TRANSACTIONS ON SCIENCE AND TECHNOLOGY

The early growth performance of *Octomeles sumatrana* in a spacing and fertilizer trial at Segaliud Lokan Forest Reserve, Sandakan, Sabah

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ABSTRACT *Octomeles sumatrana* is a fast-growing indigenous commercial timber species commonly used in enrichment planting in Sabah. The high production corridor (HPC) is an extensive network of forest areas designated for restoration through enrichment planting to fill in forest gaps created during harvesting. The objectives of the paper to assess the early survival and growth performance of *O. sumatrana* in a spacing and fertiliser trial on a severely degraded forest site. The RCBD trial was established with three block replicates (spacing) and three plot replicates (fertiliser) was established. Six months after planting, the height, collar diameter and survival of seedlings were determined. The two-way ANOVA indicated that the mean height and collar diameter of *O. sumatrana* differed significantly by both spacing treatment ($F(3)=18.73$, $p<0.001$), ($F(3)=15.198$, $p<0.001$), respectively and by spacing x fertiliser treatments ($F(6)= 3.19$, $p< 0.00471$), ($F(6)= 3.51$, $p< 0.00231$), respectively. However, the fertiliser treatments were not significantly different ($p> 0.05$). Tukey's HSD Test for multiples comparisons found that the mean value of mean height of *O. sumatrana* was significantly different between spacing S1 and S2 (+ 45.73 cm), between spacing S1 and S3 (+ 78.09 cm), and spacing S1 and S4 (+40.22 cm). Mean collar diameter of *O. sumatrana* was significantly different between spacing (S1) and S2 (+ 10.21 mm), between spacing S1 and S3 (+ 18.52 mm), and spacing S1 and S4 (+9.77 mm). The mean of mean height of *O. sumatrana* was significantly different between spacing x fertiliser treatments S1F2 and S1F1 (+ 14.02 cm), and S1F2 and S1F3 (+ 50.59 cm). Mean collar diameter of *O. sumatrana* was significantly different between spacing x fertiliser treatments S1F2 and S1F1 (+ 5.91 mm), and S1F2 and S1F3 (+ 13.57 mm). There was a positive correlation (r = 0.879) and statistically significance ($p < 0.01$) between the mean height and collar diameter of *O. sumatrana*. The highest mean survival of *O. sumatrana's* was (92.59% ± 26.69), the highest mean height and mean collar diameter were (206.12 ± 68.16 cm) and (43.38 ± 18.82 mm) in the S1F2 treatments, respectively. The early growth performance of *O. sumatrana* present promising data for forest rehabilitation particularly within open gaps exposed to sunlight in forested areas.

KEYWORDS: *Octomeles sumatrana*; Enrichment planting; Forest restoration; spacing, fertiliser
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Original Article

INTRODUCTION

The most common impact of the forestry industry is forest degradation (Chaudhary *et al.,* 2016). Due to detrimental impacts of forest degradation, an extensive network of forest area known as the High Production Corridor (HPC) was established for forest rehabilitation implemented at the Segaliud Lokan Forest Reserve (SLFR), Sabah, Malaysia. The HPC is an enrichment planting corridor along roads and skid trails to assist with natural regeneration. The HPC forest restoration model was created to ensure long-term economic advantages from sustainable forest management methods (SLFR, 2024).

Forest enrichment planting is a vital silvicultural technique in forest rehabilitation to fill gaps left by logging (Doucet *et al.,* 2009; Lopes *et al.,* 2008; Schwartz *et al.,* 2013). *Octomeless sumatrana* Miq. locally known as Binuang (Datiscaceae) is an indigenous, fast-growing commercial forest species that

has received much attention from forestry stakeholders (Chung *et al*., 2008). *Octomeles sumatrana* forms gregarious stands in disturbed habitats, such as logged-over forests (Lee *et al*., 2005; Sugau *et al*., 2010). Therefore, it was recommended for planting in forest gaps that lack natural regeneration. *Octomeles sumatrana* was proposed for enrichment planting on open severely degraded sites at SLFR, Sandakan. This species substitute for light hardwood dipterocarps (Sugau *et al*., 2017). Before using a species for extensive enrichment planting operations, it is crucial to understand the silviculture treatments that influence seedling growth and survival (Perumal *et al*., 2017). This paper reports the preliminary result of survival and growth performance of *O. sumatrana* seedlings in a spacing and fertiliser trial within the HPC model area at SLFR Sandakan, Sabah.

METHODOLOGY

Study area

The study area SFLR is also known as FMU 19(B), located in the Sandakan region of Sabah Malaysia (between longitudes 117° 23' E and 117° 39' E and latitudes 5° 20' N and 5° 27' N). In the SFLR, all forestry operations are carried out within the HPC model area, defined as the region within 50 metres of forest roads and trails. The silviculture trial was established in Compartment 10 and 11, which has been classified as an open area. The number of potential crop trees (PCTs) at the site was used to indicate the forest degradation level. The open degraded site is defined as an area having total sunlight exposure and containing < 80 PCTs per hectare (Sabah Forestry Department, 2009). At the study site, the average annual temperature is 27.7°C, and the average annual precipitation is 253.7 mm, with the highest precipitation occurring in January and December 2019 (Malaysian Meteorological Department, 2020)

Experimental design

The Randomised Complete Block Design (RCBD) was used with three block replicates for spacing and plot replicate for fertiliser treatments, respectively. Each replicated block represents the planting spacing treatment between *O. sumatrana* seedlings treatments, which were 4 m x 4 m (S1), 5 m x 5 m (S2-control), 4 m x 8 m (S3), and 8 m x 8 m (S4). Each block contained three plots representing the fertiliser treatments using Egyptian rock phosphate (ERP) and Nitrogen Phosphate (NP) compound fertiliser (Table 1). Nine seedlings were planted in each plot, totalling 324 *O. sumatrana* seedlings. The experiment was established in May 2019.

Table 1. The experimental fertilizer treatments

Duration	During Planting	Three months after planting	Six months after planting
F1 (Control)	ERP (100g/plant)	Compound 25g/plant	Compound 50g/plant
F2	ERP (125g/plant)	Compound 50g/plant	Compound 75g/plant
F3	ERP (150g/plant)	Compound 75g/plant	Compound 100g/plant

Growth performance assessment

The growth performance assessment was based on the height, collar diameter and survival rate of *O. sumatrana* seedlings. The first measurements were recorded immediately after planting and then six months after planting. The height of the seedlings was measured from the soil surface to the highest living apex bud, and the collar diameter was measured at 5cm above the soil surface. Before conducting Two-way analysis of variance (ANOVA), Levene's test was used to assess equality of variances and Shapiro-Wilk test to evaluate normality assumptions. Two-way analysis of variance (ANOVA) and post hoc test (Tukey HSD) were performed to test for the significance of spacing

treatment, fertilizer treatment, and spacing x fertilizer interaction effect on the mean growth performance. Growth data of *O. sumatrana* under SDFL for the spacing, fertiliser and spacingxfertiliser treatments were ranked from 1 for the best performing and progressively in increment number for lesser performance for each growth parameter. Treatments with similar growth values are given similar ranks. Then, determine the mean rank for each treatment to identify the best performance. The treatment with the smallest value in mean rank had the best overall growth performance. All statistical analyses were conducted in R studio (R version 3.6.2), and the graph was constructed using IBM SPSS Statistics 22. Climate data was obtained from January until December 2019 and sourced from the Malaysian Meteorological Department.

RESULT AND DISCUSSION

For mean height and collar diameter of *O. sumatrana*, Levene's test rejected the null hypothesis of equal population variances, F (11,24) = 1.94, p = 0.085 and F (11,24) = 1.131, p = 0.381, respectively. There were no outliers, and the data was normally distributed for each group as assessed by Shapiro-Wilk test ($p < 0.05$). There was a positive correlation ($r = 0.879$) and statistically significance ($p < 0.01$) between the mean height and collar diameter of *O. sumatrana*. Table 2 showed the mean height of the *O. sumatrana* was 144.86 cm with a standard deviation of 69.42. Meanwhile, the mean collar diameter of the *O. sumatrana* had a mean of 27.58 mm (SD = 17.98).

Table 2. Descriptives analysis for mean height and collar diameter of *O. sumatrana*

	N	Minimum	Maximum	Mean	Std. Deviation
Height	290	6.00	367.00	144.86	69.42
Collardiameter	290	4.05	87.12	27.58	17.98

Table 3 showed excellent early growth performance of *O. sumatrana* seedlings planted in the 4m x 4m (S1) spacing with the highest mean height and collar diameter at 185.79 cm and 37.18 mm, respectively. However, *O. sumatrana* had the lowest mean height (107.71 cm) and collar diameter (18.66 mm) at 4m x 8m (S3) spacing treatment. Therefore, the different spacing treatments significantly affected the mean height and collar diameter of *O. sumatrana* six months after planting as shown in Figure 1. The two-way ANOVA indicated that the mean height and collar diameter of O. sumatrana differed significantly by spacing treatment ($F(3)=18.73$, $p<0.001$), ($F(3)=15.198$, $p<0.001$), respectively. Tukey's HSD Test for multiples comparisons found that the mean value of mean height was significantly different between spacing (S1) and S2 (+ 45.73 cm), between spacing S1 and S3 (+ 78.09 cm), and spacing S1 and S4 (+40.22 cm). Mean collar diameter of *O. sumatrana* was significantly different between spacing (S1) and S2 (+ 10.21 mm), between spacing S1 and S3 (+ 18.52 mm), and spacing S1 and S4 (+9.77 mm).

Tree spacing affects the individual trees' growth, wood properties, and morphology (Millet *et al*., 2013). Rachmat *et al*. (2019) reported that *O. sumatrana* attained a high total height and diameter breast height (DBH) of 208.37 cm and 4.263 cm, respectively, one year after planting with a spacing of 3 m x 3 m. In another study, 30-month-old *O. sumatrana* in 3m x 3m spacing also showed the best growth (Bogidarmati & Darwo, 2019). Therefore, the height and DBH of *O. sumatrana* in 4m x 4m is higher than those in the 3m x 3m at six months of planting. Rachmat's findings concur with results from the Sabah Forestry Department and TSH Forestry Sdn Bhd trial plots using 4m x 4m planting spacing for *O. sumatrana* as recommended in the Plantation Guide (March 2008) by Sabah Forestry Department (Lee *et al*., 2008).

Table 3. The mean growth parameters of *O. sumatrana* at 6 MAP on SDFL for different spacing and fertiliser treatments.

Treatment	Survival (%)/(Rank)	Height (cm) /(Rank)	Collar diameter (mm) /(Rank)	Rank
S1 (4m x 4m)	88.89±31.62/(2)	185.79±81.35$_{a}$/(1)	37.18±19.52$_{a}$/(1)	1.3
S2 (5m x 5m)	92.59±26.35/(1)	140.06±60.14$_{b}$/(3)	26.97±17.44$_{b}$/(3)	2.3
S3 (4m x 8m)	87.65±33.1/(3)	107.71±46.3$_{c}$/(4)	18.66±11.55$_{c}$/(4)	3.6
S4 (8m x 8m)	88.89±31.62/(2)	145.58±63.31$_{b}$/(2)	27.41±17.71$_{b}$/(2)	2
F1	89.81±30.39/(1)	142.12±73.96a/(2)	27.18±18.17$_{a}$/(2)	1.6
F2	89.81±30.39/(1)	151.61±67.46$_{a}$/(1)	29.08±17.41$_{a}$/(1)	1
F3	88.89±31.57/(2)	140.81±66.8$_{a}$/(3)	26.47±18.45$_{a}$/(3)	2.6
S1F1	92.59±26.69/(1)	192.1±90.89$_{ab}$/(2)	37.47±19.77$_{ab}$/(2)	1.6
S1F2	92.59±26.69/(1)	206.12±68.16$_{a}$/(1)	43.38±18.82$_{a}$/(1)	1
S1F3	81.48±39.58/(4)	155.53±78.27$_{abcd}$/(4)	29.8±18.28$_{abcd}$/(5)	4.3
S2F1	92.59±26.69/(1)	119.93±56.67$_{cd}$/(10)	23.25±14.44$_{bcd}$/(7)	6
S2F2	88.89±32.03/(2)	127.55±46.60$_{cd}$/(8)	22.41±13.33$_{bcd}$/(9)	6.3
S2F3	96.29±19.24/(1)	170.95±63.85$_{abc}$/(3)	34.76±20.96$_{ab}$/(3)	2.3
S3F1	85.19±36.2/(3)	101.17±23.93$_{d}$/(11)	15.70±7.01$_{d}$/(12)	8.6
S3F2	92.59±26.69/(1)	121.26±61.82$_{cd}$/(9)	22.31±13.35$_{bcd}$/(10)	6.6
S3F3	85.19±36.2/(3)	99.5±41.89$_{d}$/(12)	17.64±12.45$_{cd}$/(11)	8.6
S4F1	88.89±32.02/(2)	152.41±72.65$_{abcd}$/(5)	31.54±20.53$_{abc}$/(4)	3.6
S4F2	85.19±36.2/(3)	150.45±57.39$_{abcd}$/(6)	27.86±14.89$_{abcd}$/(6)	5
S4F3	92.59±26.69/(1)	134.53±59.88$_{bcd}$/(7)	23.03±16.84$_{bcd}$/(8)	5.3
ANOVA				
Spacing	NS	***	***	
Fertilising	NS	NS	NS	
Spacing-Fertilising	NS	**	**	

(**Note:** ns = not significant, means with different subscripted letters (a, b, c) indicate significant difference at $p < 0.05$ (** = $p< 0.001$; *** = $p< 0.0001$) between spacing, fertiliser and combination of different treatments, F1 (Control): ERP 100g (planting), NPC 25g (3 MAP), NPC 50g (6 MAP), F2: ERP 125g (planting), NPC 50g (3 MAP), NPC 75g (6 MAP), F3: ERP 150g (planting), NPC 75g (3 MAP), NPC 100g (6 MAP))

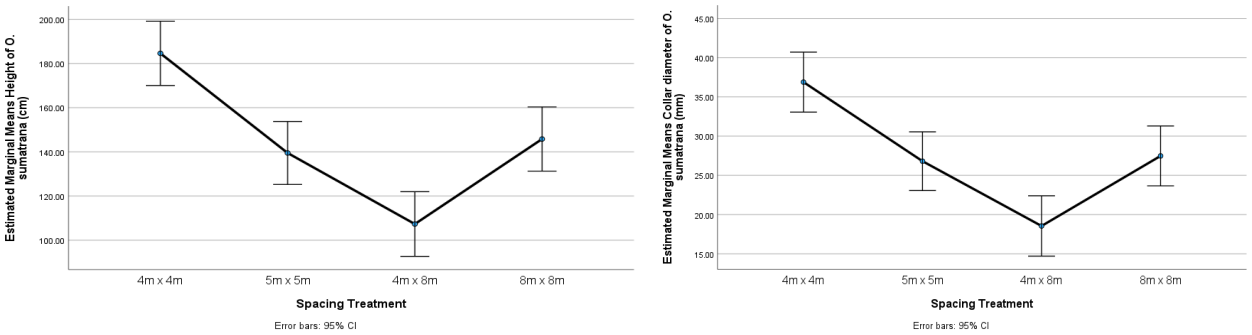

Figure 1. Marginal mean height (a) mean collar diameter (b) of *O. sumatrana* seedlings in different spacing treatments.

Adequate spacing would allow the formation *O. sumatrana* canopy to not overlap with each other, so there is no rivalry for nutrients and space (Kosasih *et al*., 2006). Meanwhile, Lee *et al.* (2005) reported that the best growth of 12 year-old *O. sumatrana* was in 5m x 5m spacing. The past findings highlight the requirement of increased spacing with older age for sustained growth of *O. sumatrana* in connection to the arrangement of planting distances during the different stages of life. In this study, the narrower spacing between trees may facilitate initial growth. But a wider spacing between trees could be advantageous for long-term development and the extension of the canopy. Further research and analysis on the growth patterns of *O. sumatrana* at different stages of tree maturity might yield significant information regarding the optimal spacing for this species under varying growth conditions.

The mean height and collar diameter of *Octomeles sumatrana* were not significantly different ($p<0.05$) between the fertiliser treatments. Table 3 showed the highest mean height (151.61 cm) and collar diameter (29.08 mm) for *O. sumatrana* applied with F2 fertiliser. Meanwhile, the lowest mean height and collar diameter were *O. sumatrana* treated with F3 and F1 (control). The F2 resulted in better growth than the control fertiliser treatment. The slight increase in P and N application helps nutrient uptake from the soil and leafy growth. However, the effects of fertiliser treatments are not significant on the early growth of young *O. sumatrana* as shown in Figure 2. *O. sumatrana* have large leaves that could be a factor for the source of its high density, fast tree growth and closed canopy cover (Bogidarmnati & Darwo, 2019). For *O. sumatrana*, the application rate of 400-600g NPK per seedling showed the optimum height and base diameter. Bogidarmanti & Darwo (2019) and Hebert *et al.* (2006) both reported that using bioactive compost charcoal at 4 kg/planting hole could increase the diameter and height of *O. sumatrana* stands up to twice 30 months after planting.

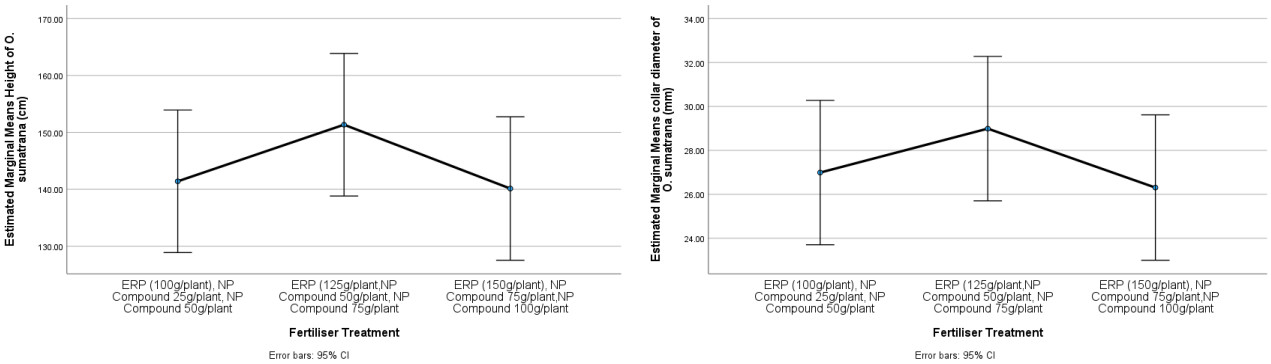

Figure 2. Marginal mean height (a) mean collar diameter (b) of *O. sumatrana* in different fertiliser treatment.

Table 3 showed that treatments S1F2 yielded the highest growth performance (mean height = 206.12 cm, mean collar diameter = 43.4 mm). The two-way ANOVA indicated that the mean height and collar diameter of *O. sumatrana* differed significantly spacing x fertiliser treatments ($F(6)= 3.19$, $p< 0.00471$), ($F(6)= 3.51$, $p< 0.00231$), respectively. The mean of mean height of *O. sumatrana* was significantly different between spacing x fertiliser treatments S1F2 and S1F1 (+ 14.02 cm), and S1F2 and S1F3 (+ 50.59 cm). Mean collar diameter of *O. sumatrana* was significantly different between spacing x fertiliser treatments S1F2 and S1F1 (+ 5.91 mm), and S1F2 and S1F3 (+ 13.57 mm). The lowest growth performance was in S3F1 and S3F3 treated seedlings. Based on Figure 3, the mean height and collar diameter of *O. sumatrana* were significantly different ($p<0.05$) between the spacing treatments six months after planting. The spacing x fertiliser treatment with suitable rate able to improve the growth process of young seedlings (Sarvade *et al*., 2014).

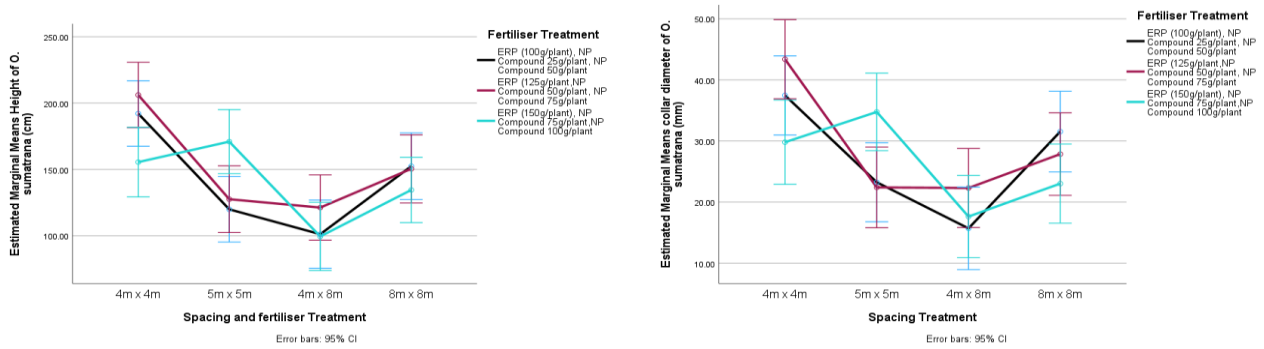

Figure 3. Marginal mean height (a) and collar diameter (b) of *O. sumatrana* seedlings in different spacing and fertiliser treatment.

The average survival rate of *Octomeles sumatrana* ranged from 81.5 to 96.29% between the different spacing, fertiliser and combination treatments. *O. sumatrana* grew well under open areas based on past planting experiences. It is well known for its fast-growing and light-demanding characteristics (Lee *et al*., 2005; Sugau *et al*., 2010). The average survival rate of *O. sumatrana* was up to 30 months old was more than 75% at an altitude > 300 m above sea level (Bogidarmnati & Darwo, 2019).

CONCLUSION

Octomeles sumatrana is a promising tree species for forest restoration efforts in sun-exposed open forest gaps. The early growth performance of *O. sumatrana* is excellent in height, collar diameter and survival with spacing (S1 – 4m x 4m), fertiliser (F2-ERP (125g), NP Compound (50g) and NP Compound (75g) per plant) and a combination S1F2 treatments. Narrower spacing between *O. sumatrana* seedlings may facilitate initial growth. However, there are no significant effect by fertiliser treatment on *O. sumatrana* seedlings on 6 MAP. The combination of spacing and fertiliser treatment accelerates the height, collar diameter and survival of *O. sumatrana* in 6 MAP. Further assessment of *O. sumatrana* growth performance over a long duration is required to understand the response of *O. sumatrana* seedlings to the silvicultural treatments in an open degraded site.

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