Technische Universität Dresden

Dendromass4Europe.eu

D4 EU

Water use of hybrid poplar (*Populus deltoides* Bart. Ex Marsh x *P. nigra* L. 'AF2') growing across contrasting site and groundwater conditions in western Slovakia

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About the project

Dendromass4Europe (D4EU, 2017 – 2022) aims at establishing sustainable, Short Rotation Coppice (SRC)-based, regional cropping systems for woody biomass (dendromass) production on marginal agricultural land. The dendromass produced in SRC (ligneous biomass, bark and wood) is supplied to dedicated bio-based value chains that create additional income and job opportunities in rural areas. The supply chains will be tailored for optimum efficiency of supply logistics and for reducing CO_2 emissions. Innovative bio-based materials, including eco-fungicidal packaging materials, will help to replace fossil-based materials.

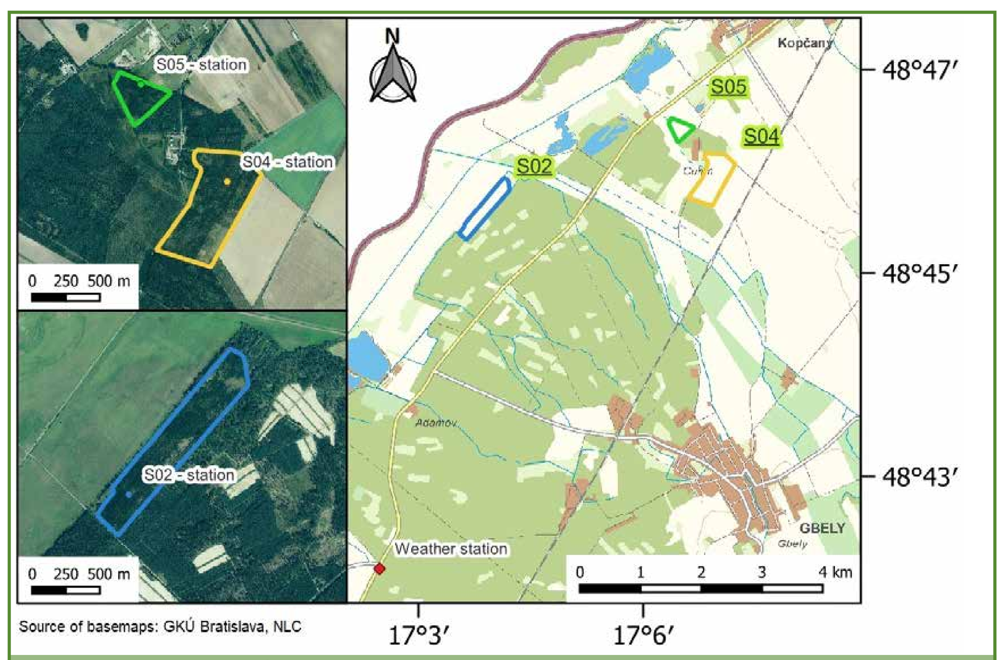

Fig. 1: Location of study area and experimental plots near the village of Kopčany, western Slovakia fibre pulp for packaging

Introduction

- Water use by short rotation coppices (SRC) has been a focus of research in the last decades.
- Consideration of local site conditions for the quantification of transpiration is necessary.
- Need to quantify potential impacts of hybrid poplars on water balance.
- Contribution of useful information for plantation managers with focus on bioenergy and other ecosystem services.

Realization

Objective of the study

- To quantify water use of clone 'AF2' in a young and low-density, plantation on sites with contrasting groundwater (GW) conditions
- To determine the influence of meteorological and soil-related site conditions on transpiration.

Hypothesis

H1: There are differences in transpiration among the stands based on soil water conditions and accessibility to groundwater.

H2: The influence of the meteorological conditions in transpiration is limited by the different soil-related site conditions.

Fig. 2: Installation of soil matric potential sensors TensioMARK® on site S4-D

Materials and Methods

Three experimental plots on poplar stands: similar soil texture and contrasting GW accessibility: higher GW (S5-N), lower GW (S4-D), and fluctuating GW levels (S2-F).

A soil profile pit (1.5 m width × 2 m length × 1.5 m depth) and a GW well on each site (Fig. 3).

At 30, 60 and 90 cm soil depths: sensors for soil moisture and matric potential (Fig. 3). Soil and GW data: 15-min resolution.

Sapflowmeter devices (Heat Ratio Method) installed according to the diameter breast height distribution.

Sentinel-2 SNAP toolbox → Leaf Area Index (LAI) of growing season.

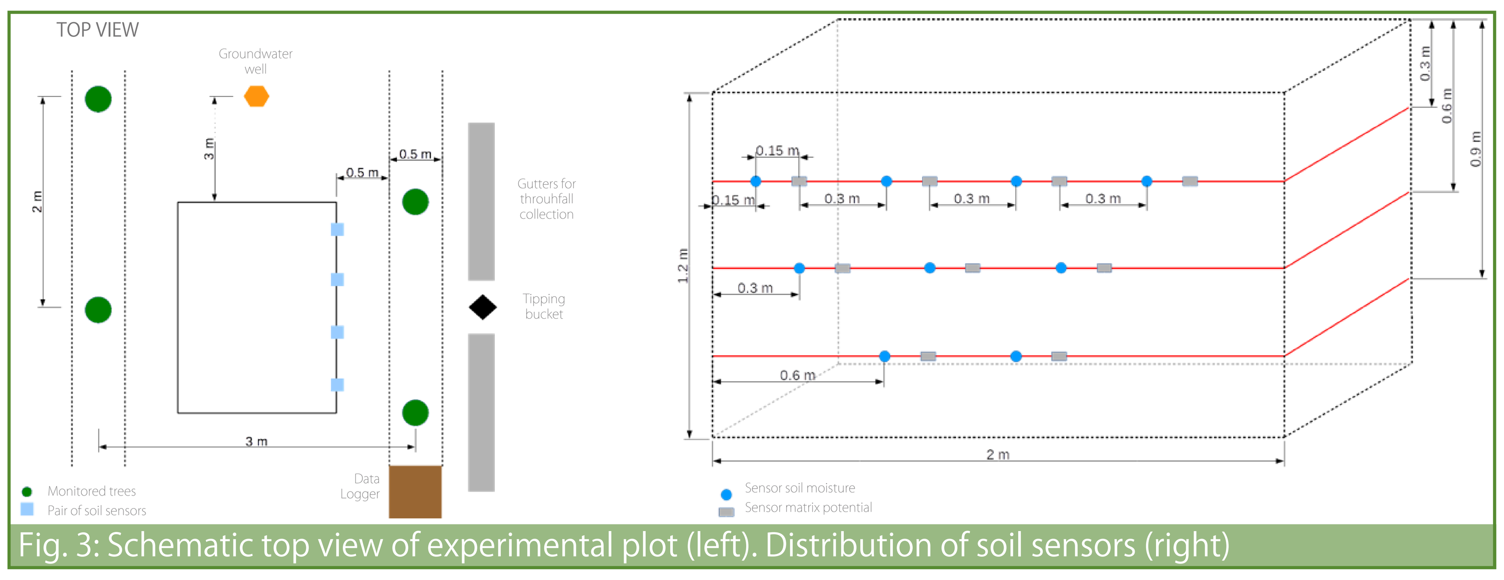

Fig. 3: Schematic top view of experimental plot (left). Distribution of soil sensors (right)

Fig. 4: Sapflowmeter (Heat Ratio Method)

Tree-based transpiration

To derive tree transpiration (T, mm) from the sapflow measurements (Fs, L) → modification of the approach proposed by Bloemen *et al.*

$$T = Fs * \frac{LAI\ canopy}{A\ crown}$$

Statistical analysis

Differences in the daily mean transpiration among trees and sites → one-way ANOVA.

Significant differences → Tukey's Honestly Significant Difference (HSD).

Results and Discussion

Tab. 1: Transpiration values of all monitored trees on the study sites. Site with higher groundwater table (S5-N), site with lower groundwater table (S4-D), and site with fluctuating groundwater table (S2-F). * Tree within the most frequent DBH class; ** Tree within a smaller DBH class; *** Tree within a bigger DBH class

	Daily Transpiration in Growing Season 2019 (DOY 115-273) (mm)						
Tree - ID	Min	Median	Mean	Max	Standard deviation	Sum Total	Data gap (number of days)
S5-T1*	0.002	8.5	7.8	15.2	4.4	717	77
S5-T2*	0.09	10.0	9.3	18.9	3.7	955	39
S5-T3***	-0.07	11.5	10.9	25.6	6.1	1644	18
S5-T4**	-0.19	5.5	5.0	10.3	2.3	715	5
S4-T1*	0.008	3.6	3.0	5.7	1.6	380	41
S4-T2*	0.06	3.4	3.0	5.6	1.5	469	12
S4-T3***	0.056	3.1	2.7	4.9	1.4	330	43
S4-T4***	0.02	10.7	9.3	22.4	5.6	1347	14
S2-T1***	0.12	7.4	7.1	15.8	4.5	810	52
S2-T2*	0.08	6.5	5.9	12.0	3.5	879	16
S2-T3***	0.004	9.1	8.1	14.0	4.0	1012	42
S2-T4**	0.04	5.0	4.5	8.9	2.3	698	5

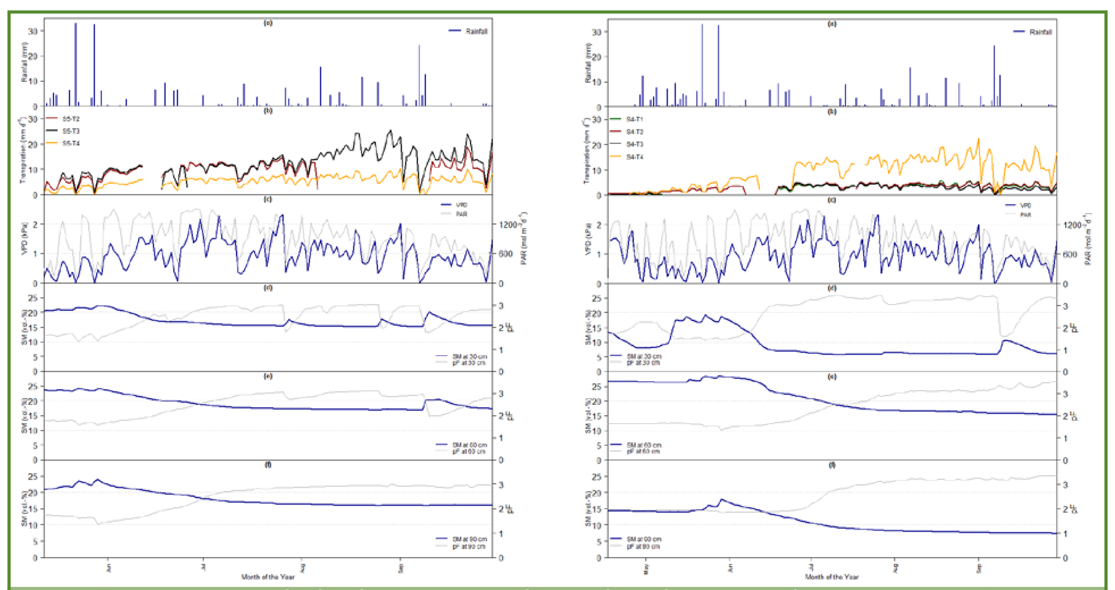

Fig. 5: Transpiration linked to meteorological and site conditions on site S5-N (high GW level, left) and S4-D (lower GW level, right).

Silt proportion higher at the three evaluated depths at site S5-N → improved water retention capacity and higher tree transpiration

At 60 cm depth at site S4-D → clay content higher, accumulation of water infiltrating from the upper soil layers. Lower transpiration

Transpiration rates showed statistical differences among the sites ($p < .001$).

Tab. 2: Results of Tukey's HSD test multiple comparison of daily mean transpiration among the site with higher GW level (S5-N), site with lower GW level (S4-D) and site with fluctuating GW level (S2-F).

		Mean Difference	95 % Conf. Interval Lower Bound	Upper Bound	Sig.	Mean separators
S5-N	S4-D	3.738	3.070	4.405	0.000	a
S5-N	S2-F	2.312	1.606	3.017	$1e^{-06}$	b
S4-D	S2-F	-1.426	-2.079	-0.774	0.000	c

Degree of association among transpiration and meteorological and soil-related variables differed among sites (Hypothesis 1).

On the site with optimal water conditions, soil-related site and meteorological conditions determine the transpiration. For drier areas, soil water availability controls transpiration rates (Hypothesis 2).

Tab. 3: Pearson's correlation test among daily mean transpiration values and meteorological and soil-related variables (**** = $p < .0001$)

	Daily mean transpiration per site		
Variable	S5-N	S4-D	S2-F
Daily transpiration	1	1	1
Rainfall	-0.30 ****	-0.17 ****	-0.29 ****
Groundwater	0.48 ****	0.32 ****	0.37 ****
Air Temperature	0.38 ****	0.37 ****	0.62 ****
VPD	0.46 ****	0.33 ****	0.57 ****
PAR	0.27 ****	0.24 ****	0.44 ****
SM	-0.45 ****	-0.31 ****	-0.59 ****
pF	0.46 ****	0.34 ****	0.62 ****

Conclusions

On the site with a higher groundwater level, tree water use was higher. At the site with low groundwater level, transpiration was limited by soil water availability.

Soil water availability and groundwater accessibility are critical for biomass production at the study sites.

On sites where trees may reach the groundwater, potential impacts on local water balance should be closely monitored.

Our results provide a basis for future studies on scaling water use by hybrid poplars to stand level.

Fig. 6: Experimental plot

References:

Bloemen J, Fichot R, Horemans JA, Broeckx LS, Verlinden MS, Zenone T, Ceulemans R (2017) Water use of a multigenotype poplar short-rotation coppice from tree to stand scale. GCB Bioenergy 9:370–384. https://doi.org/10.1111/gcbb.12345

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