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Aquatic Botany 82 (2005) 27–38

Aquatic botany

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Carbon isotope composition of *Phragmites australis* in a constructed saline wetland

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Received 25 September 2004; received in revised form 13 February 2005; accepted 23 February 2005

Abstract

We hypothesize that salinity stress may leave a specific pattern of δ^{13}C variation in common reed (*Phragmites australis* (Cav.) Trin. Ex Steudel), a species potentially susceptible to salinity. We measured dry weight and δ^{13}C of *P. australis* transplanted in a constructed saline wetland four times between July 2001 and May 2002. Shoot dry weight (590–3090 g m^{-2}) of *P. australis* was negatively correlated with rhizosphere salinity. Shoot δ^{13}C values (−27.1 to −23.8‰) in the saline wetland were less negative than that of control samples (−28.7 to −28.2‰) collected from non-saline riparian zones nearby. In addition, the δ^{13}C values became less negative, indicating decreased carbon isotope discrimination, as salinity increased. These results are consistent with published gas exchange measurements that showed that salinity stress could decrease CO_2 diffusion rate by reducing stomatal and/or mesophyll conductance. However, we could not preclude the possibility of growth reduction caused by salinity effects on carboxylation. We suggest that the non-destructive and time-integrating δ^{13}C measurement is a useful tool in monitoring responses of *P. australis* to environmental conditions in saline wetlands.

Keywords: Carbon isotope discrimination; Common reed; Constructed wetland; Saline water; Salinity stress

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doi:10.1016/j.aquabot.2005.02.005

1. Introduction

Common reed (*Phragmites australis* (Cav.) Trin. Ex Steudel) has been extensively planted in artificial wetlands to purify contaminated water because of its plasticity to changes in environmental conditions and high productivity (Kern and Idler, 1999). Because *P. australis* can survive under saline conditions (Lissner and Schierup, 1997), it has often been observed to invade natural and constructed tidal wetlands and is now being planted in salt-affected wetlands constructed on tidal land (Chambers et al., 1999; Yun et al., 2003). Although *P. australis* can acclimate to saline conditions by suppressing salt transport to shoot or through salt sequestration or exclusion (Flowers et al., 1977), experimental evidence clearly indicates that high salinity levels impair their growth mainly through osmotic stress or ionic toxicity or both (Lissner et al., 1999a,b; Burdick et al., 2001).

Osmotic stress may result in reduced stomatal and/or mesophyll conductance (limitation on CO_2 diffusion), which restricts the availability of intercellular CO_2 for carboxylation (Brugnoli and Lauteri, 1991; Ouerghi et al., 2000). Meanwhile, ionic toxicity can impair photosynthesis by decreasing carboxylase activity (limitation on CO_2 carboxylation) (Seemann and Sharkey, 1986; Brugnoli and Bjorkman, 1992). Munns et al. (1995) suggested that osmotic stress and ionic toxicity usually occur in sequence, osmotic stress in the early phase followed by ionic toxicity in the later phase of salinity stress. In a controlled pot experiment with spinach (*Spinacia oleracea* L.), Delfine et al. (1998) found that irrigation with saline water decreased stomatal (or mesophyll) conductance without affecting carboxylase activity up to 20 days of irrigation; however, salts accumulated during the 20 days prohibited the enzyme activity thereafter. In contrast, Gibberd et al. (2002) found that irrigation with saline water concurrently decreased stomatal conductance and carboxylation rate in carrot (*Daucus carota* L.). These studies were conducted during a short period under controlled environmental conditions. Evaluation of the effect of salinity stress (limitations on CO_2 diffusion and carboxylation) on growth performance of plant species in a time-integrating manner over the whole growing season would improve our understanding of the mechanisms underlying the growth responses to salinity stress.

Since Smith and Epstein (1970) measured stable carbon isotope ratio ($\delta^{13}C$) for a variety of plants in saline wetlands, the $\delta^{13}C$ in plant tissues has been correlated with gas exchange responses of several plant species (both halophytes and non-halophytes) to salinity stress (e.g. Brugnoli and Lauteri, 1991; Isla et al., 1998; van Groenigen and van Kessel, 2002). Because plants tend to discriminate against ^{13}C during CO_2 diffusion and enzymatic assimilation, changes in the ratio of intercellular (C_i) and ambient CO_2 partial pressure (C_a) resulting from limitations on CO_2 diffusion (CO_2 supply) or carboxylation (CO_2 consumption) alter ^{13}C enrichment of plant tissue (Farquhar et al., 1989). The relationship between plant $\delta^{13}C$ and C_i/C_a can be described as (Farquhar et al., 1989):

$$\delta^{13}C_{\text{plant}} = \delta^{13}C_{\text{air}} - a - (b - a)\frac{C_i}{C_a} \tag{1}$$

where $\delta^{13}C_{\text{plant}}$ and $\delta^{13}C_{\text{air}}$ are $\delta^{13}C$ of plant and atmospheric CO_2 (normally $\sim(-8‰)$), respectively, C_i/C_a the ratio of intercellular to atmospheric CO_2 concentration, a and b are the carbon isotope discrimination against ^{13}C during CO_2 diffusion through stomata (normally $\sim$4.4‰) and during CO_2 fixation (normally $\sim$27‰), respectively. Although the