EFFECT OF DIFFERENT FERTILIZER TREATMENT ON *MAGNOLIA CHAMPACA* AND *HOPEA ODORATA* IN DEGRADED MONTANE FOREST

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ABSTRACT

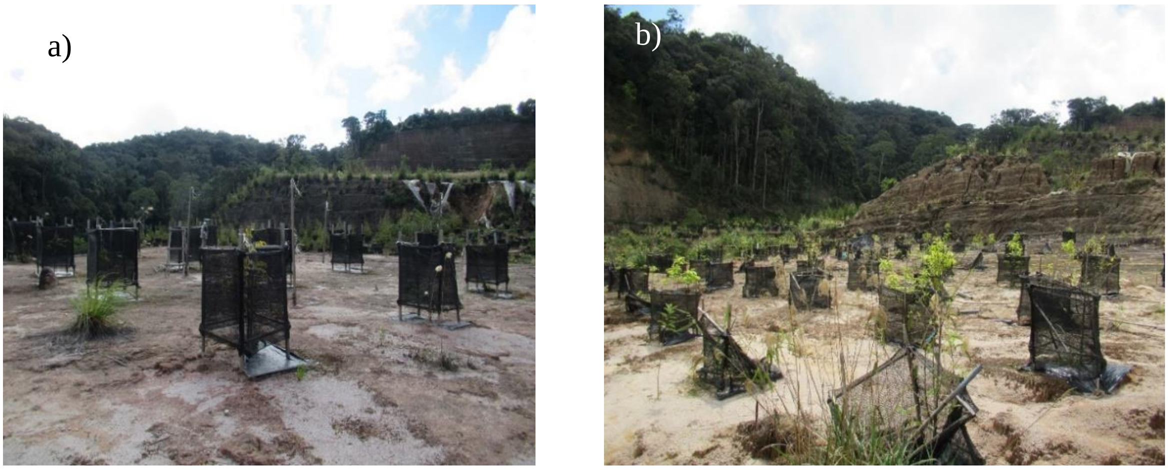
An experiment on effect of different fertilizer treatment was applied on Magnolia champaca (Cempaka kuning) and Hopea odorata (Merawan siput jantan) in Bukit Jerut Forest Reserve. The montane forest area was degraded as the topsoil was removed after the area was encroached for agriculture development. Each of the plant was treated with three (3) different fertilizer and a control (without fertilizer): 1) NPK 8:8:8 (300g granular), 2) Asid Humic (liquid) and 3) NPK 8:8:8 (300g, granular) + Asid Humic. The stand age is about three years old and divided into three blocks. The diameter of each tree was taken at the stem, 3 inch from the ground for eight months. Results eight (8) months after introducing with treatment showed that using NPK 8:8:8 + Asid Humic is the best treatment for both Magnolia champaca and Hopea odorata with an average diameter of 6.5 mm and 6.3 mm increment respectively.

Key words: degraded area, fertilizer treatment, montane forest, Bukit Jerut Forest Reserve.

INTRODUCTION

The district of Cameron Highlands (4◦28ʺN, 101◦23ʺE), Pahang, is located on the main range of Peninsular Malaysia. It lies between 1,070 and 1,830 m above sea level. The total land area is 71,218 ha. It was a mountainous region with steep slopes. Gradients exceeding 20◦are common. The climate is favourable to the cultivation of tea, sub-tropical vegetables and flowers (under rain-shelter). Crop production is sustained by high fertilizer and manure applications. However, agriculture in this environment is characterized by high levels of soil erosion and environmental pollution. Results indicated that soil loss was in the range of 24–42 ton/ha/yr under vegetables and 1.3 ton under rain-shelter. Sediment load in the vegetable sub-catchment reached 3.5 g/L, 50 times higher than that associated with flowers under rain-shelter and tea (Aminuddin et al, 2005). Bukit Jerut Forest Reserve located near Cameron Highlands-Lipis district border and the Ulu Jelai Power Station project, the project is located approximately 150 km north of Kuala Lumpur. The nearest town is Ringlet, about 40 km away. The power station is accessible from route JKR-ft102 connecting the towns of Ringlet and Sungai Koyan (TNB, 2016). Bukit Jerut Forest Reserve Tringkap, Cameron Highland is a montane forest with total area of 8,084.62 ha and elevation of 1,617 metres (5,305 ft). The once green and vibrant forest was left barren when 34 ha from the area was degraded as the topsoil was removed after the area was encroached and cleared for agriculture development (photo as in **Figure 1**). These anthropogenic activities had led to environmental degradation through alteration of soil physical, chemical and biological properties. Topsoil removal is based on removing the nutrient rich topsoil leaving the nutrient poor sandy subsoil containing far lower N and P levels (Rasran et al., 2007; van den Berg et al., 2003). Topsoil removal instantly shrinks the soil organic matter pool result in decreasing the desurfaced soil's ability to replenish soil organic matter.

Figure 1: Planted site of a) Hopea odorata and b) Magnolia champaca



Globally, it is estimated that montane forest watersheds provide water for over 4 billion people (Vorosmarty et al., 2005). Forests in Malaysia are an important and valuable natural resource of the country. A part from being a source for quality tropical timber, it also plays a role as a support system for the basic needs of life. In addition, among the main importance role of forests are in reducing the incidence of flash floods, soil erosion and mud deposits, controlling water balance and climate change as well as inland protection and genetics. In the tropical regions, lower montane forest is a type of forest with elevation between 1,200-1,500 m from sea level (Figure 2). It refers to the rainforest on mountain slopes that are distinctly different from the lowland rainforest that covers the plains, flatlands, and low hills (FDPM, 2016). Generally, this forest formation can be considered an intermediate zone between the montane cloud forest located at much higher altitudes (Table 1).

Figure 2: Forest type in Malaysia (Forestry Department of Peninsular Malaysia, 2016)

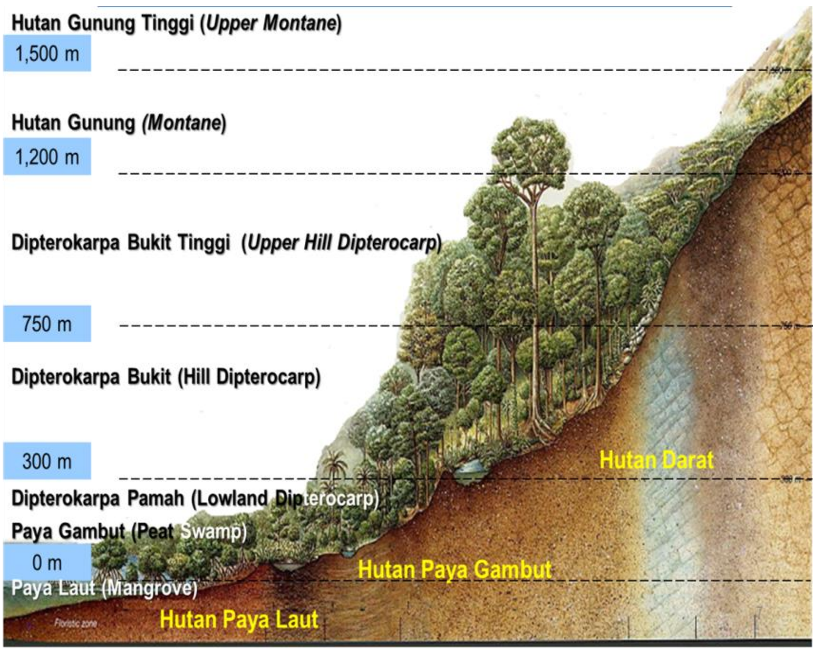


Table 1: Altitudinal zones in humid Malesia (Richards, 1996)

Zone	Altitude (m)	Vegetation	Formation
Tropical Lowland subzone Collline subzone	0-1000 0-500 500-100	Closed high forest	Lowland tropical forest and monsoon forest
Submontane	1000-1500	Closed high forest poor in mosses	Lower montane forest
Montane	1500-2400	Closed high forest: above 2000m with decreasing stem diameter and increasing density of moss	
Subalpine	2400-3600 3600	Dense low forests with emergent, often mossy with conifers Forest limit	
Alpine	4000-4500 4000	TREELIMIT	Stony desert with grasses
Nival	4600+	PERMANENT SNOW	

The ecosystem functions of mountain forest are very similar to those described for the tropical lowland evergreen rainforests. The significance of forests on slopes, is even higher for the protection of watersheds through control of erosion, leakage of nutrients and control of water release. The latter function is of particular importance, since these forest formations form the upper portions of watersheds. The water holding capacity of forest soil and the increased precipitation within intact forest leads to a more predictable water supply for irrigation (Pennafiel, 1994). Water availability increases by the presence of trees in mossy forests through wind-driven interception of moisture (Doumeng et al., 1994).

Topsoil removal is based on removing the nutrient rich topsoil leaving the nutrient poor sandy subsoil containing far lower N and P levels (Rasran et al., 2007; van den Berg et al., 2003). Human influence and ecological status is the most important reason for the rapid dwindling of montane forests and the conversion to agricultural lands for temperate zone crops, in particular vegetables or flowers (Pennafiel, 1994) or due to fires. It did not reduce pH and levels of extractable Ca in the upper soil to levels similar to those found on the adjacent heathland and other heathland sites. The pH of heathland soils is typically between 3.6 and 4.1 (Marrs et al., 1992, 1998; Pywell and Webb, 1994, 1995,2002).

The soil's water-holding capacity is reduced by lack of soil organic matter and increased runoff capacity due to lower porosity and infiltration. Soil microbial activity is also adversely affected. It is estimated that approximately 2% of global terrestrial net primary productivity was lost each year due to dryland degradation (Zika and Erb, 2009). Moreover, topsoil removal decreases the unsaturated zone above the groundwater table because part of this zone was removed. These new conditions are favourable for the typical heather vegetation type, and establishment of the heather vegetation is generally successful after topsoil removal (V. Geissen et.al. 2013). Therefore, this experiment was carried out to identified an effect of different fertilizer treatment applied on *Hopea odorata* (Merawan siput jantan) and *Magnolia champaca* (Cempaka kuning) species.

Hopea odorata or Merawan Siput Jantan is also known locally by other interesting names such as Cengal Pasir, Cengal Kampung, Cengal Pulau and Cengal Mas. As implied in these local names, *H. odorata* belongs to the same family as the true Cengal (*Neobalanocarpus heimii*) namely Dipterocarpaeae. The genus name, *Hopea*, honours Dr John Hope (1725-1786) who was a Scottish botanist at the Edinburgh Botanic Garden, U.K., while the species name, *odorata*, refers to the fragrant flowers (Norzielawati & Lee., 2018). Dipterocarpaceae are known to have winged fruits and also produce resin. The fruit of this species is an ovate-conical nut with two-wings. The flowers are pale yellow and leaves unequal-sided. The main characteristic for identification of this species is the presence of the pore-like domatia in the leaf axils. The tree has scaly bark and the inner bark is dull brown or greenish yellow and sometimes tinged very faintly pink. The timber from *Hopea odorata* is classified as medium heavy hardwood. This large-sized tree of up to 45 m in height is used for reforestation programs and forest plantations besides being a popular used as ornamental and shade tree.

Naturally, *Hopea odorata* is distributed from Bangladesh, the Andaman and Nicobar Islands, Indo-China, Thailand, Indonesia, and Malaysia. In Peninsular Malaysia, it is a well-known tree in Pulau Langkawi, Perlis, Kedah, northern Perak, Kelantan, and Terengganu (Symington, 2004). It is found in lowland dipterocarp forest and seasonally dry tropical rain forests, mainly growing in riparian areas, and is rarely found far from river or streams. This species is very common in Peninsular Malaysia because it has been widely planted, especially as a roadside tree. However, in the wild it is rare, and the species is considered as Vulnerable (VU) for Malaysia (Chua et al., 2010) due to forest clearance. In the coastal area of central Terengganu, *H. odorata* was once planted as a multipurpose tree by local villagers for boundary marker, as shade tree and for timber for building houses. Many mature trees can still be seen in the rural areas. It finally found its way as an urban landscape tree during the earlier phase of Klang Valley's greening program in the seventies.

Magnolia champaca or previously classified as *Michelia champaca* is a large evergreen tree in the family Magnoliaceae. The genus name for *Magnolia*, commemorates to Pierre Magnol (1638 – 1715), a French professor of Botany, while the species name *champaca*, refers to its Sankrit name Campaka. Its popular known locally as a Cempaka Kuning, Champaca, Champak, Yellow Champaka, Orange Chempaca, Chempaca Orange Champak, and Orange Champaka, grows naturally in primary lowlands to montane rainforests of the Eastern sub-Himalayan region as well as the Western Ghats (Troup, 1921; Hossain & Nizam, 2002). It is extensively planted in other parts of tropical Asia (Sri Lanka to Indonesia, Vietnam and China) and cultivated in tropical Central and South America and Africa (Candiani et al., 2004; Orwa et al., 2009; Tropicos®, 2012). Champa is also found in the Himalayas, up to north-eastern India, south India and South-East Asia at altitudes of 600-1300 m.

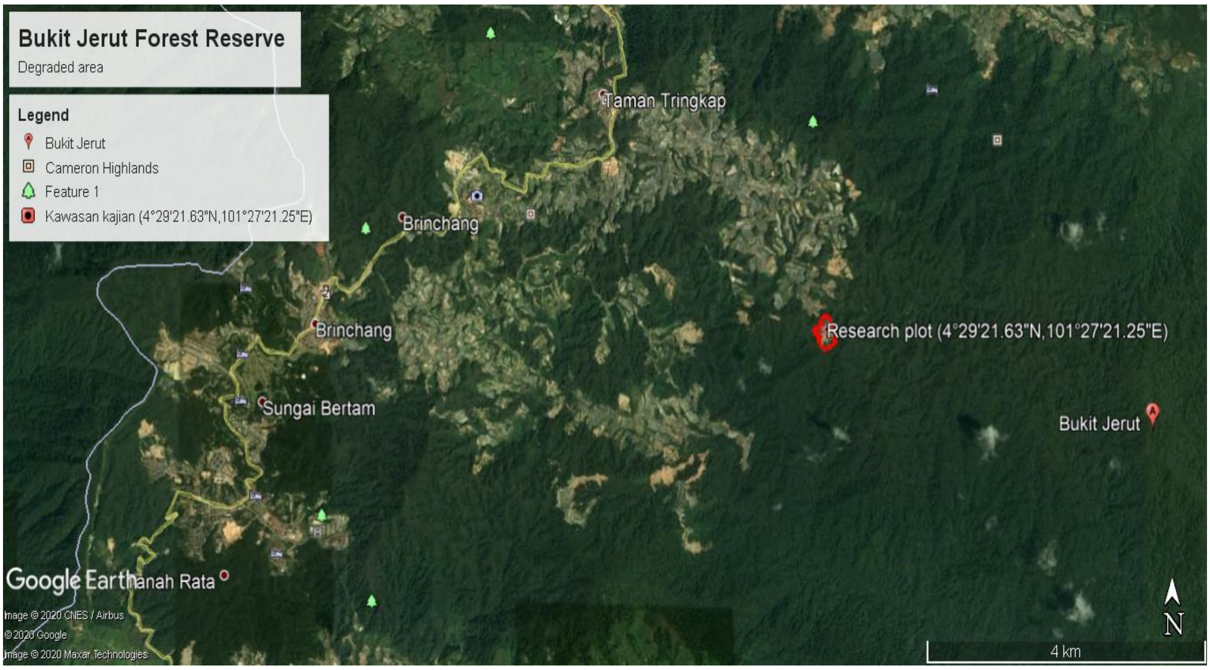
Magnolia champaca is a tree up to 50 m or taller with up to 1.9 m DBH. The size of tepals can reach about 15-20 cm with a yellow colour. Staminal connective is protruding and forming a long tip. Buds, young twigs, young petioles, and young leaf blades are pale yellow velvet-hairy. Twigs are ascending and forming a narrow emboliform crown. Stipular scar 0.3-1 x as long as petiole. Leaf stalks are 2-4 cm with elliptic or ovate shape of 10-20 x 4.5-10 cm, slightly puberulous below, base broadly wedge-shaped or rounded and tip long-pointed tip falling off. Fruit is 7-15 cm with mature carpels obovoid-ellipsoid shape of 1-1.5 cm and tuberculate. Seeds are 2-4 per carpel and rugose. Generally, the flowering was occurred in June-July.

Magnolia champaca is well known for its sweetly scented flowers (Armiyanti et al., 2010), and various parts of the plant provide fodder, timber, fuel, medicines, and antifungal compounds (Orwa et al., 2009). The species is often planted around Hindu and Jain temples. Meanwhile, the plant has been identified as a well performing primary tree species in reforestation and restoration projects throughout southern and south-eastern Asia (Fernando et al., 2013; Hoque et al., 2004; Raman et al., 2009; Bhatt et al., 2010). *M. champaca* is a culturally important tree in the tropics with a high commercial value and popular for its fragrant flowers. Its natural regeneration is rare (Fernando et al., 2013).

METHODOLOGY

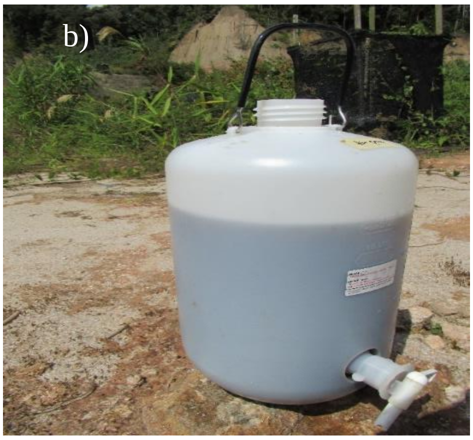
The study area is located in Bukit Jerut Forest Reserve, Tringkap, Cameron Highland (map as in Figure 3). Temperatures at a Cameron Highland are mild, with an average daytime reading of 24 °C and an average night-time reading of 14 °C, while the average annual rainfall is 2,660 mm with peaks in the months of May and October (Aminuddin et al, 2005). Rainfall, recorded approximately 14 km away, was generally distributed fairly evenly throughout the year, with the annual amounts for 2017 was 2,746mm (108.1") of precipitation is accumulated. However, the month with the least rainfall in Cameron Highlands was January when the rain falls for 11 days and typically collects with only 95.3mm (3.8") of precipitation rain. October is the month with the most rainfall in Cameron Highlands, Malaysia. Rainfalls for 23 days and accumulates 373mm (14.7") of precipitation. With an average high-temperature of 23.3°C (73.9°F) and an average low-temperature of 15.8°C (60.4°F), April is the warmest month in Cameron Highlands. With an average high-temperature of 21.1°C (70°F) and an average low-temperature of 14.9°C (58.8°F), December is the coldest month in Cameron Highlands, Malaysia (Weather Atlast, 2017).

Figure 3: Study area in Bukit Jerut Forest Reserve (4°29’21.63” N, 101°27’21.25” E)



Two plants were chosen with different species namely *Hopea odorata* (Merawan Siput Jantan) and *Magnolia champaca* (Cempaka Kuning). Each of the plant was applied with three (3) different fertilizer treatment (T) and a control (without fertilizer): T1) Control, T2) NPK 8:8:8 (300g, granular), T3) Humic Acid (liquid) and T4) NPK 8:8:8 (300g, granular) + Humic Acid. **Figure 4** shows two types of fertilizer used in this study. The stand age is about three years old (planted in year 2017) and divided into three blocks for each species. The diameter of each tree was taken at the stem, 3 inches from the ground for eight (8). Plants height was taken using meter stick from ground level. Diameter increment results were then analyse using statistical program.

Figure 4: Two (2) type of fertilizer treatment were used a) NPK 8:8:8 and b) Humic Acid liquid



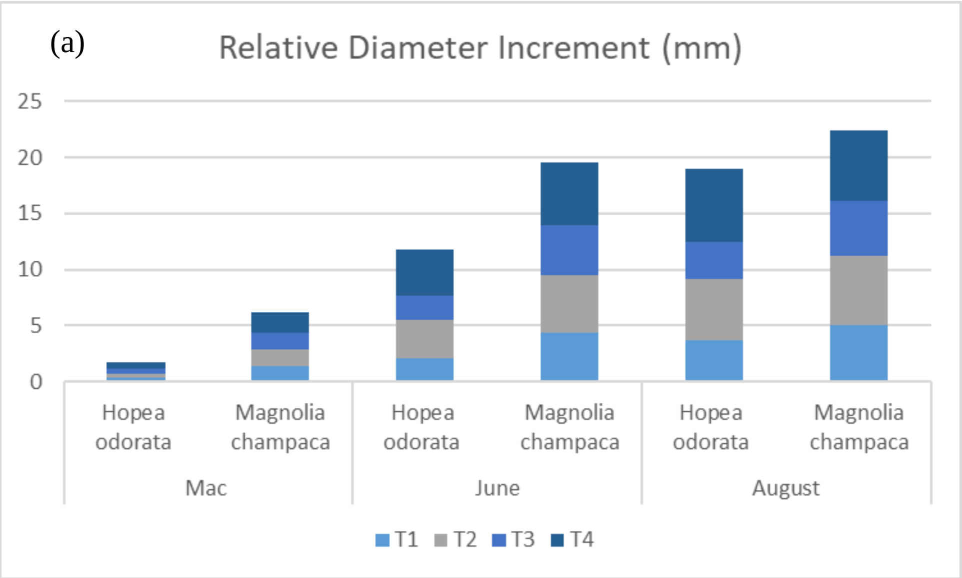
RESULTS AND DISCUSSION

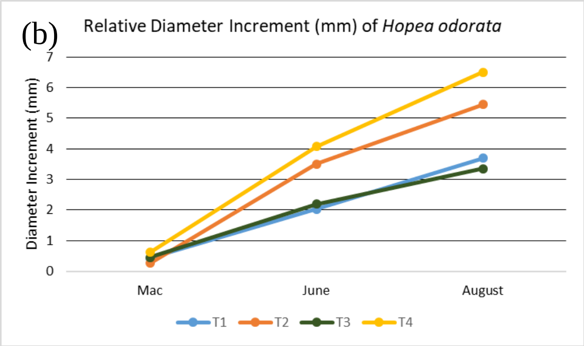
Table 2 shows the results of relative diameter increment for *H. odorata* and *M. champaca*. The results showed that treatment 4 (T4: NPK 8:8:8 + Humic Acid) is the best treatment after eight (8) months for both *H. odorata* and *M. champaca* with relative diameter increment of 6.3 mm and 6.5 mm respectively. The graph in Figure 5 (b) and (c) showed that treatment 4 has the highest relative diameter increment, which is closely followed by treatment 2 for both species. Meanwhile, treatment 1 (T1: Control) and treatment 3 showed no significant difference in the results. Most of the time, *Magnolia champaca* grew better than *H. odorata* (bar graph as in Figure 5 (a)). In terms of relative height increment, *H. odorata* and *M. champaca* respectively grew the most with 0.59 mm in treatment 3 (T3: Humic Acid (liquid)) and 0.09 mm in treatment 2 (Table 3).

Table 2: Diameter measurements (mm) for *Hopea odorata* and *Magnolia champaca*

Treatment	Relative Diameter Increment (mm)					
	Mac		June		August	
	Hopea odorata	*Magnolia champaca*	*Hopea odorata*	*Magnolia champaca*	*Hopea odorata*	*Magnolia champaca*
T1	0.43	1.38	2.03	4.34	3.69	5.00
T2	0.26	1.51	3.5	5.16	5.45	6.18
T3	0.45	1.44	2.19	4.49	3.35	4.90
T4	0.62	1.84	4.07	5.51	6.5	6.30

Figure 5: (a) Relative diameter increment (mm) of (b) Hopea odorata and (c) Magnolia champaca





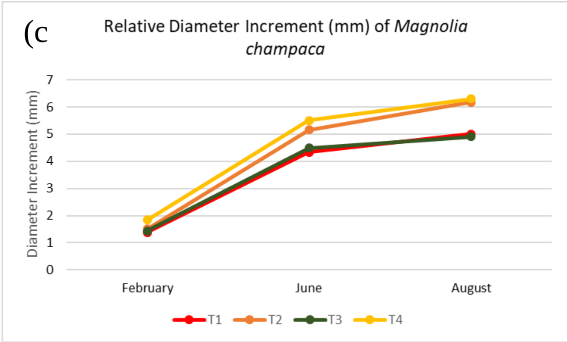


Table 3: Height measurements (mm) for *Hopea odorata* and *Magnolia champaca*

Treatment	Relative Height Increment (mm)					
	Mac		June		August	
	Hopea odorata	*Magnolia champaca*	*Hopea odorata*	*Magnolia champaca*	*Hopea odorata*	*Magnolia champaca*
T1	0.04	0.03	0.09	0.07	0.14	0.07
T2	0.70	0.04	0.10	0.07	0.13	0.09
T3	0.39	0.04	0.10	0.06	0.59	0.06
T4	0.07	0.03	0.14	0.07	0.20	0.07

The results of this study demonstrated that the fertilizer treatment of NPK 8:8:8 (300g, granular) improved the growth performance of *H. odorata* and *M. champaca* in degraded area. Nitrogen (N), phosphorus (P) and potassium (K) fertilizers were essential mineral elements needed for plant functions like metabolism processes, aerial growth like leaves development (Lynch et al., 1991; Lawlor, 2002; dos Santos Jr et al., 2006) and plant establishment (Khan et al., 2010; Ikenganyia et al., 2017; Bernstein et al., 2019) which regularly utilized. Besides, humic acid act as complementary to N, P, and K (Khaled and Fawy, 2011; Safwat et al., 2014; Akladious and Mohamed, 2018) as it improved fertilizers efficiency, prevent fertilizers leaching and erosion, decreases fertilizers toxicity, increases plant production (Kumar et al., 2013), enhancing soil biological, chemical and physical properties (Gümüş and Şeker, 2015; Bernstein et al., 2019) and act as plant biostimulant (Peña-Méndez et al., 2005; Bernstein et al., 2019). Those multitude functions of NPK fertilizer and humic acid as a sort of soil conditioner explain the findings in the result.

Chambers et al. (1996) also found that topsoil removal had no effect on the pH of the upper soil. In the current experiment, topsoil removal will have removed the acidic sand at the top of the soil profile, exposing the more calcareous clay beneath it. Topsoil removal also reduced levels of organic matter in the upper soil, making plant species to establish poorly due to their poor water retention capacity (Bannister, 1964; Gimingham, 1992). Thus, the application of a suitable fertilizer combination enhanced the growth performance of plants (Bechem et al., 2013) and produced a better seedling quality (Hoque et al., 2004) compared to plants without nutrient-enriched soil. Lamb et al. (2005) wrote that biodiversity in the degraded area can be restored with a better regeneration management technique. The study by dos Santos Jr et al. (2006) found that the soil was impoverished of macro- and micro-nutrients due to topsoil removal, which explains the least average relative diameter increment results in treatment 1. Soil with nutrients deficiency will limit the biodiversity and productivity of the area (Kinyua et al., 2010).

Significant differences between NPK and Humic acid were found between treatment 2 and treatment 4 as parameters measured. Nevertheless, there were no significant differences observed between treatments in Analysis of variance (ANOVA) (**Table 5**). The results in this study were comparable with the study by Nussbaum et al. (1995) located in degraded soils in Sabah, Malaysia where the tree species chosen in the study recorded positive improvement of seedling performance with fertilizer application. According to Nussbaum et al. (1995), there are several explanations due to insignificance result of fertilizer treatments. Firstly, other factor that might limit the plant growth is shade conditions. *Hopea odorata* is a shade-tolerant species that need nurse trees as a shade for rapid growth in its early development before gradual removal of the canopy disturbance as the *H. odorata* develops (Dong et al., 2014; Dong et al., 2016). Secondly, the plants might not obtain the nutrients due to leaching, denitrification and immobilisation. Finally, the different physiology of tree species explains the different of its responses as different species need different fertilizer (Bechem et al., 2013). Therefore, to determine regeneration planting success, plant survival in the field of degraded areas is a good indicator (dos Santos Jr et al., 2006).

Table 4: ANOVA test for diameter result of *Hopea odorata* and *Magnolia champaca*

Source of Variation	F crit	df	*Magnolia champaca*		*Hopea odorata*	
			F	P-value	F	P-value
Sample	2.624124	3	0.370553	0.774293	7.655516	0.000052
Columns	2.624124	3	11.52630	2.669012	15.58926	1.122146
Interaction	1.900058	9	0.050117	0.999979	0.309723	0.971696

CONCLUSION

This study indicated that the fertilizer treatment improved the growth performance of *H. odorata* and *M. champaca* in degraded area, but was not significantly improved due to other limiting factors. Hence, regeneration in the degraded area required further studies on other factors such as shade conditions, biomass, photosynthesis, the introduction of pioneer species, short-term and long-term fertilization, soil bulk density, and natural regeneration so that plant species in degraded area could be improved and thus guaranteeing their survival following out planting in regeneration programs. The present study is hoped to provide helpful information for better regeneration programs and management policy in the degraded area. Regeneration efforts to recuperate degraded areas especially forests should be well planned and managed so that its function as ecosystem stabilizer could be sustained.

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