Effects of Sodium Chloride on Tepary Bean

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ABSTRACT

Osmotic adjustment is one of the adaptive responses of plant species to salinity, In tepary bean seedlings, salinity led to osmotic adjustment in different parts of the seedlings. The osmotic potential of the leaves increased to 340mM(-1MPa)in seedlings treated with - 0.75 MPa NaCl. Water and osmotic potential of leaves and proximal part of the roots were more negative than the controls whereas the turgor potential remained about the same. The osmotic adjustment of the tepary bean may result from the synthesis and accumulation of free sugars and amino acids or the accumulation of inorganic ions within the tissue. A quantitative analysis of the sugars and amino acids from salt stress treated tepary bean seedlings showed that they would contribute only -0.15 MPa to the osmotic adjustment whereas inorganic ions would contribute -0.45 MPa. The sum of these osmotic potentials is -0.6 MPa which is -0.4 MPa short of the observed osmotic values. These results suggest that additional substances also contribute to the osmotic adjustment of tepary beans.

INTRODUCTION

Salt accumulation in agricultural soils is an increasing problem for agricultural productivity in arid and semiarid regions of the world. Many primary agricultural areas in western U.S. such as California and Arizona, in spite of sophisticated agricultural systems, are now facing salt problems due to irrigation with water containing high levels of salts. Sodium chloride salinity adversely affects the growth and yield of many crop plant species; however, some species have adapted to salinity. Beans are a classic example of a salt sensitive crop. Successful growth and reproduction of crop plants grown under saline conditions requires changes in their metabolism to cope with the salinity stress. Tepary beans have been reported not to tolerate dry climate and saline conditions (Goertz, 1988) but the mechanism of tolerance is still unknown and it is the aim of this research to elucidate the physiological basis of the tolerance. Tepary bean is an important dietary constituent of the Indian cultures such as O'odham, Pima, and Seri and has been cultivated by these tribes for centuries.

MATERIALS AND METHODS

White tepary bean, Phaseolus actifolius and navy bean (Phaseolus vulgaris) seeds were germinated in vermiculite for 5 days and the resulting seedlings transferred to solutions of aerated modified Hoagland's solution. Seedlings were grown at 25C under photoperiod of 13 hr with light intensity of 400 u Em S at canopy level. Salt treatment began 24 hr after the transplanting and NaCl was added to the Hoaglands medium in increments of -0.25 MPa per day until the desired level was reached. Salt solution of 0, -0.25, -0.50, and -0.75 MPa were used in this study. Plant height, shoot fresh and dry weights and leaf area were measured. All measurements were conducted every three days. Free amino acids were extracted and estimated by the methods of Bieleski and Turner (1966). The free sugars were extracted in the same way as the amino acids but quantitative of sugars was conducted by the methods of Dubois, et al, 1956 and HPLC procedures (Miller, 1989). The osmotic and water potentials were determined with Merrill thermocouple psychrometer. The stored data from the psychrometer

was transferred to computer and analyzed with communication program (Procomm).

RESULTS AND DISCUSSION

Growth analysis of tepary bean seedlings showed that the length, shoot fresh and dry weights, root fresh and dry weights, leaf area, leaf area index (LAI) and relative growth rate were reduced by -0.75 MPa salinity. The reduction of navy bean growth was greater than tepary bean indicating tepary bean tolerated the salt stress better. The determination of osmotic adjustment of the different parts of the seedlings revealed that -0.75 MPa salt treatment led to a significant increase in osmoticum of all the parts as compared to control, (Table 1). Because osmotic adjustment occurred in the salt treated seedlings, a quantitative analysis of the free amino acids and sugars was conducted to determine how much they contributed to the increase in osmotic potential. The free sugars and amino acids contributed 38 mM and 19 mM to the adjustment, respectively. These levels (-0.15 MPa) accounted for only a small part of the total osmotic adjustment. A quantitative determination of the Na, Cl, K ions in the seedlings showed that contributed 174 mM (0.45 MPa) to the adjustment. The values of the organic and inorganic solutes add up to -0.6 MPa which is -0.4 MPa less than the total osmotic adjustment. Additional unidentified solutes must be present in the seedling that contribute to the adjustment; the unknown solutes may be betaine or other inorganic ions.

Table 1. Osmoticum (mM) in tepary bean leaves, proximal part of the root (Section 1) and the remaining part of the root (Section 2) after being treated with various NaCl levels for 72 hours.

Solution Osmotic Potential	Osmotic adjustment (mM)		
	Leaves	Section 1 of the root	Section 2 of the root
0	249 a	204 a	208 a
-0.50	431 b	350 b	336 ab
-0.75	598 c	364 b	379 b

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