Effect of Salinity Stress on Physiology of Plants

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Introduction

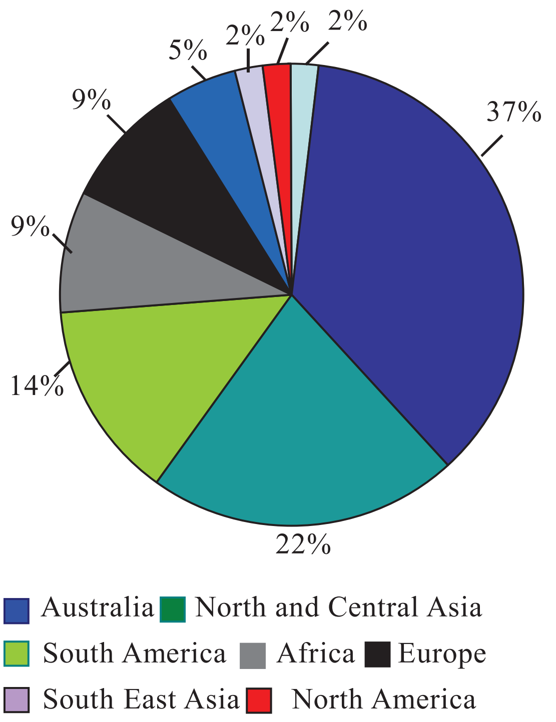
One of the major environmental facet that reduce plant productivity is salinity, and this stress cause reactions in plants due to water stress; moreover, this environmental concerns affect plants more than is commonly thought Serrano (1999). All soil in which water-soluble salts exceed 4 dS m^{-1} is considered saline. Water stress due to salinity is probably the most significant abiotic factor limiting plant and also crop growth and development. Salinity stress induce osmotic stress and metabolic responses of the affected plants. Water deficit affects the germination of seed and the growth of seedlings negatively.

Salinity in soil or water is one of the major stresses and, especially in arid and semi-arid regions, can severely limit crop production. The deleterious effects of salinity on plant growth are associated with low osmotic potential of soil solution (water stress), nutritional imbalance, specific ion effect (salt stress), or a combination of these factors. Salt stress is also one of the most significant environmental constraints limiting crop productivity in arid and semi-arid regions (Asraf and Harris, 2004). Salinization problems are on the increase mainly due to poor irrigation drainage or agricultural practices, low quality water, thus leading to net accumulation of ions in the root zone. Salt stress is first perceived by the root system and impairs plant growth by inducing an osmotic stress caused by reduced water availability and from the ion toxicity due to solute imbalance in the cytosol (Munns, 2005).

Figure 1.**Global distribution of salt-affected areas (Khan *et al.,* 2011)**

EFFECTS OF SALINITY ON PLANT LIFE-

The effects of salinity on plants cover a spectrum from mild osmotic effects which are



not easily detected, reduction of shoot and root growth that are more obvious and on the other extreme, chlorosis, necrosis and senescence of young and old leaves (Munns, 200). Salt stress adversely affects plant growth, development and productivity by generating ion toxicity (accumulation of toxic level of Na^+ and Cl- ions), oxidative Stress (excess ROS production) inducing nutritional deficiencies/ imbalance (decreases mineral uptake and mineral solubility) creating osmotic stress and water deficits.

Physiological effects of salt stress

Salinity effects on photosynthesis

Salt stress causes decrease in plant growth and productivity by disrupting physiological processes, especially photo-synthesis. The accumulation of intracellular sodium ions at salt stress changes the ratio of K : Na, which seems to affect the bioenergetic processes of photosynthesis.Iyengar and Reddy (1996) noted that decreases in photosynthetic rate in saline condition resulted from a number of factors including:

- High osmotic potential and reduced water availability to plants result in cell membrane dehydration and reduction the permeability of CO2 and consequently photosynthetic electron transport decreases via shrinkage of intercellular spaces.
- Due to toxicity of NaCl ions, the Cl- ion inhibits photosynthetic rate through its inhibition of NO^{3-}N uptake by the roots, consequently reduced NO^{3-}N uptake combined with osmotic stress may explain the inhibitory effect of salinity on photosynthesis.
- Stomata closure causes reduction in CO_2 supply so that the availability of CO_2 for carboxylation reactions restricted.
- Advancing senescence induced by salinity.
- Changes in cytoplasmic structure enzyme activities.
- Reduction in sink activities as a result of negative feedback.
- Some evidence showed that growth is reduced more rapidly at lower concentrations of sodium in the leaf than in photosynthesis. This means that plants can withstand a certain loss in photosynthetic rate without any effect on growth.

Salinity effects on water relations

Two components of a plant's water relations are water potential and hydraulic conductivity. Water potential refers to the potential energy of water relative to pure water, and therefore determines the direction of water movement, where water moves from a location with a higher water potential to a location with a lower water potential. Hydraulic conductivity refers to the ease with which water can flow from one location to another and therefore affects the rate of water movement.

- In high salt concentration, plants accumulate more Na^+ and Cl^- in the tissues of the leaves than normal situation. Subsequently, by increasing Na^+ and Cl^- within the leaf tissues lower osmotic potentials occurs and resulted in more negative water potentials.
- Root hydraulic conductance reduction decreases the amount of water flow from the roots to the leaves, thus, causing water stress in the leaf tissues.

Salinity effects on photosynthetic pigments

Several researchers showed that generally the chlorophyll and total carotenoid contents of leaves decrease under salinity where the chlorosis start from oldest leaves during the salt stress.It is observed that the total chlorophyll content of the mature leaves increases considerably due to increasing concentrations of NaCl. Chlorophyll content in plants correlates directly to the healthiness of plant. The resistance of photosynthetic systems to salinity is associated with the capacity of the plant species to effectively compartmentalize the ions in the vacuole, cytoplasm and chloroplast.

Salinity effects on ion levels and nutrient contents

In saline conditions, absorption of Na^+ and Cl^- competes with up taking nutritional elements such as K^+, N, P, and Ca^{2+} by plants, which create nutritional disorders result in yield quantity and quality reduction. Several researchers indicated that increased NaCl concentration in root zone of plants causes accumulation of Na^+ and Cl^- in shoot tissues and decline Ca^{2+}, K^+ and Mg^{2+} levels in a number of plants.

Salinity effects on leaf and root growth

There is some evidence that with increasing salinity, the leaves of plant change anatomically, for example, in *Atriplex sp.*, cotton and bean increase of spongy cell diameter, palisade diameter, palisade cell length, mesophyll thickness and epidermal thickness occurred. Adversely, Parida*et al.* (2005) noted that by increasing salinity both epidermal and mesophyll thickness and intercellular spaces in leaves of *Brugueiraparviflora*decreased, also Delfine*et al.* (1998) showed that intercellular spaces in leaves of spinach declined with increasing the salinity. Romero-Aranda *et al.* (2001) in a study on salinity effects on tomato indicated that in the face of salinity a reduction in stomatal density was observed.

The root is the first organ of plant affected by salinity. Munns (2005) showed that root influences on ion accumulation and leaf growth, they noted it can be one of the mechanisms of salt tolerance. Vaughan *et al.* (2002) investigated effects of salinity on different alfalfa rooting (low- and high-fibrous rooting characteristics) of populations under increasing salinity condition and found that root production in high-fibrous root types was stimulated more than low-fibrous root types at low and medium salinity. They noted across salinity treatments, final root length density (cm root length per cm^3 soil volume) was 24% higher for high-fibrous root types, and herbage yield of high- fibrous root types was 14% higher than low-fibrous root types. High fibrous rooting in alfalfa is a trait with potential usefulness as a salinity stress avoidance mechanism. Root growth has been used as a standard for screening of alfalfa salinity tolerance (Vaughan *et al.,* 2002).

Salinity effects on seed germination

Salinity not only delays but also decreases seed germination. Due to the toxic effects of salt and water uptake and root growth is restricted preventing seedling emergence. Germination of seeds is one of the most critical phases of plant life greatly influenced by salinity (Misra and Dwivedi, 2004).

Ansari *et al.* (2012) reported a significant reduction in the germination percentage; seed reserve utilization as well as growth of rye. Earlier, Ansari *et al.* (2012) had shown relation to seed performance, germination percentage and seedling indices. Decline in seed reserve utilization, seedling growth and different indices of seeds under stress conditions were also reported for mountain rye.

Conclusion

Soil salinity is causing a great threat to global food productivity, leading to similar basic challenges in cultivating crops in a sustainable manner under saline conditions in developing and developed countries.In the future, some techniques such as gene editing systems may be used to address this global issue. It will promote biotechnological applications and molecular breeding of salt-tolerant crops, which can increase the usage of saline land and crop production.

Refernece

Ansari, O. and Sharif-Zadeh, F., (2012) Osmo and hydro priming improvement germination characteristics and enzyme activity of Mountain Rye (Secalemontanum) seeds under drought stress. *J. Stress Physiol. Biochem*., 8: 253-261.

Ashraf, M. and Harris.(2004) Potential indicators of salinity tolerance in plants.*Plant Sci*., 166: 3–16.

Delfine, S., Alvino, A., Zacchini, M. and Loreto, F. (1998) Consequences of salt stress on conductance to CO2 diffusion, Rubisco characteristics and anatomy of spinach leaves. *Aust Journal of Plant Physiol.,*25: 395-402.

Iyengar, E. and Reddy, M. (1996) Photosynthesis in highly salt tolerant plants.*Handbook of photosynthesis*. Marshal Dekar, Baten Rose, USA pp: 897-909.

Khan, A.A.,McNeilly, T.,Azhar, F. (2011) Stress Tolerance in Crop Plants.*Int. J. Agric. Biol.* 3: 250–255.

Misra, N. and Dwivedi, U.N. (2004) Genotypic difference in salinity tolerance of green gram cultivars. *Plant Sci.,* 166: 1135-1142.

Munns, R., (2005) Response of crops to salinity. *International Salinity Forum*.,339: 25–27.

Parida, A. and Das, A. (2005) Salt tolerance and salinity effects on plants. *Ecotox Environ Safe.,*60: 324-349.

Romero, A.R., Soria, T. and Cuartero J. (2001) Tomato plant-water uptake and plant-water relationships under saline growth conditions.*Plant Sci.,*160:265-272.

Serrano, R., Macia, F.C. and Moreno, V. (1999) Genetic engineering of salt and drought tolerance with yeast regulatory genes.*Hort. Sci.,*78: 261-269.

Vaughan, L., MacAdam, J., Smith, S. and Dudley, L. (2002) Root growth and yield of differing alfalfa rooting populations under increasing salinity and zero leaching.*Crop Sci*., 42: 2064- 2071.

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