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Implementation of Plant Selection Based-On Plant Growth on Revegetation of Peatland in South Kalimantan

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Abstract**—***Tropical peatland is remaining to play a critical geographic, political, and economic role in globalization. Revegetation maintains a vegetation cover on peat and able to increase humidity and decreasing fire risks. The selection of adaptable plants that growing on peatland are the main factors of revegetation accomplishment. The location of the research was in the peat forest of Pulantani village, Haur Gading District, Hulu Sungai Utara Regency, South Kalimantan Province, Indonesia and carried out for 12 months. The plants used are Dyera costulata, Hevea brasiliensis, Melaleuca cajuputi, and Shorea balangeran. Revegetation species were analyzed by calculating percent of plant life and plant growth. Characteristics of revegetation area of the peat forests cover with pure stands of trees and poles of Combretocarpus rotundatus species. Percent of plant life during seed distribution activities are varies between the four species. S.balangeran has the highest percentage of life with a value of 97%, H.brasiliensis has 96%, M.cajuputi has 88% and D.costulata has 77%. There was a decrease in percent growth over time after planting with S.balangeran has the highest percentage compared to other types. Percent growth of S.balangeran is 100% at the beginning of planting (t_0), 96.7% after 1 month of planting (t_1), 93.4% after 3 months of planting (t_2), 84.40% after 8 months of planting (t_3) and decreased up to 55% after 12 months of planting (t_4). Although the phenomenon that occurs is that no tree species achieves 75% growth success , S.balangeran is highly recommended as a selected species in the revegetation of peatlands.*

Keywords**—*****Peatland, plant species, plant growth, revegetation, S.balangeran.***

I. INTRODUCTION

Peatlands along with tropical forests are providing not only important on the ecological, but also benefits to climate [1] and a wide range of socio-economic from the local to the global scale. However, it is threatened by anthropogenic activities, including agricultural conversion, timber harvesting, peatland drainage and associated fire [2]. Southeast Asian as a region with 60% of global tropical peatland, is continuing to play a critical geographic, political, and economic role in globalization [3].

Indonesian peatlands have been damaged due to various activities. Forest Watch Indonesia in 2014 was reporting that the area of natural forest lost on peatlands reached 1.1 million ha from 2009 - 2013. Kalimantan as one of the largest islands in Indonesia that has peat forest is indicating the area of peatlands had decreased by 2.9% per-year over a period of 20 years. Peat swamp area in Kalimantan has decreased from an area of 4.93 million ha to 2.18 million ha from 1990-2010 million ha [4]. Burnt peat forests generally have low natural regeneration [5]. A study by [6] shows that the relative humidity contributes most to the burned area in Kalimantan. Meanwhile, revegetation is able to maintain a vegetation cover on peat and increasing humidity in the soil and air, slowing peat decomposition and also decreasing fire risks, thus becoming the second important tenet of peatland restoration after restoration of the hydrology [7]. Moreover, peatland restoration is also maintaining carbon pools (Vasquez, 2021). Furthermore, it is recommended that forest cover should be maintained at the existing level [8]. Peat rehabilitation is a conservation effort in order to save peat forests. Rehabilitation activities can be carried out by using revegetation methods. Revegetation is also expecting to improve damaged peat ecosystems.

An important factor determining the success of revegetation is by selection of the right species and adaptable to the peat environment. The selection of local species (native species) is highly recommended since it has several advantages including aspects of plant health, land productivity, biodiversity and ecosystem services [9] - [12]. Some species recommended in the rehabilitation of peat swamp forest rehabilitation are including *Dyera lowi, Alstonia pneumatophora, Combretocarpus rotundatus, Shorea pauciflora, Tetramerista glabra, Melanorrhoea walichii, Barringtonia racemosa, Syzigum spp*. and *Gonystylus bancanus* [13].

Previously, [14] shows *S.balangeran*, *M.cajuputi* and *D.costulata* as vegetations that grow on the peatland. *M.cajuputi* dan *S.balangeran* were found to be dominant in the peat forest of Muara Kendawang, West Kalimantan [15]. *M.cajuputi* and *S.balangeran* are the main commodities of paludiculture for peatlands in South Kalimantan and Central Kalimantan [16]. One of the species suitable for planting in burnt peat swamp forests is including *S.balangeran* [17], [18] and *D.costulata* [18]. *D.costulata* is the most suitable species to be developed on deep peatlands due to it has the fastest growth [19]. *Hevea brasiliensis* is an exotic plant that can grow on peatlands. Seedling plant species in this research consist of four species that are three local peat forest species and a type of exotic species. Those selected species as recommended [20] are *Dyera costulata, Melaleuca cajuput, Shorea balangeran* and *Hevea brasiliensis* (as an exotic species).

One of the area in Kalimantan which has peatlands is Pulantani Village, Haur Gading District, Hulu Sungai Utara Regency, South Kalimantan. Peatlands in Pulantani village are being degrading. Repeated fires are a phenomenon that occurs in the Pulantani village peatlands. According to the results of identification of the degradation level of existing peatlands, the Pulantani village area is considered as a priority area for revegetation. The problems of revegetation activities in peatland are limited on the environmental components. The relatively long drought in the dry season triggers land/forest fires. The long period of the rainy season also triggered flooding in the peat forest area. Low pH and soil fertility are also limiting factors in revegetation in peatlands. These constraints can be solved by various effort. One of the efforts is selecting suitable species to plant in peat areas.

II. MATERIAL AND METHODS

The research location is in the peat forest of Pulantani village, Haur Gading District, Hulu Sungai Utara Regency, South Kalimantan Province, Indonesia. The times of data collected were 12 months (December 2018 - December 2019). The times needed in data collection are t_0 = early planting, t_1 = 1 month after planting, t_2 = 3 months after planting, t_3 = 8 months after planting and t_4 = 12 months after planting. Description of research location is shown in Fig.1.

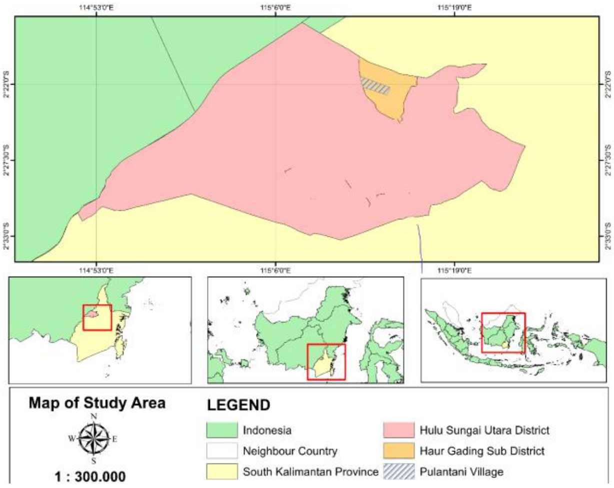

Fig.1: Map are of research location

The research equipment includes field survey tools, distance measuring tools, camera for documentation and a set of computers. The observation of plant composition on peat land for revegetation area is using quadrats plot. There were 15 plots of 10 m x 10 m area measurements and placed in revegetation site. The 10 m × 10 m used to record trees with DBH (Diameter at Breast Height) ≥ 5 cm. The vegetation parameters were number of individuals and species identity. Data of the composition of vegetation types are analyzed descriptively in the revegetation plot. Hypothetically, there are at least 2 species of tree vegetation (woody plants) contained in the planned revegetation location.

The plant species acting as material were *Dyera costulata (D.costulata)*, *Hevea brasiliensis*

(H.brasiliensis), *Melaleuca cajuputi* (*M. cajuputi*), and *Shorea balangeran (S.balangeran)*. The height of the plant seeds used in the study was ± 100 cm. Plant height after early planting in the field was ± 80 cm. During planting plot of peat revegetation, spacing used in planting plot is 4 m x 5 m and equal to 500 seedling/ ha. The planting plot was 21 ha in size, so that there were total of 10,500 seedlings used. The planting hole made with a size of ± 30 x 30 x 30 cm^3. The data recorded is the number of individuals and the number of plant species. The data used are the results of measurements at t_0 = early planting, t_1 = 1 month after planting, t_2 = 3 months after planting, t_3 = 8 months after planting and t_4 = 12 months after planting. Data analyzed by calculating the percentage of plant growth. Percent growth measurement carried out through the following formula:

$$T = \frac{\sum hi}{\sum Ni} \times 100\% \qquad (1)$$

where:

T = percent of plant growth

$\sum hi$ = number of living plants

$\sum Ni$ = the total number of plants planted

The standard of success for revegetation growth used is 75% (according to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.105/Menlhk/Setjen/Kum.1/12/2018 concerning Procedures for Implementation, Supporting Activities, Providing Incentives, and Guidance and Control Forest and Land Rehabilitation Activities). The research hypothesis is that all species selected have a survival rate > 75%

III. RESULTS

The site of revegetation of peat forest in Pulantani village is dominated by tree (≥ 10 cm dbh) of *Combretocarpus rotundatus* due to repeated fires have limited tree species that can grow on peatlands. These limitations cause only *C.rotundatus* that can live and develop to form a pure stand.

The number of tree species consisting of one species is an indication that the peat revegetation area has been degraded. Repeated fires result in only certain species that can survive. *C.rotundatus* is included in the category of less fire tolerant species that can adapt to repeated fire events [21]. This result is different from the hypothesis that there are at least 2 species found in degraded peat forests. It is also different from [22] that burned peat areas were dominated by pioneer species such as *C.rotundatus* dan *Cratoxylon arborescens.* Meanwhile, *Malaeuca cajuputi* is pioneer wood species that usually occur in degraded peatland [23]. *M.cajuputi* is a species of a tree vegetation that is able to grow on peat swamp soil in South Kalimantan and has a low pH [24]. Based on the density of trees, stands of *C.rotundatus* are included in the rare category. Descriptions of vegetation found in revegetation sites are shown in Fig.2.

Fig.2: C.rotundatus stands on the peatland

There are at least 6 species of undergrowth are found on revegetation area of peatland. Species of undergrowth were including *Eichhornia crassipes*, *Lepironia articulata*, *Melastoma malabathricum*, *Phragmite scarka*, *Salvinia molesta*, *Stenochlaena palustris*. *C.rotundatus* stands which are classified in the rare category cause revegetation patterns using enrichment planting models with a spacing of 4 m x 5 m (target number of plants of 500 stems /ha).

The percentage of seedling life during seed distribution activities are varies between species. The results of the percentage of plant life using Equation (1) are described in Fig.3. Fig.3 shows that the lowest percentage of plant life during seed distribution activities is *D.costulata*. Characteristics of seedlings with weak stems, morphological shapes of leaves and roots that are not firmly formed in the polybags compared to other related species are factors that cause *D.costulata* species to have low resistance during the seed distribution process. The height of *D.costulata* seedling with a size of ≥100 cm is unable be supported properly by the organic media available in the poly bag. Based on the field observations, the use of *D.costulata* seedling with a height of ± 30-40 cm is ideal and supported by planting media in a poly bag. Sufficient organic matter supported by the media in a poly bag is reducing the risk of death during seed distribution.

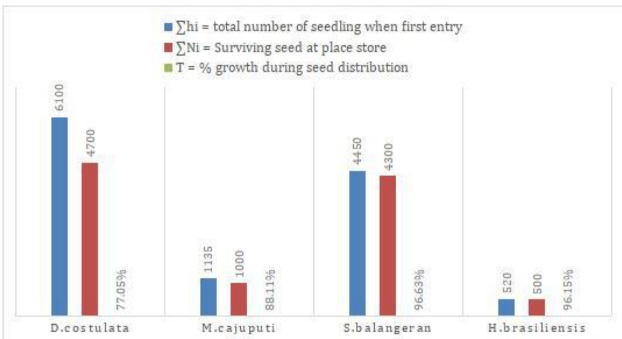

Fig.3: The percentage of seedling life during seed distribution activities

The ability of roots to be firmly supported by the media in a polybag in order to reduce the risk of death during seed distribution. Regulations in revegetation of peatlands require the use of seeds with a height of ≥ 100 cm. This phenomenon is considered during determining the height of the seedlings used in the revegetation in order to deliberate the characteristics of the use of plant species. The percentage of plant life had been measured from the beginning of planting (t_0), 3 months after planting (t_1), 8 months after planting (t_3), and 12 months after planting (t_4). The percentage of life obtained from research results are varies based on the species. The results of measurements of the number of live plants are listed in Table 1.

Table 1. Number of live plants in revegetation activities

Species	T_0	T_1	T_2	T_3	T_4
D.costulata	4700	4375	3520	340	80
M.cajuputi	1000	955	865	218	118
S.balangeran	4300	4157	4018	3645	2372
H.brasiliensis	500	478	470	210	10
Total	10500	9965	8873	4413	2535

The number of plants with the highest survival rate is *S.balangeran*, while the species with low survival rates are *D.costula* and *H.brasiliensis*. The weather factor in this case is the high rainfall that instigated flooding/inundation. It occurred in the 3rd, 4th and 5th month of planting activities. The long period of inundation with a height of ≥ 2 m has increased plant mortality. The dry season period starts from the 7th month to the 11th month. The percentage of plant life in revegetation activities is shown in Fig.4.

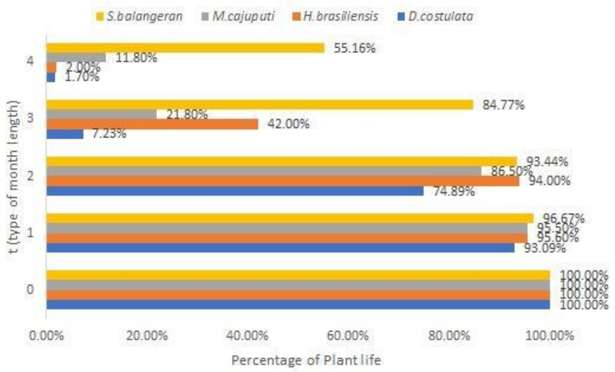

Fig.4: Correlation between number of plants (in percentage) and duration (in type of month length)

Percentage of plant life shows the difference between each plant. *S.balangeran* has the largest growth percentage from 100% at the beginning of planting (t_0), decreasing to 96.7% after 1 month of planting (t_1), decreasing to 93.4% at 3 months after planting (t_2), to 84.40 % after 8 months of planting (t_3) and decreased to 55% at 12 months after planting. Plant growth rates are still quite high at the beginning of planting until the 3rd month after planting (75% -94%). None of the species reached a survival rate of 75%. Species with growth percent > 50%, is *S.balangeran*. The success of growing *S.balangeran* is still higher than the results of other research which shows that the percent growth is only 50% after 8 months of planting (Tata and Pradjadinata, 2016)

The fourth month of the planting activity occurred inundations reaching ≥ 150 cm and exceeded plant height. Height and duration of inundation periods increase plant mortality. Flooded habitation impacted on the disruption of plant physiological processes and resulting in a lack of plant growth and even plant death [25]. Not all type of plants can withstand flood, plants will die after 4-6 weeks of inundation exceeding the height of the seeds planted [26]. *S.balangeran* indicated to be resistant to inundation. [27] stated *S.balangeran* still grow at a water level of 90 cm above the peat soil surface. In this research, *D.costulata* were not able to live well at the study site. However, *D.costula* seedling will develop well if planted with a mound system and not flooded for a long time. *D.costulata* seedling showed the best growth at a water level of 20 cm below the peat soil surface [18]. *H.brasiliensis* can grow well on peatlands if water management and cultivation techniques are carried out properly and correctly. Moreover, *H.brasiliensis* will produce good growth by planting a mound system and the ideal water level in peatlands is 60-100 cm.The 7th to 11th months enters a relatively long period of dry season. A period of drought and a rise in temperature during the dry season results in mortality in revegetation plants. Survival rate of seedlings that planted in reforestation area depends on tree adaptation to water logged, drought and fire [19].

The percentage of life of *S.balangeran* is higher than other species. It is indicating that *S.balangeran* is highly recommended for peat revegetation plants. For ecological value, *S.balangeran* is used as a promising species for restoring degraded peatland [28]. In addition, *S.balangeran* has a wide ecological range, able to grow in a variety of soil and environmental conditions, has adaptability in the open vegetation and able to compete with weeds [29]. [30] confirmed that *S.balangeran* could grow in very deep peat. *S.balangeran* grows on peat areas in which the water management has improved and grows dominantly on peat areas whose water systems have been damaged [31].

The high percentage of plant mortality is a signal that the number of seedlings for enrichment planting should be increased. Additional enrichment seeds in revegetation activities with a number of 20% of the total seeds should be considered to increase the number. This is related to the relatively low percentage of revegetation plant growth on peatlands.

IV. CONCLUSION

The peatland revegetation accomplishment on the limited capacity of land can be resolved by selecting well adapted species to the peatland environment. *S.balangeran* selection is highly recommended species for peatland revegetation activities. Percent growth above 50% is an indicator of well adaptation of *S.balangeran*. Periodicity of the long rainy season has the potential to cause inundation which can cause plant death. The dry season is a natural factor which has the potential to increase temperatures and fire events. The combination of climatic and edaphic factors from peat forests is a factor that limiting the success of plant growth. The percentage of the prepared seedlings during revegetation activities on peatlands must be in view of the phenomenon of the low success of revegetation of peatlands.

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