Agricultural Water Management 97 (2010) 1486–1494

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

# Effects of irrigation strategies and soils on field-grown potatoes: Gas exchange and xylem [ABA]

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ARTICLE INFO

*Article history:*
Received 3 October 2009
Accepted 2 May 2010
Available online 8 June 2010

*Keywords:*
Photosynthesis rate
Stomatal conductance
Xylem [ABA]
Partial root-zone drying irrigation
Deficit irrigation
Soil textures
Potato

ABSTRACT

Gas exchange was measured in potatoes (cv. Folva) grown in lysimeters (4.32 $m^2$) in coarse sand, loamy sand, and sandy loam and subjected to full (FI), deficit (DI), and partial root-zone drying (PRD) irrigation strategies. PRD and DI as water-saving irrigation treatments received 65% of FI and started after tuber bulking and lasted for six weeks until final harvest. Midday photosynthesis rate ($A_n$) and stomatal conductance ($g_s$) of fully irrigated (FI) plants were lowest in coarse sand and mean $A_n$ of diurnal measurements in FI, PRD and DI tended to be lower in this soil as compared with the loamy sand and sandy loam. The results revealed that diurnal values of $A_n$ and $g_s$ in PRD and DI were consistently lower than FI without reaching significant differences in accordance with findings that xylem [ABA] in PRD was significantly higher than FI, and tended to be higher than in DI. Diurnal measurements showed that $A_n$ reached peak values during mid-morning and midday, while $g_s$ were highest during the morning. Intrinsic water use efficiency ($A_n/g_s$) correlated linearly well with the leaf to air vapor pressure deficit (VPD) and the slope of the line revealed the rate of $A_n/g_s$ increase per each kPa increase in VPD, i.e. approximately 10 μmol $mol^{-1}$. Transpiration efficiency ($A_n/T$) of PRD was higher than DI, which shows slightly better efficient water use than DI. The slope of the linear relationship between transpiration efficiency and VPD decreased from −2.03 to −1.04 during the time course of the growing season, indicating the negative effect of leaf ageing on photosynthesis and thus on plant water use efficiency. This fact shows the possibility to save water during last growth stages through applying water-saving irrigations without much effect on transpiration efficiency.



## 1. Introduction

It is well established that roots imposed to drying soil produce more ABA than under normal conditions, which then regulate stomatal conductance ($g_s$). Many studies have shown that $g_s$ decreases exponentially with increasing xylem [ABA] (Tardieu and Davies, 1993; Tardieu et al., 1996; Gutschick and Simonneau, 2002; Liu et al., 2005). The non-linear relationship between xylem [ABA] and $g_s$ along with the non-linear relationship between $g_s$ and photosynthesis arte ($A_n$) under drought stress (Morison et al., 2008) are interesting findings when investigating the physiological responses of crops to drought stress. The common deficit irrigation (DI) and its modified form as partial root-zone drying irrigation (PRD) are the water-saving irrigation strategies that may impose some restrictions on the crop physiological parameters depending on the severity and timing of the drought stress (Ahmadi, 2009). The principle of applying PRD is that half of the root zone receives water in one irrigation event and the other half receives water in the next irrigation event so that changing the irrigation sides induces production of root-originated ABA from the dry side that regulates the $g_s$ and $A_n$.

Due to its sparse and shallow root system (Opena and Porter, 1999), potato is recognized as a drought sensitive crop (a review by Yuan et al., 2003). Many studies agree with this, even though there are evidences that different potato cultivars show contrasting responses to drought stress (Deblonde and Ledent, 2000; Fabeiro et al., 2001; Tourneux et al., 2003a,b; Lahlou et al., 2003; Vos and Haverkort, 2007). In a progressive soil drying experiment in a greenhouse, Liu et al. (2005) showed that xylem [ABA] of potatoes increased as soil dried, and at moderate soil moisture deficit

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doi:10.1016/j.agwat.2010.05.002