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Groove Planting System (GPS) Analysis of The Growth of Teak (*Tectona grandis*) in Ex-Limestone mining land

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Abstract. Groove planting system (GPS) is one of the modifications in the plant planting system on ex-limestone mining land. The method used in the implementation of the GPS to create a basin in the form of an elongated groove on the ex-limestone mining land that has not been reclaimed. *Tectona grandis* can be grown on less fertile land. This is even recommended by the government, where forest areas were set for planting with teak limited to places that are less fertile and steep. The growth of a plant can be influenced by environmental factors and genetic factors. The interaction between these two factors will determine the growth of a plant. The purpose of this study was to analyze the effectiveness of the Groove planting system (GPS) on the growth of teak (*Tectona grandis*) in limestone ex-mining areas. The method in this research was an experimental method which was carried out in the former limestone quarry of PT Semen Indonesia in 2020. The results showed that the growth of teak seen from the parameters of plant height, bar chart, leaf number and leaf color increased. For example, leaf color with a conventional system has a scale of 3 with a GPS scale of 5. Conclusion The GPS method is very effective for the growth of teak (*Tectona grandis)* because there is an increase in growth and color scale in terms of plant height, stem diameter, number of leaves and leaf color parameters.

Keywords: Effectiveness; Groove Planting System (GPS); Tectona grandis

I. INTRODUCTION

Ex-mining land will experience compaction due to the use of heavy equipments. It becomes difficult to cultivate, usually has a poor drainage and aeration system, so it will affect the process of root development and plant growth. Excavation of pumice destroys ground surface, because the traditional excavations carried out by the community leave deep holes. On the other hand, in limestone mining areas, former mining generally leaves abandoned footprints. The surface of the area as a growing space is dominated by limestone. The soil was only found in rock hollows and cracks, so the growing space becomes narrow. As a result, the vegetation that grows after mining was limited to certain points. The growth process can also be hampered due to damage to soil structure and loss of soil nutrients. To carry out vegetative reclamation on land conditions like this, it was recommended to make planting holes with a minimum size of 40 x 40 x 40 cm in deep and light soil solum or 60 x 60 x 60 cm or even larger in dense and difficult soils processing [1].

Groove planting system (GPS) is one of the modifications in the plant planting system on ex-limestone mining land. The method used in the implementation of the GPS is to create a basin in the form of an elongated groove on the ex-limestone mining land that has not been reclaimed. The soit structure of the ex-limestone mine area is very hard, requiring the process of using heavy equipment (rock breaker) to create a basin. The size of the groove basin used is 110 wides with a depth of 60 cm [2]. After the basin made, topsoil was sprinkled on each groove basin until it was flush with the surface of the ex-lime mining area. Plants were planted with a spacing of 200 cm in each furrow. The distance of the plants between the grooves is 500 cm, because 400cm used for vehicle roads at the time of watering [1]. Teak tree (*Tectona grandis*) is a type of tree that produces broadleaf wood that is

deciduous in the dry season and is of high quality. Teak trees are generally large, straight trunks, can grow to a height of 30-40m. Teak trees that are hundreds of years old can reach a height of 40-45 meters with a diameter of 1.8 - 2.4 meters. However, the average height of teak trees reaches 9-11 meters, with a diameter of 0.9-1.5 meters [2].

This plant can be grown on less fertile land. This is even recommended by the government, where forest areas are set for planting with teak limited to places that are less fertile and steep [2]. The growth of a plant can be influenced by environmental factors and genetic factors. The interaction between these two factors will determined the growth of a plant. Therefore, the growth of a plant can be supported by seeking optimal environmental factors for the plant [3]. This study aimed to analyze the effectiveness of the groove planting system (GPS) konsisten dengan penulisan, di atas GPS menggunakan huruf besargps) on the growth of teak (*Tectona grandis*) in former limestone quarries.

II. RESARCH METHODS

A. Creating Groove Building Groove

After the reclamation location was determined, the next step was to build a groove using a rock breaker with dimensions of 100 m long, 110 cm wide, 60 cm deep (Figure 1). In an area of ± 1 Ha, there were a total of 25 grooves with the distance between the grooves and other grooves was 4 m. The spacing for each tree was 4 x 2 m, so the number of trees needed 1250 trees/ha.

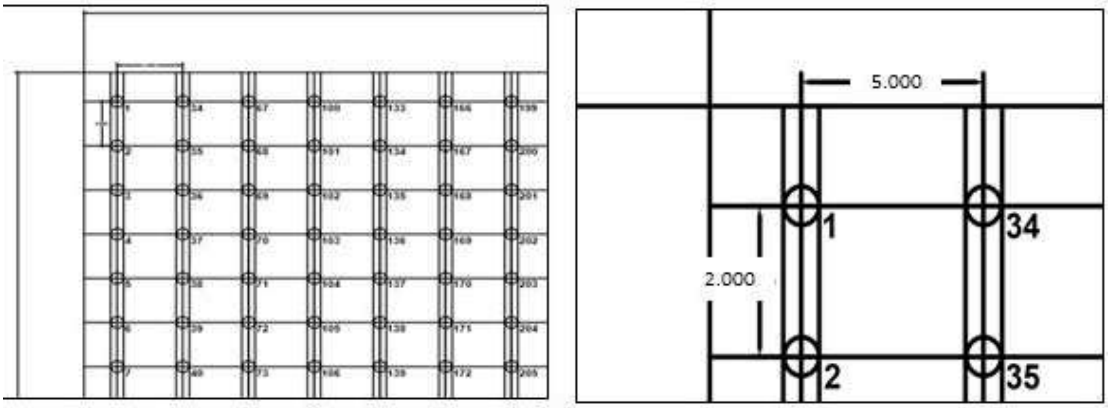

Figure 1. Groove design in the 2019 GPS Reclamation Plan made with a spacing of 4x2 m, with dimensions of length 100 mx width of groove 110 cmx depth of 60 cm.

Meanwhile, for the 2020 GPS reclamation plan on an area of 3 hectares, modifications were made to the 2019 reclamation design, namely 100 cm long, 75 cm wide and 48 cm deep (Figure 2). The distance between the grooves with other grooves was 3.25m. The spacing for each tree was 4 x 3 m, so the number of trees needed 825 trees/ha.

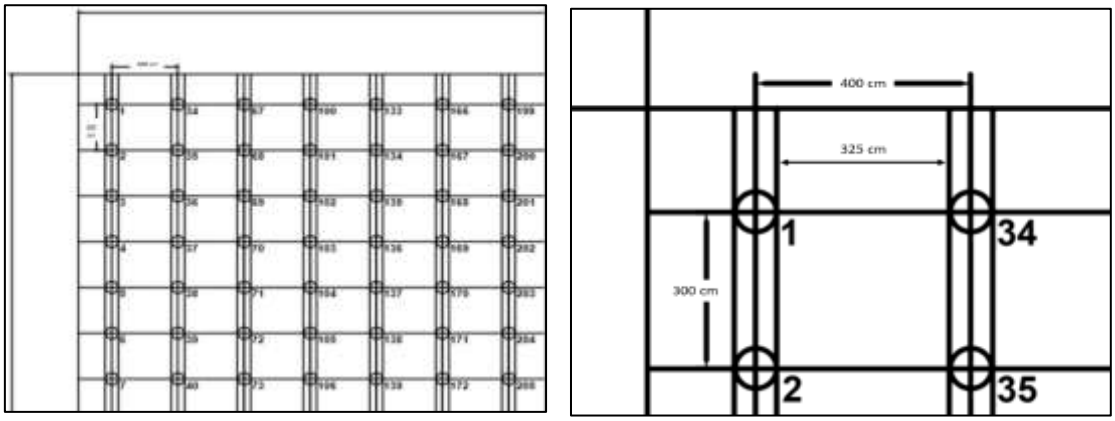

Figure 2. The groove design in the 2020 GPS Reclamation Plan was made with a spacing of 4x3 m, with dimensions of 100 m long x 75 cm wide grooves x 48 cm deep.

B. Spreading top soil in the groove

The distribution of topsoil started with taking the topsoil at a predetermined location (Kasiman) and transporting it by dump truck. Next, the topsoil was spread with the arrangement according to the grooves that have been made previously. The topsoil was leveled with the help of a PC 200 excavator and manpower used a hoe.

C. Planting

Planting was carried out by making a planting hole using a soil drill machine with a diameter of ± 20 cm and

a depth of 30 cm. The size of planting hole was used 50 cm x 50 cm. Next, the teak plant was inserted and covered with soil until the soil hole is covered. Then a 50 cm long bamboo stake is inserted which serves to uphold the plant and at the same time provide a marker for the plant. Teak plants that were needed are from shoots, cuttings and seeds. Apakah umur bibit seragam?

D. Data Collection and Plant Growth Analysis

The stage of collecting plant growth data in the Groove Planting System (GPS) on ex-limestone mining land was carried out by measuring the growth parameters of teak plants on reclamation land, including plant height, plant diameter, leaf color, number of leaves and number of branches [4]. Furthermore, the statistical analysis of the results and description of the results was carried out on the existing data.

III. RESULT AND DISCUSSION

GPS is a planting system with grooves made on the planting area, in this case the land was ex-lime mining. The planting system will affect plant growth, so plant growth can be used as an indicator of the effectiveness of the planting system used. Therefore, in this study, we observed the effectiveness of GPS on the growth of teak (*Tectona grandis*) planted on ex-lime mining land.

Observations were made to compare the growth of teak (*Tectona grandis*) planted with conventional planting systems and with groove systems (GPS). The conventional planting system in this study was a planting system that is carried out by spreading topsoil on ex-lime mining land. While the planting system with GPS was carried out by making grooves on ex-lime mining land with dimensions of 100m long, 110cm wide, and 60cm deep. After that, topsoil was spread in the groove. Observed teak plants were divided into 3 groups. The first group is teak which is grown using a conventional planting system. The second group is teak plants planted with GPS derived from teak seedlings from shoots. While the third group is teak plants planted with GPS whose seeds are seeds from teak seed nurseries.

Growth increased in plant elements such as plant height and plant stem diameter up to a certain time [5]. Therefore, the growth of teak (*Tectona grandis*) in this study was observed through several parameters, namely plant height, stem diameter, number and color of leaves. In addition, this study also observed physical and chemical environmental factors such as soil temperature, soil pH, and soil moisture. The following is a description of each of these parameters.

Parameter analysis of teak (Tectona grandis) plant height

Plant height is one of the parameters commonly used to measure plant growth. Plant height is an easily observed parameter. The increased in plant height can be influenced by many factors, both internal and external factors. Internal factors can be in the form of genetics from the seeds used. While external factors, one of which is the planting system used, in this case the conventional planting system and GPS.

Measurement of plant growth in this study was carried out for 5 months. However, until this report was made, the measurements had only been carried out for 2 months. Figure 3 below showed the average teak plant height of the three groups observed after 5 Months After Planting.

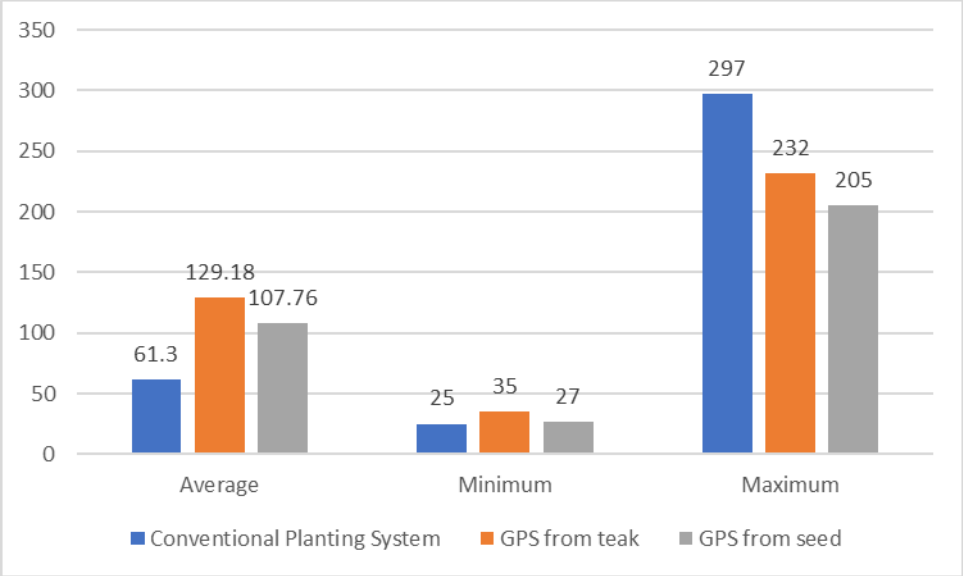

Figure 3. Bar chart of Teak Plant Height on Former Limestone Mining Land (in cm).

Figure 3 showed average height of teak planted with a groove system (GPS) using seedlings from shoot cuttings showed the highest value, which was 129.18 cm. Meanwhile, teak planted with a GPS system with seeds

from teak seeds showed an average height of 107.76 cm. The lowest average value was seen in conventionally grown teak plants with a value of 61.3 cm. In teak plants grown with this conventional system, the seeds used are teak seeds from local teak seeds. This shows that the planting system with GPS gives better results when compared to the conventional planting system based on the parameters of the average plant height.

In Figure 3, it can also be seen that the minimum and maximum height values of teak were planted both conventionally and with the GPS system. The minimum height yield in Figure 1 shows consistency with the average plant height, where the highest minimum value was also found in the teak plant group in the GPS system whose seeds came from shoot cuttings (35 cm), followed by teak plants on GPS whose seeds came from seeds. local teak (27 cm), and the lowest value was found in teak grown with conventional systems (25 cm).

Different results showed in the maximum height of the 3 groups of observations. On Figure 1 it can be seen that the height of teak planted in the conventional system shows a value of 297 cm, while teak from shoot cuttings on GPS is 232 cm, and teak from seeds with the GPS system is 205 cm. This difference is not only influenced by the planting system used. However, teak planted in the conventional system has been planted since 2016. Meanwhile, teak in the GPS system, both from shoot cuttings and seeds, was only planted in January 2020. Thus, there is a large age difference, where teak in the conventional system is approximately 3 years old, while teak in the GPS system is only about 5 months old.

Based on the calculation of the average annual increase in teak plant height in the conventional system, it is also low, where the average annual increase in teak plant height in the conventional system is only 20.43 cm/year. Several studies have shown that the average annual increment of teak plant height reaches 2 m/year [6], 0.9 m/year-3.8 m/year [5], and 59.3 cm/years-279.05 cm/year [7]. Meanwhile, for teak with GPS system, the average annual increment reached 310.03 cm/year (seedling from shoot cuttings) and 258.62 cm/year (seedling from seed). Rip itself is defined as the increase in the growth of tree dimensions (height, diameter, base plane, volume) or of stands associated with age in a certain area unit [5].

Meanwhile, the height of teak plants on GPS, which are both 5 months old, shows different values. This difference may be influenced by the type of seed used, where teak from shoot cuttings showed a higher average plant height value than teak from seeds. This is because the different seeds will mainly affect the root structure, where teak from shoot cuttings has fibrous roots. Meanwhile, teak that comes from seeds has a taproot. This difference in root structure will affect the activity of cell division in plant meristem tissue. In addition, it will also affect the reach of roots in obtaining nutrients to support the growth of the teak plant itself.

Parameter analysis of teak (Tectona grandis) stem diameter

The diameter of the teak plant stem is the result of secondary growth of a plant. Figure 4 showed the results of measuring the stem diameter of teak plants on ex-mining land of PT. Semen Indonesia (Persero) Tbk.

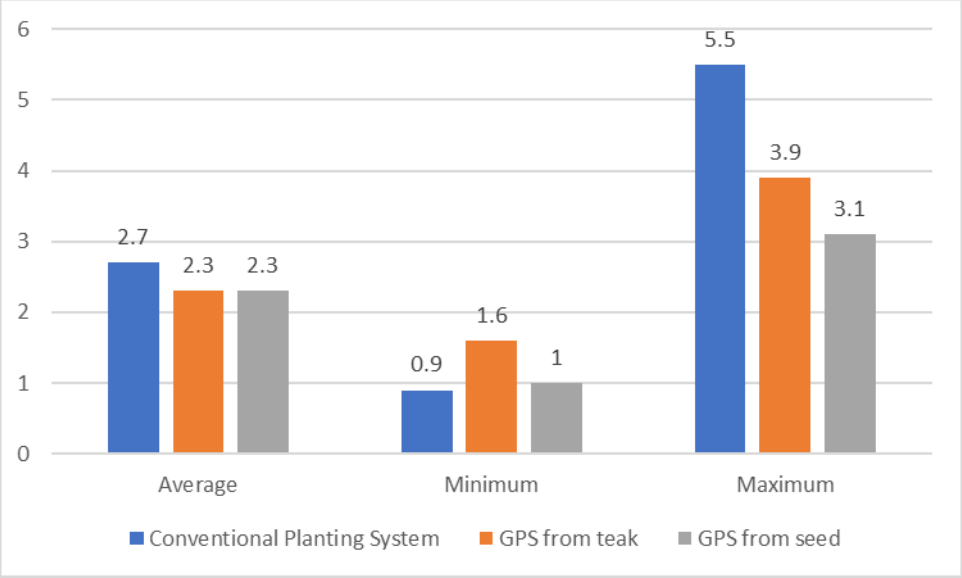

Figure 4. Bar chart of Teak Plant Stem Diameter on Former Limestone Mining Land (in cm).

Based on Figure 4 showed the average stem diameter is the highest in teak planted in conventional systems, with a value of 2.7 cm. While the average stem diameter of finger plants on GPS both from shoot cuttings and seeds is

the same, which is 2.3 cm. At the minimum value of the highest stem diameter in teak from shoot cuttings on the GPS system with a value of 1.6 cm, followed by the diameter of teak from seeds in the GPS system with a value of 1.0 cm, and the lowest minimum value in conventionally grown teak with a value of 0, 9 cm. At the maximum value, conventionally grown teak has the highest maximum stem diameter value, which is 5.5 cm. Meanwhile, teak plants with shoot cuttings on GPS were 3.9 cm and the highest diameter for teak plants from seeds planted with the GPS system was 3.1 cm.

The results obtained in this study showed that the diameter of teak plants in the conventional system had the highest value compared to other groups. This is due to the large age difference. However, when calculating the average increment of stem diameter, the highest value was obtained in GPS teak shoot cuttings with a value of 5.6 cm/year, followed by GPS seeds at 5.4 cm/year, and the lowest value in conventional teak with 0.9 cm/year.

The average value of the stem diameter of conventional teak plants aged 3 years is also relatively low when compared to several studies which show the average diameter of native teak plants aged 18 months which can reach 1.81 cm [7], and 3 ,46-4.1 cm in 2-year-old teak plants [8].

Stem diameter in dicotyledonous plants shows secondary growth activity by secondary meristems in the form of cambium. The increase in plant diameter is strongly influenced by the results of ongoing photosynthesis [9]. Thus, indirectly the increase in stem diameter will also be influenced by the number and color of leaves. In addition to the number and color of leaves, the increase in stem diameter is also influenced by root structure. This root structure will affect the plant in obtaining nutrients that can support various cell activities, including cell division. In addition, the factor where it grows also plays an important role in supporting plant growth [10].

Another parameter that can also be used to describe plant growth is the number and color of leaves. The number of leaves affects the process of photosynthesis carried out by plants. The process of photosynthesis will affect various processes in the plant body. Like the number of leaves, leaf color is also closely related to the process of photosynthesis. The leaves of the teak plant are green, where the green color is obtained from the presence of chlorophyll in the leaves. Chlorophyll is a pigment that is responsible for the process of photosynthesis. The following Figure 3 shows the results of measuring the number and color scale of teak leaves on the ex-lime mining area of PT. Semen Indonesia (Persero) Tbk.

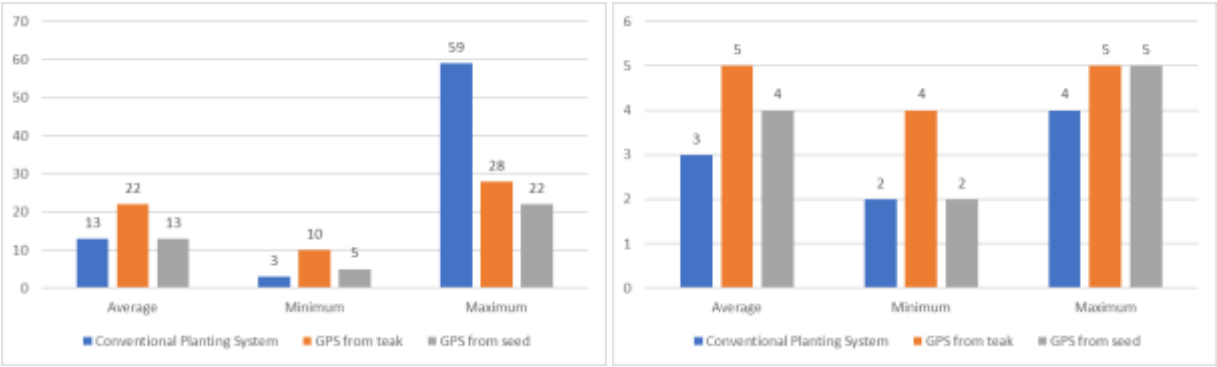

Figure 5. Bar chart Number of Leaves (a) and Leaf Color Scale (b) Teak Plants on Former Limestone Mining Land

Based on Figure 5 (a) it can be seen the average number of leaves in the three research groups, and it appears that the teak plant group from shoot cuttings planted with the GPS planting system had the highest average number of leaves, which was 22 leaves. In teak plants grown with conventional and GPS systems, the number of leaves was 14 and 13, respectively. The minimum number of leaves was also highest in the GPS group with shoot cuttings, which was 10 leaves. Followed by the minimum number of leaves in the GPS group from seeds with a total of 5 leaves, and the conventional group with 3 leaves. Meanwhile, for the maximum number of leaves, teak in the conventional system had the highest maximum number of leaves, i.e. 59, followed by the GPS group of shoot cuttings with a total of 28 leaves, and finally the number of leaves in the GPS seed group with 22 leaves.

The number of leaves of a plant can be influenced by several things, including nutrition. However, nutrition is not the only factor that affects the number of leaves. It was caused the teak plant is a plant that will drop its leaves in the dry season. In addition, when data were collected, several teak plants were attacked by caterpillars, so that some of their leaves were eaten by the caterpillars. Basically, the leaf organ in plants plays an important role because it is the place where photosynthesis occurs. The food produced from the photosynthesis process will

support plant growth, both in increasing stem height, increasing stem diameter, and the number of leaves themselves [9]. Basically, the large number of leaves allows the amount of chlorophyll and the cross-sectional area of the leaf surface to be large, so that the plant is able to take advantage of the intensity of sunlight that is not too high for optimal photosynthetic activities [11]. In Figure 5 (b) it can be seen the results of leaf color scale measurements based on the Leaf Color Chart (LCC). In the figure it is known that the average leaf color scale in the GPS shoot cuttings group is 5, the GPS seeds are on a scale of 4, and the conventional group is on a scale of 3. While at the lowest leaf color scale, the teak plant group from seeds planted on GPS and conventional systems show the same scale, namely 2. While teak on GPS derived from shoot cuttings seeds shows the lowest leaf color scale value 4. The highest leaf color scale is found on GPS teak plants shoot cuttings and teak on GPS from seeds that shows a scale of 5. While in teak plants in the conventional system it shows a scale of 4. Leaf color is influenced by the levels of N in the plant because it plays a role in the formation of chlorophyll [12].

IV. CONCLUSION

The Groove planting system (GPS) method is very effective for the growth of Teak (*Tectona Grandis*) plants on limestone ex-mining land based on plant height parameters, stem diagrams, number of leaves and leaf color. There was an increase in the growth of stem height, stem diagram, number of leaves and leaf color scale compared to conventional methods.

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