Measured Sap Flow and Estimated Evapotranspiration of Tropical *Eucalyptus urophylla* Plantations in South China

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Abstract: During the period of September 12, 1999 to September 24, 2000, we measured sap flow of eucalyptus (*Eucalyptus urophylla* S.T. Blake) plantations using heat pulse technique, and the relevant environmental vaiables, such as soil evaporation and canopy interception, etc, at Hetou and Jijia sites, Leizhou Peninsula, Guangdong Province. Based on the measurements of sap flow and estimates of evapotranspiration, the following can be concluded: (1) the maximum of diurnal xylem sap flux density (SFD) at Hetou, where covered with coarse-textured soils formed on Quaternary sediments, was almost twice of that at Jijia, where located on clay-rich soils derived from basalt; (2) SFD was highly correlated to water vapor pressure deficit (VPD) of ambient air near the canopy layer; (3) the correlation between SFD and air temperature also depends on soil properties and soil water potential; (4) the relative differences between measured and modeled evapotranspiration were small, being 5.26% at Hetou and 6.14% at Jijia; (5) the plantation transpiration accounted for 62.2% and 51.3% of the evapotranspiration at Hetou and Jijia, respectively; and (6) the averaged SFD per unit leaf area (ASPULA) was a good index to estimate the amount of water consumption of tree species.

Key words: *Eucalyptus urophylla* plantation; water consumption; sap flux density (SFD); vapor pressure deficit (VPD); transpiration; evapotranspiration

Concerns over excessive water use by exotic eucalyptus species have been raised in several countries where commercial plantations have been established (Calder *et al.*, 1997; Kallarackal *et al.*, 1997), but water use characteristics of many species planted in various climates and physiographic settings have not yet been fully understood. There is still much to learn about how the physiological and environmental factors impact on the water use by eucalyptus plantations (Hatton *et al.*, 1998).

To quantify the hydrological influences of eucalyptus plantations established over 200 000 hm^2 on the Leizhou Peninsula, Guangdong Province, South China, many researchers carried out some catchment studies for more than 20 years (Zhou *et al.*, 1995), including continuous measurement of microclimatic variables, soil and underground water dynamics, runoff and soil erosion mechanism, etc. Because of lacking of accurate quantitative estimation of plantation transpiration and the related studies, we have not yet reached any comprehensive conclusions about the hydrological influences of eucalyptus plantations on the water balance at catchment scale.

Direct measurement of sap flow is an accurate method to determine the transpiration of a single tree (Steinberg *et al.*, 1990; Grime *et al.*, 1995). Sap flow measurements had rarely been used to estimate transpiration of an entire stand before the 1960s (Ladefoged, 1963; Doley *et al.*, 1966). Such extrapolation requires not only accurate measurements of sap velocity, but also detailed inventories of stand-level properties including spacings between tree stems or crowns (Hatton *et al.*, 1990), basal stem area, leaf area or sapwood area (Hatton *et al.*, 1995). Although the scaling-up from individual trees to a stand based on sapwood area are conceptually simple, estimations of an individual tree or forest water use by this way are subject to large uncertainties (Smith *et al.*, 1996; Kostner *et al.*, 1998), among which the most important is the actual proportion of water transport passing through the sapwood (Wullschleger *et al.*, 2000). Previous studies have shown that radial variation in sap

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velocity is large in many woody species (Dye *et al.*, 1991; Becker, 1996; Phillips *et al.*, 1996; Oren *et al.*, 1999), with sap velocities being the greatest in the outer sapwood and progressively lower toward heartwood. Zhou *et al.* (2002) reported that the radial variation in sap flux density (SFD) was a function of sapwood thickness for two eucalyptus plantations at both sites, which has provided a way to estimate the average SFD throughout the sapwood of a tree based on several monitoring points, resulting in a more accurate method of scaling-up of transpiration from individual trees to a stand.

Heat-balance method and heat-pulse method are two main methods for continuous measurement of SFD without disturbing the natural environments, compared with weighting method. Heat-balance method uses sap flow gauges, each consisting of a flexible heating element and two thermocouples, pressed firmly against the outside of the stem above and below the heating element. Sap flow is calculated by the temperature difference between thermocouples above and below the heated stem section after subtracting heat loss due to conduction by stemwood (Sakuratani, 1981; Baker *et al.*, 1987; Granier, 1987; Steinberg *et al.*, 1989). Heat-pulse (compensation) method uses heat-pulse sensor, each composing of a heater and an unheated thermocouple pair, and being connected in two sides of the heater in vertical direction for measuring the temperature difference (Granier, 1987; Barrett *et al.*, 1995). The latter provides a practical means to estimate the water use of individual trees and is often a reasonably accurate alternative for measuring forest and woodland transpiration in a complex heterogeneous terrain (Hatton *et al.*, 1995).

A heat-pulse system developed by Edwards Industries of New Zealand was used to quantify the water use of *Eucalyptus urophylla* at the two different sites on Leizhou Peninsula. The system offers superior accuracy and more reliable than all other alternative equipment. Development and customization software for convenient SFD data collection and analysis were done by CFTT (Center for Forest Tree Technology, Victoria 3084, Australia).

This paper is to deal with SFD dynamics, and the correlations between SFD and environmental factors of two *Eucalyptus urophylla* plantations. Based on this, the laws of transpiration and water consumption were then discussed, and evapotranspiration was calculated by a theoretical model (Zhou *et al.*, 1988).

1 Materials and Methods

1.1 Site description

The plantations are located at two sites (Hetou and Jijia) in the Nandu River watershed on Leizhou Peninsula, Guangdong Province, China. The Hetou site (21°05' N, 109°54' E) is on sandy soil of sedimentary origin, while the Jijia site (20°54' N, 109°52' E) is on basalt-derived clay soil, approximately 40 km away. The climate is tropical, with long term monthly mean air temperature of around 28 ℃ for July and 16 ℃ for January. Annual rainfall varies from 1 300 mm in the south to 2 500 mm in the north of the peninsula with high monthly variations. Over 80% of the rain falls between April and September, up to half of this is due to typhoon that occurs up to seven times per year. At the study sites, the *E. urophylla* plantations were planted in mid-1996 (3 m × 2 m spacing at the Hetou site, 2.0 m × 1.5 m spacing at the Jijia site). A 40 m × 40 m plot was taken at each site in Sept., 1999, and a set of standing trees within the plot were selected for monitoring according to the diameter distribution of the stand.

1.2 Environmental monitoring

Instruments for measuring air temperature, relative humidity, solar radiation and wind speed were installed at both sites in September 1999, and half-hourly measurements were recorded using a data logger. Rainfall above the canopy was measured using a tipping bucket rain gauge. Soil water contents were also measured at four depths (50, 150, 250 and 350 cm) using soil moisture sensors (Theta Probes, Delta T Devices, UK).

Soil particle size composition was measured using samples taken every 30 cm to a depth of 4 m at two locations within the sampling area at each site, and cores were excavated from 4 spots to a depth of 0.8 m for bulk density determination. Points on the soil moisture characteristic curve describing the relationship between soil water content in mass fraction to matrix potential was obtained by the filter paper method.

1.3 Measurement of soil evaporation and canopy interception

Soil evaporation was measured by several small lysimeters placed in different locations at both sites. The lysimeters can allow the soil water to exchange freely through the bottom of the equipment. Soil evaporation over a given period was estimated as the net reduction in weight after accounting for rainfall input.

Rainfall was measured by tipping bucket rain gauges, and throughfall by a series of 4 troughs placed beneath the canopy with a total area of 1.06 m^2. The troughs drained into a large tipping bucket recorder (1.0 mm). Stemflow was measured using PVC hosepipe cut in half laterally and nailed tightly around the trunks of four trees and also drained each to a tipping bucket recorder (0.5 mm). Daily interception was the difference of rainfall and the sum of throughfall and stemflow.

1.4 Sapwood area and other supplementary measurements

The sapwood area was calculated using empirical equations relating the measured sapwood area (y, cm^2) to stem diameter (x) at breast height (1.3 m) (DBH, x, cm): $y = 0.281\,5x^2 + 1.141\,1x$ ($R^2 = 0.90$) for Hetou, and $y = 0.302\,7x^2 + 1.718\,9x$ ($R^2 = 0.92$) for Jijia. Supplementary measurements, such as probe separation (i.e., the accurate distance between the heater and the two thermocouples), wound size, volumetric water and wood contents of the selected standing trees were accurately measured regularly to correct SFD. Probe separation was accurately determined by spacing blank probes outside the cambium at a distance equal to the depth of the sensor implanted. Wound size, wood and water contents were measured by the method described in Hatton *et al.* (1990). Individual tree leaf area (LA) (m^2) was the leaf area index (LAI-estimated with the Canopy Area Analyzer, LAI2000, Li-Cor, Inc., Lincoln, NE) multiplied by the vertical projection area of the canopy. Six U6 (a clone of *E. urophylla*) trees were randomly selected at both sites to obtain the relationship between LA (m^2) and DBH (cm) ($LA = 1.521\,8\ DBH^{1.082\,1}$ ($R^2 = 0.90$, $n = 6$, $P = 0.01$)). The relationship was used to estimate leaf areas of other trees in the stand.

1.5 Sap flux density monitoring

During the observed period, heat-pulse sensors were cycled through a representative sample of trees (20 at Hetou and 18 at Jijia) for about 4–6 weeks per tree at both sites. Four heat-pulse probes were positioned at the breast height in each tree in four different directions (North, South, East and West) and inserted into the sapwood in different depths according to the tree diameter. The controlled module/data logger was programmed to provide a heat-pulse. Measurements were recorded every 30 min. Zhou *et al.* (2002) reported that the radial variation in SFD was a function of sapwood thickness at both sites: $y = 5.006\,2x^3 - 9.116\,1x^2 + 4.454\,4x + 0.463\,4$ ($R^2 = 0.81$, $n = 72$, $P = 0.01$) for Hetou, and $y = 3.667\,5x^3 - 7.295\,5x^2 + 3.682\,6x + 0.567\,4$ ($R^2 = 0.94$, $n = 80$, $P = 0.01$) for Jijia (where, y is the ratio of SFD of one sensor to the average of four sensors placed at different depths, x is the ratio of the depth of sensor to the radial sapwood thickness). The relationships were used to calculate the average SFD of the whole sapwood of a tree. The transpiration of a single tree and a stand can be calculated from the average SFD using the methodology of Edwards *et al.* (1984) and Olbrich (1991).

1.6 Measured and calculated evapotranspiration

Total evapotranspiration E_t (mm) is the sum of canopy transpiration E_c (mm), soil evaporation E_s (mm), and evaporation from canopy interception and dew E_i (mm), that is:

$$E_t = E_c + E_s + E_i \qquad (1)$$

Total evapotranspiration E_t (mm) can be also calculated using the following theoretical model (Zhou *et al.*, 1988; 1995):

$$E_t = E_p\left\{1 + \frac{S}{E_p} - \left[1 + \left(\frac{S}{E_p}\right)^{\frac{nh}{h^2-h-1}+h+1}\right]^{\frac{1}{\frac{nh}{h^2-h-1}+n+1}}\right\} \qquad (2)$$

where, E_p is the potential evapotranspiration of the whole plantation in a day (mm), and is calculated using the amount of radiation energy entering the plantation and other meteorological variables; s is the daily change of water storage in the ecosystem after considering the rainfall amount in the same day (mm). Here the daily change of available soil water is taken as a substitute for s, because the amount of water in vegetation biomass of both plantations is much smaller than that in the soil, and is therefore not included in s. h is relative humidity in fraction. n is a dimensionless constant (0– ∞), representing the water holding capacity of an ecosystem. For example, n is equal to ∞ for an ecosystem with water outflow being zero, and is equal to zero for an ecosystem with all water flowing away. Here, we assumed n to be 0.75 at Jijia and 1.25 at Hetou.

E_p was estimated using the Penman-Monteith equation:

$$E_p = \frac{\gamma e_a + R_0\Delta}{\gamma + \Delta} \qquad (3)$$

where γ is the psychrometric constant, 0.61; R_0 is the net radiation expressed in the same unit as E_p (mm); Δ is the slope of the saturated water vapor pressure with temperature curve at air temperature t (℃); e_a is given by equation (4):

$$e_a = (0.27 + 0.002\,43\,v)(e_s - e_d) \qquad (4)$$

where e_s and e_d are saturated water vapor pressure at air temperature t (℃) and actual water vapor pressure at a reference height, respectively, and v is the wind speed at the same reference height.

2 Results

2.1 Diurnal patterns of SFD

All SFD values for *E. urophylla* plantation on four dates, Spring (March 16, 2000), Summer (Jun. 11, 2000), Autumn (Sept. 14, 1999) and Winter (Dec. 8, 1999), showed strong diurnal variations (Fig.1). Half hourly SFD increased in the morning, peaked just after 12:00, and decreased towards early evening.

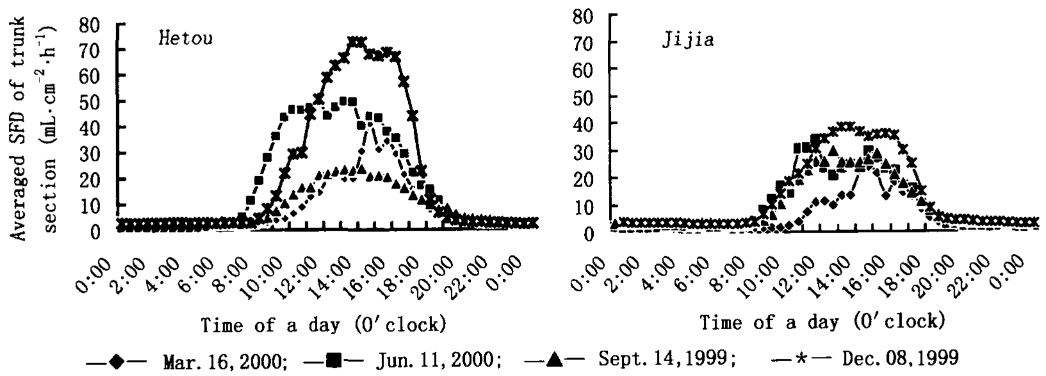

Fig.1. Diurnal variation of sap flux density (SFD) of *Eucalyptus urophylla* stands on four dates in Spring, Summer, Autumn and Winter at both sites. Each SFD value represents the mean of four sensors in four directions and depths.

ANOVA test showed that SFD at both sites were significantly different ($P < 0.001$). On average, SFD of *E. urophylla* plantation at Jijia was about half of that at Hetou, despite of that the distance between both sites is less than 40 km and their topography is similar. This probably resulted from soil physical properties.

2.2 Annual dynamics of soil water content

Figure 2 shows that the daily available soil water content differed significantly between both sites, but annual average values are not significantly different, being equal to 336 ± 36 mm at Hetou and 350 ± 81 mm at Jijia. Compared with the basalt-derived clay soil at Jijia, the Hetou sandy soil with a sedimentary origin has a looser structure, and its lateral soil water exchange and infiltration should be much quicker. As a result, for Hetou site, the decreased soil water near the roots resulted from water consumption by transpiration and soil evaporation can be easily compensated in time with water or rainfall from the neighboring area, leading to a milder change in available soil water content near the root. However, it was opposite for Jijia soil.

2.3 Impact of soil water content on SFD

Figure 3 shows the relationship between daily SFD and available soil water content during Sept. 12, 1999 to Sept. 24, 2000. Correlation between daily SFD and available soil water is not statistically significant for Hetou ($R^2 = 0.04$), but is significant for Jijia ($R^2 = 0.13$). The results suggest that SFD is limited by available soil water at Jijia but not at Hetou, even though the annual average available soil water content at both sites was similar. The results reported here also demonstrated that the "availability" of soil water is strongly affected by some soil physical properties.

Because of the higher water conductivity of sandy soil at Hetou, water supply for transpiration was sufficient, SFD is not limited by available soil water and the forest stand would consume much more water than that of Jijia, despite

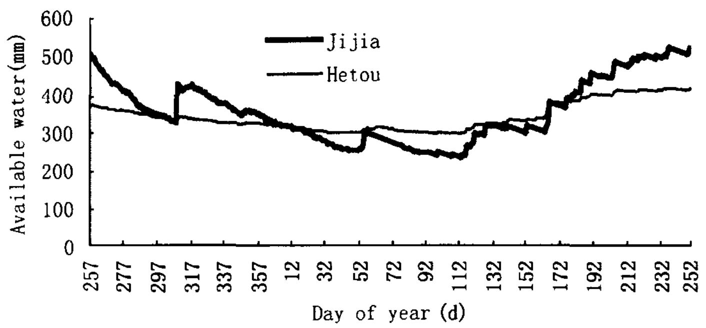

Fig.2. Available soil water content of the top 4 m soil at both sites during the studying period (Sept.12, 1999–Sept.24, 2000). Available soil water was calculated as the difference between field moisture content and moisture content at the matric potential –1 500 kPa.

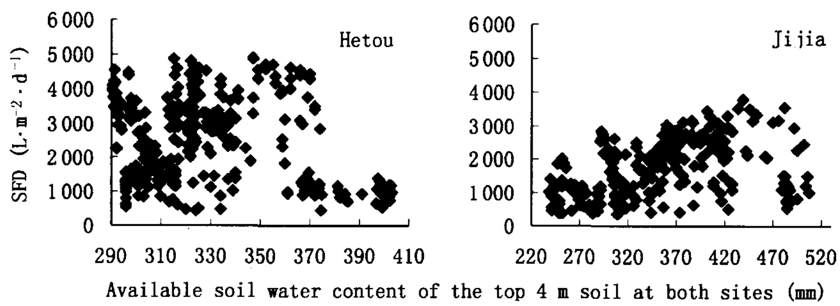

Fig.3. The relationship between daily sap flux density (SFD) and available soil water content.

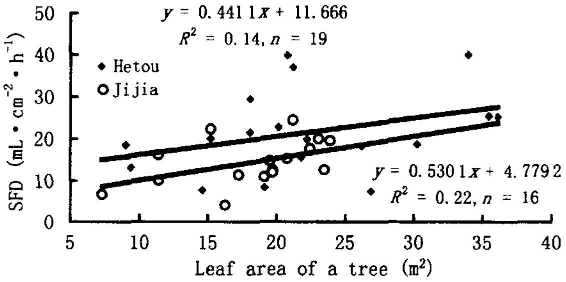

Fig.4. Variation of sap flux density (SFD) with leaf area for the sampled trees.

of same tree species at both sites.

2.4 SFD and leaf area

Average LAI was 1.98 for Hetou and 1.51 for Jijia, respectively. The relationship between measured SFD and calculated leaf area of individual trees is shown in Fig.4.

The amount of average leaf areas of whole trees at Hetou and Jijia sites was 21.2 m^2 and 14.9 m^2, respectively. SFD tends to increase with the leaf area at both sites, even though the correlation was not statistically significant (Fig. 4). Because of the correlation among leaf area, sapwood area, crown size and basal area of an individual tree, it is very difficult to separate the effect of leaf area from those of the other factors on SFD.

The averaged SFD per unit leaf area (ASPULA) at Hetou and Jijia were 1.083 ± 0.520 and 0.838 ± 0.306 $mL \cdot cm^{-2} \cdot h^{-1} \cdot m^{-2}$, respectively. Since the plantations at both sites were of the same variety, the difference in ASPULA between them resulted mainly from difference in the environmental factors, among which the available soil water content played a crucial role as described above.

2.5 SFD and environmental factors

Figure 5 shows the variations of SFD with air temperature, relative humidity and saturated water vapor pressure deficit for one year at Hetou and Jijia sites.

Regressions were fitted to the measurements of SFD and each of the environmental variables. The results are shown in Table 1 together with the statistics of the regressions.

Figure 5 and Table 1 indicate that air temperature, relative humidity and VPD had statistically significant influences on the SFD of *E. urophylla* plantations at both sites, except for air temperature at Jijia. Relative humidity and air temperature are two important environmental variables that affect SFD, but VPD influences SFD by increasing the driving force of transpiration directly, and is the most significant environmental variables (Oren *et al.*, 2001).

2.6 Evapotranspiration

The evapotranspiration (E_t) as shown in Fig.6 was calculated using equation (2). It can also be obtained by summing E_c, E_s and E_i. Table 2 shows the annual values transformed from the available data days in Fig.6.

Relative difference in the estimated E_t by two methods is 5.26% at Hetou, 6.14% at Jijia. The amount of transpiration estimated from the measured SFD accounts for 62.2% of evapotranspiration at Hetou, and 51.3% at Jijia. Considering of the low LAI values at both plantations and their difference in soil properties, we consider that the transpiration fractions of total evapotranspiration are reasonable.

Although the maximum of the diurnal SFD variations at Hetou are almost twice as large as those at Jijia during four seasons with a few exceptions, average daily E_t and E_c are 2.88 ± 1.19 mm and 1.43 ± 0.55 mm at Hetou, 2.94 ± 1.74 mm and 1.47 ± 0.67 mm at Jijia, respectively, and are not significantly different between two sites. The standard deviations of daily E_t and E_c at Hetou are smaller than those at Jijia, because soil moisture at Hetou varied less than that at Jijia, retesting the great impact of available soil water

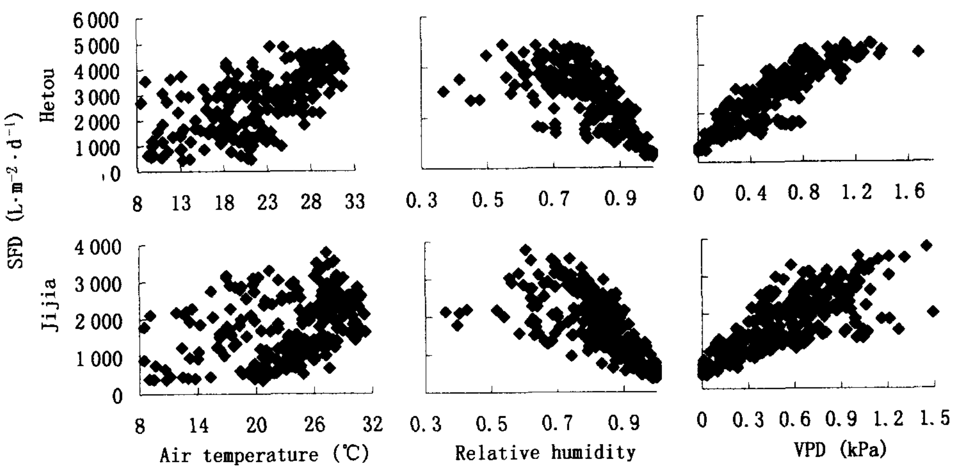

Fig.5. Relationship between sap flux density (SFD) and environmental factors at Hetou and Jijia sites. VPD, vapor pressure deficit.

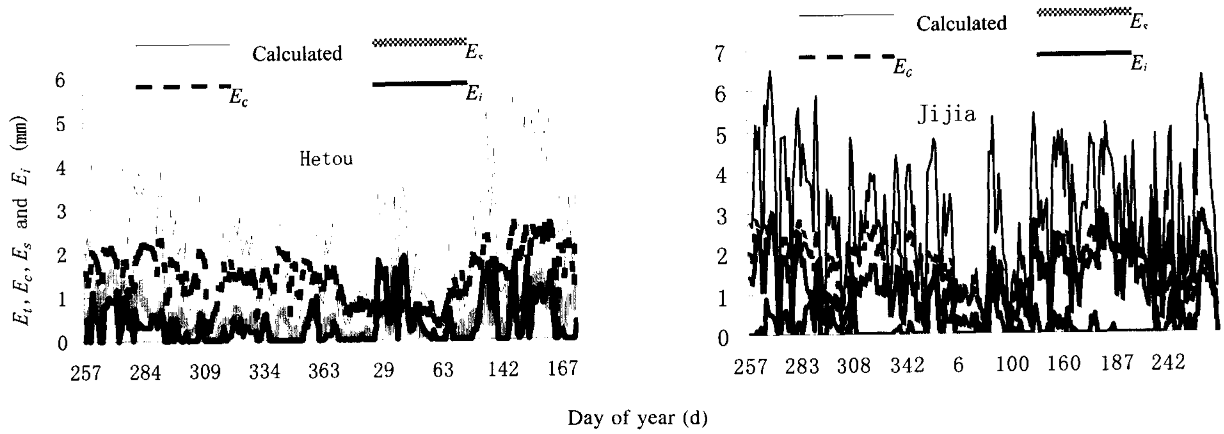

Fig.6. E_t and E_c during the studying period (Sept.12, 1999–Sept.24, 2000). Some data are missing as a result of lighting-induced equipment failure. E_c, canopy transpiration; E_i, evaporation from canopy interception and dew; E_s, soil evaporation; E_t, total evapotranspiration.

Table 1 Relationship between sap flux density (SFD) and each of environmental variables at Hetou and Jijia sites

Sites	Factors	Relationships	
Hetou	SFD (*y*) and air temperature (*x*)	$y = 127x - 80$	($R^2 = 0.39$, $n = 220$, $P = 0.001$)
	SFD (*y*) and relative humidity (*x*)	$y = 1\,570\,x^{-1.956}$	($R^2 = 0.34$, $n = 205$, $P = 0.001$)
	SFD (*y*) and VPD (*x*)	$y = 3\,638\,x^{0.489}$	($R^2 = 0.75$, $n = 235$, $P = 0.001$)
Jijia	SFD (*y*) and air temperature (*x*)	$y = 57x + 442$	($R^2 = 0.13$, $n = 195$)
	SFD (*y*) and relative humidity (*x*)	$y = 1\,023\,x^{-1.995}$	($R^2 = 0.34$, $n = 185$, $P = 0.001$)
	SFD (*y*) and VPD (*x*)	$y = 2\,367\,x^{0.435}$	($R^2 = 0.71$, $n = 225$, $P = 0.001$)

VPD, vapor pressure deficit.

Table 2 E_t, E_c, E_s, and E_i during the available data days and the whole year

Sites	Available days	E_c (mm)	E_s (mm)	E_i (mm)	E_t (equation (1)) (mm)	E_t (equation (2)) (mm)	Relative difference (%)
Hetou	207	291.0	103.9	73.3	468.2	444.2	5.26
	365	513.2	183.2	129.2	825.6	783.3	
Jijia	225	361.2	287.8	54.5	703.5	661.5	6.14
	365	585.9	466.9	88.4	1 141.2	1 073.2	

Abbreviations are the same as in Fig.6.

content on E_t and E_c.

3 Discussion

Two causes might result in the low correlation between SFD and leaf area. One is the measurement errors. Hatton *et al.* (1990) reported that errors in SFD measurements were approximately 13%, and there was the additional potential error in the flux estimates for individual stem when stratified sampling of SFD with depth and bole quadrant based on four sensors of 25%. Another possibility is that it is very difficult to separate the effect of leaf area from those of the other factors on SFD, because leaf area is an integrated factor related to sapwood area, crown size and basal area of an individual tree. Previous studies also found a poor linear relationship between leaf area and transpiration flux during water stress (Greenwood *et al.*, 1982; Hatton *et al.*, 1995). However, impact of leaf area on SFD should not be neglected, Oren *et al.* (1999) reported that an approximately 40% reduction in LAI by a hurricane resulted in a decreases of about 18% in SFD and stand transpiration.

Average SFD per unit leaf area (ASPULA) is an important index for estimating water use of various species, as proposed by Phillips *et al.* (2002). It can also be used to estimate the practical water consumption of a species, superior to the traditional index—water use efficiency (water use per unit increase of biomass), which is mainly determined by species' genetic characteristics and other environmental conditions. The ASPULA value of U6 trees, 1.083 2 $mL\cdot cm^{-2}\cdot h^{-1}\cdot m^{-2}$ at Hetou and 0.8376 $mL\cdot cm^{-2}\cdot h^{-1}\cdot m^{-2}$ at Jijia, were much larger than those of mountain ash (*E. regnans*) trees (0.11 $mL\cdot cm^{-2}\cdot h^{-1}\cdot m^{-2}$) and hazel (*Pomaderris aspera*) trees (0.36 $mL\cdot cm^{-2}\cdot h^{-1}\cdot m^{-2}$) (Vertessy *et al.*, 2001). According to the data from Roberts *et al.* (2001), the ASPULA values were 0.08, 0.36, and 0.47 $mL \cdot cm^{-2} \cdot h^{-1} \cdot m^{-2}$ for *Eucalyptus sieberi* L. Johnson forests in 160, 45, and 14 years old. It demonstrated that the index ASPULA could also reflect the influences of plantation age on its water use.

Sap flux along the tree trunk is driven by the water potential difference between two different heights of a tree, which are influenced by both environmental variables near the canopy and soil water potential near the roots. Different soil types at Hetou (sandy soil) and Jijia (clay soil) have led to different soil water potentials at both sites. As compared with Jijia site, pressure deficit between soil water potential and leaf water potential at Hetou is greater, and therefore water flux trough the stem at Hetou is also greater, even though the climatic conditions are very similar at both sites. The daily and diurnal maximum SFD at Hetou were almost twice of those at Jijia (Fig.1). In the following we shall discuss the possible causes for the differences.

Firstly, the differences in tree physiological characteristics, such as sapwood areas, leaf areas, and diameters, etc., at both sites, have significant influences on SFD, as have been shown in previous studies (Dunn *et al.*, 1993; Roberts *et al.*, 2001). Secondly, the crown stomatal conductance and leaf hydraulic conductance may vary with tree size and tree height at both sites. Phillips *et al.* (2002) found that the crown stomatal conductance, leaf specific hydraulic conductance and the sapwood conductivity in the overstory of *Pseudotsuga menziesii* trees differed greatly for trees with different heights. Thirdly, there may be much active lateral soil water flow at Hetou, and the water loss from evapotranspiration can be more promptly replenished after rainfall because of the loose structure of sandy soil. Finally, the microclimatic factors, VPD or relative humidity, air temperature, radiation, etc., though only differed a little between both sites, also contribute partly to the difference in SFD. There was an obvious nonlinear relationship between hourly VPD and SFD at both sites, the study of Vose *et al.* (2000) on cottonwoods *Populus deltoides* showed similar result. The regression relationship between SFD and air temperature is less significant at Jijia than at Hetou, which indicated that the influence of air temperature on water pressure deficit between canopy and roots (as mentioned above) was more indirect compared with VPD or relative humidity. Both canopy transpiration and soil evaporation will increase with air temperature, pressure difference in xylem will not therefore increase quickly. This mechanism is more important for clay soil than for sandy soil because of their different soil water conductivity.

Sap flow through the stem is also driven by negative pressure that relies on the cohesion of sap water. Different species (or varieties) have their own maximum SFD values under a certain negative pressure. Environmental variables and physiological characteristics of species can influence SFD only within the range of 0 to maximum SFD. Maximum SFD may be affected by the hydraulically or chemically mediated feedbacks during stomatal closure under conditions when too much water was lost from transpiration. Therefore, maximum SFD, can be used as another valuable index for evaluating water consumption of a plantation.

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华南桉树人工林树液流通量及蒸散作用

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摘要： 通过对广东省湛江市雷州半岛桉树(*Eucalyptus urophylla* S.T. Blake)人工林的树液流通量、环境因子、土壤蒸发、林冠截留和林分特性相关指标一年多的连续观测，以及通过一个理论公式对日蒸散量的计算，得出了如下结论：(1)土壤特性及由此决定的土壤水势对树液流通量，以及树液流通量密度(SFD)与气温的关系有一定影响；(2)林冠层的VPD(空气饱和差)对SFD有显著影响；(3)由测定和计算得来的蒸散量在河头和纪家分别有5.26%和6.14%的偏差，可以认为这两种方法有较好的一致性；(4)河头和纪家的林分蒸腾量占总蒸散量百分比分别为62.2%和51.3%；(5)树种单位叶面积水平上的SFD是评价该树种水分利用的重要指标。

关键词： 桉树人工林；水分消耗；树液流通量密度(SFD)；空气饱和差(VPD)；蒸腾作用；蒸散作用

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