



Effects of Salt Stress on Some Characteristics in Crop Plants

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Abstract Salinity is a major environmental factor determining plant productivity and plant distribution. It affects more than 10 percent of arable land and salinization is rapidly increasing on a global scale, declining average yield for most major crop plants by more than 50 percent. Salt stress occurs in areas where soils are naturally high in salt and precipitation is low and/or where irrigation, hydraulic lifting of salty underground water, or invasion of sea water in coastal areas brings salt to the surface soil that inhabit plants. Salt tolerance in higher plants is regulated by a number of different physiological and biochemical processes. There is evidence that high levels of salt cause an unbalance of the cellular ions leading in both ion toxicity and osmotic stress. Basic metabolic pathways such as photosynthesis and respiration are affected by salinity. A response of respiration to salinity is primarily associated with the direct effects of salinity on enzyme function.

Keywords Genetic Diversity, Salt Tolerance, Respiration, Ion toxicity

Introduction

Salinity is a major environmental factor determining plant productivity and plant distribution. It affects more than 10 percent of arable land and salinization is rapidly increasing on a global scale, declining average yield for most major crop plants by more than 50 percent [1]. Salt stress occurs in areas where soils are naturally high in salt and precipitation is low [2] and/or where irrigation, hydraulic lifting of salty underground water, or invasion of sea water in coastal areas brings salt to the surface soil that inhabit plants. Globally 20% of irrigated land and 2.1% of dry land agriculture suffers from the salt problem and NaCl is the predominant salt causing salinization [3]. Salinity adversely affects germination, growth, physiology and productivity by reducing the ability of plants to take up water causing imbalance in osmotic potential; ionic equilibrium and nutrient uptake [4]. This article is review and the aims are effects of salt stress on some characteristics in crop plants.

Physiological and biochemical processes

Salt tolerance in higher plants is regulated by a number of different physiological and biochemical processes. There is evidence that high levels of salt cause an unbalance of the cellular ions leading in both ion toxicity and osmotic stress [5], leading to the production of active O₂ species (AOS) such as superoxide (O₂⁻), hydrogen peroxide (H₂O₂) and hydroxyl radicals (OH⁻) [6]. The production of AOS creates oxidative stress in plants exposed to salinity or other stresses. For example, AOS have been shown to cause oxidative damage to DNA and proteins and peroxidation of lipid structures [6-7] as well as inactivation of antioxidant enzymes [8]. Some reports suggest that resistance to oxidative stress is one of the prominent aspects of plant salt tolerance [9-10].



Genetic Diversity for Salt Tolerance in Plants

The extensive genetic diversity for salt tolerance that exists in plant taxa is distributed over numerous genera [11]. Most crops are salt sensitive or hypersensitive plants (glycophytes) in contrast to halophytes, which are native flora of saline environments. Some halophytes have the capacity to accommodate extreme salinity because of very special anatomical and morphological adaptations or avoidance mechanisms [11]. However, these are rather unique characteristics for which the genes are not likely to be introgressed easily into crop plants. Research of recent decades has established that most halophytes and glycophytes tolerate salinity by rather similar strategies often using analogous tactical processes [12]. The cytotoxic ions in saline environments, typically Na^+ and Cl^- , are compartmentalized into the vacuole and used as osmotic solutes [4, 13]. It follows then that many of the molecular entities that mediate ion homeostasis and salt stress signaling are similar in all plants [12]. In the fact, the paradigm for ion homeostasis that facilitates plant salt tolerance resembles that described for yeast [14]. The fact that cellular ion homeostasis is controlled and effected by common molecular entities made it feasible to use of model genetic organismal systems for the dissection of the plant salt stress response [14-15]. Research on the plant genetic model *Arabidopsis* has increased greatly our understanding of how cellular salt tolerance mechanisms are integrated and coordinated in an organismal context, and are linked to essential phenological adaptations. Since *Arabidopsis* is a glycophyte, a salt tolerant genetic model will be required to delineate if salt tolerance is affected Most by form or function of genes or more by differences in the expression of common genes due either to transcriptional or post-transcriptional control [16].

Respiration

Basic metabolic pathways such as photosynthesis and respiration are affected by salinity. A response of respiration to salinity is primarily associated with the direct effects of salinity on enzyme function [17]. High concentrations of salinity have often been reported to increase in respiration. This increase in respiration is greater in salt sensitive than salt tolerant species [16].

Osmotic adjustment

Osmotic adjustment is regarded as an important adaptation of plants to salinity because it helps to maintain turgor and cell volume. Plants are able to tolerate salinity by reducing the cellular osmotic potential as a consequence of a net increase in inorganic and solute accumulation [18]. During osmotic adjustment, the cell tends to compartmentalize most of the absorbed ions in vacuoles at the same time they synthesize and accumulate compatible organic solutes in the cytoplasm in order to maintain the osmotic equilibrium between these two compartments. Although the energetic cost of osmotic adjustment by inorganic ions is much lower than that conferred by organic molecules synthesized, this could also led to produce toxic effects because such high concentration of toxic ions may interfere with normal biochemical activities within the cell [19]. Thus, a better understanding of these mechanisms and processes would enhance our efforts to improve the salinity tolerance of crop genotypes.

Ion toxicity

Further, it facilitates severe ion toxicity by depositing high concentration of Na^+ which causes membrane disorganization, inhibition of cell division and expansion. In addition, it impairs a wide range of cellular metabolism including photosynthesis, protein synthesis and lipid metabolism [20-21]. Lichtenthaler et al. (2005) found that salt stress was responsible for decreased biosynthesis of chlorophyll and inefficiency of photosynthesis all of which ultimately leading to lowered economic productivity [22-23]. The decline in photosynthesis due to salinity stress could be due to lower stomata conductance, depression in carbon uptake and metabolism, inhibition of photochemical capacity or a combination of all these factors [24].



Antioxidants

Defence mechanisms against free radical-induced oxidative stress involve: (i) preventative mechanisms, (ii) repair mechanisms, (iii) physical defenses, and (iv) antioxidant defences. The plants defend against these reactive oxygen species by induction of activities of certain antioxidative enzymes such as catalase, peroxidase, glutathione reductase, and superoxide dismutase, which scavenge reactive oxygen species [25]. Activities of antioxidative enzymes such as ascorbate peroxidase, glutathione reductase, monodehydroascorbate reductase (MDHAR), dehydroascorbate reductase (DHAR), and Mn-SOD increase under salt stress in wheat, while Cu/Zn-SOD remains constant and total ascorbate and glutathione content decrease [26]. In soybean root nodules ascorbate peroxidase, catalase, and glutathione reductase activities decrease under salt stress, while superoxide dismutase and reduced glutathione increase and malondialdehyde and total protein remain unchanged [27].

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