SAP FLOW PATTERN OF MATURED *ACACIA MANGIUM*

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ABSTRACT

The sap flow pattern of matured Acacia mangium planted at Beach Ridges Interspersed with Swales (BRIS) soil assessed to determine the variation of sap volume of different diameter sizes. Sizes selected are 19.2, 19.5 and 23.2 cm in diameter at breast height (dbh). Sap flow meter (SFM) used to assess the sap volume rates at the interval of 30 minutes within 24 hours for 5 months. Day and night sap flow pattern of Acacia mangium shows that sap volume is high during day time compared night time. Monthly sap volume for 19.5cm dbh was range between 63 to 163 liter month^{-1}; 58 to 171 liter month^{-1} (19.2 cm dbh) and 67 to 187 liter month^{-1} (23.2 cm dbh). On daily basis, all trees consume about an average of 4 to 6 liter day^{-1}. The variation in sap volume was contributed by the sapwood layer in the tree. The sap volume variations were almost similar for all three sizes.

Key words: Sap Flow, Acacia mangium, Diameter sizes, BRIS soil.

Introduction

Efficient use of water by plants is one of the important factors for the plants to growth and manufacture food which is highly dependent on water. Water use is a measure of plant performance to transport water from soil which has long been of interest to agronomists, foresters and ecologists. In forestry systems, the efficiency of water use by plants is a critical link between timber production and water management while at the global level it is connecting to the water and carbon cycle by terrestrial plants and is expected to increase in the future due to the increasing carbon emissions. Information about the rate of water use by commercial timber species also help in the selection of appropriate species for an area that can be used in forest plantation activities so that these activities can produce maximum results and at the same time contribute to the management of water resources in the plantation landscape.

The study of sap flow is important to estimate how much water consumed by tree in certain period of time. It is useful for plantation planning and water management. In watershed management, variation of water use by species within the watershed will shape the volume of water supplied by the catchment. The study on sap flow and water use has been widely conducted in temperate country but less has been done in Malaysia. Finding by Du and Yang,1995; Cienciala et al, 1997; Lagergren and Lindorth, 2002 suggested that sapflow or transpiration of trees may be closely related to plant hydraulic variables and environmental factors especially soil types. According to Scott (2005), there are evidence indicates that plantation forestry may have specific hydrological characteristics that are related to the fast rate of growth of the species used, with corresponding high water consumption, and the short rotation period of the forest stands, which does not permit the catchment water balance to achieve hydrological stability as the forest cover ages. According to Nisbet (2005), the amount of water used by trees is strongly influenced by climate. In addition, soil can also affect water use by influencing the amount of water that is available in the soil to maintain transpiration. The design of a forest exerts a marked influence on its overall water use through determining the mix

of species and crops ages and the amount of open space where the mixed-aged forest will usually have a lower water use compared to a single-aged (Nisbet, 2005).

This study aims to collect baseline data on sap flow of matured *Acacia mangium* planted at Beach Ridges Interspersed with Swales (BRIS) soil. *Acacia mangium* was selected in this study based on its importance under the Malaysian plantation programme and availability in FRIM Research Station. Acacias are of considerable industrial importance for tropical reforestation and rehabilitation of degraded and problematic soil due to its fast growing characteristic. A study by Hua *et al.* (2011) on the nighttime sap flow of *Acacia mangium* found that nighttime flow was substantial and showed seasonal variation similar to the patterns of daytime. The mean nighttime sap flow was higher in the less precipitation year than in the highest precipitation year since more daytime transpiration and low soil water availability in the relatively dry year cause more nighttime sap flow. This shows that sap flow is closely associated with soil water availability. This paper reports the study of sap flow pattern in matured *Acacia mangium*. Generally, this study emphasize on hydrological character of the tree water use.

Material & method

This study was conducted at FRIM's Research Station in Setiu, Terengganu. This research station establish in 1996 at 51 hectares area. Generally this area cover by Beach Ridges Interspersed with Swales or commonly known as BRIS soil which contains of mostly sand with little nutrient to support plant growth. These areas stretch along the coast of Kelantan, Terengganu and Pahang which experience very hot weather during dry period and flooding during wet period (Shamsuddin, 1990). The soil is mostly sandy and have poor water and nutrient retention properties (Mohd. Ghazali *et al.*, 2007).

Sap flow in matured *Acacia mangium* was measured using sap flow meter (SFM) with heat ratio method (HRM). Is a self-contained, standalone instrument for the measurement of sap flow or transpiration in plants. Utilizing the Heat Ratio Method (HRM) principle the Sap Flow Meter is able to measure both high and low flow rates in both small woody stems & roots as well as large trees. This method was developed by the University of Western Australia and partner organisations, ICRAF and CSIRO, the HRM principle has been validated against gravimetric measurements of transpiration and used in published sap flow research since 1998 (www.ictinternational.org.com).

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. Prior to the measurement, apparatus and equipment for establishment of SFM sensor was prepared. This includes of SFM sensor, drill, drill pin guide and methyl orange. It followed by preparing tiny holes for sensor insertion. Drill pin guide use to ensure that the holes prepared diametrical or straight. Sensors inserted according to the sequences which followed by downstream pin at the top position, heater (red color pin) at the middle and finally upstream pin at the bottom position. 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 brought to the laboratory to measure its fresh 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. Three 20 x 20 meter plots were established at 11 years *Acacia mangium* stand for comparison. Diameter measurement and leaves count were also conducted within the plots. Leaves samples collected for Leave Area Index (LAI) measurement. The sap flow was measured 24 hours for 10 months at 30 minutes interval. Measurement was taken from middle of Jun 2014 to middle of March in 2015. However due to some equipment problem, reporting are for observation from Jun 2014 to October 2014 only.

Results & discussion

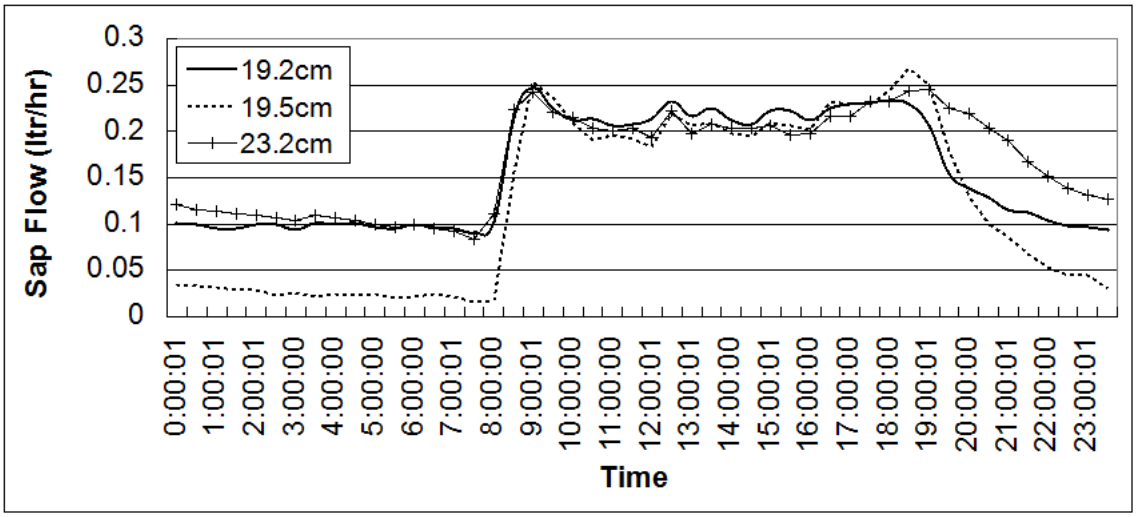
General information of Acacia mangium

There are 44 *Acacia mangium* trees within the plots with maximum dbh at 32.9 cm dbh and minimum 8.1 cm dbh. Maximum height recorded was 13.1 meter while minimum was 5.3 meter. The crown diameter ranges between 4 to 90 m^2. Mean leaves count per tree was between 8000 to 14,000 with LAI varies from minimum 26.30 cm^2 to the maximum of 118.20 cm^2. The average LAI according to plots are 64.94 cm^2 (plot 1), 72.84 cm^2 (plot 2) and 90.36 cm^2 (plot 3).

Day and night sap flow pattern of matured Acacia mangium

Observation of 24 hours (day and night) pattern of matured *Acacia mangium* (Figure 1) found that sap transport was slower and stable during midnight (12.00am) until early morning (7.00am). It started to rise up after 8.00 am and stabilized until 7.00 pm in the afternoon. During daytime, there was an up and down sap transport which was affected by the cloudy and sunshine conditions. It took longer time for the sap flow to decrease in *Acacia mangium*. This situation suspected was due to the longer sunshine effect and late stomata closure.

Figure 1: The 24 hours trend of sap flow in *Acacia mangium*



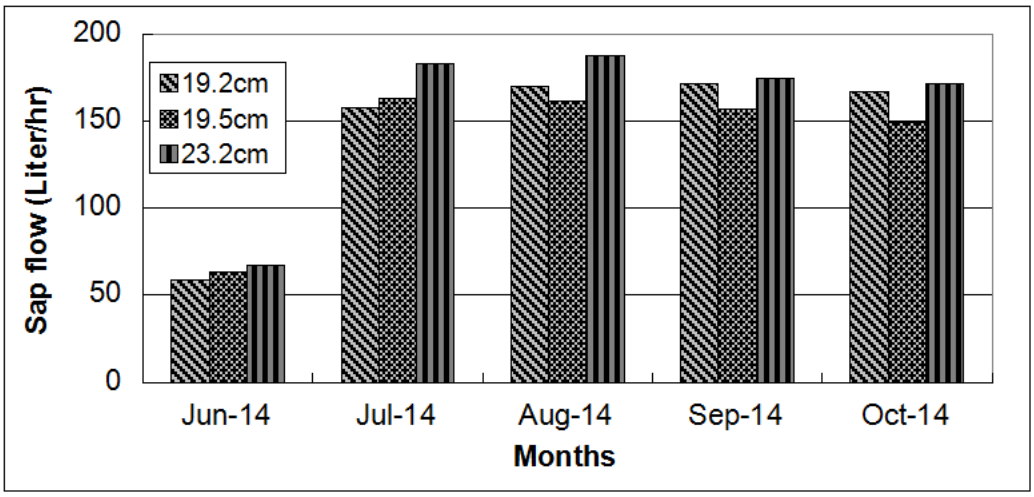
Daily Sap Flow Volume

Daily sap flow volume for *Acacia mangium* at BRIS soil was range from the minimum of 3.7 liter day $^{-1}$ to maximum 6.8 liter day $^{-1}$. Minimum daily sap volume was increasing for 19.2 cm dbh while it was the other way around for 19.5cm dbh. It was maintained at around minimum 5 liter day $^{-1}$ for tree sized 23.2cm dbh. The maximum sap consumption by the *Acacia mangium* was maintained for all trees during the observation months. It was around 5 to 7 liter day $^{-1}$. Counting the daily maximum and minimum value resulted in the average sap volume of Acacia mangium at 4.8 to 5.7 liter day $^{-1}$ (19.2cm), 4.8 to 5.2 liter day $^{-1}$ (19.5cm) and 5.5 to 6.0 liter day $^{-1}$ (23.2cm).

Monthly Sap Flow Volume

Based on the five months observation data, it was found that bigger tree size transport more sap compared to the smaller one. The total monthly sap volume for 23.2 cm dbh ranges between 67 to 187 liter month^{-1} compared to 63 to 163 liter month^{-1} (19.5cm) and 58 to 171 liter month^{-1} (19.2 cm). The monthly variations (Figure 2) show that maximum total sap volume in 19.2 cm was in September 2014, August for 23.2 cm and July for 19.5 cm. All reading in June 2014 was lesser from the rest of the months because data only available for 15 days. Since rainfall and relative humidity data was not available for the observation months, the association between these parameters are not be able to discuss.

Figure 2: Total monthly sap volume of *Acacia mangium*



Conclusion

The pattern of sap flow in matured *Acacia mangium* at BRIS soil was characterised by the sunshine effect with notable difference between smaller and bigger stem sizes. The late decreasing sap transport marked the late stomata closure which was associated with the photosynthesis activities in the tree. The baseline data collected in this study can be further improved with more replicate and comparison with other soil types.

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