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Mohamed Abdulla Ahmed *

Horticulture and Landscape department, collage of Agriculture, Tikrit University, Iraq

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Physiological effects of salt stress on plant growth.

ABSTRACT

Salinity affects plant growth by causing physiological and morphological changes, which reduces its vegetative system. This appears through decreases in stem length, number of leaves, as well as lateral branches and diameter of plant organs.There are two types of salinity: soil salinity and water salinity. Soil salinity means soil characterized by a high percentage of dissolved salts, mostly of which are chlorides, sulfates and carbonates, to a degree harmful to plant growth. If the soil contains dissolved salts in high quantities, water potential can be reduced to negative level. A distinction between salt stress and ionic stress must be noticed. The first term is used when salt concentration is so high that water potential of growing substrate drops to a significant level (05.0 - 1.0 MPa). If the decrease in water potential was slight and undetectable, the effect here is in the form of ionic stress. A simplified definition of salt stress can be given as an increase in the concentration of salt in plant cells to the degree that affects the physiological properties. This is due to a decrease in the water potential of growing substrate which negatively affects the morphological characteristics of plant. Water potential determines the water movement from the soil to the root or from one cell to another.

INTRODUCTION

Salinity is one of the most critical abiotic environmental stressors to which plants are exposed. This negatively affects plant growth and reduces productivity (Koca et al., 2007; Parida and Das, 2005). Salinity has become a serious problem for plant growth and reduces crop yields all over the world. Salt stress causes various physiological and metabolic changes, such as nutritional imbalance (Manik et al, 2019). Some NaCl-tolerant plants implement a series of adaptations including morphological and physiological to withstand salinity. Biochemical modification such as root / shoot ratio and total chlorophyll content are involved. In addition, changes in leaves anatomy, eventually, lead to preventing toxicity of leaf ion (Alon et al, 2017). Impact of salinity is also extended to soil properties. Physical, chemical and hydraulic characteristics are negatively affected (Muhsen, 2021).

Plants differ in terms of their response to salt stress and mechanism to withstand this stress. Biological researches have had primary focus this problem (Munns and Tester, 2008, and. Zhu2002). Salinity stress can extremely weaken plant growth due to increase in sodium chloride (NaCl) concentration and osmotic pressure during first stage of plant life. This occurred when high concentrations of ions presented in the soil. Eventually, a difficulty in water absorbing take place in saline medium (Flowers and Colmer, 2008, Munns,1993). The world loses about ten million

* *Corresponding author: E-mail*: mohmeed.abdullah@tu.edu.iq

hectares of arable land annually due to salinization. Salinized land in the world has reached about 900 million hectares (Munns, 2002).

Plants exposed to salt stress adapt all their biological processes to tolerate changes in soil and water. Therefore, plant produces reactive oxygen species known as free radicals, Hydroxyl radical (OH), and Hydrogen Peroxide (H2O2) or Superoxide $O2^{-}$ (ROS). These destroy organelles of living cells such as mitochondria and chloroplasts by degrading the cytoskeleton. ROS affect plant growth and production through damaging cell membrane (Mishra and Choudhari, 1999) or inhibition of Calvin cycle enzymes (Fatma et al., 2014). Plant responses to salt stress are varied, as each plant has a complex set of morphological and physiological characteristics. This reduces absorption of toxic ions accumulated in root cavities and ground section of the plant. This also reduces accumulated ions in young organs and growing parts of shoot system (Starck and Kozinska, 1980). The medicinal value of edible, salt-tolerant plants has been documented. These plants showed an ability to prevent various chronic diseases in modern societies (Ksouri et al., 2007).

Salinity is considered one of the main obstacles that limit productivity of agricultural crops worldwide. However, plants differ in their response to salinity depends on plant types and species (Oztekin,2011). Ramakrishna and Ravishankar (2011) et al. In their studies on abiotic stress, included the effects of salinity on secondary active substances in plant. Salinity is one of threatening factors to horticultural production decreasing germination rate and delaying emergence of seedlings. (Begum et al.,1996, Siddiky et al, 2014.).

This factor can cause yield deterioration by affecting growth parameters. It can disturb water balance, which leads to nutrition imbalance as well as affect physiological and biochemical processes in plant. This stressor may also affect crop during both germination and reproduction phases leading to a decrease in plant growth and development .That is, too high internal ion concentration (ion increase /toxicity) and nutritional imbalance (ion deficiency) (Lewit, 1980).

Mechanism of plant endure against salinity varies from plant to another. This is related to various aspects including genes of proteins in which ions control the physical and chemical properties. Salt plays an important role in directing cells to withstand salt stress to some point before the toxicity (Jenks et al, 2007).

Salinity damage and growth stages:

The damage of salinity to the plant can be summarized as follows:

1-Impeding absorption of some essential elements for growth due to presence of ions such as sodium ions.

2-Ion poisoning on cell results from accumulation of high levels of sodium, chloride and sulfate more than plant cell capacity.

3-Decrease water absorption due to osmotic tension applied to roots in growing plant under high salinity.

4- Genotoxic occurred when salts concentration increased in cell cytosol to critical level. In this case, DNA is deteriorated and destroyed immediately (Elsahookie ,2013).

Plant tolerance to salinity is also deferent according to stages of growth and plant type. These stages can be summarized as follows:

1- Germination and emergence.

2-seedling and branching.

3-Elongation, flowering and fertilization.

Among problems plant breeders face is plant tolerate salt at a certain stage but not later stages. That is each stage has certain genes to work for certain mechanism. Therefore, it is necessary to test the plant tolerance for the other stages . plants have salt glands can be ranged 5000- 6000 glands per square centimeter of a leaf (Luttge and Lauchli,2014).

Salt-tolerant plants have many modifications in leaves, roots and stems different from what cultivated plants do. This needs special studies to diagnose tolerance mechanisms.

Effect of salinity on plant:

Salinity affects the shape of plant cells, as well as plant appearance. It also impacts respiration rate, carbon synthesis, and dry matter productivity per unit area. Generally, plant root,

leaf, and stem cells become smaller when grown in saline .Cell walls are also damaged by salt stress, as the cell walls thicken and tend to stiffen. That means they are less plasticity and more rigidity due to accumulating of salt in cells as well as some compounds such as Glucan.

Accordingly, the cells have more solid walls when exposed to salt stress. Some cells may collect starch and fat granules in chloroplast. At the same time, to get rid of high concentration of sodium ions, cell vacuoles increase in size. They occupy a large space of the cell cytoplasm to collect the most significant amount of salts. Different compounds, hormones or metabolic, in the cell are also affected positively or negatively. Many activities have been observed to increase the synthesis of ABA, SA, IAA and ethylene in salinity tolerant plants. This is to protect cell osmo-protectants on one hand and fix the damage of salinity on the other hand (Hillel 2000).

Physiological mechanism of plant tolerance:

Plants differ in their tolerance to salt stress based on group of genes responsible of phenotypic, anatomical, chemical and functional characteristics (Elsahookie, 2013). Salt stress is tolerated by biological management of plant cells. This may be done through accumulating inorganic ions in cells. It may also be through functions of multiple genes. In addition, ability of plant, grown under high salinity, to manage their osmosis to adapt and survive is also studied (Flowers, 2014).

Salinity level in growth medium can reduce the levels of endogenous hormones that encourage growth in tissues exposed. These are necessary for multiplication, elongation, growth and survival under salt stress (Kaya et al. 2009). The high osmotic pressure, presence of NaCl, in growing substrate changes some plant tissues behavior. This forces the plant to direct the greater part of energy in different path. This energy available for metabolic processes is directed towards building an osmotic potential inside cell to encounter high osmotic pressure in the substrate. This occurred at the expense of the building processes necessary to perpetuate processes involved in growth cell division and expansion (Smith et al.1992). Behavior of plants to tolerate salinity was also examined by treating with some plant hormones. However, the action of these compounds when they are internally manufactured (endogenous) is different when external (Exogenous).

Thus, adding these compounds may maintain the completion of plant life cycle. Nevertheless, it does not increase plant yield under salinity stress. Amino acids and proteins concentrations were also greater than normal under salinity stress. These compounds and many others are subject to increase or decrease in the plant when exposed to abiotic stress.

The compounds play an important role in some plant species in protecting cells from stress damage. They have mechanisms to switch from one foem to another by action of their specific enzymes. All of this falls under the term Metabolome. One of the things must be known is these compounds have a role through their interaction with energy compounds (NADPH and ATP).

When the compounds are positive, they maintain energy rate in the plant, however, when negative, synthesis of oxidants (ROS) cannot be tolerated. Hence, plat growth is weak under such stress. Salinity causes less cell division and size, small size of stomata, less leaf area, and lower rate of carbonization as well as decreased yield (Elsahookie, 2013).

Several researches in this aspect have shown that plasma membrane has an active role in maintaining its plasticity under stress. This ensures the natural permeability of water and ions among cells. This also prevents harmful ions from damaging cells, especially inner wall (tonoplast) of cytoplasm and vacuoles. Moreover, displays cell ability to increase size of vacuoles and block sodium ions particularly. In this case, the cell is insulated from potential damage of sodium ions which moved from cell cytosol to the walled vacuole. This leads cell to be stable functionally under stress, as one or more of the following occurs (Jury and Vaux, 2007):

1- Restriction or exclusion of sodium ions from cell cytosol by plasma membrane.

2-Trapping sodium ions inside the vacuoles.

3- Expulsion sodium ions from the cell to Apoplast. This is all linked to many genes, such as so-called Salt Overly Sensitive Proteins (SOS), specialized in controlling salt ions.

CONCLUSION

According to presented, plants grown in saline environments have a particular physiological and anatomical mechanism for toleration. Salt stress resistance varies based on the type of plant, genetic traits (specialized genes for salt control). Salinity may significantly reduce plant growth in general. However, it has positive effects in increasing many plants' proteins, amino acids and sugars.

Intensively, studies in this regard should be conducted. Many types of plants need to be tested under salt stress condition. increase crops' ability to tolerate salt stress must be aimed.

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التأثيرات الفسلجية للأجهاد الملحي في نمو النبات

محمد عبدالله احمد

قسم البستنة وهندسة الحدائق – كلية الزراعة – جامعة تكريت – صلاح الدين - العراق

الخلاصة

تؤثر الملوحة على نمو النبات و دلك بإحداث تغيرات فسيولوجية ومورفولوجية في النبات ينتج عن ذلك اختزال المجموع الخضري ، ويظهر ذلك من خلال الانخفاض في طول الساق و الاختزال في عدد الأوراق وكذلك التقليل من الفروع الجانبية وقطر الأعضاء النباتية . هناك نوعين من الملوحة هما: ملوحة التربة وملوحة الماء، ويقصد بملوحة التربة - بأنها الاراضي التي تتميز بارتفاع نسبة الامالح الذائبة وأهمها الكلوريدات والكبريتات والكربونات بدرجة ضارة لنمو النبات. إن احتواء التربة على الالمالح الذائبة بكميات عالية سوف تقلل من الجهد المائي للماء فيصبح سالبا ولابد من التفريق بين الاجهاد الملحي والاجهاد الايوني كون المصطلح الاول يستعمل حينما يكون تركيز الملح عاليا لدرجة ينخفض معه الجهد المائي لوسط النمو لمستوى محسوس (05.0 – 1.0 ميجاباسكال) أما إذا كان الانخفاض في الجهد المائي طفيفا وغير محسوس فان ذلك يعني أن التأثير هنا يكون بشكل إجهاد أيوني stress Ion . ويمكن إعطاء تعريف مبسط للأجهاد الملحي بأنه عبارة عن زيادة تركيز الملح في خلايا النبات لدرجة تؤثر على الخواص الفسيولوجية للنباتات بسبب انخفاض الجهد المائي لوسط النمو الامر الذي ينعكس بشكل سلبي على الصفات المورفولوجية للنبات. وان الجهد المائي هو الذي يحدد حركة الماء من التربة الى الجذر او من خلية لأخرى .

الكلمات المفتاحية:
فسلجة نبات، اجهاد ملحي , نمو النبات , كلوريد الصوديوم , محتوى