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Crop tolerance against salt stress

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Introduction

Soil salinity can be defined as the proportion or content of salts in the soil. The process by which soil salinity developed is known as soil salinization. The process of soil salinization is occurred by several factors such as use of poor quality of ground waters for irrigation the crops [1]. Natural processes such as mineral weathering and gradual withdrawal of an ocean are also main inducing factors of soil salinization. If the Na^+ is predominant, soils can be classified as sodic-soils. Na^+ is one of the major toxic elements that hampers the growth and productivity of a variety of crops [2]. Soil types with high Na^+ content creates problems for crops because of very poor structure which limits or prevents water infiltration and drainage [3]. It has been documented that three major membrane transport systems are involved in the mechanisms to avoid Na^+ toxicity, namely: (1) Na+ efflux from roots to the rhizosphere, (2) Na^+ sequestration into vacuoles and (3) Na^+ exclusion from leaf blades. Ca^{2+} and K^+ elements may help to plants by coping with salt stress. In addition to Na^+, Cl^- is also toxic element to plants if soil is under the effect of excessive salt stress [3].

According to an estimate, about 33% and 20% of irrigated and cultivated lands, respectively are salt degraded across the world. Salt affected soils can be classified as saline, sodic or saline-sodic depending the soil electrical conductivity, sodium adsorption ratio and pH. The classification of salt-affected soils has been presented in Table 1 [4].

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Table 1: Soil classification based on soil salinity level.

	Soil property		
Soil type	Electrical conductivity (dS m^{-1})	Sodium adsorption ratio	pH
Non-saline, non-sodic	<4	<13	<8.5
Saline	>4	<13	<8.5
Sodic	<4	>13	>8.5
Saline-sodic	>4	>13	>8.5

Weathering of soil minerals release salts which are leached out of soil with draining water depending on sufficient rainfall. Besides to mineral weathering, salts are also deposited through precipitation and dust. In dry regions salts may accumulate, causing natural soil salinity Salt-affected soils can be ameliorated by leaching soluble salts out of soil with excess irrigation water [5].

Salt affected soils can cause detrimental effects on plant growth and yield. Salt tolerant crops should be a good option to tolerate soil salinity and protect crop yield loss. The severe soil salinity causes a reduction in both yield and quality of crops. Crops may demonstrate different salt tolerance depending on soil properties, growth stage, and agronomical practices including salt-resistant rootstocks [6]. The detrimental effects of salt stress on plant growth are because of two key reasons: (1) Osmotic stress reduces water uptake by roots and causes internal dehydration, with effects similar to those caused by drought, and (2) direct accumulation of salts leads to ion toxicity that disturbs metabolic processes, particularly in photosynthetic cells. Injury in plant tissues appears when salts loaded in transpiring tissues exceed the capacity of plants to extrude them from the cytoplasm, which mainly depends on the processes of Na^+ extrusion from roots, Na^+ unloading from the xylem, and Na^+ sequestration in vacuoles [4].

In the majority of crops, tolerance against salt stress is regulated with time at different developmental stages and diverse traits are involved in tolerance at each sensitive growth stage, and a variety of genes regulate these traits. For example, rice is relatively tolerant during germination, tillering, grain filling, and maturity but sensitive during the seedling stage, panicle initiation, flowering, and pollination. Some barley genotypes are extremely tolerant during germination but sensitive at the seedling and early vegetative stages, and then become more tolerant during grain filling and maturity [6]. Knowledge of the specific mechanisms that are hampered or negatively influenced by salt stress at critical growth stages will assist targeting of specific genes or alleles to improve tolerance. A considerable advancement has been made in exploring the mechanisms and processes of salt tolerance in numerous crops, yet there is need of advancing salt tolerance processes and mechanisms in crops to understand the complexity of plant responses to salt stress.

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