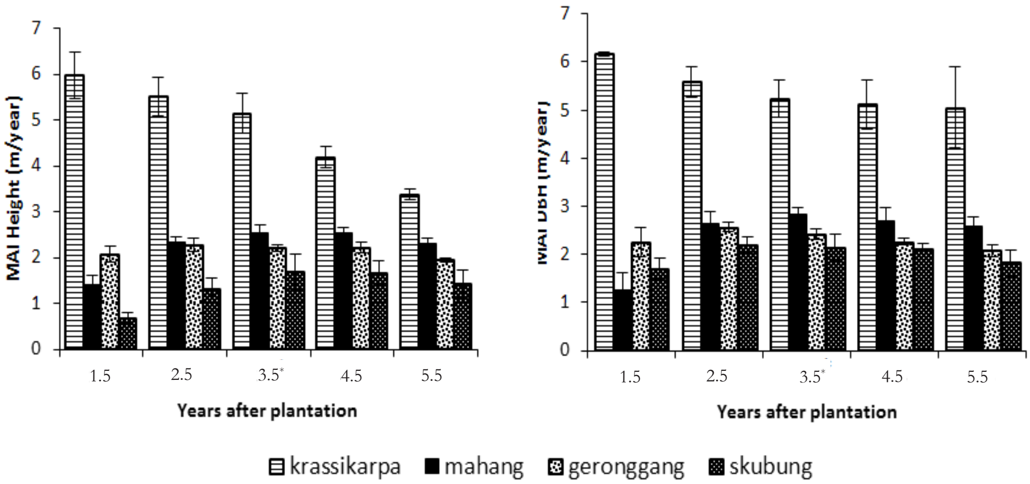

Figure 3. The growth increment of three native tree species and krassikarpa (exotic species) observed until 5.5 YAP in drained peatland of Pelalawan, Riau (data = mean ± Sd, n = 5).

*)=Source: Junaedi (2016)

of krasikarpa during the observation was still significantly ($p<0.05$) higher than all the three native species. The growth rate of height and DBH of krasikarpa at 5.5 YAP (Ht = 3.38 m/year and DBH = 5.05 cm/year) was 1.46 and 1.95 times faster than those of the best native species which was mahang (Ht = 2.31 m/year and DBH = 2.59 m/year). Among the native tree species, the height of mahang at 5.5 YAP was growing 1.2 and 1.6 times faster than that of geronggang (Ht = 1.96 m/year) and skubung (Ht = 1.42 m/year), respectively; while for DBH it was 1.2 and 1.4 times faster than that of geronggang (DBH = 2.08 cm/year) and skubung (DBH = 1.82 cm/year), respectively.

B. Yield

In general, the best wood volume and MAI among the observed native tree species until 5.5 YAP was obtained in mahang. The wood volume (117.9 m^3/ha) and its MAI (21.4 m^3/ha/year) of mahang was significantly ($p < 005$) higher than that of geronggang (V = 72.1 m^3/ha and MAI = 13.1 m^3/ha/year) and skubung (V = 20.9 m^3/ha and MAI = 3.8 m^3/ha/year) at 5.5 YAP (Figure 5). However, the wood volume of mahang was significantly lower than that of krasikarpa. The wood volume of krasikarpa was 4.7 and 1.4 fold higher than mahang for wood per tree and stand volume, respectively (Figure 4).

This study on growth performances of three native species was focused on the purpose to obtain the candidate of native tree species to be grown on peatland of HTI-pulp. The wood in HTI-pulp in general have been harvested at 4–5 YAP (Suhartati et al., 2013). The data on growth performance and yield of the native tree species in this study was measured until 5.5 YAP, therefore, the data of this study should be sufficient to assess the feasibility of native trees for HTI-pulp. This was also supported by the curves of MAI (wood volume) and CAI (wood volume) of each species (Figure 5). The MAI and CAI curve of skubung and krasikarpa were intersected at 5 YAP and below 6 YAP for mahang and geronggang (Figure 5).

As the performance of exotic species in HTI-pulp has been declining, there were great expectations on the performance of native tree species in this study. The expectation was fulfilled by the higher survival rate of all native tree species than that of krasikarpa (exotic species). This result is in accordance with some prior studies that native tree species had better survival rate than exotic tree species (Farias

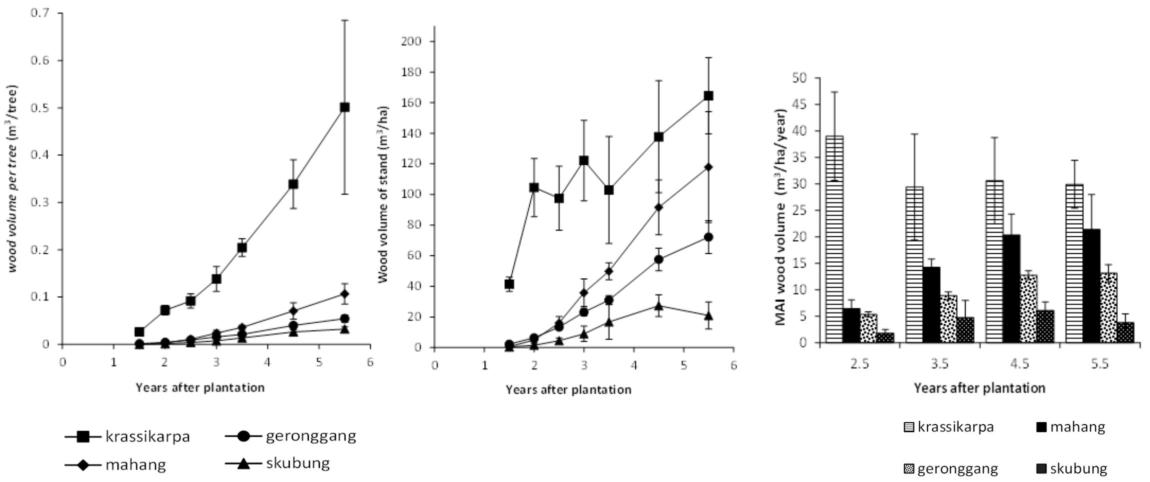

Figure 4. Wood volume (m^3/tree and m^3/ha) and MAI (m^3/ha/year) of three native tree species and krassikarpa (exotic species) observed until 5.5 YAP in drained peatland of Pelalawan, Riau (data = mean ± Sd, n = 5)

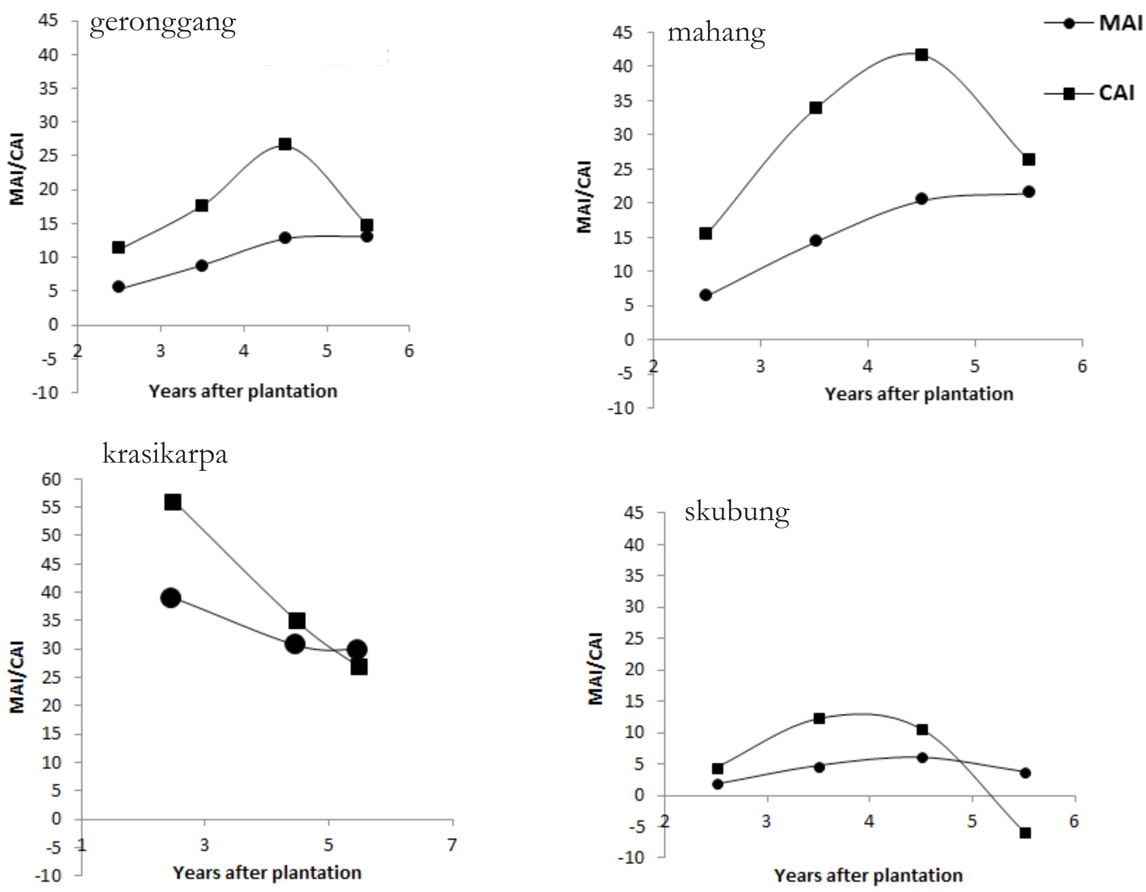

Figure 5. The curve of MAI (wood volume, m^3/ha/year) and CAI (wood volume, m^3/ha/year) of three native tree species and krassikarpa (exotic species) planted on drained peatland of Pelalawan, Riau

Figure 6. The symptoms of dieback on skubung and mahang planted in drained peatland of Pelalawan, Riau

et al., 2016; Lampela et al., 2017; Subiakto, Rachmat, & Sakai, 2016). Regardless, this study found that in terms of survival rate, geronggang is the most promising native tree species for HTI-pulp. This tree had the highest survival rate which was relatively stable until 5.5 YAP. This result confirmed the study of Mojiol et al. (2014) in peatland of Sabah, Malaysia, which found the best survival rate of geronggang.

The high survival rate of geronggang was presumably because this native tree was not prone to attacks of pests and diseases. In contrary, mahang and skubung suffered rather high tree mortality caused by attack of diseases, particularly at 5.5 YAP. The attack was indicated by dieback symptoms on those two native tree species that was particularly occurring in skubung with survival rate of <40% at 5.5 YAP (Figure 6). However, this study did not conduct specific observation on pests and diseases thus the exact diseases that attacked the plants yet to be identified.

Based on visible symptoms observed in the field, it was suspected that most mortality occurred in krasikarpa (exotic species) was related to pest and disease attack as well. The symptoms were visibly clearer on krasikarpa than on the native species (Figure 8). This indicated the higher susceptibility of the exotic species (krasikarpa) to pest and disease attack than those of the native tree species. The result was similar with other studies in which several species were more severely prone to pest and disease attack when they were planted outside their natural range, such as in *Acacia* spp., *Eucalyptus* spp., and poplar (Herath et al., 2016; Wingfield, 2003).

Although the study did not carried out specific analysis to identify the disease, but the signs and symptoms observed in the field indicated that the mortality of krasikarpa may strongly be related to attacks of *Ganoderma* sp., *Ceratocystis* sp. and termite (Figure 7). The signs of *Ganoderma* sp. and termite attacks were evidently observed in the field, while *Ceratocystis* sp. attack was assumed based on the symptoms e.g. lesion and the discoloration around the bark, xylem and cambium (de Beer, Duong, Barnes, Wingfield, & Wingfield, 2014; Rahayu, Nurjanto, & Pratama, 2015; Tarigan et al., 2011) (Figure 7). Several studies were also reported the attacks of *Ganoderma* sp., *Ceratotocystis* sp. and

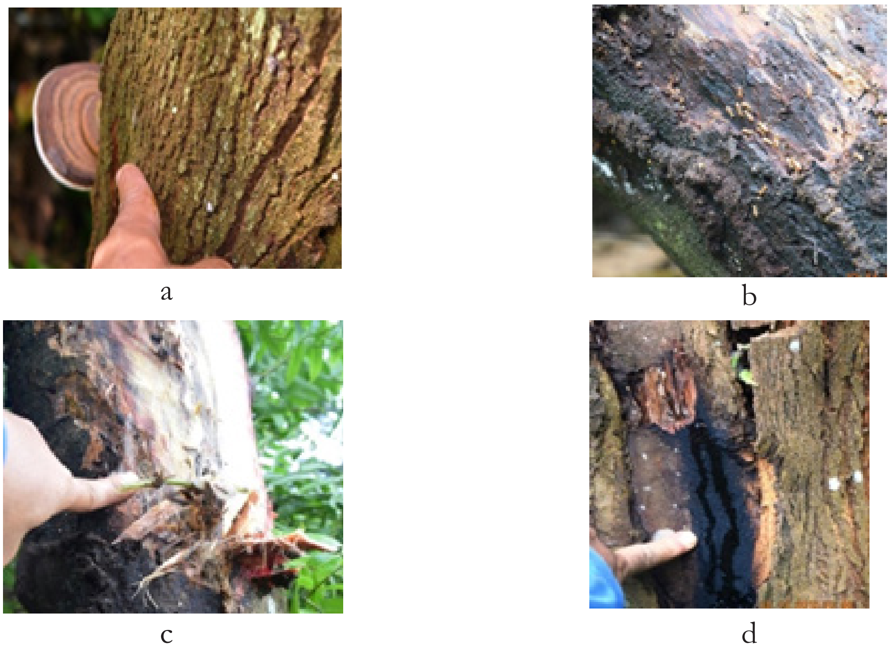

Figure 7. The signs and symptoms of pests and diseases attacks on krasikarpa in drained peatland of Pelalawan, Riau

Remarks: a = The body of presumed *Ganoderma* sp., b = termites, c = discoloration, d = lesion

termite on acacias around the world (Francis et al., 2014; Haggar, Briscoe, & Butterfield, 1998; Tarigan et al., 2011).

However, in term of survivorship of the native tree species is better than that of krasikarpa was not followed by equally better growth and yield performance. The growth and yield of krasikarpa was superior to those of the tested native tree species. Yet, the growth comparison between the natives and the exotic was actually rather unjust considering the krasikarpa used in this study was developed from tree improvement program while the natives were from wildling/unimproved seedlings. Comparison on growth and yield of the natives with those of the supposedly unimproved krasikarpa demonstrated less gap of growth between the two tested objects. The height and DBH increment of the supposedly unimproved krasikarpa were 2.8 m/year and 3 cm/year at 1.6 YAP (Cole, Yost, Kablan, & Olsen, 1996), which were not ominously different from those of mahang and geronggang in this study (Figure 3).

The growth performance displayed by mahang and geronggang qualifies them as fast growing species. Growth of other native tree species were reported by several previous studies (Table 1) as comparison to those two tested species. Therefore, this study is then promoting mahang and geronggang as the candidates of native tree species to be grown in peatland of HTI-pulp, but tree improvement program to enhance the growth quality of the seedlings is a prerequisite. For instance, tree improvement program had been successful to improve the yield of *Eucalyptus* spp. in Brazil from 10–17 m^3/ha/year to 25–70 m^3/ha/year (Gonçalves et al., 2013; Leksono, 2016). It is highly possible to achieve the same success result as of eucalyptus in Brazil with geronggang and mahang in peatland that without tree improvement the yield of geronggang and mahang reached 13.1 m^3/ha/year and 21.4 m^3/ha/year, respectively (Figure 6).

Geronggang as a matter of fact has more potential than mahang for peatland HTI-pulp. Geronggang displayed the best and more

Table 1. The growth performances of several native tree species planted around tropical area

No.	Species	Height growth (m/year)	DBH growth (cm/year)	Locations	References
1.	*Shorea balangeran*	0.23 – 1.62	0.78 – 2.41	Kalimantan (Peatland)	Hilwan, Setiadi, & Rachman, (2013) & Lampela et al. (2017)
2.	*Parashorea smythiesii*	0.49 – 2.40	0.87 – 3.97		
3.	*Shorea leprosula*	0.9	1.4	Riau, Indonesia (Peatland)	Subiakto et al. (2016)
4.	*Dacryodes rostrata*	0.12	-	Kalimantan, Indonesia (Peatland)	Lampela et al. (2017)
5.	*Sterculia* sp.	0.1			
6.	*Terminalia microcarpa*	1.18	1.42		
7.	*Ochroma pyramidae*	0.42	1.92	Mexico (Dryland)	Da˜nobeytia et al. (2015)
8.	*Alnus acuminiata*	0.95	1.81	Columbia (Dryland)	Bare & Ashton (2015)
9.	*Alstonia scholaris*	0.6	-	Kalimantan, Indonesia (Dryland)	Mawazin & Susilo (2016)
10.	*Khaya anthotecha*	1.22	-	Tanzania (Dryland)	Muiambo (2016)
11.	*Artocarpus hispidus*	1.3	3.2	Malaysia (Dryland)	Yamada, Watanabe, Okuda, Sugimoto, & Azlin (2016)
12.	*Artocarpus altilis*	2.3	2.3		

stable survivorship and it was also not prone to pest and disease thus good productivity and sustainability of HTI-pulp can be expected. In addition, cultivation activity in peatland is regulated by the Government of Indonesia and it declares that only peatland with a water table depth of <40 cm below the surface is permitted for plant cultivation (Indonesian Republic, 2016). Although the depth of water table in the study site is not always below 40 cm, but it occasionally could reach 20 cm below the surface especially in wet season (Husnain et al., 2014) and geronggang could survive at that level of water table although further research on this matter is required. Therefore, the higher and more stable survivorship of geronggang, as well as its possible ability to adjust to lower water table, has made this species a better candidate for peatland HTI-pulp than other tested native trees. Moreover, the wood consumption of geronggang (4.83 m^3 wood/ton pulp) for pulp production is lower than that of mahang (6.49 m^3 wood/ton pulp) (Aprianis, 2016). It indicates a lower cost for geronggang than that for mahang on wood transportation from forest to factory and also pulp processing.

Skubung showed the poorest survivorship and growth among the tested species. However, other study noted the promising growth of skubung that was planted in dry land (ultisol), with height and DBH increments of 1.9–3 m/year and 2.2–3.8 cm/year, respectively (Amirta et al., 2016; Susanto et al., 2017). It was reported that skubung naturally can be found not only in peatland but also in dry land (Lim et al., 2014; Raphael, Yan, Yap, & Tan, 2015; Suhartati et al., 2012). Therefore, skubung is more recommended to be planted in dry land than peatland.

IV. CONCLUSION

This study increased the availability of species-specific information on the suitability of three native tree species [mahang (*Macaranga pruinosa)*, skubung (*Macaranga gigantea)* and geronggang (*Cratoxylum arborescens*)] to be grown in pulpwood plantation in peatland; regarding the survival, growth and yield performances. In the selection of the three native tree species for that purpose, the study also included other aspects into consideration such as the volume of wood consumption in pulp manufacturing, the government regulation and the pulpwood plantation sustainability. Based on the study results, the promising native species were mahang and geronggang, Nonetheless, the promising performances has not made mahang and geronggang feasible to be directly developed in real plantation. The growth performance of those two natives were still lower than that of krasikarpa, therefore, tree improvement program in order to optimize growth and yield performances of mahang and geronggang is strongly recommended prior the development of those native trees as pulpwood plantations in peatland HTI-Pulp.

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