ECTOMYCORRHIZAL FUNGI INCREASED EARLY GROWTH OF *Shorea balangeran* (Korth.) Burck UNDER NURSERY AND FIELD CONDITIONS IN DEGRADED PEAT SWAMP FOREST

(Fungi Ektomikoriza Meningkatkan Pertumbuhan Awal *Shorea Balangeran* (Korth.) Burck pada Kondisi Persemaian dan Lapangan di Hutan Rawa Gambut Terdegradasi)

by / oleh :

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ABSTRACT

Seedlings of *Shorea balangeran* (Korth.) Burck were inoculated with spores of four ectomycorrhizal (ECM) fungi, *Calvatia* sp., *Boletus* sp., *Scleroderma* sp. and *Strobilomyces* sp., and were grown in pots containing sterilized peat soil for six months under nursery conditions and transplanted in field conditions. Four ECM fungi were collected from peat soil of Nyaru Menteng, Palangka Raya, Central Kalimantan. Six-months-old inoculated seedlings were transplanted into degraded peat-swamp forest. The ECM fungal colonization was 59-67% in inoculated seedlings under nursery conditions. Colonization of *S. balangeran* (Korth.) Burck increased shoot height, stem diameter, leaf number, and shoot fresh and dry weight 6 months after transplanting under nursery conditions. Shoot height, stem diameter, leaf number and survival rates of *S. balangeran* (Korth.) Burck were higher in the inoculated seedlings 40 months after transplanting under field conditions than in the control seedlings. It is suggested that inoculation of indigenous ECM fungi in native tree species is useful for reforestation of degraded peat-swamp forests.

Keywords : ectomycorrhiza, spore, *Shorea balangeran* (Korth.) Burck, peat-swamp forest, nursery and field.

ABSTRAK

Bibit *Shorea balangeran* (Korth.) Burck telah diinokulasi oleh empat jenis cendawan ektomikoriza (ECM) *Strobilomyces* sp., *Calvatia* sp., *Boletus* sp., dan *Scleroderma* sp. selama enam bulan di persemaian dan ditanam 40 bulan pada kawasan hutan rawa-gambut terdegradasi di Kalimantan Tengah. Empat jenis cendawan ektomikoriza berasal dari Nyaru Menteng, Palangka Raya, Kalimantan Tengah. Benih *S. balangeran* (Korth.) Burck diinokulasi dengan spora empat jenis ECM dan ditumbuhkan pada polybag yang berisi gambut selama enam bulan di persemaian. Bibit *S. balangeran* (Korth.) Burck yang telah berumur enam bulan ditanam pada kawasan hutan rawa-gambut yang terdegradasi. Kolonisasi ektomikoriza *Boletus* sp. Dan *Scleroderma* sp. secara signifikan meningkatkan pertumbuhan tinggi dan diameter *S. balangeran* (Korth.) Burck 40 bulan setelah ditanam di lapangan. Dari hasil penelitian ini bahwa diperlukan inokulasi ECM lokal terhadap pertumbuhan jenis-jenis Dipterokarpa pada kondisi di persemaian untuk mempercepat rehabilitasi kawasan hutan rawa-gambut terdegradasi.

Kata kunci: ektomikoriza, spora, *Shorea balangeran* (Korth.) Burck, hutan rawa-gambut, persemaian dan lapangan.

I. INTRODUCTION

The biological and economic importance of *Dipterocarpaceae* lies in the extraordinary dominance of its members over vast areas in tropical rain forests of Southeast Asia (Bawa, 1998). With approximately 510 species and 16 genera, the family may not be particularly large among tropical woody groups. Other families such as *Euphorbiaceae*, *Myrtaceae*, *Rubiaceae*, *Annonaceae*, and *Lauraceae* have more taxa than the *Dipterocarpaceae*, however, they are pan tropical in distribution. Some important genera of *Dipterocarpaceae* are *Shorea*, *Dryobalanops*, *Hopea*, *Vatica*, *Parashorea* and *Dipterocarpus* (Soerianegara and Lemmens, 1994). *Shorea* consist of about 194 species and be the greatest diversity occurs in Sumatra (23 species), Mollucas (1 species) and Kalimantan (62 species). Unfortunately, their existence is decreasing because of over-exploitation, forest fire and illegal logging. *Shorea balangeran* (Korth.) Burck is distributed over scattered locations of Bangka, Belitung and Kalimantan islands and attain a height of 30 m and diameter up to 60 cm. This species is common and occurs often gregarious in tropical peat-swamp forest. *S. balangeran* (Korth.) Burck is economically important, because it produces a major source of durable wood (heavyweight hardwood) and valuable resin can be obtained from the wood.

Tropical peat-swamp forests have been decreasing due to forest fire, illegal logging, conversion of forests into industrial and agricultural lands, rubber tree and palm oil plantation or forest plantation estate for pulp and paper. Degraded peat-swamp forests are recognized as low values of forest resources without successful natural regeneration and dominated by grassland including fern, sedge or scrub (Page et al., 1999; Kobayashi, 2000). Indonesian government has a program of national movement to accelerate rehabilitation of degraded peat-swamp forests. However, it is not easy to rehabilitate this ecosystem immediately because it is necessary to select and produce high-quality tree seedling species for rehabilitation. *Mycorrhizas* affect the maintenance of vegetation in various ecosystems, and may play an important role in rehabilitation of degraded peat-swamp forest (Tawaraya et al., 2003).

Dipterocarpaceae, *Fagaceae*, *Pinaceae*, and some genera of *Myrtaceae* are known to form *ectomycorrhizas* (ECM) (Alexander and Lee, 2005). All *Dipterocarpaceae* surveyed to date are associated with ECM fungi (Högberg, 1982; Smits, 1994; Lee, 1998), and fungal families with greatest diversity in Southeast Asian dipterocarps forests include the *Sclerodermataceae*, the *Russulaceae*, the *Boletaceae* and the *Amanitaceae* (Smits, 1994; Sims et al., 1997). ECM fungi may have a great potential for the regeneration of tropical forests *Dipterocarpaceae* is a large and diverse family, with great ecological amplitude, and ECM dipterocarps are found in a wide range forest types, growing under wide range of nutrient regimes (Smits, 1994; Alexander and Lee, 2005). The ECM formation has been shown to increase plant growth of *Shorea curtisii* Dyer ex King and *S. Leprosula* Miq. (Lee and Lim, 1989), *S. macroptera* Dyer (Turner et al., 1993), *Hopea odorata* Roxb. and *H. helferi* Brandis (Yazid et al., 1994) under nursery conditions. However, little is known about the effect of ECM inoculation on the growth of dipterocarps species or *Shorea* species originated from a peat-swamp forest under nursery conditions.

In tropical forest, the use of ECM *Pisolithus tinctorius* (Pers.) Coker & Couch has been tested with *Pinus caribaea* Borelet in field conditions after three years on savana in Liberia, Africa (Marx et al., 1985). Five ECM fungi increased plant growth of hybrid eucalypts (*Eucalyptus urophylla* S.T. Blake x *E. kirtoniana* F. Muell) 50 months after outplanting in a nutrient-poor acidic sandy savanna soil in the Congo, Africa (Garbaye et al., 1988). This kind of field experiment has been already described in temperate area with four ECM species inoculated to *Pseudotsuga menziesii* (Mirbel) Franco (Douglas Fir) in northern Spain (Pera et al., 1999), and

ECM *Laccaria bicolor* (Maire) P.D. Orton inoculated to *P. menziesii* (Mirbel) Franco (Douglas Fir) in central France (Selosse et al., 2000). However, there are no reports on the effect of ECM inoculation on the growth of *Shorea* species origin from a peat-swamp forest under field conditions.

Several works have been reported on the type of ECM inoculum used in tropical tree species. Mycelia of ECM have been inoculated to increase plant growth of *Hopea* spp. (Yazid et al., 1994). Tablet spores of ECM have confirmed to be effective on several eucalypt species (de la Cruz, 1990). Spore suspension of ECM fungi has been tested to tropical tree *Eucalyptus urophylla* S.T. Blake (Chen et al., 2006) and cuttings of *Shorea leprosula* Miq. (Omon, 2002), but little work has been undertaken on the inoculation of dipterocarps with fungal spore suspension. Objectives of this study were to investigate the effect of four ECM species inoculation using spore suspension on plant growth of *Shorea balangeran* (Korth.) Burck under nursery and field conditions. These ECM fungi were chosen because they are native in peat-swamp forest.

II. MATERIALS AND METHODS

Seeds of *S. balangeran* (Korth.) Burck were obtained from Nyaru Menteng arboretum in Central Kalimantan, Indonesia (2° 43' S; 111° 38' E). Peat soil used for the pot experiment was collected from a peat swamp forest in Kalampangan, Palangka Raya, Central Kalimantan (2° 13' S; 113° 56' E). Peat soil was sterilized in a drum by heating over a wood fire for 1 hour. The pH (H₂O) of the peat soil was 3.3, available P (Bray-1) was 5.91 mg kg⁻¹. A preliminary experiment showed that this sterilization procedure got rid of most of the ECM and pathogenic fungi. Seeds of *S. balangeran* were soaked for two hours and gently washed with running water. These seeds were sown in polyethylene pots (size 15 cm × 10 cm) containing 500 g sterilized peat soils. Pots containing seeds were transferred to a nursery at the University of Palangka Raya, Central Kalimantan. One seedling was grown per pot under a 75% shading intensity net to control solar radiation.

Fruit bodies of *Calvatia* sp., *Boletus* sp., *Scleroderma* sp. and *Strobilomyces* sp. were obtained from basidiomes in the field under native trees of *S. balangeran* at Nyaru Menteng arboretum in Central Kalimantan. Fruit bodies were identified previously by Dr Tamai (Hokkaido University, Japan) in 2002. Each fruit bodies of ECM species were blended in distilled water (1:10, v/v) for 60 s using a blender on low speed. A drop of Tween 80 was added to assist suspension. Inoculation of seedlings was carried out 10 days after germination. Seedlings in each treatment were given 10 ml of spore suspension. The spore suspension was added in a 2-3 cm deep hole near the seedling using a five ml pipette. All pots were put on bricks in nursery beds to avoid cross contamination and to ensure good drainage. The seedlings were irrigated with tap water everyday and weeds were removed. The following treatments were used: (1) untreated (control), (2) *Calvatia* sp., (3) *Boletus* sp., (4) *Scleroderma* sp. and (5) *Strobilomyces* sp. There was no mixture ECM in this study because the study would like to know the best one of ECM fungi.

Experiment site was located in Kalampangan zone near Kapuas border, Central Kalimantan. The peat soil at study site has very low pH (<4), this is assumed due to a high organic matter which producing some organic acid compounds through decomposition process under waterlogged conditions (Tuah et al., 2000). Annual precipitation is 2776 to 3393 mm/year; mean annual temperature is 30°C. Natural regeneration was very poor. Native vegetations of this site are dominated by *Combretocarpus rotundatus*, *Melaleuca cajuputi*, *Polystichum setiferum*, *Imperata cylindrica*, *Melastoma* sp. and various species of grasses. In November 2002, one

hundred of seedlings per treatment were planted in Kalampangan. The seedlings were planted individually in planting hole (15 cm x 15 cm x 15 cm) and a line spacing was 1 m x 1 m. Maintenance of the seedlings after transplanting was each six months in the first year of plantation. Chemical fertilizer was not added in the nursery and the field experiment.

Shoots and roots were harvested six months after being inoculated with ECM fungi. Shoot height, stem diameter, leaf number, and fresh and dry weight were measured. After measuring the fresh weight of shoots, its dry weight was determined after drying at 70°C for 72 hours. To calculate the percentage of ECM colonization, roots were cleaned using running water to separate them from the soil and then the root systems were spread on trays. The total number of root tips and the number of ECM short roots were counted under a dissecting microscope.

Verification of ECM colonization was obtained by examining the cross section of root tips (cut manually) under a compound microscope for the presence of mantle and Hartig net (Brundrett *et al.*, 1996). Plant height, leaf number and survival rates were measured 2, 4, 6, 8, 14, 16, 19, 22, and 25 months after transplanting in field conditions. Plant height, stem diameter, and survival rates were measured 40 months after transplanting in field conditions. Survival rates were calculated as follows; Survival rates (%) = number of viable seedlings / number of initial seedlings 100 x 100. Data were statistically analyzed using analyses of variance (ANOVA) with the statistical software StatView 5.0 (Abacus Concepts). Comparison of means was done using the least significant difference (LSD) method at 5% probability level where the F-value was significant.

III. RESULTS

A. Nursery conditions

At the end of 6 months in nursery, *Calvatia* sp., *Boletus* sp., *Scleroderma* sp. and *Strobilomyces* sp. formed ECM in *S. balangeran* seedlings. ECM colonization was higher than 50% in all inoculated seedlings (Table 1.). There was no difference in percentage colonization between four ECM species. Control seedlings were colonized by indigenous of ECM fungi. In the nursery conditions, ECM colonization of *S. balangeran* using spores suspension of *Calvatia* sp., *Scleroderma* sp. and *Strobilomyces* sp. increased plant height, fresh and dry weight (Table 1.). ECM colonization of *Boletus* sp. Increased only plant height. There was no difference in stem diameter and leaf number between four ECM and control seedlings.

Table 1. Shoot height, stem diameter, leaf number and ectomycorrhizal colonization of *S. balangeran* inoculated with four ECM fungi six months after transplanting under nursery conditions in Palangka Raya, Central Kalimantan

Treatment	Plant growth					ECM colonization (%)
	Shoot height (cm)	Stem Diameter (mm)	Leaf number (/plant)	Fresh weight (g/plant)	Dry Weight (g/plant)	
Untreated	23.8a*	2.3a	9.0a	2.0a	0.68a	12a
<i>Calvatia</i> sp.	31.2b	2.4a	9.7a	3.4b	1.12c	67b
<i>Boletus</i> sp.	28.7b	2.4a	10.0a	2.2a	0.74a	67b
<i>Scleroderma</i> sp.	28.7b	2.4a	9.0a	2.7b	0.88b	60b
<i>Strobilomyces</i> sp.	27.5b	2.4a	9.3a	2.5b	0.91b	59b

*Values with the same letter are not significantly different ($p < 0.05$)

B. Field conditions

In the field conditions, ECM colonization did not increased plant height and leaf number two, four and six months after transplanting (Table 2.). There was no significant difference between four ECM species and control seedlings.

Table 2. Shoot height, leaf number and survival rates of *S. balangeran* inoculated with four ectomycorrhizal fungi two, four and six months after transplanting under field conditions in Kalampangan zone, Central Kalimantan.

Treatment	Parameter								
	2 months			4 months			6 months		
	Height (cm)	Leaf number (/plant)	Survival rates (%)	Height (cm)	Leaf number (/plant)	Survival rates (%)	Height (cm)	Leaf number (/plant)	Survival rates (%)
<i>Untreated</i>	41.01a*	9.2a	100	44.95a	6.3a	96	49.46a	7.6a	88
<i>Calvatia</i> sp.	43.79a	9.9a	100	46.03a	6.5a	98	53.32a	8.0a	94
<i>Boletus</i> sp.	43.28a	8.6a	100	45.45a	6.1a	91	55.00a	8.3a	86
<i>Scleroderma</i> sp.	41.02a	7.1a	100	47.18a	6.6a	95	54.38a	9.0a	87
<i>Strobilomyces</i> sp.	39.66a	6.4a	100	42.64a	5.2a	94	48.22a	6.9a	93

*Values with the same letter are not significantly different ($p < 0.05$)

ECM colonization of *Boletus* sp. and *Scleroderma* sp. increased plant height and leaf number 8, 14, 16, 19, 22, and 25 months after transplanting (Fig. 1). There was no difference in height and leaf number between *Calvatia* sp., *Strobilomyces* sp. inoculated and control seedlings. ECM colonization of *Boletus* sp., *Scleroderma* sp. and *Strobilomyces* sp. increased plant height and stem diameter 40 months after transplanting in the field (Table 3.). ECM colonization of *Calvatia* sp. increased only plant height. There was not different in stem diameter between *Calvatia* sp. inoculated and control

Seedlings. Survival rates of *S. balangeran* seedlings were increased with ECM colonization of *Calvatia* sp. and *Strobilomyces* sp. 40 months after transplanting in the field (Table 3.).

Fig 1. Shoot height and leaf number of *S. balangeran* (Korth.) Burck inoculated with four ECM fungi 8, 14, 16, 19, 22 and 25 months after transplanting under field conditions in Kalampangan zone, Central Kalimantan (○ untreated; ■ *Calvatia* sp.; □ *Boletus* sp.; ■ *Scleroderma* sp.; ■ *Strobilomyces* sp.).

Table 3. Shoot height, stem diameter and survival rates of *S. balangeran* (Korth.) Burck inoculated with four ectomycorrhizal fungi 40 months after transplanting under field conditions in Kalampangan zone, Central Kalimantan

Treatment	Parameter		
	Height (cm)	Stem diameter (cm)	Survival rates (%)
Untreated	206.63a*	2.74a	83
<i>Calvatia</i> sp.	222.57c	2.83a	89
<i>Boletus</i> sp.	240.45c	3.03b	81
<i>Scleroderma</i> sp.	233.53c	3.67c	79
<i>Strobilomyces</i> sp.	213.55b	3.28c	85

*Values with the same letter are not significantly different ($p < 0.05$)

IV. DISCUSSION

Even though the ECM of *Dipterocarpaceae* in tropical rain forests of Southeast Asia has been reported (Alexander *et al.*, 1992; Smits, 1994; Lee and Alexander, 1996), the role of ECM in dipterocarps species originated from peat-swamp forest needs to clarify. Our results demonstrate for the first time that ECM fungi have positive effects on *S. balangeran* (Korth.) Burck six months under nursery conditions and 40 months after transplanting in the field. Colonization by four ECM species were identified as the most appropriate fungi for improving early growth of *S. balangeran* (Korth.) Burck six months under nursery conditions. Furthermore, *Boletus* sp. and *Scleroderma* sp. proved to be competitive and effective to increase plant growth of *S. balangeran* (Korth.) Burck 40 months after transplanting in the field. Therefore, *Boletus* sp. and *Scleroderma* sp. are to be ECM fungi candidate for production of *S. balangeran* (Korth.) Burck under nursery and field conditions. Ecological categories of ECM fungi may be more useful for summarizing fungal performance in the field than in the growing conditions of nurseries (Brundrett *et al.*, 2005; Omon (2002).

Plants with *Calvatia* sp., *Boletus* sp., *Scleroderma* sp. and *Strobilomyces* sp. were not different in height, and leaf number than untreated seedlings during the 2 - 6 months in field conditions. At the time, November 2002-May 2003 was rainy season. It was possible due to waterlogged conditions that all roots of *S. balangeran* (Korth.) Burck were in very saturated with water. Water table in experiment site was close to or above the peat surface throughout 6 months fluctuates with the intensity and frequency of rainfall. Water has become a factor creating other problems i.e. waterlogged stress. Rhizosphere is the part of plant in stress conditions when the oxygen supply for root consumption is being reduced mainly by microorganism respiration. Anaerobic respiration may leads to the synthesis and translocation of some toxic components, and affected various processing activities within plants (Naiola and Osaki, 2000). The transplanting shock and waterlogged conditions by the ECM plants six months after transplanting could be critical to the success of the plantation. After eight months transplanting in the field (July 2003), *Boletus* sp. and *Scleroderma* sp. increased the growth of *S. balangeran* (Korth.) Burck in drought periods. Both ECM species consistency increased plant growth 14, 16, 19, 22, 25, and 40 months after transplanting in the field. *Boletus* sp. and *Scleroderma* sp. were more adaptable compared with *Strobilomyces* sp., *Calvatia* sp., and control seedlings in waterlogged and drought periods. *Strobilomyces* sp. and *Calvatia* sp. lately increased of plant height of *S. balangeran* (Korth.) Burck 40 months after transplanting under field conditions. Field experiments are affected by strong variation in climatic, such as waterlogged conditions in

the rainy season or drought periods in the summer, *edaphic* and microbiological factors can influence the spreading of ECM inoculated to waterlogged or drought and cause a lack of inoculation effects (Pera *et al.*, 1999). According to our knowledge, there are no references in the literature indicating ECM effect on *S. balangeran* (Korth.) Burck in Southeast Asia region. In Madagascar, the use *Pisolithus microcarpus* increased plant height of *A. crassicaarpa* 19 months after transplanting in the field experiment (Ducousso *et al.*, 2004). In a dry tropical area, *Pisolithus albus* and *Scleroderma dyctiosporum* increased plant growth of *Acacia holosericea* after 24 months transplanting in the field in Senegal (Duponnois *et al.*, 2005). In temperate area, *Laccaria bicolor* mycelia or spore suspensions of *Melanogaster ambiguus*, *Rhizopogon colossus*, and *R. subareolatus* increased plant growth of *Pseudotsuga menziesii* 5 years after transplanting in northern Spain. *Laccaria bicolor* increased plant growth of *P. menziesii* eight years after transplanting in France (Selosse *et al.*, 1999). In Spain, *Rhizopogon* spp. increased plant growth of *Pinus pinea* 20 months after transplanting in formerly arable land (Parladé *et al.*, 2004).

Survival rates of seedlings are important for the first establishment plant growth of *S. balangeran* (Korth.) Burck after transplanting in the field. The role of ECM in the survival rates of *S. balangeran* (Korth.) Burck requires more careful analyses because survival rates were not different between ECM seedlings and control seedling. Survival rates of ECM plants in average were decreased four months (94.5%) and six months (90%) after transplanting in the field conditions. Control seedlings were also decreased four months (96%), and six months (88%) after transplanting. It was possible also that waterlogged conditions can affect the survival rates of ECM plants. Survival rates of ECM plants were consistency steady in 8, 14, 16, 19, 22 and 25 months (88%) after transplanting and control seedlings were in 86%. Moreover, survival rates of ECM and control plants were not different (83%) in 40 months after transplanting in the field. It was possible that there was cross contamination with inoculated plants because line spacing was only 1 m x 1 m. If control plants were colonized by ECM fungi of inoculated plants they could increase plant growth of control plants. However, we didn't measure ECM colonization 40 months after transplanting under field conditions. In a dry tropical area, survival rates of *A. holosericea* inoculated by *Pisolithus albus* or *Scleroderma dictyosporum* were higher (98-100%) than control plants (81%) 12 months after transplanting in the field in Senegal. In the temperate forest, inoculation with *Rhizopogon roseolus* increased in 20% the survival of *Pinus pinea* seedlings over control seedlings after 43 months outplanted in Spain (Parladé *et al.*, 2004). Efforts to inoculate tree seedlings with ECM fungi have generally focused on one fungus or a limited number of fungi, which may not be appropriate if benefits from increased fungal diversity are expected, or improved functional diversity is required (Brundrett *et al.*, 2005). It may be possible that in disturbed habitats, there is a succession of ECM fungi where a few pioneering fungi are gradually replaced by an increasing diversity of ECM fungi characteristic of undisturbed habitats (Gardner and Malajczuk, 1988; Lu *et al.*, 1999). Because of the difficulties of monitoring the ECM fungal species in the field samples without using molecular techniques (Di Battista *et al.*, 2002), no data on the determination of each ECM inoculated in the root systems of *S. balangeran* plants are available. Field growth performance of *S. balangeran* (Korth.) Burck is still observed for several years.

In this study, spore density of each ECM species was not measured and it is not known how many spores germinated under nursery conditions and resulted in ECM formation with *S. balangeran* (Korth.) Burck. Spore density can influence ECM formation (Lu *et al.*, 1998). Furthermore, Chen *et al.* (2006) recommended that spore densities of *Scleroderma* species 10^4 be used for inoculation of containerized eucalypts and that spores be stored at 4° C until use. The main disadvantages of spore *inoculum* are genetic variability, the lack reliable laboratory methods to determine spore viability and the delay in mycorrhization compared with vegetative

mycelium (Brundrett *et al.*, 1996). The use of *Boletus* sp. spores in nursery scales is not widely practiced however because amount of *Boletus* sp. spores are limited compared with *Scleroderma* sp. spores. *Boletus* sp. may also be possible to develop with vegetative mycelium. These vegetative inocula of selected fungal strains have been recommended as the preferred method (Brundrett *et al.*, 1996). However, large quantities of viable inoculum are needed for application on an operational scale and the storage of vegetative inoculum usually adversely influences its effectiveness. Spore-based inoculum was also easier to use and much less expensive to produce than mycelial slurries. *Scleroderma* sp. are also good candidates for inoculating programs in degraded peat-swamp forest since these species apparently adapt to many ecological habitats and they are easy to use as spore inoculum (Jeffries, 1999; Chen *et al.*, 2006). Further research on factors that regulate spore germination is required to improve both the speed and consistency of ECM formation. It may also be possible to increase the reliability of inoculation by using mixtures of fungal taxa (Brundrett *et al.*, 2005).

V. CONCLUSION

In conclusion, colonization of four native ECM species can increase plant growth of *S. balangeran* (Korth.) Burck 6 months after transplanting under greenhouse conditions. Colonization *Boletus* sp. and *Scleroderma* sp. can consistency increase plant growth of *S. balangeran* (Korth.) Burck 40 months after transplanting in the field. *Strobilomyces* sp. and *Calvatia* sp. was delay to increase only of plant height of *S. balangeran* (Korth.) Burck after 40 months under field conditions. Survival rates of *S. balangeran* (Korth.) Burck were not different between ECM and untreated plants. These results were affected by climatic influences, such as waterlogged or drought periods can reduce the first establishment of ECM plants in the field conditions. *Boletus* sp. (late stage) and *Scleroderma* sp. (early stage) can be used to inoculate *S. balangeran* (Korth.) Burck in nurseries because these fungi are well adapted to the environment conditions encountered in this area which could explain this better effect on plant growth. It is suggested that inoculation of indigenous ECM fungi to native tree species under nursery conditions is useful for rehabilitation degraded peat-swamp forests.

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