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Improvement of Falcataria moluccana Root Growth by Giving Empty Palm Oil Fruit Bunches (EFB) Biochar in Growing Media

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Abstract. Sengon (*Falcataria moluccana*) is a fast-growing species widely planted in Industrial Plantation Forests (IPF/HTI) and has high economic value. The provision of planting material must be well prepared and planned to get the appropriate nursery planting media composition. The Empty Palm Oil Bunches (EFB) biochar application improves soil's chemical and physical properties to provide nutrients for plants. This study aims to determine the effect of the application of EFB biochar on the growth of sengon roots. The experimental design was completely randomized (CRD) by applying four treatment levels and 20 repetitions. The treatments were (A) 100% soil (control), (B) 5% EFB biochar, (C) 10% EFB biochar, and (D) 15% EFB biochar. The data were then analyzed by analysis of variance to see the effect of the treatment on the observed root growth parameters, followed by the 5% Least Significant Difference (LSD) further test to determine differences between treatments. The parameters observed were root length, root volume, root wet weight, and root dry weight. The result showed that the application of EFB biochar increased the growth of sengon roots compared to the control. The greater the dose of the addition of EFB biochar given to the growing media, the more it showed a positive response in improving the growth of sengon roots. In this study, the 15% dose showed the best results compared to other treatments.

Keyword: Biochar, Empty Palm Oil Fruit Bunches (EFB), *Falcataria moluccana*, Pyrolysis, Waste

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1 Introduction

Along with the development of the building materials industry with its various uses such as mal board, simple furniture, match industry, pencils, particle board, and paper pulp industry raw materials [1] and the rate of forest degradation is getting higher, causing a gap between supply

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and demand for wood industry raw materials. Sengon (*Falcataria moluccana*) is a species of wood that has the potential to be developed to meet the increasing needs of the wood industry [2]. Therefore, to develop sengon cultivation, it is necessary to have sufficient quantities of quality seeds. The provision of planting material through the nursery process is the first step in developing the sengon industry by providing seeds that must be properly prepared and planned. In producing quality sengon seeds, which can later produce optimally, it is necessary to have the composition of the nursery planting media according to what is needed by the plant seeds.

Biochar is black charcoal resulting from heating biomass in limited or no oxygen conditions, called the pyrolysis process [3]-[4]. The characteristics of biochar are also influenced by the type of material used [5]. The lignocellulosic materials, such as wood and plant residues (rice straw, rice husks, empty oil palm bunches, and sago waste), are the raw materials for biochar [6]. The number of Empty Palm Oil Fruit Bunches (EFB) is 23% of the total fresh fruit bunches processed [7]. EFB waste is widely used as organic fertilizer in the form of compost [8]. Compost can improve soil properties but is easily decomposed by soil microbes, so it is needed in large quantities [9]. Based on this, organic matter is needed, which is difficult to decompose in the soil, one of which is biochar. Biochar is composed of aromatic carbon rings making it more stable and durable in soil [9] (> 400 years) because it is difficult to decompose [10]. The return of organic matter to the soil will affect the soil microbial population directly and indirectly affect the soil's health and quality [11]. EFB is used as biochar material because it contains nutrients needed by soil and plants [12] and as waste utilization.

The physical change of EFB, which has a large volume into a smaller biochar, can stimulate its application in growing media [13]. According to [14], biochar has a high ash content which causes the specific gravity of biochar to be very low. The ash content of EFB at a combustion temperature of 600^{o}C is 13.09% [15]. It makes biochar difficult to mix evenly with the planting medium. Therefore, mixing biochar with soil and water is applied to overcome the issue. Mixing biochar is expected to increase the specific gravity of biochar for a more effective and efficient application.

Providing EFB biochar in planting media plays a role in improving the chemical and physical properties of the soil [16]. Good soil physical properties will affect the ability of roots to grow and develop [17]. The ability to absorb nutrients and water also requires strong and wide roots, affecting plant productivity and growth [18]. Fast-growing species, such as sengon, require large amounts of nutrients, especially at the beginning of growth [19]. The efforts to increase the growth of sengon are by improving soil quality and providing nutrients for plants [20]. This study aims to determine the effect of EFB biochar application on sengon root growth during nursery as an effort to utilize EFB waste and restore biomass in the soil.

2 Research Method

The research was conducted at the Greenhouse and Laboratory of Silviculture and Forest Protection, Faculty of Agriculture, University of Lampung. The raw material for biochar was produced at a partner company, PT. Kendi Arindo. According to [4], the manufacture of biochar from the wet EFB materials is not directly burned. The arrangement of EFB in the kiln begins with a 40 cm high pile of bricks covered with a thin metal plate and dry rubber wood, which were placed under the metal plate as fuel during biochar production from EFB (Figure 1). Before the EFB was put into the kiln, perforated metal pipes were arranged vertically to distribute the hot gas from burning rubber wood. The EFB was then put into a kiln, and the dry rubber wood under a metal plate was burned.

The EFB biochar combustion process lasts three days at a peak temperature of 600°C. The kiln's temperature was measured every hour for four days and was adjusted by opening the control hole when the temperature decreased and closing it when it increased. The cooling process lasts for seven days. EFB biochar was crushed and sieved with a uniform size of about 0.5 mm and then mixed with soil and water before being applied as a growth medium for sengon.

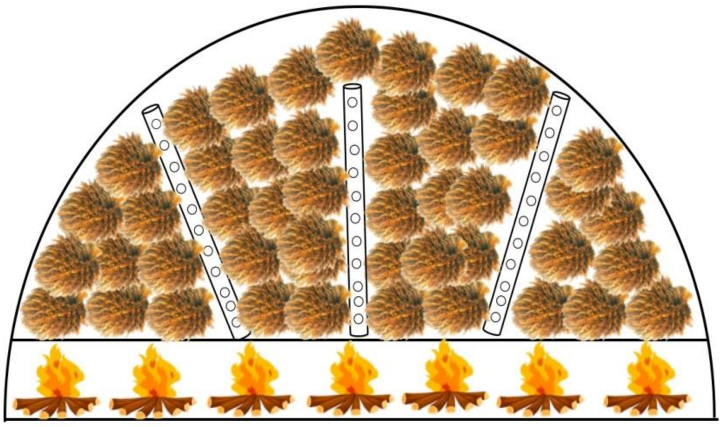

Figure 1 EFB arrangement in the kiln [7]

Sengon seeds were soaked in hot water at 80°C for 24 hours [21]. The seeds were then planted in sand media in a germination tub for one month. Next, the sengon seeds were transferred to the 7.5 x 20 cm polybags containing 250 g of soil. After that, EFB biochar was applied simultaneously according to the setting treatment. Seedling care includes watering, weeding, and controlling plant pests. The pests were ants and mealy bugs, which were controlled manually.

This study used a laboratory-scale experimental method. The experimental design was completely randomized (CRD) by applying four treatment levels and 20 repetitions. The treatments were (A) 100% soil (control), (B) 5% EFB biochar, (C) 10% EFB biochar, and (D) 15% EFB biochar. Previous research [31] showed that the optimal EFB biochar composition was 15%. After four months of weaning, the plants were dismantled to observe the root growth parameters, i.e., root length, root volume, root wet weight, and root dry weight. The data were then analyzed by analysis of variance to see the effect of the treatment on the observed root growth parameters, followed by the 5% Least Significant Difference (LSD) test to determine differences between treatments.

3 Result and Discussion

3.1 Results of variance analysis

The data were analyzed using analysis of variance. Recapitulation of the analysis of variance is presented in Table 1.

Table 1 Recapitulation of the analysis of variance

Parameters	F-count	
Root Length (cm)	2.99	*
Root Volume (ml)	14.08	**
Root Wet Weight (g)	9.25	**
Root Dry Weight (g)	7.47	**

Notes: *: The difference is significant at the 0.05 level; **: The difference is significant at the 0.01 level

The results of the variance analysis showed that the addition of EFB biochar had a significant effect on the parameters of root length, root volume, root wet weight, and root dry weight. Therefore, the 5% BNT test was continued, and the results are presented in Figure 2-5.

3.2 Root Length

The addition of EFB biochar significantly affected the length of sengon roots. Based on the results of further tests, all EFB biochar treatments were able to increase root length. The treatment with 15% EFB biochar was better than the 10%, 5% EFB biochar treatment, and the control. It is due to the maximum biochar dosage in improving the physical properties of the soil [18]. Soil with optimum physical properties will stimulate roots to grow and develop [22]. Soil with suitable porosity and density will support the roots of sengon to penetrate deeper and wider [23], allowing the roots to move more freely and triggering the roots to grow longer [24]. Nutrient absorption will be maximized with proper root growth [25]. Suitable root growth directly increases root length and volume value [26] (Figure 2).

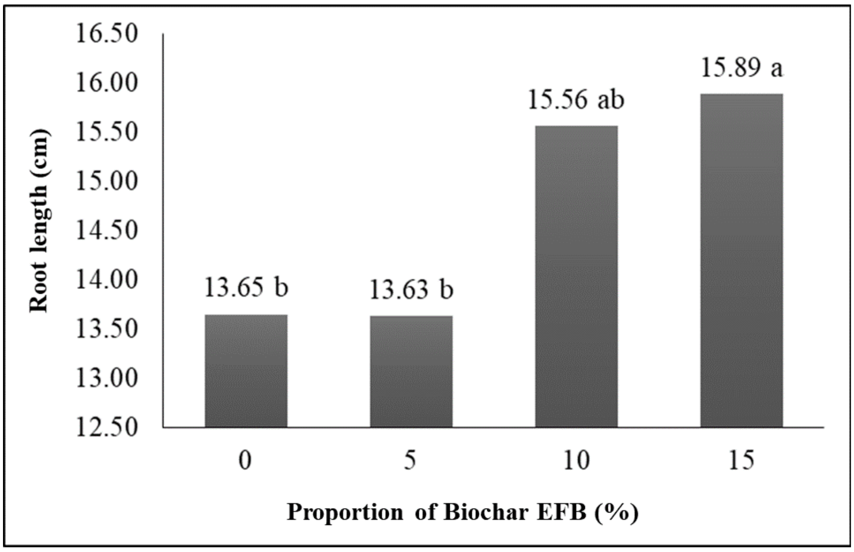

Figure 2 Effect of EFB biochar on sengon root length (LSD=1.97)

Note: Numbers followed by the same letters are not significantly different based on the further test of least significant difference (LSD) 5%.

3.3 Root Volume

The EFB biochar application had a very significant effect on the volume of sengon roots. Based on the results of further tests, all EFB biochar treatments increased the volume of sengon roots compared to the control. The best treatment was shown at a 15% EFB (Figure 3). An increase in root volume will increase water and nutrient availability. Therefore, plants' water and nutrient uptake also increase [22]. It aligns with the previous research [27], which showed that applying EFB-encapsulated biochar could increase root volume by 11.5 ml. Applying biochar in growing media that is in direct contact with plant roots can affect the morphology and function of plant roots [28]. It affects the growth space of plant roots when applied to soil [19].

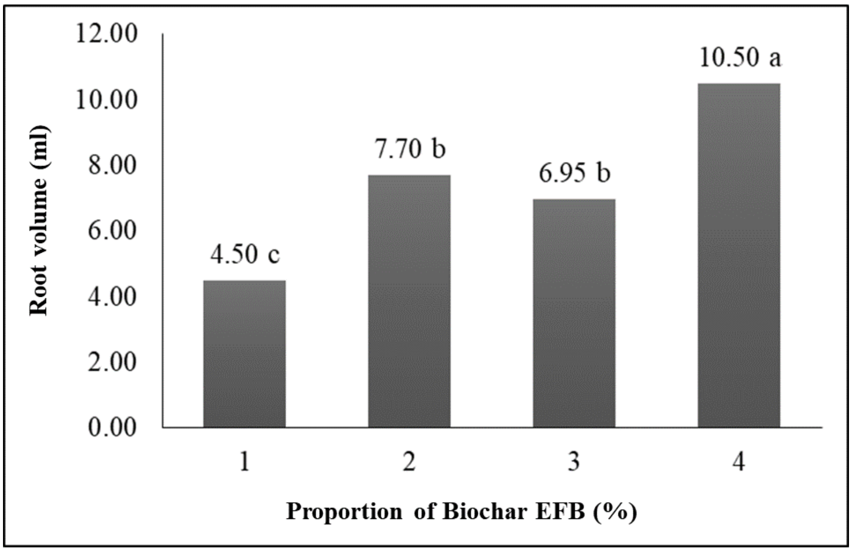

Figure 3 Effect of EFB biochar on sengon root volume (LSD=1.85)

Note: Numbers followed by the same letters are not significantly different based on the further test of least significant difference (LSD) 5%

3.4 The Wet Weight and Dry Weight of Root

The application of EFB biochar had a very significant effect on the wet weight of the roots. Based on the results of further tests, all EFB biochar treatments increased the wet weight of the roots compared to the control. The best treatment was shown at a dose of 15% EFB (Figure 4).

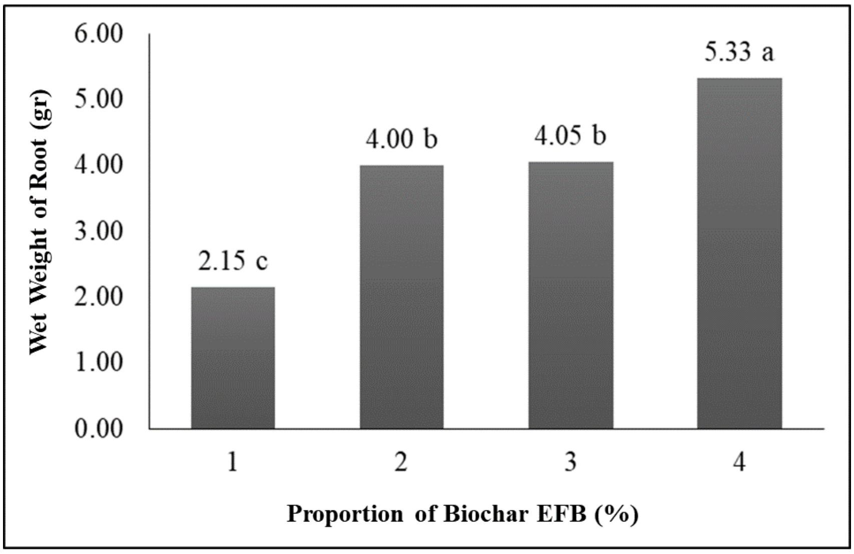

Figure 4 Effect of EFB biochar on root wet weight (LSD =1.21)

Note: Numbers followed by the same letters are not significantly different based on the further test of least significant difference (LSD) 5%.

The application of EFB biochar had a very significant effect on root dry weight (Figure 5). Based on further test results, all EFB biochar treatments were able to increase root dry weight. The treatment with 15% EFB biochar was more promising than the other treatments. It is the optimum dose in providing habitat for microorganisms in the soil, which is closely related to the availability of nutrients, texture, and moisture. It supports the root system [31]. A high root dry weight value indicates that root formation is very good. Hence, plants have the potential to absorb and utilize nutrients and water better for tissue formation and photosynthesis [29]. Plants that experience water shortages can absorb water maximally through the expansion and depth of the increasing root system [24]. An efficient root system will improve the rate of transport and the amount of water transported to the canopy, reduce water loss through the epidermis and reduce heat absorption through the rolling or folding of leaves [30]. The growth of plant roots is followed by an increase in plant canopy growth to increase the total dry weight [18].

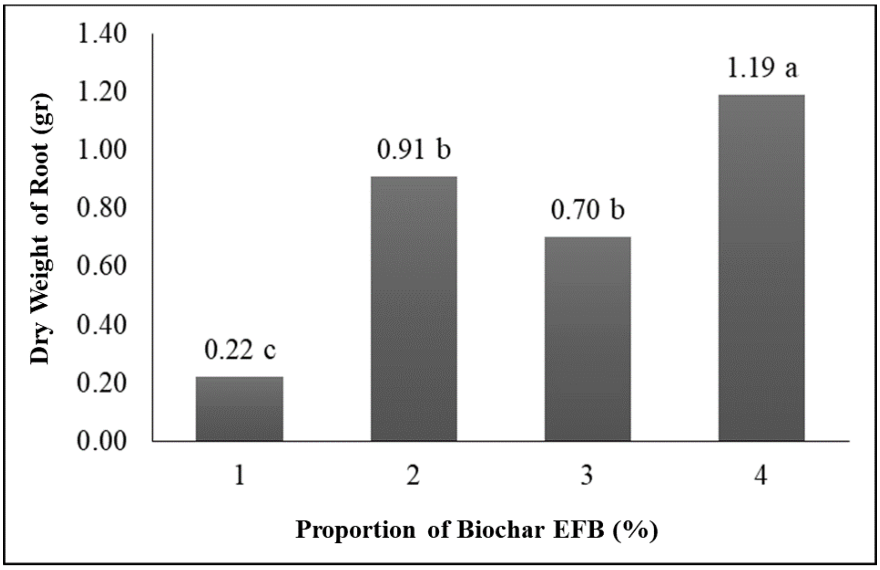

Figure 5 Effect of EFB biochar on root dry weight (LSD = 0.42)

Note: Numbers followed by the same letters are not significantly different based on the further test of least significant difference (LSD) 5%.

4 Conclusions

The application of EFB biochar increased the growth of sengon roots compared to the control. The greater the dose of the addition of EFB biochar given to the growing media, the more it showed a positive response in improving the growth of sengon roots. In this study, the 15% dose showed the best results compared to other treatments.

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