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Water Use Variations of *Tectona grandis*

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Abstract

Water use pattern of Tectona grandis planted at lowland forest assessed. The assessment was made for a different tree size of Tectona grandis. Two sizes selected were 16cm and 38 cm in diameter at breast height (dbh). Sapflow meter used to assess the sap velocity rates within 24 hours. Diurnal sapflow of Tectona grandis shows that mean velocity is high during day time compared night time. Small diameter has high sapflow compared to that of bigger diameter. A flow rates was high at the inner layer and less at outer layer for smaller tree. The variation was vice versa when the tree getting bigger.

1. Introduction

Tectona grandis is a large, deciduous tree that is dominant in mixed hardwood forests. Teak (Tectona grandis) belongs to the family Verbenaceae and is predominantly tropical and subtropical (Zuhaidi et al, 2011). This relatively fast growing species which can achieve maximum height of approximately 85 m (Hashim and Mohd Nor, 2002).

The use of water by plants is one of the important factors for the plant to grow and to process food. Water use efficiency is the photosynthesis production rate at which water evaporates into the air through transpiration. Amount of water used by plant has been the subject of worldwide research since long time ago which was driven by the needs of water resource managers and planners to understand the effect of forest on water supplies (Bosch and Hewlett, 1982; McCulloch and Robinson, 1993). Usually trees use or lose water by two processes. These includes of root water uptakes from the soil and the interception of water by the surfaces of leaves, branches and trunks during rainfall (Tom Nisbet, 2005). Short study has been conducted at Mata Ayer, Perlis to determine the variations of water use in Tectona grandis stand. This study aims to collect baseline data on water movement of different tree size in Tectona grandis under the same conditions. Generally, this study emphasize on hydrological character of the tree water use. Continuous measurement conducted for 15 days using Sap flow sensor to measure total plant water use on hourly and daily basis.

Information on the rate of water use by commercial timber species useful in the selection of suitable species pertaining to the drainage condition of an area. This information can be used in plantation forest activities to produce maximum yield. At the same time the information will also contribute to the management of water resources in the plantation landscape. When the water movement and water usage in certain tree is known, it will give implies to the manager to plant special tree according to their water demand and the site drainage condition. This could help in maximising yield and minimise operational cost.

2. Materials and Methods

The study was conducted at FRIM's Research Station in Mata Ayer, Perlis. It is located in compartment 23 of the Mata Ayer Forest Reserve, Jalan Padang Besar, Perlis. The forest reserve covers an area of 455 ha. Generally the topography is flat and

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drained by the Sungai Chucor. The elevation of the area is 30m above sea level.

Sap flow in Tectona grandis was measured using sap flow sensor (SFM) with heat ratio method (HRM). The SFM sensor includes of three probes that were downstream probe, heater and upstream probe. The length of each probe is 3.5cm. The SFM powered with internal 4 V 1 Amp DC Lithium polymer batteries that is used to operate the instrument. A 12V external battery supplies used for two weeks measurement at 30 minutes interval.

The wood sample taken using borer applied with Methyl Orange for 15 minutes. After 15 minutes, the length of bark and sapwood measured. The wood sample sent to the laboratory to measure its fresh weight and dried weight. The results from SFM were corrected with this information to determine the values of sap flow in the Sap flow tool lite software

3. Results and Discussion

3.1. Rainfall of the Mata Ayer, Perlis during Observation

The study area received a total of 590 mm rainfall during the observation month that occurred within 13 days of the month (Figure 1). The highest was 180 mm day-1 with the average of 17mm day-1

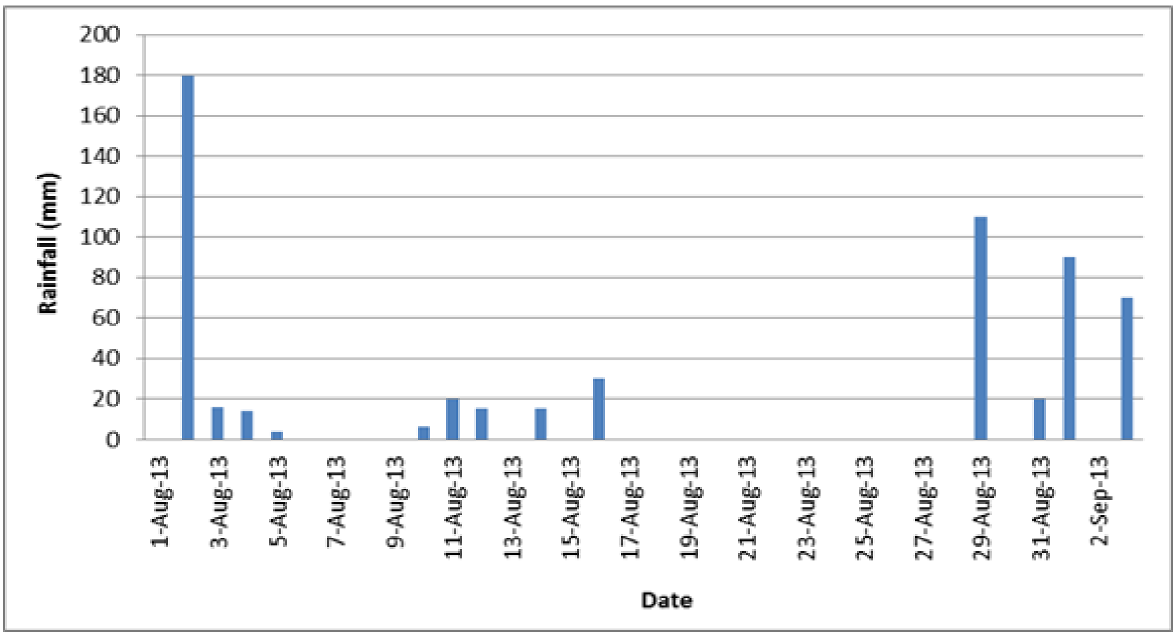

Figure 1: Rainfall observe at SPF Mata Ayer, Perlis in August 2013

3.2. Daily Sap Flow in Tectona grandis

Daily observation shows that water flow in the tree is associated with rainfall. Flows are stable during antecedent rainfall but started to fluctuate after rainfall. This may be associated with the increase of available water in the soil. The daily flow for the bigger tree is very small and was not much affected by the rainfall event. The average water movement was 19 liter day-1 in small tree and only 0.13 liter day-1 in bigger tree (Table 1). Water movement pattern of 16 and 38 cm Tectona grandis is similar but differ in the amount of water transported (Figure 2).

Table 1: Summary of water use in different tree size of Tectona grandis

Tree	16 cm DBH	38 cm DBH
Average flow (liter day^{-1})	19.17058	0.130545
Maximum flow (liter day^{-1})	30.92268	0.173668
Minimum flow (liter day^{-1})	5.762312	0.006063
Ratio (Max – Min)	25.16037	0.167606

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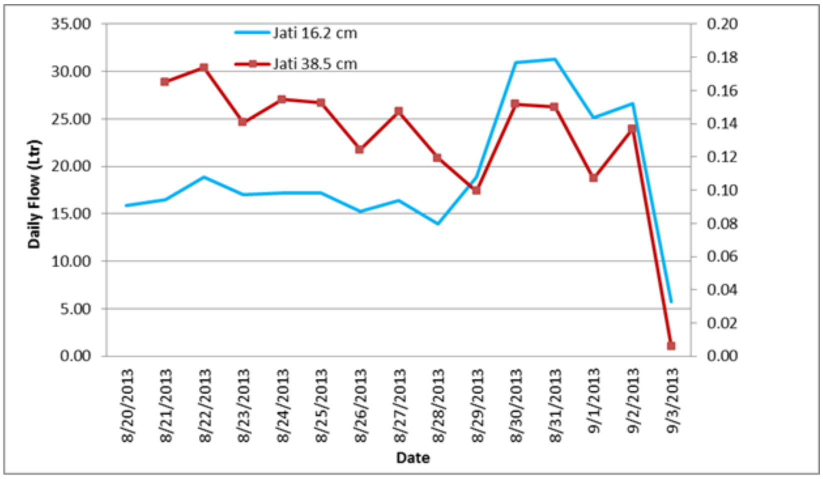

Figure 2: Daily flow of the water use in Tectona grandis from 20/08/2014 to 03/09/2014.

3.3. Mean sap velocity of Tectona grandis

Over 600 data obtained in 15 days sap flow measurement. It show that variations in sap velocity was pronounce in smaller tree while more stable in a bigger tree. The presence of rainfall has no effects on the sap velocity in bigger tree. Mean sap velocity was increase at the rate of 3.6 cm hr-1 within five hours and drop slowly at the rate of 2.2 cm hr-1 in smaller tree. The rate of mean velocity in bigger tree varies only between 0.8 cm hr-1 during rising condition and drop at 0.6 cm hr-1. The mean average velocity is 6.5 cm hr-1 (16cm dbh) and 2.3 cm hr-1 (38 cm dbh) with the standard deviation of 6.8 for smaller tree and 4.7 for bigger tree. The correlation coefficient between the mean sap velocity in both tree is r=0.9. This shows that the pattern of sap velocity in smaller and bigger trees is strongly correlated. The correlation is differ in their amount. This situation suspected due to the active growth in smaller tree compared to the bigger tree. It was also suspected that the bigger tree taking water from groundwater while smaller tree use only soil water. Therefore, the tension in bigger tree is high compared to small tree because it need more energy to pull water from underground level. Whereas the smaller tree use only water from the soil water which is nearer to the surface.

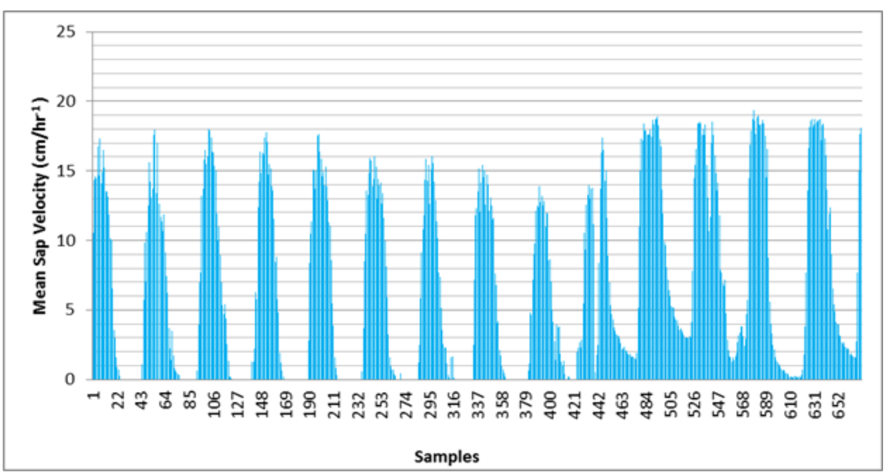

Figure 3: Mean sap velocity in 16.2 cm Tectona grandis sampled at 30 minutes interval for 15 days

Table 2: Summary of the sap velocity value of the 16 and 38 cm Tectona grandis at 30 minutes interval.

	Tectona grandis 16 cm	Tectona grandis 38 cm
Average	6.544	2.325672
Max	19.381	8.960567
Min	-2.279	-6.82841
SD	6.891301	4.782269

Diurnal variations of sap flow in Tectona grandis shows that tree sizes influence the differences in sap velocity between outer and inner layer. Biggest tree perform high sap velocity at the inner layer within the sapwood compared to cambium or bark. The velocity differences between these layers are 1.1 cm hr-1. Maximum sap velocity for bigger Tectona grandis is 11 cm hr-1 for inner layer and 6.6 cm-1 for outer layer. The range of sap velocity for inner layer is 14 cm hr-1 while outer layer is 8.8 cm hr-1. In smaller tree, sap velocities tend to be high at outer layer compared to inner layer. The differences between these layers are 30 cm hr-1 with maximum velocity is 33 cm hr-1 in outer layer compared to 2.5 cm hr-1 at the inner layer.

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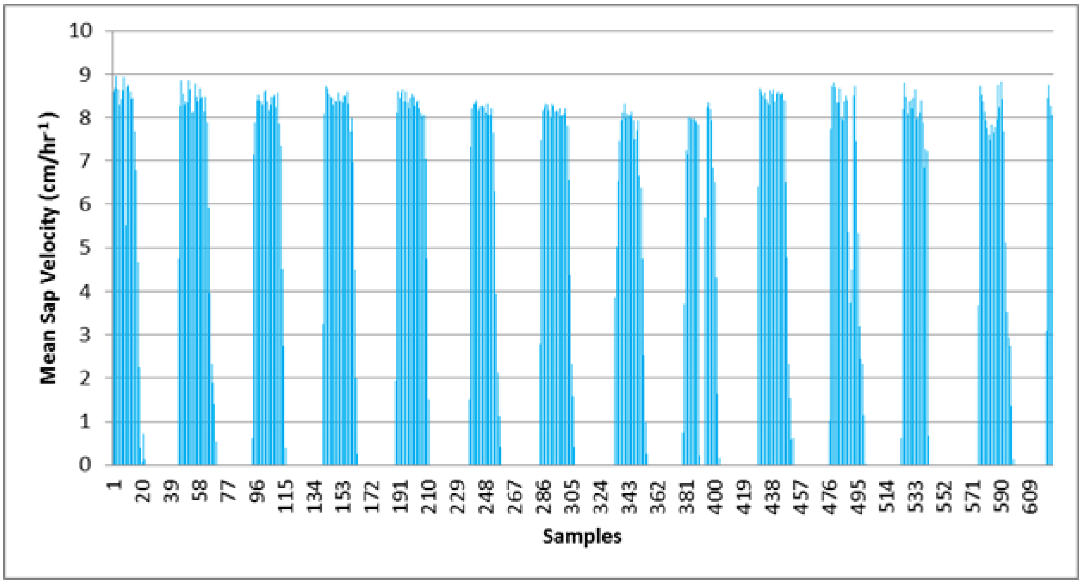

Figure 4: Mean sap velocity in 38.5 cm *Tectona grandis* sampled at 30 minutes interval for 14 days.

3.4. Diurnal Variation in Different Tree Size of Tectona grandis

Sap velocity of the Tectona grandis is stable during night. It started to rise at 8.00 a.m when the sunshine appear and getting even higher at 9.00 a.m. to 5.00p.m. The rising curve of the water use might also associate with the stomata opening in the leaves. The curves gradually decrease at 6.00 p.m onward. Sap velocity trend in the bigger tree is moving gradually between the inner and outer layer. However, in the smaller tree sap velocity move very fast at the outer layer and slower at the inner layer. This may be due to the proportion of sapwood in the smaller tree. This situation is expected to become stable when the tree is getting bigger

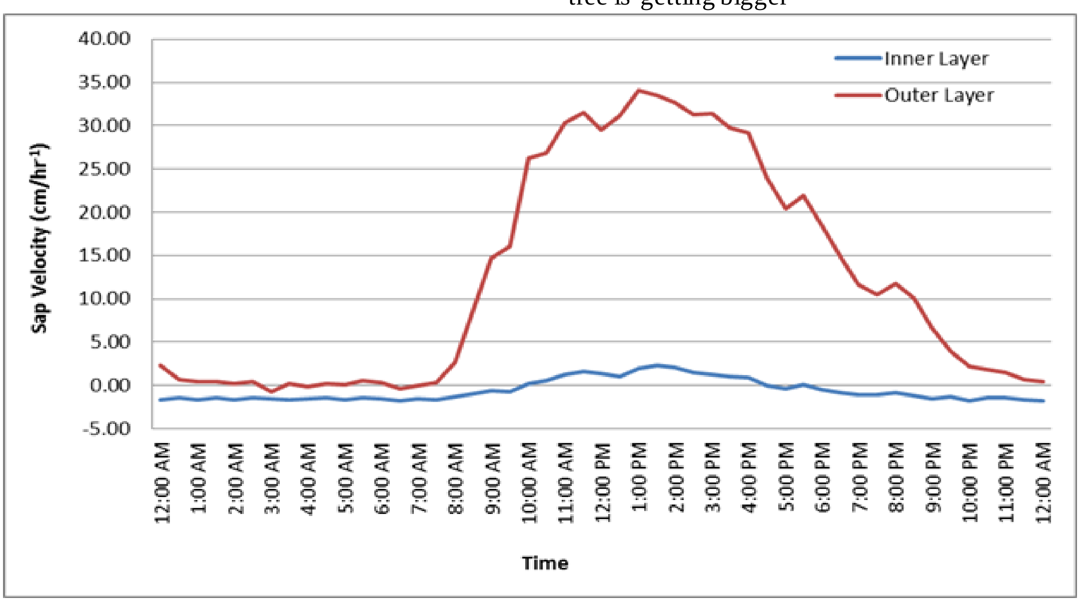

Figure 5: Diurnal sap velocity of the 16 cm DBH Tectona grandis

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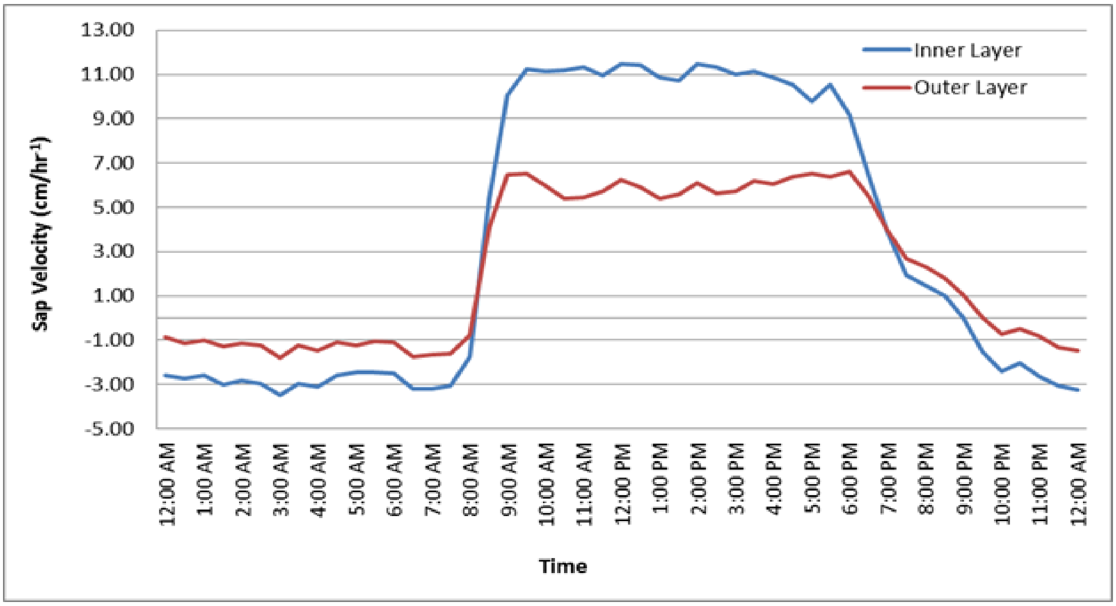

Figure 6: Diurnal sap velocity of the 38.5 cm DBH Tectona grandis

4. Conclusions

Differences in tree size of the Tectona grandis gives variations in sap flow. There are many factors influence sap flow variation in tree such as transpiration and photosynthesis activities, root system and physiology of the tree. Sapwood proportion may also play important roles in water movement of tree. Diurnal variation could be due to appearance of sunlight in the morning or day time and the tree works actively in daytime for its daily processes such as transpiration and photosynthesis. Whereas, at night time, the trees could not work actively because the is no sunlight to support their processes. Overall observation found that bigger tree tend to consume less water. Thus, it will maintain the water storage in the groundwater. This is useful for the trees during drought where water is scarce. Further study is needed to clarify the water use in tectona grandis concerning their sizes and factor affecting. More factors need to be included in the study to get clearer explanation on the trend of the water use in tectona grandis.

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