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## Impact of Forest Rehabilitation using *Eucalyptus* spp. on Soil Properties at Sg. Betis Forest Reserve, Lojing, Kelantan

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### ABSTRACT

The forest reserve of Sg. Betis, Lojing, Kelantan is one of the earliest plots to utilize *Eucalyptus* for forest rehabilitation purposes, due to the tree's fast-growing characteristic that is able to accelerate soil restoration for degraded forest. *Eucalyptus* has a deep root system that can help to hold the soil and is able to reach moisture deep in the ground, in order to survive droughts. This study was conducted to determine the impact of forest rehabilitation on degraded land using *Eucalyptus* spp. The soil properties were determined prior to planting (October 2017) and after planting (August 2018). Soil analyses showed that there is improvement in selected soil properties after a year of planting.

### 1. Introduction

Total forest cover in Asian countries in 2005 was estimated to be 203 million hectares, which is 45 percent of the region's total land area [1, 2]. However, in many Asian countries, resources in terrestrial and coastal ecosystems are under increasing treat of deforestation or clearing due to the growing population and the extension of agricultural lands into forests and other ecologically sensitive areas. Tropical forests in Asia can be found scattered in the islands of Indonesia, Malaysia, Thailand, Myanmar, Laos and Cambodia. The countries with the largest forest areas in Asia and the Pacific is China followed by Australia, Indonesia and India (Fig. 1).

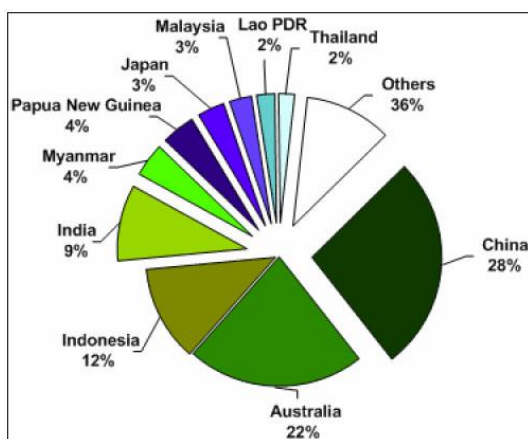


Fig. 1 Countries with the largest forest area in Asia and the Pacific, 2005

*Eucalyptus* trees act as carbon deposits, require less energy consumption, experience lower rates of erosion, less management-intensive, offer greater biodiversity, enable a higher degree of multifunctionality and improve balance in the water cycle [3-5]. Besides, *Eucalyptus* have better productivity as only small surface area is required. The tree also exhibits higher environment adaptation, fast growth, and has

industrial potential. *Eucalyptus* wood is an important resource for pulp production industry.

Soil quality can be defined as the capacity of soil to function well in providing nutrients needed for plants to grow [6-9]. Soil functions include sustaining biological diversity, activity and productivity. Soil should be able to regulate water as well as filtering, buffering, degrading organic and inorganic materials [10,11]. *Eucalyptus* was found to successfully grow on degraded parts of the Sg. Betis forest. However, soil studies are yet to be carried out for the plot. The result on soil analyses is essential in proving that planting of *Eucalyptus* does help in increasing the soil quality.

### 2. Experimental Methods

#### 2.1 Sg. Betis Forest Reserve

Sg. Betis Forest Reserve is located in Lojing, Gua Musang, Kelantan. The *Eucalyptus* plot was established at Compartment 200 on 30 hectares of land. This forest reserve is managed by the Forestry Department of Kelantan State. This study was conducted at the *Eucalyptus* plot.

#### 2.2 Soil Sampling and Laboratory Analyses

Composites soil samples were collected from three different adjacent plots at the depth of 0-20 cm and 20-40 cm depth (Table 1) [12-14]. Soil properties analysed include soil texture, bulk density, exchangeable bases and cation exchange capacity [15-18].

Table 1 Location of soil sampling

Plot	Plot Location	Slope
1	4.721713° N, 101.58268° E	85.3
2	4.721651° N, 101.582315° E	84.3
3	4.721518° N, 101.581813° E	83.5

#### 2.3 Statistical Analyses

A one-way analysis of variance (ANOVA) followed by post-hoc Tukey test ( $p < 0.05$ ) was used to compare the analyses results between sampling plots. The SPSS ver. 16.00 was used for the data calculation. Mean different letters indicate significant difference at  $p < 0.05$ .

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3. Results and Discussion

The soil texture of study plot is sandy clay loam category. Percentage of sand is high and followed by clay (Table 2).

Table 2 Percentage of soil texture of study plot at Sg. Betis forest reserves

Fraction	Percentage (%)
Sand	68%
Silt	4%
Clay	28%

There was significant difference found for moisture content for between plots for October 2017 and August 2018 sampling (Figs. 2 and 3). Walden et al. [21] found that *E. globulus* induces water repellence across a range of sites in the south-west of Western Australia. Therefore, soil moisture content increase with the plantation of *Eucalyptus* in Australia. This shows that *Eucalyptus* tree is more efficient in water use than other species because this tree does not dry out soil and adapts its water consumption. This percentage of soil moisture content result also shows that *Eucalyptus* tree does not decrease the soil moisture content in Lojing, Kelantan.

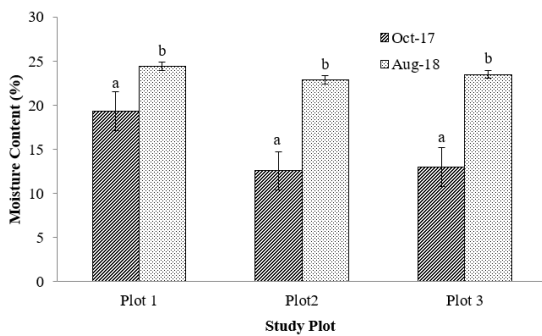


Fig. 2 Mean soil moisture content at 0-20 cm depth (Mean different letters indicate significant difference at p<0.05)

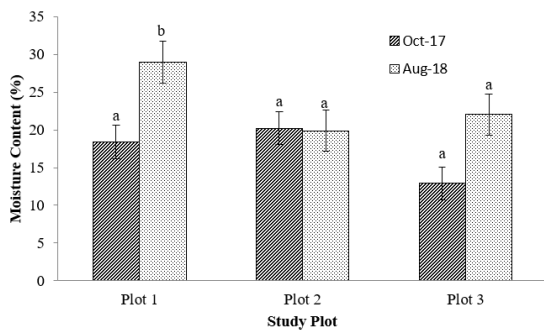


Fig. 3 Mean soil moisture content at 20-40 cm depth

3.1 Soil pH

There was significant difference detected for soil pH for every plot between October 2017 and August 2018 at all plot. At the depth of 0-20 cm (Fig. 4), pH level increased from 5.24 to 5.44. At soil depth 20-40 cm (Fig. 5), the soil pH value increased by 0.02 from October 2017 to August 2018 at the soil depth of 20-40 cm (Fig. 5). The results show that planting *Eucalyptus* helps to improve soil pH value of the degraded land.

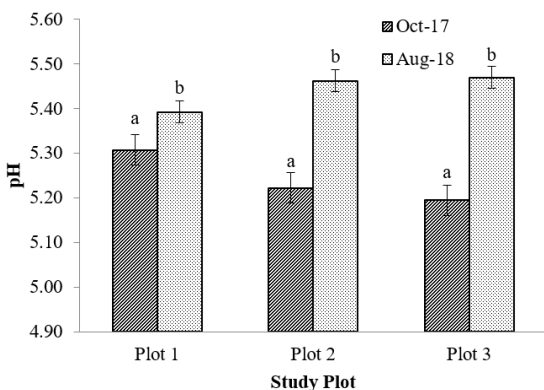


Fig. 4 Mean pH value at 0-20 cm depth  
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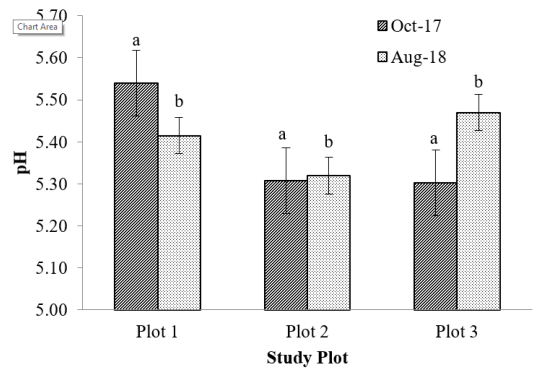


Fig. 5 Mean pH value at 20-40 cm depth

3.2 Total Soil Carbon

The total carbon content in 0-20 cm depth decreased for plot 2 and plot 3 (Fig. 6). As for 20-40 cm depth (Fig. 7), total carbon content was also found to be decreasing from October 2017 to August 2018 at plot 1 and 2. The decrease in the total soil carbon might be due to *Eucalyptus* tree is efficient at capturing carbon dioxide, fixing carbon and generating oxygen [20].

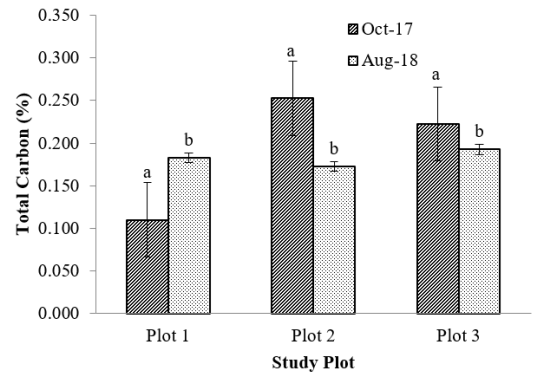


Fig. 6 Mean total C at 0-20 cm depth

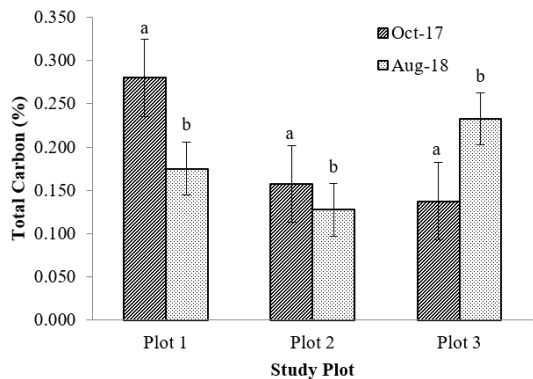


Fig. 7 Mean total C at 20-40 cm depth

3.3 Total Soil Nitrogen

The nitrogen content in soil of *Eucalyptus* plantation increased at plot 2 and plot 3 for 0-20 cm depth (Fig. 8).

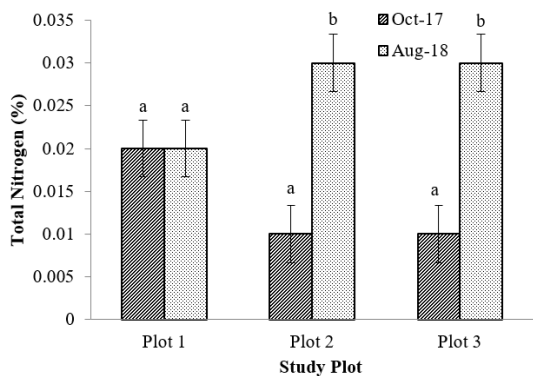


Fig. 8 Mean total N at 0-20 cm depth

As for 20-40 cm depth, only plot 3 showed increase in nitrogen from October 2017 to August 2018 (Fig. 9). The nitrogen level results show that planting *Eucalyptus* tree does help in increasing the nitrogen availability.

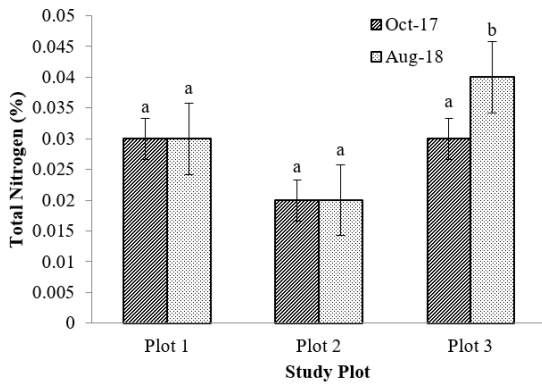


Fig. 9 Mean total N at 20-40 cm depth

### 3.4 Available Soil Phosphorus

Table 3 shows that there is no significant difference between of available phosphorus between each plot.

Table 3 Mean Available Phosphorus at each plot

Plot	Aug 2018 1	Aug 2018 2	Aug 2018 3
Depth (cm)	0-20 cm		
Available Phosphorus ( $\mu\text{g g}^{-1}$ )	0.05 $\pm$ 0.02a	0.19 $\pm$ 0.16a	0.14 $\pm$ 0.03a
Depth (cm)	20-40 cm		
Available Phosphorus ( $\mu\text{g g}^{-1}$ )	0.03 $\pm$ 0.01a	0.03 $\pm$ 0.01a	0.07 $\pm$ 0.01a

Note: Mean different letters indicate significant difference at  $p < 0.05$

### 3.5 Exchangeable Bases and ECEC

There was no significant difference for exchangeable magnesium (Mg) for both soil depth (Figs. 10 and 11).

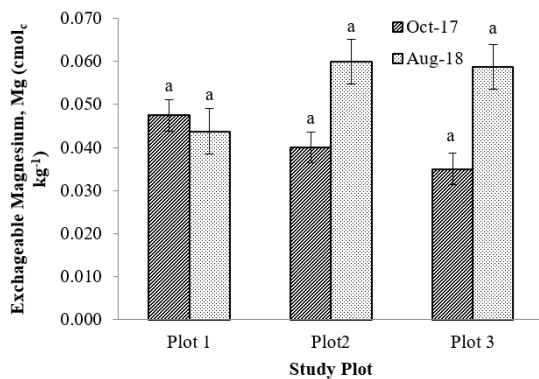


Fig. 10 Mean exchangeable Mg at 0-20 cm depth

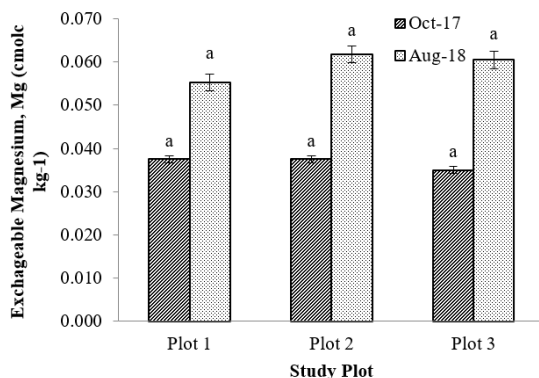


Fig. 11 Mean exchangeable Mg at 20-40 cm depth

There was significant difference for exchangeable Ca at 0-20 cm depth where the highest rate of Ca<sup>2+</sup> detected at plot 1 (Fig. 12) while the highest rate of exchangeable Ca for 20-40 cm depth is at plot 2 (Fig. 13). In average, the exchangeable Ca at 0-20 cm depth increase from 0.08 to 0.10. The <https://doi.org/10.30799/jespr.180.19050402>

average rate of exchangeable Ca also increased from 0.06 to 0.09 from October 2017 to August 2018. The exchangeable potassium (K) in the soil shows some increment for both depths (Figs. 14 and 15).

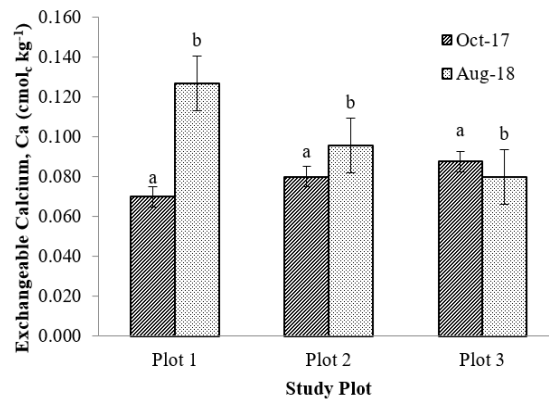


Fig. 12 Mean exchangeable Ca at 0-20 cm depth

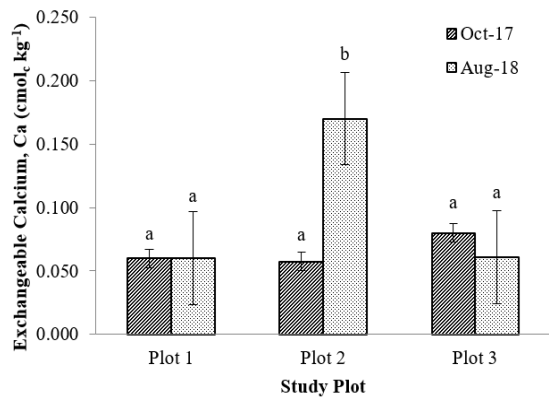


Fig. 13 Mean exchangeable Ca at 20-40 cm depth

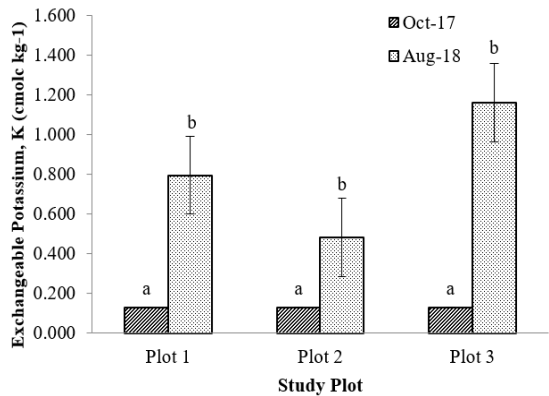


Fig. 14 Mean exchangeable K at 0-20 cm depth

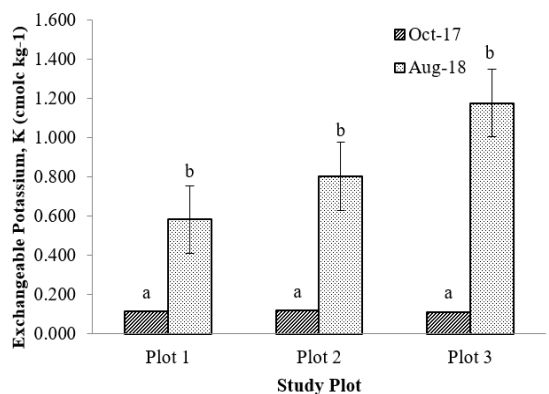


Fig. 15 Mean exchangeable K at 20-40 cm depth

Appropriate ECEC level will help to improve the available nutrient in the soil for the root uptake and assist for good *Eucalyptus* tree growth. There was significant difference for soil effective cation exchange capacity (ECEC) for every plot (Figs. 16 and 17).

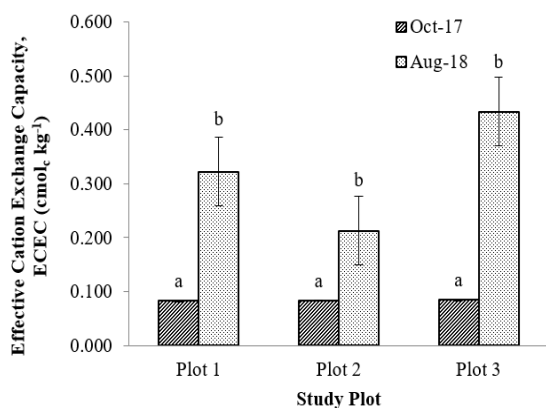


Fig. 16 Mean ECEC at 0-20 cm depth

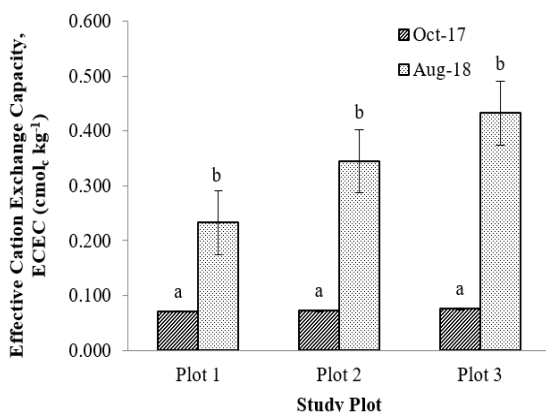


Fig. 17 Mean effective cation exchange capacity, ECEC at 20-40 cm depth

#### 4. Conclusion

The soil of study area is sandy clay loam and the soil contains 68% sand followed by clay at 28% and silt at 4%. The bulk density of the study plot is 1.15 to 1.21 range and that is quite favourable for the root growth of *Eucalyptus* tree. The growth performance of *Eucalyptus* tree can be to improve nutrient content in the soil. In this project, it is proved that *Eucalyptus* tree is efficient in water use because the moisture content of this plantation increased from October 2017 to August 2018. This species is also efficient in water uptake. The nutrients in the study plot for August 2018 soil samples had higher rate than October 2017. This showed that *Eucalyptus* can adapt to the limited nutrient availability for their growth. When the nutrient availability increased, they can grow better. With the increase of nutrient rate, the effective cation exchange capacity (ECEC) also increased. The measured variables that showed significant difference are available phosphorus, exchangeable magnesium and exchangeable calcium at 20-40 cm depth. Other measured variables did not show any significant difference. Apart from reducing soil erosion risk at the area. *Eucalyptus* plantation also gives positive impact not only by improving soil quality, but also for forest rehabilitation to develop its own flora and fauna.

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