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Plant growth and development as influenced by the salinity stress

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Abstract

Plants are force to stressful conditions due to environmental factors is called as abiotic stress. Abiotic stresses like drought, temperature extremes, floods, salinity mineral deficiency and toxicity are threatening horticultural production. These abiotic stresses posing challenges in sustaining even the current productivity levels globally. Being a tropical country, India is more challenged with penultimate combinations of abiotic stresses spatially and temporally. The country is experiencing productivity declines due to abiotic stresses which are major limitations in maintaining food security. Inter-Governmental Panel on climate change has projected that by the end of this century global earth temperature is likely to be increased by 1.8°C to 4.0°C. This climate change will aggravate the impact of abiotic stresses. This article will deal with the effects of salinity stress on plant growth and development.

Keywords: Salt stress, plant physiology, survival mechanism

Introduction

Salinity in soil or water is one of the major abiotic stresses that reduce plant growth and crop productivity. More than 800 million hectares of land throughout the world are salt affected, equating to more than 6 per cent of the world's total land area. It is estimated that of the current 230 million hectares of land under irrigation 45 million hectares are salt affected (20%) and of the 1500 million hectares of dry land agriculture, 32 millions hectare are salt affected. In India, salinity is the major problem in arid and semi-arid regions. Problem of salinity is currently causing concern over 8.5 million hectare area but threatening another 27 per cent cultivable land of the country. It is major problem in Gujrat, Western U.P., Punjab, Rajasthan and Haryana.

Salinity stress limits crop yield affecting plant growth and restricting the use of land. About 20% of all irrigated land is affected by soil salinity, decreasing crop yields (Kader, 2010) [3]. Plants are affected by salt stress in two main ways: osmotic stress and ionic toxicity. These stresses affect all major plant processes, including photosynthesis, cellular metabolism, and plant nutrition. Salt stress mainly occurs due to two factors

1. Irrigation water: Continuous usage of underground water for irrigation which brings excess salt from the underground region.
2. Types of soil: Under rainfed condition, because of high evapotranspiration, water moves upward through the soil profile and forming salt crusts on the surface of the soil. Salinity results in rapid uptake of salts to toxic levels. This can badly damage or kill trees. Fruit trees are generally considered to be sensitive and a reduced yield can be experienced even with fairly low level because water is naturally attracted to higher salt levels if soil is high in salt, it binds the water strongly and become difficult for the tree to extract.

Plants in saline areas

Plants those are sensitive to relatively high salt concentrations known as glycophytes and those that are able to grow in the presence of high salts known as halophytes. Some halophytes are referred to as salt accumulators. In these species the osmotic potential continues to become more negative throughout the growing season as salt is absorbed. Even in these plants, however, the soil solution is not taken directly into the plant. Halophytes in which the salt concentration within the plant does not increase during the growing season are known as salt regulators.

Often salt does enter the plant, but the leaves swell by absorbing water, so concentrations do not increase. This leads to the development of succulence, a common morphological feature of halophytes. Sometimes excess salt is exuded on the surface of the leaves, helping to maintain a constant salt concentration within the tissues.

Three main salinity tolerance mechanisms have been proposed by Munns and Tester (2008)^[7]: ion exclusion – the net exclusion of toxic ions from the shoot; tissue tolerance – the compartmentalization of toxic ions into specific tissues, cells and subcellular organelles; and shoot ion-independent tolerance – the maintenance of growth and water uptake independent of the extent of Na⁺ accumulation in the shoot.

Salinity effects on plants growth

Stress condition can delay growth and development, reduce productivity, and, in extreme cases cause plant death (Radin *et al.*, 1996). Salinity imposes detrimental effects on plant growth through low osmotic potential of soil solution and nutritional imbalance (Munns and Tester, 2008)^[7]. As a consequence of these primary effects of salt stress, caused by its hyperosmotic effect, secondary stresses, such as oxidative damage, often occur (Zhu, 2001)^[16]. Salinity is the most important abiotic stress that inhibits growth and productivity of crop and it is one of the world's oldest and most widely distributed environmental challenges. Salinity is defined as the presence of an excessive concentration of soluble salts in the soil which suppresses plant growth (Zaki, 2011)^[15]. Increased salinity is a stringent problem and a major limiting factor for crop production around the globe (Wahid *et al.*, 2007)^[13].

High levels of soil salinity can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and specific ion toxicity. Salt stress had adverse effects on the functioning and metabolism of plants considerably hinders the productivity (Khan and Srivastava, 1998)^[5].

Salinity has an adverse effect on seed germination of many crops by creating an osmotic potential outside the seed inhibiting the absorption of water, or by the toxic effect of Na⁺ and Cl⁻ (Khajeh-Hosseini *et al.*, 2003)^[4]. Several investigators have reported plant growth reduction as a result of salinity stress, e.g. in tomato (Romero-Aranda *et al.*, 2001)^[11], cotton (Meloni *et al.*, 2001)^[6] and sugar beet (Ghoulam *et al.*, 2002)^[2].

Effect on photosynthesis

Growth of plants is dependent on photosynthesis and, therefore, environmental stresses affecting growth also affect photosynthesis (Taiz and Zeiger, 1998)^[12]. Studies conducted by a number of authors with different plant species showed that photosynthetic capacity was suppressed by salinity (Romero-Aranda *et al.*, 2001)^[11]. A positive association between photosynthetic rate and yield under saline conditions has been found in different crops such as *Gossypium hirsutum* (Pettigrew and Meredith, 1994)^[9] and *Asparagus officinalis* (Faville *et al.*, 1999)^[1].

Decreases in photosynthetic rate as a result of salinity: (1) Dehydration of cell membranes which reduce their permeability to CO₂. High salt concentration in soil and water create high osmotic potential which reduces the availability of water to plants. Decrease in water potential causes osmotic stress, which reversibly inactivates photosynthetic electron transport via shrinkage of intercellular space. (2) Salt toxicity caused particularly by Na⁺ and Cl⁻ ions. (3) Reduction of CO₂

supply because of closure of stomata. (4) enhanced senescence induced by salinity, (5) changes of enzyme activity induced by changes in cytoplasmic structure, and (6) negative feedback by reduced sink activity

Effects on plant water uptake and ion homeostasis

Salt has two major effects on plants: osmotic stress and ionic toxicity, both of which affect all major plant processes (Yadav *et al.*, 2011)^[14]. Plants are able to take up water and essential minerals because they have a higher water pressure than the soil under normal conditions. When salt stress occurs, the osmotic pressure of the soil solution is greater than that in plant cells. Thus, the plant cannot get enough water (Kader, 2010)^[3]. In addition, its cells will have decreased turgor and its stomata will close to conserve water. Stomatal closing can lead to less carbon fixation and the production of Reactive Oxygen Species (ROS) such as superoxide and singlet oxygen. ROS disrupts cell processes through damage to lipids, proteins, and nucleic acids (Parida and Das, 2005).

Managing salinity stress

- Deep ploughing plus levelling of field
- Leaching of soluble salts
- Providing efficient drainage system
- Application of gypsum as per recommendation
- Mulching with crop residue or plastic films
- Use of organic manures.

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