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Breeding for Salt Resistance in Vegetable Crops : A Review

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ABSTRACT

Salt is naturally present in soils, surface water and groundwater systems. The most common salt causing salinity is sodium chloride, but there may be a range of other salts such as magnesium, calcium or potassium. Salinity is a major abiotic stress limiting growth and productivity of plants in many areas of the world due to increasing use of poor quality of water for irrigation and soil salinization. Plant adaptation or tolerance to salinity stress involves complex physiological traits, metabolic pathways, and molecular or gene networks. Identification of genes that play important role in salt tolerance in plants when exposed to high salt levels in soil is very important tool to improve plant tolerance in stress condition. The success in the development of crops adapted to drought and salt depends on the efficient and combined use of genetic engineering and traditional breeding tools. Moreover, we propose the domestication of new halophilic crops to create a 'saline agriculture' which will not compete in terms of resources with conventional agriculture. To improve salinity tolerance of crops, various traits can be incorporated, including ion exclusion, osmotic tolerance and tissue tolerance. We review the roles of a range of genes involved in salt tolerance traits.

Keywords Breeding, Salt, Vegetable, Abiotic, Resistance.

INTRODUCTION

Salinity is derived from the Latin word Selenium meaning "salt cellar" and its meaning "condition or quality of being". Salinity refers to the presence of soluble salts in soil or water. The development of salt-tolerant cultivars normally requires the transfer of several genes due to the multigenic character of plant resistance or tolerance to this abiotic stress .

In India alone, 7 million hectares of land are salt affected. Globally, more than 800 million hectares (Mha) of land are estimated to be salt-affected (FAO 2008). These soils cover a range of soils defined as saline, saline–sodic and sodic.

The impact of salinity on the economic exploita-

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tion of land for agriculture and forestry is very severe salt-affected soils occupy 7% of the world land area, and salinity is also a problem that is increasing rapidly. The ability of plants to survive salinity stress is important for natural distribution of plant species and to agriculture.

Salinity of arable land is a problem that is becoming more and more important in many areas where irrigation is a regular agro-technical measure, and in semi-arid and arid regions in the world where atmospheric precipitations are not sufficient to flush the salts from the root zone. When irrigation water is of inadequate quality, the occurrence of chlorosis between leaf veins is commonly observed, leaf tissue necrosis often develops and flowering may not happen at all. Very great importance is ascribed to the time during which the plants were exposed to different concentrations of salts. As explained by Munns (2002).

Effects of salinity on salt-tolerant plants are the same as effects of water deficiency. Within minutes and hours of exposure to salinity salt-specific effects are not visible. If the exposure to salts lasts many days, salt-induced injuries become apparent on older leaves of salt-sensitive plants, in addition to reduced rate of leaf emergence and heavier impact on leaves than on roots, which are symptoms typical for water-stress. After weeks of exposure to salts older leaves of sensitive genotypes die and if exposure lasts several months younger leaves die and the whole plant may die before seed maturation.

Definition

Salinity is defined as the presence of excessive amounts of soluble salts that hinder or affect the normal functions of plant growth. It is measured in terms of electrical conductivity (ECe), with the exchangeable sodium percentage (ESP) or sodium adsorption ratio (SAR) and pH of a saturated soil paste extract. Salt stress is one of the most brutal environmental factors limiting the productivity of vegetable crops because most of the vegetable crops are glycophyte in nature. Salt tolerance is important in vegetables because of their cash value. One-third of the land being irrigated worldwide is affected by salinity. Therefore, saline soils are those that have saturated soil paste extracts with an ECe of more than 4 dSm^{-1}, ESP less than 15%, and pH below 8.5. Saline soils have a mixture of salts of Chloride, Sulfate, Sodium, Magnesium and Calcium ions with sodium chloride often dominant.

There are two main sources of salinity:

Primary or natural sources

Resulting from weathering of minerals and the soils developed/derived from saline parent rocks.

Secondary salinization

Caused by human factors such as irrigation, deforestation, overgrazing, or intensive cropping.

Mechanism of Salinity in Plants

Effect of excess salinity on plant growth

Response of vegetables to the presence of increased amounts of salts is primarily stunted growth (Romero-Aranda *et al.* 2001).The accumulation of salts in the leaves cause premature aging, reduces the supply of plant parts with nutrients and products of carbon assimilation of the fastest-growing plant parts and thus impair the growth of the entire plant. In the more sensitive genotypes salts accumulate more rapidly and because cells are not able to isolate the salt ions in vacuoles to the same extent as more tolerant genotypes, the leaves of more sensitive genotypes usually die faster (Munns 2002). Suggests that growth inhibition due to excessive salt concentration in the leaves reduces the volume of new leaf tissue in which excess salts can accumulate and therefore, in combination with the continuous accumulation of salts, it can lead to an increase in salt concentration in the tissue. It is often difficult to determine the relative influence of osmotic effect and the effect of the toxicity of specific ions on vegetable yield. In any case, yield losses due to osmotic stress can be very significant even before symptoms of toxicity on leaves become noticeable. Under the influence of salt stress growth of many species of vegetables is reduced, such as tomato (Romero-Aranda *et al.* 2001, Maggio *et al.* 2004), pepper (De Pascale *et al.* 2003b), celery (De Pascale *et al*.2003a) and peas (Maksimovic *et al*. 2010).

There are significant differences in salt tolerance between plant species and genotypes and similar goes for the ability to tolerate water deficiency (Munns 2002, Lukovic *et al*. 2009). In parallel the classification of waters with respect to the total concentration of salts and tolerance of selected vegetable species to salts. Salinity causes anatomical changes in leaves of many plant species. For example, the epidermis and mesophyll leaves of beans, cotton and Attriplex become thick, length of palisade mesophyll cells and diameter of spongy mesophyll cells increase and thickness of palisade and spongy layers and increasing as well in some other plant species were recorded adverse effects. In spinach leaves the presence of salt reduces the intercellular spaces but it increases stomatal density in pea (Maksimović *et al.* 2010).

Effect of excess salinity on the water regime of plants

The main cause of reduced plant growth in the presence of salt can be impairment of water regime. Increasing the salt concentration in the soil increases the osmotic pressure of the soil solution and plants cannot uptake the water as easily as in the case of relatively non-saline soils. Therefore, as the concentration of salt i.e., soil EC increases, water becomes less accessible to plants, even if the soil contains significant amounts of water and looks wet. Osmotic pressure depends on the number of particles contained in the solution and the temperature. Osmotic pressure (OP) of extracted soil solution can be expressed by the following empirical formula: OP = 0.36 x EC (dS m^{-1}). At a pressure of about 1.44 bar, corresponding to the EC of 4 dSm^{-1}, the plants start to show signs of physiological stress caused by water shortage.

As one of the mechanisms by which plants protect their cells from harmful effect of high concentration of salts is dilution, then increasing of water retention in the tissues of the plant further reduces transpiration. These factors reduce the efficiency of water usage and ultimately result in reduction of vegetable growth and yield. The vegetation period is shortened, water regime of plants is disrupted and the uptake and distribution of essential elements in both semi-controlled and field conditions is altered (Maksimovic *et al.* 2010).

Accumulation of compatible osmolites increases vegetable tolerance to osmotic stress

One of the ways plants can adapt to conditions of osmotic stress is the accumulation of salt ions, if these salts are isolated in individual cell compartments by which their involvement in metabolism is prevented. The ability to regulate the concentration of salts through compartmentation is an important aspect of tolerance to increased salt concentrations (Romero-Aranda *et al.* 2001).In the presence of salts plants often accumulate low molecular weight substances which are called compatible osmolites. These substances do not interfere with normal biochemical reactions in cells (Hasegawa *et al.*2000). Compatible osmolites are low molecular weight molecules such as proline and glycine betaine (Ghoulam *et al.* 2002, Ashraf and Foolad 2007).It is believed that under conditions of stress, proline has a role in osmotic adjustment of cells, enzymes and membrane protection and also as a source of nitrogen for a moment when conditions of stress are over (Ashraf and Foolad 2007).

The role of glycine betaine is also in maintaining pH of the cells, cell detoxification and binding of free radicals. Conditions of salt stress also lead to the accumulation of the other nitrogen compounds such as amino acids, amides, proteins and polyamines, which is often correlated with tolerance to salt (Mansour 2000). Another group of compatible osmolytes are carbohydrates, both simple sugars (glucose, fructose, sucrose, fruktani), and starch. Their most important roles, beside in osmotic adjustment, is carbon storage and neutralization of free radicals (Parida *et al.* 2002).

Effect of excess salinity on mineral nutrition of plants

Increased salt concentration in the vicinity of the root system can interfere with mineral nutrition of plants and limit vegetable yield due to salinity or osmotic value of the soil solution. Salinity affects nutrient availability to plants in many ways. It modifies binding, retention and transformation of nutrients in the soil and affects the uptake and/or absorption of nutrients by the root system due to antagonism of ions and reduced root growth. It disrupts the metabolism of nutrients in the plant, primarily through water stress, thus reducing the efficiency of utilization of nutrients. In the presence of increasing concentrations of salts some species-specific symptoms may be present, such as necrosis and burns of leaf edges due to the accumulation of Na+ and Cl- ions (Wahome 2001).

The high concentration of ions can disrupt the structure and function of cell membranes. Mineral nutrition of plants depends on the activity of membrane transporters which participate in the transfer of ions from the soil into the plant and regulate their distribution within and between cells (Tester and Davenport 2003, Epstein and Bloom 2005).

It is often considered that the use of fertilizers may aggravate problems that exist due to the presence of excessive amounts of salts in the soil. However, the lack of essential elements in accessible forms is a very common reason for poor productivity on such soils.

Effect of excess salinity on nitrogen, phosphorus and potassium uptake and metabolism

Nitrogen fertilization on saline soils is often necessary because in such soils there is a lack of accessible nitrogen and also because losses of nitrogen due to leaching typical for nitrate form (Yin *et al.*2007, Abdelgadir *et al.* 2010). Level of salinity does not affect necessarily the overall uptake of nitrogen by plants which may continue to accumulate nitrogen in the presence of excess salts despite a reduction in yield of dry matter. With the increase in soil salinity, total removal of nitrogen through the yield often decreases. Reduction in nitrogen fertilizer use efficiency is primarily a result of reduction of plant growth rate rather than the reduction of nitrogen uptake rate.

In conditions of high salinity plants may show signs of potassium deficiency due to antagonistic effects of Na+ and Ca 2+ on K+ absorption and/or abnormal Na+/K+ or Ca2+/K+ ratio. In such circumstances, the application of potassium fertilizers can increase the yield of plants. It has been shown that increased concentrations of Na+ block channel protein used for the uptake of K+, AKT1, and in this way reduce the uptake of K+. Inhibitory effect of Na+ on transport of K+ through channels in the membranes is probably more important in the phase of uptake of K+ from the soil solution than in the phase of K+ transport to the xylem (Qi and Spadling 2004). The degree of tolerance of plants to the salinity is higher if they have a more efficient system for the selective uptake of K+ instead of N+ (Ashraf 2004, Carden *et al.* 2003).

Effect of excess salinity on photosynthesis

Since plant growth directly depends on photosynthesis, stress factors that affect plant growth, affect the photosynthesis as well (Taiz and Zeiger 2006). The effect of irrigation on production of organic matter and yield of vegetables is irreplaceable, as illustrated in Table 1. The capacity of the photosynthetic appara-

Table 1. Improvement in salt tolerance of potential vegetables crops using different strategies.

Crop and strategy employed to improve salt tolerance	Trait improved	Reference
Pea		
Exogenous application of polyamines	Increase seed yield	Shabala *et al.* 2007
Inorganic nutrient like B and Ca application in nutrient medium	Increased nodule number and efficiency	El-Hamdaoui *et al.* 2003
Okra		
Application of K and humic acid in saline medium	Increased dry biomass	Paksoy *et al*. 2010
Pepper		
Application of Mn, Ca, Zn, and N sources and humic acid	Improved salt tolerance with high K+ and Ca 2+ uptake	Gulser *et al*. 2010
Exogenous application of ascorbic acid, and NaCl as pre-sowing seed treatment	Increased dry biomass	Khafagy *et al*. 2009 Khan *et al*. 2009

tus is reduced in the presence of excess salts (Ashraf 2004, Romero-Aranda *et al*. 2001). However, the intensity of photosynthesis and yield are not correlated in the same way in different plant species.

Some plants can adapt to higher salinity by biochemical changes in the photosynthetic pathway. For example, facultative halophyte Mes *Embryanthemum crystallinum* instead of the usual C3 uses CAM pathway (Cushman *et al.* 2008), Understanding the mechanisms by which salinity affects photosynthesis would help to improve conditions for growing vegetables and increase their yield, and would provide a useful tool for future genetic engineering.

Effect of excess salinity on amino acid composition, hormonal balance, antioxidant system and quality of vegetables

Changes in electrical conductivity of water, the sodium adsorption ratio (SAR) and the concentration of boron in water can affect the amino acid composition of plants. Totawat and Saxena (1974) in the greenhouse experiment found that with increasing SAR and/or boron, regardless of the electrical conductivity of water, significantly decrease the synthesis of amino acids for the species *Vigna catjang*. Synthesis of arginine, histidine, aspartate, glutamine, methionine and phenylalanine decreased, and the synthesis of lysine and valine increased. In addition to the synthesis of amino acids, which was reduced two to three times, in this experiment excess salts reduced the total amount of nitrogen in plants. Both phenomena can be explained by inhibition of the synthesis of RNA and DNA.

Salts affect the level of hormones in plants. The responses of tomato to salt stress conditions are largely determined by the concentration of endogenous ABA (Chen *et al.* 2003).

Mechanism of tolerance to salinity in vegetable crops

Pea (*Pisum sativum* L.)

Salinity effects and crop responses

Almost all morphological, physiological, and molecular attributes of pea are adversely affected by growth medium salinity. Pea shows poor seed germination under saline conditions (Bonilla *et al*. 2004) and pea growth is considerably inhibited by the rooting medium salt stress.

Salt stress causes high accumulation of free proline and increased photorespiration, stomatal resistance and CO_2 compensation concentration, where as it causes a decrease in net CO_2 assimilation rate, transpiration rate, relative water content (RWC) and protein contents (Ahmad and Jhon 2005).

Strategies to improve crop growth and yield

Under saline conditions, application of additional inorganic nutrients such as boron (B) and calcium (Ca). In nutrient medium was reported to be effective in alleviating the adverse effects of salt stress on pea (Bonilla *et al.* 2004). Application of Ca or B improved germination percentage and vegetative growth of pea at 75 mM NaCl but not at 150 mM (Bonilla *et al.* 2004).

Okra (*Abelmoschus esculentus* L.)

Strategies to improve salinity tolerance

Very little work has been reported on the improvement of salt tolerance of okra. Only (Paksoy *et al.* 2010) have reported that addition of K and humic acid to the saline medium are very effective in enhancing the salt tolerance of okra particularly at the seedling stage.

Tomato (*Solanum lycopersicum* L.)

Salinity effects and crop response

Tomato is considered by some authors to be sensitive to moderately sensitive to salt stress (Foolad 2007) and 50% yield loss occurs at moderate salinity level (5 dSm^{-1}). However, this growth reduction is more apparent in salt sensitive than that in salt-tolerant genotypes (Turhan *et al.* 2009).

Strategies to improve salinity tolerance

Grafting in tomato has been found very effective in enhancing the crop salt tolerance (Asins *et al.* 2010).

For example, a commercial tomato hybrid cv Jaguar was grafted on rootstocks of several tomato genotypes with the potential for salt exclusion.

Eggplant (*Solanum melongena* L.)

Salinity effects and crop response

Eggplant is considered to be moderately sensitive to salt stress. Salt stress also adversely affects the plants at later stages including shoot and root fresh and dry weights, shoot and root lengths and the gas exchange characteristics, net CO_2 assimilation rate, transpiration rate, stomatal conductance, and internal CO_2 concentration. In contrast, water use efficiency of eggplant is not affected by salt stress (Abbas *et al.* 2010). Potassium (K+) and Ca 2+ concentrations and the K+/Na+ ratio also decrease while concentrations of Na+ and Cl− in plant tissues increase in saline medium. Similarly, leaf glycine betaine and proline concentrations were reported to increase under saline conditions. Salinity also markedly reduces both fruit weight and number of fruits per plant (Abbas *et al.* 2010).

Strategies to improve salinity tolerance

Very few strategies have been reported in the literature to overcome the salinity-induced losses in eggplant production under saline conditions. Exogenous application of inorganic fertilizers, compatible solutes, and plant growth promoting bacteria has been found to be viable approaches to enhance salt tolerance (Abbas *et al*. 2010).

Broccoli (*Brassica oleracea* var. italica L.)

Salinity effects and crop responses

Salt stress modifies the nutritional status of broccoli by altering contents of nitrogen, phosphorus, and sulfur and activities of enzymes involved in nutritional metabolism.

Cauliflower (*Brassica oleracea* var. botrytis L.)

Salinity effects and crop responses

Cauliflower yield is also greatly reduced due to salt stress. There is a need to explore detailed responses of cauliflower to salt stress because it has become a popular vegetable all over the world.

Strategies to improve crop salt tolerance

The reason one report on the improvement of salt tolerance of cauliflower. Reported that nitrogen application to the growth medium could effectively enhance yield of cauliflower under salt stress.

Sources of salinity

The main sources and causes of salt accumulation include:

Geo-chemical weathering of rocks and parent materials and the salts brought down from the upstream to the plains by rivers and subsequent deposition along with alluvial materials,
Derived directly from sea water by flooding or intrusion into ground water resources,
Salt-laden sand blown by sea winds,
Indiscriminate and injudicious use of irrigation waters of different qualities,
Capillary rise from subsoil salt beds or from shallow brackish ground water,
Lack of natural leaching due to topographic situ ation and economic activities in arid and semi-arid regions.

Mitigation of salt stress

Seed hardening with NaCl (10 mM concentration)
Application of gypsum @ 50% Gypsum Requirement (GR),
Incorporation of daincha (6.25 t/ha) in soil before planting,
Foliar spray of 0.5 ppm brassinolode for increasing photosynthetic activity,
Foliar spray of 2% DAP + 1% KCl (MOP) during critical stages,
Spray of 100 ppm salicylic acid,
Spray of 40 ppm of NAA for arresting pre-mature fall of flowers / buds / fruits,
Extra dose of nitrogen (25%) in excess of the recommended,
Split application of N and K fertilizers,
Foliar application of ascorbic acid alone increased

number of leaves and leaf area, while in combination with zinc sulfate increased the plant height and total plant biomass,

The exogenous application of PGRs, auxins, gibberellins and cytokinins produces some benefit in alleviating the adverse effects of salt stress and also improves germination, growth, development and seed yields and yield quality,

Exogenous application of ABA reduces the release of ethylene and leaf abscission under salt stress in plants, probably by decreasing the accumulation of toxic Cl- ions in leaves,

Post-application with exogenous Jasmonic Acid can ameliorate salt stress, especially the salt-sensitive rather than the salt-tolerant cultivar

4 mM ascorbic acid and 4 mM gibberellin could increase transpiration rate, relative water content, chlorophyll b, total chlorophyll and xanthophyll content. In general, it was concluded that synergistic interaction between ascorbic and gibberellin could alleviate the adverse effects of salinity on plants,

Maintenance of high K/Na ratio by applying potash and Ca fertilization

Application of PGRs like cytokinin, GA3, IAA, cycocel, thiourea and polyamines (putrescine, spermidine and spermine) either as seed treatment or foliar spray.

CONCLUSION

The stress provoked by excess salts in the soil solution has similarities with the stress caused by lack of water, although there are differences. Excess salt has an osmotic effect, which means that the amount of water accessible for plants is reduced. Yield losses due to osmotic stress can be very significant before toxicity symptoms on plants become apparent. Increased salt concentrations can lead to a reduction in evapotranspiration, disturbances in mineral nutrition of plants, the plant hormone imbalances, and to the formation of free radicals that damage cell membranes. Expansion of leaves may be impaired and their anatomical properties altered. The high concentration of salts in the soil solution may reduce the removal of nitrogen, phosphorus and potassium so it is necessary to add these elements in the form of fertilizers.

The threshold salinity level at which most of vegetable crops are affected is poorly documented. For example, okra is considered to be semi or moderately salt tolerant, tomato sensitive to moderately sensitive, eggplant moderately sensitive to salt sensitive, and potato moderately sensitive to moderately salt tolerant. Similarly, carrot is considered a salt sensitive crop but many authors are of contradictory views about its degree of tolerance. Further studies are required to classify these vegetables and their common varieties with respect to their degree of salt tolerance.

REFERENCES

Ashraf M (2004) Breeding for salinity tolerance in plants. *Crit Rev Pl Sci* 13: 17–42.

Abbas W, Ashraf M, Akram NA (2010) Alleviation of salt-induced adverse effects in eggplant (*Solanum melongena* L.) by glycinebetaine and sugarbeet extracts. *Sci Hortic* 125: 188–195.

Abdelgadir EM, Fadul EM, Fageer EA, Ali EA (2010) Response of wheat to nitrogen fertilizer at reclaimed high terrace salt-affected soils in Sudan. *J Agric Social Sci* 6: 43-47, ISSN 1813-2235.

Ahmad P,and Jhon R, (2005). Effect of salt stress on growth and biochemical parameters of *Pisum sativum* L. *Arch Agron Soil Sci* 51: 665–672.

Allen JA, Chmnbers JL, McKinney D (2006) Intraspecific variation in the response of Taxodium distichum to improve greenhouse pepper (*Capsicum annuum)* performance under saline conditions. *New Zealand J Crop Hort Sci* 34: 283-290.

Ashraf M, Foolad MR (2007). Roles of glycine betaine and proline in improving plant abiotic stress resistance. Environmental and Experimental Botany 59 : 206–216, ISSN 0098 8472.

A Villalta I, Bernet GP, Dodd IC, Carbonell EA (2010) Genetic analysis of physiological components of salt tolerance conferred by *Solanum rootstocks*. *Appl Genet* 121: 105–115.

Bonilla I, El Hamdaoui A, Bola˜nos L (2004) Boron and calcium increase *Pisum sativum* seed germination and seedling development under salt stress. *Pl Soil* 267: 97–107.

Carden DE, Walker DJ, Flowers TJ, Miller AJ (2003) Single-cell measurements of the contributions of cytosolic Na^+ and K^+ to salt tolerance. *Pl Physiol* 131 : 676–683. ISSN 0032 0889.

Chen G, Fu X, Herman Lips S, Sagi M (2003) Control of plant growth resides in the shoot, and not in the root, in reciprocal grafts of flacca and wild-type tomato (*Lysopersicon esculentum*), in the presence and absence of salinity stress. *Pl Soil* 256 : 205-215, ISSN 0032 079X.

Cushman JC, Agarie S, Albion RL, Elliot SM, Taybi T, Borland AM (2008) Isolation and characterization of mutants of common ice plant deficient in Crassulacean Acid Metabolism. *Pl Physiol* 147 : 228–238. ISSN 0032 0889.

De Pascale S, Maggio A, Ruggiero C, Barbieri G (2003) Growth, water relations, and ion content of field grown celery under saline irrigation (*Apium graveolens* L. var. dulce [Mill.] pers.). *J Am Soc Horticult Sci* 128 : 136-143. ISSN 0003 1062.

De Pascale S, Ruggiero C, Barbieri G, Maggio A (2003) Physiological response of pepper (*Capsicum annuum* L.) to salinity and drought. *J Am Soc Horticult Sci* 128 : 48-54, ISSN 0003 1062.

El-Hamdaoui A, Redondo-Nieto M, Torralba B, Rivilla R, Bonilla I, Bolaños L (2003) Influence of boron and calcium on the tolerance to salinity of nitrogen-fixing pea plants. *Pl Soil* 251: 93–103.

Epstein E, Bloom AJ (2005) Mineral Nutrition of Plants, Principles and Perspectives. 2nd edn. Sunderland, MA. Sinauer Associates, ISBN 97808 78931 729.

FAO (2008) Working with Local Institutions to Support Sustainable Livelihoods. Food and Agriculture Organization, Rome, Italy.

Flowers TJ, Yeo AR (1989) Effects of salinity on plant growth and crop yields, In Cherry JH (ed). North Atlantic Treaty Organization Advanced Science Institutes Ser vol G19. Environmental stress in plants, pp 101–119.

Ghoulam C, Foursy A, Fares K (2002) Effect of salt stress on growth, inorganic ions and proline accumulation in relation of osmotic adjustment in five sugar beet cultivars. *Environm Experim Bot* 47: 39-50, ISSN 0098 8472.

Gülser F, Sönmez F, Boysan S (2010) Effect of calcium nitrate and humic acid on pepper seedling growth under saline condition. *J Environml Biol* 31 (5) : 873–876.

Hasegawa PM, Bressan RA, Zhu JK, Bohnert HJ (2000) Plant cellular and molecular responses to high salinity. *Ann Rev Pl Physiol Pl Mol Biol* 51: 463-499. ISSN 0066-4294.

Khafagy MA, Arafa AA, El-Banna MF (2009) Glycine betaine and ascorbic acid can alleviate the harmful effects of NaCl salinity in sweet pepper. *Aust J Crop Sci* 3: 257–267.

Longstreth DJ, Nobel PS (1979) Salinity effects on leaf anatomy. *Pl Physiol* 63 : 700–703. ISSN 0032-0889.

Luković J, Maksimović I, Zorić L, Nagl N, Perčić M, Polić D, Putnik-Delić M (2009) Histological characteristics of sugar beet leaves potentially linked to drought tolerance. Indust Crops Prod 30 : 281-286. ISSN 0926-6690.

Maas EV (1986) Salt tolerance of plants. *Appl Agric Res*.1: 12 -26.

Maas EV (1990) Crop salt tolerance, In: Agricultural Salinity Assessment and Management, Tanji KK (ed), Amer. Soc. Civil Engrs., New York, pp 262-304. ISBN 08726-27624.

Maksimović I, Putnik-Delić M, Gani I, Marić J, Ilin Ž (2010) Growth, ion composition, and stomatal conductance of peas exposed to salinity. *Central Europ J Biol* 5 : 682-691. ISSN 1895-104X.

Mansour MMF (2000) Nitrogen containing compounds and adaptation of plants to salinity stress. *Biologia Plantarum,* 43 : 491–500. ISSN 0006-3134.

Munns R (2002) Comparative physiology of salt and water stress *Pl Cell Environ* 25 : 239–250. ISSN 0140-7791.

Neumann P (1997) Salinity resistance and plant growth revisited. *Pl Cell Environm* 20 : 1193-1198. ISSN 0140 -7791.

Paksoy M, T¨urkmen ¨O, Dursun A (2010) Effects of potassium and humic acid on emergence, growth and nutrient contents of okra (*Abelmoschus esculentus* L.) seedling under saline soil conditions. *Afr J Biotech* 9: 5343–5346.

Qi Z, Spalding EP (2004) Protection of plasma membrane K+ transport by the salt overly sensitive Na+-H+ antiporter during salinity stress. Pl Physiol 136 : 2548-2555, ISSN 0032-0889.

Romero-Aranda R, Soria T, Cuartero J (2001) Tomato plant water uptake and plantwater relationships under saline growth conditions. *Pl Sci* 160 : 265–272, ISSN 0168-9452.

Shabala S, Cuin TA, Pottosin II (2007) Polyamines prevent Na Cl-induced K + effl ux from pea mesophyll by blocking nonselective cation channels . *FEBS Lett* 581 : 1993 – 1999 .

Taiz L, Zeiger E (2006) Plant Physiology, 4th edn, Sinauer Associates, Inc, ISBN 08789-38567.

Turhan A, Seniz V, Kusc¸u, H (2009) Genotypic variation in the response of tomato to salinity. *Afr J Biotechnol* 8 : 1062–1068.

Wahome PK (2001) Mechanisms of salt stress tolerance in two rose rootstocks, *Rosa chinensis* 'Major', *R. rubiginosa. Sciencia Horticulturae* 87 : 207-216, ISSN 0304-4238.

Yin F, Fu B, Mao R (2007) Effects of nitrogen frtilizer application rates on nitrate nitrogen distribution in saline soil in the Hai River Basin, China. *J Soils Sediments* 7 : 136–142. ISSN 1439-0108.