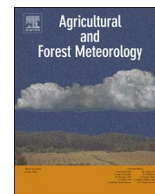




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Water requirements of short rotation poplar coppice: Experimental and modelling analyses across Europe

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ABSTRACT

Poplars are among the most widely used short rotation woody coppice (SRWC) species but due to their assumed high water use, concerns have been raised with respect to large-scale exploitation and potentially detrimental effects on water resources. Here we present a quantitative analysis of the water requirements of poplar SRWC using experimental data and a soil water balance modelling approach at three different sites across Europe. We used (i) eddy covariance (EC) measurements (2004–2006) at an irrigated SRWC grown on a previous rice paddy in northern Italy, (ii) Bowen ratio and energy balance (BREB) measurements (2008–2015) and EC (2011–2015) at a SRWC in rain-fed uplands in the Czech Republic, and (iii) EC measurements (2010–2013) at a SRWC on a previous agricultural land with a shallow water table in Belgium. Without any calibration against water balance component measurements, simulations by the newly developed soil water balance model R-4ET were compared with evapotranspiration (*ET*) measurements by EC and BREB with a resulting mean root mean square error (*RMSE*) of 0.75 mm day⁻¹. In general, there was better agreement between EC and the model (*RMSE* = 0.66 mm day⁻¹) when EC data were adjusted for lack of energy balance closure. A comparison of the simulated and measured soil water content yielded a mean *RMSE* of 0.03 m³ m⁻³. The mean annual crop coefficient, i.e. the ratio between actual and reference *ET*, was 0.82 (ranging from 0.65 to 0.95) while the monthly maxima reached 1.16. These values indicated that *ET* of poplar SRWC was significantly lower than *ET* of a well-watered grass cover at the annual time scale, but exceeded *ET* of the reference cover at shorter time scales during the growing season. We show that the model R-4ET is a simple, yet reliable tool for the assessment of water requirements of existing or planned SRWC. For very simple assessments on an annual basis, using a crop coefficient of 0.86 (adjusted to a sub-humid climate), representing an average value across the three sites in years with no evident drought stress, is supported by this analysis.

1. Introduction

Short rotation woody coppice (SRWC) cultures of *Populus* (poplars) and *Salix* (willows) are well known for high productivity, which make them suitable as bioenergy crops (Anderson et al., 1983; Isebrands and Richardson, 2014; King et al., 2013). To ensure high SRWC yields, a sufficient water supply is required (Deckmyn et al., 2004; Kim et al., 2008). Maintaining a favorable soil water balance typically relies on

adequate and well-distributed precipitation or on access to a shallow water table, which in turn requires careful site selection (King et al., 2013; Lindroth and Båth, 1999; Trnka et al., 2016). In most cases, irrigation of SRWC is economically inefficient and environmentally unsustainable (Kim et al., 2008; Persson, 1997). Moreover, bioenergy is a low-input commodity and any increase of (energy) inputs and carbon footprint inherently linked with intensive management, is undesirable (Djomo et al., 2011; Fischer et al., 2017; King et al., 2013).

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