Growth and Anatomical Structure of Wheat as Affected by Zinc and Salinity

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INTRODUCTION

Soil salinity is a major agricultural problem in arid and semi-arid regions. About 3.5 M ha of the cultivated farms are affected by salinity in Iran. Morphology, anatomy and metabolism of plant species are also deeply affected by salt stress. Zinc is necessary for root cell membrane integrity (Marschner and Cakmak 1986). External Zn concentrations may mitigate the adverse effect of NaCl by inhibiting Na^+ and Cl^- uptake or translocation (Alpaslan et al. 1999). Our objective was, therefore, to study the possible protective role of Zn against salinity by changes in chemical and anatomical structure of wheat.

METHODS

Twenty calcareous soil samples were collected from different regions of the Khorasan province in Iran. A pot experiment was conducted with wheat (*Triticum aestivum* L. cv. BC Roshan). The soil samples were salinized by adding saline water (100 mM NaCl + $CaCl_2$ prepared with the same equivalents). Zinc was applied at the rates of 0 and 10 mg Zn kg^{-1} as $ZnSO_4.7H_2O$. The plants were harvested 12 weeks after planting, and stem segments (2cm above soil surface) were taken (Gadallah and Ramadan 1997). Stem diameters and thicknesses of vessels were determined using an ocular micrometer with a light microscope. Shoot and root dry matter were determined, Zn^{2+} and Ca^{2+} concentrations were measured in shoots using an Atomic Absorption (AA) instrument, Na^+ and K^+ were measured by spectrophotometry.

RESULTS AND DISCUSSION

Root and shoot growth of wheat was inhibited by salinity (Table 1). The salinity-induced dry-weight reduction was more severe in roots than in shoots. Dry weights increased with Zn application to 4.1 and 18.2% for shoots and to 3.4 and 8.6% for roots in non-saline and saline soils, respectively. Shoot/root ratios increased with salinity and higher Zn levels. The Zn concentration in shoots increased by adding Zn in non-saline and saline soils, but salinity resulted in significantly lower Zn levels. The Na concentration increased in shoots with salinity, but it decreased with increasing Zn levels. The K/Na and Ca/Na ratios in shoots were lower in saline soils. The application of Zn increased K/Na and Ca/Na ratios.

Table 1. Shoot and root dry weights of wheat, Zn, Na concentrations, and K/Na, Ca/Na ratios in shoot affected by Zn and salinity.

Zn (mg /kg)	Salinity (mM)	Dry weight (g/pot)		Concentration (g/kg)		K/Na	Ca/Na
		Shoot	Root	Zn	Na		
0	0	7.63 b†	0.921 a	4522 b	2.52 c	10.41 a	1.43 b
	100	2.70 d	0.180 b	1865 d	8.47 a	1.70 c	1.09 c
10	0	7.96 a	0.954 a	7398 a	2.64 c	9.61 a	1.42 b
	100	3.30 c	0.197 b	3740 c	3.49 b	4.50 b	2.75 a

†Values were compared using a Duncan multiple range test at the 95% level.

Salinity and Zn treatments induced structural changes in wheat stems. Stem diameters and the number of vascular boundles decreased in salinity stressed plants (Fig.1). The relative thickness (RT) of the pith also increased under saline conditions. The Zn application improved the formation of vascular tissues and increased the number of vascular tissues in unstressed and stressed plants.

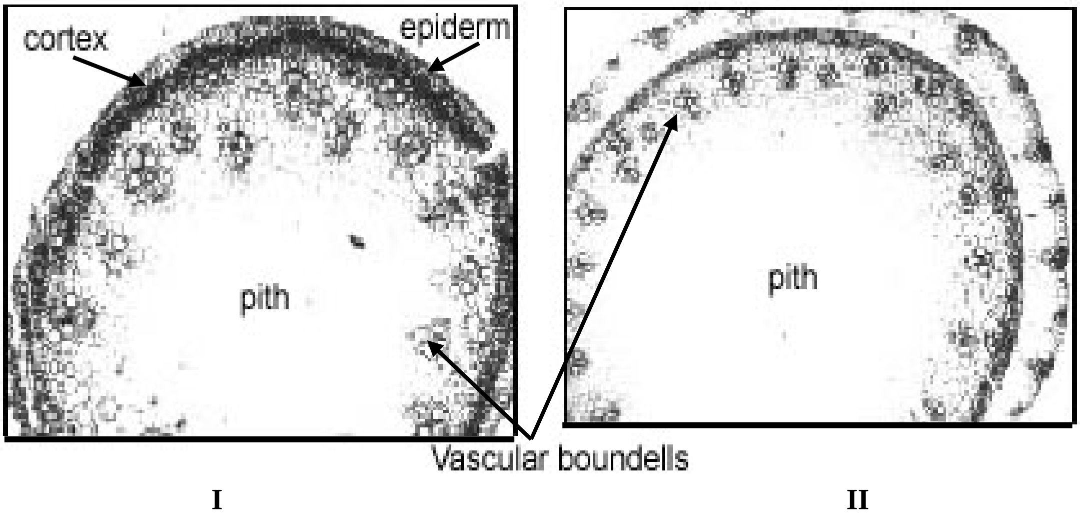

Fig 1. Cross-section of wheat stem in 100 mM salinity, without (I) and with 10 mg/kg Zn (II) treatments.

The lower shoot and root dry weights due to salinity are attributed to water stress, Na^+ toxicity, and ionic imbalances in the plant. High concentrations of Na^+ cause a range of osmotic and metabolic problems for plants. Metabolic toxicity of Na^+ is a result of its ability to compete with K^+ for binding sites that are essential for cellular function (Rahid et al. 2004). The positive effect of Zn on shoot dry weight of wheat under salinity could be explained by enhanced membrane integrity, and the resulting decrease in Na^+ uptake and translocation from root to shoot. Anatomical disturbances in stems due to salinity have been reported. Responses to salinity are often expressed as anatomical and cytological changes. In this study, it was shown that salinity caused inhibition of the growth of vascular elements. The addition of Zn protected vascular tissues from salinity effects by inhibiting Na^+ uptake and translocation in the plant.

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