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Growth responses of Phragmites karka – a candidate for second generation biofuel from degraded saline lands

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Global changes like rapidly increasing population, limited fresh water resources, increasing salinity and aridity are the major causes of land degradation. Increasing feed production for bioenergy through direct and indirect land use cause major threat to biodiversity besides competing with food resources. Growing halophytes on saline lands would provide alternate source of energy without compromising food and cash crop farming. Phragmites karkahas recently emerged as a potential bio-fuel crop, which maintains optimal growth at 100 mM NaCl with high ligno-cellulosic biomass. However, temporal and organ specific plant responses under salinity needs to be understood for effective management of degraded saline lands. This study was designed to investigate variation in growth, water relations, ion-flux, damage markers, soluble sugars, stomatal stoichiometry and photosynthetic responses of P. karka to short (0-7 days) and long (15-30 days) term exposure with 0 (control), 100 (moderate) and 300 (high) mM NaCl. A reduced shoot growth (∼45%) during earlier (within 7 days) phase was observed in 300 mM NaCl compared to control and moderate salinity. Reduced leaf elongation rate and leaf senescence from 7th day in 300 mM NaCl (and later in moderate salinity) correspond to increasing hydrogen peroxide and malondialdehyde contents. Leaf turgor loss represents the osmotic effect of NaCl at both concentrations, however turgor recovered completely in moderate salinity within a week. Plant appeared to use both organic solutes (soluble sugars) and ions (Na++K++Cl-) for osmotic adjustment along with improved water use efficiency under saline conditions. Turgor loss in high salinity (300 mM NaCl) was related to increased bulk elastic modulus and decreased hydraulic capacitance which ultimately resulted in low water potential. Leaf Na+ and Cl- accumulation increased earlier (from 7th day) in 300 mM NaCl and later in 100 mM. Higher ion sequestration in different organs was found in the following order: root > senesced leaves > young leaves. Moreover, plants maintained nutrient homeostasis (K+, Ca++, Mg++, NO-) by selective uptake via root and transport towards leaf. Moderate salinity increased instantaneous carboxylation efficiency and water use efficiency with stomatal density and smaller pore size compared to control which supported unchanged photosynthetic rate by protecting light harvesting machinery. Low photosynthetic rate in early phase of higher salinity was related to reduced stomatal conductance, while in later phase (15-30 days) due to decreased carboxylation efficiency, effective quantum yield and Fv/Fm (at noon). In conclusion, organ specific responses to short and long term exposure in moderate salinity ensures successful plant survival, whereas long term exposure tohigh salinitywas toxic for plant growth. It is recommended that P. karka could be grown as a biofuel crop on marginally saline and degraded lands.