# BIOMASS PRODUCTION AND ALLOCATION OF *Macaranga Tanarius (L.) Mull. Arg.* FROM FOUR REGIONS IN PENINSULAR MALAYSIA

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**ABSTRACT**

The dependency of raw materials from the natural forests to cater to the needs of the country's timber industry affects the composition of the country's forest biodiversity. As one of the countries with mega-biodiversity, it is desirable to reduce the dependency on this natural resource by finding a new alternative source, which can sustain the timber industry, and at the same time not affecting the country's biodiversity. This study proposes *Macaranga tanarius*, a pioneering species found in Malaysia as an alternative source of raw material. This study examines the performance of four M. tanarius provenances from Peninsular Malaysia in terms of biomass production. The seedlings from the four provenances were then raised in the nursery for 16 months. Growth performance was monitored regularly, and by the end of the 16 months, four seedlings from each provenance were harvested and measured for biomass. Total biomass was calculated from each plant part namely, roots, stems, branches (if any), and leaves. The proportion of biomass calculated was stem > roots > leaves > branches. Only the Northern provenance developed branches. Both fresh and dry-biomass showed significant differences ($p<0.05$) between provenances in all parts. The Northern provenance showed the highest mean dry-biomass value, followed by the Eastern, Southern, and Central with 2606.36 g tree-$^{1}$, 516.45 g tree-$^{1}$, 443.70 g tree-$^{1}$, and 324.17 g tree-$^{1}$, respectively

Keyword: *Macaranga tanarius* – Biomass production - Provenance

**INTRODUCTION**

In Malaysia, there are several pioneer species from the genus Trema, Malatus, Neomalackia, Endospermum, and Macaranga found abundantly growing wild. Of these genera, the genus Macaranga seems to be the most abundant in terms of number of species and growth, and least researched; Macaranga gigantea and M. tanarius being the two top performing species regarding growth and biomass production (Susanto et. al., 2016). This study proposes *Macaranga tanarius*, a pioneering species found in Malaysia as an alternative source of raw material. This study examines the performance of four M. tanarius provenances from Peninsular Malaysia in terms of biomass production.

This species has the potential to be exploited and become a future source for the wood industry. Thus, this study was initiated after recognizing the importance of growth and yield studies of plantation-grown pioneer fast-growing species for future forest management decisions, coupled with a general lack of the knowledge on the growth and potential yield of the species planted under plantation condition.

**MATERIALS AND METHODS**

The seedlings from the four provenances were then raised in the nursery for 16 months. Growth performance was monitored regularly, and by the end of the 16 months, four seedlings from each provenance were harvested and measured for biomass. Total biomass was calculated from each plant part namely, roots, stems, branches (if any), and leaves The roots were entirely cleaned from potting soil by using tap water. The plant parts were separated into four groups namely the stem, leaf, root, and twig (if any). Each plant part was put in a paper bag and brought to the laboratory, and weighed for fresh biomass. The samples were then oven-dried at 80$^{o}$C for 72 hours until they are consistently dry (Neci, 2012). The plant parts were weighed using a digital balance. The biomass was calculated as a percentage of each proportion and compared with every provenance. Oven-dried plant parts were as in Figure 1.

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Figure 1: Samples of oven-dried *M. tanarius* parts

**Data Analysis**

Mean data were subjected to analysis of variance using procedure general linear model (glm) (SAS, 2008).

**RESULTS**

Fresh and dry matter yield of *M. tanarius* were highly significant among the provenance in all parts (Table 1)

Table 1: The analysis of variance (ANOVA) on the fresh and dry matter yield of *M. tanarius*

| Source of variation | DF | P -value Stem mass | Leaf mass | Root mass | Branches mass | Total plant mass |
|---|---|---|---|---|---|---|
| Fresh weight | | | | | | |
| Provenance | 3 | 0.0011 | 0.0001 | 0.0008 | - | 0.0001 |
| Dry weight | | | | | | |
| Provenance | 3 | 0.0008 | 0.0001 | 0.0060 | - | 0.0001 |

Significant different occurs when P-value is equal or less than 0.05.

Table 2 showed the mean biomass of *M. tanarius* provenances at 16-month old in the nursery. The Northern provenance showed a significant height and RCD differences compared to other provenances with 4.66 m and 5.30 cm, respectively. The mean stem mass, leaf mass, twig mass, root mass, and total biomass were significantly different between provenances, where the Northern provenance performed best in all parameters. At 16 months, only the Northern provenance showed development of the branches. The total fresh biomass for the Northern, Southern, Central and the Eastern provenances were 7113.0 grams, 1323.0 grams, 1198.0 grams, and 858.0 grams; and the dry biomass was 2606.4 grams, 516.5 grams, 443.7 grams, and 324.2 grams, respectively. Dry matter yield for each provenance is shown in Table 2.

Table 2: Mean height (m), root collar diameter (cm), fresh and dry biomass (g) of *M. tanarius* provenances raised in the nursery

| Parameters | Mean | | | |
|---|---|---|---|---|
| | Northern | Southern | Central | Eastern |
| Height (m) | 4.66a | 3.85b | 3.76b | 3.76b |
| Root collar diameter(cm) | 5.30a | 2.60b | 2.48b | 2.61b |
| Fresh weight (g) | | | | |
| Stem | 3750.0a | 783.3b | 737.5b | 362.5b |
| Branches | 475.0 | - | - | - |
| Leaf | 2000.0a | 306.7b | 235.0b | 282.5b |
| Root | 887.5a | 233.3b | 225.0b | 212.5 b |
| Total | 7113.0a | 1323.0b | 1198.0b | 858.0b |
| Dry weight (g) | | | | |
| Stem | 1614.4a | 342.0b | 313.1b | 168.4b |
| Branches | 125.5 | - | - | - |
| Leaf | 499.5a | 75.5b | 52.1b | 76.3b |
| Root | 366.8a | 98.9b | 78.5b | 79.4b |
| Total | 2606.4a | 516.5b | 443.7b | 324.2b |

Means with the same letter within a row are not significantly different by Duncans's Multiple Range Test (DMRT) at p≤ 0.05.

Table 3: Dry matter yield of *M. tanarius* (g tree$^{-1}$ ± S.E) of different provenance

| Plant parts | Provenances |
|---|---|

| | North | East | Central | South |
|---|---|---|---|---|
| Root | 366.88 ± 93.44 (14.1) | 98.97 ± 27.67 (17.7) | 79.45 ± 6.04 (24.5) | 78.54 ± 27.94 (19.2) |
| Stem | 1614.36 ± 357.96 (61.9) | 341.98 ± 50.35 (70.6) | 168.41 ± 62.44 (52.0) | 313.12 ± 42.71 (66.2) |
| Branches | 125.58 ± 26.10 (4.8) | n.a | n.a | n.a |
| Leaves | 499.54 ± 91.25 (19.2) | 75.50 ± 8.71 (11.7) | 76.31 ± 13.44 (23.5) | 52.04 ± 2.98 (14.6) |
| Total biomass | 2606.36 ± 437.82 (100) | 516.45 ± 83.38 (100) | 324.17± 51.85 (100) | 443.70 ± 69.53 (100) |

Figures are means of four trees per provenance; Figures in parentheses are the percentage of total

The dry biomass proportion for each provenance is shown in Table 3 and Figure 2. It shows that stem mass contributes the highest biomass proportion followed by root and leaves, ranging from 52 to 70%. Roots mass and leaves mass proportion ranged from 14 - 24 % and 11.7 – 23.5 %, respectively. Branch mass contributed only 4.8% of the total mass. However, branch development contributed to the increment of leaves mass of the plant. Smaller-sized plants have higher root mass and leaves mass proportion compared to bigger-sized plants.

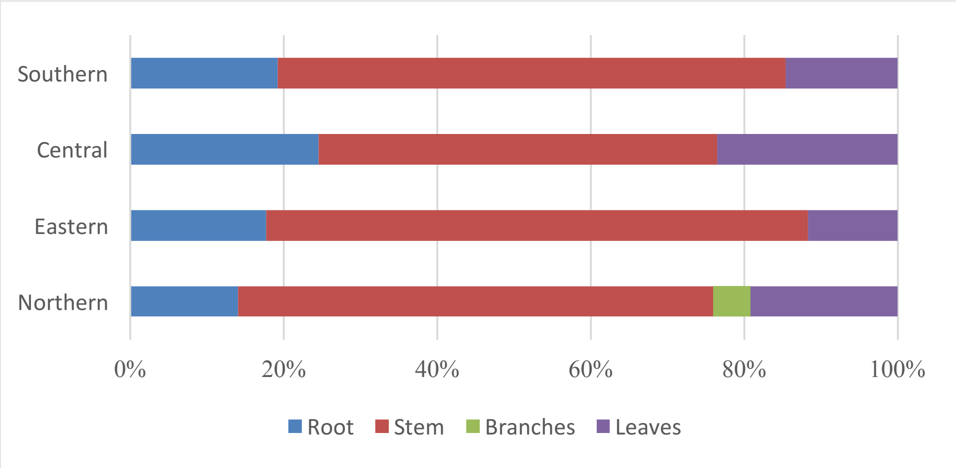


Figure 2: Biomass proportion of *M. tanarius* by provenance

Overall, based on biomass scoring index, the Northern provenance produced the lowest scoring, and the Eastern provenance captured the highest (Table 4). A smaller scoring number can be equated to a better ranking. The growth performance and biomass production for each provenance based on ranking can be arranged into the following order: Northern> Southern> Central> Eastern.

Table 4: Biomass scoring index of 16 m old *M. tanarius* raised in the nursery

| Parameters | Provenance | | | |
|---|---|---|---|---|
| | Northern | Southern | Central | Eastern |
| Height | 1 | 2 | 4 | 3 |
| Root collar diameter | 1 | 3 | 4 | 2 |
| Fresh mass | | | | |
| Stem | 1 | 2 | 3 | 4 |
| Branch | 1 | | | |
| Leaf | 1 | 2 | 4 | 3 |
| Root | 1 | 2 | 3 | 4 |
| Total | 1 | 2 | 3 | 4 |
| Dry mass | 1 | 2 | 3 | 4 |
| Stem | | | | |
| Branch | 1 | | | |
| Leaf | 1 | 3 | 4 | 2 |
| Root | 1 | 2 | 4 | 3 |
| Total | 1 | 2 | 3 | 4 |
| Total score | 12 | 22 | 32 | 33 |

Smaller scoring number equals better ranking

**DISCUSSIONS AND CONCLUSIONS**

Biomass or dry matter yield contributed to the carbon stocking. In this study, results showed that total biomass and biomass allocation were significantly different among provenances. The Northern provenance had the highest dry matter yield compared to other provenances and was significantly associated with growth performance, i.e., RCD and height of the plant. This result is similar to Poorter *et al.* (2012) that showed the biomass is strongly affected by the size of plants. Sapari (2009) in his study on the aboveground biomass of acacias showed that the diameter at breast height (DBH) has a closer relationship on the aboveground biomass compared to height. This relationship, however, is valid only for mature plants. For young plants or seedlings, both height and RCD are equally important factors that relate positively to the biomass of a plant (Bartelink, 1998).

The stem contributed the highest proportion of biomass in all provenances, with the Northern provenance showed the heaviest stem weight and significantly different from other provenances. The biomass fraction in *M.tanarius was* closely related to the size and architecture of the tree. Smaller size plants tend to have a bigger proportion of leaves and root biomass, which decreases as the plant grow. Leaves biomass, however, increases again when the plant starts to produce new branches. Nevertheless, the stem fraction remains increasing as the plant mature. Poorter (2015) demonstrated similar findings that a substantial decline in the leaf vs. root exponent with increasing plant size. Size is an important determinant of biomass fractions, as more biomass has to be invested to support plant tissue as the plant grows larger (Coleman *et al.*, 1994). However, the biomass fraction may change accordingly depending on the availability of light, $CO_2$, water, and nutrients on the physiological activities of various plant's organs (Brouwer, 1963 and Bloom *et al.* 1985).

Bartelink (1998) mentioned that the proportion of standing biomass in foliage and fine root fractions would gradually decline over time. However, the proportion of standing biomass in the stem fraction will increase progressively. Any changes in the biomass proportion were attributed to the different loss rates among components foliage and root. He also noted that suppressed tree might have lower biomass compared to the un-suppressed tree.

Root to shoot (root:shoot) ratio is one component that can be used to describe the performance of the provenances based on the biomass. For most trees under normal condition, the ratio should be within the range of 0.16 to 0.2 (Nambiar, 1980). The root:shoot ratio for the Northern and Southern provenances fell within the stipulated normal range, while the ratio was 0.3 and 0.8 for the Eastern and Central provenances, respectively. The different partitioning of a plant reflects the root:shoot ratio value due to various reasons, such as the adaptability of the plants to the environment (Nambiar, 1980; Beets *et al* 2007), nitrogen availability (Agren and Franklin, 2003) and plant organogenesis (Poluektov and Topazh, 2005).

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