Geophysical Research Abstracts
Vol. 14, EGU2012-8719-2, 2012
EGU General Assembly 2012

Biomass production and water use of Black Locust (Robinia pseudoacacia L.) for short-rotation plantation

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The early successional tree species Robinia pseudoacacia L. demonstrates a high potential for biomass production in short rotation plantations and agroforestry systems. On marginal lands and recultivated areas, often characterized by poor edaphic conditions, black locust is already successfully cropped. In southern Brandenburg (East Germany), vast areas have been exploited for lignite open cast mining and the outcome is a drastic alteration of the top soil layer and subsurface geological structure, causing a radical change of the hydrologic cycle. Soil poor in nutrient and carbon, combined with low rainfall, limits the reclamation of these areas and their use for conventional agriculture. However, promising results have been obtained by the establishment of black locust for bioenergy production.

For the evaluation of the black locust growth potential in southern Brandenburg with its sandy soils and low annual mean rainfall, detailed information about the link between growth, transpiration and soil water availability are needed. Therefore, we determined the biomass-transpiration relation and formulated the equation that describes the intertwined interaction between water use and biomass production. The equation will be integrated into mathematical tools. To reduce the numerous environmental variables involved in field experiments, we grew black locust under semi-controlled environmental conditions by using wick lysimeters. The lysimeters were filled with sandy loam soil and water was supplied solely by an automatic irrigation system in relation to the volumetric soil water content (7%, 10%, and 14%). Rainfall is excluded by a light transmissive roof. Water use efficiency (WUE) at whole plant level is evaluated by the ratio between the biomass produced during the vegetation period and the cumulative daily water use. The study encompasses ecophysiological investigations of the gas exchange (H_2O and CO_2) on single leaves, to evaluate the influence of the stomata regulation on the transpiration and the possible drought effects.

The results at whole plant level show a linear relation (n=7, R2=0.91) between the total dry biomass and the transpired water during the growing season. Based on this equation we extrapolate that black locust produced 2.32 kg of dry biomass for every cubic meter of transpired water. Therefore, the transpiration coefficient is approx. 430 l per kilogram of dry biomass. Stomatal response to water limitation occurred on the trees growing at low soil moisture (SWC=7%) during warm days (> 30°C) with a high vapour pressure deficit (VPD). Instead the well-watered trees (SWC=14%) did not show stomatal regulation whereas they increased transpiration and reduced the WUE.

The equation obtained, which links soil water availability, transpiration rate, atmospheric water demand and growth performance, extensively investigated in our studies, will be integrated into a database for modelling approach and linked with stand biomass production and growth performance under field conditions.