Characteristics of the Stem Sap Flow of Eucommia ulmoides Forest

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Abstract

In this paper, a study on the stem sap flow characteristics of mixed forest of Eucommia ulmoides forest in mountain area of West Hunan Province was made. The results showed that from June 10, 2015 to September 9, 2016, the rainfall in the study area hit 1971.84 mm and the number of rainfall was 83 times, with an average of 5 times per month and an average monthly rainfall of 131.46 mm. With the increase of rainfall, the stem flow of Eucommia ulmoides forest increased, and there was a significant linear relationship between the stem flow and rainfall. The fitting equation of Eucommia ulmoides forest can be expressed as y = 0.0218x-0.0356, R^2= 0.6376, where y is the stem sap flow, and x is the rainfall.

Keywords

Eucommia ulmoides forest, stem sap flow, mountain area of West Hunan Province.

1. Introduction

The part of rainwater flows through branches and leaves along the trunk to the ground[1], a definition called stem flow. As an important component for measuring canopy interception by water balance method, while stem flow accounts for a small proportion of the water balance and is often neglected in the study, it is of great reduction in the erosion of raindrops and washing the dust absorbed by leaves and branches, and the nutrients obtained by carrying the washed canopy directly enter the rhizosphere of the forest, to promote forest water and nutrient recycling. Consequently, stem flow research has important significance in the study of hydrological processes. At home and abroad it has been a large number of studies on rainfall redistribution in forest canopy[2-10], but less on stem sap flow characteristics of *Eucommia ulmoides* forest in mountainous area of West Hunan Province [6-10]. Therefore, in this study *Eucommia ulmoides* forest was used as the research object, and its stem flow characteristics were analyzed to reveal the change of precipitation and hydrological cycle, providing data basis for further study on the hydrological effects of forest vegetation in this area.

2. Survey of research area

The experimental site is located in the small watershed of Never Zhai (E111 degree 12', 42.836, N29 degree 25', 27.582) in Wuling Mountains, i.e. in Liangxi Village, Zengyang Town, Cili County, Zhangjiajie City, Hunan Province, about 7 km northwest of Cili County. The watershed is relatively well sealed and belongs to the second-class small tributary of Li River, which is roughly north-south, and is of a low mountain area of Wuling Mountains. The total area of the basin is 3.15 km^2, the lowest elevation (at the exit of the main channel) is 210 m, the highest elevation is 917.4 m, the length of the main channel is about 1.2 km, and the vertical ratio of the main ditch is around 28.4‰. In addition, with a complex terrain in the basin, undulating mountains, vertical and horizontal gullies, about 2.6 km/km^2 of the density of the gully, and around 28.4 ‰ of the vertical ratio of the main ditch, it has serious soil erosion. The forest is a concentrated area of returning farmland to forest, due to its coverage rate in this area over 80%, and the vegetation types oriented at returning farmland to forests and secondary forests. In this area the soil parent rock is mainly sand shale, and the soil is primarily yellow-red soil and acid soil. *Pinus massoniana* forest, *Eucommia ulmoides* forest, *Citrus reticulata*

and miscellaneous shrub forest are principal vegetation types. This experimental plots were located at the national positioning observation and research station of the forest ecosystem in Cili, Hunan.

Tab.1 Basic characteristics of the plant in plots

Stand type	Altitude/m	Slope/°	Slope direction	Parent material	Soil types	Origin	Density /(plant·hm-2)	Average height/m	Average DBH/cm	Canopy density	Main plants of shrub grass
Eucommia ulmoides forest	13	5	Northwest	Sandstone	Red soil	Plantation	5005	5.9	9.0	0.8	Rubus corchorifolius Rubus hirsutus , etc

3. Research methods

3.1 Determination of precipitation outside forest

From June 10, 2015 to September 9, 2016, HOBO U30 automatic weather station was employed to continuously observe precipitation and precipitation process, with a siphon self-gauge and a standard rainfall tube used to measure precipitation and precipitation process outside the forest.

3.2 Measurement of stem sap flow

In each plot 15 trees selected were in accordance with the tree diameter class and canopy standard. The 2.0 cm diameter polyethylene plastic hose was planted along the middle crack and wrapped around the trunk in a snake shape from 2 m height, with 30 degrees of the plastic pipe and the horizontal angle. Then, using the gap between the glass rubber hose and the trunk, the hose was placed in the sealed plastic containers. After each rain the water volume was measured, converting the area projected by canopy into the stem flow of individual tree and stand.

Trunk stream is calculated according to the following formula[11].

$$S = \sum_{i=1}^{N} \frac{S_N \cdot M_N}{A \cdot 10^3}$$

Where S is the stem flow (mm), M_N is the number of tree samples per diameter order, S_N is the stem flow (ml) of tree samples per diameter order, and A is the sample area (m^2).

3.3 Data process

Excel and SPSS17.0 statistical analysis software was applied for data processing and plotting.

4. Results and analysis

4.1 Precipitation variation characteristics

During the observation period, the precipitation data was sorted into tables according to the time period, based on the rainfall hit 1971.84 mm and the number of rainfall of 83 times(as listed in Tab.2), an average of 5 times per month and an average monthly rainfall of 131.46 mm. Referring to the optimal segmentation method proposed by Huang Yan[12], this study divided the rainy season into the following stages: spring rainy season (March-April), main rainy season (May-August), autumn rainy season (September-October), the rest of the month (1, 2, 11, December) is dry season. The precipitation of the spring rainy season, the main rainy season and the autumn rainy season accounted for 88.48% during the observation period, indicating that the dry and wet season of the Wuling Mountains in Western Hunan changed obviously and the season was distinct, and that the annual precipitation more came from the rainy season. On the other hand, the rainy season was the growth period of the main vegetation types in this study area, and abundant water was a good condition for its growth.

As shown in Table 2, 48 occurred in 2016 and 35 in 2015, during the 83 precipitations in the study area from June 10, 2015 to September 9, 2016. In addition, the total precipitation reached 1971.84 mm, which were 1412.61 mm in 2016 and 559.23 mm in 2015.

Tab. 2 Monthly rainfall during the observation period

Time	Precipitation /mm	Number
06/10/15-07/09/15	102.01	8
07/10/15-08/09/15	106.58	4
08/10/15-09/09/15	96.75	6

09/10/15-10/09/15	111.95	4
10/10/15-11/09/15	29.36	4
11/10/15-12/09/15	79.76	6
12/10/15-01/09/16	42.82	4
01/10/16-02/09/16	29.90	7
02/10/16-03/09/16	45.30	5
03/10/16-04/09/16	102.00	7
04/10/16-05/09/16	132.40	7
05/10/16-06/09/16	141.00	6
06/10/16-07/09/16	492.40	6
07/10/16-08/09/16	301.60	5
08/10/16-09/09/16	158.01	4
Total	1971.84	83

4.2 Characteristics of stem sap flow

The relationship between stem flow and rainfall in *Eucommia ulmoides* forest was illustrated in Figure 1. Among the 83 rainfalls, there were 72 occurrences of *Eucommia ulmoides* forest, and the stem flow was 155.46 mm. There was a significant linear relationship between stem flow and rainfall in *Eucommia ulmoides* forest. The fitting equation of *Eucommia ulmoides* forest can be expressed as $y = 0.0218x-0.0356$, $R^2= 0.6376$, where y is the stem sap flow, and x is the rainfall. Theoretically, when y = 0, there is no stem flow, and when the rainfall is up to 1.63 mm, the stem flow could be produced.

The stem flow of *Eucommia ulmoides* forest increased with the increase of rainfall, and when the maximum rainfall was 206 mm, the corresponding stem flow of *Eucommia ulmoides* forest was largest of 16 mm, as shown in Figure 1. It is indicated that there was a significant positive correlation between the stem flow and rainfall. The reason was that a large amount of rainfall formed penetrating rain, while part of the penetrating rain fell to the ground through the canopy, part of the rainfall could flow through the trunk to the ground, forming a trunk stem flow. Moreover, the forming trunk stem flow could increase, with the increase of rainfall that exceed the ability to carry of the trunk.

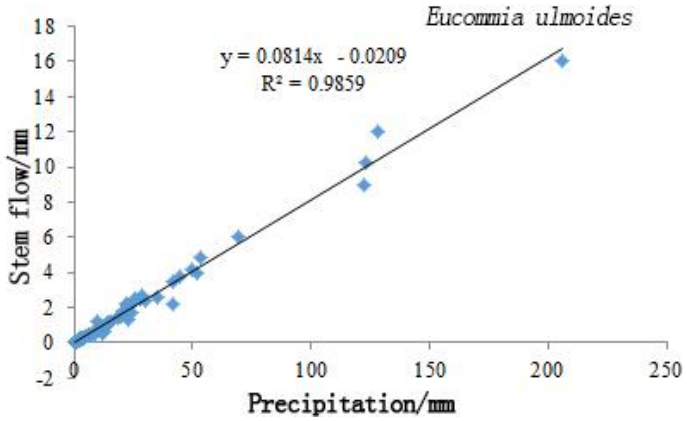

Fig. 1 Relationship between trunk runoff and rainfall of

5. Conclusion

During the observation period, the rainfall in the study area hit 1971.84 mm and the number of rainfall was 83 times, with an average of 5 times per month and an average monthly rainfall of 131.46 mm

With the increase of rainfall, the stem flow of *Eucommia ulmoides* forest increased, and there was a significant linear relationship between the stem flow and rainfall. The fitting equation of *Eucommia ulmoides* forest can be expressed as $y = 0.0218x-0.0356$, $R^2= 0.6376$, where y is the stem sap flow, and x is the rainfall.

Acknowledgements

This work is supported by the grant of Major Research and Development Program in Hunan (2017NK2223), Forestry Science and Technology Plan Project in Hunan (XLKPT201710), National Science and Technology Plan for Twelfth Five-Year in the Countryside(2015BAD07B04), National Key R & D Program of China (2017YFC0505506), and Forestry Science and Technology Project in Hunan (2012-HNLYKY-01).

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