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The Influence of Pinus brutia on the Water Balance of Fractured Mediterranean Mountain Environments

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In dry Mediterranean environments, both rainfall and temperature vary throughout the year and frequent droughts occur. The mountainous topography is characterized by steep slopes, often leading to shallow soil layers with limited water storage capacity. While for most of the tree species, these conditions can be characterized as unfavourable, Pinus brutia trees manage to survive and thrive. The main objective of this study is to define and quantify the water balance components of a Pinus brutia forest at tree level.

Our study was conducted from 30/12/2014 until 31/09/2015 in an 8966-m^2 fenced area of Pinus brutia forest. The site is located on the northern foothills of Troodos mountain at 620 m elevation, in Cyprus. The slope of the site ranged between 0 and 82%. The average daily minimum temperature is 5 ^{0}C in January and the average daily maximum temperature is 35 ^{o}C in August. The mean annual rainfall is 425 mm.

We measured the diameter at breast height (DBH) from a total of 122 trees. Based on the average DBH, four trees were selected for monitoring (two were above the average DBH and two were below). We measured soil depth in a 1-m grid around each of the four selected trees. We processed soil depths in ArcGIS software (ESRI) to create a soil depth map. We used a Total Station and a differential GPS for the creation of a high resolution DEM of the area covering the four selected trees. We installed soil moisture sensors at 15-cm depth at distances of 1 and 2 m from the selected trees and a second sensor at 30-cm depth when the soil was deeper than 20 cm.. We randomly installed four metric manual rain gauges under each trees' canopy to measure throughfall and for stemflow we installed a plastic tube around each tree trunk and connected it to a manual rain gauge. We used six sap flow heat ratio method instruments to determine sap flow rates of the Pinus brutia trees. Two trees had one sensor installed at 1.3 m height facing north. The remaining trees had two sap flow sensors facing north and south for examining azimuthal variations. Hourly meteorological conditions were observed by an automatic meteorological station.

Results showed high linear correlation between rainfall and throughfall in the four trees (R^2= 0.95-0.98). Stem flow was negligible (below 1%). Interception varied from 5% to 27% of the total rainfall. Sap flow rates were not depended on the tree size. The transpiration of the four trees on average was 90% of the rainfall. The water balance of each tree revealed that most of the water needed for transpiration is provided by the bedrock fractures. Reverse sap flow rates were measured, indicating that Pinus Brutia trees use hydraulic redistribution mechanisms.

Pinus brutia adapt to the seasonal variations in climatic conditions by regulating their transpiration rates according to water availability. Competition among trees and sunlight exposure affect their transpiration rates.