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Effects of Indole Acetic Acid (IAA) and Indole Butyric Acid (IBA) to The Growth and Rooting of Ironwood (*Eusideroxylon zwageri* Teijsm. & Binn.) Air Layering

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Abstract

Due to over exploitation, the population of Eusideroxylon zwageri is decreasing drastically. One simple technique to conserve the last remaining genetic resources of E. zwageri is by air layering. The experiment was divided into two. The experiment was conducted from July 2018 to February 2019. The first experiment was conducted using branches that grew from coppices while the second experiment using twigs that grew from normal adult trees. Randomized Block Design was applied with three replicates. The treatments were consisted of nine concentration of auxin namely 0 ppm of auxin; 1, 000 ppm; 1,500 ppm; 2,000 ppm, and 2,500 ppm of IAA and 1,000 ppm; 2,000 ppm; 3,000 ppm and 4,000 ppm of IBA. The result of experiment shows that the IBA growth regulator seems to be more effective in regulating growth and rooting of E. zwageri air layering compared to IAA. Results for air layering which was taken from coppices revealed that 1,000 ppm of IBA obtained the best results. Air layering of branches taken from coppice is possible even without any additional growth regulator. While, air layering of twigs which was taken from normal trees revealed that the best treatment is 3,000 ppm of IBA.

Keywords: air layering, E. zwageri, Indole Acetic Acid, Indole Butyric Acid

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Introduction

Bulian/*ulin*/*belian*/borneo ironwood (*Eusideroxylon zwageri* Teijsm. & Binn.), synonym to *Bihania borneensis* Meissner and *Eusideroxylon lauriflora* Auct. *E. zwageri*, is one member of the Lauraceae, tribus of Cryptocaryeae and subtribus of Eusideroxylineae (Kostermans, 1957). Natural distribution of *E. zwageri* is limited to the east until Borneo and to the west until west coast of West Sumatera; to the North is not more than N5° and to the south is until S3° (Heyne, 1927). In Borneo, *E. zwageri* grows almost in all parts of Borneo forests including Sarawak and Brunei. In South and Southeast Sumatera, it is distributed in Palembang, Bangka, Belitung, Jambi, Bengkulu, Siak, and Indragiri. *E. zwageri* also can be found in Lampung, the southern part of West Sumatera and Sijunjung. In Philippines, it can be found in forests of Tawi-Tawi Island which is belonged to Sulu archipelago (Beekman, 1949).

E. zwageri grows well in the humid climate and it also able to grow in the places with short dry season (Koopman & Verhoef, 1938). Soedibja (1952) reported that in immature stage, *E. zwageri* is a shade bearer species. It especially found on sandy soil and requires a fairly drained soil with a wet climate. Additionally, Soerianegera (1974) reported that *E. zwageri* could be found in the areas with dry sub-humid climate and humid climate with precipitation from 2,000 to 6,000 mm year^{-1}.

The timber of *E. zwageri* is used for making furniture, which produced black brownish and furniture, window and door frames, harbors, heavy construction, roofs, bridges, railway sleepers, marine pilling, boat construction, fence and house posts, heavy duty industrial flooring, tool handles, talisman, jewelers, bridges, and shingles, which are produced only by wood which has high splitability. Heyne (1927) reported that *E. zwageri*s' seeds can be used as medicine against swelling. Kostermans et al. (1994) reported the fruits are poisonous and pulverized which have been used by local people medicinally against swelling. Local people in Senami, Jambi also used the seeds as medicine (Irawan 2005). Traditionally, local people used *E. zwageri* wood that immersed in the water to relieve toothache which lead to idea that this wood possibly contain several chemical substances that have antibiotic effects or the wood just contain substances that have analgesic effects. Early investigation found that *E. zwageri*s' wood contains several chemical substances from group of alkaloid, flavonoid, triterpenoid, tanin, and saponin. Flavonoid, triterpenoid, and saponin are chemical substances that have potency as antibacterial and antivirus (Robinson 1995). Additionally, *E. zwageri*s' wood empirically proofed that has chemical substances that was able to control bacteria especially *Staphylococcus aureus.* The study confirmed antibacterial property of *E. zwageri*s' wood extract and concluded that the minimal inhibitor

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concentration (MIC) of the extract was 2% (Ajizah et al., 2007).

E. zwageri is one of the most renowned timbers of Borneo. It has been favored both for local use and export trade. Over-exploitation together with forest clearance has led to the decline of this slow-growing timber species. The increased availability of forest roads opened by concessionaires is leading to greater problems of uncontrollable exploitation in Kalimantan (Partomihardjo, 1987).

Oldfield et al. (1998) showed that *E. zwageri* is included in the list of threatened tree species. Its decline was first noted in 1955. Overexploitation and shifting agriculture had been noted in Kalimantan, Sumatera, Sabah, Sarawak, and the Philippines considered as the main factors for decreasing population of *E. zwageri* in its natural habitat. The regeneration of *E. zwageri* in logged forests is limited. The *E. zwageri* has only been planted on a small scale due to the limited supply of seeds and seedlings. Based on the IUCN red list of threatened species, *E. zwageri*s' category and criteria are *VU A1cd+2cd*. This means that *E. zwageri* is not critically endangered or endangered but is facing a high risk of extinction in the wild in the medium-term future (IUCN, 2019).

Over-exploitation, shifting cultivation, and extensive road systems by the timber industry, selective logging, and developing infrastructures were the major threats to *E. zwageri* (Peluso, 1992; Kostermans et al., 1994). WWF (2001) reported that land clearing for plantations and agriculture as well as logging had been heavy occurred in the lowlands east of the Bukit Barisan Range, mainly during the 1998–1999 economic crisis. Extensive stands of *E. zwageri* have been almost entirely destroyed in southern Sumatera.

One example of the degradation of *E. zwageri* forest is Senami forest, Jambi. The degradation is very clear from the comparison of *E. zwageri* volume in 1919, 1983, and the results of research in 2004. Irawan (2005), who conducted research in 2004, obtained that the volume of *E. zwageri* was only 5.18 m^3 ha^{-1}. Masano and Omon (1983) who doing research in the same location found significantly different figures where the volume for undisturbed forest was 120.9 m^3 ha^{-1} while for over-logged area was 56.45 m^3 ha^{-1}. Another research conducted by Gresser (1919) also in Senami forest, found that the average volume was 105.6 m^3 ha^{-1}.

One interesting characteristic of *E. zwageri* is its ability to coppice. Field data shows that all of *E. zwageri* stumps produce coppices (Irawan, 2005). The number of coppices produced by *E. zwageri* seems to not be influenced by the diameter size of the stump (Irawan & Gruber, 2004; Irawan, 2005). Ecologically, sprouting is very important for the survival of *E. zwageri* species since this species faces over exploitation. About 65 % out of plots where *E. zwageri* can be found was also obtained coppicing stumps. It indicates that the important of coppices is not only for survival of individual tree but also important for the forest stand dynamic (Putz & Brokaw, 1989; Kammesheidt, 1998; Miura & Yamamoto, 2003).

Many researchers reported that the growth rate of *E. zwageri* is very slow for mature as well as juvenile stage (Beekman, 1949; Kostermans et al., 1994; Kiyono & Hastaniah, 2000; Irawan, 2005). By coppicing, the growth rate of *E. zwageri* can be increased. Coppices may grow three times faster for the diameter and 5.6 times for the height compared to growth rate of *E. zwageri*s' seedlings. Five-year-old coppices can reach diameter between 4 cm to 9 cm depend on the varieties of *E. zwageri*.

The growth rate of coppices that much faster compared to seedlings is confirmed by local people. The explanation for this phenomenon was explained by some reports the coppices mostly have received better supports of sufficient nutrients and water from the well-developed root systems. In contrast, the root systems of the seedlings which develop simultaneously with the growth of the trees (Beekman, 1949; Irawan, 2002; Miura & Yamamoto, 2003).

The coppices are not only important for the survival of the trees and maintaining stand dynamic but also could be used as propagation materials (Beekman, 1949; Irawan, 2001). Directly, the coppices can be taken as cutting materials or as hedge orchards. Preliminary research showed that sprouts can be used as cutting materials, however the results were not good enough yet (Irawan, 1999). Another method is to utilize coppices for air layering propagation.

Based on the present status of *E. zwageri* as explained before, it is remarkably urgent to conserve and develop the remaining genetic resources of *E. zwageri*. Without any truly effort on conservation and development, the loss of genetic resources will be continued and forever. One simple but useful technique to save the last remaining genetic resources of *E. zwageri* is by air layering propagation since it will produce identical trees. The air layering technique also can be utilized for developing clonal seed orchard since it will produce identical mother trees that able to flowering and fruiting quite early with dwarfed trees (Irawan, 2018).

The preliminary experiment revealed that the air layering of *E. zwageri* can be conducted without any additional growth regulator but the root formation took place quite long time. It needs about six to eight months (Irawan, 2018). Nuraini et al. (2017) reported that there was no interaction between concentration of auxin and method on cambium scarifications on air layering propagation of *E. zwageri*. While, the treatment of 750 ppm of Indole Acetyc Acid (IAA) obtained the best results. Almost the same concentration of IAA also provided the best results for cutting of *E. zwageri* that was 700 ppm (Irawan et al., 2011). However, there was an indication that applying till 1.000 ppm of IAA still increased the percentage of rooted branches that propagated by air layering. The percentage of rooted branches propagated by air layering reached to 62.92% due to treatment of 1,000 ppm IAA (Nuraini et al., 2017). The number of this rooted air layering is higher compared to percentage of rooted branches that propagated by air layering reported by Diantina (2008) that was only 37.50%.

Another growth regulator under auxin that also potentially used for triggering rooting is Indole Butyric Acid (IBA). The IBA was reported to be efficiently triggering the rooting system of cutting of *E. zwageri* (Irawan, 1999; 2001; Utami et al., 2005; Irawan et al., 2011). Irawan et al. (2011) reported that 2,250 ppm and 3,000 ppm of IBA provided the best rooting on cutting of *E. zwageri*. This result confirmed the experiment results before that concentration of IBA from 1,500 ppm to 3,000 ppm provided the best result on cutting of

E. zwageri (Irawan, 1999; 2001). Utami et al. (2005) reported that the treatment of IBA 10 mg ℓ^{-1} of IBA obtained the best result on cutting of *E. zwageri*. While the combination of 10 mg ℓ^{-1} IBA and 50 mg ℓ^{-1} of C Vitamin also provided the best rooting of cutting of *E. zwageri* both on root number and root length.

Some of research results revealed that IAA had positive effects on *E. zwageri*s' propagation especially on cutting and air layering. Irawan (1999; 2001) reported that IAA had better effect on rooting and growth of *E. zwageri*s' cutting compared to effects of IBA. The best concentration of IAA was 500 ppm while the best concentration of IBA was 1,500 ppm and 3,000 ppm. Another research also confirmed almost the same results as reported by Irawan et al. (2011) that 700 ppm of IAA provided the best results on one and two nodes of *E. zwageri*s' cuttings. While 2,250 ppm and 3,000 ppm of IBA provided the best cutting results compared to other concentration of IBA.

Methods

The experiment was conducted for eight months from July 2018 to February 2019. The experiment was conducted on Sultan Thaha Syaifuddin (STS) Grand Forest, Batanghari District, Jambi Province. The STS Grand Forest was stated based on Decree of Forestry Ministry Number 94/Kpts-II/2001 with the size of 15,830 ha.

Experimental design The experiment was divided into two main experiment but related one to another. The first experiment was conducted using the branches that grow from coppice while the second experiment was conducted using twigs that grow from a normal adult tree. The utilization of coppices was based on the recommendation of early publications before (Irawan & Gruber, 2004; Irawan, 2005; Irawan et al., 2011; Irawan, 2018).

Randomized Block Design was applied for both experiments with three replicates. The block was determined based on the position of the branches in the coppice for the first experiment while for the second experiment, the block was based on the position the twigs on the branches of the mother trees. The treatments were consisted of nine concentration levels of auxin namely 0 ppm of auxin; 1, 000 ppm, 1,500 ppm, 2,000 ppm, and 2,500 ppm of IAA and 1,000 ppm, 2,000 ppm, 3,000 ppm, and 4,000 ppm of IBA. The concentration levels of auxin that tested were formulated based on earlier research results (Irawan, 2001; Irawan et al., 2011; Nuraini et al., 2017). The total number of experimental units was 27 for each experiment while the number of branches that propagated was five. Therefore, total number of air layering was 135 for each experiment.

The media that used for the air layering was top soil, sand, and organic matter with the comparison of 1:1:1 (Irawan, 2005). The amount of media for each air layering branch was 150 g. The media was put in the transparent plastic with 5 holes on each side. The size of selected branches was about 0.6 cm to 1.0 cm in diameter. The cutting area size for removing the bark was about 3 cm with the starting cut at 5 cm from the branch or twig base. The thin layer of cambium was removed then the auxin was applied using brush evenly at the tip part of the cutting area.

The tending of the air layering branches was done regularly including watering that applied mostly once a day except during rainy day and fertilizing that applied once a month. The fertilizer that used was liquid fertilizer that consisted of 20% of nitrogen, 15% of phosphate (P_20_5), 15% of potassium (K_20), and 1% of magnesium ($MgSO_4$). The concentration of application was 3 g ℓ^{-1}.

Parameters and statistical analysis These parameters included: percentage of life air layering branches (%), percentage of rooted air layering branches (%), shoot length (cm), stem diameter (cm), leaf area (cm²), and shoot number. The data were subjected to statistical analysis: a one-way Analysis of Variance (Anova) with variety as a factor. The statistical test for all components of variance was determined at 0.05 significance level of Duncan Multiple Range Test (Gomez & Gomez, 1984). The *t*-test was applied to find the correlation between rooted air layering branches with shoot length.

Results and Discussion

The F values of four different parameters of branches of *E. zwageri* that propagated by air layering as results of different levels of auxin concentration at eight months after treatment was presented on Table 1. Table 1 shows that three parameters of air layering which was taken from coppices are highly significant different. Those parameters are shoot length and shoot number as well as percentage of rooted air layering. Meanwhile, only two parameters of air layering which was taken from normal trees are significantly different, namely shoot number and percentage of rooted air layering. Among those four parameters, the percentage rooted air layering is the most important parameter.

Table 2 shows that all parameters of air layering taken from coppice is significantly different among treatments. Overall results revealed that 1,000 ppm of IBA obtained the best results compared to other treatments. However, in the most parameters, the 1,000 ppm of IBA is not significantly different to control (without additional growth regulator) and 2,000 ppm of IBA. The most interesting result on air layering of branches taken from coppice is that without any additional growth regulator to the air layering propagation is also still possible. The results air layering of without growth regulator still provided high percentage rooted air layering with the mean value of 46.67%. This value is not significantly different to the best performed treatment. Some other reports also confirmed that growth regulator was not always needed for tree vegetative propagation. Mulyani et al. (1999) reported that the effect of hormone was not significantly different on the shoot growth of hypocotyl cutting of *Rhizophora mucronata*.

Table 3 shows that 3,000 ppm of IBA obtained the best results on air layering of twig which were taken from normal trees compared to other treatments for all parameters. Even, this treatment is not significantly different to 2,500 ppm of IAA, 1,000 ppm and 2,000 ppm of IBA on rooted air layering but numerically, the value is much higher. The percentage of rooted air layering by 3,000 ppm of IBA was 40% while those other treatment only provided the percentage of rooted air layering with the value of 26.67%.

Table 1 The *F*-values of four different parameters of branches of *Eusideroxylon zwageri* that propagated by air layering as a result of different levels of auxin at eight months after treatment

Parameter	*F*-value	
	Branches from coppices	Twig from normal trees
Shoot length	30.74**	1.75
Shoot number	7.42**	2.83*
Percentage of life air layering branches	2.52	1.68
Percentage of rooted air layering branches	8.70**	3.63*

Table 2 Mean values of four traits of *Eusideroxylon zwageri* Teijsm. & Binn. branches which was taken from coppices propagated by air layering at eight months after treatment

Treatments	Shoot length (cm)	Shoot number	Life air layering (%)	Rooted air layering (%)
0 ppm auxin	14.65 ab	2.86 b	73.33 ab	46.67 ab
1,000 ppm of IAA	18.06 ab	3.93 b	80.00 ab	20.00 bc
1,500 ppm of IAA	9.77 b	1.53 b	53.33 b	13.33 c
2,000 ppm of IAA	20.43 ab	3.06 b	73.33 ab	26.67 bc
2,500 ppm of IAA	13.24 b	2.20 b	80.00 ab	6.67 c
1,000 ppm of IBA	29.74 a	4.73 ab	100.00 a	60.00 a
2,000 ppm of IBA	21.55 ab	3.73 b	93.33 ab	46.67 ab
3,000 ppm of IBA	10.29 b	5.80 ab	100.00 a	26.67 bc
4,000 ppm of IBA	9.73 b	8.80 a	100.00 a	6.67 c

Table 3 Mean values of four traits of *Eusideroxylon zwageri* Teijsm. & Binn. branches which was taken from normal trees propagated by air layering at eight months after treatment

Treatments	Shoot length (cm)	Shoot number	Life air layering (%)	Rooted air layering (%)
0 ppm auxin	10.72 b	6.46 b	60.00 b	13.33 bc
1,000 ppm of IAA	5.35 cd	2.53 bc	60.00 b	0.00 c
1,500 ppm of IAA	9.20 bc	2.00 bc	46.67 b	0.00 c
2,000 ppm of IAA	4.78 cd	2.33 bc	60.00 b	0.00 c
2,500 ppm of IAA	6.57 bc	2.60 bc	60.00 b	26.67 ab
1,000 ppm of IBA	6.94 bc	2.66 bc	66.67 b	26.67 ab
2,000 ppm of IBA	1.29 d	0.46 c	46.67 b	26.67 ab
3,000 ppm of IBA	30.34 a	14.80 a	100.00 a	40.00 a
4,000 ppm of IBA	4.69 cd	2.33 bc	66.67 b	20.00 bc

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The shoot length and shoot number of air layering are two parameters that are closely related. Both parameters are significantly different among treatments. For air layering which were taken from the coppice as presented on Table 2, the best shoot length was provide by 1,000 ppm of IBA with the value of 29.74 cm but the result of this treatment is not significantly different to results obtained by 2,000 ppm of IAA dan 2,000 ppm of IBA. Meanwhile for shoot number, the best result was provided by treatment of 4,000 ppm of IBA with the value of 8.80 cm but this result is not significantly different results obtained by to 1,000 ppm and 3,000 ppm of IBA. The shoot length and shoot number of air layering taken from normal trees also significantly among treatments. The best treatment for shoot length was provided by 3,000 ppm of IBA. The result of this treatments is significantly different to results of other treatments.

The shoot has an important role as a place of leaves while the most important function of leaves is to conduct the photosynthesis process. During photosynthesis, leaves convert inorganic materials to organic compounds using energy from sunlight. Those organic compounds are the main sources of energy for organ development. The leaf parameter, especially total leaf area, is the most important parameter that influences photosynthesis rate (Ceulemans & Saugier, 1991; Hari et al., 1991). Furthermore, Kirschbaum (2011) explained that increasing photosynthesis increases carbon availability for plants. However, some limiting factors especially nutrient availability will determine the increasing growth due to increasing photosynthesis.

The percentage of life air layering is also significantly different among treatments. However, the trend between air layering taken from coppices and from normal trees is slightly different. The treatment of 1,000 ppm, 3,000 ppm, and 4,000 ppm of IBA provided the highest value of life layering percentage with the value of 100%. The results of those treatments are significantly different to result of 1,500 ppm of IAA but they are not significantly different to other treatments. While for air layering which was taken from normal trees, the best result was provided by 3,00 ppm of IBA. The result of this treatment is significantly different to results of other treatments.

Table 2 and Table 3 show that the percentage of rooted air layering among treatments is significantly different one to another. The best result on percentage of rooted air layering which was taken from coppice trees was obtained by treatment of 1,000 ppm IBA. This result is not significantly different to results of control (without growth regulator) and 2,000 ppm of IBA. While, the best result on percentage of rooted air layering which was taken from normal trees was obtained by treatment of 3,000 ppm IBA. This result is not significantly different to results of 2,500 ppm of IAA, 1,000 ppm of IBA, and 2,000 ppm of IBA.

The result of experiment shows that the IBA growth regulator seems to be more effective in regulating growth and rooting of *E. zwageri* air layering for both air layering resources compared to IAA. This result is contrary to research results on cutting of *E. zwageri* before as reported by Irawan (2001) that IAA had better stimulating ability on rooting and growth of *E. zwageri* cutting compared to IBA. Nuraini et al. (2017) also reported that IAA with the concentration of 750 ppm provided the best result on propagation of *E. zwageri* using air layering even there was an indication that the concentration of IAA till 1,000 ppm still increased the percentage of rooted air layering.

However, many other researchers also provided another knowledge that IBA is an effective growth regulator for stimulating root system on cutting propagation. Salisbury and Ross (1995) stated that IBA is the most common gowth regulator applied for tree propagation by cutting. This results also confirmed previous study that the concentration of IBA between 1,500–3,000 ppm and 500 ppm of IAA obtained the best result for ironwood cutting (Irawan 1999; 2001).

Utami et al. (2005) reported that statistically there was no interaction among treatment on cutting, IBA concentration, and vitamin C to the shoot cutting of *E. zwageri*. The additional IBA with the concentration of 10 mg ℓ^{-1} provided better results to the shoot cutting of *E. zwageri* compared to 5 mg ℓ^{-1} and 15 mg ℓ^{-1} of IBA. While 50 mg ℓ^{-1} of Vitamin C provided best result compared to other concentrations of vitamin C. The cuttings tended to form more root number and root length after treatment of 50 mg ℓ^{-1} of vitamin C. The combination (mixed) between 10 mg ℓ^{-1} of IBA and 50 mg ℓ^{-1} of vitamin C was the best combination that produced the longest and the most root number compared to other treatments.

The optimal concentration of IBA for rooting was varied for different species. Concentration of 30–40 mg ℓ^{-1} IBA obtained 70% of rooting of teak (*Tectona grandi*) cutting (Wibowo et al., 2000). Cutting of *damar* (*Agathis loranthifolia* Salisb.) required IBA with the concentration of only 100 ppm for providing the best rooting performance (Danu et al., 2011) while for *Podocarpus blumei* cutting needed until 4,000 mg ℓ^{-1} IBA for performing 80% rooting (Utami et al., 2005). High concentration of IBA also needed for rooting of *Rosa centifolia* cutting where, 3,500 ppm IBA performance the best root length and root number (Al-Sagri & Alderson, 1996).

Tchoundjeu and Leakey (1996) reported IBA was effectively improved rooting system on african mahagony cutting. Their result revealed that the best concentration of the IBA was found to be 200 µg per cutting. This concentration increased the percentage of rooted cuttings and increased the number of roots per cutting. The same result also indicated by our study. There were some variations on rooting ability of cutting that treated by the same concteration of IBA. Aminah et al. (1997) reported that IBA application to the cuttings may have an indirect influence by enhancing the translocation speed and carbohydrates movement from top to the base of cuttings. This process consequently stimulates rooting.

Table 4 shows that the results of *t*-test on the comparison between air layering results from the ranches that grow from coppices and twigs from the normal trees. There is not significantly different on the results of air layering propagation that taken from branches of coppices and twigs of normal trees both percentage of life air layering and percentage of rooted air layering. Even the overall mean values of the air layering taken from coppices much higher compared to air layering taken from normal trees on both parameters. The overall mean values of percentage of life air layering taken from coppices was 83.70% while percentage of life air layering taken from normal trees was 62.98%. The overall mean values of percentage of rooted air layering taken

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from coppices was 28.15% while percentage of rooted air layering taken from normal trees was 17.04%.

Numerically, the result of this researches indicated that the air layering that taken from coppices tend to provide better results of air layering which were taken from twigs of normal trees even, based on the statistical analysis that the results of both were not significantly different. Those results seem due to the different maturation stage of both materials of air layering where the coppices have younger maturation stage compared to normal trees. As explained by Kleinschmit and Svolba (1988) that the maturation or ageing is one of the most problem of vegetative regeneration. Hendromono et al. (1996) also reported that the rooting ability of cutting of meranti (*Shorea* spp.) is decreasing with the increasing of the age of cutting materials. This phenomenon was not only for one species but tree species of shorea namely *Shorea selanica*, *S. Leprosula*, and *S. pinanga*. The same result also reported by Ofori et al. (1997) that conducted research on *Milicia excelsa* cutting.

Ofori et al. (1997) who conducted research on *M. excelsa* reported that rooting ability tended to decline with increasing age of the ortet. A negative correlation was observed between age of the donor tree and rooting percentage. The effect of treatment on final rooting percentage was highly significant overall, although there was not significant differences in rooting were observed among cuttings from the 4-years-old and those of 1- and 20-years-old stockplants.

Heavy pruning to form new coppices is one method that can be applied to reduce ageing problem both for Hardwood and Conifer (Kleinschmit & Svolba, 1988). Bolstad and Libby (1982) reported that hedging that including serial pruning on the mother trees or hedge orchards proven to reduce the ageing problem. The result of this research also confirmed the results of other researches before that coppices is not only important for recovery of logged trees but also can be utilized as propagation materials (Beekman, 1949; Irawan, 2001).

The correlation between selected parameters that observed had been tested to understand the degree of correlation between them. The Pearson correlation between shoot length and percentage of rooted air layering for air layering which was taken from coppices is significantly different (Table 5). While, the Pearson correlation between shoot length and percentage of rooted air layering for air layering which was taken from normal trees is not significantly different. It indicates that the growth of shoot will influence the root formation. As explained before, that the shoot length has correlation with the photosynthetic activity.

The relationship between shoot length and success on rooting of air layering propagation has not been reported yet. However, the correlation between cutting length and rooting ability had been reported by many studies. The effects of the cutting length on rooting in many studies was varied. Ofori et al. (1997) reported that there is no significant effect of cutting length on rooting percentage of *M. excelsa* cutting was recorded, although there was a marked positive correlation between length and shoot production. Cutting length was

Table 4 The *t*-test result of on the comparison between air layering results from the branches that grow from coppices and twigs from the normal trees

Parameters	Levene's test for equality of variances		*T*-test for equality of means			
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference
Percentage of life air layering	0.434	0.519	2.774	16	0.014	20,724
Percentage of rooted air layering	0.603	0.449	1.388	16	0.184	11,112

Table 5 The correlation between shoot length and percentage of rooted air layering at eight month after treatment

Parameter		Coppices		Normal trees	
		Rooted air layering (%)	Shoot length (cm)	Rooted air layering (%)	Shoot length (cm)
Rooted air layering (%)	Pearson Correlation	1.00	0.766*	1.00	0.489
	Sig. (2-tailed)		0.016		0.182
	N	9	9	9	9
Shoot length (cm)	Pearson Correlation	0.766*	1.00	0.489	1.000
	Sig. (2-tailed)	0.016		0.182	
	N	9	9	9	9

*. Correlation is significant at the 0.05 level (2-tailed).

negatively correlated with foliar relative water content. Yang et al. (2015) reported that the cutting size both diameter and length as well as their interaction affected the rooting ability of norway spruce cuttings. The thicker and the longer cutting materials obtained better rooting. However, the interaction between cutting length and cutting diameter should be take into consideration. When the cutting diameter was greater than or less than a certain value, rooting decreased with increasing length.

Tchoundjeu and Leakey (1996) reported that the more number of nodes that will increase the cutting length and number of leaves will also directly increase the risk of mortaliity due to water stress by increasing transpiration rate. Furthermore, Yang et al. (2015) argued that an equilibrium between photosynthesis and transpiration and the rate of water and nutrient transport are important factors influencing rooting on cutting propagation. The modest size usually has more beneficial to rooting success.

Conclusion

The result of research revealed that three parameters of air layering which was taken from coppices are highly significant different. Those parameters are shoot length and shoot number as well as percentage of rooted air layering. Meanwhile, only two parameters of air layering which was taken from normal trees are significantly different, namely shoot number and percentage of rooted air layering. Overall results for air layering which was taken from coppices revealed that 1,000 ppm of IBA obtained the best results compared to other treatments. The most interesting result on air layering of branches taken from coppice is that without any additional growth regulator to the air layering propagation is also still possible. While, air layering which was taken from normal trees revealed that the best treatment is 3,000 ppm of IBA. The result of experiment shows that the IBA seems to be more effective in regulating growth and rooting of *E. zwageri* air layering for both air layering resources compared to IAA.

Recommendation

Based on the research results, it is recommended to use 1,000 ppm of IBA for promoting root system on air layering which was taken from coppices while using 3,000 ppm of IBA for air layering which was taken from normal adult trees.

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