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Physiological and nutritional indicators of tolerance to salinity in chickpea plants growing under symbiotic conditions

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Abstract

Alterations of plant growth, nitrogenase activity and nutrient concentration as a consequence of salt treatments were studied in five chickpea (*Cicer arietinum* L.) cultivars from Spain and Syria. Plants, in symbiosis with *Mesorhizobium ciceri* ch-191 strain, were grown under controlled conditions for 32 days and subjected to salinity stress. Parameters of growth and nitrogen fixation were affected under salt stress in all cultivars tested; plant dry weight decreased by about 15% in ILC1919; and in Sirio and Lechoso about 50% with the highest salt dosage (100 mM NaCl). ILC1919 showed a less growth accompanied by a lower dry matter formation under low salt conditions compared with most of the salt sensitive cultivar. Nitrogenase activity decreased by about 60% in the salt-resistant cultivar (cv. ILC1919) and more than 90% in salt-sensitive cultivars (cv. Sirio and Lechoso) with the highest salt dosage during the reproductive growth. We show that the higher NaCl tolerance of the ILC1919 cultivar is supported by the less N_2 fixation inhibition, a higher root-to-shoot ratio, normalized nodule weight and shoot K/Na ratio; and a reduced foliar accumulation of Na^+. Moreover, our results reveal the effectiveness of these nutritional and physiological indicators in the selection of salinity-tolerant chickpea plants growing under symbiotic conditions.

Keywords: *Cicer arietinum*; Legumes; NaCl; Nutrient concentration; Salinity stress; Symbiosis

1. Introduction

Chickpea is one of the most important grain legumes traditionally cultivated in deprived areas and saline soils (Rao et al., 2002). The agronomical importance of chickpea (*Cicer arietinum* L.) is based on its high protein concentration 25.3–28.9% (Hulse, 1991) for the human and animal diet, being used more and more as an alternative protein source. Selection and breeding of cultivars that can grow and provide economic yield under saline conditions constitute more permanent and complementary solutions to minimize the repercussions of the salinity (Ashraf and McNeilly, 2004). Salinity occurs through natural or human-induced activities that result in the accumulation of soluble salt in soil and the problem of soil salinity is expected to boost in the future with the progress of desertification process and greenhouse effect. In plants, salinity drastically affects photosynthesis (Seeman and Sharkey, 1986; Soussi et al., 1998), nitrogen metabolism (Cordovilla et al., 1994; Mansour, 2000; Santos et al., 2002), carbon metabolism (Delgado et al., 1993; Soussi et al., 1999; Balibrea et al., 2003) and provokes disorders in plant nutrition which may lead to deficiencies of several nutrients and high levels of Na^+ (Cordovilla et al., 1995a; Grattan and Grieve, 1999; Mengel and Kirkby, 2001). Such physiological changes will result in a decrease in plant growth and consequently in crop yield.

The establishment and activity of the legume-*Rhizobium* symbiosis, particularly the *Cicer arietinum-Mesorhizobium ciceri*, have been known to be susceptible to salinity (Saxena et al., 1994; Rao and Sharma, 1995; Rao et al., 2002). The nodulation capacity of chickpea under stress has been used as an indicator to select chickpea genotypes grown in Indian soils (Rao et al., 2002; Garg and Singla, 2004). In addition, differences of N_2 fixation efficiency in cultivars within the same species such as faba bean (Cordovilla et al., 1995b),

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